Klamath Basin Integrated Fisheries Restoration and Monitoring Plan (IFRMP)

Plan Document

February 2023

Klamath Basin Integrated Fisheries Restoration and Monitoring Plan (IFRMP)

Plan Document

February 2023

Suggested Citation: ESSA and Klamath Basin Working Groups. 2023. Klamath Basin Integrated Fisheries Restoration and Monitoring Plan (IFRMP): Plan Document. Prepared by ESSA Technologies Ltd. for the Pacific States Marine Fisheries Commission (PSMFC) and the U.S. Fish and Wildlife Service (USFWS). 380 pp. + APPENDICES

More information available at: https://ifrmp.net/
Klamath IFRMP Prioritization tool: http://klamath.essa.com

Cover Photo: Confluence of Salmon River with Klamath River | USFWS 2007
Inside Cover Photo: Coho Spawning on Salmon River | BLM 2015

Pacific States Marine Fisheries Commission
Portland, Oregon 97202
www.psmfc.org

Table of Contents

Note to Readers

This Plan was funded by the U.S. Fish and Wildlife Service.

While past and parallel efforts at restoring the Klamath Basin have been invaluable, expert reviews have called for a more transparent, science-driven, coordinated, and holistic approach to restoring ecological processes and fish populations across the Klamath Basin to yield the greatest possible benefits for whole-ecosystem recovery (NRC 2004, 2008).

In response, the IFRMP was developed between 2016-2022 to provide a unifying framework and tools to inform federal agencies (and other interested parties) on the highest priority basin-scale functional watershed restoration actions to help reverse the declines of multiple native Klamath Basin fish populations. The U.S. Fish and Wildlife Service (USFWS) contracted with Pacific States Marine Fisheries Commission to complete this Plan. PSMFC then subcontracted with ESSA Technologies Ltd. who did the majority of the work the reader sees here. Special recognition and pride of authorship should be given to:

Clint Alexander, ESSA, President
Natascia Tamburello, ESSA, Sr. Systems Ecologist
Marc Porter, ESSA, Sr. Systems Ecologist
Cedar Morton, ESSA, Sr. Systems Ecologist
Darcy Pickard, ESSA, Sr. Statistician
Aaron Tamminga, ESSA, Systems Ecologist
Caitlin Semmens, ESSA, Systems Ecologist
Laurelle Santana, ESSA, Communications Coordinator for the IFRMP

The USFWS directed the planning team to engage with over one hundred experts, practitioners, natural resource managers, and other interested participants from a wide range of organizations in a collaborative planning process designed around a set of guiding principles consistent with prior recommendations of the National Research Council. Federal Coordination Group and Sub-regional Working Group members have also provided invaluable individual input, reviewing and in some instances co-authoring IFRMP sub-products described in this document. We gratefully acknowledge all contributors for their time and expertise.

While the collaborative science underpinning the IFRMP triangulates the restoration and monitoring actions that are the most needed, the IFRMP and those parties involved in its development do not constitute a decision-making body. **Nothing in the IFRMP constitutes an official federal agency position or obligation for current or future action. Federal decisions, including funding decisions, will continue to be made by the federal agency or bureau with the statutory authority to make such decisions, consistent with federal appropriations and aspirations of these entities to apply best state-of-science information such as that developed for the IFRMP.**

Implementation of any restoration or monitoring activity requires cooperation and support of private landowners, states, federal agencies, Tribes, local governments and other organizations that call the Klamath Basin home. Many considerations related to cost, permitting constraints, support among landowners and other key stakeholders and other interannual factors will always need to be considered by decision authorities when making actual restoration and monitoring project funding decisions year to year. Consequently, some projects listed in the IFRMP might not ultimately be implemented.

As described in the IFRMP, recommendations are provided for implementation to bring the Plan to life including a recommended process for periodically updating Restoration Action Agenda. To the hundreds of collaborators that helped build and review this Plan and its candidate actions to date – thank-you for your time, expertise and dedication.

Finally, the authors acknowledge that this Plan is not perfect and there may be ideas and concepts that did not make it into this version of the IFRMP. We invite stakeholders to submit comments on the IFRMP to Matt Baun, Klamath Coordinator for the U.S. Fish and Wildlife Service (Matt_Baun@fws.gov).

For further information on the IFRMP contact:

Chris Wheaton, Pacific States Marine Fisheries Commission, 205 SE Spokane Street, Suite 100 Portland, Oregon 97202 (Phone: 503.595.3100; Email: CWheaton@psmfc.org).

Photo: Redband trout in the Upper Klamath River | Jonny Armstrong for OSU 2018, used under a CC by 2.0 licence

Acronyms and Abbreviations

Acronym / Abbreviation	Meaning
AM	Adaptive Management
BCMOE	BC Ministry of Environment and Climate Change Strategy
BDA	Beaver Dam Analogues
BI	Biological Interactions
BiOp	Biological Opinion
BLM	US Bureau of Land Management
CDFW	California Department of Fish & Wildlife
cfs	Cubic Feet Per Second
CPI	Core Performance Indicator
CRMP	Coordinated Resources Management Planning
CWA	Clean Water Act
DDP	Definite Decommissioning Plan
DO	Dissolved Oxygen
DQO	Data Quality Objectives
EPA	US Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Units
FCFH	Fall Creek Fish Hatchery
FERC	Federal Energy Regulatory Commission
FG	Fluvial Geomorphic
FP	Fish Populations
H	Habitat
HAB	Harmful Algae Bloom
HCP	Habitat Conservation Plan
HUC	Hydrologic Unit Code
IFRMP	Integrated Fisheries Restoration and Monitoring Plan
IRPT	IFRMP Restoration Prioritization Tool
IGD	Iron Gate Dam
IGFH	Iron Gate Fish Hatchery
IRCT	Interior Redband Conservation Team
Karuk DNR	Karuk Department of Natural Resources
KBMP	Klamath Basin Water Quality Monitoring Plan
KHSA	Klamath Hydroelectric Settlement Agreement
KRRC	Klamath River Renewal Corporation
LKR	Lower Klamath River
LKRP	Lower Klamath River Restoration Plan
LWD	Large Woody Debris
MCDA	Multi-Criterion Decision Analysis
MDAT	Mean Daily Average Temperature
MDMT	Maximum Daily Maximum Temperature
MKR	Mid-Klamath River
MKSFRP	Mid Klamath Sub-basin Fisheries Recovery Plan
MKWC	Mid Klamath Watershed Council
MRRIC	Missouri River Recovery Implementation Committee
MUK	Mid-Upper Klamath
MWAT	Mean Weekly Average Temperature
MWMT	Mean Weekly Maximum Temperature
N	Nitrogen
NAIP	National Agricultural Imagery Program

Acronym / Abbreviation	Meaning
NCRWQCB	North Coast Regional Water Quality Control Board
NGO	Non Governmental Organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic & Atmospheric Administration
NRC	National Research Council
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OSU	Oregon State University
OWL	Open Water Likelihood
OWRD	Oregon Water Resources Department
P	Phosphorus
PCR	Principle Component Regression
PCSRF	Pacific Coastal Salmon Recovery Fund
PHWA	Preliminary Healthy Watersheds Assessments (EPA program)
PIT	Passive Integrated Transponder
PSMFC	Pacific States Marine Fisheries Commission
PWA	Pacific Watershed Associates
QA / QC	Quality Assurance / Quality Control
RM	River Mile
ROD	Record of Decision
SET	Stream Evolution Triangle
SFT	South Fork Trinity
SONCC	Southern Oregon/Northern California Coast Coho Salmon
SOP	Standard Operating Procedure
SRCD	Siskiyou Resource Conservation District
SRRS	Salmon River Restoration Plan
SRWC	Scott River Watershed Council
SRWSR	Shasta Watershed Stewardship Plan
SVRCD	Shasta Valley Resource Conservation District
TAMWG	Trinity Adaptive Management Working Group
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TRRP	Trinity River Restoration Plan
TSS	Total Suspended Solids
UAV	Unmanned Aerial Vehicles
UKBWAP	Upper Klamath Basin Watershed Action Plan
UKL	Upper Klamath Lake
UKR	Upper Klamath River
USBR	US Bureau of Reclamation
USDC	US Department of Commerce
USDI	US Department of the Interior
USFWS	US Fish & Wildlife Service
USGS	United States Geological Survey
WI	Watershed Inputs
WRTC	Watershed Research and Training Center
YTEP	Yurok Tribe Environmental Program
YTFD	Yurok Tribal Fisheries Department

Acknowledgements

The Klamath Basin Integrated Fisheries Restoration and Monitoring Plan (IFRMP) prioritization results are the product of the coordinated efforts of a vast team committed to improving fishery restoration practices in the Klamath Basin.

The data, advice, and tools developed for the IFRMP would not have been possible without the invaluable contributions of the more than one hundred participants (Appendix A). Federal Coordination Group and Sub-basin Working Group members who collectively over the course of Phase 2 (2017-2018), Phase 3 (2019-2020), Phase 4 (2020-2021) and Phase 5 (2021-2022) committed **many hundreds of hours** of time to the development and review of this Plan. IFRMP Sub-basin and Disciplinary Working Groups are comprised of habitat (including water quality) and fish professionals with regional and local expertise. Contributions included provision of data, professional judgement, opinions, critiques, and other input to inform development of a well-integrated basin-wide Plan for the Klamath. Pathways for input included one-on-one interviews, group webinars and workshops, survey responses, and review and critique of intermediary draft products.

We are sincerely grateful for the participant's time and expertise and commend all who contributed for their patience and dedication.

Photo: IFRMP Workshop | Natascia Tamburello 2017, with permission

Executive Summary

Overview and Major Outcomes

The Klamath Basin of south-central Oregon and northern California is one of the largest rivers on the Pacific Coast and was also historically one if its most significant producers of salmon and other native fish. Unfortunately, a wide range of historical and ongoing human activities across the Basin, including construction of four lower Klamath River hydroelectric dams across the river's mainstem as well as numerous smaller dams along its tributaries, have contributed to reduced flows, habitat loss, and increases in nitrogen and sediment inputs in waters that are already naturally phosphorus-rich. Adding to these pressures are more frequent and extended droughts and forest fires associated with accelerating global climate change. For fish, some of these impacts represent key stressors which have significantly impaired underlying watershed functional processes, reduced water quality, and contributed to dramatic declines in the populations of many native fish.

Impacts to fish have been deeply felt by many who live, work, and fish across the basin and have led to decades of conflict and debate over how to restore fisheries of great cultural, health and economic importance while also sustaining other natural goods and services. Many local, Tribal, state, and federal organizations have responded by spearheading a diverse range of restoration efforts, most recently including an effort to remove four lower Klamath River hydroelectric dams.

The **vision** of the Klamath Basin IFRMP is to provide a unifying framework for planning the coordinated restoration and recovery of native fish species from the headwaters to the Pacific Ocean, while improving flows, water quality, habitat and ecosystem processes. The IFRMP serves as the blueprint that describes the highest priority flow, water quality, and habitat restoration and monitoring actions that, in combination with related restoration initiatives, can help reverse the declines of multiple native Klamath Basin fish populations. The Plan helps to answer the basic question: ***given all we know, which functional watershed restoration actions will provide the broadest possible benefits to multiple native Klamath Basin fish species – throughout the Basin and within each sub-basin***. By helping to identify priority restoration actions, the IFRMP will also help inform the wise allocation of funds for restoration and monitoring work in the Klamath Basin.

This final **IFRMP Plan Document** brings together:

- Key basin-wide restoration goals, objectives, and indicators of success
- A list of 146 priority restoration project concepts across 12 subbasins, which are meant to be implemented over many years.

Header Photo: Wood River Wetland | Greg Shine for BLM 2016

- Strategies for closing gaps in basin-wide monitoring for important indicators of fish and watershed status
- Cost estimates for proposed restoration and monitoring activities.
- Recommendations for ongoing plan implementation and adaptively updating restoration priorities through time.

Importantly, the IFRMP acknowledges, weaves together, builds on, and in some cases defers to the many other important prior and ongoing restoration planning processes focused on a narrower set of objectives for specific species, stressors, or regions. In doing so, the IFRMP addresses a long-standing recommendation of the National Research Council to better integrate and close gaps across multiple restoration planning initiatives by providing a standardized and holistic approach to functional ecosystem and habitat restoration planning across the Klamath Basin as a whole.

The implementation of the 36 highest priority activities within this plan (defined as the top-3 ranking project concepts per sub-basin) **over one implementation cycle** comes in at an expected mid-range cost of roughly **$185 Million USD** ($173 Million USD for restoration over 5 years and $12 Million USD for long-term monitoring over 10 years). The cost of implementing all recommended activities in this Plan rises to an expected to cost roughly **$541 Million USD** ($470 Million USD for restoration over 5 years and $71 Million USD for long-term monitoring over 10 years). Refer to Section 4.2.2 and 5.1.2 for more information on restoration and monitoring costs, respectively.

However, it is not feasible or appropriate to pursue all of these project concepts across the basin at the same time, nor would it necessarily be possible to implement one specific project concept in every one of the many sub-basins where it has been recommended to occur. This is partly due to capacity and funding constraints, but also because some projects are expected to be more beneficial if other projects are completed first – for example, addressing water quality issues at a project site before investing in instream habitat restoration – and also because priorities may change over time as events, conditions, and restoration activities in the basin continue to evolve.

To recognize this constraint, the IFRMP has recommended a model whereby participants review and update lists of priority restoration project concepts on a regular basis by working together in an iterative participatory process. This process leverages the IFRMP and linked **Restoration Prioritization Tool** to select a shorter list of restoration project priorities that may be ready for implementation over the next one to two years. This list of near-term restoration priorities represents the **Draft FRMP Restoration Action Agenda (RAA)** for a specific time period.

The latest RAA, available on the IFRMP (https://ifrmp.net/), is meant to provide one source of information to help guide funding considerations. Through this process, restoration practitioners can use the IFRMP to further develop restoration concepts presented in the Plan and submit **detailed proposals for specific projects** that address elements of one or more IFRMP and RAA priorities. This model ensures that restoration occurring in the basin strikes balance between restoration projects that are most beneficial to multiple species and restoration projects that proposal proponents are ready and willing to implement.

The USFWS intends to update both the RAA and the IFRMP periodically to reflect changing conditions, needs, and knowledge in the basin through an adaptive management process that will include additional engagement with participants.

A Participatory Restoration Planning Process

The IFRMP is the culmination of a seven-year collaborative planning process spanning five phases:

- **Phase 1 (2016-2017) focused on information gathering and synthesis**
- **Phase 2 (2017-2018) aimed to clarify IFRMP objectives, frameworks and conceptual models**
- **Phase 3 (2019-2020) aimed to create and test a prioritization method based on multiple criteria**
- **Phase 4 of (2020-2021) aimed to provide more information to support implementation of the Plan**
- **Phase 5 of (2021-2022) aimed to finalize the 2023 - 2024 Plan document, create a 2023-2024 Restoration Action Agenda and develop recommendations for implementation**

Over these five phases, the planning team engaged with a vast team of collaborators committed to improving fishery restoration practices in the Klamath Basin. The data, advice, and tools developed for the IFRMP would not have been possible without the invaluable contributions of the **more than one hundred participants** with expertise on the Klamath Basin (documented in Appendix A the IFRMP Plan Document) who collectively committed many hundreds of hours of time to the development and review of these products. Contributions included provision of data, professional judgement, opinions, critiques, and other input to inform development of a well-integrated basin-wide Plan. Pathways for input included one-on-one interviews, group webinars and workshops, survey responses, and numerous rounds of iterative review and feedback on draft products. **We are sincerely grateful to those participants who contributed their time, expertise, and dedication across many years of this planning process**

Restoration Goals and Objectives

Restoration goals are statements of broad outcomes to be achieved, while restoration objectives are specific and measurable tasks that must be done to make the related goal achievable. The goals and objectives of the IFRMP shown here were drawn and adapted from existing plans to ensure alignment with other ongoing restoration planning work in the Basin and validated by planning participants through a collaborative, facilitated process involving workshops, technical meetings and surveys.

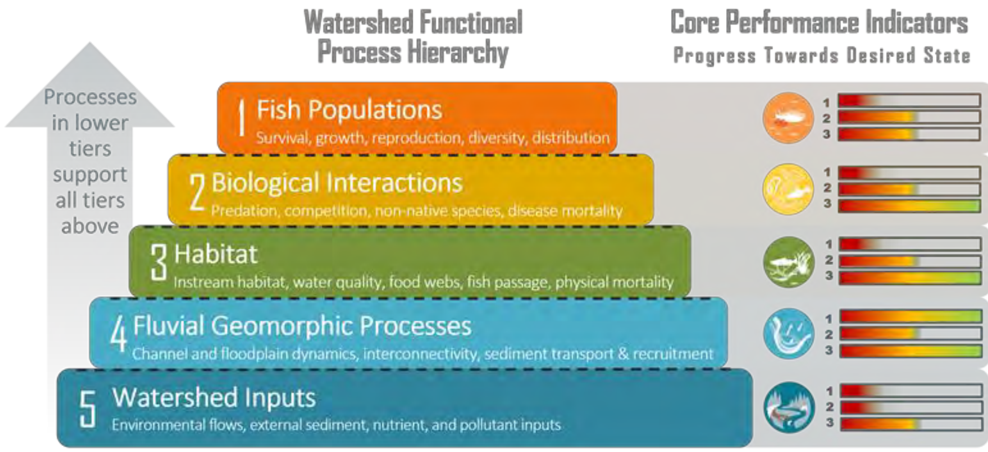
Restoration Prioritization Framework and Tool

Scientists in river restoration ecology increasingly call for more interconnected approaches to restoration at the basin scale. Current approaches *seek to address multiple root causes of ecosystems degradation* by focusing on restoring ecological processes and functions for the entire landscape rather than the resulting consequences for individual locations and species. This method of restoration work is known as *process-based restoration*. Effective prioritization frameworks provide an organized, repeatable, and transparent reasoning for making restoration decisions, given limited funding, capacity, potential biases, and time. In this sense, prioritization refers to the process of scoring and ranking potential restoration actions to determine the most beneficial sequencing. The goal of IFRMP prioritization is to inform funding and implementation decisions, and to begin logically grouping top-tier priority restoration projects.

Klamath IFRMP Goals and Objectives Hierarchy

Whole-Basin Nested Goals	Nested Objectives
Fish Populations (FP) 1. Achieve naturally self-sustaining native fish populations	1.1 Increase juvenile production
	1.2 Increase juvenile survival and recruitment to spawning populations
	1.3 Increase overall population abundance and productivity, particularly in areas of high existing abundance or potential future abundance or in special or unique populations
	1.4 Maintain or increase life history and genetic diversities
	1.5 Maintain or increase spatial distributions as necessary
Fisheries Actions (FA) 2. Regulate harvest to support self-sustaining populations.	9 2.1 Improve management and regulations/enforcement of harvest, bycatch and poaching of naturally produced fish such that populations do not decline and can recover. ******While essential for recovery of fish populations, this objective and objective 3.1 are outside the scope of the IFRMP and falls under the responsibility of federal and state agencies with jurisdiction over harvest management.*
Biological Interactions (BI) 3. Reduce biotic interactions that could have negative effects on native fish populations	9 3.1 Do not generate adverse competitive or genetic consequences for native fish when carrying out hatchery, production, or conservation actions
	3.2 Minimize disease-related mortality by reducing vectors and factors known to lead to fish disease outbreaks
	3.3 Reduce impacts of non-native plant and animal species on native fish
Habitat (H) 4. Improve freshwater habitat access and suitability for fish and the quality and quantity of habitat used by all freshwater life stages	4.1 Restore fish passage and re-establish channel and other habitat connectivity, particularly in high-value habitats (e.g., thermal refugia)
	4.2 Improve water quantity and quality for fish growth and survival
	4.3 Enhance, maintain community and food web diversity supporting native fish
	4.4 Reduce fish mortality due to entrainment, scour, stranding
	4.5 Enhance and maintain estuary, mainstem, tributary, lake, wetland, and refuge habitats for all freshwater life stages and life histories of fish
Fluvial Geomorphic Processes (FG) 5. Create and maintain spatially connected and diverse channel and floodplain morphologies	5.1 Improve and maintain productive sediment delivery, storage, sorting, and transport dynamics
	5.2 Increase channel and floodplain dynamics and interconnectivity
	5.3 Promote and expand establishment of diverse riparian and wetland vegetation that contributes to complex channel and floodplain morphologies
Watershed Inputs (WI) 6. Improve water quality, quantity, and ecological flow regimes	6.1 Improve instream ecological flow regimes year-round for the Klamath River mainstem and its tributaries in all sub-basins
	6.2 Reduce anthropogenic sediment inputs while maintaining natural and beneficial sediment inputs
	6.3 Reduce external nutrient and pollutant inputs that contribute to detrimental bio-stimulatory conditions

9 **Note: Under the direction of the IFRMP Federal Coordination Group, fishery management actions, and related fish population monitoring is relevant to the Plan but considered 'already in place' and thus out of scope of IFRMP. However, we are integrating with new monitoring undertaken by ODFW, CDFW, and other agencies.**



Klamath IFRMP Process-Based Restoration Principles

After careful consideration of alternatives, and *multiple* rounds of peer-review by Sub-basin Working Group (SBWG) participants, we adopted a **multi-criteria scoring approach** for prioritization. Our multi-criteria scoring process is automated through an interactive web-based **Klamath IFRMP Restoration Prioritization Tool** designed expressly for this purpose, detailed further in Section 3.6. The IFRMP's multi-criterion prioritization framework is based on **six key questions** to ask when considering any restoration project concept:

1. Are focal fish present in the place a project is being proposed?
2. How impaired is the watershed in the place a project is being proposed (how much is restoration needed)?
3. How many stressors is this project going to address?
4. How far and wide will project benefits be felt?
5. Is it feasible to implement this project in this place?
6. How much do we care about the answers to each question?

Restoration Recommendations

The Klamath IFRMP document contains **146 proposed restoration project *concepts*** defined as a broad vision for a specific types of restoration actions in one or more specific priority sub-watersheds of a sub-basin where that action is most needed. These actions were gathered from recommendations within many prior restoration plans in the basin, carrying forward many decades of prior efforts and expertise, and built upon with additional projects put forward by IFRMP planning participants across several phases of the IFRMP planning process. The full set of 146 sub-basin restoration projects are listed on the following page and additional project details and their cost ranges are broken out by sub-basin in Section 4.

The **top three priorities emerging from each sub-basin are shown in Table 4-1** in the main report, and (excluding monitoring) this single approximately 5 year implementation cycle has a collective estimated mid-point cost of $173 Million USD. This estimate does not include uncosted projects for which no cost information was available at the time of writing, though some of these project costs will likely be significant (see Section 3.7). The remaining 110 project concepts which would need to be completed over the subsequent two decades adds $310 Million USD at the estimated mid-point.

High-Level Summary of IFRMP Priorities by Sub-Region of the Klamath Basin

Sub-Region	Thematic Restoration Priorities Across Projects
	Current restoration priorities in the **Upper Klamath Lake Sub-Region** are largely focused on the restoration of riparian areas, and healthy watershed processes, particularly channel migration, connectivity, flows, and watershed inputs affecting water quality. Improvements to these processes are expected to have broad cascading benefits for fish habitats and populations. Many of these restoration activities were selected as priorities because participants felt they needed to be implemented first to improve the outcomes of other restoration actions identified in the IFRMP.
	Current restoration priorities in the **Mid-Upper Klamath River Sub-Region** are focused on restoring riparian areas, and healthy watershed processes, particularly channel migration, connectivity, cold water refugia, and flows, before addressing other restoration needs. Improvements to these processes are expected to have broad cascading benefits for fish habitats and populations. As these underlying issues are addressed, there is also a desire to improve riparian and instream habitats in select reaches where they are limiting for fish.
	Current restoration priorities in the **Lower Klamath Sub-Region** are focused on restoring channel connectivity, complexity, and flows, in part through ongoing measures to address overall flows, conveyance and distribution of flows, and temperature management associated with the operation of the Trinity and Lewiston dams in the region. Improvements to these processes are expected to have broad cascading benefits for fish habitats and populations. As these underlying issues are addressed, there is also a desire to improve riparian and instream habitats in select reaches where they are limiting for fish.

List of all IFRMP Priorities by Sub-Basin of the Klamath Basin *(listed in order from higher to lower priority)*

UPPER KLAMATH LAKE SUB-REGION

UPPER KLAMATH LAKE SUB-BASIN

UKL 1	Work with agriculture interests and others to improve riparian grazing management and undertake riparian actions to improve habitat conditions in key Upper Klamath Lake tributaries.
UKL 8b_11_11b	Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge
UKL 14	Work with agriculture interests and others to separate out and treat tailwater discharge in key areas of the sub-basin
UKL 11a	Supplement spawning gravels in key sub-basin tributaries to benefit trout and returning anadromous salmonids.
UKL 3	Restore fringe wetlands in priority areas identified in the UKBWAP to improve water quality and habitat for endangered suckers.

UKL 13	Remove priority fish passage barriers at small dams and culverts across key sub-basin tributaries.
UKL 16	Manage livestock in upland areas to improve vegetation structure, control erosion and reduce sediment flow into streams.
UKL 7	Work with agriculture interests and others to improve summertime flows by encouraging irrigation water use efficiencies and voluntary transfer of water rights for instream flows to benefit fish and riverine processes
UKL 6	Reconnect key springs in the sub-basin and restore surrounding habitat to provide fish refuges during periods of poor water quality.
UKL 10a	Supplement shoreline spawning gravels for lake-spawning suckers in Upper Klamath Lake.
UKL 9	Screen priority diversions around Upper Klamath Lake and other key areas using physical or non-physical exclusion barriers.
UKL 8a	Reconstruct channelized portions of key sub-basin tributaries to improve fish habitat, increase water residence time, and maximize groundwater recharge
UKL 2	Work with agriculture interests and others to improve irrigation practices to reduce sediment and phosphorus loading to key streams in the Upper Klamath Lake sub-basin.
UKL 4	Establish DSTWs across the sub-basin to reduce nutrient loading to Upper Klamath and Agency lakes or downstream tributaries.
UKL 10b	Ensure access for suckers to Upper Klamath Lake shoreline spawning areas by managing lake levels.

WILLIAMSON SUB-BASIN

Williamson 4_7	Work with agriculture interests and others to improve grazing practices and fence and/or plant vegetation to improve riparian and instream conditions within the Williamson River and key tributaries
Williamson 5	Reconnect channels to restore fish access to existing cold-water springs in Williamson River mainstem reaches, key tributaries.
Williamson 3_8b	Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge
Williamson 10	Improve hydrological and habitat connectivity both within the Williamson River delta and between the Williamson River mainstem and key tributaries.
Williamson 6	Improve connection of Williamson River to the Klamath Marsh NWR and convert existing drains & levees into depressional wetlands.
Williamson 9	Thin lodgepole pine forest encroaching into the upper Williamson River to prevent loss of upland meadows.
Williamson 8a	Add spawning gravels to reaches of the Williamson River to improve habitat conditions for Redband Trout.
Williamson 11	Undertake multiple linked road-related restoration and re-construction projects to enable improved fish passage while diminishing sediment transport into sub-basin streams.
Williamson 2	Undertake upland forest management and prescribed burns to create forest gaps for improved snowpack accumulation and slow release water storage.

SPRAGUE SUB-BASIN

Sprague 3	Work with agriculture interests and others to improve riparian grazing management and undertake riparian actions to improve habitat conditions in the Sprague river mainstem and key tributaries.
Sprague 7b_9	Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge
Sprague 4	Promote channel migration and improve habitat conditions in the Sprague River mainstem and key tributaries by removing levees and roads.
Sprague 8	Construct DSTWs to reduce nutrient loading and improve water quality in key Sprague sub-basin tributaries.
Sprague 6	Address fish passage issues (particularly for Redband Trout) at road/stream crossings in key areas of the sub-basin.
Sprague 5	Restore cold-water springs that have been ponded or otherwise disconnected in the Sprague River mainstem, key tributaries.
Sprague 11	Improve riparian grazing practices in USFS allotments and some private rangelands within the Sprague sub-basin.
Sprague 10	Undertake upland forest management and prescribed burns to create forest gaps for improved snowpack accumulation and slow release water storage.
Sprague 7a	Add spawning gravels where needed to improve in-stream habitat conditions in key Sprague sub-basin streams.

LOST SUB-BASIN

Lost 9d	Work with agriculture interests and others to install riparian fencing along the mainstem Lost River to reduce grazing impacts.
Lost 11a	Work with agriculture interests and others to improve fish ladder at Keno Dam for better upstream passage for migratory fish species.
Lost 1	Work with agriculture interests and others to improve water use efficiencies throughout the Klamath Project to improve water quality and stream temperatures.
Lost 11b	Improve the fish ladder at Link River Dam to provide better upstream passage for migratory fish species
Lost 3	Explore acquisition of water rights to increase instream flows in key Lost River tributaries.
Lost 5	Install fish screens in the Keno impoundment reach to prevent adult and juvenile fish mortality

Lost 9	Improve habitat conditions at the mouth of Willow Creek/Clear Lake to provide spawning habitat for endangered suckers.
Lost 8	Install passage infrastructure at Harpold and other diversion dams currently restricting access to potential upstream spawning habitats above Tule Lake.
Lost 10a	Improve condition and extent of spawning habitat for suckers in Tule Lake/Lost River.
Lost 7	Install passage infrastructure at Gerber and Miller Diversion dams to allow access to potential upstream spawning habitats in Miller Creek.
Lost 2	Reconfigure Willow Creek/Clear Lake forebay to improve access to Willow Creek spawning areas at low flows.
Lost 10b	Reconfigure and reconnect channels in Sheepy Creek to improve habitat conditions for endangered suckers.

MID-UPPER KLAMATH SUB-REGION

UPPER KLAMATH RIVER SUB-BASIN

UKR 5c	Undertake riparian planting to reduce erosion into the Upper Klamath River mainstem and key tributaries.
UKR 19	Identify and implement projects to protect existing or potential cold-water refugia for fish
UKR 5b	Work with agriculture interests and other to install fencing along riparian corridors to reduce erosion into the UKR mainstem and key tributaries.
UKR 10	Reconnect floodplains and off-channel habitats by removal of levees and other barriers within the UKR sub-basin.
UKR 5a	Improve riparian grazing management to reduce erosion into the UKR mainstem and key tributaries.
UKR 15	Restore reservoir footprint to former conditions in the UKR (once major dams are removed)
UKR 16	Replace existing culverts with bridges at priority road crossings in UKR tributaries to improve access to upstream habitats.
UKR 17	Restore upland wetlands and meadows to improve cold water storage and flood attenuation in the UKR sub-basin.
UKR 7	Reduce fuels and re-introduce low intensity fires to re-establish natural fire regimes across the UKR sub-basin.
UKR 14	Install fish screens at diversions of priority concern within the UKR sub-basin.
UKR 3	Improve irrigation practices to increase instream flows in UKR tributaries to benefit fish and riverine processes
UKR 18	Install BDAs in key UKR tributaries to provide improved seasonal fish rearing habitats.
UKR 20	Address restoration needs of PacifiCorp Parcel A lands
UKR 6	Implement upland road decommissioning in key areas of the UKR sub-basin with high fine sediment input.
UKR 13	Remove/repair road/stream crossings to restore fish passage to upstream habitats within UKR tributaries.
UKR 4	Implement projects to reduce warm tailwater inputs to tributaries in the UKR.

MID KLAMATH RIVER SUB-BASIN

MKR 8	Undertake riparian planting to reduce water temperatures and improve fish habitats.
MKR 6_10	Remove sediment barriers, construct low flow channels to provide access to existing cold water refugia in the MKR sub-basin
MKR 11	Reconnect off-channel habitats by removing or reconfiguring stream levees and dikes.
MKR 14	Install BDAs to provide seasonal fish rearing habitats in MKR tributaries.
MKR 4a	Decommission forestry roads to reduce fine sediment inputs to MKR streams.
MKR 9	Implement projects to provide for fish passage at identified priority fish passage barriers across the MKR sub-basin.
MKR 12	Install in-channel structures such as LWD, boulders, etc. to improve condition of fish habitats.
MKR 3	Manage water withdrawals across the MKR sub-basin to increase instream flows during critical low flow periods.
MKR 5	Undertake upland vegetation management as needed to restore a fire adapted landscape across the MKR sub-basin.
MKR 16	Restore upland wetlands and meadows to improve cold water storage and flood attenuation in the MKR sub-basin.

SHASTA SUB-BASIN

Shasta 6	Undertake riparian rehabilitation actions to maintain shading, reduce water temperatures and improve instream habitat within priority mainstem Shasta River sites.
Shasta 3	Increase cold water refuge habitats for fish in the upper Shasta sub-basin through improved irrigation and groundwater management and secured water rights.
Shasta 9	Undertake habitat restoration projects in streams across the sub-basin to restore floodplain connectivity, create new rearing habitats.
Shasta 1	Work with agriculture interests and others to manage water withdrawals across the Shasta sub-basin to maintain instream flows and to overcome low water barriers to upstream habitats.

Shasta 5	Implement projects to reduce warm tailwater inputs in prioritized implementation areas as guided by the Shasta sub-basin's Tailwater Reduction Plan.
Shasta 10	Add spawning gravels to priority sediment impoverished river reaches as guided by Shasta's Spawning Gravel Evaluation and Enhancement Plan.
Shasta 7	Implement projects to provide for fish passage at identified priority fish passage barriers across the Shasta sub-basin.
Shasta 2	Relocate, redesign, or eliminate the Parks Creek diversion to improve instream flows for fish.
Shasta 8a	Restore fish passage above Dwinnell Dam through removal of the dam.
Shasta 4	Adjust discharges from Dwinnell Dam to improve water temperatures, dissolved oxygen concentrations downstream of dam.
Shasta 8b	Restore fish passage above Dwinnell Dam through construction of dam bypass infrastructure.

SCOTT RIVER SUB-BASIN

Scott 14	Restore upland wetlands and meadows to improve cold water storage and flood attenuation in the Scott River sub-basin.
Scott 15	Callahan Dredge Tailings Remediation
Scott 11	Install appropriate in-channel structures such as LWD, boulders, etc. to improve condition of fish habitats in priority tributaries.
Scott 7	Improve/decommission priority roads identified in Five Counties Road Erosion Inventory to reduce fine sediment inputs to streams.
Scott 3	Implement winter flooding of agriculture land in the Scott River sub-basin as a method of groundwater recharge.
Scott 10	Restore floodplain connectivity and create refuge habitats across Scott River sub-basin streams as identified in the SRWC plan.
Scott 13	Reduce fuel loads and undertake prescribed burns across the southwest Scott River sub-basin to reduce wildfire risks.
Scott 2	Enforce compliance with existing water and environmental laws and regulations for ensuring instream flows within the sub-basin.
Scott 4	Improve irrigation system water use efficiencies and associated monitoring in the sub-basin to benefit fish, riverine processes.
Scott 1	Acquire water rights from willing sellers within priority areas of the Scott River sub-basin to help maintain instream flows for fish.
Scott 5	Remove physical and hydrologic barriers blocking fish passage to key thermal refuge areas within the Scott River sub-basin.
Scott 9	Encourage beaver colonization and/or install BDAs to provide seasonal fish rearing habitats in the mainstem and key tributaries.
Scott 6b	Undertake riparian planting to increase shading, help reduce water temperatures and improve fish habitats within priority streams.
Scott 12	Establish Conservation Easements adjacent to key areas of the Scott River mainstem to allow for levee, dike, and berm removal.
Scott 6a	Improve grazing management of riparian areas to maintain shading, reduce water temperatures, improve fish habitats in priority streams.
Scott 8	Remove or reconfigure priority river/stream levees and dikes identified in the SRWC plan to restore channel form, floodplain connectivity.
Scott 6c	Install fencing along riparian corridors to reduce grazing damage to riparian habitats within priority streams.

SALMON RIVER SUB-BASIN

Salmon 7	Restore upland wetlands and meadows to improve cold water storage and runoff attenuation in the Salmon River sub-basin.
Salmon 5	Protect and enhance existing cold-water refugia through improved maintenance and management of existing riparian areas.
Salmon 3	Build and improve connection to off-channel rearing habitats in Salmon sub-basin tributaries.
Salmon 2	Undertake mine tailing remediation in priority reaches of the Salmon River and North and South Forks mainstems and reconnect floodplains
Salmon 4	Install LWD, boulders, other in-channel structures to improve fish habitats within the Salmon River and sub-basin tributaries.
Salmon 8	Remove physical barriers blocking fish passage to key thermal refuge areas within the Salmon River sub-basin.
Salmon 6a_6	Undertake riparian planting and management to reduce water temperatures within priority reaches of NF, SF Salmon River
Salmon 1	Undertake upland vegetation management as needed to restore a fire adapted landscape across the sub-basin.

LOWER KLAMATH RIVER & ESTUARY SUB-REGION

LOWER KLAMATH RIVER SUB-BASIN

LKR 11	Install BDAs in key tributaries in the LKR to promote increased base flows and provide improved rearing habitats.
LKR 7	Plant riparian vegetation along key LKR tributaries to reduce water temperatures.
LKR 6	Increase habitat connectivity and enhance floodplain habitats in key LKR streams
LKR 10	Install LWD to increase floodplain connectivity and provide cover for spawning and rearing fish in key LKR tributaries.
LKR 3_4	Upland road decommissioning and drainage system improvements to reduce sediment inputs and promote hydrologic restoration throughout the LKR Sub-basin

LKR 13	Remove feral cattle from key LKR tributaries where wild herds exist.
LKR 12	Remove non-native estuary plants from key LKR estuary and off-estuary tributary habitats.
LKR 14	Conduct juvenile fish rescues and relocation in key LKR tributaries prone to seasonal drying.
LKR 15	Seek opportunities to conduct thinning of forest stands and cultural and prescribed burns to restore historic prairie habitats within key LKR tributary watersheds.

TRINITY SUB-BASIN

Trinity 1	Implement managed flows from Trinity and Lewiston dams, gravel augmentation, and reconnect floodplains by removing levees and constructing off-channel habitats.
Trinity 5	Reconnect floodplains in the mainstem Trinity River below the North Fork confluence and key tributaries by removing levees and constructing off-channel habitats.
Trinity 4	Maintain flows in Weaver Creek by alternatively using Trinity River to provide summer water to the Weaverville Community Services District.
Trinity 6	Install in-channel structures such as LWD, boulders, etc. to improve fish habitats in priority tributaries.
Trinity 8	Implement projects to provide for fish passage at identified priority fish passage barriers across the Trinity River sub-basin.
Trinity 17_18	Install temperature control device for Trinity Reservoir and evaluate and develop a new conveyance system from Trinity Reservoir to the Carr tunnels to improve temperature management
Trinity 16	Undertake upland vegetation management as needed to thin forest and reduce fuels across the Trinity River sub-basin.
Trinity 15	Translocate beaver and install BDAs to impound water and create seasonal fish rearing habitats in Trinity River tributaries, particularly in the Weaver basin.
Trinity 2_11	Implement projects in Trinity River tributary streams to improve flows to decrease water temperatures and increase dissolved oxygen.
Trinity 14	Increase Trinity recreational harvest of introduced Brown Trout, adjust hatchery release practices to minimize trout predation on juvenile salmon.
Trinity 12	Stocking of spring Chinook and summer steelhead into Trinity streams where currently extirpated and carcasses where populations still exist.
Trinity 7	Install fish passage infrastructure at Lewiston and Trinity Dams to allow access to upstream habitats.
Trinity 13	Stock Trinity and Lewiston lakes to establish landlocked salmon and/or trout runs, using only fish of Trinity Basin genetic stock.

SOUTH FORK TRINITY SUB-BASIN

SF Trinity 5	Decommission roads and improve road drainage systems to reduce fine sediment delivery to South Fork Trinity streams.
SF Trinity 3	Increase groundwater storage in the South Fork Trinity Sub-basin through upland wetland restoration actions.
SF Trinity 2	Increase storage capacity and delivery capability of Ewing Reservoir to allow increased seasonal water flows in Hayfork Creek.
SF Trinity 6	Reduce cattle grazing and install fencing in riparian areas to reduce fine sediment inputs into sub- basin streams.
SF Trinity 9a	Install LWD, boulders and other in-channel structures to increase habitat complexity in key South Fork Trinity tributaries.
SF Trinity 1a	Identify diversion flow impacts and cease unauthorized water diversions across the Trinity River sub-basin
SF Trinity 7	Improve planning and oversight of diversions to protect thermal refugia in tributaries of the South Fork Trinity sub-basin.
SF Trinity 1b	Work with agricultural irrigators to reduce diversions by developing an incentives and enforcement program to increase flows.
SF Trinity 12	Repair the levee in Hyampom Valley by the municipal airport to reduce downstream erosion.
SF Trinity 9b	Reconnect channels to increase habitat complexity in key South Fork Trinity tributaries.
SF Trinity 4	Stabilize slopes, revegetate vulnerable areas to reduce fine sediment delivery to South Fork Trinity streams through mass wasting events.
SF Trinity 10	Implement projects to provide for fish passage at identified priority fish passage barriers across the South Fork Trinity sub-basin.
SF Trinity 11	Identify priority screening needs at diversions within the South Fork Trinity sub-basin.

Monitoring Recommendations

IFRMP monitoring is intended to provide broad-scale, ongoing tracking of CPI status and trends to confirm that whole-basin recovery of species, habitats, and watershed processes is occurring and is being maintained over time. While **IFRMP monitoring will focus on evaluating basin-wide status and trends**, additional support and funding are also needed to ensure that other ongoing monitoring programs across the Basin will be able to continue to evaluate local project implementation and effectiveness. In many cases, it will be possible to leverage and integrate existing local monitoring efforts within the basin to inform understanding of status and trends, particularly for fish populations which are already well monitored by state and federal agencies and their partners. **In other cases, new monitoring will be needed under the IFRMP to fill existing monitoring gaps**.

Through a series of webinars convened by the IFRMP in June-August 2021 subject-area experts **identified important monitoring gaps** and made **recommendations as to where/how the IFRMP could best supplement existing monitoring** information to improve basin-scale assessments of CPI status and trends. These recommendations were vetted through additional literature review where possible. Participants noted the importance of **co-locating monitoring sites** for multiple CPIs to minimize sampling effort, the need for **improved standardization of data collection** and storage, the importance of coarse **system-wide assessments**, and the need for better **event-driven monitoring** associated with large storms. Once a full portfolio of monitoring necessities was identified, individual recommendations were ranked into five tiers (Tier 1 – Tier 5) of priority based on the discussions during working groups and expert judgement. Tier 1 monitoring activities are considered the most important for near-term implementation and provide the most comprehensive understanding of basin-wide status and trends. These monitoring priority ranks were also further refined by participants during the 2022 IFRMP RAA planning workshop. The set of Tier 1 priority monitoring actions is shown below; further information on the other monitoring actions and priority ranks can be found in Appendix H of the IFRMP Plan Document. **Implementing Tier 1 monitoring over 10 years has been costed at approximately $12.2 Million USD.**

Key Klamath IFRMP Monitoring Priorities

Watershed Process Tier	CPI	Description
Watershed Inputs	5.2.1 Seasonal Instream Flow	Expand existing network of real-time streamflow gaging stations
	5.2.2 Nutrient Loads	Establish network of automated water samplers
	5.2.3 Fine Sediment Loads and Turbidity	Expand/maintain network of continuous real-time sondes (top priority sites)
Fluvial Geomorphic Processes	5.3.2 Geomorphic Flushing / Scouring Flows	Characterize flushing flows with gage data and transport measurement calibrations
	5.3.4 Channel Complexity	Assess basin-wide planform complexity from aerial imagery
	5.3.5 Sediment Transport	Map substrate sizes with remote sensing (bathymetric LiDAR, air photos)
Habitat	5.4.1 Water Temperature	Expand/maintain network of continuous real-time sondes (top priority sites)
	5.4.2 Water Chemistry (DO, pH, conductivity)	Expand/maintain network of continuous real-time sondes (top priority sites)
	5.4.3 Turbidity	Expand/maintain network of continuous real-time sondes (top priority sites)
	5.4.4 Thermal Refugia	Identify and map thermal refugia across the basin with airborne thermal infrared remote sensing
	5.4.5 Nutrients	Establish network of automated water samplers
	5.4.6 Nuisance phytoplankton and associated algal toxins	Expand/maintain existing monitoring network for evaluating levels of nuisance phytoplankton/algal toxins with indirect measures
	5.4.7 Stream Habitat Condition (Physical)	Assess basin-wide planform complexity from aerial imagery
	5.4.8 Riparian Condition	Assess riparian vegetation with aerial NDVI
Biological Interactions	5.5.1 Disease	Expand existing monitoring network for *Ceratonova shasta* and *Parvicapsula minibornis*
	5.5.1 Disease	Expand existing monitoring network for *Ichthyopthierius multifiliis* (Ich) and *Flavobacterium columnarae* (Columnaris)
	5.5.2 Invasive aquatic species	Establish eDNA sampling network for monitoring invasives
Fish Populations	5.6.1 Focal Species Population Indicators	Establish eDNA sampling network for monitoring distribution of focal fish species
	5.6.1 Focal Species Population Indicators	Fill existing or upcoming gaps on life-cycle monitoring

Recommendations for Implementation

Because the IFRMP identifies over 140 proposed restoration projects that will likely take more than two decades to complete, there is an ongoing need for learning and adjustment through time. Doing this successfully will require several near-term actions as well as longer-term actions to create the enabling conditions for success. These enabling conditions include well-defined tools, workflow pathways and resources to support implementation; ongoing collaboration and learning through monitoring and science synthesis; applying ongoing adaptive management learning updates to the Plan to reflect current context; and clear and dedicated governance partnerships to coordinate and maintain momentum over time.

Section 6 of the report describes recommendations for ongoing implementation of the IFRMP that have been drawn from participants across the planning process and are provided here for further consideration. While some of these recommendations are specifically directed at the FWS, and are clearly identified as such, most are recommendations for consideration by all entities involved in restoration within the basin. Collaborative efforts to carrying out these recommended actions will help to support the ongoing implementation of the IFRMP to deliver the greatest returns on the considerable investments in the IFRMP planning process and ensure the best restoration outcomes for fish, fish habitats, and the ecosystems and communities that rely on them.

The recommendations identified below are mutually supportive of each other and organized in three major categories:

I - Sustain Tools & Linkages to Funding Solicitations

I.1 – As appropriate, all organizations funding restoration in the basin should consider issuing solicitation guidance that encourages proposals to link to IFRMP and RAA priorities

I.2 - FWS should consider supporting long-term maintenance of IFRMP Restoration Prioritization Tool and consider extending the Tool to include a project and data tracking atlas

I.3 – FWS should consider sponsoring the IFRMP website to consolidate key resources and communications

II- Support Ongoing Collaborative Learning Frameworks

II.1 - Articulate how Adaptive Management will help guide the approach to evidence-based decision-making throughout implementation of the IFRMP

II.2 - Support regular Science Symposia to disseminate learning, measure progress, and decide on updates to future IFRMP Restoration Action Agenda priorities

II.3 - Create a monitoring coordination group and work towards standardizing Basin-wide data collection and assessments

II.4 - Provide ongoing impartial technical facilitation to help address emerging issues

III – Establish Ongoing Coordination for IFRMP Implementation

III.1 – Stakeholders in the basin should discuss the establishment of formal and informal coordination roles, agreements, and activities to for IFRMP implementation to sustain ongoing adaptive management and fish population and habitat recovery

In conclusion, it is very rare to achieve the degree of sustained collaboration afforded by the IFRMP planning process and to emerge with a Basin-wide package of practical restoration and monitoring priorities. While no Plan is perfect, the IFRMP stands alone in its commitment to integrate and apply available restoration knowledge at the Basin-wide scale. Between 2016 and 2022 the USFWS provided stable funding (including riding out a global pandemic) while many dedicated participants gave hundreds of hours of their time to create and vet the IFRMP. The IFRMP is a blueprint for fish habitat restoration and monitoring needs in the Klamath Basin and integrates and applies available restoration knowledge at the Basin-wide scale. A set of recommendations identified in Section 6 the Plan provides a package of actionable workflows and tools to sustain ongoing value and relevance.

Now is the time for the Basin to come together to make significant progress in restoring the Klamath Basin. This work has delivered the vision of the Klamath Basin IFRMP to provide a unifying framework for planning coordinated recovery of native fish species from the headwaters to the Pacific Ocean while improving flows, water quality, habitat, and ecosystem processes. All are to be commended for their efforts and the legacy of collaboration that was created. The act of maintaining the IFRMP and its products will inspire others to continue to trust more, do more, and learn more together.

Photo: Shortnose Suckers | Jason Chin for USFWS

1 Introduction

This Section

- Presents the overarching vision and motivation for embarking upon developing the IFRMP.
- Delivers a concise overview of challenges and stressors.
- Identifies the key focal fish species at the heart of the Plan.
- Describes the IFRMP's guiding principles and approach to collaboration and engagement.

1.1 Overview of the Klamath Basin

The Klamath Basin of south-central Oregon and northern California is one of the largest rivers on the Pacific Coast and was historically one of its greatest producers of salmon and other native fish (Hamilton et al. 2005; NRC 2008; Thorsteinson et al. 2011; NMFS 2015). Local communities continue to point out that several fish species that have naturally occupied the Klamath Basin are moving closer towards extinction. Indeed, the Basin has long been the backdrop for a tale of detrimental changes to the entire watershed and surrounding lands (Chaffin et al. 2015). Such changes have interested and concerned a variety of participants who have since dedicated significant time towards finding ways to restore fish populations throughout the Klamath Basin. This effort largely includes preserving dynamic watershed processes and habitats capable of supporting thriving fisheries and other critical ecosystem functions. The headwaters of the river start at a low-gradient, dry region featuring large areas of farm and ranch lands, wetlands, lakes, and meandering tributaries fed by yearly snowmelt and springs. Downstream of Upper Klamath Lake, the Lower Klamath Basin's physical and aquatic features differ naturally due to geology and a series of four lower Klamath River hydroelectric dams. Although the Lower Basin still supports some agriculture and widespread logging activity, much of the region is still wilderness, with steep forested mountains that shed rainfall overland into fast running streams supplying a majority of runoff to the Klamath River. The river meets the sea at an estuary that is small but nonetheless serves an essential role to many Klamath River fish, and particularly anadromous fish like salmon that breed and rear in fresh water, but live most of their life in the ocean (Vanderkooi et al. 2011).

While forestry, agriculture, and rangeland have come to dominate many areas of the Klamath Basin, other important commercial resources include fisheries, mining, and recreation. Tourism, retail trade, educational services, health care/social assistance, and manufacturing are also important sources of employment in the main population centers of Klamath Falls, Yreka, and Weaverville. In 2004, the Basin was home to approximately 187,000 people (NRC 2004; USFWS 2013a,b; Oregon Historical Society 2017). This population includes Indigenous peoples who have lived, hunted, and fished in the Klamath Basin since time immemorial. The Basin is home to six federally-recognized Tribes: The Klamath Tribes (the Modoc, Klamath and Yahooskin people), Hoopa Valley Tribe, Yurok Tribe, Karuk Tribe, Quartz Valley Indian Reservation, and Resighini Rancheria, as well as the Shasta Nation which is not federally recognized.

This introduction provides only the briefest of introductions to the complex history and ongoing environmental issues facing the fish of the Klamath Basin today. These are explored in much greater detail in a prior volume, the Klamath Basin Integrated Fisheries Restoration and Monitoring Synthesis Report (ESSA 2017).

Figure 1-1. Map of the Klamath Basin showing major dams, sub-basin, and sub-regional boundaries used throughout this plan. Note that these boundaries are used in this report primarily to facilitate synthesis and should not be misinterpreted as indicating separated or self-contained ecosystems, as the basin functions as a single unified ecosystem.

1.2 Current Conditions & Stressors

> "[Recovery of endangered] fishes in the Klamath Basin cannot succeed without aggressive pursuit of adaptive management principles, which in turn require continuity, master planning, flexibility, and conscientious evaluation of the outcomes of management."
>
> NRC 2004 (p 343)

A wide range of historical and ongoing human activities across the Klamath Basin have disrupted natural watershed processes. These activities include the construction of four lower Klamath River mainstem hydroelectric dams, numerous smaller dams, agriculture, ranching, logging, and legacy mining have contributed to reduced flows, habitat loss, and poor water quality due to sediment and nutrient inputs (NRC 2008; Stanford et al. 2011; USDI et al. 2012; USDI, USDC, NMFS 2013; ESSA 2017, Jumani et al. 2022). Nutrient inputs in particular also accumulate in major bodies of water within the basin, including Upper Klamath Lake and reservoirs upstream of major dams, where they contribute to toxic algal blooms that can be harmful or even deadly to fish, wildlife, and humans. Further adding to these pressures are more frequent and extended droughts and forest fires associated with global climate change. For fish, some of these impacts represent **key stressors**, or detrimental conditions that are most limiting to their resilience. Too many compounding key stressors constrain the productivity, abundance, distribution, and diversity of both migratory and resident fish species considered in this Plan (Figure 1-2).

A more detailed exploration of key stressors in each sub-region and sub-basin along with potential restoration ideas can be found in Section 4 of this Draft Plan. More information about key stressors are also summarized in the prior Klamath Basin Synthesis Report (ESSA 2017).

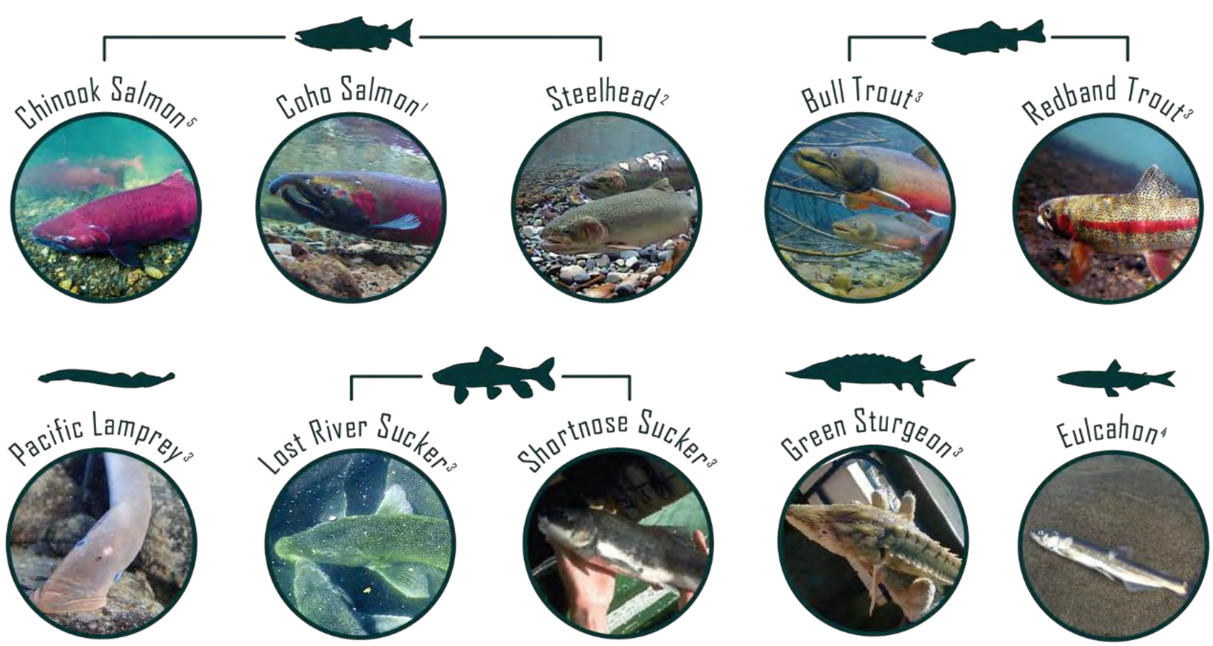


Figure 1-2. IFRMP focal fish species. Photos credited to (1) BLM, (2) Oregon State University, (3) ODFW, (4) Jason Ching, (5) USFWS, (5) Sam Beebe, all images public domain or licensed under CC by 2.0.

Key stressors significantly reduce the function of unseen watershed processes, negatively impacting water quality, and contributing to smaller, less productive, and less healthy populations of many native fish (Figure 1-2), including spring- and fall-run Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*O. kisutch*), and steelhead trout (*O. mykiss*), as well Pacific Lamprey (*Entosphenus tridentata*), eulachon (*Thaleicthys pacificus*), Green Sturgeon (*Acipenser medir*ostris), Bull Trout (*Salvelinus confluentus*), Redband Trout (*O. mykiss newberrii*), and the endangered shortnose sucker (or Koptu) (*Deltistes luxatus*) and Lost River sucker (or C'waam) (*Chasmistes brevirostris*) (Hamilton et al. 2005; NRC 2008; Stanford et al. 2011; USDI et al. 2012; USDI, USDC, NMFS 2013; ESSA 2017). In some cases, these species have even disappeared from some parts of the basin where they once thrived.

These losses have been *deeply* felt by many who live, work, and fish across the Basin. As a result, there have been decades of conflict and debate over how to restore fisheries of great cultural, health, and economic importance. These conflicts arise when other natural goods and services must be prioritized alongside restoration efforts, such as water supply and hydroelectric power for farmers, ranchers, and local communities, which often requires trade-offs (Chaffin et al. 2015). All concerned parties recognize that significant and urgent action is needed to support the recovery of these species and the benefits they provide to local ecosystems and communities. Numerous local, Tribal, state, and federal organizations have responded by leading many different restoration efforts, most recently including an effort to remove four large hydroelectric dams in the lower Klamath River. Surrender and decommissioning this infrastructure involves the full removal of the hydroelectric dams on the Klamath River in Klamath County (Oregon) and Siskiyou County (California), as well as restoring the surrounding lands that have been impacted by the dams.

On June 17 2021, FERC approved the transfer of the Lower Klamath Hydroelectric Project license (No. 14803) from PacifiCorp to the Klamath River Renewal Corporation and the states of Oregon and California, as co-licensees; a key step in the process of surrendering and decommissioning the four dams. On November 17 2022, the Federal Energy Regulatory Commission (FERC) unanimously approved the surrender of the Lower Klamath Project License and the decommissioning of the four hydroelectric dams in the Lower Klamath Project. The License Surrender Order was the final step and decision by FERC needed to allow the Klamath River Renewal Corporation (KRRC) to decommission and remove the four hydroelectric dams.

While past and current efforts at restoring the Klamath Basin have been invaluable, expert reviews have called for a more transparent, science-driven, coordinated, and holistic approach to restoring ecological processes and fish populations across the Klamath Basin (NRC 2004, 2008). This need for basin-wide integration and coordination has become and remains increasingly urgent. Endangered Lost River (C'waam) and shortnose (Koptu) suckers are nearing extinction in parts of the Klamath Basin, and plans to restore salmon, lamprey and steelhead to the Upper Klamath Basin are underway.

1.3 The Klamath Basin Integrated Fisheries Restoration and Monitoring Plan (IFRMP)

Origins and Vision

In 2016, the U.S. Fish and Wildlife Service (USFWS) engaged the Pacific States Marine Fisheries Commission (PSMFC) and ESSA to develop this Draft Integrated Fisheries Restoration and Monitoring Plan (IFRMP or Plan). The purpose of the IFRMP is to help coordinate restoration efforts across the Klamath Basin to support the recovery of native fish populations. The USFWS directed the planning team to engage with experts, practitioners, natural resource managers, and other interested participants from a wide range of organizations in a collaborative planning process. This engagement was grounded in a set of **guiding principles** which follow the recommendations of the National Research Council (2004, 2008):

1. Using a big-picture approach to restoring ecological processes for the entire basin while recognizing how efforts are intricately connected. This includes restoring and monitoring both ecological processes and the fish populations that rely on them.
2. Using the best available science, relying on (rather than re-inventing) past research and discoveries.
3. Using an inclusive, transparent process involving representatives of all interested groups, with many opportunities for peer review.
4. Using an Adaptive Management (AM) framework and best practices to promote learning and allow for Plan adjustments over time.
5. Providing strong scientific evidence to guide future decisions with restoration and monitoring priorities of both fish population and ecological processes.

The **vision** of the Klamath Basin IFRMP is to provide a unifying framework for planning coordinated recovery of native fish species from the headwaters to the Pacific Ocean while improving flows, water quality, habitat, and ecosystem processes. The IFRMP (or Plan) will serve as the blueprint that describes the highest priority flow, water quality, and ecosystem process ("habitat") restoration. The Plan outlines monitoring actions that, together with related restoration activities, can help reverse the declines of multiple fish populations.

The IFRMP serves as the blueprint that describes the highest priority process-based watershed restoration and monitoring actions that can help reverse the declines of multiple native Klamath Basin fish populations.

The Plan provides an answer to the basic question: ***given all we know, which functional watershed restoration actions will give the greatest and widest range of possible benefits to native Klamath Basin fish species – throughout the Basin as a whole and within each sub-basin?*** By helping to identify and cost priority restoration and the monitoring actions needed to track their effects, the IFRMP will also help inform the wise allocation of limited funds for restoration and monitoring work in the Klamath Basin. Importantly, The USFWS intends to update this Plan periodically to reflect changing conditions, needs, and knowledge in the basin through an adaptive management process based on additional engagement with participants who are willing to help make the plan better.

Phases of Collaborative Development

The IFRMP is the culmination of a seven-year collaborative planning process spanning five phases that are summarized below.

Phases 1 and 2 (2016-2018) of IFRMP development focused on information gathering and synthesis, resulting in a detailed Synthesis Report and Initial Draft IFRMP. The Synthesis Report combines information from literature review, interviews, and workshops into a detailed overview of the Klamath Basin's history, characteristics, and environmental stressors. This includes a summary of the biology and ecology of important fish species and their responses to these environmental stressors, along with documenting the quality and quantity of previous restoration and monitoring efforts. The Synthesis Report also reviewed other potential restoration types, methods, effectiveness, and real world applications within the Basin. The report serves as a useful starting point for practitioners, natural resource managers, and other interested participants who are new to these efforts, as it represents the most recent effort to capture the full breadth of information needed to make informed decisions involving the Klamath Basin.

The following **Initial Draft IFRMP** aimed to outline information and prioritization requirements, build the proposed structure of the Plan, and provide initial ideas surrounding potential restoration actions. Ongoing information summaries in this phase included reviewing literature and planning participant engagement to collaborate and review the best available evidence and best practices for organizing watershed restoration frameworks. Participants were also asked to identify suitable indicators of watershed function as well as links between stressors and the fish species considered in this plan. This design stage provided a consistent framework that allowed for a systematic review of restoration projects capable of addressing these stressors and facilitated further planning, designing, and monitoring across the Klamath Basin. This step was followed by a first pass at adding potential restoration actions into the plan based on review of previous restoration actions identified in prior initiatives and planning documents focussed on watershed and species restoration. These initial, unprioritized project lists provided a starting point for participants in the planning process to respond to, change, and build upon in later phases of planning.

Phase 3 (2019-2020) of developing the IFRMP created and applied a prioritization method based on multiple criteria to enable methodical, repeatable, and transparent ranking of Klamath Basin restoration actions as they benefit focal fish populations. The criteria and framework itself is based on best practices for a functional approach[1] to watershed restoration. This approach aims to address both root causes and side effects of habitat damage, maximizing the benefits of restoration for as many species in as many places as possible (see Section 3.4 for details). Both the data to inform criteria scoring as well as the refined, prioritized, restoration project concepts came from (1) the best available evidence from previous studies gathered in Phases 1 and 2 of IFRMP development, (2) recommendations for restoration actions in previous watershed or species recovery plans and assessments, and (3) expert opinions from practitioners working

[1] The IFRMP intentionally uses the term "**functional watershed restoration**" rather than "habitat restoration". A 'functional watershed' goes beyond habitat restoration and addresses how ecosystem processes are interconnected, affecting riparian and aquatic components *as well as* habitat (see Figure 2-1 in section 2.1). In other words, **habitat is one category of a broader hierarchy** of interacting processes and conditions that support each other. In this framework, the quality and quantity of particular habitats is often a good indicator of condition but alone does not describe underlying cause for a given state, nor what activities would best support a desired state.

across the Klamath Basin collected through written submissions, surveys, interviews, and both virtual and in-person workshops within a series of Sub-Basin Working Groups (see Appendix A for a detailed list of participants), and subject to multiple rounds of peer-review using these same approaches. We used the Scott sub-basin as a pilot basin for testing and refining the Sub-Basin Working Group process. This pilot included discussing the mechanics of the prioritization scheme, such as defining the appropriate extent of space and time for planning (see Section 3.2), defining the scope of the restoration project concept, determining the right level of detail to include in projects, and the approach for collectively defining the focal area for each proposed project. This step also yielded important early feedback about the accuracy of maps detailing species' location and extents, as well as restoration action and connections to environmental stressors. Feedback from this pilot application were used to refine the prioritization scheme rationale and the collaborative process for developing projects and priorities across all other Sub-Basin Working Groups.

Everything discussed thus far comes together in a **web-based Klamath IFRMP Restoration Prioritization Tool (IRPT)** that applies the prioritization method in real-time based on user inputs (see http://klamath.essa.com; Guest Username: ifrmpguest; Guest Password[2]: table-box-12). This tool allows **different prioritization scenarios to be created** through a combination of customizable factors on the individual scoring criteria. The IFRMP Restoration Tool recognizes that practitioners in different parts of the Basin may have different perspectives on restoration goals and objectives (see Section 3), and so creates an environment that can cater to a variety of users.

The prioritization scores resulting from these efforts and described in this report are *not* meant to be viewed as final, formal recommendations for project to be built exactly as described. Instead, the lists of project concepts and initial priority rankings in this Plan are meant to:

(1) **provide a big-picture view of key restoration actions**, which restoration experts and practitioners feel are needed to restore self-sustaining fish populations in the Klamath Basin. This broader view also recognizes that the full suite of project concepts recommended cannot be accomplished all at once.

(2) **provide a starting point for group discussions to define a narrower near-term Klamath Basin Restoration Action Agenda (RAA)** that can then by built upon to develop detailed and actionable proposals for future restoration projects to submit to future solicitation processes for implementation funding. In this way, the RAA bridges science-driven restoration needs outlined in the plan with practitioner interests and capacity for implementation, increasing the likelihood of successful restoration outcomes. This Action Agenda is periodically updated to reflect changing conditions, priorities, and restoration progress in the basin.

Phase 4 of the IFRMP planning process (2020-2021) aimed to provide more information that would support executing the plan, including:

(1) **Generating cost estimates for restoration and monitoring actions** in the IFRMP.

(2) **Creating monitoring plan recommendations that close key gaps in tracking basin-wide recovery efforts, based on status and trends Core Performance Indictors**

[2] Note: If these login credentials do not work for you, it is most likely because of a local information technology security policy put in place by your organization. Contact your local systems administrator / local IT helpline for assistance.

(CPIs) across all levels (see Section 2.3 for more information about CPIs). Ongoing monitoring of CPIs will reveal worrisome signals that could mean more investigation or effort is needed in a given area, or alternatively reveal positive signals where habitat conditions are improving following restoration efforts. While the IFRMP focuses on **standardizing key CPIs to measure basin-wide status and trends,** other ongoing monitoring programs across the Basin should continue to monitor and assess local project performance.

(3) **Reviewing and fine-tuning how the IFRMP aligns with other regional restoration plans** (Figure 1-3, Section 0) to ensure the work is building on existing efforts, filling important gaps, or at least coordinating with other initiatives.

(4) **Improving the usability of the Klamath IFRMP Restoration Prioritization Tool** by adding the ability to visualize spatial data to support future engagement and prioritization.

Phase 5 of (2021-2022) aimed to finalize the plan document, **create a 2023-2024 Restoration Action Agenda and develop recommendations for implementation** of the plan, including fine-tuning proposed project details, developing recommendations for closing gaps in monitoring basin-wide recovery, generating cost estimates for proposed restoration and monitoring actions, and further refining the Restoration Prioritization Tool. This phase also developed guidance for periodically updating the IFRMP and Restoration Action Agenda over time.

Recommendations for remaining activities to support the implementation of the IFRMP in 2023 and beyond are ongoing and described in Section 6.

The IFRMP is organized around major sub-basin watersheds within the Klamath Basin. For each sub-basin, the IFRMP identifies specific stressors that have negative impacts on native fish. It then identifies priority restoration actions that could be taken to help alleviate these stressors, provides information on the costs of these actions, and outlines important monitoring activities needed to consistently track basin-wide recovery as restoration actions are implemented. Components of monitoring activities will in turn feed into new rounds of updates to restoration action priorities, revealed by periodically updating and re-applying the Klamath IFRMP Restoration Prioritization Tool (see Section 6). The intent of the IFRMP is not to replace other existing planning efforts, but to strategically bring together existing plans and planning efforts at the basin-wide scale within an Adaptive Management framework (Figure 1-3).

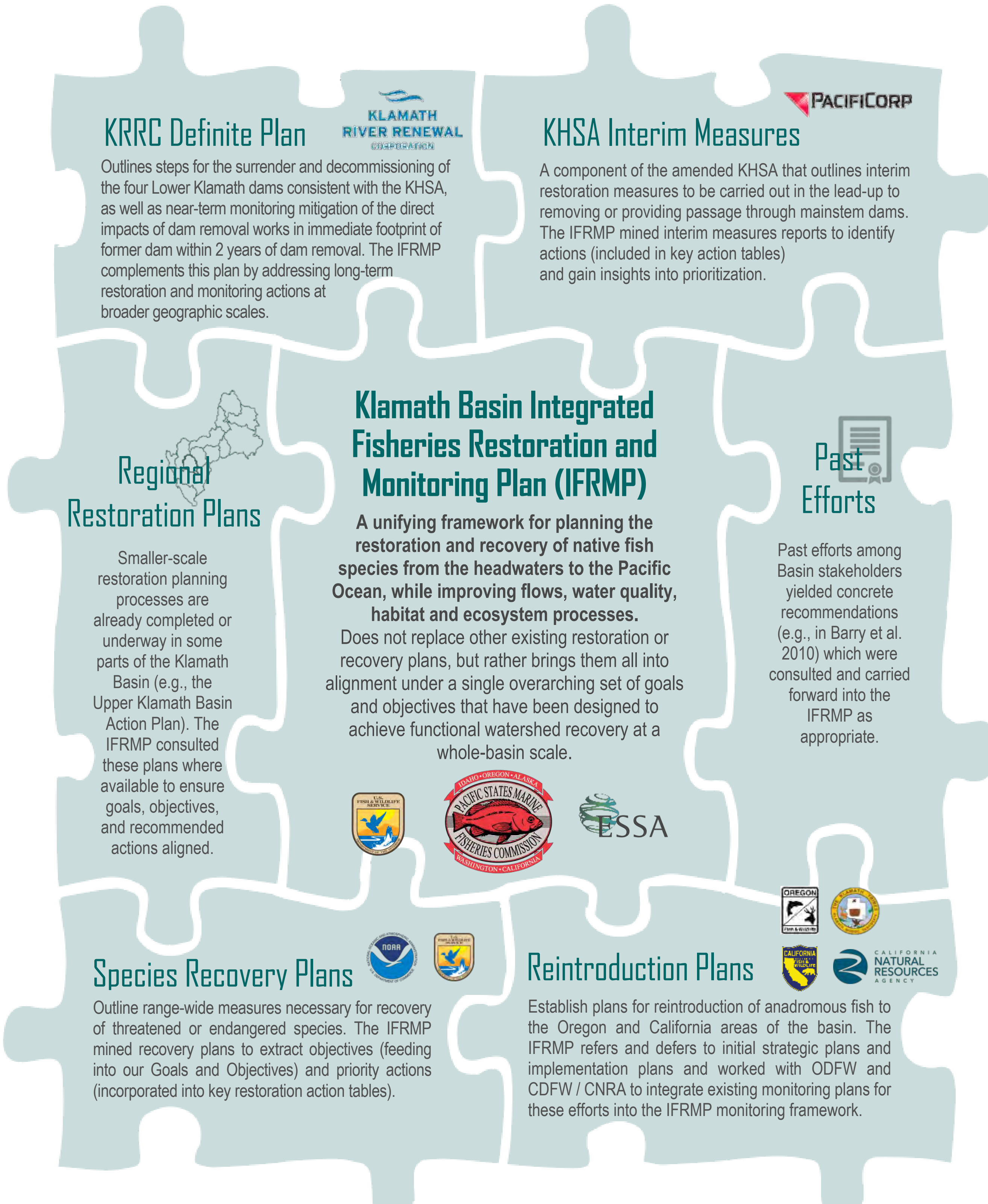
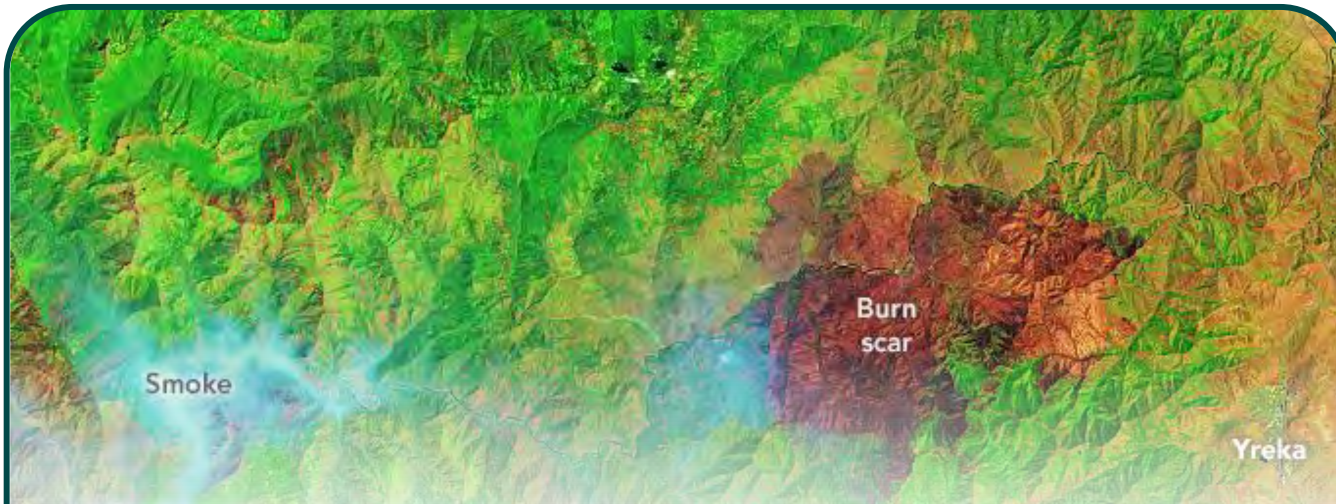


Figure 1-3. A schematic of the interrelationships between the IFRMP and other parallel restoration initiatives.



False-color satellite image of the 2022 McKinney Fire, spanning the mainstem Klamath River near Yreka, CA, showing smoke plume and extensive burn scar. This fire has been linked to a severe mass-mortality event of multiple species of fish in the Klamath River. (Photo by NASA)

Box 1-1: The IFRMP and Climate Change Resilience in the Klamath Basin

The effects of climate change are already being felt across the Klamath Basin with serious consequences for species, ecosystems, and communities, and these effects are expected to grow worse in the future (Barr et al. 2010). Research to date has predicted the Basin is likely to experience increasing average air temperatures, increasing the number of extreme heat days; and changing yearly and seasonal rainfall patterns, including less snowpack, more rain in winter, lower flows in summer, and extreme rainfall events. All of these effects are also expected to contribute to changes in yearly and seasonal stream flow, groundwater levels, and water quality (ESSA 2017, USDI, USDC, NMFS 2013). These effects will no doubt impact fish and other species living within the Klamath basin through increasing temperature stress, higher sediment and nutrient delivery, and greater risks of disease, which negatively impact water and the quality, quantity, and connectivity of fish habitats (Barr et al. 2010). These impacts will contribute to changes in watershed characteristics and function, including the distribution of fish and fish habitat, the spread of invasive plants and fish, changes to volume, flow, and timing of water processes that reshape watershed structure, and more frequent and intense wildfires (Parks and Abatzoglou, 2020; Barr et al. 2010). There is also a growing risk of losing wetland areas due to less soil moisture and water availability, which could increase total phosphorus concentrations in both headwaters and lowlands in waterways that are already naturally phosphorus-rich (Records et al. 2014, Snyder and Morace 1997).

Rather than considering climate change through a separate set of actions, the IFRMP addresses climate change adaptation through a broader lens of process-based watershed restoration (Figure 2-1, Table 2-1). The IFRMP is designed to prioritize actions that contribute to restoring watershed functional processes at landscape scales, which are expected to support healthy fish habitat and populations, more natural watershed function, and overall resilience to multiple stressors, including climate change. Many restoration actions within the IFRMP indirectly contribute to climate change resilience across the Klamath Basin and reflect previously recommended actions for improving resilience (Barr et al. 2010), including: managing and monitoring forests to reduce the risk of wildfires; restoring river bank (riparian) areas and reconnecting cold-water springs to

Box 1-1: The IFRMP and Climate Change Resilience in the Klamath Basin (cont'd)

create pockets wherein species can escape hot temperatures and flush out sediment inputs after climate-related fires; enabling a consistent stream flow and promoting wetland restoration to increase water storage, which help mitigate effects caused by drought; improving how watersheds are connected to allow enable climate-driven species migrations to find more suitable habitats; and stabilizing banks and slopes to lessen wear down after extreme rainfall events (Paukert et al. 2021, Beechie et al. 2019, Scheller and Parajuli 2018, Herbold et al. 2018, Justice et al. 2017a, Isaak et al. 2015, DeBano and Neary 1996).

There are also opportunities for restoration to contribute *directly* to climate change mitigation. For example, the Upper Klamath Basin contains extensive peat wetlands, one of the highest-potential natural land-based carbon sinks, many of which are severely damaged. This type of wetland is seen as the most efficient carbon stores of all terrestrial ecosystems, storing twice the carbon of comparable forest volume, and provides opportunities for both environmental and economic benefits (Fennessy and Lei 2018). For example, fueled by an emerging carbon market, the Delta Carbon Program centered around carbon storage of tidal wetlands in the Sacramento / San Joaquin Delta have come up with a blueprint for building a diverse partnership between interested parties that addresses fish and wildlife habitat, economic sustainability, and carbon storage. Restoring or conserving the volumes and flows associated with peat wetlands likely represents one of the most important and overlooked carbon storage opportunities in the Klamath Basin and would provide significant subsidiary benefits for nutrient enrichment, fish and wildlife habitat, as well as contribute to maintenance of the water budget through surface and soil water storage and ground water augmentation. In addition, the IFRMP considers climate change risk explicitly within the prioritization process by including the NorWest future stream temperature projections for the Klamath Basin as one of several proxy core performance indicators (CPIs) that informs the severity of habitat stressors or 'restoration needs' in different locations, and this data layer is viewable in the web-based IFRMP Restoration Planning Tool. The IFRMP also provides monitoring recommendations that will ultimately improve our ability to track climate impacts (e.g., stream temperature, stream flow, locating cold water refugia) in specific locations and inform future restoration priorities and resource allocation for areas most impacted by climate change.

Overall, the suite of project concepts and monitoring recommendations identified in the IFRMP are expected to increase resilience against climate change in Klamath Basin at watershed and species levels. In addition, as project concepts within this plan move forward to implementation planning, it will be critical to consider how restoration initiatives themselves respond to climate change to ensure that they will continue to provide their intended benefits under future climate conditions (Battin et al. 2007). Many restoration funding opportunities are increasingly requesting that proposed projects be evaluated on their ability to withstand climate change impacts against overall restoration outcomes to ensure that the benefits of restoration are more likely to persist over time (Timpane-Padgham et al. 2017).

2 Basin-Wide Restoration & Monitoring Framework

This Section

- Presents the overarching goals and objectives that will guide implementation of the IFRMP.
- Links goals and objectives to core performance indicators.
- Describes the way the Plan will address phasing and sequencing of restoration and monitoring.

2.1 Guiding Principles for Process-Based Restoration

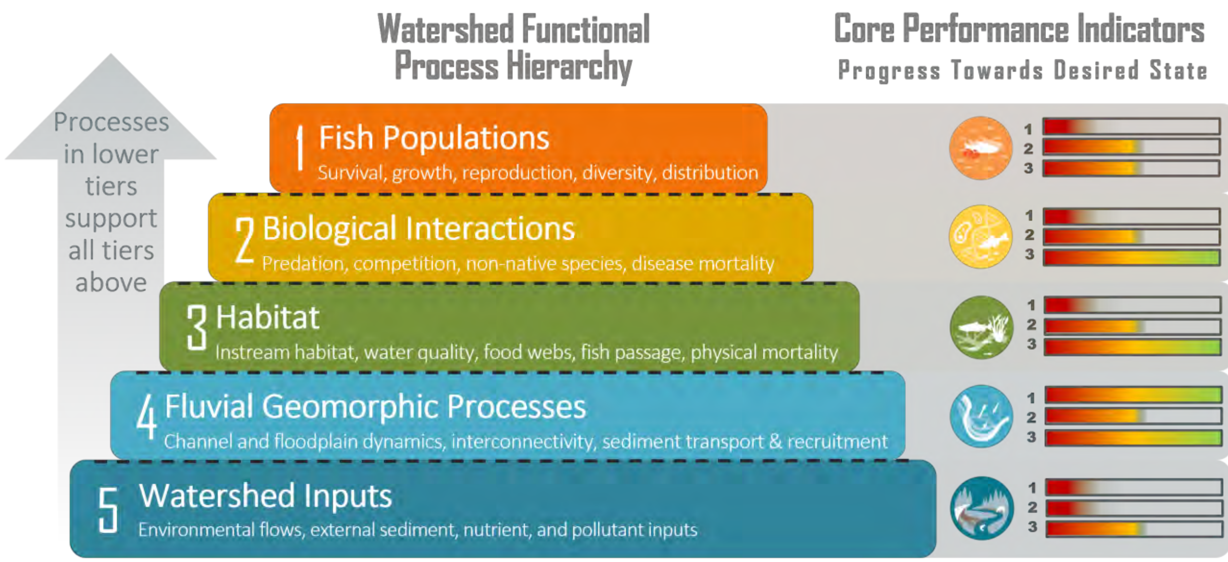


Figure 2-1. Diagram illustrating the concept of bottom-up restoration by tier of watershed processes, where practitioners should focus first on addressing the underlying causes at the base of the hierarchy before carrying out restoration in other tiers that rely on this foundation (after Roni and Beechie 2013, Harman et al. e2012). The stylistic heat-map colored bars underneath "Core Performance Indicators" represent different metrics that have been selected to measure the status of conditions within the different biophysical tiers and are used to track progress towards achieving the desired state.

Scientists in river restoration ecology increasingly call for more interconnected approaches to restoration at the basin scale. Current approaches ***seek to address multiple root causes of ecosystems degradation*** by focusing on restoring ecological processes and functions for the entire landscape rather than the resulting consequences for individual locations and species (Beechie et al. 2010, Whipple et al. in revision). This method of restoration work is known as ***process-based restoration***. In practice, process-based restoration urges thinking 'outside the channel' and including more watershed-scale actions that address the movement of mineral and nutrients into the watershed (tier 5, Figure 2-1) and the process of how watershed structure and flows shape the environment around it (or hydrogeomorphic) (tier 4, Figure 2-1) which drive channel conditions (tier 3, Figure 2-1) and, ultimately, how healthy a habitat is (Palmer et al. 2014). Process-based restoration recognizes the inherent hierarchical nature of watershed processes, where improving the hydrogeomorphic and biogeochemical processes at the bottom of the pyramid are expected to result in benefits move up to the top of the pyramid in more localized channel, habitat, and population processes (Roni and Beechie 2013, Harman et al. 2012). Carefully considering how each tier builds off the previous tier helps to fully understand the maximum potential benefits of restoration actions (Fischenich 2006). Furthermore, addressing root causes results in a natural prioritization of restoration actions, both across and within watershed functional tiers (Figure 2-1) (Roni and Beechie 2013). Most importantly, process-based restoration encourages thinking about many different, yet interrelated restoration actions that can work better together to achieve broader restoration goals (Beechie et al. 2010).

This holistic approach requires examining sets of suggested restoration actions for their immediate, individual benefits and larger, long-term potential impact to ecosystem-scale recovery (Beechie et al. 2010, Luoma et al. 2015). Section 3 describes an approach to evaluating collective benefit across tiers of watershed processes using multiple sources of evidence and discusses types of restoration actions that are considered in this plan. The broad-scale evaluation provides a starting point for larger conversations among restoration planners who need to consider many other factors including current events, species conservation needs, financial or legal constraints, and other special circumstances. These factors are further discussed in the prioritization framework described in Section 3.5, which provides a series of steps for examining the importance of individual restoration project concepts within the broader process-based restoration framework.

To determine how well these projects are working to restore ecological function, any watershed restoration plan must also have defined goals, objectives, and indicators for tracking progress towards the desired state of the system. These are described further in the next section.

2.2 Goals and Objectives

Restoration goals are statements of broad outcomes to be achieved, while restoration objectives are specific and measurable tasks that must be done to make the related goal achievable (Beechie et al. 2008, 2013). The goals and objectives of the IFRMP were drawn and adapted from existing plans to ensure alignment with other ongoing restoration planning work in the Basin. These plans are updated with input from regional stakeholders to ensure they still meet practitioners' needs, and organized into the biophysical hierarchy (Table 2-1) for the major tiers of watershed function (Figure 2-1). This approach follows best practices for functional restoration planning outlined by the Environmental Protection Agency (Harman et al. 2012). Under this method, the base tiers of the hierarchy include watershed inputs and fluvial geomorphic processes describing how water moves through the watershed, which naturally support functions in all tiers above them, such that improving the function of these lower tiers also benefit habitat and biological functions in the tiers above.

It is important to understand that natural systems often recover slowly, and that there will be a time lag between successfully restoring an underlying watershed process and noticing the benefits of these actions at higher levels of the hierarchy. Thus, ***many of these goals and objectives, particularly higher-order goals and objectives related to fish populations, may take many decades to achieve*** (Doyle et al. 2005, Gilvear et al. 2013, Bellmore et al. 2019). In some cases, it may take several decades after the supporting watershed processes are restored to detect broader benefits. For this reason, we recommend tracking overall progress towards outlined goals ***within each watershed process tier*** (Figure 2-1) rather than measuring success against a small subset of specific metrics at higher biological tiers (e.g., only monitoring fish population change and using that as a measure of entire restoration progress). There are other considerations for monitoring at ***different spatial scales*** that we return to later in this section and in Section 5 on monitoring actions and costs.

Table 2-1: Klamath IFRMP Goals and Objectives Hierarchy.

Whole-Basin Nested Goals	Nested Objectives
Fish Populations (FP) 1. Achieve naturally self-sustaining native fish populations	1.1 Increase juvenile production 1.2 Increase juvenile survival and recruitment to spawning populations 1.3 Increase overall population abundance and productivity, particularly in areas of high existing abundance or potential future abundance or in special or unique populations 1.4 Maintain or increase life history and genetic diversities 1.5 Maintain or increase spatial distributions as necessary
Fisheries Actions (FA) 2. Regulate harvest to support self-sustaining populations.	2.1 Improve management and regulations/enforcement of harvest, bycatch and poaching of naturally produced fish such that populations do not decline and can recover. ***While essential for recovery of fish populations, this objective and objective 3.1 are outside the scope of the IFRMP and falls under the responsibility of federal and state agencies with jurisdiction over harvest management.*
Biological Interactions (BI) 3. Reduce biotic interactions that could have negative effects on native fish populations	3.1 Do not generate adverse competitive or genetic consequences for native fish when carrying out hatchery, production, or conservation actions 3.2 Minimize disease-related mortality by reducing vectors and factors known to lead to fish disease outbreaks 3.3 Reduce impacts of non-native plant and animal species on native fish
Habitat (H) 4. Improve freshwater habitat access and suitability for fish and the quality and quantity of habitat used by all freshwater life stages	4.1 Restore fish passage and re-establish channel and other habitat connectivity, particularly in high-value habitats (e.g., thermal refugia) 4.2 Improve water quantity and quality for fish growth and survival 4.3 Enhance, maintain community and food web diversity supporting native fish 4.4 Reduce fish mortality due to entrainment, scour, stranding 4.5 Enhance and maintain estuary, mainstem, tributary, lake, wetland, and refuge habitats for all freshwater life stages and life histories of fish
Fluvial Geomorphic Processes (FG) 5. Create and maintain spatially connected and diverse channel and floodplain morphologies	5.1 Improve and maintain productive sediment delivery, storage, sorting, and transport dynamics 5.2 Increase channel and floodplain dynamics and interconnectivity 5.3 Promote and expand establishment of diverse riparian and wetland vegetation that contributes to complex channel and floodplain morphologies
Watershed Inputs (WI) 6. Improve water quality, quantity, and ecological flow regimes	6.1 Improve instream ecological flow regimes year-round for the Klamath River mainstem and its tributaries in all sub-basins 6.2 Reduce anthropogenic sediment inputs while maintaining natural and beneficial sediment inputs 6.3 Reduce external nutrient and pollutant inputs that contribute to detrimental bio-stimulatory conditions

Note: Under the direction of the IFRMP Federal Coordination Group, fishery management actions, and related fish population monitoring is relevant to the Plan but considered 'already in place' and thus out of scope of IFRMP. However, we are integrating with new monitoring undertaken by ODFW, CDFW, and other agencies.

2.3 Core Performance Indicators

Core Performance Indicators Linked to Goals and Objectives

The objectives in Table 2-1 are linked to indicators that allow for monitoring and tracking progress towards objectives. These serve to not only communicate progress on achieving these objectives, but also on Whole-Basin Goals. Although a wide range of potential indicators of watershed function exist, only a few can be reliably tracked given constraints on time and funding. The indicators selected for this purpose are known as **Core Performance Indicators (CPIs)**. CPIs can be thought of as the 'vital signs' of a watershed; serving as fundamental measures that can provide an overall snapshot of river basin health in the same way that heart rate, blood pressure, and body temperature provide an overall snapshot of human health.

Monitoring CPIs should happen alongside other types of monitoring already occurring in the basin. We recognize some monitoring may be limited in space and time to track project implementation and effectiveness, other monitoring will need to continue across all hierarchical tiers (Figure 2-1). for ongoing tracking of status and trends and to confirm the recovery achieved is maintained over time. Implementers of the Plan may in the future leverage the **IFRMP Restoration Prioritization Tool (IRPT)** to update and track CPI status and as the IRPT uses the associated scores as part of one of its ranking criterion for assessing the prioritization of restoration actions. As with vital signs in medicine, worrisome signals in monitoring of CPIs may mean further diagnostic investigation is needed, either through more monitoring or special studies.

Core Performance Indicators Across Spatial Scales

The large size of the Klamath Basin and its many nested sub-basins, tributaries, and sites require special attention to the way the proposed restoration and monitoring framework can be applied across both large and small geographic footprints. As a result, it will be important to consider how indicators can be applied across spatial scales (including site or reach, tributary or lake, sub-basin (including portions of the mainstem), and whole basin), which has been an important elements other watershed restoration programs (Steel et al. 2010, del Tánago et al. 2016, Corneil et al. 2018, Kuemmerlen et al. 2019). CPIs measured through smaller site- or reach-scale monitoring can be aggregated or combined across sub-watersheds to reflect status and trends at larger spatial scales. However, CPIs measured at broader landscape scales, for example, using approaches like remote sensing, cannot always be rolled down to the site scale

Monitoring indicators at different spatial scales can also reveal scale-dependent interactions between local and regional habitat quality that may influence restoration outcomes and guide the future direction of restoration efforts (Pander and Geist 2013). For example, stream invertebrates,' population and growth responds differently to changes in small sediment matter at different spatial scales (Larsen et al. 2009), and restoration efforts at a site level have greater benefits over invertebrate communities when tributary/lake habitat quality is between 'good' and 'poor' (Stoll et al. 2016). Similar scale-dependent responses have also been documented for restoring vegetation in areas surrounding lakes and rivers (Staentzel et al. 2018). These results would not be possible without thorough monitoring at local and regional levels. Monitoring at multiple spatial scales could also disentangle the benefits of many smaller restoration projects or even compare the benefits of larger versus smaller restoration projects across the landscape (Roni 2019).

Core Performance Indicators of This Plan

Table 2-2 presents the draft CPIs proposed for use in this Plan. This set of CPIs were initially developed through reviewing literature of common watershed status indicators and further refined though review, a preference survey, and a follow-up webinar discussion with participants from multiple Sub-basin Working Groups at the beginning of Phase 3.

Because data are not currently available for all the selected CPIs across the Klamath Basin, we worked with Sub-basin Working Group members to select from among another set of currently available basin-wide stand-in data sets to use as **CPI proxies** in Phase 3. Proxies were included if participants judged them to be relevant in most areas of the Klamath Basin. It is expected that CPI proxies will be overridden when local data in those areas is more accurate or relevant than the proxy data. These proxies are viewable on the IFRMP Restoration Prioritization Tool's map viewer (access via https://ifrmp.net/). Eventually, all proxies will be replaced by more appropriate and locally-relevant data collected expressly for this purpose as part of a standardized basin-wide monitoring program, as described in Section 0. Details on how CPIs and proxies are used for prioritization are further described in Section 3.

2.4 Restoration and Monitoring Phasing & Sequencing

Beyond tracking and reporting, CPIs and their current status can also be used for planning restoration priorities over time. By looking at the status of CPIs alongside current restoration objectives, practitioners can see whether one aspect of watershed function has recovered enough to shift more, but not necessarily all, effort and resources towards another aspect in need of improvement. For example, if issues with watershed inputs and fluvial geomorphic processes (see Figure 2-1) have been addressed and improved, it may be time to shift the focus of restoration to instream habitat improvement projects. Here, we define moving between restoration priorities within one functional tier of watershed processes as **sequencing** (e.g., shifting from a focus of reducing pollution loads to one of improving instream flows within the same Watershed Inputs process tier) and moving from emphasis on one functional tier to another as **phasing** (e.g., shifting from a focus on improving overall water quality in the Watershed Inputs tier to a focus on improving instream flows in the Fluvial Geomorphic Processes tier). Operationalizing these concepts is one appropriate technical sub-topic as part of IFRMP implementation. Once more restorations actions have been completed and basin-wide CPI monitoring data begins to flow, sequencing and phasing should be revisited at future Klamath Science Symposia.

Phasing and sequencing can also be considered at a range of spatial scales. Thus, an organization working at the reach scale could theoretically use this framework with local-scale CPIs to guide and report on a particular tributary's restoration status. Meanwhile, larger organizations like state and federal agencies could also use this framework with CPIs applicable at landscape-scales to guide restoration strategy at the broader sub-basin or basin scales. Although these organizations may be working separately at different scales, using the same framework and CPIs allows for data-sharing, reporting, and transparency across scales and collaborators.

Because Klamath Basin is so large and has so many different restoration needs in its sub-basins, **the decision to move from one phase of restoration to the next at any scale should to be determined through group discussion based on multiple sources of evidence**, rather than a singular decision criteria or set of rules. Beyond CPI status, these discussions may consider how effective the action is, how much it may cost, the ease of carrying out the action, and other special circumstances. How these considerations influence sequencing and phasing is further

Table 2-2: IFRMP Core Performance Indicators (CPIs) selected by Working Group participants across goals and relevant objectives and associated CPI proxies used currently within the Klamath IFRMP Restoration Prioritization Tool. The hyperlinks in this table direct users to later parts of this plan addressing monitoring strategies for these CPIs. Underlined text in the CPI column links to the relevant section of the IFRMP Monitoring Recommendations.

Goal	Objectives	CPIs	CPI proxies
Fish Populations (FP) **1. Achieve naturally self-sustaining native fish populations.**	FP1: Maintain or increase spatial distributions	• Focal species presence/absence • % of historical habitat occupied	• Mapped current distributions of focal fish species in the Basin • Mapped current distributions of focal fish species in the Basin vs. mapped known historical distributions of focal fish species
	FP2: Increase juvenile production	• Presence of spawning • Presence of rearing • Productivity	None identified
	FP3: Increase juvenile survival and recruitment to spawning populations	• Recruitment	None identified
	FP4: Increase overall population abundance and productivity, particularly in areas of high existing abundance or potential future abundance or in special or unique populations	• Abundance	None identified
	FP5: Maintain or increase life history and genetic diversities	• Life history diversity • Age structure/demographics • Genetic diversity	None identified
Biological Interactions (BI) **3. Reduce biotic interactions that could have negative effects on native fish pops.**	BI1: Do not generate adverse competitive or genetic consequences for native fish when carrying out conservation-oriented hatchery supplementation as needed **[Outside scope of IFRMP, included here for completeness]**	NA	NA
	BI2: Minimize disease-related mortality by reducing vectors and factors known to lead to fish disease outbreaks	• Prevalence of disease pathogens • Prevalence of disease-related mortality	None identified
	BI3: Reduce impacts of non-native plant and animal species on native fish	• Presence of invasive aquatic species	• Trout Unlimited - Number of aquatic invasive species per subwatershed
Habitat (H) **4. Improve freshwater habitat access and suitability for fish and the quality and quantity of habitat used by all freshwater life stages**	H1: Restore fish passage and re-establish channel and other habitat connectivity, particularly in high-value habitats (e.g., thermal refugia)	• See FP 1	• EPA - Density Road-Stream Crossing • Trout Unlimited - Ratio current max. stream network connectivity to historical (inland)
	H2: Improve water temperatures and other local water quality conditions and processes for fish growth and survival	• Thermal refugia • Water temperature • Water chemistry • Turbidity • Nutrients	• NorWeST Mean Aug Stream Temperatures – 2040s

Goal	Objectives	CPIs	CPI proxies
		• Chlorophyll-a • Nuisance phytoplankton & cyanotoxins	
	H3: Enhance, maintain community and food web diversity supporting native fish	• None brought forward as priority to support	None identified
	H4: Reduce fish mor tality due to entrainment, scour, stranding	• None brought forward as priority to support	None identified
	H5: Enhance and maintain estuary, mainstem, tributary, lake and wetland habitats for all freshwater life stages and life histories of resident and anadromous fish	• Riparian condition • Stream habitat condition (physical)	• EPA - % Potentially Restorable Wetlands
Fluvial Geomorphic Processes (FG) **5. Create and maintain spatially connected and diverse channel and floodplain morphologies**	FG1: Increase and maintain coarse sediment recruitment and transport	• Sediment transport	None identified
	FG2: Increase channel and floodplain dynamics and interconnectivity	• Geomorphic flushing flows • Channel complexity • Floodplain connectivity	• EPA - % Developed, High Intensity in HCZ (Hydrologically Connected Zone); • Net river-floodplain exchange in unconfined reaches
	FG3: Promote and expand establishment of diverse riparian and wetland vegetation that contributes to complex channel and floodplain morphologies	• Large wood recruitment and retention	• EPA - % Developed, High Intensity in RZ (riparian zone) • EPA - Density all roads in RZ (riparian zone)
Watershed Inputs (WI) **6. Improve water quality, quantity, and ecological flow regimes**	WI1: Improve instream ecological flow regimes year-round for the Klamath River mainstem and tributary streams	• Instream flows	• Trout Unlimited - Water Quantity Sub-Index, • Trout Unlimited - Flow volume change risk II (base flow)
	WI2: Reduce anthropogenic fine sediment inputs while maintaining natural and beneficial fine sediment inputs	• Fine sediment loads	• USGS - Count of past placer mines in sub-watershed • EPA - PHWA Wildfire Vuln. Sub-index • EPA - Density all roads in Watershed
	WI3: Reduce external nutrient and pollutant inputs that contribute to bio-stimulatory conditions	• Nutrient loads	• Trout Unlimited - # Diversions per stream mile • EPA - % Agriculture in Watershed

discussed in Section 3 on prioritization. Decisions to move between phases and sequences means associated monitoring framework will also change over time. For example, knowing whether or not a species currently exists in a given habitat takes priority over monitoring that species' abundance or genetic diversity.

Restoration practitioners will need to think about **dependencies** between projects being considered and ranked in priority. We define dependency as the need for a project to be completed before another project can take place. In cases where a high-ranking project is dependent on a lower-ranking project, restoration practitioners could complete these projects together. For example, building and reconnecting side-channel habitat is likely to be more beneficial after more foundational limiting factors such as water quality issues in the area are already addressed.

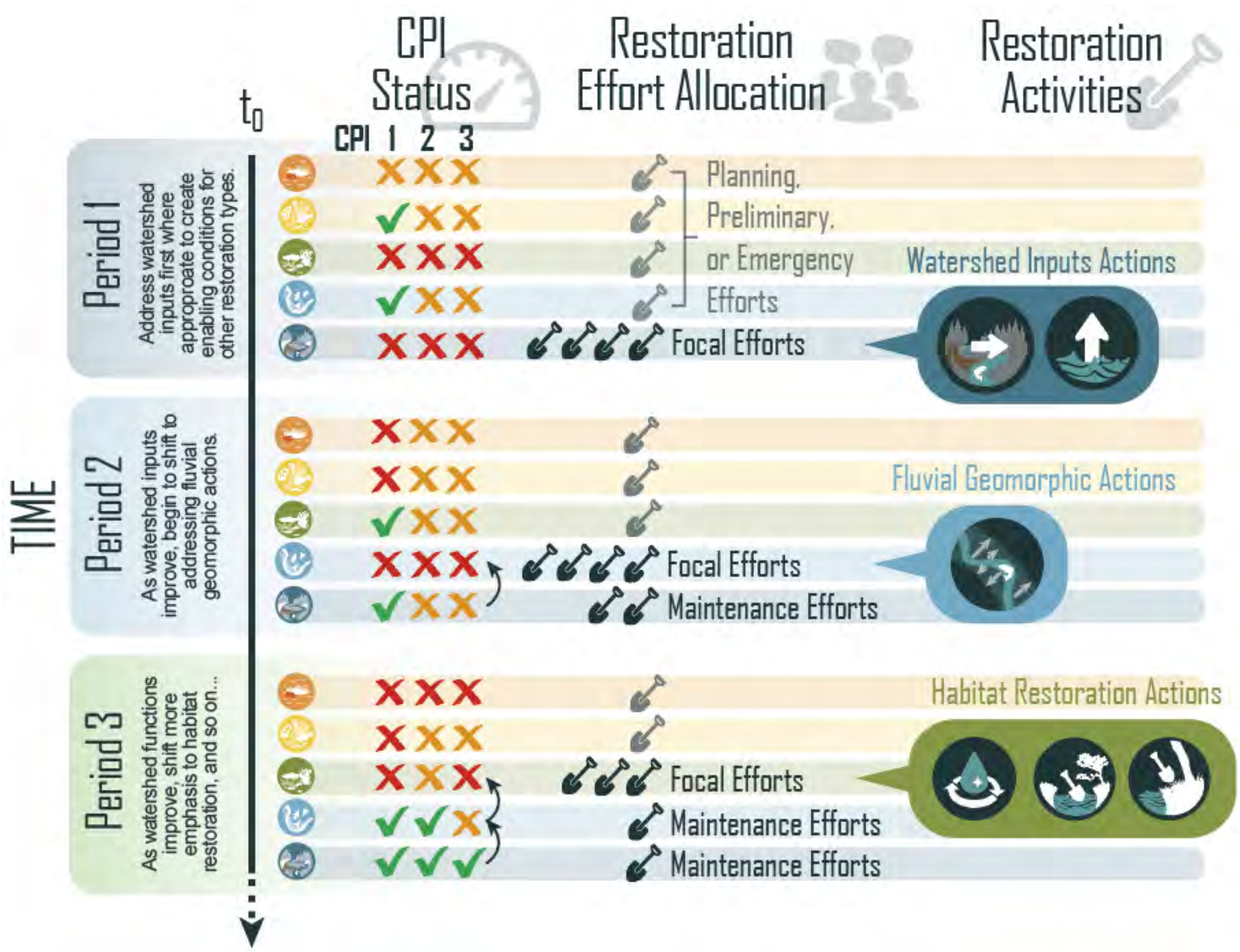


Figure 2-2: Application of the restoration framework over time, where the status of CPIs within each watershed functional tier inform restoration practitioners' discussions about where to focus restoration effort (i.e., at the first tier with CPIs in poor status) and which restoration activities should take place at the focal tier, which may differ across sub-basins and scales. The prioritization framework described in Section 0 provides practitioners with more information about which specific projects to pursue. CPI status and restoration decisions at all scales can drive reporting of overall basin status through communication tools such as watershed report cards.

2.5 Alignment with Other Planning Efforts

The Integrated Fisheries Restoration and Monitoring Plan (IFRMP) is **the only Klamath plan that addresses the entirety of the Klamath basin and harmonizes priorities for ten native fish species.** The IFRMP uses standardized tools that reveal what functional watershed restoration actions are most likely to provide the broadest possible benefits to achieve basin-wide recovery for these ten species. The Plan is centered on preventing the extinction of several native fish species throughout the vast geographical area that is Klamath basin. This is no easy task, as there are many competing uses for the river, multiple dams and diversions affecting flow and habitat connectivity, great uncertainty about what restoration actions would be most effective, as well as climatic, social, and political challenges in implementing these restoration actions. In response to this complexity, the IFRMP is creating **a rigorous prioritization framework to pull together the multiple, diverse pieces of evidence relevant to native fish species habitats, core performance indicators, and potential restoration actions**. Our work on the IFRMP includes reviewing other pre-existing and in-development plans for sub-regions and sub-objectives around the Klamath Basin.

While the IFRMP is the only basin-wide overarching synthesis for multiple key focal fish species, there are at least **eleven other important sub-basin plans in existence that are also meant to address aspects of functional watershed restoration and recovery for native fish populations in particular regions of the basin** (Appendix H). This Plan Alignment sub-section of the IFRMP summarizes how these ten plans are both unique in some features and mutually supportive of one another (Table 2-3). Our summary of these parallel plans includes reviewing:

- The objectives of the related plans (i.e., the motivation for each plan);
- The target species and focus of the restoration actions for those species;
- The spatial scale of the plan's evaluation (i.e., priority locations);
- Key performance indicators used in the plan;
- The monitoring focus of the related plans; and,
- A big-picture assessment of how the plan aligns with the IFRMP and what is unique about each plan (i.e., what does a particular plan address that the IFRMP does not).

Table 2-3 provides a high-level summary of the similarities and unique features of these various plans as they relate to the IFRMP, while the related Appendix H contains a short summary of the plans that either have been or are under development in the Klamath basin as of the time of publication. This provides an important tool for building on the efforts of different research and restoration practice teams around the basin and will help managers and practitioners understand key differences between the basin-wide IFRMP and these other helpful plans. For example, the IFRMP is typically evaluating and recommending *concepts* of restoration projects at the sub-watershed scale rather than proposing *specific projects* at a stream reach scale. The cross-walk table (Table 2-3) also provides helpful clues on monitoring priorities. For example, where two or more plans overlap in their core performance indicators (CPIs), this may mean one should plan to monitor both CPIs (e.g., revealing multiple benefits). Meanwhile, differences in recommended CPIs *may* mean further alignment or standardization is needed. It may also reflect differing goals between effectiveness monitoring and status and trends monitoring. Often, where one plan "leaves off", another plan begins (Table 2-3). For this reason, it is important to focus on how plans support one another rather than trying to develop just one 'best' plan.

Table 2-3: High-level cross-walk table summarizing the scale, similarities and unique features of various Klamath Basin fish population restoration plans, including the IFRMP.

Plan Name	Objectives	Sub-basins	Restoration Actions	Targeted Fish Species	Scale of Evaluations	Indicators	Monitoring Focus
Upper Klamath Basin Watershed Action Plan (UKBWAP)	Provides science-based guidance regarding types of restoration projects necessary to address specific impairments to riverine and riparian process and function., and develop monitoring regimes tied to quantifiable restoration objectives at multiple scales within the Upper Klamath Basin.	Upper Klamath Lake, Williamson, and Sprague sub-basins.	Actions that are intended to generally improve wetland, riverine, riparian, and floodplain process and function so to achieve water quality goals and improve habitat conditions for threatened/sensitive fish species.	Current resident species: Lost River Sucker, Shortnose Sucker, Redband Trout, and Bull Trout Anadromous species after dam removal: Chinook salmon, Coho salmon, Steelhead trout, Pacific Lamprey.	Reach-scale (specifically, 3-mile reaches on major streams and 3-mile shoreline segments along Upper Klamath Lake). In total, the UKBWAP scores habitat condition for 268 stream reaches and 41 Upper Klamath Lake shoreline segments in the Upper Klamath Basin) and watershed-scale.	Numerous indicators relating to the risk of habitat degradation and the current condition of fish habitats: channelization, channel incision, levees & berms, wetlands, riparian & floodplain vegetation, Irrigation practices, springs, fish passage, roads, fish entrainment, large woody debris, and spawning substrate.	UKBWAP is intended to inform both project-scale effectiveness monitoring needs and also watershed-scale status & trends monitoring regimes.
	Unique Plan Elements & IFRMP Alignment: The IFRMP prioritizes packages of classes/types of specific restoration projects themselves. The UKBWAP prioritizes specific locations where restoration is most needed, focusing/zooming in on impairment metrics at 3-mile resolution. Restoration types of actions within the UKBWAP were considered and many included within the IFRMP for the three Upper Klamath sub-basins. The IFRMP does not attempt to prioritize exactly where restoration should occur (something the UKBWAP does seek to provide advice on) as this is impractical at the basin wide scale. Like the UKBWAP, many other plans are identified in the IFRMP for other locations that help with 'zooming in' needs. Habitat condition is only one component of the IFRMP scoring criteria used within a multi-criteria methodology. Amongst other criteria, the IFRMP evaluates/scores differences in (average) habitat condition throughout the entire Klamath basin at the sub-watershed (HUC12) scale. The UKBWAP evaluates/scores habitat condition at a much finer scale resolution (i.e., 3-mile delineated stream reaches and lake segments) within Upper Klamath Lake, Williamson and Sprague sub-basins. The data needed to perform this finer scale assessment is not available consistently throughout the entirety of the Klamath Basin. The IFRMP has analogues/proxies for many of the UKBWAP metrics (at HUC12 scale, available basin-wide), and in addition to them, melds 4 other criterion to generate our prioritization scores. We not only consider habitat degradation/impairment (Criterion 2), we also focus in particular on the degree of overlap with ten (10) priority fish species (Criterion 1), the number of stressors that would be addressed by the type of proposed restoration (Criterion 3, links to IFRMP conceptual models), the scale of perceived benefit of the restoration action beyond the project footprint (Criterion 4), and eventually (this hasn't been turned on yet, needs more work in Phase 5 of IFRMP) the impenetrability of the restoration action (Criterion 5). Regarding Criterion 2, the UKBWAP does a better, higher resolution job of addressing this criterion. It would be ideal to tackle things at this resolution if it where practical at the basin wide scale, which it currently is not. The IFRMP has had a very robust engagement effort with multiple entities, more than 130 people have contributed directly in many working groups since 2016, with many hundreds of hours of input. etc. We have intentionally not focused on only public lands, though proponents of IFRMP restoration projects will have more work to do to address the issue of Implementability through partnerships with private landowners. Targeted fish species within the UKBWAP are all represented within the IFRMP's 10 focal fish species of concern, which are designated as targets for associated functional watershed restoration actions to be coordinated by the IFRMP. The UKBWAP supports a unique web-based Interactive Reach Prioritization Tool (IRPT) for quantifying/rating habitat condition of upper Klamath Basin stream reaches and Klamath Lake shoreline segments. The Klamath IFRMP Restoration Prioritization Tool (http://klamath.essa.com/) uses six criteria including Criterion 2 - CPI Status: the magnitude of impaired ecosystem processes and fish habitats, used as an indicator of restoration need (Table 3 1). The IRPT prioritizes locations for restoration throughout the entirety of the Klamath basin including these 3 sub-basins.						
Implementation Plan for the Reintroduction of Anadromous Fish into the Oregon Portion of the Upper Klamath Basin	To provide recommended efforts to be undertaken within the Oregon portion of the Upper Klamath Basin to reintroduce anadromous fish to suitable, historically-occupied areas above the site of Iron Gate Dam.	Upper Klamath River, Williamson River, Sprague River, and Upper Klamath Lake sub-basins.	This plan **does not itself focus on habitat restoration actions but is instead intended to guide the reintroduction of anadromous fish species (which may include both passive and active reintroduction actions).**	Chinook Salmon, Coho Salmon, Steelhead Trout, and Pacific Lamprey	Fish population evaluations will be at the scale of upper Klamath River mainstem reaches and upper Klamath basin stream/tributary reaches.	Numerous indicators relating to fish population response to reintroduction efforts: presence/absence, distribution (spatial structure), abundance (number of spawners), productivity (recruitment), life history diversity, genetic diversity/population structure, disease pathogen prevalence/intensity, fish health	Immediately following the availability of passage, monitoring will focus on determining if anadromous fish are migrating into habitat immediately above the dams. As fish populations become more widely established, monitoring will be more specific and focused toward management objectives, such as determining adult escapement, juvenile productivity, and spatial distribution within each sub-basin.
	Unique Plan Elements & IFRMP Alignment: The Oregon Reintroduction Implementation Plan focuses principally on determining whether anadromous fish populations are returning to the upper Klamath Basin after removal of the major Klamath River dams and the strategies for their reintroduction (passive or active) have been successful. **Targeted fish species for monitoring within this plan (i.e., Chinook Salmon, Coho Salmon, Steelhead, and Pacific Lamprey) are all represented within the IFRMP's 10 focal fish species of concern**, which are designated as targets for associated functional watershed restoration actions to be coordinated by the IFRMP. **Once fish have access to the upper basin (defined as the parts of the watershed above Keno Dam) following dam removal, the IFRMP will further "reward" functional watershed restoration projects in the upper basin as the Range Overlap criteria is updated to reflect more target re-introduced fish species are able to access those habitats** (section 3.5.1).						
Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources	To provide a framework for the reintroduction and monitoring of anadromous fish in the upper Klamath Basin of California once fish passage is restored through removal of the four mainstem hydroelectric dams on the Klamath River. This is a	Upper Klamath River restricted to California and include the Klamath River and associated tributaries from the Iron Gate Dam upstream to the Stateline.	**This plan does not itself focus on habitat restoration actions** but is instead intended to guide the reintroduction of native anadromous species that were historically known to occur in the Klamath River upstream of Iron Gate Dam. **This plan relies on monitoring and an adaptive management strategy with volitional migration as the preferred method for reintroduction**,	Spring and fall-run Chinook Salmon, Coho Salmon, Steelhead Trout, and Pacific Lamprey	Evaluation of fish populations within this plan will be **restricted to California and include the Klamath River and associated tributaries from the Iron Gate Dam upstream to the Stateline (referred to as the monitoring reach).** The monitoring reach encompasses approximately 31.2 kilometers of the mainstem	Numerous indicators relating to fish population response to reintroduction efforts: occupancy (spatial and temporal), distribution, abundance, age structure, productivity, hatchery component (pHOS), pre-spawning mortality, out-migrant timing, seasonal habitat use by juveniles, genetic diversity, life-history diversity, fish health, pathogen prevalence.	Monitoring within this plan is intended to measure and track the rate of change in the number of fish per species per year in the monitoring reach following removal of the dams. The proposed approach is to monitor volitional migration for three to four generations (12 to 15 years) depending on species. Monitoring will follow a four-phased approach: Phase I – Reintroduction, Phase II – Establishment, Phase III – Productivity and

Plan Name	Objectives	Sub-basins	Restoration Actions	Targeted Fish Species	Scale of Evaluations	Indicators	Monitoring Focus
Agency and the California Department of Fish and Wildlife	working draft document at the time of writing.		while also including general guidance for active reintroduction, if necessary and appropriate.		Klamath River and approximately 26.3 kilometers of tributary habitats.		Abundance, and Phase IV – Spatial Structure and Diversity
	Unique Plan Elements & IFRMP Alignment: **The California Reintroduction Implementation Plan focuses principally on determining whether anadromous fish populations are returning to the California areas of the upper Klamath River sub-basin after removal of the major Klamath River dams** and the strategies for their reintroduction and re-establishment in the upper Klamath River (natural through volitional migration or active through transplantation). **Targeted fish species for monitoring within this plan (i.e., Chinook Salmon, Coho Salmon, Steelhead, and Pacific Lamprey) are all represented within the IFRMP's 10 focal fish species of concern,** which are designated as targets for associated functional watershed restoration actions to be coordinated by the IFRMP. **Once fish have access to the monitoring reach following dam removal, the IFRMP will further "reward" functional watershed restoration projects in the upper basin as the Range Overlap criteria is updated to reflect more target re-introduced fish species are able to access those habitats** (Section 3.5.1).						
Klamath Hydroelectric Settlement Agreement (KHSA) Definite Decommissioning Plan (DDP) - KHSA DDP	Restore fish passage to over 400 stream-miles of historic fish habitat and formerly inundated lands. Dam removal will also eliminate the reservoirs associated with algae blooms and improve water quality that will benefit the region's wildlife, recreation, economy, and human health.	Klamath River mainstem and several tributary watersheds straddling the California and Oregon borders that comprise the Lower Klamath Project (Scott; Shasta; Upper Klamath River; Upper Klamath Lake; Sprague; Lost sub-basins).	If implemented, the KHSA DDP will result in the largest dam decommissioning project in North America, removing four (4) PacifiCorp dams: JC Boyle, Copco No. 1 & No. 2 and Iron Gate. Implement required site remediation and restoration efforts to improve spawning and rearing habitat, including mitigation actions to avoid prolonged impacts related to elevated suspended and larger grain sediment loads.	Anadromous fish are expected to be amongst the primary beneficiaries of dam removal: Pacific Lamprey, Steelhead, Coho salmon, Fall-run Chinook salmon, and Spring-run Chinook salmon with modest anticipated habitat benefits for four (4) resident species: Shortnose suckers, Lost river suckers, Redband trout and Rainbow trout.	Site-scale; Reach-scale; Watershed-scale. Specific point locations, specific river mile delineated stream reaches and lake segments over multiple sub-watersheds.	Numerous physical indicators: river discharge, water temperature, suspended sediment, turbidity, bedload movement, dissolved oxygen, numerous water quality analytes and monitoring for specific contaminants. Fish presence monitoring, redd and carcass surveys in key tributaries, juvenile outmigration monitoring and visual observations of fish densities, fish behavior, visible disease and injury. During drawdown various water quality and visual fish behavior (health) monitoring efforts will take place to inform the need for capture and relocation of target species and life stages.	The amended KHSA DDP monitoring focus is intended to inform Target Metric achievement utilising large array of performance indicators listed in sixteen (16) topic area Management Plans and their embedded sub-plans. Depending on the indicators, monitoring will occur for approximately five years between 2023-2028 or 2025-2029. Tracking the evolution of sediment transport, sediment deposition is a key focus.
	Unique Plan Elements & IFRMP Alignment: **The KHSA DDP is centered around one restoration action: large scale dam removal** and potential assisted sediment evacuation methods and tracking sediment evolution, related water quality measures and effectiveness of fish passage. **Short-term fish capture and relocation efforts are important** components. **The KHSA DDP has many target species in common with the IFRMP**, essentially the same focal species **though the IFRMP has a proportionately higher focus on resident, non-anadromous species.** There are many other parallels with CPIs for habitat, water quality, watershed inputs and fluvial geomorphic processes. The web-based interactive **Klamath IFRMP Restoration Prioritization Tool** (http://klamath.essa.com/) **captures a broader range of watershed process and habitat considerations** within its algorithms **for scoring/ranking watersheds for all classes of functional watershed restoration prioritization throughout the entire Klamath basin**. *The KHSA DDP is itself one of the highest-ranking restoration actions within the IFRMP*. **The KHSA DDP program duration is roughly 2022 – 2029**, while the IFRMP is an implementation framework for a **multi-decadal adaptive restoration plan.** As part of dam decommissioning, **CDFW will relocate all aquaculture production from the Iron Gate Fish Hatchery (IGFH) to an upgraded Fall Creek Fish Hatchery (FCFH) facility.**						
Mid Klamath Sub-basin Fisheries Recovery Plan (MKSFRP)	Identify and recommend actions that will improve conditions for the sub-basin's anadromous fish, both through restoration of aquatic and terrestrial environments and protection of unimpaired environments.	Eight sub-watersheds identified within the Mid-Klamath sub-basin (Volcanic Outer Region, Checkerboard, Red Butte, Grider Elk, Siskiyou, Western Marble Mountain, Orleans, and Red Cap).	On-the-ground work such as **removal of barriers to fish passage, dam removal, fish screen installation, road decommissioning or closure, grazing management, revegetation of riparian areas**, and monitoring efforts such as macroinvertebrate sampling, observation of the influence of hatchery fish on wild salmon, and disease studies.	Anadromous fish species of particular concern within the plan are Chinook salmon, Coho salmon, Steelhead, Green Sturgeon, and Pacific Lamprey.	Evaluations for the MKSFRP are undertaken at the sub-watershed scale, with the eight sub-watersheds identified within the Mid-Klamath sub-basin.	Several indicators: stream flow, water temperature, water quality (pH, conductivity, DO, turbidity), fish barriers, fish disease, fish health, fish harvest, chinook spawning escapement, steelhead holding counts, outmigrants, and thermal refugia.	Monitoring is focused on fish population monitoring, stream flow monitoring, water quality monitoring, physical habitat monitoring, and monitoring of restoration sites. There are short and long term monitoring goals (including effectiveness monitoring).
	Unique Plan Elements & IFRMP Alignment: The MKSFRP specifies restoration actions and monitoring for on-the-ground restoration, management, public and community outreach, and monitoring, and highlights the importance of cooperation among several stakeholder groups. These restoration action types were considered by the IFRMP and many included for prioritization.						
Klamath Reservoir Reach Restoration Prioritization Plan	To summarize habitat conditions, identify key limiting stresses and threats, identify restoration actions, identify diversions that need screening/flow restoration and prioritize those restoration actions.	The plan encompasses the Klamath River mainstem and tributaries from Iron Gate Dam to Link River Dam	This effort resulted in the identification and prioritization of 82 habitat restoration projects, 91 potential diversion screening projects and 38 potential flow restoration projects	Salmonids are the primary focus, but these actions will likely also benefit suckers and lamprey as well.	NOAA assessed habitat conditions, identified limiting factors, and identified restoration actions throughout 63 miles of mainstem habitat and 39.4 miles of tributary habitat from Iron Gate dam to Link River Dam	The projects identified address stressors and indicators that include fish entrainment, flow, temperature, channel modification, fish habitat, LWD and riparian conditions.	There is no monitoring elements described in this plan because they are described in detail in the IFRMP, the CDFW Klamath Monitoring Framework and the ODFW/Klamath Tribes Reintroduction Plan
	Unique Plan Elements & IFRMP Alignment: The idea for this plan was born out of NOAA's early participation in the IFRMP process. We realized that there was a lot of information on habitat and restoration priorities below Iron Gate Dam and above Link River Dam, but there were large gaps in information in the reservoir reach. This plan identified site specific restoration actions and assessed habitat conditions in the reservoir reach (O'Keefe et al. 2022).						

Plan Name	Objectives	Sub-basins	Restoration Actions	Targeted Fish Species	Scale of Evaluations	Indicators	Monitoring Focus
Shasta Watershed Stewardship Plan (SRWSR)	Improve water quality and habitats for sensitive species through an adaptive management-focused stewardship framework.	Restoration takes place throughout the Shasta sub-basin.	Actions include **riparian fencing, riparian planting, tailwater management, removal of fish barriers, stream flow augmentation, and spring restoration/ reconnection**.	Anadromous fish of greatest concern including Steelhead, Coho salmon, and Chinook salmon.	Restoration is at the reach scale throughout the Shasta sub-basin. Monitoring takes place at specific river reaches, and a fine geographic scale.	Indicators include: water temperature, dissolved oxygen concentrations, pH, nutrient concentrations.	Monitoring is focused on water temperature and dissolved oxygen concentrations, however pH and nutrient concentrations are also monitored.
	Unique Plan Elements & IFRMP Alignment: These restoration action types were considered by the IFRMP and many included for prioritization. Building partnerships in order to foster collaboration is highly emphasized throughout the SRWSR. Priority monitoring locations are at specific river reaches that are considered most impaired in order to track and quantitatively evaluate the effectiveness of restoration activities at natural river breakpoints.						
Scott River Strategic Action Plan	To improve the effectiveness of natural resource management and enhancement by both assessing watershed condition and by providing a basis for setting priorities for future restoration and management actions in the Scott River sub-basin.	Scott sub-basin	Restoration actions that focus on improving water quality and fish habitat conditions. Restorations include **bank stabilization, fish passage and screening of diversions, riparian fencing and replanting, alternative stock water systems, tailwater return systems, and road decommissioning.**	Anadromous salmonids (Coho Salmon, Chinook Salmon, and Steelhead Salmon	Assessments of fish population status and habitat conditions at a variety of spatial scales: 1) whole sub-basin, 2) sub-watersheds (defined as collections of springs within the same geographic area), 3) Scott River mainstem reaches, and 4) tributary streams.	Numerous water quality and physical indicators: water temperature, in-stream habitat condition, riparian condition, channel conditions, thermal refugia, stream flow, suspended and deposited sediment Biological response indicators: macroinvertebrates, spawner abundance, smolt outmigrants, juvenile habitat utilization	Monitoring is intended to contribute to long-term status & trend monitoring while also providing input into Scott River sub-basin watershed restoration and land management planning by providing data to assess the effectiveness of implemented restoration projects.
	Unique Plan Elements & IFRMP Alignment: Many of the elements of the Scott River Strategic Action Plan parallel the structure of the IFRMP. For example, assessed biological values and habitat condition metrics evaluated within the SAP are generally consistent with many of the Core Performance Indicators (CPIs) intended for evaluation and monitoring within the IFRMP, **the key difference between the two programs being the spatial scale of habitat condition evaluations. The IFRMP is focused on evaluating/scoring differences in (average) habitat condition at a broad sub-watershed (HUC12) scale whereas the SAP evaluates habitat condition at finer scale resolutions (i.e., Scott River mainstem reaches, tributary streams).** **Restoration actions considered within the SAP mirror those identified within the IFRMP as potential actions for the Scott River sub-basin.** **Identified fish species of primary concern within the SAP are represented within the IFRMP's 10 focal fish species of concern,** which are designated as targets for associated functional watershed restoration actions to be coordinated by the IFRMP. The purpose of the SAP and IFRMP therefore overlap considerably and alignment of these programs will be of benefit for ensuring that the most effective actions (what and where) are undertaken for achieving maximum benefit for upper basin fish populations.						
Salmon River Restoration Plan (SRRS)	Collaboratively restore and protect aquatic habitats used by native fish communities in high-priority drainages of the Salmon River watershed.	63 drainages throughout the Salmon River sub-basin.	Restoration is directed to addressing the greatest risks to their physical and biological integrity. **Restoration is focused on ensuring habitat conditions support the many fish communities present throughout the Salmon River**.	Anadromous fish such as spring and fall Chinook salmon, summer and winter steelhead, Coho salmon, Pacific lamprey, and green sturgeon, as well as non-anadromous species such as Klamath speckled dace, Klamath small scale sucker, and marbled sculpins.	The SRRS assesses restoration of priority areas within the Salmon River sub-basin at the drainage scale. The sub-basin consists of 63 drainages, averaging approximately 7,500 acres.	Indicators include sedimentation from upslope areas (mass wasting, surface erosion, surface water runoff), fire fuel availability, channel stability, water quality, habitat connectivity, fish community integrity.	The SSRS is focused mainly on monitoring stream temperatures and stream flow. Monitoring follows the Klamath Land Resource Management Plan framework.
	Unique Plan Elements & IFRMP Alignment: The SRRS uses data collected from monitoring stations to prioritise restoration projects in particular drainages through cumulative effects modeling.						
Lower Klamath River Restoration Plan (LKRP)	Seeks to restore aquatic habitat conditions within Lower Klamath River tributaries to a level that supports viable, self-sustaining populations of native salmonids	Lower Klamath River	Emphasizes **upslope watershed restoration actions related to remediation of diversions and erosional problems** that may generate sediment inputs (e.g., **road / skid trail decommissioning, road upgrades, slope stabilization**). The LKRP considers that success of in-stream restoration depends on addressing upslope conditions and sediment sources. Tributaries are ranked for potential restoration actions using a **restoration prioritization matrix that scores streams based on six criteria: 1) Anadromous salmonid diversity, 2) Relative biological importance (e.g., source areas, thermal refugia, off-channel habitat), 3) Channel & riparian condition, 4) Habitat connectivity, 5) Road density, and 6) Stream crossing density.**	The LKRP focuses on restoring habitat conditions for anadromous salmonids using Lower Klamath sub-basin tributaries (i.e., Chinook Salmon, Coho Salmon, steelhead Trout, and Coastal Cutthroat Trout).	The LKRP assesses habitat condition at the scale of tributary streams (i.e., 30 anadromous fish-bearing tributaries with the Lower Klamath sub-basin).	Habitat condition indicators: water quality (water temperature, dissolved oxygen, turbidity), stream discharge, stream channel condition, and riparian condition.	Monitoring within the LKRP is intended to provide input into Lower Klamath Basin watershed restoration and land management planning by providing long-term baseline data to assess the effectiveness of implemented restoration projects and to monitor any physical and/or biological changes resulting from anthropogenic activities.

<table>
<tr><th>Plan Name</th><th>Objectives</th><th>Sub-basins</th><th>Restoration Actions</th><th>Targeted Fish Species</th><th>Scale of Evaluations</th><th>Indicators</th><th>Monitoring Focus</th></tr>
<tr><td></td><td colspan="7">Unique Plan Elements & IFRMP Alignment: Many of the elements of the LKRP parallel the structure of the IFRMP. For example, assessed biological values and habitat condition metrics evaluated within the LKRP are generally consistent with many of the Core Performance Indicators (CPIs) intended for evaluation and monitoring within the IFRMP, the key difference between the two programs being the spatial scale of habitat condition evaluations. The IFRMP is focused on evaluating/scoring differences in (average) habitat condition at a broad sub-watershed (HUC12) scale whereas the LKRP evaluates/scores habitat condition at a finer scale resolution (i.e., tributary streams).

The LKRP uses an unique watershed restoration prioritization matrix for scoring/ranking streams for potential restoration actions.

Restoration actions considered within the LKRP mirror those identified within the IFRMP as potential actions for the Lower Klamath River sub-basin.

Three of the four targeted fish species within the LKRP are represented within the IFRMP's 10 focal fish species of concern, which are designated as targets for associated functional watershed restoration actions to be coordinated by the IFRMP. The exception is targeting of Coastal Cutthroat Trout within the LKRP, which is not a focal species within the IFRMP. The purpose of the LKRP and IFRMP therefore overlap considerably and alignment of these programs will be of benefit for ensuring that the most effective actions (what and where) are undertaken for achieving maximum benefit for upper basin fish populations.</td></tr>
<tr><td rowspan="2">Trinity River Restoration Plan (TRRP)</td><td>The long-term goals of the Program are to: 1) restore the form and function of the Trinity River; 2) restore and sustain natural production of anadromous fish populations in the Trinity River to pre-dam levels; and 3) to facilitate full participation by dependent Tribal, commercial, and sport fisheries through enhanced harvest opportunities.</td><td>Primary focus on the Trinity River basin between Lewiston Dam and the North Fork. Secondary focus in all watersheds of the Trinity, including the South Fork.</td><td>The TRRP Record of Decision described six components of restoration: (1) flow management out of Lewiston Dam; (2) sediment management; (3) channel rehabilitation in the mainstem Trinity above the North Fork; (4) watershed rehabilitation; (5) infrastructure improvements; and (6) adaptive management.</td><td>Fall-run Chinook salmon, spring-run Chinook salmon, coho salmon, steelhead, Pacific lamprey, and green sturgeon</td><td>TRRP objectives for harvest include the entire Trinity basin, including the South Fork. However, the 40-mile reach between Lewiston Dam and the North Fork are the primary focus for restoration efforts. Watershed restoration activities are implemented and evaluated more broadly throughout the Trinity and South Fork sub-basins.</td><td>Indicators include water temperature, flow, fine and coarse sediment, bed mobility and scour, sediment storage, cottonwood seed dispersal, riparian encroachment, large wood, fish habitat, spawner abundance, smolt production and productivity (i.e., recruits per spawner).</td><td>Monitoring efforts are currently under review through the Refinements process. Monitoring to date includes a combination of effectiveness monitoring (e.g., habitat changes at channel rehabilitation sites) and status and trends monitoring to evaluate progress towards goals (e.g., smolt production and spawner abundance</td></tr>
<tr><td colspan="7">Unique Plan Elements & IFRMP Alignment: There is strong alignment between the TRRP and the IFRMP in both directions (a) the TRRP addresses many of the CPIs of interest to the IFRMP in the mainstem Trinity and (b) the IFRMP provides guidance on watershed restoration opportunities in the Trinity and South Fork Trinity as well as monitoring the impacts of poor water quality and disease in the Lower Klamath River which negatively affect the survival of smolts leaving the Trinity basin.</td></tr>
</table>

3 Approach to Restoration Prioritization

This Section

- Provides a high-level overview of how restoration was prioritized
- Describes the scoring criteria used and the prioritization tool employed.
- Describes how estimated cost ranges for restoration actions were determined.

3.1 Overview

Designing a restoration plan for an entire river basin requires a framework that can organize and prioritize restoration activities that will be a best fit for overall ecosystem function and target species (Beechie et al. 2008). **Effective prioritization frameworks provide an organized, repeatable, and transparent reasoning** for making restoration decisions, given limited funding, capacity, and time (Beechie et al. 2008, Roni et al. 2013). In this sense, **prioritization refers to the process of scoring and ranking potential restoration actions to determine the most beneficial sequencing.** The goal of prioritization is to inform funding and implementation decisions, and to begin logically grouping top-tier priority restoration projects.

The resulting prioritization scores are not intended to be perfect, definitive decisions but a thoughtful and balanced identification of restoration actions. Prioritization scores will help structure adaptive management and stakeholder discussions (including conversations around giving certain criteria more weight than others). Moreover, restoration priorities are not static and must be repeatedly examined as pressures in different locations shift, available funding changes, natural disturbances unfold in different areas of a stream network, and monitoring indicators generate new information on the effectiveness of restoration actions (Roni et al. 2013).

Structured prioritization frameworks help clarify the decision-making process for funding agencies, proposal reviewers, project leaders, and other stakeholders that will be affected by these decisions. These frameworks also allow for repeating reprioritization on a regular basis as projects are completed, new opportunities are identified, and new information becomes available. Prioritization can take place at the level of the basin, watershed, sub-watersheds, or reaches, or even by habitat type, but prioritization at smaller scales needs to be consistent with a basin-wide restoration strategy. These regional-scale frameworks may also take a multi-step approach involving prioritization of restoration actions within watersheds, followed by prioritization of restoration needs across watersheds of the broader river basin (Beechie et al. 2008, Roni et al. 2013). It is also common for overall restoration strategies to consider or even give precedence to urgent issues such as action to prevent losses of critically endangered species or adjusting to recent severe disturbances, like wildfires. Repeated application of the prioritization approach that incorporates new information about the basin learned through monitoring and prior restoration in turn provides a direct link to adaptive management as it allows for priorities to shift and management plans to change accordingly.

Designing and implementing restoration measures is not only a scientific exercise but requires creativity, political encouragement, and social cooperation. **Prioritization systems drive rational, neutral dialogue amongst rating committee members, managers, and interested participants - but they are not a precise "computer formula" that can replace human**

decision-making (Beechie et al. 2008, Roni et al. 2013). It is therefore very important that all rating/scoring steps are clearly documented so that funding partners, those reviewing restoration projects, and those proposing the projects, can easily follow this process and understand that **prioritization can and should be consistently repeated across multiple rounds of restoration planning over time**.

3.2 Defining Restoration Actions and Projects for Prioritization

The IFRMP uses a standardized classification system for restoration actions in order to consistently describe restoration projects across multiple rounds of prioritization. This classification system is based on an analysis of restoration actions originally organized as a Data Dictionary for the NOAA Pacific Coastal Salmon Recovery Fund (PCSRF) for the purpose of standardizing restoration grant tracking and reporting process. Although this classification system was originally developed with anadromous fish in mind, it is still broadly applicable to watershed restoration and has been adopted and refined to reflect the relevant restoration actions in the Klamath Basin.

Within this classification system, watershed restoration actions directly benefiting fish habitat and populations fall into one of nine major **Action Type Categories** which group similar restoration actions. These are further divided into **Action Types** describing specific restoration actions, which are briefly noted in Table 3-1. This classification system was first used in the Klamath Basin IFRMP Synthesis Report (ESSA 2017) as an attempt to catalogue and quantify past restoration efforts in the Klamath Basin, and has been be carried forward into the IFRMP for consistency throughout proposed restoration projects. The full definitions of each Action Type are available in Appendix B, while the full IFRMP Restoration Action Data Dictionary is available as a spreadsheet from the IFRMP website (https://ifrmp.net/).

Restoration projects within the IFRMP may have one or more Action Types (from one or more Action Type Categories) and are linked with specific sub-watersheds and a project narrative that provides the localized context for implementation. Action Types (and Action Type Categories) are fundamental pieces of information to be cross-referenced with a range of spatial and non-spatial datasets in order to connect the project with other information related to the prioritization criteria described in Section 3.4. Briefly, these criteria consider the importance of specific fish species, the general level of existing watershed damage, the specific watershed stressors that Action Types should address, the scale of other additional benefits, and how easily the project could be implemented.

Most of the restoration projects put forward for prioritization in the IFRMP are described in general terms and often propose a suite of restoration actions over a large area that would be implemented gradually, as a series of many discrete 2-5 year projects at specific sites over a timeframe of up to 20 years. For this reason, the units being prioritized as part of this plan should be thought of as **Restoration Project Concepts**, which can inform more detailed proposals for discrete projects that would be implemented at one or more specific locations and over a specific timeframe.

Policy Focused Actions

It should be noted that a small subset of restoration project concepts are focused on more regulatory or policy-level changes than boots-on-the-ground restoration. These projects are flagged using a policy icon (left) in proposed project concept tables. Such actions are likely to require reginal or basin-wide collaboration among decision-makers and stakeholders for effective implementation, and may be the types of actions advanced by a basin-wide restoration oversight group (See Section 6) rather than individual project proponents.

Table 3-1: IFRMP Restoration Action Type Categories and Definitions (see Appendix B for details on Action Types)

Action Type Category	Definition and Example Action Types
	This category includes actions that result in the installation, improvement or maintenance of screening systems that prevent fish (especially juveniles) from entrainment into areas that do not support fish survival; for example, into irrigation diversion channels.
	These actions improve or provide for fish migration up and down stream, including fish passage at road crossings (bridges or culverts), barriers (dams or log jams), fishways (ladders, chutes or pools), weirs (log, rock). Restoring fish passage in the Klamath Basin is particularly relevant to anadromous fishes given historical restriction of access to hundreds of miles historical habitat due to both mainstem dams and smaller diversion dams.
	These actions maintain and/or increase the flow of water to provide needed fish habitat conditions. Action Types used can include temporary water rights purchases/leases, permanent dedication of instream flows, or irrigation practice improvements including water conservation projects to reduce stream diversions or extractions.
	These actions increase or improve physical conditions and/or connectivity within the stream environment (below the high water mark) to increase fish abundance. Historical approaches focused on placement of instream structures, while recent approaches are more complex and include channel reconfiguration, streambank stabilization, and use of low-tech process-based restoration techniques like beavers or beaver dam analogues to increase stream complexity.
	These actions focus on restoring riparian vegetation to improve fish habitat, food production, stream temperature regulation, and runoff capture and deposition. The most frequently used Action Types or techniques in this category include grazing management, the installation of riparian exclusion fencing, and riparian planting to accelerate the recovery of native species on previously grazed streambanks.
	These are landscape-level actions implemented above the floodplain and intended to benefit fish habitat, for example, by reducing or eliminating fine sediment or nutrient inputs from upland areas into streams. In the Klamath Basin, Action Types in this category may include: (1) rehabilitating or decommissioning logging roads, and (2) upland grazing management, and (3) managing upland vegetation to reduce the risk of severe wildfires.
	This category includes actions that aim to directly improve instream water quality by reducing the impacts of instream point or non-point pollution, such as manure storage practices, improvements to irrigation systems to reduce runoff, and water treatment or recycling systems. Note this category is defined by the activity, rather than the stressor addressed, and many other types of restoration can also indirectly improve water quality.
	This category includes actions designed to improve, restore, or create wetland, meadow, or floodplain areas connected streams that are known to support fish production through their role in providing spawning, nursery, or feeding habitat. Action types used may include breaching dikes, re-flooding, and re-planting historical wetlands as well as creation of artificial wetlands.
	This category includes actions that result in improvement of or increase in the availability of estuarine or nearshore marine habitat (tidally influenced areas) such as tidal channel restoration, tidal floodplain connectivity, tidegate fish passage or diked land conversion.

3.3 Defining Spatial and Temporal Scales for Prioritization

For any planning and prioritization process, it is essential to define the locations-based and time-based scales over which planning prioritization will take place. Any geographical or timescale limitations must also be understood.

The spatial scale for restoration planning in this plan is defined according to the framework provided by the USGS Hydrologic Unit Code (HUC) classification system. HUC allows for a standardized, logical framework for prioritizing watershed processes restoration that can take advantage of public data sets that make use of the same framework. Within the IFRMP, **restoration planning starts at the HUC12 level, the smallest hydrologic scale of sub-watersheds**. HUC12s exist within sub-basins (HUC8) of the broader Klamath Basin (HUC6). For example, data on species locations, watershed status indicators (i.e., CPIs, see Section 2.3), and project areas are organized at the HUC12 level. This is the finest resolution within the HUC classification system and is both sufficient for broader restoration planning and functions as a starting point for more detailed planning for reach- and site-scale restoration projects. Furthermore, in recognizing how drastically restoration needs and contexts can vary across the Klamath Basin, we carried out independent project prioritization processes for each sub-basin of the broader Klamath Basin. This decision was made in part to encourage fair and equal consideration of restoration needs across all parts of the Klamath Basin, which are critical for different fish species and watershed function in their own unique ways. **This means that project scores and rankings cannot be compared across sub-basins - a lower score for a project in one sub-basin does not imply it is a less important project within a different sub-basin, or at the overall basin scale.**

We recognize that this organizational framework comes with its own limitations, such as emphasizing projects occurring *within* sub-basins over projects *spanning* sub-basins. This framework makes it more challenging to consider restoration within alternative spatial frameworks, such as ‘firesheds’ and ‘foodsheds’ that are grounded in Indigenous’ cultural views and would support restoration planning better aligned with self-determination and social, economic, and ecocultural revitalisation on Indigenous lands (Sarna-Wojcicki et al. 2019). To address these shortcomings, **it is necessary to establish an overarching governance process for considering how groups of sub-basin projects contribute to whole-basin recovery. This process should also identify and lead broader initiatives that require coordinated planning at the whole-basin scale** (as is the case for removal of the four major mainstem dams) to support whole-basin recovery. These may involve coordinating responses to basin-wide issues like water quality, fish disease, invasive species, and climate change, and may take the shape of ‘passive restoration’ (i.e., coordination, organization, or policy initiatives) rather than the more direct ‘active restoration’ tactics that are discussed in this current version of the IFRMP (Speed et al. 2016). Section 6 will provide some initial recommendations about what such a governance process might look like.

The temporal scale for restoration planning is defined by the average amount of time it takes a singular, independent restoration project to be implemented once funding is approved. Resource agencies typically do not give restoration funding more than a few years into the future, so we are defining **a realistic temporal planning unit for one restoration project implementation cycle as 2-5 years**. We also recognize that many kinds of restoration projects can take longer than 5 years to plan, permit and implement, and that some types of restoration may take decades of ongoing effort to maintain. However, even these longer-term projects are usually completed in a series of smaller, more manageable phases. In such cases, those applying for funding may wish to highlight near-term work as one phase of a longer-term project, and new phases of ongoing restoration projects could carry forward into future IFRMP prioritization planning cycles. Longer-term projects and needs will become clearer during future consultation of the IFRMP and such projects can be repeatedly re-entered into the Klamath IFRMP Prioritization Tool for future planning and prioritization cycles.

3.4 Multi-Criteria Scoring Approach

After careful consideration of alternatives, and multiple rounds of peer-review by Sub-basin Working Group (SBWG) participants, we adopted a **multi-criteria scoring approach** for prioritization. This multi-criteria scoring process is automatically done within a web-based **Klamath IFRMP Restoration Prioritization Tool** designed expressly for this purpose, detailed further in Section 3.6. The resulting prioritization scores and order should be used as a launching point for informed and structured discussions of the benefits, opportunities and risks of different strategies for planning, rather than a rigid list defining exactly what restoration must occur. The Prioritization Tool's initial sequencing will need to be adjusted by reviewers over time to reflect dependencies between projects or other contextual factors that are not easy to capture through the type of criteria included in the Tool. Any prioritization method, whether our Prioritization Tool or another, should be applied every few years as the state of the system and social landscape change over time.

The multi-criterion prioritization framework developed in Phase 3 is based on **six key questions to ask when considering any restoration project. These questions are linked to criteria as outlined in Table 3-2 and described in detail in Section 3.5**. These criteria are informed by a mix of both scientific data as well as expert opinions from natural resource management practitioners working in the region. Striking this balance ensures that the IFRMP is a science-based plan first and foremost, but also one that considers current knowledge and understands local context. These criteria are described in greater detail in the sections that follow, including information on raw inputs to connect to each criterion, expert review, and validation of inputs, and how raw inputs are rolled up into a single criterion score for each project. Additional information on criteria is also available on the Klamath website: https://ifrmp.net/.

Prioritization scores and ranks reflect the suggested order of projects to meet the overarching goal of obtaining the greatest benefits across the most focal species and stressors across a given sub-basin. They do NOT reflect the overall importance or validity of a proposed project, and a lower prioritization score does NOT mean a project should be disregarded. For example, some projects may have greater benefit if they are placed later in the restoration planning order, after other projects have already been completed, while in other instances *some* lower-ranking projects may be prioritized due to local context absent from in the tool (e.g., and they are easier to implement, less expensive, or take advantage of time-constrained funding or cost-sharing opportunities). These scores and ranks will also differ by prioritization objectives (such as single-species management), importance to other organizations and initiatives, and location within the basin. Differing criteria considerations can be reflected by assigning different weights to the criteria and in different parts of the basin.

It is important to understand that the initial priorities identified in this Integrated Fisheries Restoration and Monitoring Plan (IFRMP) are not meant to be fixed, nor the only source of information behind restoration decision-making.

Table 3-2: A summary of key prioritization questions and corresponding criteria used to score and rank proposed restoration projects to determine their priority sequencing based on currently available information.

Key Prioritization Question	Corresponding Criterion	Source of Information
1. Are focal fish present in the place a project is being proposed?	**Criterion 1 - Range Overlap:** Overlap of relevant focal species distributions, past and present, with the location(s) of the proposed restoration project.	Data-driven *(with expert validation of data)*
2. How impaired is the watershed in the place a project is being proposed (how much is restoration needed)?	**Criterion 2 - CPI Status:** The magnitude of impaired ecosystem processes and fish habitats, used as an indicator of restoration need.	Data-driven *(with expert validation of data)*
3. How many stressors is this project going to address?	**Criterion 3 - Stressors Addressed:** The total number of stressors addressed by the restoration action (with reference to biophysical tiers & species of concern)	Data-driven *(with expert validation of data)*
4. How far and wide will project benefits be felt?	**Criterion 4 - Scale:** Perceived scale of restoration project benefit for relevant focal species, from local to basin-wide benefit.	Expert elicitation *(through surveys)*
5. Is it feasible to implement this project in this place?	**Criterion 5 - Implementability**: Reflecting how easy it would be to implement the project based on current expert-based understanding of cost, permitting, political, logistical, or other similar considerations.	Expert elicitation *(through surveys and facilitated discussion)*
6. How much do we care about the answers to each question?	**Criterion Weights (W):** Are set collectively by each Sub-Basin Working Group and are applied to each criterion above to determine their relative importance, which may vary by sub-basin or scenario under consideration.	Expert elicitation *(through facilitated discussion)*
Overall Prioritization Formula		

$$\begin{aligned}\textit{Prioritization Scores} = \; & (W_1 * Range\ Overlap) \\ & +(W_2 * CPI\ Status) \\ & +(W_3 * Stressors\ Addressed) \\ & +(W_4 * Scale\ ) \\ & +(W_5 * Implementability)\end{aligned}$$

Restoration project priorities will naturally change over time, depending on the project parameters defined in the Klamath IFRMP Restoration Prioritization Tool (e.g., HUC locations), future adjustments to criteria, and the various weighting factors applied by participants towards sub-criteria and focal species of interest. The projects identified in this draft report represent the collective wisdom of a large team of planning participants between 2020 and 2022 (Appendix A). The tools developed for the IFRMP are built to allow these projects to be updated and revised over time easily (i.e., removing, adding, and revising definitions of said projects).

As noted earlier in this document, once near-term priorities are set, the intent is for this shortlist of projects to inform further development of more detailed and actionable project proposals from practitioners in the basin. This intent stems from recognizing that goals are periodically updated to reflect changing conditions, priorities, and restoration progress in the basin. Final decisions about specific projects to fund and implement will be informed by immediate, near-term priorities, but also by professional judgement, which will take into additional information such as account current events in the basin, landowner interests, opportunities created by scheduled maintenance or construction, and the emphasis for restoration in a particular watershed by multiple agencies or stakeholders. The process for updating plan priorities and decisions around project funding has not yet been determined, but Section 6 provides some recommendations on how this might unfold through a rigorous, participatory, and transparent process.

3.5 IFRMP Prioritization Criteria

3.5.1 Criterion 1: How Is Range Overlap Assessed?

What Is This Criterion?

The **Range Overlap** prioritization criterion is designed to evaluate how much of the area of a proposed restoration project overlaps with areas that are important for focal fish species. This is assessed by using the best available information on a focal fish species' historical habitat, current habitat, federally-designated critical habitat, and special emphasis area as defined by working groups. These data are available for each of the ten focal species of the IFRMP and have been mapped to every sub-watershed (HUC12) in the Klamath Basin.

What Data Inform This Criterion?

Key datasets used to compile species habitat information include ODFW Fish Habitat Distribution Data, USFWS Critical Habitat Designation data, UC Davis PISCES Fish Range and Occurrence Data, the Pacific Lamprey Assessment And Template For Conservation Measures In California (Luzier et al. 2011, Goodman and Reid 2012) and the Species Status Assessment for the Endangered Lost River and Shortnose Sucker (USFWS 2019c). Each of these data sources were reviewed by local species experts and suggested changes to these range maps were made accordingly. The raw data used to set the range overlap criterion are summarized in a series of **species range maps** in the sub-basin chapters within Section 4 and are also viewable within the IFRMP Restoration Prioritization Tool.

How is the Information Used in Prioritization?

Within the prioritization equation, **a restoration project located in one or more HUC12 sub-watersheds receives one Range Overlap point for meeting each of the conditions below for *each* focal species:**

- Overlaps with area of **historical distribution**
- Overlaps with area of **current distribution**

- Overlaps with **federally-designated critical habitat**
- Overlaps with areas identified by participants as **special emphasis areas (e.g., "anchor habitat")** These are areas that are thought to be particularly important for focal species production in the near future, warranting special consideration when prioritizing restoration sites. This could include places that were historically connected to or near higher functioning habitats and could help to strengthen the resilience of remaining populations.

For each HUC12 assigned to a restoration project, range overlap scores are generated for each of the ten species (and, when applicable, their different run types) including Eulachon, Coho, Spring Chinook, Fall Chinook, Summer steelhead, Winter steelhead, Sockeye, Pacific Lamprey, Green Sturgeon, Lost River Sucker, Shortnose Sucker, Bull Trout, and Redband Trout. Scores are determined per the categories above and then summed together for each species that has range overlap with the restoration project. Each species' summed score is added together for a total range overlap score, and is then normalized on a 0 to 10 point scale based on the raw point scores for all proposed restoration projects within the study frame. **The candidate restoration project with the highest raw score receives the maximum point allowance of 10 for the range overlap criterion. The other candidate restoration projects within the study frame are ranked accordingly.** The diagram below illustrates the range overlap criterion scoring using Bull Trout as an example across three different sub-watersheds where a project is occurring within a larger sub-basin. A project with no current, historical, federally-designated or special emphasis Bull Trout range overlap will be given a 0 criterion score, whereas a project that has all categories that overlap will be given a score of 4. Finally, this normalized range overlap score can be modified by a weighting factor (W1; 0-1 scale) that lets participants control the importance of the total species range overlap criterion ***itself*** within the restoration project concept's overall prioritization score.

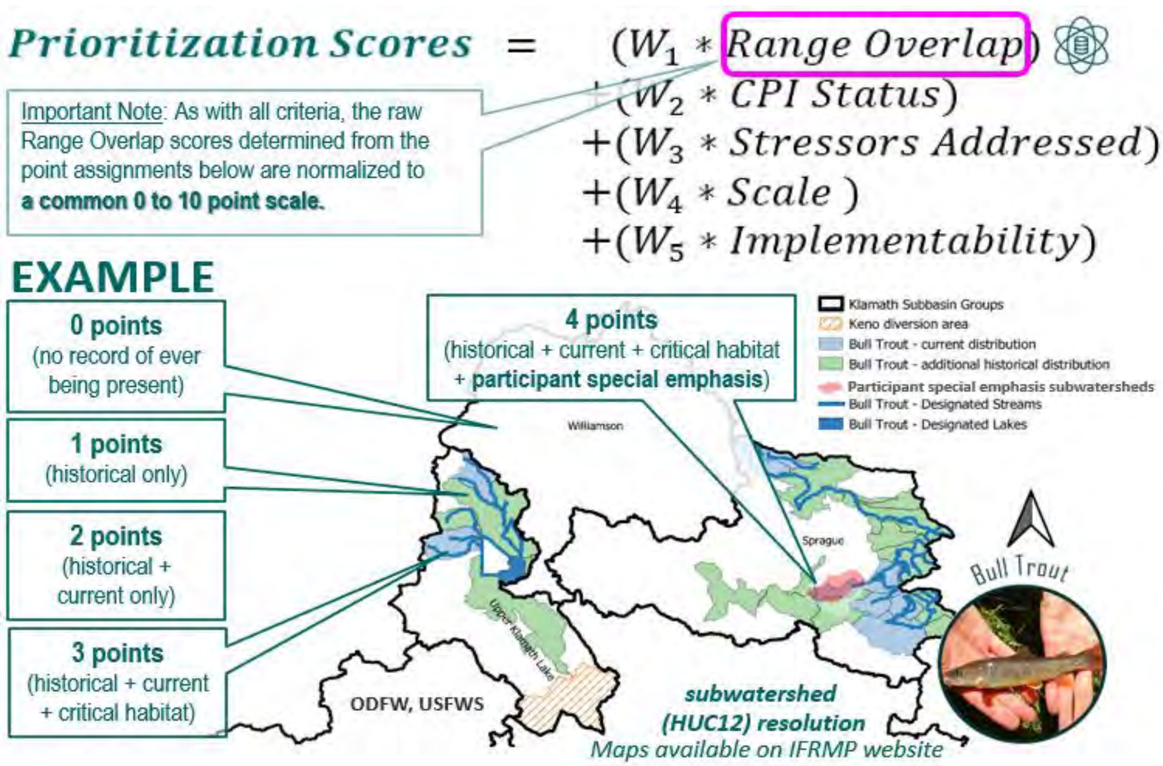


Figure 3-1. A visual summary of how the Range Overlap criterion score is determined.

3.5.2 Criterion 2: How Is Restoration Need Assessed?

What Is This Criterion?

In the IFRMP, **Core Performance Indicators (CPIs)** are indicators participants have identified to represent fish habitat and watershed function status. The intent is for these to be used for future *monitoring of status and trends* in the Klamath Basin.

Within the IFRMP multi-criteria scoring prioritization framework, **CPI scores** are intended to act as a measure of the overall degree of existing habitat damage which can be interpreted as ‘restoration need’ in areas of current or potential fish habitat. To date, several CPIs have been suggested that relate to one of the functional watershed process tiers (outlined in Section 2.1) and also fit within one of four spatial scales (outlined in Section 2.3). The list of suggested CPIs has been repeatedly refined through participant feedback via a CPI Survey and a CPI Webinar, and further refinements were made during engagement workshops for the development of basin-wide monitoring recommendations (as described in Section 0 of this document). To ensure consistency across all candidate restoration projects, the CPIs that inform this criterion **must be available throughout the entire basin**. Section 0 details specific CPIs that are preferred for informing more detailed monitoring of status and trends, as well as project level effectiveness.

What Data Inform This Criterion?

Without a basin-wide monitoring framework yet in place, data on all proposed CPIs are not yet available for all parts of the basin, which makes make it challenging to fairly compare projects against one another using the prioritization scheme.

Until monitoring efforts at a basin-wide scale provide field data on preferred CPIs, we have worked with participants to identify a suitable range of landscape-scale **CPI proxy (or substitute) indicators** for each of the selected CPIs. CPI proxy indicators are associated with publicly available data at the sub-watershed (HUC12) hydrologic scale throughout the Klamath Basin. Decisions about which proxies to include in the final list involved participant reflections on the quality of proxy data, appropriateness for prioritization (more so than simply monitoring), and level of group agreement towards the proxy. These proxy indicators were used to automatically create “default scores” for CPI status in the interactive Klamath IFRMP Restoration Prioritization Tool to help approximate “functional watershed restoration need” when data for that CPI are otherwise not readily available. There is a long history of using landscape-scale metrics for smaller watershed restoration projects (e.g., Thom et al. 2011 for the Columbia River Basin and Fesenmeyer et al. 2013 across the state of California), and these metrics help to provide an even playing field for comparing a given project location’s habitat degradation to that in other locations across the entire basin. Thus, **only CPI proxy data was used for this first round of prioritization as data for preferred CPIs themselves was not yet consistently available across all CPIs, species, and areas of the Klamath Basin.** We readily acknowledge that these proxies may not represent best available science regarding the degree of damage or impairment in all sub-basins – for example, in the upper basin above Keno dam, these proxies should be replaced by the more detailed and locally-relevant measures of impairment as developed through the Upper Klamath Basin Watershed Action Plan (UKBWAP). **Ultimately, the intent is for these proxies to be supplemented or replaced with field data on actual CPIs collected through a rigorous basin-wide monitoring program.** The interactive Klamath IFRMP Restoration

Prioritization Tool is built so that CPI proxy data can be replaced with data that are more detailed and locally relevant.

The final list of CPI proxies selected by participants to be used in first-pass prioritization is summarized in Table 2-2. The original data for each CPI proxy can be viewed within the online Klamath IFRMP Restoration Prioritization Tool's map explorer (described in Section 3.6), which illustrates how values for each CPI proxy vary across sub-watersheds (HUC12s) of the Klamath Basin. Although participants were given multiple opportunities for manually overriding default proxy CPI data before, during, and after sub-basin webinars, participants chose not to do so at this stage. Future efforts to identify ideal CPI datasets broadly available throughout the entirety of the Klamath Basin and ways to integrate these datasets into the tool, as well as integrating more locally-relevant datasets such as those in the UKBWAP, will continue as the plan is implemented[3].

Preferred CPIs for status and trends monitoring are introduced in Table 2-2 and are the subject of Section 0. For the reasons mentioned above, **these CPIs were not used to inform initial prioritization**.

How is the Information Used in Prioritization?

CPI proxy data for each indicator exists for every HUC12 sub-watershed in the Klamath Basin and are normalized from their original units of measure to a common scale of 0 to 10 to allow for comparison across sub-watersheds.

These normalized **individual HUC12 CPI proxy scores must be grouped** together into a single score for any proposed restoration project, which could include multiple HUC12 sub-watersheds. The scores are first grouped across HUC12 sub-watersheds where the project takes place (and then collected for each functional tier into a single tier score (as summarized in Figure 3-2). Users can then **apply tier weights** to control the importance of impairment in each watershed process tier. For example, CPI scores for fluvial geomorphic process damage may be more important due to current local restoration strategies, and so deserve a higher weight than CPIs in other tiers to reflect the current local restoration strategy. Lastly, tier scores and weights are used to generate a single weighted average score (Step 4) to arrive at one final weighted score reflecting overall habitat impairment in the project location.

In addition, **users can use a toggle function in the prioritization tool to choose between prioritizing Low, Moderate, or High Impairment** areas depending on the local context and restoration objectives. In some cases, it may be more desirable to prioritize a moderately impaired habitat instead of a highly impaired habitat, which may actually be too severely damaged to achieve effective restoration outcomes. **The tool currently defaults to prioritizing moderate impairment**, unless sub-basin participants chose otherwise.

[3] Such future changes will require code updates to the Klamath IFRMP Restoration Prioritization Tool.

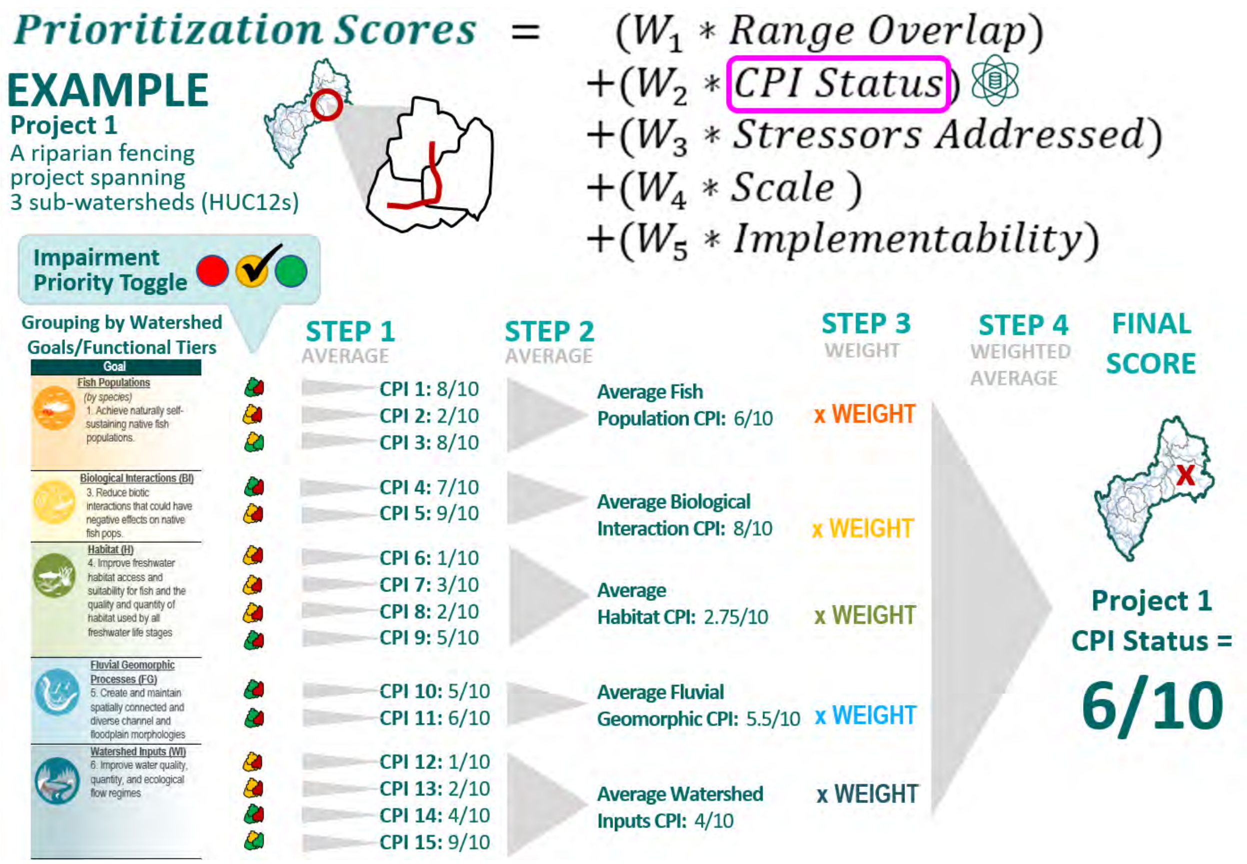


Figure 3-2. A visual summary of how the "Habitat Restoration Need" or CPI criterion score is determined using *hypothetical CPIs* grouped within watershed tiers for illustrative purposes only and not intended to match final CPIs selected by participants. Where preferable CPIs were not available, CPI proxies were used in the same way. Importantly, participants were able to choose which level of impairment should be prioritized in a sub-basin to reflect different strategies.

3.5.3 Criterion 3: How Are Number of Stressors Addressed by Restoration Assessed?

What Is This Criterion?

The **Number of Stressors Addressed** prioritization criterion looks at how many stressors a given *type* of restoration action tackles and how minimizing these stressors will impact the focal fish species at the project location.

This helps to provide a rough idea of the range of benefits associated with different *types* of projects and further informs the Scale of Benefit criterion (see Section 3.5.4).

What Data Inform This Criterion?

Linkages between focal species, project types, and key stressors were previously identified using conceptual models created in Phase 2 of the IFRMP planning process. Linkages are formed from published literature as well as surveys and workshops from IFRMP participants during Phase 2, and were updated through additional participant input during Phase 3 of the IFRMP planning process.

The IFRMP Action-Stressor Definitions and Linkages Data Dictionary) details restoration action types, stressor types, stressors addressed by each type, and linkages between actions and the stressors they are expected to help address. Each stressor type, or category, also falls under a functional watershed process tier.

These Action Types and stressors were pulled from the original NOAA Pacific Salmon Restoration Fund Data Dictionary and modified to reflect the chain of events between stressor-species-actions, which were captured in the Phase 2 conceptual models. The conceptual models from Phase 2 provide the framework for classification system for (1) which watershed restoration Action Types address which key stressors, and (2) which key stressors matter for which species and, by linking those two elements, we can understand (3) which actions should benefit which species. In some cases, the original framework includes multiple related stressors for a specific stressor type (e.g., there are 5 stressors linked to water quality condition). To avoid unbalanced weighting due to some repetitiveness in similarly detailed stressor types, the original complete list of 71 stressors was mapped onto a smaller set of 21 unique stressor categories.

How is the Information Used in Prioritization?

Because stressors are species-specific, the first step in determining the overall score for this criterion is to identify which focal species are present in the project area, using the same species location data in the Range Overlap criterion. Importantly, **this score considers both the current[4] and historical ranges for species.** The next step involves a stressor-action linkage database (based on the stressor-action linkage dictionary noted above) that is scanned to obtain a total number of unique stressor categories addressed by the Action Type(s) associated with the overall project, summed up for each focal species found within the project area.

Each stressor category is then assigned two weights (from 0 to 1) based on the overall sub-basin-specific priority level as determined by Sub-Basin Working Groups to capture the importance of the:

(i) **functional watershed process tier associated with each stressor category**, and

(ii) **species importance weight of each species benefiting from addressing the stressor** category.

For each stressor category, **the product of these weights is calculated and then normalized to a common scale from 0 to 10** (Step 5). The final "tier-weighted" and "species-weighted" score for the project is the sum of these weighted scores across all the stressor categories that the project tackles. This sum **is then normalized relative to the maximum stressor score across all projects in the sub-basin in order to compare the stressor strength across all projects on one comparable scale (from 0 to 10).**

Note that, because stressors categories are summed, **projects covering more HUC12 sub-watersheds may receive higher scores**, but only if known species locations are widely spread out across the sub-basin. Where this is the case, higher scores reflect a real advantage in the number of stressors addressed by a project that impacts multiple species.

[4] If dam removal is implemented as planned, these species range maps and related Klamath IFRMP Restoration Prioritization Tool calculations will need to be updated as part of ongoing adaptive management.

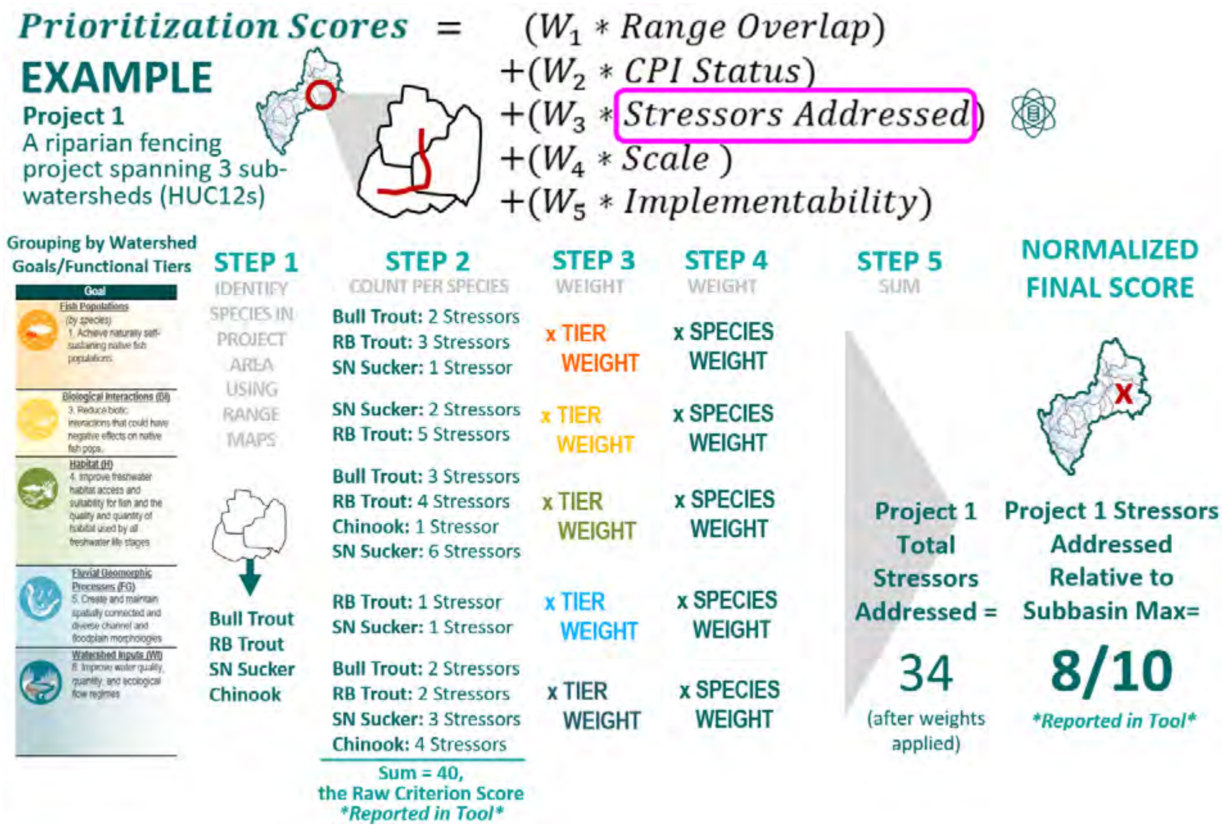


Figure 3-3. A visual summary of how the Number of Stressors Addressed criterion score is determined using hypothetical numbers of stressors *for illustrative purposes only* – these figures are not meant to represent actual stressor counts per species in any specific area.

3.5.4 Criterion 4: How Is the Scale of Potential Benefits Assessed?

What Is This Criterion?

The **Scale of Potential Benefit** criterion is intended to reflect how far and wide *beyond* the project area the benefits of a restoration action are expected to be felt. This is distinct from the project's actual geographical footprint. For example, a project that decreases nutrient inputs to an important stream will impact fish in waterways downstream of the project area, and a project that removes a dam may benefit fish who can now migrate into newly accessible upstream areas. This criterion is based on the expert judgement of participants and acts as a stand-in for quantitative assessments, for example, more complex data-driven hydrological network analysis. This type of analysis quantifies potential downstream benefits of upstream actions, but goes beyond the scope of our present work.

What Data Inform This Criterion?

The scores assigned to various scales of benefit are illustrated in Figure 3-4, following **the standard 0 - 10 point raw scoring scale used for each of the IFRMP scoring criteria**. Each individual proposed restoration project is given a single score based on the Sub-Basin Working Group responses to a Scale of Benefit Survey and discussions within each group. Web-based survey methods can be designed and deployed during organized meetings to develop weighting preferences that are representative of a broad audience (Nelitz and Beardmore 2017, Diederich et al. 2012). On the survey, participants were asked to assign a Scale of Benefit score to each proposed restoration project based on the following definitions for each scale:

- **Site Scale Benefits:** The project results in significant functional benefits to fish habitat benefits within a small area directly within the project footprint (e.g. channel structure that creates pool rearing habitat). These benefits may arise from any one or more of the different functional watershed process tiers (Figure 2-1) interacting with mechanisms impacting in-stream fish habitat.
- **Stream/Tributary Scale Benefits:** The project results in significant functional fish habitat benefits both within the project footprint and to other localized HUC12s that are upstream, downstream, and/or adjacent to the project site (e.g. planting on river banks creates more shading over the stream and results in cooler water temperatures at the project site and for a certain length of stream below the site; removing a stream culvert opens up habitat at the site and also creates more habitat opportunities within the stream network above the culvert).
- **Sub-basin Scale Benefits:** The project results in significant functional fish habitat benefits across the majority of HUC12s in the sub-basin (e.g. irrigation practices that benefit flows in all sub-basin streams). These benefits may come from one or more of the different functional watershed process tiers (Figure 2-1) and interactions controlling in-stream fish habitat conditions.
- **Whole Klamath Basin Scale Benefits:** The project results in broad, significant functional fish habitat benefits across most or all sub-basins with the Klamath Basin. Examples include: a series of actions completed within approximately 5 years that dramatically reduced nutrient inputs in the upper watershed, enforced water use restrictions, and substantially improved flow management at dams with fish passage facilities or reconnecting key thermal refugia critical for the population persistence of migratory species or the removal of four mainstem Klamath River dams.

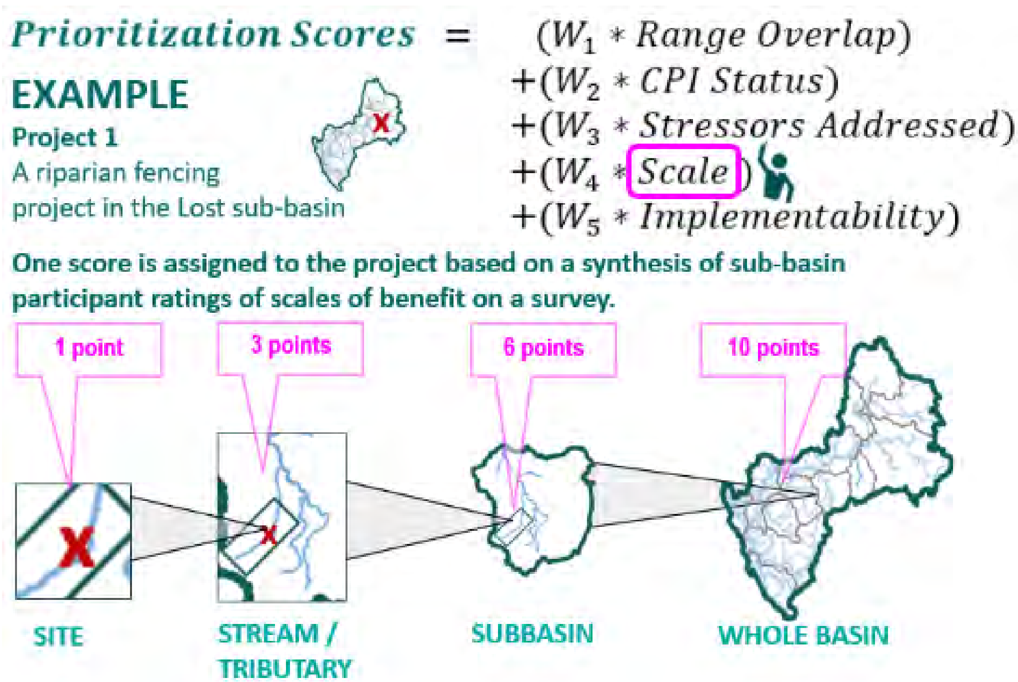


Figure 3-4. A visual summary of how the Scale of Benefit criterion score is determined.

Participants were also encouraged to limit their interpretation of these definitions **to the individual incremental project under consideration for prioritization, NOT the cumulative total of the class of the project** that may already be implemented in the sub-basin over many years or consider the impact of that class of action *if it were to be* implemented generally among multiple sub-basins. The planning team also further screened Scale of Benefit score for consistency across sub-basin teams and helped align different interpretations for consistent scoring across the entire basin.

How is the Information Used in Prioritization?

The Scale of Benefit scores for each proposed restoration project are multiplied by the weight assigned to the Scale of Benefit criterion. This value is used directly in the overall project prioritization score sum without further changes.

3.5.5 Criterion 5: How is Implementability Assessed?

What Is This Criterion?

Opposition can cause restoration projects to grind to a halt if decision-makers do not consider the importance of social and logistical considerations (Stinchfield et al. 2008). The **Implementability** (or feasibility) prioritization criterion evaluates how easy participants think it would be to plan and apply a particular type of restoration action. **The Implementability criterion encompasses several aspects that can be categorized as: 1) red tape, 2) technical/logistical feasibility, and 3) agreeability.** Though cost may also be a factor, we consider cost a separate criterion entirely (see Section 3.7). Each of these three categories can be broken down into the subcategories shown in Figure 3-5.

What Data Inform This Criterion?

We developed scores for proposed IFRMP restoration projects' implementability using expert focus groups and surveys, targeting each of the six subcategories listed in Figure 3-5. For the three subcategories under **red tape**, and the technical subcategory under **technical/logistical feasibility** (4 of 6 subcategories) we treated these as generic basin-wide sub-criteria for broad project types and land ownership types. We used a three-step process involving focus group discussions and polling of expert views;participants first answered draft polls, then discussed results during focus group meetings, and finally re-did the polls. Poll results were further refined after the process, upon reviewing feedback received during the focus group meetings. There were three final polls: 1) administrative/legal feasibility, 2) permitting and environmental compliance, 3) technical feasibility. The administrative/legal and technical feasibility polls had participants rank 10 broad project types ("Action Type Categories", see Section 3.2 and Appendix B) in order from most to least feasible. Similarly, the permitting and environmental compliance poll ranked the 10 broad project types, but also factored in 8 land ownership types (e.g., private, state, federal, Tribal). We used the ranks from the final poll results as scores for the four relevant subcategories.

We treated the remaining two subcategories (logistical feasibility and agreeability) as project-specific, requiring feedback from participants with local knowledge of the real-world context. We issued a survey using SurveyMonkey asking participants to rate each individual project as High, Medium, or Low feasibility for the sub-basins where participants work regularly or otherwise have extensive knowledge. These results produced the High, Medium, or Low rating for each project for these two subcategories.

Figure 3-5. Factors affecting 58mplementability and their definitions used for scoring purposes’

RED TAPE

Administrative/legal Feasibility (by broad project type)	The general level of administrative/legal effort and complexity typically associated with Action Type Categories (e.g., miscellaneous administration, legal review, water rights and land appraisals, etc.)
Permitting and Environmental Compliance (by broad project type)	The general level of permitting and environmental compliance complexity typically associated with Action Type Categories (e.g., 401 certification, TMDLs).
Permitting and Environmental Compliance (by land ownership type)	The general level of permitting and environmental compliance complexity typically associated with land ownership types (e.g., 401 certification, TMDLs).

All Red Tape sub-criteria scores were determined via polling and discussion with expert focus groups

TECHNICAL/LOGISTICAL

Technical feasibility (by broad project type)	The general level of effort and complexity for “boots on the ground” implementation typically associated with Action Type Categories (e.g., anything involving shovels, helicopters, heavy machinery, etc.)
Logistical feasibility (by specific project)	The specific level of effort and complexity for “boots on the ground” implementation expected for proposed Projects in the Klamath prioritization tool given local knowledge about terrain, accessibility, available personnel, lag time to implementation. Participants to flag specific HUCs.

Technical feasibility scores were determined via polling and discussion with an expert focus group. Logistical feasibility scores were determined via participant survey

AGREEABILITY

Agreeability (by specific project)	The extent to which specific Projects in the Klamath prioritization tool are likely to be implemented given local knowledge about existing levels of collective support across agencies, Tribes, landowners, and other relevant parties.

Agreeability scores were determined via a participant survey

How is the Information Used in Prioritization?

After surveying participants, each subcategory had a set of response metrics to appropriately inform the final score. For broad Action Type Categories, we assigned scores (polled ranks) to projects using Action Types (there are multiple Action Types associated with each Action Type Category, per Appendix B), since each project is associated with at least one unique Action Type . For the single land ownership metric (polled rank), we estimated the approximate area of each land ownership type within the project HUC12s, multiplied these by the polled ranking values, and summed ownership types together to get an area-weighted score per project. For the project-specific metrics (High, Medium, Low response frequencies) we used the most re-occurring response (mode) within the survey results to get a High, Medium, or Low rating per project (High =3, Med = 2, Low =1). In some cases, responses resulted in very different subcategory scores associated within a project, so rather than simply averaging conflicting scores we applied a weighting rule that sets the overall project score toward lower feasibility. This rule assumes that if a project has one or more highly feasible sub-components but also one sub-component that is highly *in*feasible, that one component is more likely to set the entire project infeasible and non-executable. Therefore, the project deserves an overall score that indicates it is less likely to be implemented easily. Since not all these metrics are on the same scale, we normalized them to a common scale (1-10) and combined the sub-categories into red-tape (3 sub-components), technical/logistical (2 sub-component), and agreeability (1 sub-component). We calculated a final score by adding the normalized scores for these three components together. Lastly, based on feedback received during the Klamath IFRMP workshop held in Ashland in September 2022, we applied adjustments to these scores (e.g., 30% increase/decrease depending on feedback). More details on how workshop input was used to adjust scores is available in detailed supplementary materials on the Klamath IFRMP Website (https://ifrmp.net/).

Note that funding agencies have their own processes to determine the implementability of a project. When opportunities to pursue restoration projects on private lands arise, real-world decision-making needs to involve objective consultation practices. The implementability scores presented here should be viewed as a starting point for those practices.

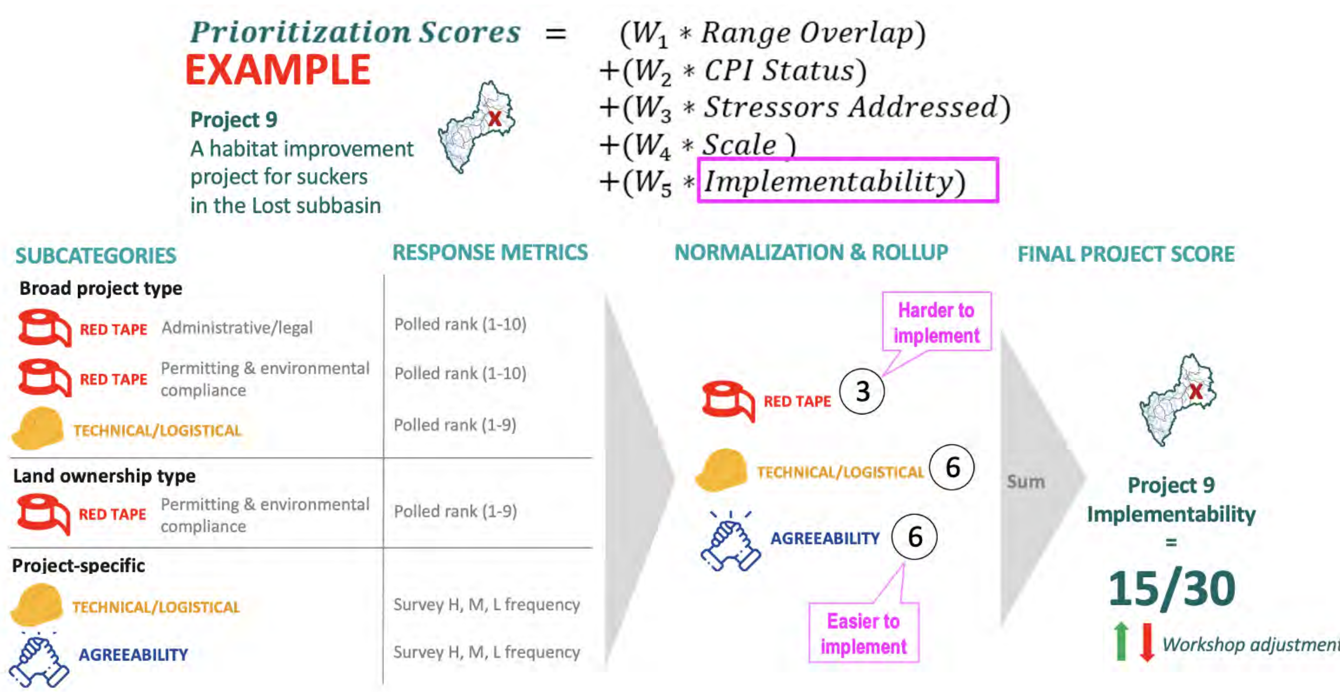


Figure 3-6. A visual summary of how the Implementability criterion score is determined.

3.6 Klamath IFRMP Restoration Prioritization Tool

As part of creating the Plan, our team developed an interactive, web-based **Klamath IFRMP Restoration Prioritization Tool** (Figure 3-7; access via https://ifrmp.net/). A video demo of this tool can be found here. The Prioritization Tool and associated database are the foundation beneath the IFRMP and helps us meet the following restoration planning needs:

- pulling together the multiple strands of prioritization information into one place to access and review easily;
- automatically calculating criteria scores and sorting projects based on numerous input data that can be collected across Klamath basin;
- allowing users to actively change input data (such as the CPI proxy indicator data with more detailed, site-specific information (Section 3.4.2)) and adjust the relative importance of criteria during facilitated webinars with Sub-basin Working Groups to see how sorting results shift in real time;
- hosting an efficient, one-stop service where users can add new restoration projects and remove others to adapt to changing conditions, needs, and opportunities in the basin as documented through monitoring ,
- providing a quick way to access prioritization results and associated project metadata, and
- consistently organizing and informing future prioritization efforts and discussions within the basin.

The Tool has been developed to **allow restoration planning participants to adjust weights for different criteria, watershed process tiers, and species to reflect changing restoration goals, objectives, and funding contexts**. For example, participants may choose to place higher importance on actions that reduce the number of stressors operating at the Watershed Input and Fluvial Geomorphology levels compared to other tiers if there is overall group agreement that this is the large limiting factor for fish populations in a particular sub-basin. Similarly, participants may choose to place higher importance on the Habitat tier or on a specific fish species if new funding opportunities arise for these specific uses. Decisions whether to give criteria higher importance or more weight require expert judgment and must be agreed upon by restoration planning participants working in the given sub-basin.

The Klamath IFRMP Prioritization Tool (https://ifrmp.net/ provides a thorough, transparent, and consistent method for prioritization across the entire Klamath basin.. **The tool is specifically designed to be routinely updated with the results from ongoing adaptive management and monitoring**. Readers are encouraged to log into the tool (Guest Username: ifrmpguest / Guest Password[5]: ifrmp2020) and experiment with different weighting systems to test the sensitivity of project prioritization ranks.

The resulting set of ranked restoration projects from every round of the Tool will provide **a starting point for more focused discussions among authorities responsible for selecting the best projects for restoration, whether they be at the sub-basin or sub-regional or basin-wide**

[5] Note: If these login credentials do not work for you, it is most likely because of a local information technology security policy put in place by your organization. Contact your local systems administrator / local IT helpline for assistance.

scale. As funding becomes available, the intention is that this Plan and the real-time, "living" prioritization tool will be repeatedly applied to guide future funding decisions. Similarly, **the relationships defined in the databases underlying the Tool would also need to be updated as results from ongoing monitoring appear and insights on key focal species' stressors are revealed**.

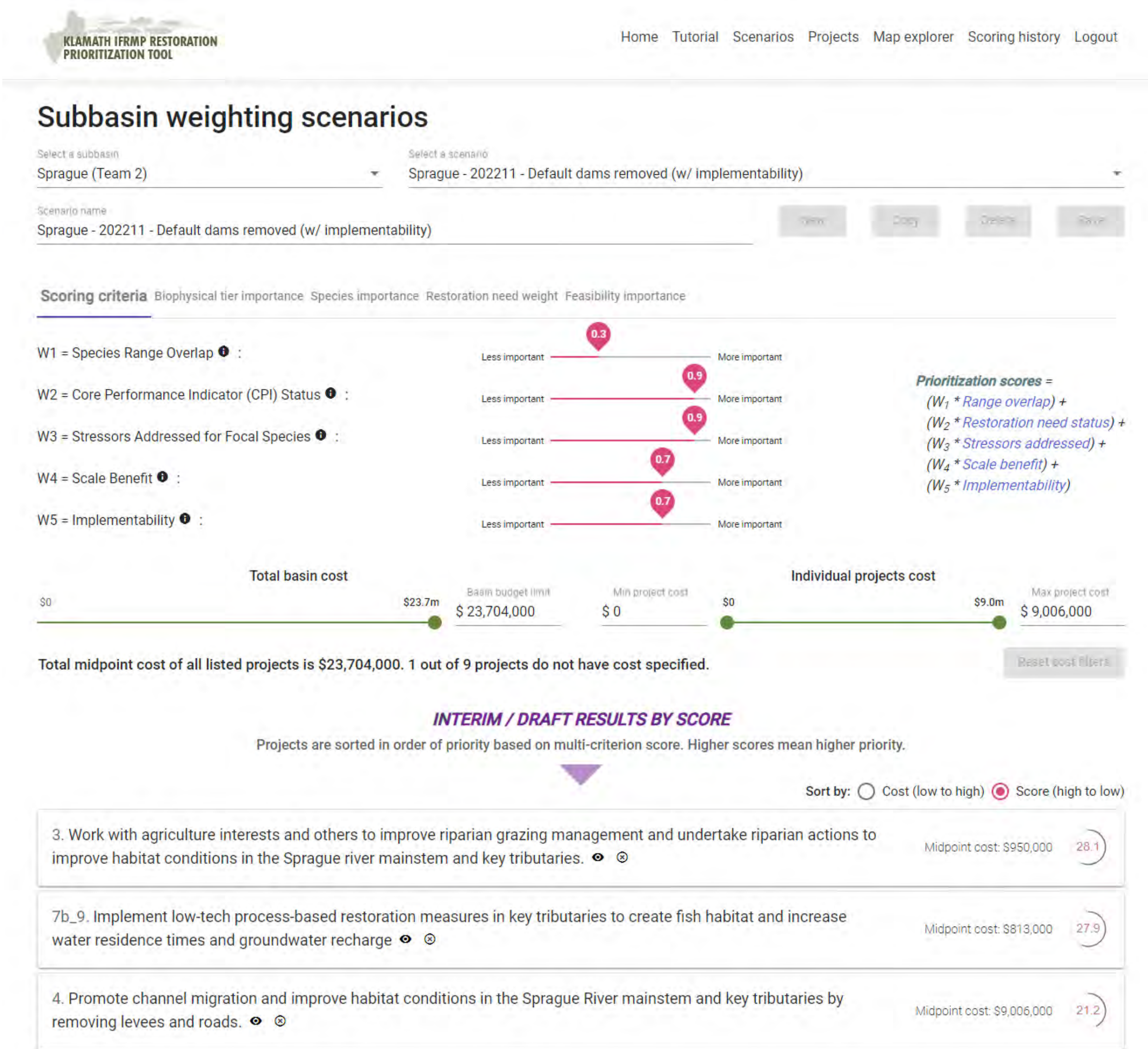


Figure 3-7. A screenshot of the main prioritization interface of the Klamath IFRMP Restoration Prioritization Tool, accessible to Sub-Basin Working Group participants through their login credentials via http://klamath.essa.com/.

NOTE: Projects and rankings identified in the IFRMP restoration planning process are not binding to federal agencies and do not imply federal funding, or future federal funding, is automatically granted to specific restoration projects.

3.7 Establishing Cost Ranges for Restoration Actions

A major focus during Phase 4 of IFRMP development was estimating cost ranges for approximately **146 restoration projects** identified in this plan. The goal was to provide a rough, idea of the resources required to fulfill different restoration objectives across the basin. Cost range estimates for IFRMP restoration projects (Appendix D, Appendix E) include **design, permitting, and implementation** stages of a project. Note that **effectiveness monitoring** costs are also important. Our project cost ranges may include effectiveness monitoring if it is a *typical permitting requirement* associated with implementing that type of action. We exclude the costs of **status and trends monitoring**, which were developed during Phase 5 (2022) of the IFRMP and are reported separately in Section 0 and Appendix G.

Importantly, cost range estimates for different projects should be interpreted as additional context to inform discussions and high-level planning. Cost estimates themselves do NOT factor into project prioritization or influence project rankings.

To develop cost ranges, we used a multistep process that included: 1) combining existing restoration action cost databases into a single cost database, 2) reaching out to expert participants to validate database cost ranges or provide alternative cost ranges, and 3) validating cost ranges using standardized cost documentation.

For Step 1, we found 22 cost databases for restoration projects within the Klamath basin through internet searches and conversations with participants during previous phases of the IFRMP process. These databases are listed in Table C - 1 with a detailed description of data treatment.

Step 2 was a multi-step process leading to participant validation of database cost ranges *or* provision of suggested alternative cost ranges. To prepare for the costing exercise, participants were assigned to subbasin regions and asked to become familiar with the IFRMP restoration projects **stored in the Klamath IFRMP Restoration Prioritization Tool** (http://klamath.essa.com/scenarios; Guest Username: ifrmpguest; Guest Password[6]: ifrmp2020). They were then directed to review the tutorial videos in the tool interface and navigate to the Scenarios tab within the Tool to view the list of proposed restoration projects for the "…current hydrosystem" scenario (the first scenario listed in the tool for that subbasin). Participants then selected individual projects within the Tool and viewed each project's main properties: *Action Types, HUC12s, Stressors, Target Species,* etc.

When deciding for costing purposes what is needed to address the project's relevant stressors, participants were asked to consider the spatial scope defined by the project's assigned HUC12s over a **2-5 year** timeframe. In other words, **the costs we have identified reflect the cost of one major round of restoration carried out over a 2-5 year implementation timeframe within the proposed focal areas.** Additional rounds of restoration *not costed here* may be required to complete the project's objectives.

Costing was done at the sub-project, or *Action Type*, level. To be successful, each project requires the implementation of one or more Action Types, and each Action Type is associated with different costs that are summed to get a total cost per-project (see Appendix B). We provided participants with a library of 48 **Action Type Cost Profiles** (Figure 3-8) containing High, Medium, and Low cost ranges derived from the cost databases. For each project, participants were asked to use these

[6] Note: If these login credentials do not work for you, it is most likely because of a local information technology security policy put in place by your organization. Contact your local systems administrator / local IT helpline for assistance.

Profiles alongside project descriptions in the Klamath IFRMP Restoration Prioritization Tool to **indicate whether a *single implementation* of each Action Type would fall within one of the cost ranges**. If participants did not agree with the cost ranges in the Profile, we asked them to supply their own suggested cost range, direct us to other project examples (specific studies, reports), or connect us with other individuals with relevant knowledge. We also asked participants to indicate how confident they were in the cost ranges they assigned to each action type.

A final critical step was having participants identify the **number of implementations of each Action Type** needed to bring the restoration project to completion in 2-5 years. This process was repeated for each subbasin with which the costing participant had experience.

Riparian planting			
Supporting information:			
Cost ranges from existing databases for a single implementation of this Action Type*	**Low** $0.1 – 7.9K	**Medium** $7.9 – 21.2K	**High** $21.2 – 93.3K
Main subbasin(s) these data are from	Scott, Shasta	Scott, Lost	Sprague, Scott, Lower Klamath River, Shasta, Upper Klamath Lake
Main database(s) these data are from	CalFish, UC_Davis_NRPI, USFWS_PFW	NOAA_PNW, USFWS_PFW, USFWS_YrekaOffice	ORWI_Direct, NOAA_PNW, USFWS_PFW, CalFish
If, for a specific project, you cannot assign the above cost ranges to this Action Type (e.g., no data or ranges seem off), please fill in the following:			
List key cost drivers, other than the number of units, typically associated with L/M/H implementations of this action type (biggest drivers only - – see Worked Example for guidance):			
Driver 1____?			
etc…			
<insert rows as needed>			
Recommended standard cost unit for this Action Type (e.g., 1 mile, 1 ha, 1 structure):			
What is the ***cost range*** *per unit?*			
How many units in a typical implementation?			
Your revised cost ranges (range x #units)			
NOW REVISIT THE HOMEWORK EXCEL SHEET. CAN YOU NOW ASSIGN A L, M, H COST RANGE? IF NO, REVISE THE ABOVE AS NEEDED UNTIL YOU CAN, OR PROVIDE COMMENTS BELOW AND/OR IN THE HOMEWORK SHEET. NOTE THAT H, M, L **COST RANGES MAY VARY FROM PROJECT TO PROJECT FOR THE SAME ACTION TYPE**. DON'T FORGET TO FILL IN THE OTHER COLUMNS (CONFIDENCE & NO. IMPLEMENTATIONS NEEDED)			
Key sources (reports, databases, people) and/or comments about this cost profile:			

Figure 3-8: Example Action Type cost profile used during participant costing homework exercise.

To document results for each Action Type, we then prepared "expanded cost ranges" (Appendix D) and cost result profiles (Appendix E). The expanded cost ranges are the result of multiplying *single implementation* costs for an Action Type by the number of implementations indicated by participants for a given project (note that individual Action Type cost ranges may vary depending on the project and subbasin). The cost result profiles also report cost ranges per Action Type, along with confidence ranges, number of participant responses, and the number of records within the original cost database(s) that have cost ranges falling within the *per implementation* cost range. Metadata are provided as bullet points reflecting useful participant comments about per-unit costs and cost drivers, relevant cost information from standardized cost documentation, and any additional points related to database cost information. We relied on proxy cost-ranges from other sub-basins when cost ranges or number of implementations could not be identified.

As a final step (Step 3), we cross-validated cost range results using standardized cost documentation recommended by participants (see Thomson and Pinkerton 2008, and Evergreen 2003) and we indicate any differences between our results and standardized costs in the cost result profiles in Appendix E.**Error! Reference source not found.**

The combination of database, participant, and standardized cost information permitted an approximation of cost ranges for 73 (50%) of 146 IFRMP projects, and the use of proxy cost ranges for 62 (42%) additional projects for **a total of 135 (92%) of 146 projects fully costed** (Table C - 1). We were unable to identify cost ranges for all restoration actions assigned to all projects in all sub-basins, leaving 21 (partially) un-costed projects that either had no cost data available (6%) or had data gaps that could not be filled (7%), where, for example, per unit costs were available for an Action Type but there was not enough information to reliably roll up to project-level costs (Table C - 2).

4 Recommended Restoration Actions & Cost Ranges

This Section

- Summarizes the results of the application of our collaborative, multi-criteria prioritization process for each sub-basin in a series of summary tables.
- Provides additional details on key stressors, focal species, monitoring programs, and other relevant restoration studies or plans relevant to each sub-basin.
- Provides initial thoughts on basin-wide prioritization to be carried into Phase 4 of work.

4.1 Setting the Prioritization Context

Any prioritization exercise is strongly influenced by the goals, objectives, values, and anticipated conditions under which these projects might be expected to take place. On June 17, 2021 the Federal Energy Regulatory Commission (FERC) approved the transfer of the license for the Lower Klamath Hydroelectric Project (Project) from PacifiCorp to the Klamath River Renewal Corporation (KRRC) and the states of Oregon and California, as co-licensees. FERC noted that the transfer is an important step in the surrender proceeding. On November 17, 2022, FERC) finalized the environmental impact statement and granted the surrender of the dams to KRRC. Prior to this decision, for the purposes of the IFRMP. **By the time prioritization discussions took place, participants assumed dam removal would occur in the near future.** The majority of Sub-basin Working Group participants felt many restoration activities would be *more* effective with the four lower Klamath River hydroelectric dams removed. However, the majority of these same **participants also acknowledged that the ranked order and choices of restoration actions themselves would not significantly change in most sub-basins had the mainstem dams remained.**

The **Klamath IFRMP Restoration Prioritization Tool (IRPT)** includes different scenarios that often have alternative weighting schemes on component criteria. Strong differences in priorities alter the ordering of highest priority restoration project concepts. IRPT scenarios follow a "**yyyymm**" naming convention to make it possible to identify the latest, most relevant participant scenarios. Additional IRPT scenarios will emerge in future engagements as participants iteratively update Restoration Action Agenda and as conditions continue to change.

4.2 Overarching Basin-Wide Restoration Priorities

This section provides prioritization results for over 146 proposed restoration projects that focus on recovery and resilience for focal fish species in specific sub-basins. However, there is also interest from agencies and other organizations working at broader spatial scales to understand the highest priority restoration projects that could also provide benefits at a whole-basin scale. A whole-basin prioritization exercise could either gather the top projects from each sub-basin or, in a future effort, explore the use of additional basin-wide prioritization criteria to highlight key projects that benefit the whole basin.

The **top three projects from each sub-basin prioritization process are shown in Section 4.2.1.** During the next phase of Plan development, additional review of implementability and project order will further refine sub-basin priorities. Thus far, sub-basin restoration action priorities are provided in a series of **compact subbasin profiles** starting with Figure 4-3 and mirrored for all sub-basins. Costs for the 146 restoration projects identified by IFRMP participants are summarized in Section 4.2.2.

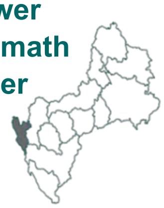
4.2.1 Top Priorities Across Sub-Basins

The top three projects from each sub-basin (36 projects over entire basin) are shown in Table 4-1 and have an estimated mid-point cost of USD 173 million. This estimate does not include uncosted projects, some of which will likely be significant (see Section 3.7). The remaining 110 projects adds USD 310 million at the estimated mid-point. The full list of 146 sub-basin restoration projects and their cost ranges are provided in sections that follow.

Table 4-1: A snapshot of the top 3 projects within each sub-basin and their corresponding prioritization scenario (PS), along with estimated total cost ranges (numbers correspond to thousands of USD),presented in order that they appear in the report facilitate navigation across the list. Note that ordering of sub-basins does NOT reflect any kind of priority of sub-basins themselves (which has not been assessed in this Plan) and that restoration actions identified below do NOT constitute an official federal agency position or obligation for current or future action, or funding. Project numbers match detailed project descriptions provided within each sub-basin section.

Sub-Basin	Top Three Ranking Projects in First-Pass Prioritization	Cost Range (in $USD 2020 K)
Upper Klamath Lake 	• **Project 1.** Work with agriculture interests and others to improve riparian grazing management and undertake riparian actions to improve habitat conditions in key Upper Klamath Lake tributaries. • **Project 8b_11_11b.** Reconnect channelized portions of key sub-basin tributaries to improve fish habitat, increase water residence time, and maximize groundwater recharge. • **Project 14.** Work with agriculture interests and others to separate out and treat tailwater discharge in key areas of the Upper Klamath Lake sub-basin	• **#1:** $438 – 1,438 – 2,688 • **#8b_11_11b:** $653 – 3,283 – 5,888 * • **#14:** $295 – 1,390 – 2,300 • **TOTAL: $1,386 – 6,111 – 10,876**
Williamson 	• **Project 4_7.** Work with agriculture interests and others to improve grazing practices and fence and/or plant vegetation to improve riparian and instream conditions within the Williamson River and key tributaries. • **Project 5.** Reconnect channels to restore fish access to existing cold-water springs in Williamson River mainstem reaches and key sub-basin tributaries. • **Project 3_8b.** Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge.	• **#4_7:** $1,125 – 5,800 – 11,450 * • **#5:** $6,190 – 7,104 – 8,139 * • **#3_8b:** $3,260 – 5,848 – 8,671 * • **TOTAL: $10,575 – 18,752 – 28,260**
Sprague 	• **Project 3.** Work with agriculture interests and others to improve riparian grazing management and undertake riparian actions to improve habitat conditions in the Sprague river mainstem and key tributaries.	• **#3:** $300 – 950 - 2,150 • **#7b_9:** $188 – 813 - 2,125 • **#4:** $1,081 – 9,006 – 26,225* • **TOTAL: $1,569 – 10,769 – 30,500**

Sub-Basin	Top Three Ranking Projects in First-Pass Prioritization	Cost Range (in $USD 2020 K)
	• **Project 7b_9.** Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge. • **Project 4.** Promote channel migration and improve habitat conditions in the Sprague River mainstem and key tributaries by removing levees and roads.	
Lost 	• **Project 9d.** Work with agriculture interests and others to install riparian fencing along the mainstem Lost River to reduce grazing impacts. • **Project 11a.** Work with agriculture interests and others to improve the fish ladder at Keno Dam to provide better upstream passage for migratory fish species. • **Project 1.** Work with agriculture interests and others to improve water use efficiencies throughout the Klamath Project to improve water quality and stream temperatures.	• **#9d:** $375 – 1,050 – 1,800 • **#11a:** $10 – 30 – 45 • **#1:** $10,825 – 11,150 – 11,400 • **TOTAL: $11,210 – 12,230 – 13,245**
Upper Klamath River 	• **Project 5c.** Undertake riparian planting to reduce erosion into the Upper Klamath River mainstem and key tributaries. • **Project 19.** Identify and implement projects to protect existing or potential cold-water refugia for fish • **Project 5b.** Work with agriculture interests and others to install fencing along riparian corridors to reduce erosion into the Upper Klamath River mainstem and key tributaries.	• **#5c:** $200 – 200 –200 • **#19:** $960 – 1,144 – 1,880 • **#5b:** $720 – 1,440 – 1,800 • **TOTAL: $1,880 – 2,784 – 3,880**
Mid-Klamath River 	• **Project 8.** Undertake riparian planting to reduce water temperatures and improve fish habitats. • **Project 6_10.** Remove sediment barriers or construct low flow channels to provide access to existing cold water refugia within the Middle Klamath River sub-basin. • **Project 11.** Reconnect off-channel habitats by removing or reconfiguring stream levees and dikes.	• **#8:** $125 – 138 – 150 * • **#6_10:** $5,858 – 12,494 – 19,105 * • **#11:** $3,444 – 10,961 – 27,050 * • **TOTAL: $9,427 – 23,593 – 46,305**
Shasta 	• **Project 6.** Undertake riparian rehabilitation actions to maintain shading, reduce water temperatures and improve instream habitat within priority mainstem Shasta River sites • **Project 3.** Increase cold water refuge habitats for fish in the upper Shasta sub-basin through improved irrigation management and secured water rights • **Project 9.** Undertake habitat restoration projects in streams across the Shasta sub-basin to restore floodplain connectivity and create new rearing habitats.	• **#6:** $100 – 175 – 225 • **#3:** $395 – 1,090 – 1,750 * • **#9:** $3,042 – 5,617 – 7,914 * • **TOTAL: $3,537 – 6,882 – 9,889**
Scott 	• **Project 14.** Restore upland wetlands and meadows to improve cold water storage and flood attenuation in the Scott • **Project 15.** Callahan dredge tailings remediation • **Project 11.** Install appropriate in-channel structures such as LWD, boulders, etc. to improve condition of fish habitats in priority tributaries.	• **#14:** $8,748 – 17,749 – 26,822 * • **#15:** $4,665 – 8,890 – 13,257 * • **#11:** $800 – 1,675 – 2,433 * • **TOTAL: $14,213 – 28,314 – 42,512**

Sub-Basin	Top Three Ranking Projects in First-Pass Prioritization	Cost Range (in $USD 2020 K)
Salmon 	• **Project 7.** Restore upland wetlands and meadows to improve cold water storage and flood attenuation in the Salmon sub-basin • **Project 5.** Protect and enhance existing cold-water refugia through improved maintenance and management of existing riparian areas in the sub-basin. • **Project 3.** Build and improve connection to off-channel rearing habitats in Salmon sub-basin tributaries.	• **#7:** $3,890 – 8,818 – 13,345 * • **#5:** $1,674 – 3,940 – 6,166 * • **#3:** $2,465 – 5,730 – 8,520 * • **TOTAL: $8,029 – 18,488 – 28,031**
Lower Klamath River 	• **Project 11.** Install BDAs in key tributaries in LKR to promote increased base flows and provide improved rearing habitats. • **Project 7.** Plant riparian vegetation along key Lower Klamath River tributaries to reduce water temperatures. • **Project 6.** Increase habitat connectivity and enhance floodplain habitats in key Lower Klamath River streams.	• **#11:** $190 – 367 – 543 * • **#7:** $125 – 138 – 150 * • **#6:** $3,012 – 6,274 – 9,148 * • **TOTAL: $3,327 –6,779 – 9,841**
Trinity 	• **Project 1.** Implement managed flows from Trinity River from Trinity and Lewiston dams, gravel augmentation, and reconnect floodplains by removing levees and constructing off-channel habitats. • **Project 5.** Reconnect floodplains in the mainstem Trinity River below the North Fork confluence and key tributaries by removing levees and constructing off-channel habitats. • **Project 4.** Maintain flows in Weaver Creek by alternatively using Trinity River to provide summer water to the Weaverville Community Services District.	• **#1:** $1,732 – 21,428 – 56,760 • **#5:** $963 – 3,120 – 6,510 • **#4:** $25 – 100 – 150 • **TOTAL: $2,720 – 24,648 – 63,420**
South Fork Trinity 	• **Project 5.** Decommission roads and improve road drainage systems to reduce fine sediment delivery to South Fork Trinity streams. • **Project 3.** Increase groundwater storage in the South Fork Trinity Sub-basin through upland wetland restoration actions. • **Project 2.** Increase storage capacity and delivery capability of Ewing Reservoir to allow increased seasonal water flows in Hayfork Creek.	• **#5:** $60 – 180 – 390 • **#3:** $6,460 – 12,470 – 18,480 • **#2:** $500 – 1,200 – 2,000 • **TOTAL: $7,020 – 13,850 – 20,870**

*Project has one or more Action Types for which cost data was missing (gap), therefore should be considered "incomplete".

4.2.2 Cost Ranges for All Restoration Actions

With data gaps in mind (see Appendix D, Table C - 2), **the total cost to carry out all 146 proposed project concepts in the Klamath IFRMP** (see Appendix D, Table C - 1) **would have an estimated midpoint cost of $484 million (2020 USD) and an upper value of $814 million.** This range occurs due to varying responses from participants during the costing exercise and, importantly, varying numbers of implementations needed for an Action Type in a given sub-basin. This range does ***not*** include the cost of decommissioning the four mainstem dams (JC Boyle, Copco No. 1 & No. 2 and Iron Gate) nor the cost of implementing the required site remediation and restoration efforts (funded via the Klamath Hydroelectric Settlement Agreement Definite Decommissioning Plan or KHSA DDP). **When implemented, the KHSA DDP will result in the largest river restoration effort in the United States at an estimated cost of $450 million (in**

the event of a cost overrun, California, Oregon and PacifiCorp will provide up to $45 million in additional funds).

Regarding data gaps shown in Table C - 2, these are Action Types for which there are no data available from either the synthesized cost databases, participant responses, or standardized cost documentation. In some cases, we were able to compile some data but they were insufficient for developing full cost ranges (e.g., we found per unit costs but these lacked a project-specific indication of how many units would be needed for a single implementation, or how many implementations would be needed for completion). In some cases, participants indicated costing would be very difficult to estimate. For example, Action Type "riparian area conservation grazing management" is a management action but, for costing purposes, participants felt it would be best addressed by other Action Types like fencing. These data gaps should be prioritized during future reviews to determine which gaps are feasible or meaningful to cost. **With the right expertise, costing focus groups would be efficient in resolving several of these gaps.**

Appendix D provides expanded cost range results for each project by sub-basin. These cost range data are incorporated into the Klamath IFRMP restoration prioritization tool as additional metadata to aid decision makers in allocating funds for restoration efforts.

A reminder that in our collaborative discussions on restoration costs we asked participants to scale and constrain their input to what could feasibly be accomplished in a 2-5 year period (including/following permitting) (as described in Section 3.7) rather than describe a multi-phase, multi-year package of actions that practitioners would like to see happen over ~20 years. We heard and understand that many kinds of restoration projects can take longer than 5 years to plan, permit and implement. Participants were reminded that those restoration projects would need to be re-added to the Klamath IFRMP Restoration Prioritization Tool and structured as batches of what is implementable/completable in a 2–5-year time frame. We adopted this timeframe as a realistic temporal planning unit because resource agencies typically do not issue "20 years" of restoration funding. However, the 2–5-year scope restriction does not mean that the restoration work for this project should be fully completed within that time. It is acknowledged that some types of restoration may take ten, twenty or more years of ongoing effort to complete and maintain. Those projects and needs will become clear during future implementation of the IFRMP and such projects will need to be re-entered as many times as needed into the Klamath IFRMP Prioritization Tool to complete restoration across all focal areas of interest.

The restoration projects and the restoration project costs identified in the IFRMP are not an unchanging checklist of all restoration projects needed to "fix" the Klamath Basin. Taking the total estimated midpoint cost to carry out all 146 proposed projects of $484 million (2020 USD), and assuming the average duration of time to complete these projects is 3.25 years, the annual total midpoint cost per year of restoration funding needed is roughly around $149 million dollars (2020 USD). Therefore, by extension, ***if*** **the number of rounds of functional watershed restoration actions required over the entire basin to largely restore the entire Klamath basin is around 5 (or 20 years)[7], the total estimated midpoint cost for all restoration is around $3 billion (2020 USD). The high-end estimate for 5 rounds (or 20 years) of carrying out these actions is nearly $5 billion.** We report this overall "price-tag" as a high-level basin-wide cost estimate with the understanding that not all projects in the prioritized lists will receive funding within the next 5 years.

[7] The total number of rounds of restoration and duration of time required to restore functional watershed processes, flows, water quality, habitat and ecosystem processes.is a major uncertainty. The use of 5 rounds or 20 years is purely for illustration purposes to assist decision-makers interpret IFRMP restoration project cost numbers.

4.3 Upper Klamath Lake Sub-region

The Klamath River's headwaters begin in the gently sloped desert, forest, wetlands, marshlands and open valleys of the Upper Klamath Basin sub-region. These headwaters are supplied primarily by springs emerging from underground reserves recharged by snowmelt rather than by rainwater. This region supports a diverse range of commercial activities including agriculture and cattle ranching in the region surrounding Upper Klamath Lake and the Basin's larger rivers, as well as forestry in its uplands.

These activities have produced a number of critical **stressors** in this sub-region (Table 4-2). In a system already sensitive to evaporation, draining large wetland areas, straightening and diking natural waterways, and establishing irrigation diversions have contributed to stream channels disconnecting from their floodplains, less natural flooding events, increased fish passage or entrainment hazards, and loss of fish habitat. At the same time, some livestock grazing practices have contributed to the erosion of nutrient-rich soils and the loss of riparian vegetation, which plays an important role in sediment capture and stream shading. Collectively, these developments have severely impacted water quality in Upper Klamath Lake and its upstream tributaries, which are already sensitive to an excessive amount of nutrients due to high natural background loadings of phosphorus from volcanic sediments. Within the lake itself, resulting nutrient-rich conditions contribute to toxic algal blooms that raise pH and lower dissolved oxygen content. This type of environment is harmful to fish health and may prevent successful migration, spawning, and rearing in affected waterways (Adams et al. 2011, Stanford et al. 2011).

This subregion is also notable for the multi-stakeholder Upper Klamath Basin Watershed Action Plan (UKBWAP) initiative currently in progress, which is a regional effort to identify restoration actions, mechanisms, and suitable implementation sites at a more localized scale than this basin-wide plan. Upper Basin working group participants were particularly concerned that identified IFRMP Action Type-stressor linkages (direct and indirect) were not reflecting the existing work for the UKBWAP, so additional effort has been made to align these two efforts. However, the IFRMP is not intended to match the detailed local water quality considerations of the Upper Klamath Basin Watershed Action Plan (at least in its initial phases). Instead, we view the IFRMP as being complementary for guiding work at different scales. Although the UKBWAP provides valuable guidance for restoration, it does not cover all Action Types or regions of the Upper Klamath Basin (notably, excluding the Lost sub-basin), and should be considered alongside other plans and initiatives with similar objectives.

Note that because the Butte sub-basin in this sub-region is primarily a closed sub-basin with no natural surface water connection to the Klamath River and no significant populations of focal fish species, it is not profiled in this plan.

- **Sub-basins:** Upper Klamath Lake, Williamson, Sprague, Lost, and Butte
- **Key Species:**
    - **Current**: Shortnose & Lost River suckers (ESA Endangered), Bull Trout (ESA Threatened), Redband Trout (ESA Special Concern)
    - **Historical**: Chinook Salmon, Coho Salmon, steelhead, Pacific Lamprey (potential recolonization after passage restored).

Header Image: Upper Klamath Lake in Early Winter | Natascia Tamburello by permission

Table 4-2: Synthesis of hypothesized stressors (X) and key stressors (yellow highlighted) affecting focal fish species/functional groups across the Upper Klamath Basin sub-region (as identified through IFRMP Synthesis Report and technical group conceptual modeling exercises).

Upper Klamath Lake (UKL) sub-region						
Stressor Tier	Stressor	Focal Fish Species				
		SU	RT	BT	CH/CO/ST (future)	PL (future)
Watershed inputs (WI)	9.2.1 Klamath River flow regime	X	X		X	X
	9.2.2 Instream flow (tributaries)	X	X	X	X	X
	9.2.4 Lake disturbance (e.g. fetch)	X	X		X	
	8.7 Chemical contaminants (below UKL)	X	X		X	X
	3.1.1 Hypereutrophication	X	X		X	X
	7.2.1 Increased fine sediment input/delivery	X	X		X	
	7.1.1 Decreased coarse sediment input/delivery		X		X	
	4.2 Large woody debris		X	X	X	X
Fluvial-geomorphic processes (FG)	9.2.1. Groundwater interactions	X	X	X	X	X
	6.1.1 Channelization	X	X	X	X	X
	6.2.3 Fine sediment retention	X	X	X		X
Habitat (H)	8.1 Water temperature	X	X	X	X	X
	8.2 Dissolved oxygen	X	X	X	X	X
	8.5 pH	X	X	X		X
	1.1 Anthropogenic barriers	X	X	X	X	X
	6.2 Instream structural complexity	X	X	X	X	X
	9.2.3 Lake levels	X				
	2.3.1 Fish entrainment	X	X	X	X	X
Biological Interactions (BI)	2.1.2 Predation (fish)	X	X	X	X	X
	2.1.2 Predation (mammals/birds)	X	X	X	X	X
	2.2 Pathogens	X	X		X	
	3.2 Competition	X		X	X	
	10.1 Hybridization	X		X	X	
	3.3.2 Abundance of invertebrate prey	X	X	X	X	

SU = endangered suckers (Lost River and Shortnose suckers), RT = Redband Trout, BT = Bull Trout, CH = Chinook Salmon, CO = Coho Salmon, ST = steelhead, CH/CO/ST = Chinook, Coho & steelhead combined, PL = Pacific Lamprey. Stressor numbering is adapted from NOAA's Pacific Coastal Salmon Recovery Fund 'Ecological Concerns Data Dictionary' available from:
https://www.webapps.nwfsc.noaa.gov/apex/f?p=309:13::::::

The Wood River Wetland in the Upper Klamath Basin, which has been the site of many restoration efforts in recent years (Photo by Greg Shine, BLM)

Box 4-1: Wetlands of the Klamath Basin

Historically, the Upper Klamath Basin, (Klamath and Lost River watersheds above Keno Dam) was characterized by the abundance and extent of aquatic habitat. In 1826 upon seeing the Upper Klamath Basin trapper Peter Skene Ogden wrote “the Country as far as the eye can reach [was] one continued Swamp and Lakes.” Subsequently, in 1907 the naturalist William Finley stated “The country is overspread with great lakes, several of them from twenty to thirty miles across; and reaching out on all sides of these are vast marsh areas and tule fields extending for miles and miles" (Finley 1907a:12). He later called the Upper Klamath Basin, “The Everglades of the West” based on the expansiveness of wetlands and the diversity and abundance of fish and wildlife he observed. Dominating this wet landscape were five key wetland/lake complexes: Klamath Marsh, Upper Klamath Lake, Lower Klamath Lake, Clear Lake and Tule Lake. Prior to European settlement, this massive aquatic ecosystem supported over 350,000 acres (Akins 1970). These wetlands provided for a diversity of fish, wildlife and plant communities, and a robust population of people. This aquatic ecosystem was the hydrologic driver of the watershed and was resilient to variability in climatic and hydrologic variability due to abundance of wetland and water storage capacity in the organic soils.

With settlement came a devaluation of wetlands, where their lands were viewed as impediments to progress although their rich organic soils were key to agriculture development. For example, the Reclamation Act of 1902 described the lands of the Upper Klamath Basin as “sunbaked prairie and worthless swamps”. In 1905, construction of the Klamath Reclamation Project started as a single purpose project to convert wetlands of the Upper Basin to agricultural production (USFWS 2016). The Klamath Project and other efforts destabilized the hydrology of the Klamath Basin by altering the natural checks and balances in the water budget. Tule Lake and Lower Klamath Lakes were removed from the landscape. Clear Lake transformed to an evaporative pool. The outflow of Upper Klamath Lake was modified with a dam and the bays and deltas were cut off with levees which altered the elevation maximum and minimums the lake could be managed. Above Upper

Box 4-1: Wetlands of the Klamath Basin (cont'd)

Klamath Lake, sections of rivers were channelized and leveed to promote more rapid movement of water to Upper Klamath Lake.

Upper Klamath Lake is now the primary storage reservoir for the Klamath Project. Despite its size, the lack of depth proves inefficient in supporting the competing demands on water supply. Effectively 80% of the original natural water storage capacity of the Upper Klamath Basin has been lost due to land modification and lack of water delivery. Compounding the challenges of this hydrologic shortfall, requirements for downstream deliveries, elevation requirements on the lake, and agricultural demand exceed the hydrologic capacity of the lake and modified watersheds (BOR 2016). In response to this water supply shortfall, actions to remedy the problem are exacerbating the deficits in the water budget. Removal of irrigation on floodplains, conversion to lined irrigation systems, and increased reliance on ground water have pushed the Upper Klamath basin to a consumptive water budget. Consumption of water exceeds the annual supply and the natural mechanisms to store water, wetlands, floodplains, and peat soil that once dominated this landscape, have been functionally removed through water management decisions (e.g., King et al. 2021, Donnelly et al., 2020, Donnelley et al., 2022).

In slightly over 100 years, the Upper Klamath Basin has experienced 95% percent loss of wetland habitat with recent drought years pushing that number even higher. The effects on the ecosystem services and species have been catastrophic. Wetlands of the Upper Klamath Basin drove the water budget and, with modification, the resiliency of the water budget has been lost. Where a water-charged basin once ensured resiliency in the face of climatic variability, drying of the organic soils has now altered the nutrient cycle and allowed nutrients locked in organic soil to mobilize through wind and water erosion and enter waterways where they contribute to eutrophication. At the same time, endemic fish that relied on dynamic aquatic conditions have lost habitat essential for survival, spawning, recruitment and refugia. Today, native fish are extirpated from both Lower Klamath Lake and Tule Lake and are clinging to existence in Clear Lake and Upper Klamath Lake, while anadromous fish species have experienced these effects as changes timing, quantity, and quality of water that discharges out of the Basin. Moreover, the Upper Klamath Basin, globally recognized as one of the most critical landscapes for migratory waterbirds has experienced a near 99% decline in waterbird populations.

As restoration practitioners consider ways to restore watershed processes throughout the Klamath Basin, it will be important to consider the many opportunities that restoration of wetlands in the upper basin can provide for addressing multiple stressors and objectives within the IFRMP.

UPPER KLAMATH LAKE

SUB-BASIN RESTORATION & MONITORING PROFILE

Photo: Upper Klamath Lake in Winter | Natascia Tamburello 2017, by permission

4.3.1 Upper Klamath Lake Sub-basin

This sub-basin is noteworthy for containing the largest population center in the Upper Klamath Basin sub-region (Klamath Falls) along with extensive ranching and agricultural lands, significantly altered hydrology, the presence of Upper Klamath Lake and Agency Lake and surrounding wetlands, and several protected areas including parts of Crater Lake National Park, Fremont-Winema National Forest, and Upper Klamath National Wildlife Refuge. Many parts of this watershed are affected by high stream temperatures, low dissolved oxygen, high pH, and high nutrient loading, which can influence downstream water quality in Upper Klamath Lake. Link River Dam in this sub-basin marks the boundary of the Upper Klamath Basin as defined for planning purposes in the IFRMP.

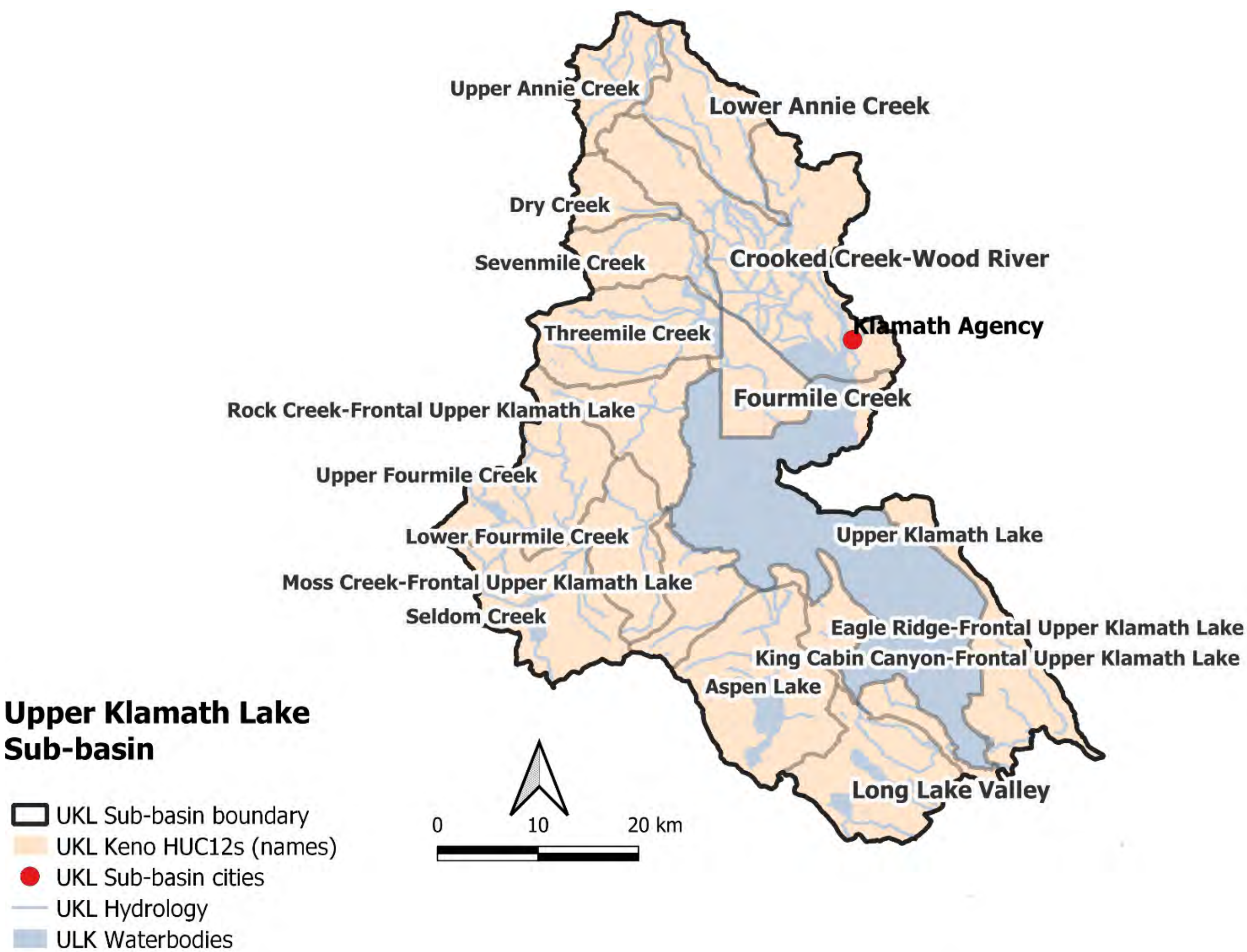


Figure 4-1: Reference map of the Upper Klamath Lake sub-basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current**: Shortnose Sucker, Lost River Sucker, Redband Trout, Bull Trout
- **Historical**: Chinook Salmon (fall-run and spring-run), summer steelhead, Pacific Lamprey,

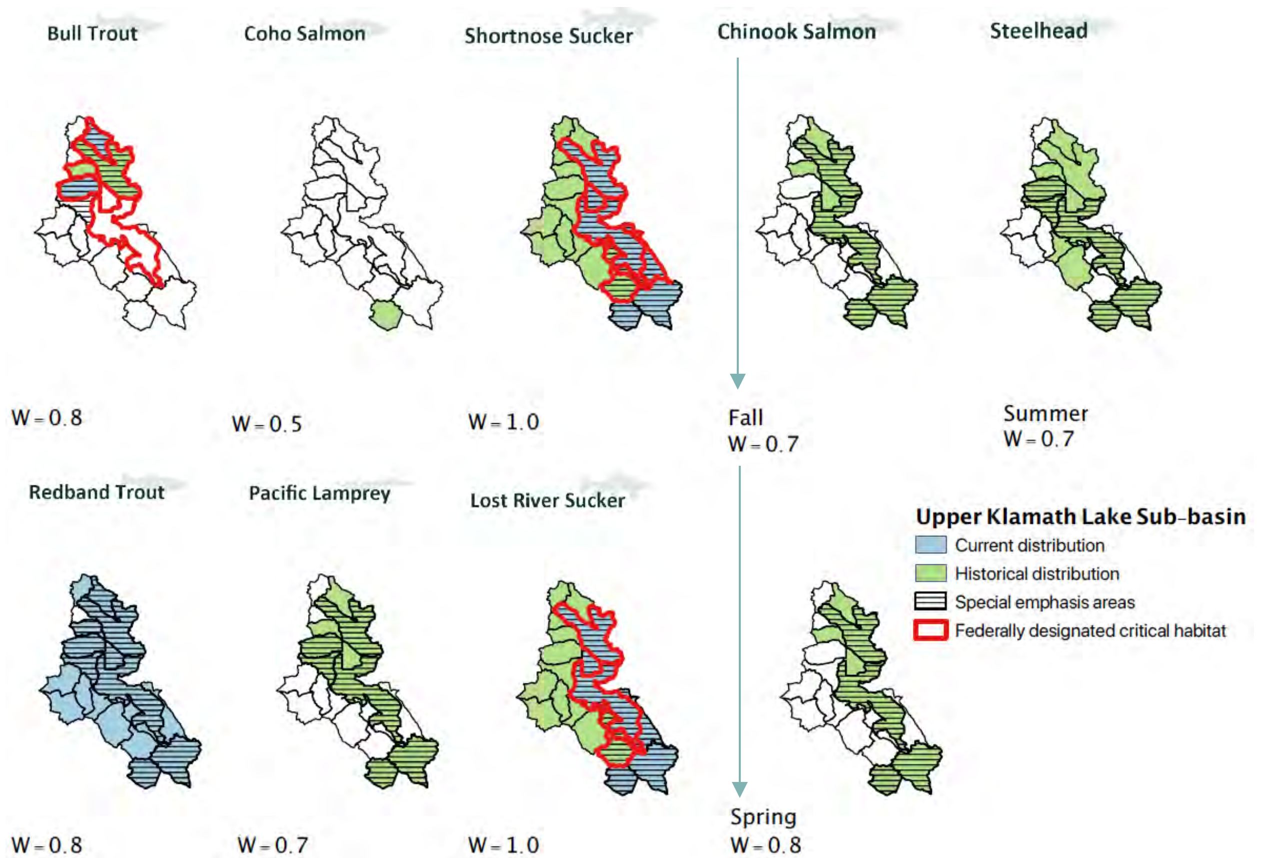


Figure 4-2: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the Upper Klamath Lake sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors

Table 4-3: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the Upper Klamath Lake sub-basin, listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. SU = suckers, BT = Bull Trout, RT = Redband Trout, CS = Chinook Salmon (future), PL = Pacific Lamprey (future) and, for this sub-basin only, L = Lake stressors primarily and T = Tributary stressors primarily.

Key Stressors	Tier	Stressor Summary for the Upper Klamath Lake Sub-basin	Species				
			SU	RT	BT	*CS*	*PL*
Water Quality - Hypereutrophication (DO, pH) *(L)*	WI	Concern within Upper Klamath Lake as a result of hypereutrophication due to nutrient inputs from surrounding agricultural lands[1]. Streams in the UKL considered to be water quality impaired based on phosphorus (TP and PP) and total suspended solids (TSS) include Fourmile Creek, Sevenmile Creek, Crooked Creek, Annie Creek, and the Wood River[6].	●	○	○	○	○
Water Temperature *(L/T)*	WI	Concern in Upper Klamath Lake as a result of shallow lake depth, and in its upstream tributaries due to increasing air temperatures, warm tailwater returns, and reduced instream flows. Tributaries of the Wood River upstream of UKL are 303d listed for temperature in summer months[1].	○	●	●	●	○

Key Stressors	Tier	Stressor Summary for the Upper Klamath Lake Sub-basin	Species				
			SU	RT	BT	*CS*	*PL*
Instream Flow *(T)*	WI, FG	Stream flow restoration priorities include waterways immediately surrounding UKL, Agency Lake[2], particularly tributaries north of UKL which may see the greatest shifts towards drier conditions in a future climate (Thorne et al. 2015).	○	○	○	○	○
Fish Entrainment *(T)*	H	Entrainment in unscreened diversions is a concern for all fish species, with the highest concentrations of unscreened diversions found in tributaries of the Wood River[1,3]. Particular streams rated most highly impaired for fish screening include Lower Annie Creek, Crane Creek, Upper Crooked Creek, Upper Short Creek, and the middle reaches of Sevenmile Creek[6]. Furthermore, substantial numbers of suckers are entrained into the East Side and West Side hydroelectric canals at Link River Dam and drawn downstream below the dam (USFWS 2012).	●	●	●	●	●
Habitat Complexity (mesohabitats) *(T)*	H	Concern relating to instream habitat including suitable gravels (for spawning) and large woody debris and riparian vegetation or wetlands (for juvenile rearing and adult feeding and shelter). Of greatest concern in areas listed as critical habitat for BT (Threemile Creek, Sun Creek), RT (Wood River, Sevenmile Canal & Creek, Fourmile Creek), and suckers (UKL, lower Wood River, and lower Crooked Creek)[4]. Streams considered most impaired by engineered channelization that limits habitat complexity include Upper Crooked Creek, and lower reaches of Fourmile, Sevenmile Creeks[6].	●	●	○	●	●
Anthropogenic barriers *(T,L)*	H	In tributaries, relates to loss of physical access to suitable spawning and rearing areas for suckers, Redband Trout, and Bull Trout due to fish passage barriers. Tributaries where access may be particularly limited by fish passage barriers include Link River, Threemile Creek, Fourmile Creek, Agency Creek, Upper Crooked Creak, and Annie Creek[5,6]. In Upper Klamath Lake, access relates to effect of lake levels on juvenile sucker access to lake fringe wetlands (USFWS 2012).	●	○	○	○	○

Spatial stressor hotspots identified from (1) Trout Unlimited Conservation Success Index (Fesenmeyer et al. 2013) data, (2) ODFW Streamflow Restoration Prioritization Maps, (3) ODFW 2013 Diversion Screening Priority List (4) CDFW BIOS Map of USFWS Species Critical Habitats (5) ODFW 2013 Fish Passage Priority List (6) UKB WAP Restoration Prioritization Framework Tool

Sequences of Restoration Projects for the Upper Klamath Lake Sub-Basin

The **summary infographic** in Figure 4-3 provides a compact overview of the Upper Klamath Lake sub-basin restoration project priorities and their distribution across the sub-basin. Table 4-4 presents the detailed results of the 2022 iteration of the IFRMP restoration sequencing process for the Upper Klamath Lake sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-4. The full list represents all important project concepts that should be considered in the coming decades. The projects listed have a cost range of $6.7M - $43.4M – $97.7M (low, estimated midpoint, high), and have been collated from projects proposed in prior local or regional restoration plans and studies and in-depth discussions among participants in the Upper Klamath Lake Sub-basin Working Group who represent scientists, restoration practitioners, and resource users in the sub-basin (see Acknowledgements section).

Figure 4-3: Summary for the Upper Klamath Lake sub-basin, including key stressors, cost ranges, and projects. In the Key Summary Table, note that L refers to stressors in Upper Klamath Lake and T refers to stressors in Tributaries (see next page).

Upper Klamath Lake Sub-basin

Sub-Basin Summary

This small sub-basin is notable for the largest population center in the Upper Klamath Basin Sub-Region (Klamath Falls) along with extensive ranching and agricultural lands, the presence of the large Upper Klamath Lake and Agency Lake and surrounding wetlands, and several protected areas including parts of Crater Lake National Park, Fremont-Winema National Forest, Upper Klamath National Wildlife Refuge.

Restoration Summary

A diverse variety of projects were identified by the working group for improving habitat conditions. Projects rated most highly covered a range of needed restoration activities: improving water quality through tailwater treatment and wetland restoration (Projects 14 and 3), improving stream flows (Project 7), improving general instream habitat conditions (Projects 1, 11, 11a, and 8b) and improving fish passage at Link Dam (Project 12). These should be considered among the top group of restoration projects to be considered first for implementation.

Projects ranked as of more intermediate restoration importance covered a range of mitigations/restorations relating to screening of diversions, spring reconnections, establishment of DSTWs, management of livestock, and channel reconnections.

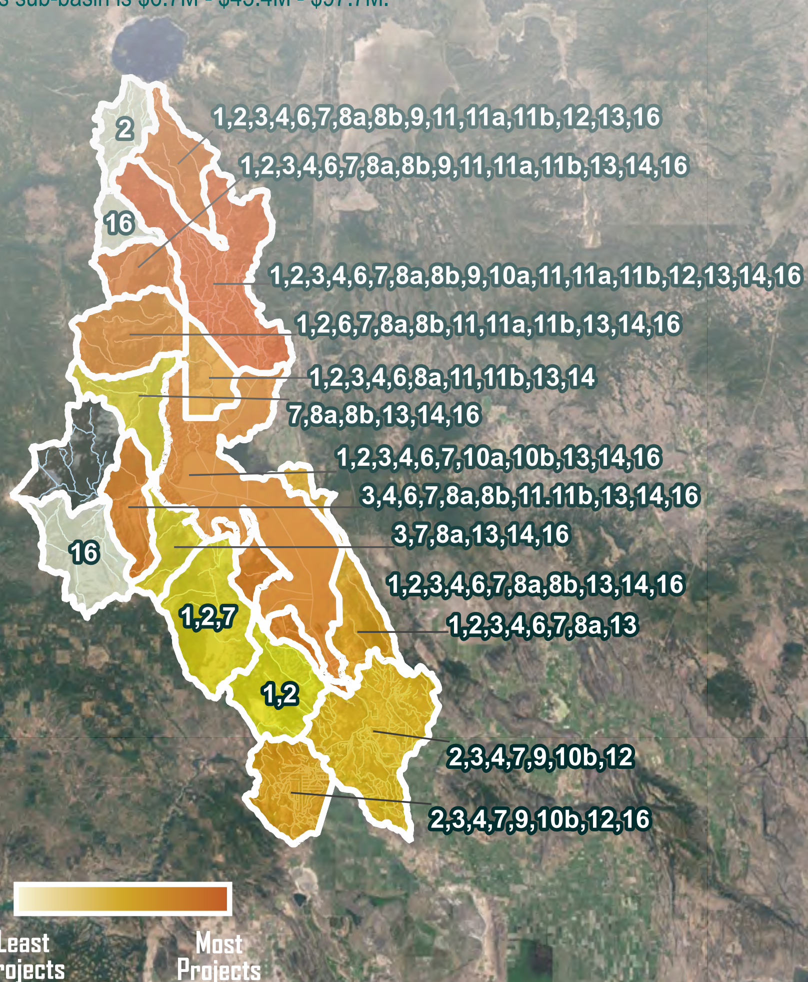
Key Stressor Summary

Key Stressors	Focal Species (Current and *Future*)				
	SU	RT	BT	*CS*	*PL*
Hypereutrophication (DO, pH) *(L)*					
Temperature *(L)*					
Instream Flow *(T)*					
Fish Entrainment *(T)*					
Habitat complexity *(T)*					
Access to Spawning & Rearing Habitats *(L, T)*					

L = Lake, T = Tributary

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is $6.7M - $43.4M - $97.7M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP UKL sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting, and **arrows** indicate linkages between projects.

Project ID & Description	Tiers
UKL 1 - Improve riparian grazing management and undertake riparian actions to improve habitat conditions in key Upper Klamath Lake tributaries | **26.5**	H, FG
UKL 8b_11_11b - Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge | **24.4**	WI, H, FG
UKL 14 - Separate out and treat tailwater discharge in key areas of the Upper Klamath Lake Sub-basin | **21.7**	WI
UKL 11a - Supplement spawning gravels in key sub-basin tributaries to benefit trout and returning anadromous salmonids. | **19.3**	H
UKL 3 - Restore fringe wetlands in priority areas identified in the UKBWAP to improve water quality and provide habitat for endangered suckers | **19.2**	H
UKL 13 - Remove priority fish passage barriers at small dams and culverts across key sub-basin tributaries | **19.0**	H
UKL 16 - Manage livestock in upland areas of the sub-basin to improve vegetation structure, control erosion and reduce sediment flow into streams | **18.7**	WI
UKL 7 - Improve summertime flows by encouraging irrigation water use efficiencies and voluntary transfer of water rights for instream flows to benefit fish and riverine processes | **18.7**	WI, FG
UKL 6 - Reconnect key springs in the sub-basin and restore surrounding habitat to provide fish refuges during periods of poor water quality | **18.7**	FG, H
UKL 10a - Supplement shoreline spawning gravels for lake-spawning suckers in Upper Klamath Lake | **18.3**	H
UKL 9 - Screen priority diversions around Upper Klamath Lake and other key areas in the sub-basin using physical or non-physical exclusion barriers | **18.1**	H
UKL 8a - Reconstruct channelized portions of key sub-basin tributaries to improve fish habitat, increase water residence time, and maximize groundwater recharge | **17.6**	FG
UKL 2 - Improve irrigation practices to reduce sediment and phosphorus loading to key streams in the Upper Klamath Lake Sub-basin | **16.4**	WI
UKL 4 - Establish DSTWs across the sub-basin to reduce nutrient loading to Upper Klamath and Agency lakes or downstream tributaries | **15.8**	WI
UKL 10b - Ensure access for suckers to Upper Klamath Lake shoreline spawning areas by managing lake levels | **11.0**	H, WI

The sequences and scoring in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria. Additional considerations such as implementability, cost, and dependencies among projects may influence the ultimate sequencing of projects. The working group did not identify any specific dependencies between projects, but they did provide preliminary suggestions of broad sequencing of grouped projects. In this regard they suggested that projects 1, 8b_11_11b, and 14 could be considered as a first sequence of projects for implementation, followed by project 11a, and then projects 3 and 13 (see Table 4-4 for project descriptions). Other remaining projects could then be implemented in any order. Sequencing of projects will be very important for maximizing benefits in the sub-basin. While discussion of this topic has been initiated determining the best sequencing for multi-project implementation across the Upper Klamath Lake sub-basin needs further deliberation by the working group.

To facilitate consistent comparison across the sub-basins, results in Table 4-4 are shown for the Upper Klamath Lake sub-basin assuming a scenario where the four lower Klamath River hydroelectric dams have been removed (with other factors, including climate similar to current conditions). The majority of UKL Sub-basin Working Group participants felt that most restoration activities will be more effective with the four lower Klamath River hydroelectric dams removed[8], but the majority of these same participants also acknowledged that that the sequencing and choices of restoration actions themselves are not expected to change significantly even if the Klamath mainstem were not removed (which as of November 17 2022 appears highly unlikely). The Sub-basin Working Group identified the following additional scenarios with the potential to influence restoration priorities in the Upper Klamath Lake sub-basin. Should any of these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

- Changes in water rights regulation
- Implementation of conservation easement programs[9]
- Fish passage through the Klamath hydro project
- Sucker population status
- Improved agricultural practices
- Acceptance of voluntary restoration actions by the farming community
- Changes in the Biological Opinion related to flow management

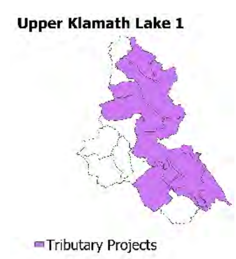
A diverse variety of projects were identified by the working group for improving habitat conditions in the Upper Klamath Lake sub-basin. Projects that rated most highly in the IFRMP Tool covered a range of needed restoration activities: improving riparian grazing management, creating fish habitat and improving water residence time, as well as improving water quality through tailwater treatment and (Projects 1, 8b_11_11b, and 14), and improving general instream and wetland habitat conditions (Projects 11a, 3, and 13). These should be considered among the top group of restoration projects to be considered first for implementation. Projects ranked as of more intermediate restoration importance included Projects 16, 7, 6, 10a, and 9. These covered a range of mitigations / restorations relating to upland livestock management, irrigation and water rights improvements, reconnecting springs, shoreline gravel supplementation at lakes, and screening of priority diversions. Projects ranked lower included Projects 8a, 2, 4, and 10b. These focused on reconnecting tributaries, reducing sediment inputs and phosphorus loading, establishing DSTWs to reduce nutrient loading, and improved sucker access to lakeshore spawning areas.

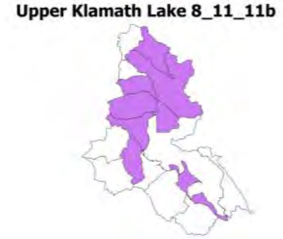
---

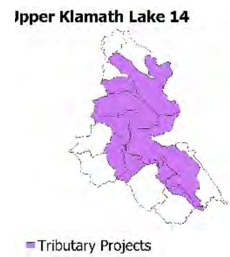
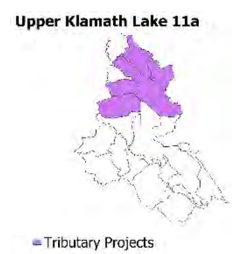
[8] Until Phase 5 of IFRMP development it was not clear what the final FERC decision would be with regards to dam removal so IFRMP facilitators asked participants to consider both dams in and dams out scenarios.

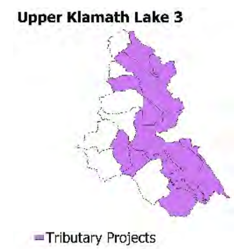
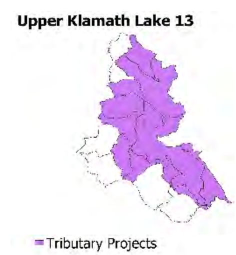
[9] A conservation easement is a voluntary agreement with a nonprofit land trust or government agency that allows a landowner to limit the type or amount of development on their property while retaining private ownership of the land (www.fire.ca.gov; https://www.calandtrusts.org/conservation-basics/conservation-tools/conservation-easement/).

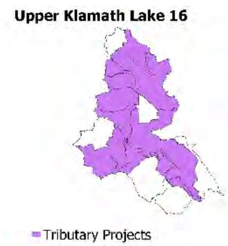
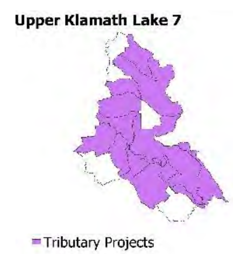
Table 4-4: Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the Upper Klamath Lake (UKL) sub-basin, with projects scored higher to be considered first for implementation. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name (in parentheses). Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-1 while special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin IFRMP planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

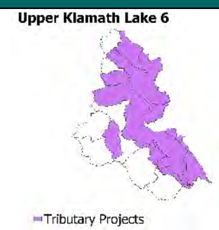
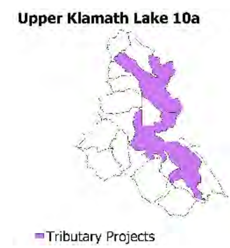
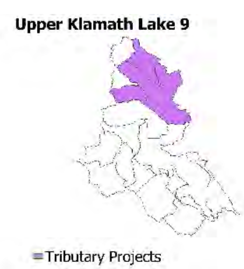
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
Upper Klamath Lake 1 (26.5)	**Work with agriculture interests and others to improve riparian grazing management and undertake riparian actions to improve habitat conditions in key Upper Klamath Lake tributaries.** **Project Description:** Manage grazing strategies using rotation or variable timing on private lands in the Wood River, which has the highest concentration of stream miles in this sub-basin that are 303d listed for nutrients, to reduce riparian degradation, streambank erosion, and cattle nutrient inputs (USFWS 2015, IRCT 2016). Additionally, conduct riparian planting to restore riparian corridors to re-establish canopy, shade, and instream habitat along streams that flow into Upper Klamath Lake to reduce nutrient and sediment loading (PacifiCorp 2018), particularly along Threemile Creek and the Wood River and its tributaries (USFWS 2015, IRCT 2016). Facilitate riparian planting through cooperative agreements, conservation easements or land acquisition as needed. Lastly, deploy physical fences to exclude/prevent unwanted disturbance of riparian areas and planted vegetation in order to preserve the benefits of the related restoration actions. **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Riparian planting, Fencing, Riparian area conservation grazing management **Near-Term Focal Areas (map):** 9 sub-watersheds, Annie Creek*,**, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Threemile Creek*,**, Fourmile Creek*,**, Aspen Lake, Eagle Ridge-Frontal Upper Klamath Lake*,**, King Cabin Canyon-Frontal Upper Klamath Lake*,**, Upper Klamath Lake*,** **Cost range ($K):** $438 – 1,438 – 2,688 (incomplete – no "riparian area conservation grazing management" data) 	**1.02**	**5.97**	**7.25**	**5.25**	**7**
Upper Klamath	**Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge.**	**0.76**	**6.68**	**8**	**3.5**	**5.43**

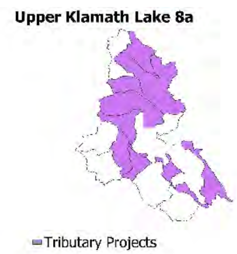
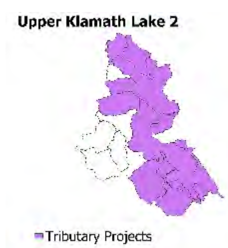
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
Lake 8b_11_11b (24.4)	**Project Description:** Strategic restoration through beaver management (where permissible under local regulations) or beaver dam analogues to increase water residence time with benefits for maximizing groundwater recharge, improving base flows, and creation of fish habitat. Emphasis on channelized portions of Sun Creek, Annie Creek, Sevenmile Creek/Canal and Fourmile Creek / Canal (Barry et al. 2010), and reconnection of Threemile Creek and Cherry Creek to Fourmile Creek (IRCT 2016), located within the Threemile Creek sub-watersheds. Spawning and rearing habitat in these areas can be further enhanced by pairing process-based restoration actions with the addition of large wood and spawning gravels to benefit trout and, later, returning anadromous salmonids, with an emphasis on the Wood River and its tributaries (Barry et al. 2010). Preliminary observations from such efforts on tributaries of the Williamson River have shown that gravels of the size preferred by Coho and Chinook Salmon can also be used by adfluvial Redband Trout, which may help to streamline gravel augmentation programs for multispecies benefit (Hereford et al. 2018). Such projects should be carefully reviewed for adequate flow conditions to prevent potential exacerbation of disease caused by *C. shasta* through inadvertent enhancement for substrate habitat of the intermediate annelid worm host (Hillemeier et al. 2017). **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Channel structure placement, Spawning gravel placement, Addition of large woody debris, Beavers & beaver dam analogs **Near-Term Focal Areas (map):** 8 sub-watersheds, Annie Creek*,**, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Lower Fourmile Creek, Fourmile Creek*,**, Rock Creek-Frontal Upper Klamath Lake**, Eagle Ridge-Frontal Upper Klamath Lake*,**, Threemile Creek  **Cost range ($K):** $653 – 3,283 – 5,888					
Upper Klamath Lake 14 (21.7)	**Work with agriculture interests and others to separate out and treat tailwater discharge in key areas of the Upper Klamath Lake sub-basin** **Project Description:** Provide assistance to ag operators to create the capability to filter winter pump-off in a manner that can be integrated into their operations by modifying irrigation practices and treating return flow (via DSTWs, bioswales, etc.) that would otherwise be pumped directly to UKL. A comprehensive strategy is being developed to separate out and treat tailwater discharge in the northeast section of the lake (UKL / Westside Canal / Sevenmile Creek / Wood River). **Dependencies / Project Linkages:** No dependencies identified	**0.78**	**6.53**	**7.18**	**5.25**	**1.92**

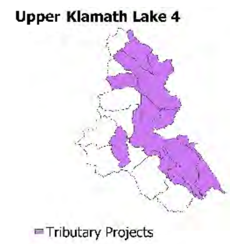
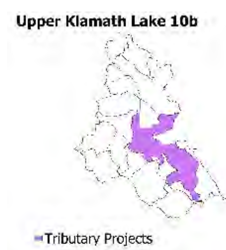
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
	Primary Action Types: Irrigation practice improvement, Tailwater return reuse or filtering, Stormwater filtering, Artificial wetland created **Near-Term Focal Areas (map):** 9 sub-watersheds, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Lower Fourmile Creek, Threemile Creek*,**, Fourmile Creek*,**, Rock Creek-Frontal Upper Klamath Lake**, Moss Creek-Frontal Upper Klamath Lake, Eagle Ridge-Frontal Upper Klamath Lake*,**, Upper Klamath Lake*,** Note that focal areas are subject to change based on future recommendations of North Coast Regional Water Quality Control Board.  **Cost range ($K):** $295 – 1,390 – 2,300 (incomplete – no "stormwater filtering" data)					
Upper Klamath Lake 11a (19.3)	**Supplement spawning gravels in key sub-basin tributaries to benefit trout and returning anadromous salmonids.** **Project Description:** Improve spawning habitat in tributaries through addition of spawning gravels the Wood River and its tributaries to benefit trout and, later, returning anadromous salmonids (Barry et al. 2010). Preliminary observations from such efforts on tributaries of the Williamson River have shown that gravels of the size preferred by Coho and Chinook Salmon can also be used by adfluvial Redband Trout, which may help to streamline gravel augmentation programs for multispecies benefit (Hereford et al. 2018). **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Spawning gravel placement **Near-Term Focal Areas (map):** 4 sub-watersheds, Annie Creek*,**, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Threemile Creek*,**  **Cost range ($K):** $150 – 350 – 550	**1.37**	**8.58**	**0.8**	**3.5**	**5.09**
Upper Klamath Lake 3 (19.2)	**Restore fringe wetlands in priority areas identified in the UKBWAP to improve water quality and provide habitat for endangered suckers.** **Project Description:** Pursue restoration of additional lake fringe wetlands through wetland reserve easements, land acquisition and flooding, and other types of restoration (e.g., in the Wood River Wetlands as well as through planned levee breaching on former wetlands on Barnes Ranch and Agency Lake Ranch). Priority wetlands are currently being identified through the Upper Klamath Basin Watershed Action Planning process (PacifiCorp 2018). In addition to improving water quality, this is expected to provide habitat for lake-rearing suckers. This sub-basin is a priority Conservation Opportunity Area for wetland restoration under the Oregon Conservation Strategy (ODFW 2016).	**0.71**	**6.11**	**5.44**	**5.25**	**1.64**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
	Dependencies / Project Linkages: No dependencies identified **Primary Action Types:** Wetland improvement/restoration, Dike or berm modification/removal **Near-Term Focal Areas (map):** 10 sub-watesheds, Annie Creek*,**, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Lower Fourmile Creek, Fourmile Creek*,**, Moss Creek-Frontal Upper Klamath Lake, Long Lake Valley*,**, Eagle Ridge-Frontal Upper Klamath Lake*,**, King Cabin Canyon-Frontal Upper Klamath Lake*,**, Upper Klamath Lake*,**  **Cost range ($K):** $694 – 8,406 – 25,150 (based partly on cost data from Trinity)					
Upper Klamath Lake 13 (19.0)	**Remove priority fish passage barriers at small dams and culverts across key sub-basin tributaries.** **Project Description:** Assess, prioritize, and remove or improve passage at smaller fish passage barriers including small hydroelectric or diversion dams and culverts in this sub-basin, guided by the ODFW 2013 Fish Passage Priority List. Priorities in this basin include 12 fish passage barriers across Threemile Creek, Fourmile Creek & Canal, Sevenmile Canal, Annie Creek, Sun Creek, and Agency Creek. **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Minor fish passage blockages removed or altered, Culvert installed or improved at road stream crossing **Near-Term Focal Areas (map):** 11 sub-watersheds, Annie Creek*,**, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Lower Fourmile Creek, Threemile Creek*,**, Fourmile Creek*,**, Rock Creek-Frontal Upper Klamath Lake**, Moss Creek-Frontal Upper Klamath Lake, Eagle Ridge-Frontal Upper Klamath Lake*,**, King Cabin Canyon-Frontal Upper Klamath Lake*,**, Upper Klamath Lake*,**  **Cost range ($K):** $25 – 400 – 1,200 (incomplete – no data for "culvert installed or improved at road stream crossing")	**0.72**	**6.46**	**3.45**	**3.5**	**4.82**
Upper Klamath Lake 16 (18.7)	**Manage livestock in upland areas of the sub-basin to improve vegetation structure, control erosion and reduce sediment flow into streams.** **Project Description:** Upland livestock management via livestock watering schedules and grazing management plans (e.g., installation of upland ditches) to control erosion and sediment flow into streams and promote more heterogeneous vegetation structure, diversity and biomass. **Dependencies / Project Linkages:** No dependencies identified	**0.3**	**6.46**	**1.97**	**5.25**	**4.76**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
	<u>Primary Action Types:</u> Upland livestock and grazing management  **<u>Near-Term Focal Areas (map):</u>** 12 sub-watersheds, Annie Creek*,**, Dry Creek, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Seldom Creek, Lower Fourmile Creek, Threemile Creek*,**, Rock Creek-Frontal Upper Klamath Lake**, Moss Creek-Frontal Upper Klamath Lake, Eagle Ridge-Frontal Upper Klamath Lake*,**, Upper Klamath Lake*,**, Keno Reservoir-Klamath River** **<u>Cost range ($K):</u>** $775 – 4,650 – 9,300					
Upper Klamath Lake 7 (18.7) Policy Focused Action	**Work with agriculture interests and others to improve summertime flows by encouraging irrigation water use efficiencies & voluntary transfer of water rights for instream flows to benefit fish and riverine processes** **<u>Project Description:</u>** Implement improvements in summertime stream flows through increased water use efficiency, transfer of water rights to instream uses, and other voluntary actions to benefit fish and riverine processes, particularly in the Wood River (Annie Creek and Crooked Creek), and Fourmile Lake, which is in the Upper Fourmile Creek sub-watershed (IRCT 2016).  **<u>Dependencies / Project Linkages:</u>** No dependencies identified **<u>Primary Action Types:</u>** Water leased or purchased, Manage water withdrawals **<u>Near-Term Focal Areas (map):</u>** 15 sub-watersheds, Annie Creek*,**, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Lower Fourmile Creek, Threemile Creek*,**, Rock Creek-Frontal Upper Klamath Lake**, Moss Creek-Frontal Upper Klamath Lake, Aspen Lake, Long Lake Valley*,**, Eagle Ridge-Frontal Upper Klamath Lake*,**, King Cabin Canyon-Frontal Upper Klamath Lake*,**, Upper Klamath Lake*,**, Klamath Falls-Klamath River**, Keno Reservoir-Klamath River**, Upper Fourmile Creek **<u>Cost range ($K):</u>** $1,869 – 6,362 – 10,708 (incomplete – no data for "manage water withdrawal")	**0.32**	**6.11**	**5.81**	**5.25**	**1.23**
Upper Klamath Lake 6 (18.7)	**Reconnect key springs in the sub-basin and restore surrounding habitat to provide fish refuges during periods of poor water quality.** **<u>Project Description:</u>** Reconnect springs and restore surrounding habitat (e.g., through addition of large woody debris) to ensure access to high-quality spring-fed refuges during periods of poor water quality, with a focus on the Wood River as well as Pelican Bay in Upper Klamath Lake (USFWS 2012). **<u>Dependencies / Project Linkages:</u>** No dependencies identified **<u>Primary Action Types:</u>** Instream flow project (general), Water quality project (general)	**1.12**	**6.82**	**4.62**	**3.5**	**2.61**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
	Near-Term Focal Areas (map): 9 sub-watersheds, Annie Creek*,**, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Lower Fourmile Creek, Threemile Creek*,**, Fourmile Creek*,**, Eagle Ridge-Frontal Upper Klamath Lake*,**, King Cabin Canyon-Frontal Upper Klamath Lake*,**, Upper Klamath Lake*,** **Cost range ($K):** $150 – 1,070 – 2,110 					
Upper Klamath Lake 10a (18.3)	**Supplement shoreline spawning gravels for lake-spawning suckers in Upper Klamath Lake.** **Project Description:** Improve habitat quantity and quality of shoreline springs in Upper Klamath Lake for lake-spawning suckers through reasonable gravel substrate improvement and expansion, taking care to consider and mitigate any unintended consequences of gravel addition (USFWS 2012). **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Spawning gravel placement **Near-Term Focal Areas (map):** 2 sub-watersheds, Crooked Creek-Wood River*,**, Upper Klamath Lake*,** **Cost range ($K):** $25 – 200 -550 	**3**	**6.61**	**0.8**	**3.5**	**4.36**
Upper Klamath Lake 9 (18.1)	**Screen priority diversions around Upper Klamath Lake and other key areas in the sub-basin using physical or non-physical exclusion barriers.** **Project Description:** Identify and screen roughly 100 unscreened diversions (per 2013 ODFW inventory) around Upper Klamath Lake (especially Lake Ewauna and pumps) and on the Wood River, using physical or non-physical barriers suitable for excluding suckers, trout, and eventually anadromous salmonids and lamprey (Barry et al. 2010, USFWS 2015, IRTC 2016). Priority diversions in the Wood River sub-watershed are identified and ranked in the ODFW 2013 Priority Unscreened Diversion Inventory for the Klamath Basin. Screening to prevent downstream entrainment of suckers and possibly Redband Trout into the East Side and West Side hydroelectric canals at Link River Dam should also be explored (USFWS 2012). **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Fish screens installed **Near-Term Focal Areas (map):** 3 sub-watersheds, Annie Creek*,**, Sevenmile Creek*,**, Crooked Creek-Wood River*,** **Cost range ($K):** $315 – 2,835 – 5,828 	**1.49**	**9**	**0.85**	**1.75**	**5.01**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
Upper Klamath Lake 8a (17.6)	**Reconstruct channelized portions of key sub-basin tributaries to improve fish habitat, increase water residence time, and maximize groundwater recharge.** **Project Description:** Strategic restoration through hydrologic reconstruction and re-meandering to increase water residence time with benefits for maximizing groundwater recharge, improving base flows, and creation of fish habitat. Emphasis on channelized portions of Sun Creek, Annie Creek, Sevenmile Creek/Canal and Fourmile Creek / Canal (Barry et al. 2010), and reconnection of Threemile Creek and Cherry Creek to Fourmile Creek (IRCT 2016), located within the Threemile Creek sub-watersheds. Should be combined with low-tech process-based restoration measures. **Dependencies / Project Linkages:** No dependencies identified.  **Primary Action Types:** Mechanical channel modification and reconfiguration **Near-Term Focal Areas (map):** 10 sub-watersheds, Annie Creek*,**, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Lower Fourmile Creek, Threemile Creek*,**, Fourmile Creek*,**, Rock Creek-Frontal Upper Klamath Lake**, Moss Creek-Frontal Upper Klamath Lake, Eagle Ridge-Frontal Upper Klamath Lake*,**, King Cabin Canyon-Frontal Upper Klamath Lake*,** **Cost range ($K):** $625 – 9,450 – 25,000	**0.5**	**7.03**	**2.62**	**3.5**	**3.96**
Upper Klamath Lake 2 (16.4)	**Work with agriculture interests and others to improve irrigation practices to reduce sediment and phosphorus loading to key streams in the Upper Klamath Lake sub-basin.** **Project Description:** Minimize irrigation return flow via conversion of flood or furrow irrigation into drip, sprinkler, or gated pipe irrigation to reduce sediment and phosphorus loading and retain agricultural soils in the Sprague River, Williamson River, Upper Klamath Lake, Wood River, Lost River, Upper Klamath East, and Butte Creek (PacifiCorp 2018).  **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Irrigation practice improvement **Near-Term Focal Areas (map):** 11 sub-watersheds, East Fork Annie Creek, Annie Creek*,**, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Threemile Creek*,**, Fourmile Creek*,**, Aspen Lake, Long Lake Valley*,**, Eagle Ridge-Frontal Upper Klamath Lake*,**, King Cabin Canyon-Frontal Upper Klamath Lake*,**, Upper Klamath Lake*,** **Cost range ($K):** $94 – 437 – 750	**0.73**	**5.41**	**2.19**	**5.25**	**2.84**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
Upper Klamath Lake 4 (15.8)	**Establish DSTWs across the sub-basin to reduce nutrient loading to Upper Klamath and Agency lakes or downstream tributaries.** **Project Description:** Establish a network of Diffuse Source Treatment Wetlands (DSTWs) to capture phosphorus and nitrogen and reduce loading to Upper Klamath and Agency lakes or downstream tributaries (PacifiCorp KHSA Interim Measures Phase 2, 2018). **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Artificial wetland created **Near-Term Focal Areas (map):** 8 sub-watersheds, Annie Creek*,**, Sevenmile Creek*,**, Crooked Creek-Wood River*,**, Lower Fourmile Creek, Fourmile Creek*,**, Eagle Ridge-Frontal Upper Klamath Lake*,**, King Cabin Canyon-Frontal Upper Klamath Lake*,**, Upper Klamath Lake*,**  **Cost range ($K):** $660 – 3,080 – 5,720	0.99	5.9	2.25	5.25	1.45
Upper Klamath Lake 10b (11.0)	**Ensure access for suckers to Upper Klamath Lake shoreline spawning areas by managing lake levels.** **Project Description:** Improve habitat quantity and quality in Upper Klamath Lake for lake-spawning suckers during periods of poor water quality (July to September) by managing lake levels to ensure spring connectivity (USFWS 2012), in a way that is consistent with BiOp and project operation plans. **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Manage dam releases (Link River Dam) **Near-Term Focal Areas (map):** 1 sub-watershed, benefits accrue to spawning populations in Upper Klamath Lake*,**, but note that the actions themselves involve changes in operations to Link River Dam in the Klamath Falls-Klamath River**subwatershed (part of the Lost Sub-Basin)  **Cost range ($K):** no cost data available	2.9	0.9	1.23	5.25	0.7

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC & SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, sub-regional working group input via surveys and webinars.

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the Upper Klamath Lake sub-basin

Of the focal fish species currently found throughout this sub-basin, ***Shortnose Sucker and Lost River Sucker*** are of the greatest immediate conservation concern, with captive rearing programs in place to counter continuing population declines. ***Redband Trout*** and ***Bull Trout*** populations in this sub-basin are also of conservation concern. ***Chinook Salmon***, ***steelhead***, and ***Pacific Lamprey*** all once occupied this sub-basin in the past and are expected to fully return to this sub-basin following restoration of fish passage from the Lower Klamath River.

Within the Upper Klamath Lake sub-basin, Upper Klamath Lake and the Wood River Valley is a priority Conservation Opportunity Area under Oregon's Conservation Strategy, with recommended conservation actions such as maintain or improve wetland habitats through reconnection of lakeside wetlands, restore natural waterbody connections to the Williamson River Delta, and restore riparian habitat to increase habitat complexity (ODFW 2016).

The following table summarizes select major past restoration activities in this sub-basin and the fish species these activities have benefited. Though these restoration actions are considered complete, not all habitats have yet regained full ecological function. Some of these activities have occurred at smaller scales and yielded local benefits, but these are not yet so impactful as to detect improvements in water quality conditions at the sub-basin scale.

Table 4-5: Summary of major restoration efforts in the Upper Klamath Lake sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit (including focal species not currently present in the sub-basin).

Key Restoration Activities in the Upper Klamath Lake sub-basin to Date	Species Benefiting				
	SU	RT	BT	*CH/ST*	*PL*
Restoration of large swaths of lake fringe wetlands including the Williamson River Delta and Wood River wetlands to improve water quality and rearing conditions as well as spawning conditions for suckers at lakeside springs and in tributaries (via addition of gravels). These actions also benefit other species using these habitats.	●	○	○	○	○
Selected water management (including improved irrigation conveyance efficiency, tailwater capture & treatment) and grazing management activities have been completed to reduce nutrient inputs to Upper Klamath Lake.	●	●	●	●	●
Instream and riparian habitat restoration in tributaries of the Wood River Valley above Upper Klamath Lake, including whole-channel reconstruction of Sun Creek, addition of gravel, large wood, and riparian restoration (Buktenica et al. 2018).	○	●	●	○	○
Screening of agricultural diversions (especially screening of the A-canal) to reduce entrainment and the removal of some fish passage barriers in tributaries to Upper Klamath Lake.	●	●	●	●	●
Construction and confirmed use of the Link River fish ladder to restore upstream passage for suckers and other fish back into Upper Klamath Lake (USFWS 2012).	●	○		●	●

Current State of Monitoring & Data Gaps

Past and Ongoing Monitoring:

There are numerous past and present monitoring programs in this sub-basin thanks to a variety of partnerships between The Klamath Tribes, the USGS, the USFWS, the ODFW, the Oregon Water Resources Department (OWRD), Oregon State University (OSU), Trout Unlimited (TU), and private landowners.

Water quality data has been collected by The Klamath Tribes (and more recently by the USGS) at sites in and above Upper Klamath and Agency lakes since the late 1980s (Kann 2017a, b). Sampling includes water nutrients, temperature, water chemistry, discharge, and other material critical for aquatic life (i.e., chlorophyll-a, phaeophytin, algal toxins, aquatic biota).

Since 1995, the USGS has also conducted a long-term capture-recapture program to assess the status and changes of Lost River and Shortnose suckers. This program is ongoing and feeds into what may be the most detailed long-term dataset for any non-anadromous endangered fish in the US. Suckers are captured and tagged with passive integrated transponder (PIT) tags during their annual spawning migrations and occasionally during special translocation projects to better understand their behavior and inform conservation work (Hewitt et al. 2014, 2018; Banet and Hewitt 2019). . Much of the USGS work on suckers builds upon a foundation of earlier long-term research on suckers carried out by Dr. Douglas Markle of Oregon State University (OSU), and continues to contribute to our understanding of fish in this sub-basin through research by Dr. Jonny Armstrong on the movement ecology of tributary-spawning Redband Trout and their use of cold-water springs.

The USFWS and partners also monitor Lost River and Shortnose sucker fry survival and health in Upper Klamath Lake (Foott 2004; Stone et al. 2017) and the Klamath Basin Area Office of the U.S. Bureau of Reclamation (USBR) has monitored juvenile and adult suckers in Upper Klamath Lake and Lake Ewauna for nearly two decades. Monitoring juveniles at the A-Canal Fish Evaluation Station (FES) by the USBR is a Monitoring and Reporting requirement in the 2019 Biological Opinion (BiOp) (USFWS 2019a).

The Oregon Department of Fish and Wildlife (ODFW) also works with partners to conduct a large number of fish restoration and monitoring projects in the Oregon portions of the Klamath Basin (ODFW 2016). Most of these efforts are focused on population monitoring for a variety of listed and unlisted species, however, ODFW also conducts water temperature monitoring for Redband Trout habitat. Additional monitoring of groundwater and streamflow is also conducted by OWRD.

Trout Unlimited (TU) conducts monitoring in the Upper Klamath Lake sub-basin to help guide future restoration actions. TU collects information on stream temperatures and flows, water quality, and channel form and geomorphology, often in collaboration with private landowners. TU also partners with Crater Lake National Park staff to document the movements of Bull Trout in Sun Creek and Wood River.

Figure 4-4 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring across agencies in the Upper Klamath Lake sub-basin. In general, there are strong coordinated programs for monitoring of both juvenile and adult Shortnose and Lost River suckers in the Upper Klamath Lake sub-basin (e.g. USGS PIT tag monitoring network). Project implementation and localized effectiveness of individual restoration projects are generally tracked as part of funding reporting requirements (although this data is not always readily available).

As indicated by the Klamath Basin Monitoring Program (KBMP), an organization that coordinates the compilation and sharing of natural resource information in the basin, many groundwater and surface water quantity and quality monitoring sites occur within the Upper Klamath Lake sub-basin, particularly where water is taken for irrigation and impacts from agriculture are common. However, occasional equipment failures and gaps between monitoring stations suggest room for improvement, particularly to help achieve the spatial resolution needed to track restoration effectiveness. As one example, seasonal nutrient loading is well-characterized in some locations such as the mouths of major tributaries to UKL and along parts of the Sprague River, but gaps remain in critical areas including the Wood River Valley and specific locations on the Sprague River system.

Upper Klamath Lake Sub-basin Monitoring Summary

Habitat Monitoring	Watershed Inputs	Weather	●
		Streamflow	●
		Groundwater	●
		Riparian & Landscape	●
	Fluvial-Geomorph	Sediments & Gravel	●
		Stream Morphology	●
	Habitat	Stream Temperature	●
		Water Quality	●
		Habitat Quality	●
		Barriers & Injury	●
		Marine/Estuary	NA
	Biota	Invasive Species	●

			Suckers	RB Trout	Bull Trout
Population Monitoring	Abundance	Juvenile Abundance (anad)	NA	NA	NA
		Spawner Abundance (anad)	NA	NA	NA
		Abundance (non-anadr)	●	●	●
	Harvest	Harvest (in-river)	NA	●	
		Harvest (ocean)	NA	NA	NA
	Distrib-ution	Temporal Distribution	●	●	●
		Spatial Distribution	●	●	●
	Demo-graphics	Stock Composition		●	●
		Age Structure	●		
	Biota	Disease	●	●	

● Known monitoring activities (past or ongoing)

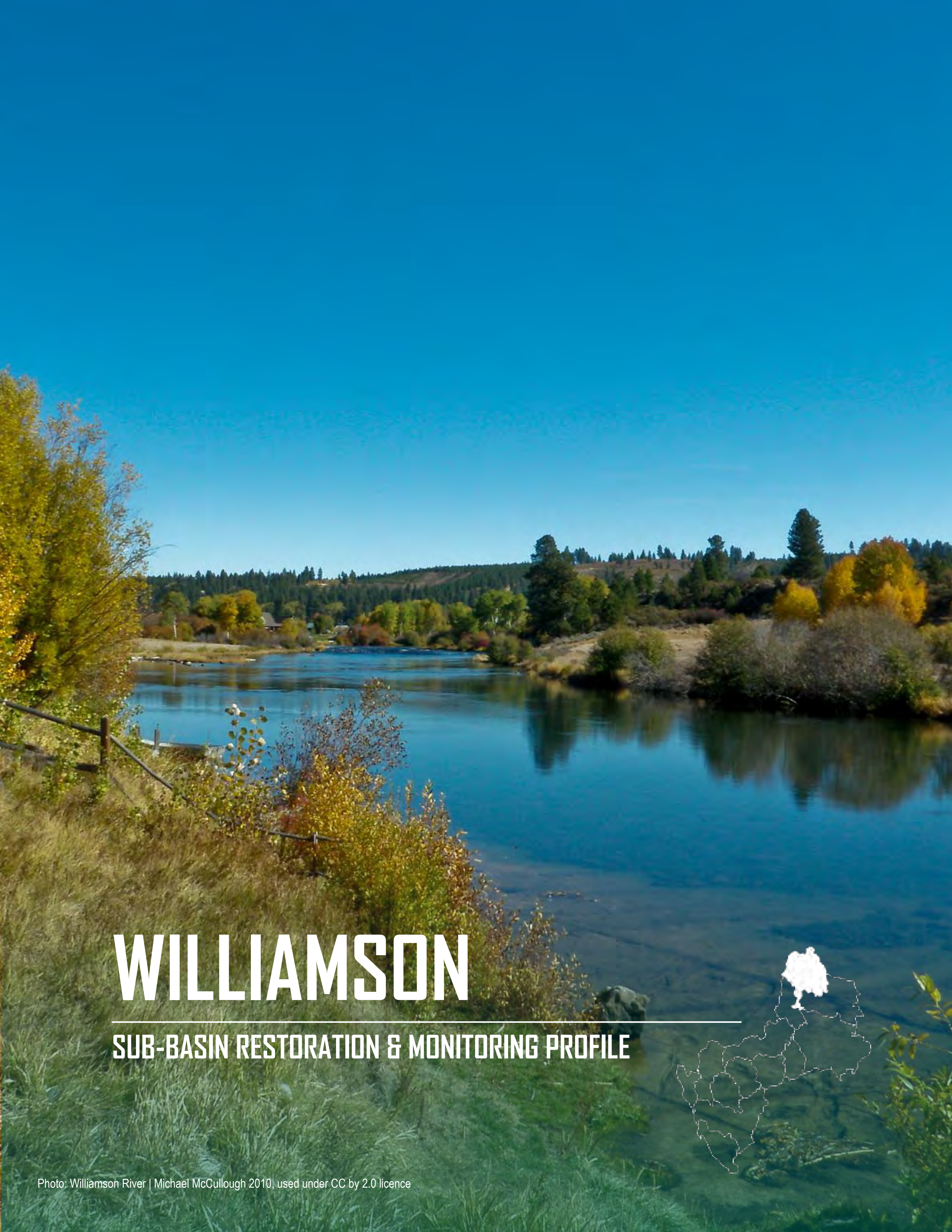
NA Monitoring not relevant to this sub-basin

Figure 4-4. Synthesis of past and ongoing monitoring activities in the Upper Klamath Lake sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017, Section 2.5, Appendix H):

- Oregon Conservation Strategy, with multiple opportunity areas in this sub-basin.
- Klamath Tribes Wetland and Aquatic Resources Program Plan (LaGreca and Fisher 2015)
- Klamath Tribal Water Quality Consortium Upper Klamath Basin Nonpoint Source Pollution Assessment and Management Program Plan (KTWQC 2018)
- Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)
- Water Quality Restoration Plan for the Upper Klamath Basin (USFS and BLM 2003)
- ODEQ Upper Klamath Lake Drainage Total Maximum Daily Load and Water Quality Management Plan
- Fremont, Winema, Klamath, and Modoc National Forest Land and Resource Management Plans
- Klamath Falls Resource Area Management Plan
- The Upper Klamath Basin Watershed Action Plan (UKB WAP; The Upper Klamath Basin Watershed Action Plan Team 2021) overseen by The Klamath Tribes and collaborating Klamath Basin restoration entities, summarizes regional restoration needs and identifies and prioritizes specific candidate sites for restoration activities, including those activities identified in the PacifiCorp Interim Measures 11 Priority Projects List (PacifiCorp 2018). Further information can be explored using the web-based Interactive Reach Prioritization Tool (IRPT).
- The Reintroduction Implementation Plan of Anadromous Fish into the Upper Klamath Basin overseen by the Oregon Department of Fish and Wildlife (ODFW) and The Klamath Tribes, which will outline additional management, restoration, and monitoring activities to benefit anadromous fish recolonizing this area following restoration of fish passage, and are likely to provide overlapping benefits to resident fish.



WILLIAMSON

SUB-BASIN RESTORATION & MONITORING PROFILE

Photo: Williamson River | Michael McCullough 2010, used under CC by 2.0 licence

4.3.2 Williamson Sub-Basin

This sub-basin is notable for the Williamson River, which contains Sprague River flows, provides roughly half of the flow into Upper Klamath Lake, and is characterized by relatively low stream temperatures, high dissolved oxygen, high pH, and high nutrient loading upstream of its confluence with Sprague River. This sub-basin also contains agricultural, grazing, and forestry lands as well as several protected areas including parts of Crater Lake National Park, Fremont-Winema National Forest, and the Klamath Marsh National Wildlife Refuge.

Figure 4-5: Reference map of the Williamson sub-basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current**: Shortnose Sucker and Lost River Sucker, Redband Trout
- **Historical**: Summer steelhead, Chinook Salmon (fall-run and spring-run), Pacific Lamprey

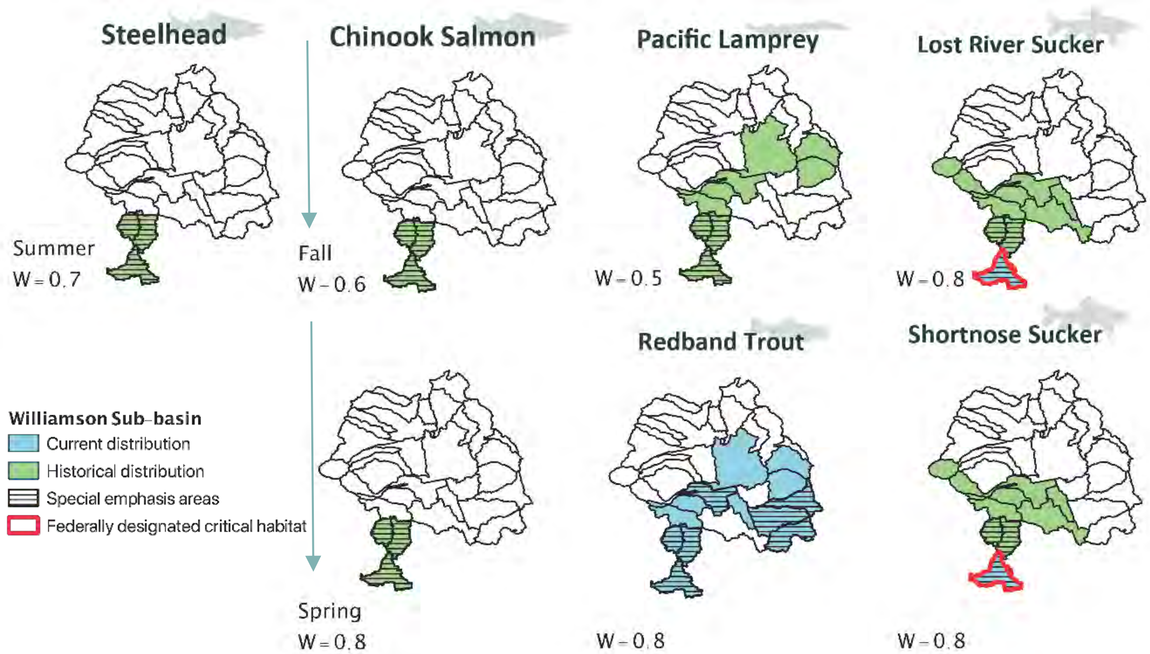


Figure 4-6: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the Williamson sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors

Table 4-6: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the Williamson sub-basin, listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. SU = suckers, RT = Redband Trout, CS = Chinook Salmon (future), PL = Pacific Lamprey (future).

Key Stressors	Tier	Stressor Summary for the Williamson Sub-basin	Species			
			SU	RT	*CS*	*PL*
Instream Flow	WI, FG	The highest stream flow restoration priorities in this sub-basin are for tributaries in the area around the Williamson River Delta feeding into Upper Klamath Lake (important for suckers and Redband Trout)[1] as well as upstream reaches between Hog Creek and the mid Upper Klamath Marsh area, which contains a high density of agricultural diversions, followed by reaches along the Upper Williamson River near and above the confluence with Jackson Creek[2,3]. In addition, areas along the northern-most boundary of this sub-basin are anticipated to experience the greatest relative shift towards drier conditions in a future climate (Thorne et al. 2015).	●	●	●	○
Fine Sediment Inputs	WI	Relates to fine sediment inputs from grazing and agriculture, forestry operations, and riparian roads in this sub-basin (Evans & Associates 2005). Though not as prevalent as in other parts of the basin, areas around and downstream of the Klamath Marsh NWR are 303d listed for sediment[3]. Particular streams in the Williamson sub-basin	●	○	○	○

		considered to be water quality impaired based on phosphorus (TP and PP) and total suspended solids (TSS) include the Chiloquin, Bull Pasture, and Upper Klamath Marsh reaches of the Williamson River[5].				
Groundwater Interactions (Instream Flow, Temperature)	FG	Relates to climate and groundwater pumping effects on the strong dependence of flows in some reaches in this sub-basin on groundwater discharges, which contribute to instream flow but also provide key cold-water refugia for fish during high temperature periods (Gannett et al. 2010, Hamilton et al. 2011)[4].	●	●	●	○
Habitat Complexity (mesohabitats)	H	Relates to availability of suitable substrates for spawning, and large woody debris and other types of habitat complexity for juvenile and adult sheltering and feeding, particularly for Redband Trout, but also for suckers. Streams considered most impaired by engineered channelization that limits habitat complexity include the Bull Pasture, Wild Horse, and Lower & Upper Klamath Marsh Reaches of the Williamson River[5].	○	●	●	○

Spatial stressor hotspots identified from, (1) CDFW BIOS Map of USFWS Species Critical Habitats (2) ODFW Streamflow Restoration Prioritization Maps, (3) Trout Unlimited Conservation Success Index data (4) GANNETT ET AL. 2010 Report on Ground-Water Hydrology of the Upper Klamath Basin, Figure 7, (5) UKB WAP Restoration Prioritization Framework Tool.

Sequences of Restoration Projects for the Williamson Sub-Basin

The **summary infographic** in Figure 4-7 provides a compact overview of the Williamson sub-basin restoration project priorities and their distribution across the sub-basin. Table 4-7 presents the results of the 2022 iteration of the IFRMP restoration sequencing process for the Williamson sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-7. The projects listed here have a cost range of $13.5M – $25.6M – $39.4M (low, estimated midpoint, high), and been collated from projects proposed in prior local or regional restoration plans and studies as well as from in-depth discussions among participants in the IFRMP's Williamson Sub-basin Working Group who represent scientists, restoration practitioners, and resource users working in the sub-basin (see Acknowledgements section). The sequences and scoring in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria. Additional considerations such as implementability, cost, and dependencies among projects may influence the ultimate sequencing of projects. The working group did not identify any specific dependencies between projects but they did provide preliminary suggestions for some initial sequencing of projects. In this regard they suggested an initial ordered implementation of project 4_7 and then 5 (see Table 4-7 for project descriptions) although this represents only a starting point for this exercise. Sequencing of projects will be very important for maximizing benefits in the sub-basin. While discussion of this topic has been initiated determining the optimal sequencing steps for multi-project implementation across the Williamson sub-basin will require further deliberation by the working group.

To facilitate consistent comparison across the sub-basins, results in Table 4-7 are shown for the Williamson sub-basin assuming a scenario where the four lower Klamath River hydroelectric dams have been removed, but no other significant changes from current conditions in the Klamath Basin.

Figure 4-7: Summary for the Williamson sub-basin, including key stressors, cost ranges, and projects (see next page).

Williamson Sub-Basin

Sub-Basin Summary

This sub-basin is notable for the Williamson River, providing roughly half of all flows into Upper Klamath Lake and characterized by relatively low stream temperatures, high dissolved O_2, and optimal pH upstream of its confluence with Sprague River. This sub-basin is also host to agricultural, grazing, and forestry lands as well as several protected areas including parts of Crater Lake National Park, Fremont-Winema National Forest, and the Klamath Marsh National Wildlife Refuge.

Restoration Summary

A diverse variety of projects were identified by the working group for improving habitat conditions in the Williamson Sub-basin. Projects that rated most highly in the IFRMP Tool were primarily focused on improving riparian conditions (Projects 7 and 4), channel reconnection (Projects 5, 10, and 6), and improving instream habitat through LWD addition (Project 8b).These should be considered among the top group of restoration projects to be considered first for implementation.

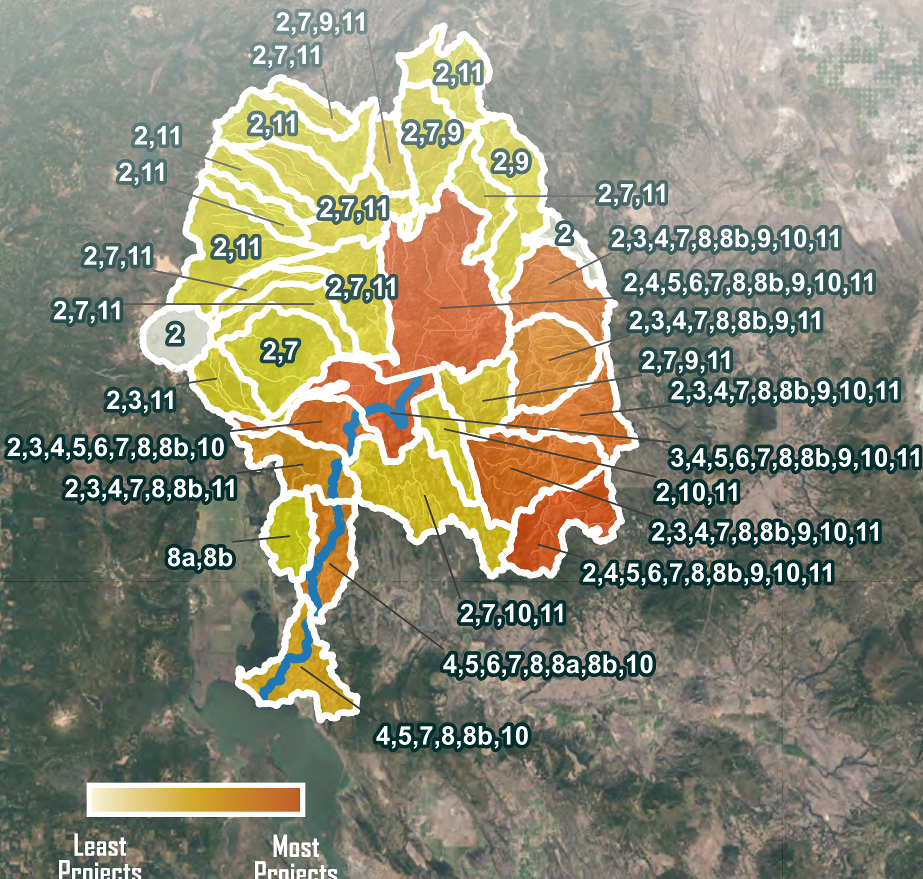
Projects ranked as of more intermediate restoration importance included Projects 9, 11, and 3. These covered a range of mitigations/restorations relating to maintaining upland meadows, road removal/improvement, and beaver management/BDAs. Projects lower on the list focused on adding spawning gravels to streams and upland forest management

Key Stressor Summary

Key Stressors	Focal Species (Current and *Future*)			
	SU	RT	*CS*	*PL*
Instream Flow				
Fine Sediment Inputs				
Groundwater Interactions				
Habitat Complexity (mesohabitats)				

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is \$13.5M - \$25.56M - \$39.4M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP Williamson sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting, and **arrows** indicate linkages between projects.

Project ID & Description	Tiers
Williamson 4_7 -Improve grazing practices and fence and/or plant vegetation to improve riparian and instream conditions within the Williamson River and key tributaries | **27.4**	FG H WI
Williamson 5 - Reconnect channels to restore fish access to existing cold-water springs in Williamson River mainstem reaches and key sub-basin tributaries | **22.5**	H FG
Williamson 3_8b - Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge | **21.9**	FG H
Williamson 10 - Improve hydrological and habitat connectivity both within the Williamson River delta and between the Williamson River mainstem and key tributaries | **19.8**	FG
Williamson 6 - Improve connection of Williamson River to the Klamath Marsh NWR and convert existing drains and levees into depressional wetlands | **19.2**	H FG
Williamson 9 - Thin lodgepole pine forest encroaching into the upper Williamson River to prevent loss of upland meadows | **19.2**	H
Williamson 8a - Add spawning gravels to reaches of the Williamson River to improve habitat conditions for Redband Trout | **15.4**	H
Williamson 11 - Undertake multiple linked road-related restoration and re-construction projects to enable improved fish passage while diminishing sediment transport into sub-basin streams | **13.5**	H WI
Williamson 2 - Undertake upland forest management and prescribed burns to create forest gaps for improved snowpack accumulation and slow release water storage | **12.2**	WI

The Sub-basin Working Group identified the following additional scenarios with the potential to influence restoration priorities in the Williamson sub-basin. Should any these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

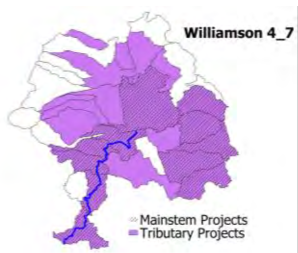
- Changes in water rights regulation
- Improved water quality
- Easement program implementation
- Fish passage through the Klamath hydro project
- Sucker population status
- Improved agricultural practices
- Acceptance of voluntary restoration actions by the farming community

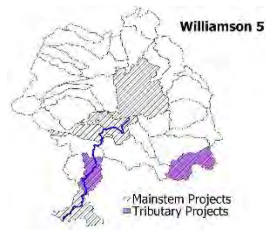
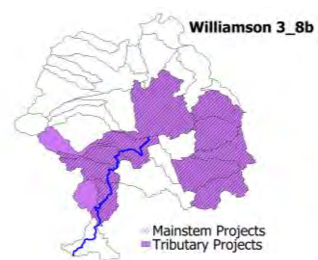
A diverse variety of projects were identified by the working group for improving habitat conditions in the Williamson sub-basin. Projects that rated most highly in the IFRMP Tool were primarily focused on improving riparian conditions **(Projects 4_7),** channel reconnection (**Projects 5, 3_8b, 10, and 6**)**.**These should be considered among the top group of restoration projects to be considered first for implementation.

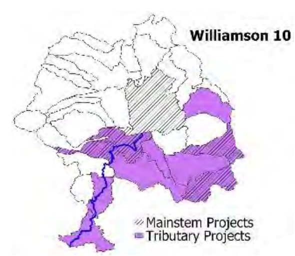
Projects ranked as of more intermediate restoration importance included **Projects 8a, and 11**. These include adding spawning gravel to improve habitat conditions, road removal/improvement, and beaver management/BDAs.

The lowest ranking restoration project in the Williamson sub-basin is upland forest management - **Projects 2**.

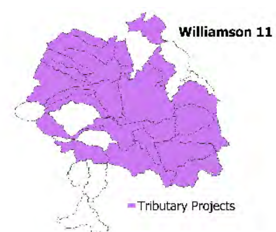
Table 4-7: Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the Williamson sub-basin, with projects scored higher to be considered first for implementation. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name. Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-5 while special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin IFRMP planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

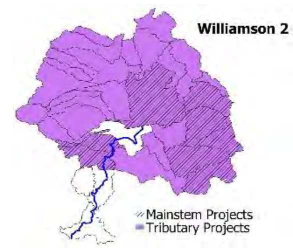
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.8)*
Williamson 4_7 (27.4)	**Work with agriculture interests and others to improve grazing practices and fence and/or plant vegetation to improve riparian and instream conditions within the Williamson River and key tributaries.** **Project Description:** Restore riparian plant communities by fencing and/or planting of native riparian vegetation along Larkin Creek and Sunnybrook Creek in the Lower Williamson River as well as the mainstem Williamson River (USFWS 2012, IRCT 2016, The Upper Klamath Basin Watershed Action Plan Team 2021), as well as other private lands with promising riparian areas particularly those immediately above and below the Klamath Marsh (Evans and Associates 2005). Fencing and planting carried out alongside grazing management strategies and off-channel watering projects to protect investment in riparian restoration. In upland areas, the USDA Forest Service can work with permittees to adjust grazing strategies for pastures and allotments to improve riparian and stream channel conditions and reduce streambank erosion and related sediment inputs, particularly in the Upper Williamson River above Klamath Marsh NWR and in other areas (IRCT 2016). These actions should help to reduce sediment inputs and improve water quality. **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Riparian planting, Fencing, Riparian area conservation grazing management, upland livestock and grazing management **Near-Term Focal Areas (map):** 19 sub-watersheds, Headwaters Williamson River**, Haystack Draw-Williamson River**, Deep Creek-Williamson River**, Aspen Creek-Williamson River, Long Prairie-Williamson River, Deer Creek, Shoestring Creek, Lost Creek, Forked Horn Springs, Silent Creek, Cow Creek, Big Springs Creek, Wildhorse Ridge-Williamson River, Klamath Marsh-Williamson River**, Fuego-Williamson River, Hog Creek, Egan Spring-Williamson River, Larkin Creek-Williamson River**, Williamson River*,**  **Cost range ($K):** $1,125 – 5,800 – 11,450	**0.8**	**5.4**	**8**	**5.25**	**8**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.8)*
Williamson 5 (22.5)	**Reconnect channels to restore fish access to existing cold-water springs in Williamson River mainstem reaches and key sub-basin tributaries.** **Project Description:** Protect, reconnect, and restore cold-water springs guided by existing groundwater studies and/or Forward-looking Infrared (FLIR) thermal cameras (Gannett et al. 2010, Barry et al. 2010), focusing on groundwater-fed reaches overlapping with focal species critical habitats, including the lower Williamson River mainstem, Larkin Creek, Larkin Springs, and Spring Creek, as well as the Upper Williamson River from the Head of River Springs to Wickiup Spring and the area around Sheep Creek (important for Redband Trout).  **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Instream flow project (general), Water quality project (general), Mechanical channel modification and reconfiguration **Near-Term Focal Areas (map):** 6 sub-watersheds, Headwaters Williamson River**, Wildhorse Ridge-Williamson River, Klamath Marsh-Williamson River**, Fuego-Williamson River, Larkin Creek-Williamson River**, Williamson River*,** **Cost range ($K):** $6,190 – 7,104 – 8,139 (based partly on costs of UKL, Lost, Sprague)	1.82	8.1	6.19	3.5	2.92
Williamson 3_8b (21.9)	**Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge.**  **Project Description:** Implement strategic low-tech, process-based restoration through beaver management (where permissible under local regulations) and or installation of check dams or beaver dam analogues in the Upper Williamson sub-basin, based on historical presence of beavers and building on successful work by the Klamath Watershed Partnership Beaver Management Project (2011-2014). Key focal areas where such measures to slow flows could improve water storage for slow release include upland wet meadows around Jack Creek, Mosquito Creek, and the southeast portion of the upstream of the Klamath Marsh Watershed that have lost riparian vegetation due to lowering of the water table and ensuing encroachment of lodgepole pines (Evans & Associates 2005). This work is critical for improving fish habitat, reversing erosion, and restoring hydro and geomorphological process and function. The benefits of this work could be further enhanced through pairing with the addition of large wood to key tributaries to benefit focal fish species, particularly redband trout.	1.12	6.3	7.38	1.75	5.37

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.8)*
	Dependencies / Project Linkages: No dependencies identified. **Primary Action Types:** Beavers & beaver dam analogs, Upland wetland improvement, Channel structure placement, Addition of large woody debris **Near-Term Focal Areas (map):** 12 sub-watersheds, Headwaters Williamson River**, Haystack Draw-Williamson River**, Deep Creek-Williamson River**, Aspen Creek-Williamson River, Long Prairie-Williamson River, Sand Creek, Wildhorse Ridge-Williamson River, Klamath Marsh-Williamson River**, Fuego-Williamson River, Egan Spring-Williamson River, Spring Creek**, Larkin Creek-Williamson River** **Cost range ($K):** $3,268 – 5,848 – 8,671					
Williamson 10 (19.8)	**Improve hydrological and habitat connectivity both within the Williamson River delta and between the Williamson River mainstem and key tributaries.** **Project Description:** Restore hydrologic processes and improve habitat connectivity, particularly by further improving connectivity in the Williamson River Delta (Barry et al. 2010) and reconnecting tributaries that once hosted historical populations of Redband Trout or other focal species to the mainstem Williamson River (e.g., reconnection or improving connections to Hog Creek, Yoss Creek, and Jackson Creek)(Evans & Associates 2005). **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Mechanical channel modification and reconfiguration  **Near-Term Focal Areas (map):** 10 sub-watersheds, Headwaters Williamson River**, Deep Creek-Williamson River**, Long Prairie-Williamson River, Wildhorse Ridge-Williamson River, Yoss Creek, Klamath Marsh-Williamson River**, Fuego-Williamson River, Hog Creek, Larkin Creek-Williamson River**, Williamson River*,** **Cost range ($K):** $625 – 1,650 – 2,700	**1.34**	**9**	**2.55**	**3.5**	**3.39**
Williamson 6 (19.2)	**Improve connection of Williamson River to the Klamath Marsh NWR and convert existing drains and levees into depressional wetlands.** **Project Description:** Restoration of Williamson River hydrology within the Klamath Marsh NWR through construction of a new sinuous channel merging into existing channels in the Refuge as well as converting existing drains and levees into complexes of depressional wetlands (USFWS 2014).	**1.29**	**4.5**	**5.18**	**3.5**	**4.76**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.8)*
	Dependencies / Project Linkages: No dependencies identified. **Primary Action Types:** Mechanical channel modification and reconfiguration, Dike or berm modification/removal  **Near-Term Focal Areas (map):** 5 sub-watersheds, Headwaters Williamson River**, Wildhorse Ridge-Williamson River, Klamath Marsh-Williamson River**, Fuego-Williamson River, Larkin Creek-Williamson River** **Cost range ($K):** $375 – 990 – 1,620 (based partly on cost data from Trinity)					
Williamson 9 (19.2)	**Thin lodgepole pine forest encroaching into the upper Williamson River to prevent loss of upland meadows.** **Project Description:** Thin lodgepole pines encroaching into meadow areas in the Upper Williamson River to prevent loss of meadows (Dickerson-Lange et al. 2017, Sun et al. 2018). Related to Action #2 in this section.  **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Upland vegetation management (inc. fuel reduction, burning) **Near-Term Focal Areas (map):** 11 sub-watersheds, Headwaters Williamson River**, Haystack Draw-Williamson River**, Deep Creek-Williamson River**, Aspen Creek-Williamson River, Long Prairie-Williamson River, Shoestring Creek, Lost Creek, Lower Jack Creek, Skellock Creek, Wildhorse Ridge-Williamson River, Klamath Marsh-Williamson River** **Cost range ($K):** $50 – 375 – 875	**0.46**	**6.75**	**0.8**	**5.25**	**5.92**
Williamson 8a (15.4)	**Add spawning gravels to reaches of the Williamson River to improve habitat conditions for Redband Trout.** **Project Description:** Improve spawning habitat in tributaries through addition of spawning substrates to benefit local focal fish species.  **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Spawning gravel placement **Near-Term Focal Areas (map):** 2 sub-watersheds, Spring Creek**, Larkin Creek-Williamson River** **Cost range ($K):** $20 – 140 – 440	**3**	**2.25**	**0.85**	**3.5**	**5.78**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.8)*
Williamson 11 (13.5)	**Undertake multiple linked road-related restoration and re-construction projects to enable improved fish passage while diminishing sediment transport into sub-basin streams.** **Project Description:** Road closure, re-location and removal of barriers to fish passage, associated culvert improvement, construction of sediment basins/collection ponds, peak-flow drainage improvements, removal or alteration of blockages, impediments or barriers to allow or improve fish passage. All of these actions enable fish passage while diminishing sediment transport into streams. **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Culvert installed or Improved at road stream crossing, Bridge installed or improved at road stream crossing, Rocked ford – road stream crossing, Road stream crossing removal, Road drainage system improvements and reconstruction, Road closure / abandonment **Near-Term Focal Areas (map):** 24 sub-watersheds, Headwaters Williamson River**, Haystack Draw-Williamson River**, Deep Creek-Williamson River**, Aspen Creek-Williamson River, Long Prairie-Williamson River, Deer Creek, Lost Creek, Miller Creek, Sink Creek, Cottonwood Creek, Tiny Creek, Forked Horn Springs, Silent Creek, Cow Creek, Big Springs Creek, Upper Jack Creek, Mosquito Creek, Skellock Creek, Wildhorse Ridge-Williamson River, Sand Creek, Yoss Creek, Klamath Marsh-Williamson River**, Hog Creek, Egan Spring-Williamson River  **Cost range ($K):** $1,830 – 3,395 – 5,003 (incomplete – no cost data for "culvert installed or improved at road stream crossing", "road stream crossing removal", and "rocked ford – road stream crossing") (range based partly on cost data from MKR, Scott, UKR, Trinity, and SF Trinity)	**0.34**	**4.95**	**2.13**	**5.25**	**0.8**
Williamson 2 (12.2)	**Undertake upland forest management and prescribed burns to create forest gaps for improved snowpack accumulation and slow release water storage.** **Project Description:** Carry out appropriate management of upland areas through best practices in forest management, prescribed fire, and managed wildfire to thin upland vegetation and to create small gaps in the forest canopy that will improve snowpack accumulation and potential water storage for slower release, in consultation with regional water resource districts (Dickerson-Lange et al. 2017, Sun et al. 2018). Related to Action #8 in this section. **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Upland vegetation management including fuel reduction and burning	**0.3**	**0.9**	**0.8**	**5.25**	**4.92**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.7)*	Implementability *(0.8)*
	Near-Term Focal Areas (map): *[Priority HUC12s identified for this action are provisional, PENDING additional review by Klamath Tribes forestry staff]* 29 sub-watersheds, Headwaters Williamson River**, Haystack Draw-Williamson River**, Deep Creek-Williamson River**, Aspen Creek-Williamson River, Long Prairie-Williamson River, Deer Creek, Shoestring Creek, Lost Creek, Miller Creek, Sink Creek, Cottonwood Creek, Tiny Creek, Forked Horn Springs, Silent Creek, Cow Creek, Big Springs Creek, Upper Jack Creek, Dillon Creek, Lower Jack Creek, Mosquito Creek, Skellock Creek, Scott Creek, Wildhorse Ridge-Williamson River, Crater Lake, Sand Creek, Yoss Creek, Fuego-Williamson River, Hog Creek, Egan Spring-Williamson River  **Cost range ($K):** $90 – 300 – 525					

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC and SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, and sub-regional working group input via surveys and webinars

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the Williamson Sub-basin

Shortnose Sucker and Lost River Sucker use a relatively small part of the sub-basin, occupying the Williamson River Delta (recently returned to wetlands) as rearing areas and spawning areas in the lower reaches of the Williamson River up to where the Sprague River joins (USFWS 2012). ***Redband Trout*** are also an important occupant of this basin that provide important Tribal and recreational harvesting opportunities. Redband Trout have important conservation populations in the Lower Williamson River up to Larkin Creek and in the Upper Williamson River near its headwaters, although it historically had a much larger range in the mainstem between these two remaining populations (IRCT 2016). ***Chinook Salmon***, ***steelhead***, and ***Pacific Lamprey*** all once historically occupied this sub-basin and are expected to fully return to this sub-basin following fish passage restoration work in the Lower Klamath River.

Within the Williamson sub-basin, the Klamath Marsh–Williamson River complex is a priority Conservation Opportunity Area under Oregon's Conservation Strategy, with recommended conservation actions such as maintaining or improving habitat connectivity, flow and hydrological function, riparian habitat, and wetland habitat (ODFW 2016). The following table summarizes select major past restoration activities in this sub-basin to date and the species which they have benefited.

Table 4-8: Summary of major restoration efforts in the Williamson sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit (including focal species not currently present in the sub-basin).

Key Restoration Activities in the Williamson Sub-basin to Date	Species Benefiting			
	SU	RT	*CH/ST*	*PL*
Levee breaching, restoration, and cross-channel reconnection of the Williamson River Delta to recreate historical wetland areas that would improve water quality and rearing conditions for suckers.	●	○	●	●
Ongoing restoration of wetlands and hydrologic processes in and around Klamath Marsh National Wildlife Refuge, and other smaller upland wetlands such as those around Jack Creek.		●	○	○
Comprehensive riparian habitat restoration throughout the basin including fencing, thinning of encroaching vegetation, replanting native riparian species, and construction of off-channel watering facilities for cattle in the Lower Williamson River below and in headwater reaches above Klamath Marsh National Wildlife Refuge.	●	●	●	●
Instream habitat restoration in Jack Creek and the Upper Williamson River near its headwaters through the addition of large wood and spawning gravels.		●	○	○

Current State of Monitoring & Data Gaps

Past and Ongoing Monitoring:

There are numerous past and present monitoring programs in this sub-basin thanks to a variety of partnerships between The Klamath Tribes, the USGS, the USFWS, the ODFW, The Nature Conservancy (TNC), Trout Unlimited (TU), and private landowners.

The USGS conducts effectiveness monitoring of sucker restoration efforts in areas of the Upper Klamath Basin, assessing restoration benefits on Lost River and Shortnose suckers of The Nature Conservancy's (TNC) Williamson River Delta Restoration Project (Burdick 2012; Wood et al. 2013). The Williamson River Delta Restoration Project was designed to address both water quality and habitat availability for sucker populations specifically. An associated long-term sucker population monitoring program was established in 2006 to assess changes in the locations, condition, abundance, and habitat use of endangered larval suckers. Following intentional levee breaches, TNC began monitoring water quality and vegetation across the purposely flooded portion of the Williamson River Delta Preserve, with vegetation monitoring that involved documenting changes in wetland diversity over time. TNC has monitored the effectiveness of these re-vegetation efforts in the delta every year since 2010. Trout Unlimited, The Klamath Tribes, the USFWS, and ODFW conduct many restoration projects in the Upper Klamath Basin directed toward Indigenous fish, including Lost River Sucker, Shortnose Sucker, Redband Trout and Bull Trout. Associated monitoring focuses on assessing occupancy/distribution, abundance, and population trends, age structure, size, and life history where data are available (particularly for Redband Trout) (ODFW 2016). ODFW and The Klamath Tribes also conduct water temperature monitoring for Redband Trout habitat.

Current Data Gaps:

Figure 4-8 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring across agencies in the Williamson sub-basin. Location-specific agency metadata (where available[10]) on monitoring projects is incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. While population monitoring of key focal species in the Williamson sub-basin appears well supported, like habitat monitoring in the lower delta of the Williamson River, KBMP's current inventory of habitat-related monitoring across the Klamath Basin indicate that the Williamson sub-basin has only a limited number of stations currently in place for long term monitoring of weather, streamflow, water quality, sediment, and water temperature. There is a strong desire to expand this water monitoring network in light of the importance of the Williamson River for fish migrating further up the Williamson or Sprague Rivers and the occurrence of Tribal water calls in the region.

[10] Note that only some available information on past monitoring activities across sub-basins provides specific location information (i.e. beyond indicating that it occurs somewhere within a sub-basin) and can be found in existing spatially-referenced databases that would allow for reliable transfer to the project's Integrated Tracking Inventory

Williamson Sub-basin Monitoring Summary

Habitat Monitoring			
Watershed Inputs	Weather	●
	Streamflow	●
	Groundwater	●
	Riparian & Landscape	●
Fluvial-Geomorph	Sediments & Gravel	●
	Stream Morphology	●
Habitat	Stream Temperature	●
	Water Quality	●
	Habitat Quality	●
	Barriers & Injury	●
	Marine/Estuary	NA
Biota	Invasive Species	●

Population Monitoring		Suckers	RB Trout
Abundance	Juvenile Abundance (anad)	NA	NA
	Spawner Abundance (anad)	NA	NA
	Abundance (non-anad)	●	●
Harvest	Harvest (in-river)	NA	●
	Harvest (ocean)	NA	NA
Distrib-ution	Temporal Distribution	●	●
	Spatial Distribution	●	●
Demo-graphics	Stock Composition		●
	Age Structure	●	●
Biota	Disease	●	●

● Known monitoring activities (past or ongoing)

NA Monitoring not relevant to this sub-basin

Figure 4-8. Synthesis of past and ongoing monitoring activities in the Williamson sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017, Section 2.5, Appendix H):

- Revised recovery plan for the Lost River Sucker (*Deltistes luxatus*) and Shortnose Sucker (*Chasmistes brevirostris*) (USFWS 2012)
- Klamath Recovery Unit Implementation Plan for Bull Trout (*Salvelinus confluentus*) (USFWS 2015)
- A Conservation Strategy for Interior Redband (*Oncorhynchus mykiss subsp.*) in the states of California, Idaho, Montana, Nevada, Oregon, and Washington. (IRCT 2016)
- A Plan for The Reintroduction of Anadromous Fish in The Upper Klamath Basin (ODFW 2008) and the associated Implementation Plan for the Reintroduction of Anadromous Fish into the Oregon portion of the Upper Klamath Basin (ODFW and Klamath Tribes 2021) which is to mainly serve as an appendix to ODFW Klamath Basin fisheries management Plan.

- Oregon Conservation Strategy, with multiple opportunity areas in this sub-basin
- Upper Williamson River Watershed Assessment and Action Plan (Evans & Associates 2005, KBEF 2005)
- Lower Sprague-Lower Williamson Watershed Assessment and Action Plan (Rabe and Calonje 2009, KBEF 2009)
- Klamath Tribes Wetland and Aquatic Resources Program Plan (LaGreca and Fisher 2015)
- Klamath Tribal Water Quality Consortium Upper Klamath Basin Nonpoint Source Pollution Assessment and Management Program Plan (KTWQC 2018)
- Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)
- Water Quality Restoration Plan for the Upper Klamath Basin (USFS and BLM 2003)
- ODEQ Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (ODEQ 2002)
- Winema and Deschutes National Forest Land and Resource Management Plans
- Upper Klamath Basin Watershed Action Plan (UKBWAP) overseen by The Klamath Tribes and collaborating Klamath Basin restoration entities, which will summarize regional restoration needs, but will also identify and prioritize specific candidate sites for restoration activities, including those activities identified in the PacifiCorp Interim Measures 11 Priority Projects List (PacifiCorp 2018).
- The Reintroduction Implementation Plan of Anadromous Fish into the Upper Klamath Basin overseen by the Oregon Department of Fish and Wildlife (ODFW) and The Klamath Tribes, which will outline additional management, restoration, and monitoring activities to benefit anadromous fish recolonizing this area following restoration of fish passage and will likely provide overlapping benefits to resident fish.

Forthcoming plans and initiatives affecting this sub-basin are under development, have recently been completed, or will soon proceed to implementation and will contribute to meeting overall restoration needs in this area. These include:

1. The Final Draft Environmental Assessment for the Klamath Marsh National Wildlife Refuge was recently completed for a preferred alternative restoration project aiming to restore the hydrology of the Williamson River and adjacent wetlands on Klamath Marsh National Wildlife Refuge through construction of a new sinuous channel merging into existing channels in the Refuge as well as converting existing drains and levees into complexes of depressional wetlands (USFWS 2014). If the preferred alternative is approved, this work would have significant positive impacts for water quality, water storage, fish passage, and fish habitat in the region surrounding the Klamath Marsh National Wildlife Refuge, particularly for Redband Trout inhabiting that area.

SPRAGUE

SUB-BASIN RESTORATION & MONITORING PROFILE

Photo: Sycan Marsh off the Sprague River | Al Case 2013, used under CC by 2.0 licence

4.3.3 Sprague Sub-basin

This sub-basin contains the Sprague River which provides nearly half of all inflows to the Williamson River and nearly one quarter of all flows to Upper Klamath Lake. Steep, narrow headwater tributaries flow into meandering, laterally active, and interconnected channels in broad valleys consisting of fine sediments. Streamflows are driven primarily by snowmelt and rainfall, while groundwater discharges significantly contribute to seasonal baseflows in many reaches.

The Sprague is one of the few rivers in this region featuring large areas where natural process regimes remain largely intact, although they have been heavily altered in others (e.g., Table 13 in O'Connor et al. 2015). Many parts of this watershed are affected by high stream temperatures, low dissolved oxygen, high pH, and high nutrient loading, which can influence downstream water quality in Upper Klamath Lake. The primary human activities in this basin include agriculture, ranching, and timber management (Newfields & Kondolf 2012). The 2021 Bootleg fire burned a very large portion of this watershed (affecting areas of the Sycan North Fork Sprague and South Fork Sprague) which could drastically affect downstream phosphorus load into Upper Klamath Lake and could affect future prioritization of restoration efforts in the sub-basin (e.g., beaver dam analogue (BDA) type projects and riparian restoration may become higher priority in the near-term).

Figure 4-9: Reference map of the Sprague Sub-Basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current**: Redband Trout, Bull Trout, Shortnose Sucker, Lost River Sucker
- **Historical**: Chinook Salmon (fall-run and spring-run), summer steelhead, Pacific Lamprey

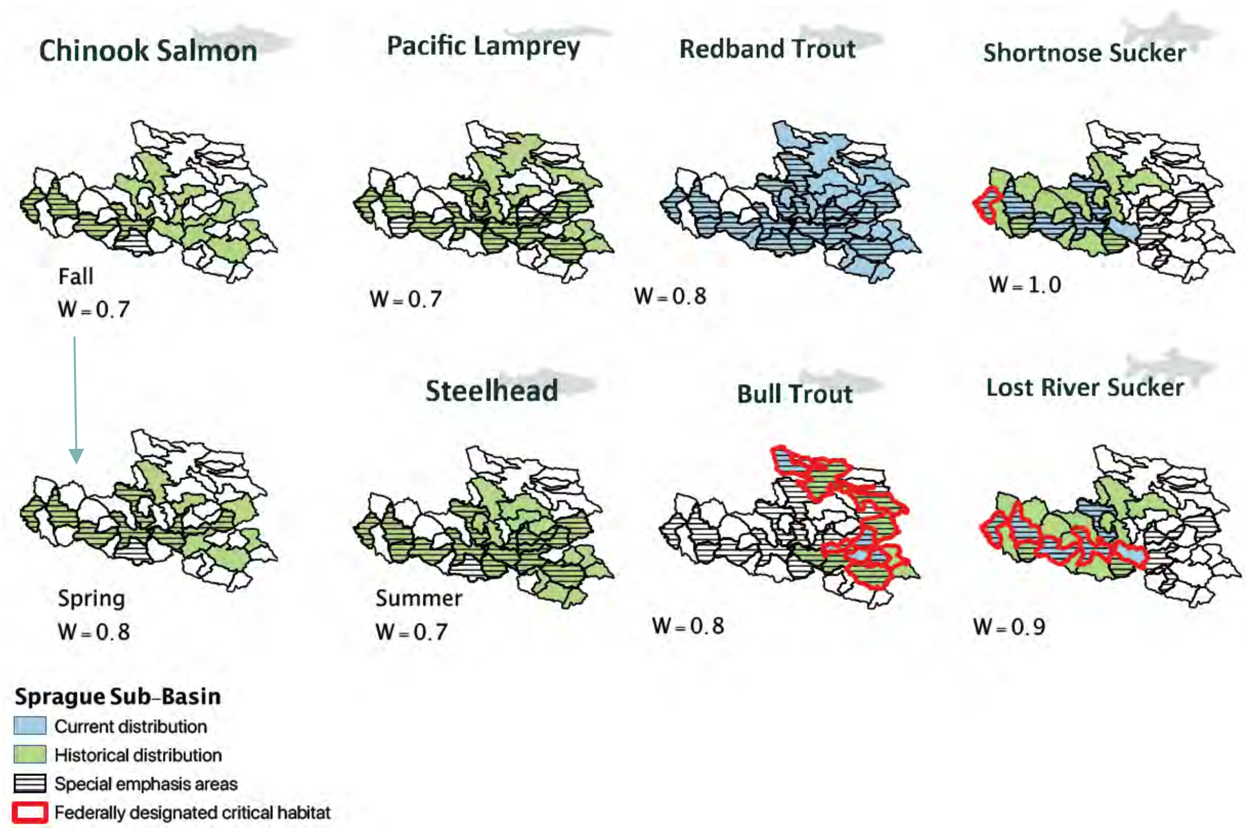


Figure 4-10: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the Sprague sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors

Table 4-9: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the Sprague sub-basin, listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. SU = suckers, BT = Bull Trout, RT = Redband Trout, CS = Chinook Salmon (future), PL = Pacific Lamprey (future).

Key Stressors	Tier	Stressor Summary for the Sprague Sub-basin	Species				
			SU	RT	BT	*CS*	*PL*
Instream Flow	WI FG	The highest stream flow restoration priorities in this sub-basin are along mainstem Sprague River near its confluence with the Williamson River, and downstream, and tributaries around Cook's Canyon, around Sycan Marsh and adjacent Long Creek (which are important for Redband Trout and Bull Trout), and around the confluence of the North and South Fork Sprague Rivers[1,2,3]	●	●	●	●	○
Fine Sediment Delivery	WI	Related to fine sediment inputs from grazing, agriculture, and riparian roads in this sub-basin (Newfields & Kondolf 2012). These sediments are naturally rich in phosphorous, and their erosion and runoff in this sub-basin, particularly from the South Fork Sprague River, contributes to excess nutrient loading to Upper	●	○	●		

Key Stressors	Tier	Stressor Summary for the Sprague Sub-basin	Species				
			SU	RT	BT	*CS*	*PL*
		Klamath Lake (Walker et al. 2015). Areas around the Lower Sprague River (near Kamkaun Spring), Sycan River, Sycan Marsh, and the North Fork Sprague are 303d listed for sediment [3]This stressor is related in part to a lack of floodplain connectivity, which historically provided more opportunities for sediment deposition within the basin.					
Groundwater Interactions	FG	Related to groundwater withdrawal effects on the strong dependence of flows in some reaches in this sub-basin on groundwater discharges, which contribute to instream flow and overall lower water temperatures, but also provide key cold-water refugia for fish during high temperature periods (Gannett et al. 2010, Hamilton et al. 2011)[4]. In this sub-basin, groundwater withdrawals are most pronounced in the reach between the settlements of Sprague River and Bly[4].	●	●	●	●	○
Water Temperature	H	Of greatest concern in the Lower Sprague River as well as Sycan Marsh, and parts of the North and South Fork Sprague Rivers which have the most stream miles that are 303d listed for temperature[2].	●	●	●	●	○
Water Quality	H	The Sprague River is 303d listed for both pH and DO. Particular streams in the Sprague sub-basin considered highly water quality impaired based on phosphorus (TP and PP) and total suspended solids (TSS) include Whitehorse Spring Creek, Lower Sycan River, and the Buttes of the Gods, Council Butte, Beatty Gap, Upper Valley, and lower South Fork Sprague reaches [5].	●	●		●	○
Anthropogenic Barriers	H	Of greatest concern for Redband Trout at road and stream crossings in the North Fork Sprague River, South Fork Sprague River, and Sycan Rivers (IRCT 2016). Streams where access may be particularly limited by fish passage barriers include Trout Creek, Whiskey Creek, Brown Creek, Upper Fivemile Creek, Meryl Creek, Deming Creek, Lower Sycan River, Upper Fishhole Creek and the lower North Fork Sprague River[5].		●		●	○
Habitat complexity (mesohabitats)	H	Relates to availability of suitable substrates for spawning and large woody debris and other types of habitat complexity for juvenile and adult refuge and feeding, particularly for Bull Trout and Redband Trout habitats in the Sycan Marsh, Sycan River, and upper North and South Fork Sprague Rivers (Connelly et al. 2007). Streams considered most impaired by engineered channelization that limits habitat complexity include Meryl Creek, Whiskey Creek, Brown Creek, Lower Fishhole Creek, Lower Paradise Creek, Deming Creek, and the Beatty Gap, Upper Valley, South Fork Sprague, and North Fork Sprague reaches of the Sprague River[5].	○	●	●	●	○

Spatial stressor hotspots identified from: (1) ODFW Streamflow Restoration Prioritization Maps, (2) Trout Unlimited Conservation Success Index data, (3) CDFW BIOS Map of USFWS Species Critical Habitats (4) Gannett et al. 2010 Report on Ground-Water Hydrology of the Upper Klamath Basin, Figure 7, (5) UKB WAP Restoration Prioritization Framework Tool

Sequences of Restoration Projects for the Sprague Sub-Basin

The **summary infographic** in Figure 4-11 provides a compact overview of Sprague sub-basin restoration project priorities and their distribution across the sub-basin.

Figure 4-11: Summary for the Sprague sub-basin, including key stressors, cost ranges, and projects (see next page)

Sprague River Sub-basin

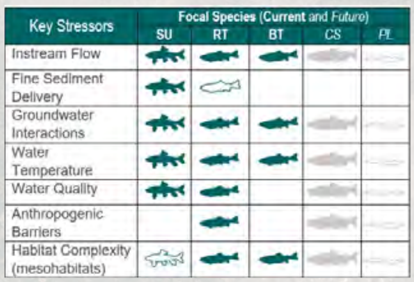
Sub-Basin Summary

This sub-basin contains the Sprague River which provides nearly half of all infows to the Williamson River and nearly a quarter of inflows to Upper Klamath Lake, and is also notable as one of the few rivers in this region where natural process regimes remain largely intact in many places, though they have been heavily altered in others. Steep, narrow headwater tributaries flow into meandering, laterally-active, and anastomosing channels in broad alluvial valleys. Surface flows are driven primarily by snowmelt and rainfall, while groundwater discharges contribute significantly to seasonal baseflows in many reaches. Many parts of this watershed are affected by high stream temperatures, low dissolved O_2, high pH, and high nutrient loading. The primary human activities in this basin are agriculture (primarily to produce hay for cattle), ranching, and timber management.

Restoration Summary

A diverse variety of projects were identified by the working group for improving habitat conditions in the Sprague Sub-basin. Projects rated highest focused on improving channel migration (Project 4), improving riparian condition (Project 3), improving instream habitat through beaver management/BDAs, improving water quality (Project 8) and reconnecting cold-water springs (Project 5). These should be considered among the top group of restoration projects to be considered first for implementation.

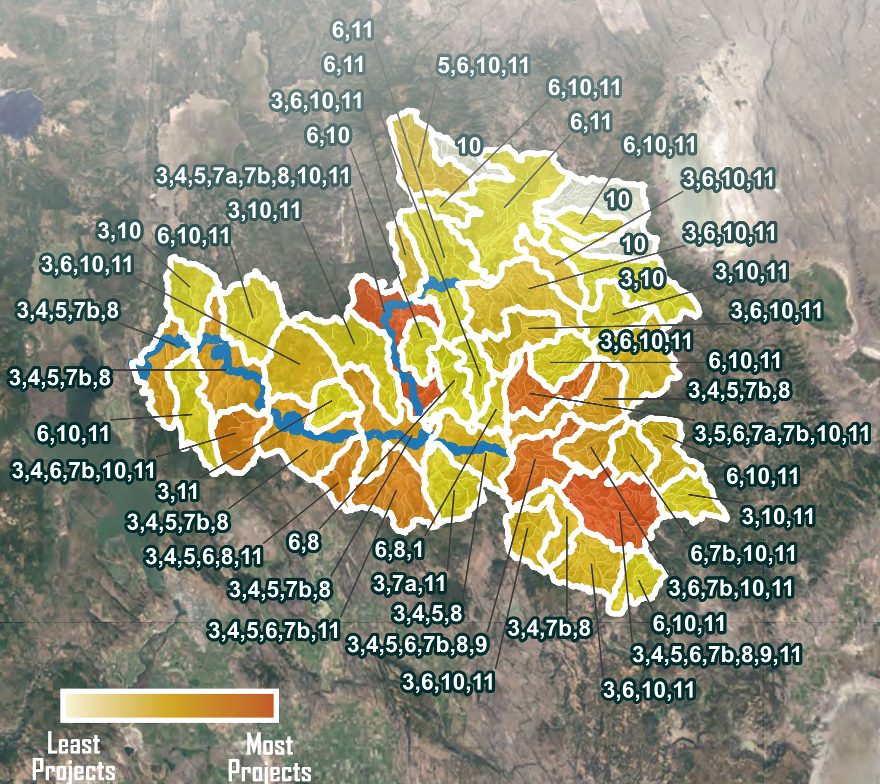
Key Stressor Summary



Projects ranked as of more intermediate restoration importance included Projects 7b, 6, and 11. These covered a range of mitigations/restorations relating to adding LWD to streams, addressing minor fish passage issues, and improving riparian grazing practices.Projects lower on the list focused on upland forest management and adding spawning gravels to streams

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is \$10.7M - \$24.5M - \$50.1M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP Sprague sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting, and **arrows** indicate linkages between projects.

Project ID & Description	Tiers
Sprague 3 - Improve riparian grazing management and undertake riparian actions to improve habitat conditions in the Sprague river mainstem and key tributaries | **28.1**	FG
Sprague 7b_9 - Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge | **27.9**	H, FG
Sprague 4 - Promote channel migration and improve habitat conditions in the Sprague River mainstem and key tributaries by removing levees and roads | **21.2**	FG
Sprague 8 - Construct DSTWs to reduce nutrient loading and improve water quality in key Sprague Sub-basin tributaries. | **20.9**	WI
Sprague 6 - Address fish passage issues (esp. for Redband Trout) at road/stream crossings in key areas of Sprague Sub-basin | **19.3**	H
Sprague 5 - Restore cold-water springs that have been ponded or otherwise disconnected in the Sprague River mainstem and key tributaries | **18.7**	H, FG
Sprague 11 - Improve riparian grazing practices in USFS allotments and some private rangelands within the Sprague Sub-basin | **16.6**	FG
Sprague 10 - Undertake upland forest management and prescribed burns to create forest gaps for improved snowpack accumulation and slow release water storage | **14.0**	WI
Sprague 7a - Add spawning gravels where needed to improve in-stream habitat conditions in key Sprague Sub-basin streams | **12.4**	H

Table 4-10 presents the results of the 2022 iteration of the IFRMP restoration sequencing process for the Sprague sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-10. The projects listed here have a cost range of $10.7M - $24.5M - $50.1M (low, estimated midpoint, high), and have been collated from projects proposed in prior local or regional restoration plans and studies as well as from in-depth discussions among participants in the IFRMP's Sprague Sub-basin Working Group who represent scientists, restoration practitioners, and resource users working in the sub-basin (see Acknowledgements section). The sequences and scoring in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria. Additional considerations such as implementability, cost, and dependencies among projects may influence the ultimate sequencing of projects. The working group did not identify any specific dependencies between projects but they did provide preliminary suggestions for initial sequencing of projects. In this regard they suggested an initial ordered implementation of projects 3, 7b_9, 4, 8, and then 6, with project 6 also occurring anytime after project 7b_9 (see Table 4-10 for project descriptions). Other remaining projects could then implemented in any order. Sequencing of projects will be very important for maximizing benefits in the sub-basin. While discussion of this topic has been initiated determining the optimal sequencing steps for multi-project implementation across the Sprague Sub-basin will require further deliberation by the working group.

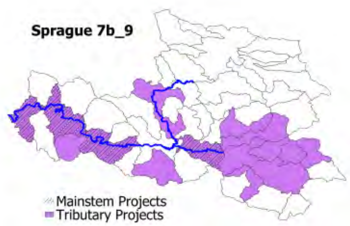
To facilitate consistent comparison across the sub-basins, results in Table 4-10 are shown for the Sprague sub-basin assuming a scenario where the four major Klamath mainstem dams have been removed, but no other significant changes from current conditions in the Klamath Basin. The Sub-basin Working Group identified the following additional scenarios with the potential to influence restoration priorities in the Sprague sub-basin. Should any these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

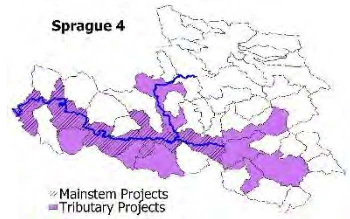
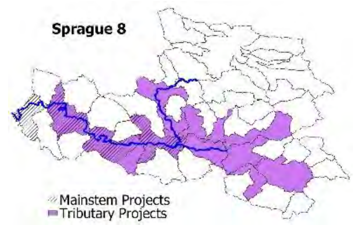
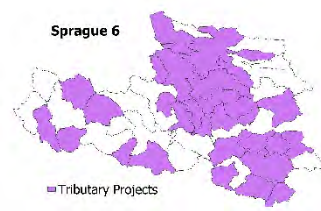
- Changes in water rights regulation
- Improved water quality
- Easement program implementation
- Fish passage through the Klamath hydro project
- Sucker population status
- Improved agricultural practices
- Acceptance of voluntary restoration actions by the farming community

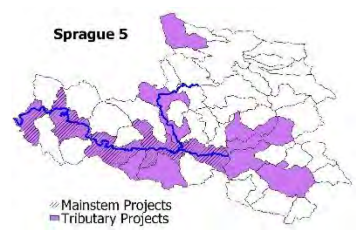
A diverse variety of projects were identified by the working group for improving habitat conditions in the Sprague sub-basin. Projects that rated most highly in the IFRMP Tool were focused on improving riparian condition **(Project 3),** creating fish habitat and retaining water **(Project 7b_9),** improving channel migration **(Project 4),** improving instream habitat through beaver management/BDAs, improving water quality **(Project 8),** and improving fish passage at road/stream crossings **(Project 6).** These are among the top group of restoration projects to be considered first for implementation. More intermediate ranks included **Projects 5, 11, and 10.** These covered a range of mitigations/restorations relating to restoring cold water springs, improving riparian grazing practices, and upland forest management. The lowest ranking restoration project was **Projects 7a,** which focuses on adding spawning gravels to streams.

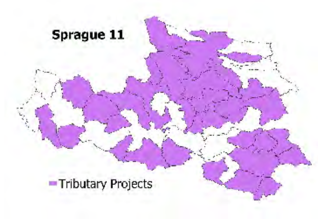
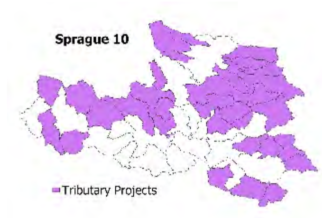
Table 4-10: Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the Sprague sub-basin, with projects scored higher to be considered first for implementation. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name. Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-9 while special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin IFRMP planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

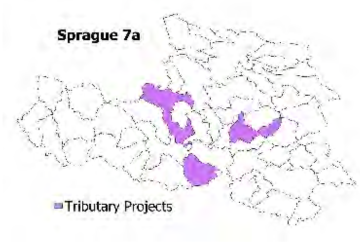
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
Sprague 3 (28.1)	**Work with agriculture interests and others to improve riparian grazing management and undertake riparian actions to improve habitat conditions in the Sprague river mainstem and key tributaries.** **Project Description:** Restore riparian plant communities through grazing management, installation and maintenance of riparian fencing, installation of off-channel watering facilities, riparian planting, and riparian corridor management agreements along the mainstem, North Fork Sprague (Fivemile and Meryl Creek, Boulder Creek), South Fork Sprague (Fishhole Creek), Long Creek, and Sycan River below Coyote Bucket (Barry 2010, USFWS 2015, IRCT 2016, UKBWAP 2021). In addition to reducing sediment inputs, this action will help to reduce stream temperatures in narrower reaches. Such riparian actions may have increased in importance following the recent Bootleg Fire that destroyed riparian vegetation throughout the Sprague sub-basin and even burned LWD in stream channels (M. Skinner, pers. Comm.). **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Riparian planting, Fencing, Riparian area conservation grazing management **Near-Term Focal Areas (map):** 29 sub-watersheds, Paradise Creek**, Shake Creek, Middle Fishhole Creek, Pole Creek, Lower Fishhole Creek**, Whitworth Creek, Middle South Fork Sprague River*,**, Deming Creek*, Lower South Fork Sprague River**, Upper North Fork Sprague River*,**, Meryl Creek**, Upper Fivemile Creek, Lower North Fork Sprague River*,**, Merritt Creek, Silver Dollar Flat, Chester Spring-Sycan River**, Brown Creek**, Flu Pond-Sprague River*,**, Tim Brown Spring, Whiskey Creek**, Rock Creek, Knot Tableland-Sprague River*,**, Chipps Spring, Trout Creek**, Cherry Creek-Sprague River*,**, Cooks Creek, Kamkoan Spring-Sprague River*,**, Whitehorse Spring, Crystal Castle Spring-Sprague River*,**  **Cost range ($K):** $300 – 950 – 2,150 (incomplete – no data for "riparian area grazing conservation management")	**1.21**	**5.86**	**8.78**	**5.25**	**7**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
Sprague 7b_9 (27.9)	**Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge.** **Project Description:** Implement strategic low-tech, process-based restoration through beaver management (where permissible under local regulations) and or installation of check dams or beaver dam analogues with the aim of Stage 0 restoration (returning to pre-channelization phase where stream valley is occupied by a forested wetland complex with many interweaving channels) to increase water residence time with benefits for maximizing groundwater recharge, improving base flows, and creation of fish habitat. Priority areas for these actions are the South Fork Sprague and tributaries throughout the Sprague sub-basin. The benefits of this work could be further enhanced through pairing with the addition of large wood to key tributaries to benefit focal fish species. **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Beavers & beaver dam analogs, Channel structure placement, Addition of large woody debris **Near-Term Focal Areas (map):** 15 sub-watersheds, Lower Fishhole Creek**, Brownsworth Creek*,**, Upper South Fork Sprague, Middle South Fork Sprague River*,**, Deming Creek*, Lower South Fork Sprague River**, Meryl Creek**, Lower North Fork Sprague River*,**, Chester Spring-Sycan River**, Flu Pond-Sprague River*,**, Whiskey Creek**, Trout Creek**, Cherry Creek-Sprague River*,**, Kamkoan Spring-Sprague River*,**, Crystal Castle Spring-Sprague River*,**  **Cost range ($K):** $188 – 813 – 1,125	**2.11**	**9**	**9**	**3.5**	**4.32**
Sprague 4 (21.2)	**Promote channel migration and improve habitat conditions in the Sprague River mainstem and key tributaries by removing levees and roads.** **Project Description:** Reduce overbank flow confinement particularly in the lowland valley by removing, notching, or setting back levees, roads, and embankments to promote channel migration, slow flows, reduce erosion, and promote sediment deposition in floodplains (Newfields and Kondolf 2012, O'Connor et al. 2015, IRCT 2016, UKBWAP 2021). This action is also expected to increase habitat complexity and is related to Action #6. **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Road drainage system improvements and reconstruction, Road closure/abandonment, Dike or berm modification/removal	**2.36**	**4.82**	**8.07**	**5.25**	**0.7**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
	 **Near-Term Focal Areas (map):** 12 sub-watersheds, Lower Fishhole Creek**, Middle South Fork Sprague River*,**, Lower South Fork Sprague River**, Chester Spring-Sycan River**, Flu Pond-Sprague River*,**, Whiskey Creek**, Rock Creek, Knot Tableland-Sprague River*,**, Trout Creek**, Cherry Creek-Sprague River*,**, Kamkoan Spring-Sprague River*,**, Crystal Castle Spring-Sprague River*,** **Cost range ($K):** $1,558 – 9,781 – 27,136 (based partly on costs from MKR, Trinity, Scott)					
Sprague 8 (20.9)	**Construct DSTWs to reduce nutrient loading and improve water quality in key Sprague sub-basin tributaries.** **Project Description:** Construct Diffuse Source Treatment Wetlands (DSTWs) to capture phosphorus and nitrogen and reduce loading to key tributaries for the betterment of downstream water quality.  **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Water quality project (general), Artificial wetland created **Near-Term Focal Areas (map):** 13 sub-watersheds, Lower Fishhole Creek**, Middle South Fork Sprague River*,**, Lower South Fork Sprague River**, Lower Fivemile Creek**, Lower North Fork Sprague River*,**, Snake River**, Chester Spring-Sycan River**, Flu Pond-Sprague River*,**, Rock Creek, Knot Tableland-Sprague River*,**, Cherry Creek-Sprague River*,**, Kamkoan Spring-Sprague River*,**, Crystal Castle Spring-Sprague River*,** **Cost range ($K):** $1,838 – 3,588 – 6,388	**2.37**	**7.95**	**3.88**	**5.25**	**1.47**
Sprague 6 (19.3)	**Address fish passage issues (esp. for Redband Trout) at road/stream crossings in key areas of Sprague sub-basin.** **Project Description:** Improve habitat connectivity throughout the basin, particularly for Redband Trout, by addressing fish passage issues at road and stream crossings, with focused efforts in the North Fork Sprague River, South Fork Sprague River, and the Sycan River watershed (ODFW 2013, IRCT 2016, Trout Unlimited 2018) **Dependencies / Project Linkages:** No dependencies identified.  **Primary Action Types:** Fish passage improvement (general), Minor fish passage blockages removed or altered, Culvert installed or Improved at road stream crossing **Near-Term Focal Areas (map):** 30 sub-watersheds, Log Spring, Calahan Creek-Long Creek*,**, Shake Creek, Dry Creek, Sycan Marsh-Sycan River*,**, Upper Fishhole Creek, Middle Fishhole Creek, Pole Creek, Upper South Fork Sprague River*, Brownsworth Creek*,**, Middle South Fork Sprague River*,**, Deming Creek*, Lower South Fork Sprague	**0.54**	**6.91**	**4.75**	**3.5**	**3.26**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
	River**, Upper North Fork Sprague River**, Cain Creek-Meryl Creek, Meryl Creek**, Upper Fivemile Creek, Huckleberry Draw, Lower Fivemile Creek**, Merritt Creek, Silver Dollar Flat, Marsh Reservoir-Sycan River**, Blue Creek, Snake River**, Whiskey Creek**, Rock Creek, Trout Creek**, Cooks Creek, Long Prairie, Copperfield Draw **Cost range ($K):** $492 – 1,967 – 3,867 (incomplete – no cost data for "culvert installed or improved at road stream crossing") (based partly on cost data from Shasta, Scott, Trinity, and UKL)					
Sprague 5 (18.7)	**Restore cold-water springs that have been ponded or otherwise disconnected in the Sprague River mainstem and key tributaries.** **Project Description:** Protect, reconnect, and restore cold-water springs that have been ponded or otherwise disconnected, guided by existing groundwater studies and/or FLIR (Gannett et al. 2010, Barry et al. 2010), focusing on groundwater-fed reaches overlapping with focal species critical habitats, including the Lower Sprague reaches between Whitehorse Spring and Kamkaun Spring which are important for suckers; the Upper Sprague mainstem, lower Sycan River, North Fork Sprague, and South Fork Sprague and their tributaries which are particularly important for Bull Trout and Redband Trout: Long Creek, Fivemile Creek, Meryl Creek, Deming Creek, Brownsworth Creek (Gannett et al. 2010, IRCT 2016). **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Instream flow project (gen.), Water quality project (gen.) **Near-Term Focal Areas (map):** 13 sub-watersheds, Calahan Creek-Long Creek*,**, Middle South Fork Sprague River*,**, Lower South Fork Sprague River**, Meryl Creek**, Lower North Fork Sprague River*,**, Chester Spring-Sycan River**, Flu Pond-Sprague River*,**, Whiskey Creek**, Rock Creek, Knot Tableland-Sprague River*,**, Cherry Creek-Sprague River*,**, Kamkoan Spring-Sprague River*,**, Crystal Castle Spring-Sprague River*,**  **Cost range ($K):** $6,045 – 6,730 – 7,395 (based partly on cost data from Lost and UKL)	**2.39**	**5.34**	**5.3**	**3.5**	**2.18**
Sprague 11 (16.6)	**Improve riparian grazing practices in USFS allotments and some private rangelands within the Sprague sub-basin.** **Project Description:** Riparian conservation grazing management for USFS allottees and some private rangelands. **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Riparian area conservation grazing management	**0.52**	**6.13**	**3.48**	**3.5**	**3.01**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)* Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
	Near-Term Focal Areas (map): 33 sub-watersheds, Paradise Creek**, Log Spring, Calahan Creek-Long Creek*,**, Shake Creek, Dry Creek, Sycan Marsh-Sycan River*,**, Upper Fishhole Creek, Middle Fishhole Creek, Pole Creek, W hitworth Creek, Upper South Fork Sprague River*, Brownsworth Creek*,**, Middle South Fork Sprague River*,**, Deming Creek*, Upper North Fork Sprague River*,**, Cain Creek-Meryl Creek, Meryl Creek**, Upper Fivemile Creek, Huckleberry Draw, Lower Fivemile Creek**, Merritt Creek, Silver Dollar Flat, Marsh Reservoir-Sycan River**, Chester Spring-Sycan River**, Brown Creek**, Tim Brown Spring, Whiskey Creek**, Rock Creek, Chipps Spring, Trout Creek**, Cooks Creek, Long Prairie, Copperfield Draw  **Cost range ($K):** no cost data available						
Sprague 10 (14.0)	**Undertake upland forest management and prescribed burns to create forest gaps for improved snowpack accumulation and slow release water storage.** **Project Description:** Carry out appropriate management of upland areas through best practices in forest management, prescribed fire, and managed wildfire to thin upland vegetation and to create small gaps in the forest canopy that will improve snowpack accumulation and potential water storage for slower release, in consultation with regional water resource districts. **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Upland vegetation management including fuel reduction and burning **Near-Term Focal Areas (map):** 30 sub-watersheds, Paradise Creek**, Long Creek**, Headwaters Sycan River*,**, Chocktoot Creek, Coyote Creek*,**, Log Spring, Calahan Creek-Long Creek*,**, Shake Creek, Dry Creek, Upper Fishhole Creek, Middle Fishhole Creek, Pole Creek, Whitworth Creek, Upper South Fork Sprague River*, Brownsworth Creek*,**, Deming Creek*, Upper North Fork Sprague River*,**, Cain Creek-Meryl Creek, Meryl Creek**, Upper Fivemile Creek, Merritt Creek, Silver Dollar Flat, Blue Creek, Chester Spring-Sycan River**, Tim Brown Spring, Trout Creek**, Cooks Creek, Long Prairie, Copperfield Draw, Whitehorse Spring  **Cost range ($K):** $90 – 300 – 525	0.3	3.77	1.47	5.25	3.2

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.9)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
Sprague 7a (12.4)	**Add spawning gravels where needed to improve in-stream habitat conditions in key Sprague sub-basin streams.** **Project Description:** Improve in-stream habitat by adding spawning gravels to improve habitat conditions for focal fish. **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types:** Spawning gravel placement **Near-Term Focal Areas (map):** 8 sub-watersheds, Meryl Creek**, Chester Spring-Sycan River**, Brown Creek**, Flu Pond-Sprague River*,**, Knot Tableland-Sprague River*,**, Cherry Creek-Sprague River*,**, Kamkoan Spring-Sprague River*,**, Crystal Castle Spring-Sprague River*,**  **Cost range ($K):** $150 – 350 – 550	**3**	**0.9**	**0.9**	**3.5**	**4.06**

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC and SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, and sub-regional working group input via surveys, webinars.

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the Sprague Sub-basin

Shortnose Sucker and Lost River Sucker use a relatively small part of the sub-basin, focussing on spawning areas in the Lower Sprague River between its confluence with the Williamson River up to the midway point between the Sycan and North Fork Sprague rivers (USFWS 2012). ***Bull Trout*** are also an important occupant of this basin with designated critical habitat in upper Long Creek above Sycan Marsh, and in tributaries of the North and South Fork Sprague rivers including Dixon Creek, Boulder Creek, Deming Creek, Leonard Creek and Brownsworth Creek (USFWS 2015). ***Redband Trout*** are the most widespread focal species in this basin with conservation populations occupying entire mainstem Sprague River and its tributaries (IRCT 2016). ***Chinook Salmon***, ***steelhead***, and ***Pacific Lamprey*** all once historically occupied this sub-basin and are expected to fully return to this sub-basin following fish passage restoration work in the Lower Klamath River.

The Sprague sub-basin contains five Conservation Opportunity Areas under Oregon's Conservation Strategy, with recommended conservation actions including maintaining or improving in-channel watershed function, flow, hydrology, and connectivity, as well as restoring riparian habitats and upland forest habitats (ODFW 2016). Table 4-11 summarizes select major past restoration activities in this sub-basin to date and the species which they have benefited.

Table 4-11: Summary of major restoration efforts in the Sprague sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit (including focal species not currently present in the sub-basin).

Key Restoration Activities in the Sprague Sub-basin to Date	Species Benefiting				
	SU	RT	*BT*	*CH/ST*	*PL*
Removal of the Chiloquin Dam in 2008 to restore fish passage for migratory Lost River Sucker and Shortnose Sucker to upstream spawning in the Sprague River (Martin et al. 2013), and removal of many smaller fish passage barriers in other parts of the sub-basin.	●	○	○	●	●
Extensive restoration to the Sycan Marsh and River region to bypass a fish passage barrier, remove road crossings, and restore form and function to the Sycan River and its floodplain in the region of the marsh created new habitat, improved groundwater recharge, and reconnected significant Bull Trout populations in Long Creek to the mainstem Sycan River (Bienz 2017).		●	●	○	○
Extensive restoration of smaller seasonal and permanent wetlands in the lower Sprague River in the vicinity of Chiloquin, including riparian fencing, planting, and cutoff plugs to restore sinuosity and improve spawning habitat for migratory suckers (NewFields and Kondolf 2012).		●	●	●	○
Riparian fencing, riparian restoration, and offstream watering projects throughout other parts of the Sprague sub-basin (NewFields and Kondolf 2012).	●	●	●	●	●

Current State of Monitoring & Data Gaps

Past and Ongoing Monitoring:

Water quality data on nutrient and sediment loads has been collected at sites in the Sprague River to Upper Klamath Lake since the late 1980s by The Klamath Tribes and, more recently, by the USGS. The Beaver Management Team of the Klamath Watershed Partnership has created baseline historical, current, and potential beaver habitat assessment maps for the Sprague River area as a foundation for a ten-year basin-wide beaver restoration effort. The UKBWAP IRPT also includes a dam suitability index that identifies areas with the physical characteristics for beaver dams and BDAs. There exist strong coordinated programs for monitoring of both juvenile and adult Shortnose and Lost River suckers in the lower Sprague (e.g. USGS PIT tag monitoring network). Project implementation and local effectiveness of individual restoration projects is generally tracked as part of funding reporting requirements (although this data is not always readily available).

Current Data Gaps:

Figure 4-12 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring across agencies in the Sprague sub-basin. Location-specific agency metadata (where available) on monitoring projects is incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. Many of the USGS/OWRD groundwater monitoring sites occur throughout the lower part of the sub-basin, while KBMP's current monitoring inventory indicates high numbers of agency gauges for monitoring of streamflow, water quality, and water temperature although these are concentrated in certain areas and not widely present across the whole sub-basin. KMBP's monitoring summary for the Sprague sub-basin indicates good coverage of monitoring stations for a range of habitat information (i.e., water quality, surface flow, groundwater, water temperature, weather) but most of these stations are concentrated in the Oregon section of the sub-basin.

Sprague Sub-basin Monitoring Summary

Habitat Monitoring			
Watershed Inputs	Weather	●
Watershed Inputs	Streamflow	●
Watershed Inputs	Groundwater	●
Watershed Inputs	Riparian & Landscape	●
Fluvial-Geomorph	Sediments & Gravel	●
Fluvial-Geomorph	Stream Morphology	●
Habitat	Stream Temperature	●
Habitat	Water Quality	●
Habitat	Habitat Quality	●
Habitat	Barriers & Injury	●
Habitat	Marine/Estuary	NA
Biota	Invasive Species	●

Population Monitoring		Suckers	RB Trout	Bull Trout
Abundance	Juvenile Abundance (anad)	NA	NA	NA
Abundance	Spawner Abundance (anad)	NA	NA	NA
Abundance	Abundance (non-anad)	●	●	●
Harvest	Harvest (in-river)	NA	●	
Harvest	Harvest (ocean)	NA	NA	NA
Distrib-ution	Temporal Distribution	●	●	●
Distrib-ution	Spatial Distribution	●	●	●
Demo-graphics	Stock Composition	●	●	●
Demo-graphics	Age Structure	●		
Biota	Disease	●		

● Known monitoring activities (past or ongoing)
NA Monitoring not relevant to this sub-basin

Figure 4-12. Synthesis of past and ongoing monitoring activities in the Sprague sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

:

- Revised recovery plan for the Lost River Sucker (*Deltistes luxatus*) and Shortnose Sucker (*Chasmistes brevirostris*) (USFWS 2012)
- Klamath Recovery Unit Implementation Plan for Bull Trout (*Salvelinus confluentus*) (USFWS 2015)
- A Conservation Strategy for Interior Redband (*Oncorhynchus mykiss subsp.*) in the states of California, Idaho, Montana, Nevada, Oregon, and Washington (IRCT 2016)
- A Plan for The Reintroduction of Anadromous Fish In The Upper Klamath Basin (ODFW 2008) and the associated Implementation Plan for the Reintroduction of Anadromous Fish into the Oregon portion of the Upper Klamath Basin (ODFW and Klamath Tribes 2021) which is to mainly serve as an appendix to ODFW Klamath Basin fisheries management Plan.
- Oregon Conservation Strategy, with multiple opportunity areas in this sub-basin
- Upper Sprague Assessment and Upper Sprague & Sycan Action Plan (Connely and Lyons 2007, KWP 2010)

- Lower Sprague-Lower Williamson Watershed Assessment and Action Plan (Rabe and Calonje 2009, KBEF 2009)
- Klamath Tribes Wetland and Aquatic Resources Program Plan (LaGreca and Fisher 2015)
- Klamath Tribal Water Quality Consortium Upper Klamath Basin Nonpoint Source Pollution Assessment and Management Program Plan (KTWQC 2018)
- Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)
- Water Quality Restoration Plan for the Upper Klamath Basin (USFS and BLM 2003)
- Winema and Deschutes National Forest Land and Resource Management Plans
- The Upper Klamath Basin Watershed Action Plan (UKB WAP) overseen by The Klamath Tribes and collaborating Klamath Bain restoration entities, which will also summarize regional restoration needs but will also identify and prioritize specific candidate sites for restoration activities, including those activities identified in the PacifiCorp Interim Measures 11 Priority Projects List (PacifiCorp 2018).
- The Reintroduction Implementation Plan of Anadromous Fish into the Upper Klamath Basin overseen by the Oregon Department of Fish and Wildlife (ODFW) and The Klamath Tribes, which will outline additional management, restoration, and monitoring activities to benefit anadromous fish recolonizing this area following restoration of fish passage and are likely to provide overlapping benefits to resident fish.

LOST

SUB-BASIN RESTORATION & MONITORING PROFILE

Photo: Tule Lake Marsh and Mount Shasta | USFWS 2010

4.3.4 Lost River Sub-basin

The Lost River sub-basin is known for its large areas of private agricultural and grazing lands, many of which benefit from irrigation through the Bureau of Reclamation's Klamath Project. The Lost River basin is a closed basin draining into Tule Lake, a terminal lake. The river was historically connected to the mainstem Klamath River through the Lost River Slough, near Klamath Falls, during periods of high runoff (USBR 2005).

Today, a portion of the Klamath River is now diverted into the Lost River system via the A-Canal, Lost River Diversion Channel, and other smaller canals, with flow being controlled by the Clear Lake and Gerber Reservoirs. To support agricultural activities, Lower Klamath Lake and Tule Lake were nearly fully drained from their original extent. This sub-basin also contains Lake Ewauna and the downstream Keno Impoundment, which represent significant water quality barriers for fish. Many parts of this sub-basin are affected by channelization and diversions contributing to fish stranding and mortality as well as seasonally high stream temperatures, high pH, low dissolved oxygen, and high nutrient loading. The Lost River sub-basin also includes the Clear Lake, Tule Lake, and Lower Klamath National Wildlife Refuges and part of the Fremont-Winema, Klamath, and Modoc and National Forests (ESSA 2017).

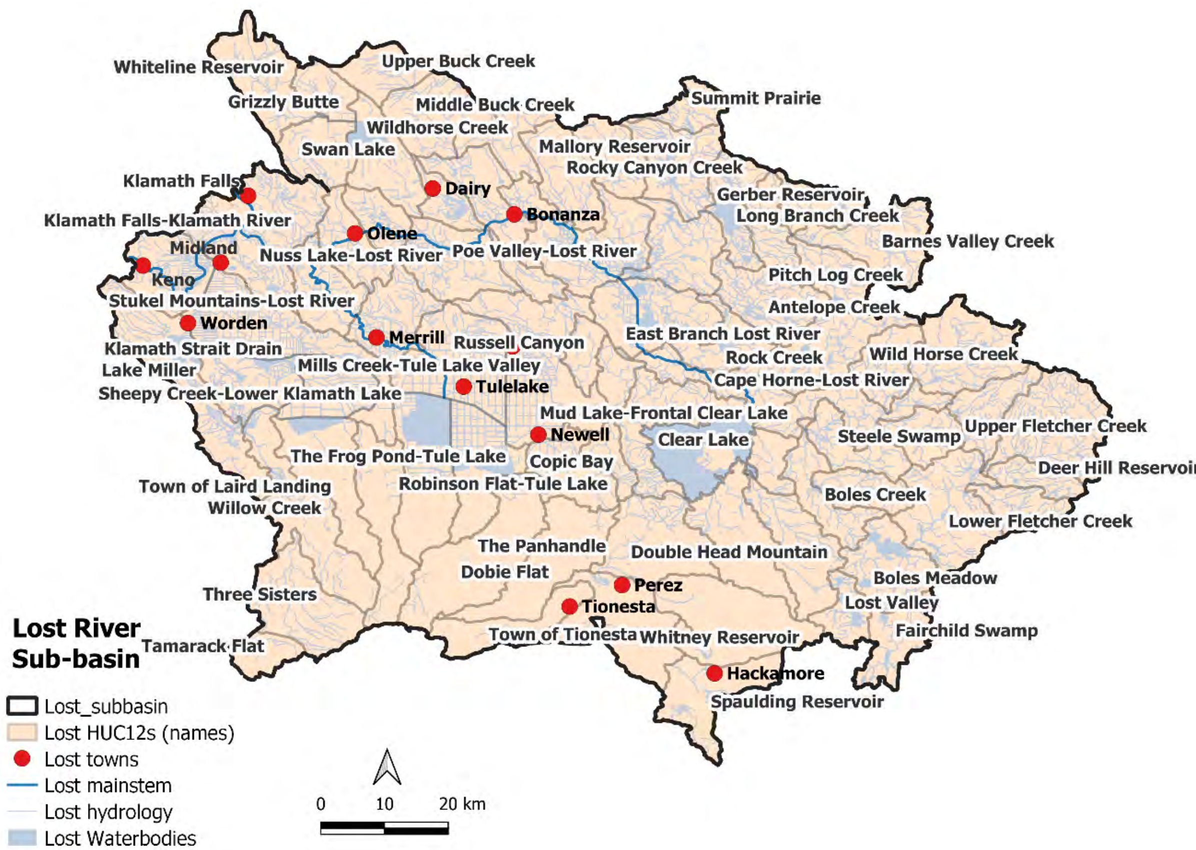


Figure 4-13: Reference map of the Lost River Sub-Basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current**: Shortnose Sucker, Lost River Sucker, Redband Trout
- **Historical**: Coho salmon, Chinook Salmon, steelhead, Pacific Lamprey were not likely present in this region other than during migration through the small part of the Klamath River mainstem that passes through this sub-basin.

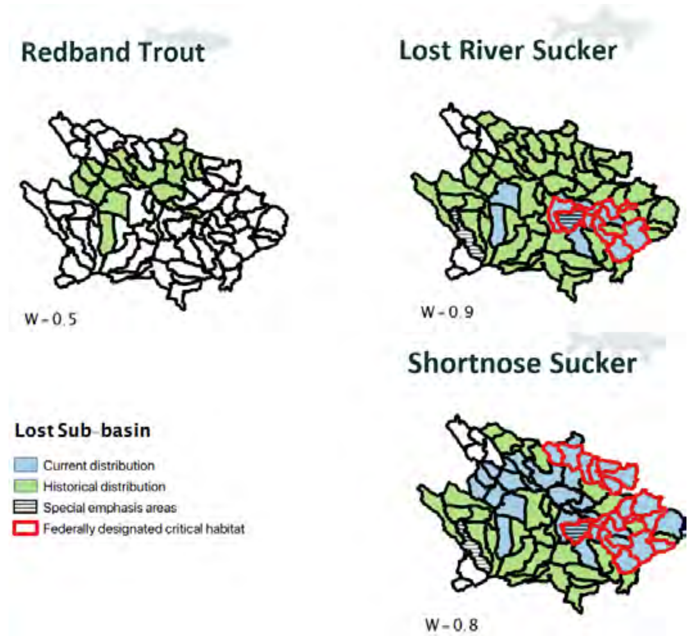


Figure 4-14: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the Lost River sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors

Table 4-12: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the Lost River sub-basin, listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. SU = suckers, RT = Redband Trout, CS = Chinook Salmon (future), PL = Pacific Lamprey (future).

Key Stressors	Tier	Stressor Summary for the Lost Sub-basin	Species			
			SU	RT	*CS*	*PL*
Instream Flow / Lake Levels	WI FG	The highest stream flow restoration priorities in this sub-basin are for those regions designated as critical spawning and rearing habitat for Lost River and Shortnose suckers, including Clear Lake, Willow Creek, Boles Creek, Fletcher Creek, and the Gerber Reservoir[1]. Use of water for irrigation as well as natural hydrologic vulnerability to drought have significantly reduced sucker habitat through lowering water levels in historical wetland areas, limiting access to shoreline spawning sites and limiting hydrologic connection to spawning streams in dry periods (particularly in Willow Creek at Clear Lake Reservoir) (USFWS 2012). Moreover, low flows may not be sufficient to trigger flow-related spawning migrations for suckers in some locations (e.g., <40 cfs in	●	●	●	○

Key Stressors	Tier	Stressor Summary for the Lost Sub-basin	Species			
			SU	RT	*CS*	*PL*
		Willow Creek) and can contribute to greater exposure to bird predation both in the lake and creek (USBOR 2018).				
Water Quality Hypereutro-phication (related to DO, pH)	WI	Related primarily to water quality issues related to upstream watershed loading from Upper Klamath Lake driving poor water quality in Lake Ewauna and the Keno Impoundment where DO often drops below levels lethal to fish (USFWS 2012). These waters flow onwards through diversion canals into the region of the Klamath Project and into Tule Lake, where water quality and DO are also often suboptimal, but only infrequently unsuitable for fish. In general, water quality is not considered to be limiting for fish in Clear Lake or the Gerber Reservoir (USBOR 2018).	●	○		
Water Temperature	FG	Water temperatures in this sub-basin are a concern in relation to their interaction with water levels and direct effects on water quality. In summer months, lower water levels in canals, impoundments, and lakes can lead to increased temperatures and lower DO which can cause physiological stress to resident fish. In the winter months, low water levels combined with very low temperatures can lead to extensive freezing of surface waters which limits oxygen diffusion and also leads to lower DO (USBOR 2018).	●	●	●	●
Fish Entrainment	H	Entrainment in unscreened diversions is a concern for all fish species, with nearly all of the upper half of this sub-basin having more than one diversion per stream mile[2]. Entrainment is a concern, particularly for suckers encountering the Ady Canal; Lost River Diversion Channel, and Willow Creek diversions[3], Anderson-Rose, Gerber, Miller Creek, and Malone dams, and several hundred small and typically unscreened diversions with unknown levels of entrainment. Prior entrainment points at the A-Canal and Clear Lake Dam have been recently screened for adults, but still entrain larvae and some juveniles, and entrainment in the Lake Ewauna and Keno Impoundment reach is an ongoing concern (USFWS 2012, USBOR 2018).	●	●	○	○
Anthropogenic Barriers	H	Relates to loss of physical access to suitable spawning and rearing areas as well as disconnection of populations for suckers and Redband Trout due to fish passage barriers (USBOR 2018). Tributaries where access may be limited by fish passage barriers include the Keno Dam, Gerber Reservoir, Miller Lake, Harpold Dam and Hunt Reservoir[4], while low water levels in Clear Lake Reservoir (<4,524 ft) and Gerber Reservoir (<4,805 ft) may also create a barrier to spawning habitats in adjacent creeks and result in missed spawning seasons for these populations of suckers (USFWS 2012, USBOR 2018). In addition, some suckers migrating up Willow Creek may become stranded above smaller dams in the tributaries of the Creek (USBOR 2018).	●	●	●	●
Habitat complexity (mesohabitats)	H	Related to the availability of suitable instream spawning and wetland rearing habitats, particularly for entrained juvenile suckers rearing in Lake Ewauna and the Keno Impoundment, and Clear Lake suckers spawning in Willow Creek (USFWS 2012).	●	○	○	○

Spatial stressor hotspots identified from, (1) CDFW BIOS - USFWS Species Critical Habitats (2) Trout Unlimited Conservation Success Index data (3) ODFW 2013 Priority Unscreened Diversion Inventory (4) ODFW 2013 Fish Passage Priority List.

Sequences of Restoration Projects for the Lost River Sub-Basin

The **summary infographic** in Figure 4-15 provides a compact overview of the Lost sub-basin restoration project priorities and their distribution across the sub-basin.

Figure 4-15: Summary for the Lost River sub-basin, including key stressors, cost ranges, and projects (see next page).

Lost River Sub-basin

Sub-Basin Summary

The Lost River sub-basin is notable for large areas of private agricultural and grazing lands irrigated by the Bureau of Reclamation's Klamath Project. The river was historically connected to the mainstem Klamath River through the Lost River Slough, near Klamath Falls, during periods of high runoff. Today, a portion of the Klamath River is now diverted into the Lost River system via the A-Canal, Lost River Diversion Channel, and other smaller canals, and flow is controlled by the Clear Lake and Gerber Reservoirs. To support agriculture, Lower Klamath Lake and Tule Lake were nearly fully drained from their original extent. This subbasin also contains Lake Ewauna and the downstream Keno Impoundment, which represent significant water quality barriers for fish. Many parts of this subbasin are affected by high stream temperatures, low dissolved O_2, high pH, high nutrient loading, and channelization and diversions contributing to fish entrainment. For the purpose of prioritization Keno Reach projects are considered in the UKL Sub-basin instead to reflect its hydrologic connectivity with Upper Klamath Lake. The Lost River subbasin also includes the Lower Klamath National Wildlife Refuges and part of the Fremont, Klamath, Modoc and Winema National Forests.

Restoration Summary

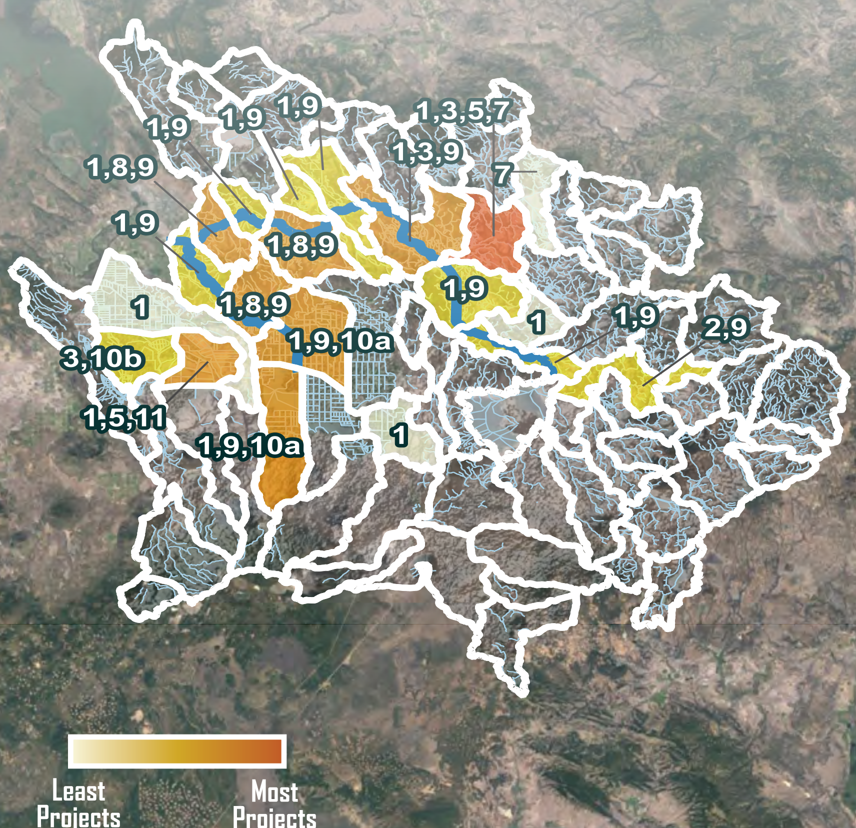
Projects in the Lost address four primary categories of stressors: water availability, fine sediment inputs, access to habitat, and habitat quality. There are a number of dependencies identified among projects which will influence the ultimate sequencing decisions. Most of projects in the Lost are very spatially focused, with the exception of Project 1 and project 9d. The two top ranked projects are distinct from one another. The first involves water use practices broadly within the sub-basin and the second involves habitat improvements focused within a specific HUC.

Key Stressor Summary

Key Stressors	Focal Species (Current and Future)			
	SU	RT	CS	PL
Instream Flow				
Water Quality (DO, pH)				
Water Temperature				
Fish Entrainment				
Anthropogenic Barriers				
Habitat Complexity (mesohabitats)				

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is $13.8M - $23.3M - $33.4M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP Lost sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting, and **arrows** indicate linkages between projects.

Project ID & Description	Tiers
Lost 9d - Install riparian fencing along the mainstem Lost River to reduce grazing impacts | **21.6**	H, FG
Lost 11a - Improve the fish ladder at Keno Dam to provide better upstream passage for migratory fish species | **20.8**	H
Lost 1 - Improve water use efficiencies throughout the Klamath Project and Klamath River Between Keno and Link River Dams to improve water quality and stream temperatures | **20.7**	WI
Lost 11b - Improve the fish ladder at Link River Dam to provide better upstream passage for migratory fish species | **19.0**	H
Lost 3 - Explore acquisition of water rights to increase instream flows in key Lost River tributaries | **18.7**	WI
Lost 5 - Install fish screens in the Keno impoundment reach to prevent adult and juvenile fish mortality | **18.1**	H, FG
Lost 9 - Improve habitat conditions at the mouth of Willow Creek/Clear Lake to provide spawning habitat for endangered suckers | **16.0**	H
Lost 8 - Install passage infrastructure at Harpold and other diversion dams currently restricting access to potential upstream spawning habitats above Tule Lake | **17.0**	H
Lost 10a - Improve condition and extent of spawning habitat for suckers in Tule Lake/ Lost River | **16.2**	H
Lost 7 - Install passage infrastructure at Gerber and Miller Diversion dams to allow access to potential upstream spawning habitats in Miller Creek | **14.0**	H
Lost 2 - Reconfigure Willow Creek/Clear Lake forebay to improve access to Willow Creek spawning areas at low flows | **13.9**	H
Lost 10b - Reconfigure and reconnect channels in Sheepy Creek to improve habitat conditions for endangered suckers | **7.5**	H, FG

Table 4-13 presents the results of the 2022 iteration of the IFRMP restoration sequencing process for the Lost River sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-13. The projects listed here have a cost range of $13.8M – $23.3M - $33.4M (low, estimated midpoint, high), and have been collated from projects proposed in prior local or regional restoration plans and studies as well as from in-depth discussions among participants in the IFRMP's Lost River Sub-basin Working Group who represent scientists, restoration practitioners, and resource users working in the sub-basin (see Acknowledgements section). The sequences and scoring in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria. Additional considerations such as implementability, cost and dependencies among projects may influence the ultimate sequencing of projects. Dependencies identified by the Sub-basin Working Groups are noted in the table. Sequencing of projects will be very important for maximizing benefits in the sub-basin but determining the optimal sequencing steps for multi-project implementation requires further deliberation among the working group. To facilitate comparison across the sub-basins, results are shown assuming the four major Klamath mainstem dams have been removed, but no other changes. The Lost Sub-basin Working Group identified the following additional scenarios with potential to influence restoration priorities. Should any these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

- TMDL or ODA enforcement actions
- Critical habitat designation changes
- Irrigation modernization

Projects in the Lost address four primary categories of stressors: water availability, fine sediment inputs, access to habitat, and habitat quality. There are a number of dependencies identified among projects which will influence the ultimate sequencing decisions. Most of projects in the Lost are very focused spatially, with the exception of Project 9d and project 1.

- **Projects 9d, 11a.** Project 9d is unique in nature from all of the other projects in this sub-basin and involves installation of riparian fencing throughout the mainstem Lost River to reduce impacts of grazing. Project 11a involves working with agriculture interests and others to provide better upstream passage by improving the fish ladder at Keno Dam.

These projects were closely followed in ranking by the following second suite of restoration projects:

- **Projects 1, 11b.** Project 1 involves improvement to water use efficiencies to improve water quality and stream temperatures. Project 11b involves establishing better upstream passage by improving the fish ladder at Link River Dam.

Projects ranked as of more intermediate restoration importance included:

Projects 3, 5, 9, 8, 10a. Project 3 involves acquiring water rights to increase instream flows. Project 5 involves installation of fish screens in three HUCs. Project 9 relates to improving sucker spawning habitat conditions at Willow Creek / Clear Creek. Project 8 about improving fish passage at diversion dams that restrict access to upstream spawning habitats above Tule Lake. Project 10a involves improving habitat for suckers and is linked to Project 8

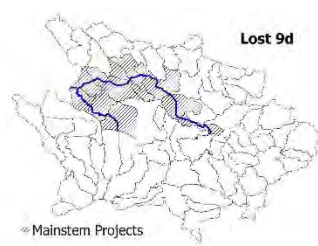
Sub-group recommendations

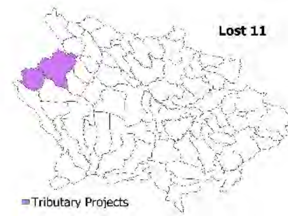
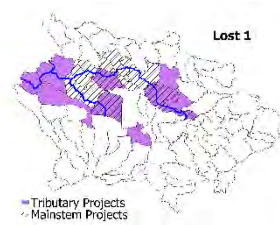
- Consider raising the rank order of project to so as to implement it in parallel with Project 9.

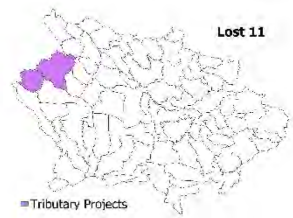
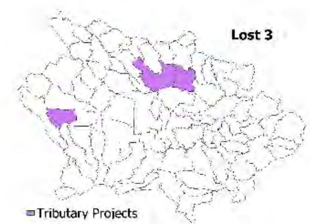
The lowest ranking restoration projects in the Lost sub-basin were:

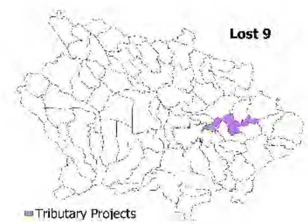
- **Project 7, 2, 10b.** Project 7 involves installing fish passage infrastructure to allow fish to access upstream spawning habitats at Miller Creek. While Project 2 is ranked relatively low, it is recommended to be implemented in parallel with Project 9 to enable access to the habitat created in Project 9. Project 10b represents an opportunity to re-establish historical distribution of endangered suckers.

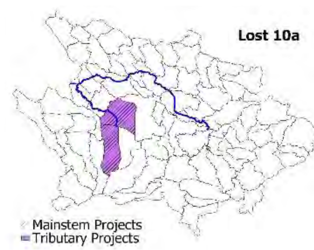
Table 4-13: Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the Lost Sub-, with projects scored higher to be considered first for implementation. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name. Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-13, while special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin IFRMP planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

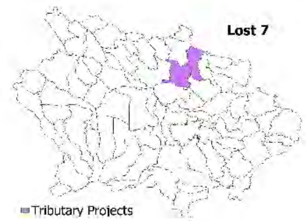
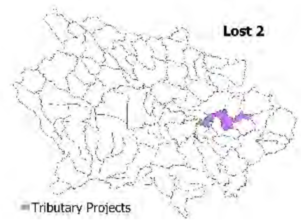
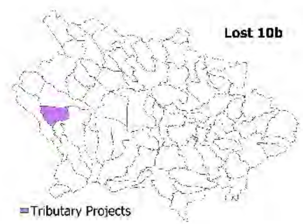
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.7)*	Stressors Addressed *(0.7)*	Scale of Benefit *(0.7)*	Implementability *(0.9)*
Lost 9d (21.6)	**Work with agriculture interests and others to install riparian fencing along the mainstem Lost River to reduce grazing impacts.** **Project Description:** Install riparian fencing along the mainstem Lost River in areas where streambanks are more accessible and there is documentation that cattle in the river are a problem that needs to be addressed to reduce impacts of grazing on riparian habitat and to reduce sediment inputs to streams. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Fencing **Near-Term Focal Areas (map):** 12 sub-watersheds, Clear Lake Reservoir-Lost River, Woolen Canyon-Lost River, Cys Branch-Lost River, Lower Buck Creek-Lost River, Alkali Lake-Lost River, Poe Valley-Lost River, Olene Gap-Lost River, Ness Lake-Lost River, Stukel Mountains-Lost River, Anderson Rose Diversion Dam-Lost River, Tule Lake Valley-Lost River, Sheepy Creek-Lower Klamath Lake  **Cost range ($K):** $375 – 1,050 – 1,800	1.31	4.36	3.48	3.5	9
Lost 11a (20.8)	**Work with agriculture interests and others to improve the fish ladder at Keno Dam to provide better upstream passage for migratory fish species.** **Project Description:** Improve the efficacy of the Keno Dam fish ladder to improve upstream and downstream passage for migrating fish, including all migratory life stages of suckers, Pacific Lamprey, and salmonids (USFWS 2012, Goodman et al. 2015, Goodman and Reid 2017, Pacific Lamprey Technical Workgroup 2017). This includes improving the attraction flows at the fish ladder and improved downstream passage through the dam that involve allowing water to spill over the gates for increased downstream passage and survival of fishes and adding fish detection systems for monitoring passage, as recommended in the Implementation plan for the reintroduction of anadromous fishes into the Oregon portion of the Upper Klamath Basin (ODFW and the Klamath Tribes 2021).	6	6.15	1.73	5.25	1.69

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.7)*	Stressors Addressed *(0.7)*	Scale of Benefit *(0.7)*	Implementability *(0.9)*
	Dependencies / Project Linkages: No dependencies identified **Primary Action Types:** Fish ladder installed/improved **Near-Term Focal Areas (map):I** 1 sub-watershed, Keno Reservoir-Klamath River** **Cost range ($K):** $10 – 30 – 45 					
Lost 1 (20.7)	**Work with agriculture interests and others to improve water use efficiencies throughout the Klamath Project and Klamath River Between Keno and Link River Dams to improve water quality and stream temperatures.** **Project Description:** Consistent with BiOp and project operations, pursue priority improvements to water conservation and irrigation conveyance efficiency projects throughout the Klamath Project. Implement measures recommended by the Natural Resources Conservation Service (NRCS) National Water Quality Initiative (NWQI) in the upper Lost River watershed for the Langell Valley-Lost River region west of Gerber Reservoir (PacifiCorp 2018). This would yield improvements for water quality, particularly related to sediment and phosphorous loading, and temperature. Planning for this project is already taking place through the Farmer's Conservation Alliance (FCA), and the Klamath Wildlife Area (KWA) planning process. **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Instream flow project (general), Irrigation practice improvement **Near-Term Focal Areas (map):** 17 sub-watersheds, East Branch Lost River, Clear Lake Reservoir-Lost River, Miller Creek, Woolen Canyon-Lost River, Cys Branch-Lost River, Lower Buck Creek-Lost River, Alkali Lake-Lost River, Poe Valley-Lost River, Olene Gap-Lost River, Ness Lake-Lost River, Stukel Mountains-Lost River, Anderson Rose Diversion Dam-Lost River, Tule Lake Valley-Lost River, Copic Bay, Klamath Strait Drain, Klamath Falls-Klamath River**, Keno Reservoir-Klamath River**  **Cost range ($K):** $10,825 – 11,150 – 11,400	**1.78**	**5.3**	**6.03**	**5.25**	**2.35**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.7)*	Stressors Addressed *(0.7)*	Scale of Benefit *(0.7)*	Implementability *(0.9)*
Lost 11b (19.0)	**Improve the fish ladder at Link River Dam to provide better upstream passage for migratory fish species.** **Project Description:** While USBR replaced an inadequate fish ladder in 2005 to allow efficient passage of endangered suckers, Redband Trout, and lampreys migrating from Lake Ewauna to Upper Klamath Lake, monitoring of fish passage following dam removal may reveal the need for further improvements to upstream and downstream passage for migrating fish, including all migratory life stages of suckers, Pacific Lamprey, and salmonids (USFWS 2012, Goodman et al. 2015, Goodman and Reid 2017, Pacific Lamprey Technical Workgroup 2017, ODFW and the Klamath Tribes 2021).  **Dependencies / Project Linkages:** No dependencies identified **Primary Action Types:** Fish ladder installed/improved **Near-Term Focal Areas (map):** 1 sub-watershed, Klamath Falls-Klamath River** **Cost range ($K):** $10 – 30 – 45	5.65	4.7	1.73	5.25	1.7
Lost 3 (18.7)	**Explore acquisition of water rights to increase instream flows in key Lost River tributaries.** **Project Description:** Contingent on the status of Redband Trout and Lost River Suckers, explore options for acquisition of water rights to increase instream flows (e.g., Miller Creek and Sheepy Creek which historically supported populations of Redband Trout (ODFW 2005, IRCT 2016) and Lost River Suckers (Mark Buettner, pers. comm.) respectively. **Dependencies / Project Linkages:** This project was described as good in theory but difficult in practice. That said it is considered important to complete prior to projects 7 and 10.  **Primary Action Types:** Water leased or purchased, Manage water withdrawals **Near-Term Focal Areas (map):** 3 sub-watersheds, Miller Creek, Cys Branch-Lost River, Sheepy Creek-Lower Klamath Lake **Cost range ($K):** $3,186 – 8,940 – 14,563 (based partly on costs from Shasta, SF Trinity, Trinity)	1.07	2.57	7	5.25	2.78
Lost 5 (18.1)	**Install fish screens in the Keno impoundment reach to prevent adult and juvenile fish mortality** **Project Description:** Screen the 60+ diversions identified in the Keno impoundment reach to prevent adult and juvenile fish mortality.	5.82	5.38	0.81	1.75	4.29

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.7)*	Stressors Addressed *(0.7)*	Scale of Benefit *(0.7)*	Implementability *(0.9)*
	Dependencies / Project Linkages: No dependencies indicated. **Primary Action Types:** Fish screens installed **Near-Term Focal Areas (map):** 2 sub-watersheds, Klamath Falls-Klamath River**, and Keno Reservoir-Klamath River** **Cost range ($K):** $170 – 1,275 – 3,145 					
Lost 9 (17.3)	**Improve habitat conditions at the mouth of Willow Creek/Clear Lake to provide spawning habitat for endangered suckers.** **Project Description:** Improve in-stream, wetland, and riparian habitat in around the mouth of Willow Creek where it meets Clear Lake, throughout upstream reaches to provide habitat for spawning suckers in Clear Lake, assuming access is not limiting (USFWS 2012). **Dependencies / Project Linkages:** Project 9 depends on Project 2 which is important for providing access to the habitat especially in low flow years. **Primary Action Types:** Instream habitat project (general), Riparian planting, Wetland improvement/restoration **Near-Term Focal Areas (map):** 1 sub-watershed, Hidden Valley-North Fork Willow Creek* **Cost range ($K):** $350 – 2,825 – 5,150 	**3.2**	**1.13**	**5.22**	**3.5**	**4.21**
Lost 8 (17.0)	**Install passage infrastructure at Harpold and other diversion dams currently restricting access to potential upstream spawning habitats above Tule Lake.** **Project Description:** Contingent on improvements to stressors on habitat in Tule Lake (see Action # 9), implement fish passage at the Anderson-Rose Diversion Dam, Lost River Diversion Dam, and Harpold Dam, which currently restrict access of Tule Lake suckers to historical spawning areas in the Lost River and restrict connectivity of Redband Trout (USBOR 2018). The Harpold Dam is on the ODFW 2013 Fish Passage Priority List.	**1.31**	**7**	**1.73**	**5.25**	**1.74**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.7)*	Stressors Addressed *(0.7)*	Scale of Benefit *(0.7)*	Implementability *(0.9)*
	Dependencies / Project Linkages: Depends on project 10 which involves improving habitat in the area which would be made accessible by project 8. **Primary Action Types:** Fish ladder installed/improved **Near-Term Focal Areas (map):** 3 sub-watersheds, Poe Valley-Lost River, Ness Lake-Lost River, Anderson Rose Diversion Dam-Lost River **Cost range ($K):** $10 – 30 – 45 					
Lost 10a (16.2)	**Improve conditions and extent of spawning habitat for suckers in Tule Lake/Lost River.** **Project Description:** Improve habitat conditions in Tule Lake and adjacent Lost River to facilitate successful spawning of suckers in Tule Lake. Improvements may include restoring and expanding areas of deep-water (>3 ft) habitat through flooding and small-scale dredging to reduce bird predation on resident suckers, as well as enhancement or expansion of spawning habitat in the connected portion of the Lost River (USBOR 2018). This would be a prerequisite to providing additional fish passage for this population, noted in Action #6. **Dependencies / Project Linkages:** Involves improving habitat in the area which would be made accessible by project 8. **Primary Action Types:** Instream habitat project (general), Mechanical channel modification and reconfiguration **Near-Term Focal Areas (map):** 2 sub-watersheds, Tule Lake Valley-Lost River, Robinson Flat-Tule Lake **Cost range ($K):** $145 – 405 – 660 	**1.66**	**3.17**	**4.36**	**3.5**	**3.52**
Lost 7 (14.0)	**Install passage infrastructure at Gerber and Miller Diversion dams to allow access to potential upstream spawning habitats in Miller Creek.** **Project Description:** Consider improving fish passage through Gerber Dam and Miller Diversion dam to benefit Gerber Reservoir suckers as well as Redband Trout by expanding potential spawning habitat to Miller Creek and restoring connectivity with the Lost River beyond Miller Creek (ODFW 2013, USBOR 2018). Both dams are on the ODFW 2013 Fish Passage Priority List, and improving passage at these points would open up nearly 20 miles of habitat for these species.	**1.78**	**4.36**	**1.73**	**5.25**	**0.9**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.7)*	Stressors Addressed *(0.7)*	Scale of Benefit *(0.7)*	Implementability *(0.9)*
	Dependencies / Project Linkages: Depends on project 3 and project 1. It is not worth enabling passage if insufficient water is available to support fish. **Primary Action Types:** Fish ladder installed/improved **Near-Term Focal Areas (map):** 2 sub-watersheds, Gerber Reservoir*, Miller Creek **Cost range ($K):** $10 – 30 – 45 					
Lost 2 (13.9)	**Reconfigure Willow Creek/Clear Lake forebay to improve access to Willow Creek spawning areas at low flows.** **Project Description:** Reconfigure the arrangement of Willow Creek with the forebay of Clear Lake to overcome limited access of adults to spawning sites in Willow Creek during low water years (USFWS 2012, 2016), potentially through construction of a more direct bypass channel capable of providing continuous passage at low flows. This action should be paired with Action #9. **Dependencies / Project Linkages:** This project supports project 9 by providing access to habitat which will be improved through project 9. **Primary Action Types:** Mechanical channel modification and reconfiguration **Near-Term Focal Areas (map):** 1 sub-watershed, Hidden Valley-North Fork Willow Creek* **Cost range ($K):** $45 – 210 – 540 	**3.2**	**1.13**	**2.48**	**3.5**	**3.62**
Lost 10b (7.5)	**Reconfigure and reconnect channels in Sheepy Creek to improve habitat conditions for endangered suckers.** **Project Description:** Improve habitat conditions in Sheepy Creek. Consider potential for re-establishing Lost River Sucker in Sheepy Creek through channel reconfiguration and connectivity. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Instream habitat project (general), Mechanical channel modification and reconfiguration **Near-Term Focal Areas (map):** 1 sub-watersheds, Sheepy Creek-Lower Klamath Lake **Cost range ($K):** $165 – 410 – 660 	**0.6**	**0.7**	**0.7**	**3.5**	**1.99**

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC and SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, and sub-regional working group input via surveys and webinars.

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the Lost River Sub-basin

Shortnose Sucker and Lost River Sucker have important conservation populations in this sub-basin including those in Clear Lake and Gerber Reservoir (designated as Critical Habitats) as well as a smaller population in Tule Lake and small pockets of populations in the mainstem Lost River (USFWS 2012, USBOR 2018). ***Redband Trout*** were historically more common in this sub-basin, particularly in the Upper Lost River, Miller Creek, and Gerber Reservoir area, but it is thought that many of these populations have disappeared and the current status of the species in this sub-basin is not well understood (IRCT 2016). Similarly, ***Bull Trout*** may have once used parts of this sub-basin, but no populations are currently recognized or managed within this region (USFWS 2015). ***Chinook Salmon***, ***steelhead***, and ***Pacific Lamprey*** would have once migrated through the small part of the mainstem Klamath River to reach other parts of the upper basin but were not historically present in the Lost River or its tributaries.

Within the Lost River sub-basin, the lower Lost River mainstem is a priority Conservation Opportunity Area under Oregon's Conservation Strategy, with recommended conservation actions including maintaining or improving connectivity, flow and hydrological function, riparian habitat, and floodplain wetland habitat (ODFW 2016). The following table summarizes select major past restoration activities in this sub-basin to date and the fish species which they have benefited.

Table 4-14: Summary of major restoration efforts in this sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit (including focal species not currently present in the sub-basin).

Key Restoration Activities in this Sub-basin to Date	Species Benefiting				
	SU	RT	*BT*	*CH/ST*	*PL*
Screening of A-Canal and Clear Lake Dam to reduce sucker entrainment (USFWS 2012)	●	○			
Establishment of a "head start" rearing program for larval and juvenile Lost River and Shortnose suckers based out of Stearns ponds in the Lower Klamath National Wildlife Refuge (USFWS 2016, Rasmussen and Childress 2018).	●				
USFWS's Partners for Fish and Wildlife walking wetlands programs to reduce the need for fertilizer and pesticide use on private lands and improve water quality around Tule Lake (USFWS 2016).	○				
Minimum water levels for Tule Lake, Gerber reservoir, and Clear Lake are now mandated by a 2019 BiOp to protect suckers (USFWS 2016, 2019a).	●				
Recent USBR Biological Assessment for the Klamath Project (USBOR 2018). While this BiOp is expected to benefit sucker, the associated changes to inflow management and ramp rates may have negative outcomes for Redband Trout, particularly in the Link River.	●	○		●	

Current State of Monitoring & Data Gaps

Past and Ongoing Monitoring:

Since 1995, USGS has implemented a long-term capture-recapture program to assess the status and dynamics of Lost River Suckers and Shortnose Suckers. In 2015, USGS began additional monitoring for juvenile suckers in Clear Lake Reservoir (Burdick et al. 2016). The goals of this program are to track year by year variability in age-0 sucker production, juvenile sucker survival, growth, and condition. The Klamath Basin Area Office of the USBR had undertaken monitoring of juvenile and adult suckers in Lake Ewauna for nearly two decades but has since discontinued this program. Monitoring of juveniles at the A-Canal Fish Evaluation Station (FES) by the USBR is a Monitoring and Reporting requirement within the 2019 Biological Opinion (BiOp) (USFWS 2019a). ODFW conducts many fish restoration and monitoring projects in the Oregon portions of the Klamath Basin (ODFW 2016). Most of these efforts are focused on population monitoring for a variety of listed and unlisted species, although ODFW also monitored temperatures within Redband Trout habitat. A high concentration of surface water quality sites, water temperature monitoring sites, and USGS/OWRD/CDWR groundwater monitoring stations occur in the Lost River sub-basin in areas where withdrawals for irrigation and impacts from agriculture are common. A high number of weather stations are present, primarily in the Oregon section of the sub-basin.

Current Data Gaps:

Figure 4-16 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring across agencies in the Lost River sub-basin. Location-specific agency metadata (where available) on monitoring projects is incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. Many USGS/OWRD groundwater monitoring sites occur throughout the lower part of the sub-basin, while KBMP's current monitoring inventory indicates high numbers of agency gauges for monitoring of streamflow, water quality and water temperature, although these were concentrated in certain areas and not widely present across the sub-basin. The KMBP inventory of the sub-basin indicates that only a limited number of agency stations are currently in place for long term monitoring of weather, and found only in the upper basin.

Lost Sub-basin Monitoring Summary

Habitat Monitoring	Watershed Inputs	Weather	●
		Streamflow	●
		Groundwater	
		Riparian & Landscape	
	Fluvial-Geomorph	Sediments & Gravel	●
		Stream Morphology	
	Habitat	Stream Temperature	●
		Water Quality	●
		Habitat Quality	
		Barriers & Injury	
		Marine/Estuary	NA
	Biota	Invasive Species	

			Suckers	RB Trout
Population Monitoring	Abundance	Juvenile Abundance (anad)	NA	NA
		Spawner Abundance (anad)	NA	NA
		Abundance (non-anad)	●	
	Harvest	Harvest (in-river)	NA	
		Harvest (ocean)	NA	NA
	Distrib-ution	Temporal Distribution	●	
		Spatial Distribution	●	
	Demo-graphics	Stock Composition	●	
		Age Structure	●	
	Biota	Disease	●	

● Known monitoring activities (past or ongoing)

NA Monitoring not relevant to this sub-basin

Figure 4-16. Synthesis of past and ongoing monitoring activities in the Lost River sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017, Section 2.5, Appendix H):

- Revised recovery plan for the Lost River Sucker (*Deltistes luxatus*) and Shortnose Sucker (*Chasmistes brevirostris*) (USFWS 2012)
- A Conservation Strategy for Interior Redband (*Oncorhynchus mykiss subsp.*) in the states of California, Idaho, Montana, Nevada, Oregon, and Washington. (IRCT 2016)
- Oregon Conservation Strategy, with one opportunity area along the lower Lost River
- Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)
- Klamath Tribal Water Quality Consortium Upper Klamath Basin Nonpoint Source Pollution Assessment and Management Program Plan (in this sub-basin, applies only to the area west of Tule Lake) (KTWQC 2018)

- Fremont, Winema and Modoc National Forest Land and Resource Management Plans
- Water Quality Restoration Plan for the Upper Klamath Basin (USFS and BLM 2003)
- ODEQ Upper Klamath and Lost River sub-basins Nutrient and Temperature Total Maximum Daily Loads (TMDLs) and Water Quality Management Plan (ODEQ 2018)
- ODA Lost River sub-basin Agricultural Water Quality Management Area Plan (ODA 2017)
- USFWS Lower Klamath, Clear Lake, Tule Lake, Upper, Klamath, and Bear Valley National Wildlife Refuges – Record of Decision for the Final Comprehensive Conservation Plan/EIS (UFWS 2017)
- Biological Opinion on the Effects of Proposed Klamath Project Operations from April 1, 2019, through March 31, 2024, on the Lost River Sucker and the Shortnose Sucker (USFWS 2019a)
- Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife (in draft form at the time of writing)

Forthcoming plans and initiatives specific to this sub-basin under development, recently completed, or soon to proceed to implementation.

- SWAMP Assessment of Wetland Treatment Potential Within the Lower Klamath Wildlife Refuge
- Tulelake Irrigation District's Sustainable Groundwater Management Act (SGMA) groundwater plan

A high-efficiency sprinkler pivot installed on an Oregon farm to replace the prior practice of flood irrigation, which some might consider inefficient, but which also has benefits for watershed hydrology. (Photo by NRCS)

Box 4-2: Considering the Potential Unintended Effects of Restoration

Ecological restoration is frequently viewed strictly through a positive lens for the benefits it can yield to the species and ecosystems intended to benefit from these activities. However, there are also instances where watershed restoration and related natural resource management measures can have unintended consequences, and the potential for such difficult trade-offs increases as restoration programs become larger in scope and encompass many target species, regions, goals, and objectives which may at times come into conflict (e.g., Salant et al. 2012, McLaughlin et al 2013, Scott et al. 2014). While restoration and natural resource management interventions might yield the intended benefits in some circumstances, they may in other circumstances have unintended effects that are important to consider and plan for when comparing and selecting potential restoration options.

For example, water conservation technologies are often presented as the best option for addressing water limitations in water scarce environments. Locally, the adoption of modern irrigation technologies has been presented in state plans as well as several conservation-oriented planning documents over the last few decades in response to regulatory drivers like the Clean Water Act, but it is not always clear whether the trade-offs of these interventions for ecological objectives have been considered.

Previous studies suggest changes to crop type (Bishop et al., 2010) and irrigation regimes (Hassanli et al., 2009; Pfeiffer & Lin, 2014) can affect overall water use. However, an increase in irrigation efficiency often increases water consumption and reduces return flows (Adamson and Loch 2019, Lock and Adamson 2015, Grafton et al. 2018), while increasing water consumption (Whittlesey 2003, Chakravorty and Umetsu 2003). Sometimes this is a result of simply using conserved water for additional production or cultivation of water intensive crops (Batchelor et al., 2014; Scott et al., 2014), or in other cases the interventions for increasing irrigation efficiency result in an increased reliance on ground water resources (Pool et al., 2014), further exacerbating water scarcity.

Box 4-2: Considering the Potential Unintended Effects of Restoration (cont'd)

Adopting water conservation technologies are also likely to increase water consumption at the expense of reducing return flows and lower aquifer recharge rates with implications for the broader ecosystem (Perez-Blanco et al. 2020, Scott et al., 2014; Ward & Pulido-Velazquez, 2008). Although return flows may be used by downstream agricultural producers or lost to evaporation or evapotranspiration, return flows also provide water resources that benefit fish and wildlife species, sustain the hydrology of wetlands which in turn provide nutrient capture and carbon storage, and contribute to improved watershed function by supporting processes like aquifer recharge that provide broader ecosystem services including drought resiliency and the attenuation of seasonal run-off events. Further, many proposed water saving solutions, such as water conservation technologies, groundwater mining, and development of irrigation reservoirs, have long-term irreversible consequences for natural resource conservation and may prolong unsustainable water practices (e.g., King et al. 2021, Donnelly et al., 2020). Flood irrigation practices are often perceived as wasteful and become the focus of water efficiency efforts, as a mechanism to generate agricultural water savings that are then used to offset over-allocation (Richter et al., 2017). Elimination of these practices, however, can unintentionally accelerate wetland loss thus, reducing fish and waterbird habitats (Ward & Pulido-Velazquez, 2008). Loss or degradation of wetland habitat in key waterbird migration sites may result in substantial ecological bottlenecks that limit population size (e.g. Murray et al., 2018; Xu et al., 2019, Donnelly et al., 2020), and may ultimately endanger the persistence of wetland obligate species.

While a reduction in water demand is widely viewed as critical for the long-term sustainability of the Klamath Basin, careful consideration of trade-offs in comparison to alternative approaches may reveal in some cases that resources are better allocated to evaluating policies (e.g., charges, quotas, buybacks, buyouts) than to subsidizing modern irrigation technologies that may increase consumption and exacerbate water scarcity (e.g. Pérez-Blanco 2021, King et al. 2021).

4.4 Mid-Upper Klamath Basin Sub-region

The Mid-Upper Klamath River sub-region is more bedrock in nature than the Upper Basin, creating more confined river channels and higher flows (Adams et al. 2011). Hydrologic processes in the mainstem Klamath River are strongly influenced by the presence of reservoirs behind four hydroelectric dams that also currently block the upstream passage for anadromous fish. Limited flushing flows, long durations of low flows, and warm water temperatures in the Klamath mainstem are all considered factors contributing to high rates of disease in Klamath salmon. Impacts to tributary systems in this sub-region include fish stranding from dewatering, disconnection from floodplains, grazing impacts on stream riparian areas, the diversion of water from numerous small dams/water withdrawals for agriculture, and the presence of extensive logging road networks (Adams et al. 2011). Historical impacts from hydraulic mining are also present in the Klamath mainstem and many tributaries within the sub-region (Stanford et al. 2011; Stillwater Sciences 2013).

- **Sub-basins:** Upper Klamath River, Mid-Klamath River, Shasta, Scott, and Salmon
- **Key Species:** Coho Salmon, Chinook Salmon, steelhead, Pacific Lamprey, Redband Trout, and Green Sturgeon

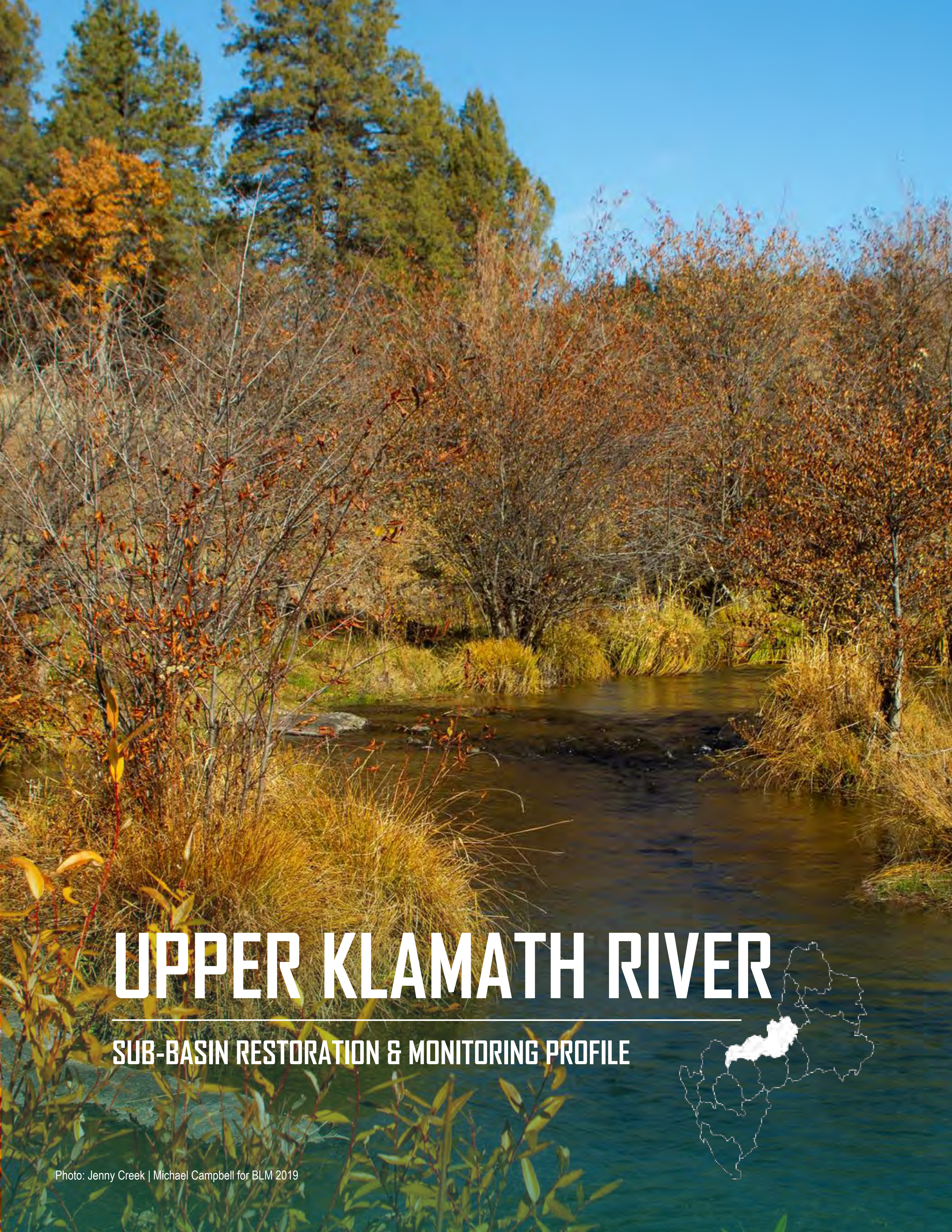
Table 4-15: Synthesis of hypothesized stressors (X) and key stressors (yellow highlighted) affecting focal fish species/functional groups across the Mid/Upper Klamath Basin sub-region (as identified through IFRMP Synthesis Report and technical group conceptual modeling exercises). Yellow highlighted cells represent suggested key stressors for a focal species or species group within a particular sub-region.

Mid/Upper Klamath River (MUK) sub-region							
Stressor Tier	Stressor	Focal Fish Species					
		PL	CH	CO	ST	RT	GS
Watershed Inputs (WI)	9.3.1 Klamath River flow regime	X	X	X	X	X	X
	9.2.2 Instream flow (tributaries)	X	X	X	X	X	
	7.2.1 Increased fine sediment input/delivery	X	X	X	X		X
	7.1.1 Decreased coarse sediment input/delivery	X	X	X	X		
	4.2 Large woody debris	X	X	X	X	X	
	3.1.2 Marine nutrients	X	X	X	X	X	
	3.1.1 Hypereutrophication					X	
	8.7 Chemical contamination						X
Fluvial-geomorphic Processes (FG)	9.2.1. Groundwater interactions	X	X	X	X	X	
	6.1.1 Channelization	X	X	X	X	X	
	6.2.3 Fine sediment retention	X	X	X	X	X	X
	8.4 Total suspended sediment						
Habitat (H)	8.1 Water temperature	X	X	X	X	X	X
	8.2 Dissolved oxygen	X	X	X	X	X	X

Header Image: Confluence of Salmon and Klamath Rivers | USFWS.

Mid/Upper Klamath River (MUK) sub-region							
Stressor Tier	Stressor	Focal Fish Species					
		PL	CH	CO	ST	RT	GS
	8.5 pH	X	X	X	X	X	
	1.1 Anthropogenic barriers	X	X	X	X	X	
	6.1 Bed and channel form	X	X	X	X	X	
	6.2 Instream structural complexity	X	X	X	X	X	
	2.3.1 Fish entrainment		X	X	X	X	X
	6.2.2 Suitable (cobble) substrate						X
	6.2.1 Deep pools						X
	7.3. Contaminated sediment						X
Biological Interactions (BI)	2.1.1 Predation (fish)	X	X	X	X	X	X
	2.1.2 Predation (mammals/birds)	X	X	X	X		X
	2.2 Pathogens		X	X	X	X	
	10.1 Hybridization		X				
	3.2 Competition		X	X	X		
	3.3.2 Abundance of invertebrate prey		X	X			X

RT = Redband Trout, BT = Bull Trout, CH = Chinook Salmon, CO = Coho Salmon, ST = steelhead, PL = Pacific Lamprey, GS = Green Sturgeon. Stressor numbering is adapted from NOAA's Pacific Coastal Salmon Recovery Fund 'Ecological Concerns Data Dictionary' available from: https://www.webapps.nwfsc.noaa.gov/apex/f?p=309:13::::::



UPPER KLAMATH RIVER

SUB-BASIN RESTORATION & MONITORING PROFILE

Photo: Jenny Creek | Michael Campbell for BLM 2019

4.4.1 Upper Klamath River Sub-basin

The Upper Klamath River sub-basin has been significantly altered by human activities, resulting in negative impacts to fish and to the traditional use of the land by the Karuk, Shasta, Modoc, and Klamath Tribes. The upper portion of the sub-basin includes four impassable mainstem dams (Iron Gate Dam (IGD)-1962, Copco 1-1918, Copco 2-1925, and JC Boyle-1958, although the latter has downstream passage). IGD is the lowest of the dams and currently limits the distribution of anadromous fish.

Irrigation and the operation of hydroelectric dams have altered the natural hydrologic regime, preventing sediment movement, negatively affecting downstream water quality, and intensifying impacts of disease. For this section, the ‘upper portion’ of the sub-basin refers to the reaches between Keno Dam and IGD and the ‘lower portion’ extends from IGD to just upstream of the river joining with Portuguese Creek. High road densities in the lower sub-basin continue to be a source of sediment. While there are legacy effects of timber harvest in the lower portion of the sub-basin, the bulk of this forest is now considered the Klamath National Forest. Long term fire suppression have increased fuel loads, leading to increasingly catastrophic fires in the upper portion of the watershed. Historic large-scale mining has also had adverse impacts in stream reaches below IGD and the disappearance or near disappearance of beaver has negatively impacted water retention for aquatic habitats throughout the sub-basin. While the issue of hatchery influences is not addressed in the IFRMP, it is important to note that the Iron Gate Hatchery likely impacts salmon populations through competition with native salmon, elevated disease transmission, and loss of genetic diversity (Quiñones et al. 2014).

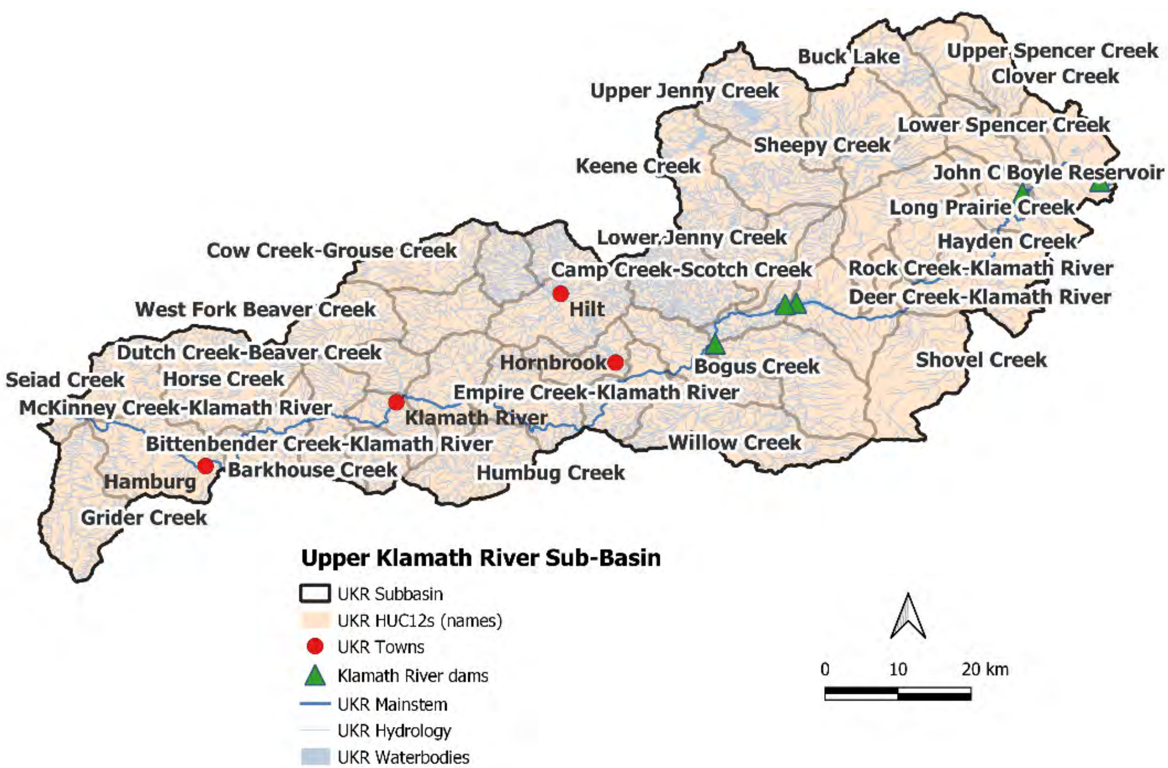


Figure 4-17: Reference map of the Upper Klamath River Sub-Basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current:**
  - Above IGD: Redband Trout
  - Below IGD: Chinook Salmon (fall -run), Coho Salmon, steelhead (spring/summer and winter), Pacific Lamprey
- **Historical:**
  - Above IGD: Chinook Salmon (fall-run and spring-run), Coho Salmon, steelhead, Pacific Lamprey
  - Below IGD: Chinook Salmon (spring-run)

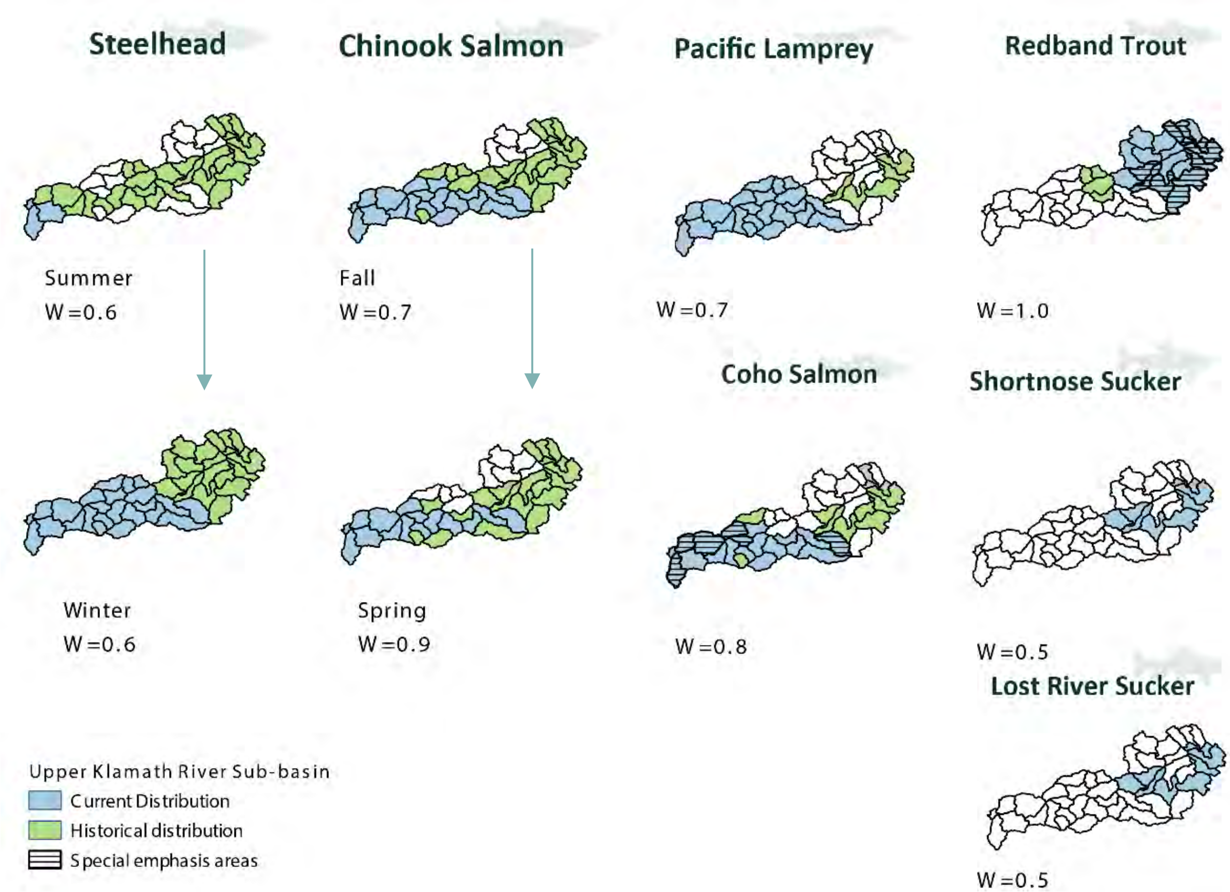


Figure 4-18: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the Upper Klamath River sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors

Table 4-16: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the Upper Klamath River sub-basin listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. RT = Redband Trout, CH = Chinook Salmon, CO = Coho Salmon, ST = steelhead, PL = Pacific Lamprey and, for this sub-basin only, we differentiate between stressors that primarily apply above vs. below IGD.

Key Stressors	Tier	Stressor Summary for the Upper Klamath River Sub-basin	Species				
			RT	CH	CO	ST	PL
Anthropogenic Barriers (Below IGD)	H	The presence of four mainstem dams completely blocks fish passage upstream of IGD, preventing access to 63.6 km of mainstem habitat between IGD and Keno Dam, numerous tributaries with suitable habitat for anadromous fish within this sub-basin (e.g., California: Slide, Scotch, Camp, Jenny, and Shovel; and Oregon: Spencer Creek) as well as several tributaries upstream of this sub-basin (e.g., Oregon: Williamson River, Wood River, and Sprague River). In addition, according to the California Fish Passage Assessment (accessed April 11, 2019) there are about 45 total barriers to fish passage in the sub-basin due to road crossings. Highway 96 runs parallel to the Klamath mainstem for the bulk of the lower portion of the sub-basin (i.e. between Cottonwood Creek and Seiad Creek). In many cases the barrier occurs at the confluence with the mainstem resulting in a significant loss of potential tributary habitat. There are also several areas within the Klamath National Forest with identified barriers, likely as a result of roads from historical timber harvest.		●	●	●	●
Klamath River Flow Regime	WI	Concern related to altered hydrologic function and flow timing/magnitude in the Klamath River mainstem below the four PacifiCorp dams due to managed water releases from operation of the Klamath Irrigation Project. In particular, timing of peak / base flows shifted after construction and the magnitude of spring and summer flows decreased. The mainstem is also impacted by agricultural water diversions upstream of IGD and within Scott, Shasta watersheds.	●	●	●	●	●
Instream Flow (tributaries[11])	WI	Tributaries with summer rearing potential are impacted by agriculture and historical timber harvest. There are many water diversions within this sub-basin[12]. Low flow conditions may also result in seasonal barriers to fish. Grazing degrades the riparian areas, increases erosion, and negatively impacts water quality. Tributary thermal refugia are limited in this sub-basin and are critical for summer rearing habitat for Coho in particular (NMFS 2014). Diversions in Empire, Willow, Cottonwood, Lumgrey, Seiad, Horse, and Humbug are known to impair Coho habitat and water quality in low flow conditions (NMFS 2014).	○	○	●	○	●
Water Quality	H	The timing and Water temperatures below IGD[13] are generally elevated in the fall when Chinook Salmon are returning, but depressed during rearing times in the spring. This shift has cascading implications: delayed adult returns (and therefore delayed spawning); delayed hatch due to cooler winter temperatures and later spring; later juvenile rearing, increased susceptibility to disease, and increased overlap with *C. shasta*. A combination of low flows, elevated		●	●	●	●

[11] This refers to tributaries within the UKR sub-basin (i.e., it excludes Shasta and the Scott which are addressed in subsequent sections).

[12] California Electronic Water Rights Information Management System and Oregon Water Resources Department Water Rights Mapping Tool, more information at: https://apps.wildlife.ca.gov/bios/?al=ds69

[13] Predicted impacts of dam removal on temperatures are greatest immediately downstream of IGD, attenuate downstream (Perry et al. 2011).

Key Stressors	Tier	Stressor Summary for the Upper Klamath River Sub-basin	Species				
			RT	CH	CO	ST	PL
		temperatures, and nutrients from upstream reservoirs tends to result in impaired water quality (e.g., low DO and increased pH) through summer. DO is a key stressor for Redband Trout below Keno Dam.					
Pathogens (Below IGD)	BI	The absence of flushing flows, immobile sediment (which favors establishment of polychaete worms), long durations of low flows and high water temperatures in the river are all considered factors contributing to the often high rates of disease in Klamath salmon resulting from pathogens like the myxosporean parasites *C. Shasta* and *P. minibicornis*, as well as by bacterial and parasitic gill infections. Fish populations in this sub-basin are particularly susceptible to disease given the length of migration and extent of exposure (NMFS 2014).		●	●	○	
Sediment Inputs	WI	There is an imbalance in sediment supply in this sub-basin. The river is in a sediment starved state for roughly 40 miles downstream of IGD (i.e., around Scott River). Lack of sediment limits the availability of spawning gravel in the mainstem and fine sediment for Pacific Lamprey rearing. Roads, timber harvest, fire, and agricultural practices have resulted in an increase in fine sediment delivery to tributaries, which reduces habitat quality for Coho Salmon.	○	○	○	○	○
Channelization and Lack of Complexity (Below IGD)	FG	Tributary and mainstem habitat complexity is limited by a lack of spawning gravel and wood, modified flows, remnant dredge piles, and impaired riparian function. Floodplain connectivity is considered non-functional in: Humbug Creek, Cottonwood Creek, and Horse Creek. Grider Creek is fully functional and the other tributaries are considered partially functioning. Historical mining and levy construction limit floodplain complexity in Seiad, Horse and Humbug Creeks. Fine sediment has filled pools, off-channel ponds, and wetlands in tributaries.	○	○	●	○	○

Stressors identified from: NMFS 2014; Sub-regional working group survey responses. *Note stressors associated with fisheries management (hatchery and harvest) are out of scope for this report and are not included in this table.

Sequences of Restoration Projects for the Upper Klamath River Sub-Basin

The **summary infographic** in Figure 4-19 provides a compact overview of the Upper Klamath River sub-basin restoration project priorities and their distribution across the sub-basin. Table 4-17 presents the results of the 2022 iteration of the IFRMP restoration sequencing process for the Upper Klamath River sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-17. The projects listed here have a cost range of $25.6M - $47.3M - $77.8M (low, estimated midpoint, high), and have been collated from projects proposed in prior local or regional restoration plans and studies as well as from in-depth discussions among participants in the IFRMP's Upper Klamath River Sub-basin Working Group who represent scientists, restoration practitioners, and resource users working in the sub-basin (see Acknowledgements section). The sequences and scoring in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria.

Figure 4-19: Summary for the Upper Klamath River sub-basin, including key stressors, cost ranges, and projects (see next page).

Upper Klamath River Sub-basin

Sub-Basin Summary

The Upper Klamath River Sub-Basin has been significantly altered by human activities resulting in negative impacts to fishes and to the traditional use of the land by the Karuk Tribe. Water diversions exceed the available water. The upper portion of the sub-basin currently includes four impassable mainstem hydroelectric dams (IGD-1962, Copco 1-1918, Copco 2-1925, and JC Boyle-1958) that alter flow regimes and sediment transport. These changes negatively affect downstream water quality, and exacerbate impacts of disease. IGD is the lowest of the dams and is the current limit of distribution for anadromous fishes. For the purposes of the IFRMP, the default assumption is the dam removal will occur in the near future, which would help to gradually reverse these limits and process alterations. The bulk of forest in the lower portion of the sub-basin is now within the Klamath National Forest where there are legacy effects of timber harvest. There are substantial restoration opportunities in this sub-basin.

Key Stressor Summary

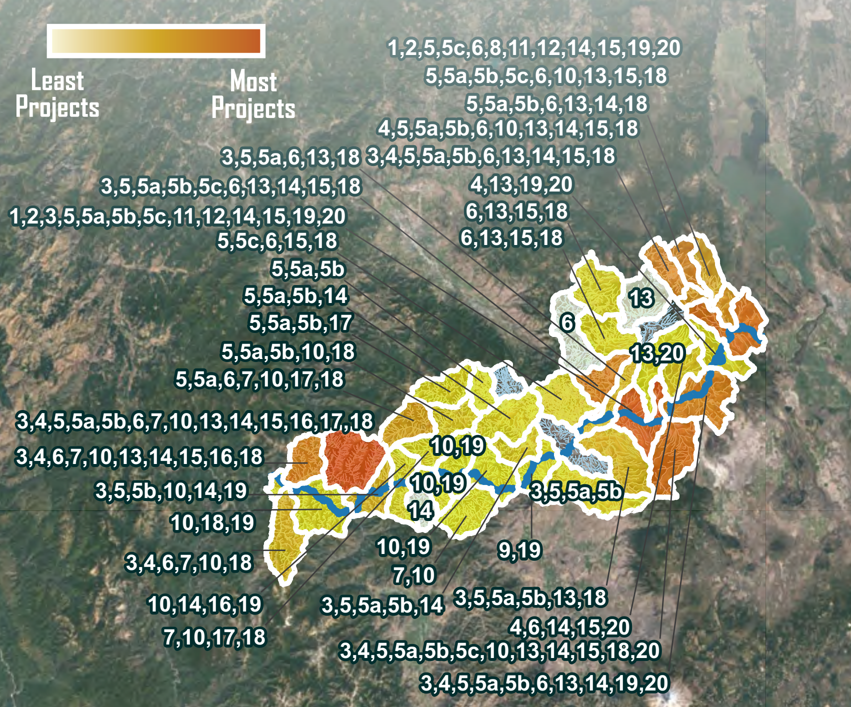
Key Stressors	Focal Species				
	RT	CH	CO	ST	PL
Anthropogenic barriers					
Klamath River flow regime					
Instream flow (tributaries)					
Water Quality					
Pathogens					
Sediment Inputs					
Channelization					

Restoration Summary

The Upper Klamath sub-basin is unique in that it hosts four main-stem dams which are central to the basin-wide restoration plan. Some projects are only relevant while the dams remain in place, whole others are only relevant if dam removal proceeds. If dams remain in place, the top projects includemanaging releases to restore a natural hydrologic regime and restoring fish passage through the use of fishways. If dams are to be removed, top projects include dam removal followed by projects to reconnect and restore floodplain and off-channel habitsts. Priorities for both scenarios are presented here, and dependencies are identified and discussed in more detail in the full report.

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is $25.6M - $47.3M - $77.8M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP UKR Sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting. Due to the complexity of project dependencies in this sub-basin, they are documented only in the report sub-basin chapter.

Project ID & Description	Tiers
UKR 5c - Undertake riparian planting to reduce erosion into the UKR mainstem and key tributaries **| 15.6**	FG WI
UKR 19 - Identify and implement projects to protect existing or potential cold-water refugia for fish **| 15.0**	H
UKR 5b - Install fencing along riparian corridors to reduce erosion into the UKR mainstem and key tributaries **| 14.7**	FG WI
UKR 10 - Reconnect floodplains and off-channel habitats by removal of levees and other barriers within the UKR Sub-basin **| 14.5**	FG
UKR 5a - Improve riparian grazing management to reduce erosion into UKR mainstem key tributaries **| 13.9**	WI FG
UKR 15 - Restore reservoir footprint to former conditions in the UKR (once four lower Klamath River hydroelectric dams are removed) **| 13.2**	H
UKR 16 - Replace existing culverts with bridges at priority road crossings in UKR tributaries to improve access to upstream habitats **| 13.1**	H
UKR 17 - Restore upland wetlands and meadows to improve cold water storage and runoff attenuation in the Upper Klamath River Sub-basin **| 12.3**	FG WI
UKR 7 - Reduce fuels and re-introduce low intensity fires to re-establish natural fire regimes across the UKR Sub-basin **| 12.1**	WI
UKR 14 - Install fish screens at diversions of priority concern within the UKR Sub-basin **| 11.9**	H
UKR 3 - Improve irrigation practices to increase instream flows in UKR tributaries to benefit fish and riverine processes **| 11.9**	WI
UKR 18 - Install BDAs in key UKR tributaries to provide improved seasonal fish rearing habitats **| 11.9**	FG H
UKR 20 - Address restoration needs of PacifiCorp Parcel A lands **| 11.7**	H FG WI
UKR 6 - Implement upland road decommissioning in key areas of the Upper Klamath River sub-basin with high fine sediment input **| 11.2**	WI
UKR 13 - Remove/repair road/stream crossings to restore fish passage to upstream habitats within UKR tributaries **| 10.9**	H
UKR 4 - Implement projects to reduce warm tailwater inputs to tributaries in the UKR **| 10.2**	WI

Additional considerations such as implementability, cost and dependencies among projects may influence the ultimate sequencing of projects. Dependencies identified by the Sub-basin Working Groups are noted in the summary tables. Sequencing of projects will be very important for maximizing benefits in the sub-basin but determining the optimal sequencing steps for multi-project implementation requires further deliberation of the working group.

The projects and scoring shown in Table 4-17 are representative of the scenario in which four lower Klamath River hydroelectric dams are to (soon) be *removed*. The Upper Klamath River Sub-basin Working Group identified the following additional scenarios with potential to influence restoration priorities. Should any these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

- Flow management reoperation
- Species status changes
- Budget changes

The Upper Klamath River sub-basin is unique in that it hosts four main-stem dams which are central to a number of restoration plans in the basin.

The following projects rank in the top tier of highest scored projects:

- **Projects 5c, 19, 5b, and 10.** Project 5c involves undertaking riparian planting to reduce erosion. Project 19 involves identification and protection of cold water refugia. Project 5b is related to erosion preventions, like 5c, and involves installing fencing along riparian corridors. Project 10 involves improving floodplain connectivity and constructing off-channel habitat within five tributaries and three mainstem locations.

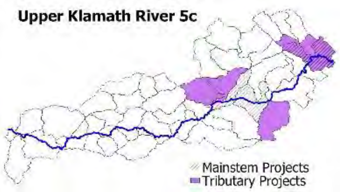
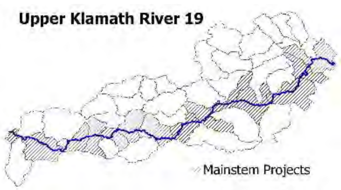
Projects ranked as of intermediate restoration importance were:

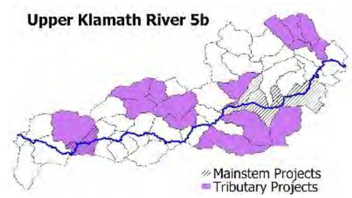
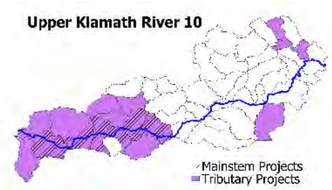
- **Projects 5a, 15, 16, 17, 7, 14.** Action types include: riparian area conservation grazing management, riparian planting, bridge installation at road stream crossings, upland wetland improvement, upland vegetation management including fuel reduction and burning, and fish screen installations.

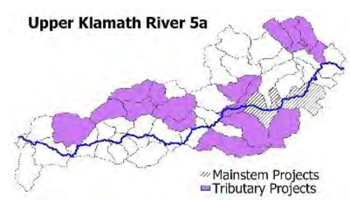
The lowest ranking restoration projects in the Upper Klamath River sub-basin were:

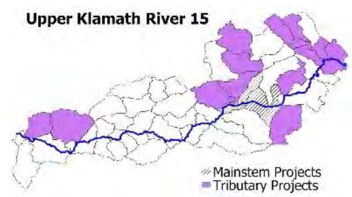
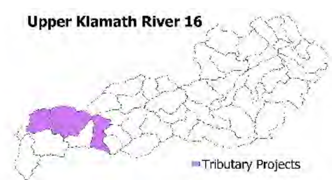
- **Projects 3, 18, 20, 6, 13, 4.** These projects represent a variety of restoration actions including BDAs, tailwater management, road decommissioning, improving road stream crossings, and purchasing of lands for conservation purposes. Several of these types of restoration projects in other sub-basins ranked relatively higher depending on the local context (were not always in the bottom tier).

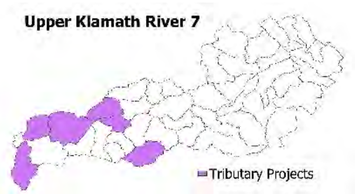
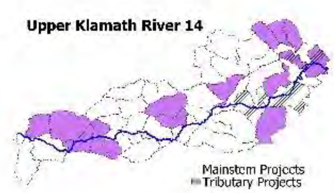
Table 4-17 Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the Upper Klamath River sub-basin under a scenario in which the four lower Klamath River hydroelectric dams are to be removed. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name. Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-17, while special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin IFRMP planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

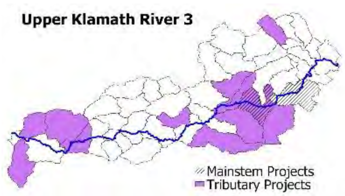
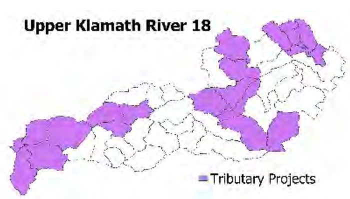
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.2)*	CPI Status *(0.4)*	Stressors Addressed *(0.5)*	Scale of Benefit *(0.6)*	Implementability *(0.6)*
Upper Klamath River 5c (15.6)	**Undertake riparian planting to reduce erosion into the UKR mainstem and key tributaries.** **Project Description:** Work to reduce erosion and fine sediment inputs through planting of riparian vegetation. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Riparian planting **Near-Term Focal Areas (map):** 6 sub-watersheds, Lower Spencer Creek**, John C Boyle Reservoir**, Shovel Creek**, Lower Jenny Creek**, Camp Creek-Scotch Creek, Fall Creek-Klamath River** **Cost range ($K):** $200 - 200 - 200 	1.05	1.67	2.38	4.5	5.99
Upper Klamath River 19 (15.0)	**Identify and implement projects to protect existing or potential cold-water refugia for fish** **Project Description:** Inventory, evaluate, protect, and improve cold water sources along the Klamath River mainstem. Anticipate the re-emergence of historical cold spring water sources currently buried under reservoirs along the PacifiCorp reach, and then protect and restore them as soon as they are 'daylighted' by dams removal. **Dependencies / Project Linkages:** There are some key locations that should be addressed in parallel to dam removal. **Primary Action Types:** Water quality project (general) **Near-Term Focal Areas (map):** 13 sub-watersheds, John C Boyle Reservoir**, Big Bend-Klamath River**, Rock Creek-Klamath River**, Deer Creek-Klamath River**, Fall Creek-Klamath River**, Brush Creek-Klamath River, Williams Creek-Klamath River, Ash Creek-Klamath River, Empire Creek-Klamath River, Little Humbug Creek-Klamath River, McKinney Creek-Klamath River, Kohl Creek-Klamath River, Bittenbender Creek-Klamath River **Cost range ($K):** $960 – 1,144 – 1,880 	1.65	4	1.18	4.5	3.64

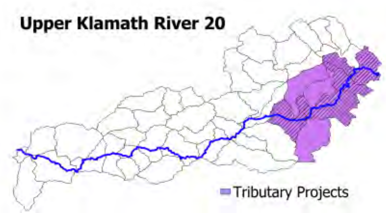
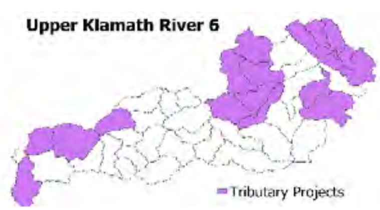
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.2)*	CPI Status *(0.4)*	Stressors Addressed *(0.5)*	Scale of Benefit *(0.6)*	Implementability *(0.6)*
Upper Klamath River 5b (14.7)	**Work with agriculture interests and others to install fencing along riparian corridors to reduce erosion into the UKR mainstem and key tributaries.** **Project Description:** Work to further improve grazing practices to reduce erosion and fine sediment inputs. The highest grazing intensity occurs downstream of IGD in Cottonwood, Bogus, Willow, Horse, and Beaver Creeks, as well as along the mainstem Klamath River corridor (NMFS 2014). Actions could include further improving grazing management plans, riparian fencing, planting vegetation, removing instream livestock watering sources. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Fencing **Near-Term Focal Areas (map):** 19 sub-watersheds, Buck Lake**, Upper Spencer Creek**, Clover Creek, Lower Spencer Creek**, Rock Creek-Klamath River**, Shovel Creek**, Deer Creek-Klamath River**, Lower Jenny Creek**, Fall Creek-Klamath River**, Upper Cottonwood Creek, Middle Cottonwood Creek, Lower Cottonwood Creek, Bogus Creek**, Willow Creek, Cow Creek-Grouse Creek, Hungry Creek-Beaver Creek, West Fork Beaver Creek**, Horse Creek**, Kohl Creek-Klamath River  **Cost range ($K):** $720 - 1,440 - 1,800	0.57	2.02	2.38	4.5	5.27
Upper Klamath River 10 (14.5)	**Reconnect floodplains and off-channel habitats by removal of levees and other barriers within the UKR sub-basin.** **Project Description:** Inventory and prioritize opportunities to reduce channelization and increase off-channel habitat. Restore floodplain processes including channel migration by removing levees and other barriers, reconnecting channel to floodplain, and/or constructing off-channel habitat (e.g., alcoves, oxbows etc.). Off-channel pond projects have been completed in Horse Creek with more in development. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Mechanical channel modification and reconfiguration, Dike or berm modification/removal **Near-Term Focal Areas (map):** 16 sub-watersheds, Dutch Creek-Beaver Creek, Hungry Creek-Beaver Creek, Lower and Upper Spencer Creek, Ash Creek-Klamath River, Humbug Creek, Shovel Creek**, West Fork Beaver Creek**, Little 	1.4	2.86	5	3	2.2

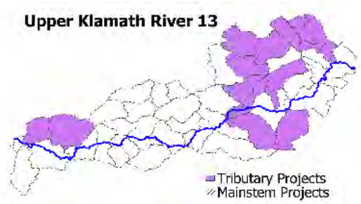
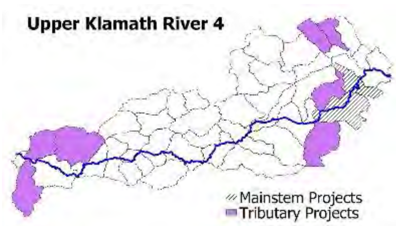
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.2)*	CPI Status *(0.4)*	Stressors Addressed *(0.5)*	Scale of Benefit *(0.6)*	Implementability *(0.6)*
	Humbug Creek-Klamath River, McKinney Creek-Klamath River, Horse Creek**, Kohl Creek-Klamath River, Grider Creek**, Seiad Creek**, Empire Creek-Klamath River, Bittenbender Creek-Klamath River **Cost range ($K):** $14,644 – 25,381 – 45,250 (based partly on cost data from Trinity)					
Upper Klamath River 5a (13.9)	**Improve riparian grazing management to reduce erosion into the UKR mainstem and key tributaries.** **Project Description:** Work to further improve grazing practices to reduce erosion and fine sediment inputs. The highest grazing intensity occurs downstream of IGD in Cottonwood, Bogus, Willow, Horse, and Beaver Creeks, as well as along the mainstem Klamath River corridor (NMFS 2014). Actions could include further improving grazing management plans, riparian fencing, planting vegetation, removing instream livestock watering sources. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Riparian area conservation grazing management **Near-Term Focal Areas (map):** 18 sub-watersheds, Buck Lake**, Upper Spencer Creek**, Clover Creek, Lower Spencer Creek**, Rock Creek-Klamath River**, Shovel Creek**, Deer Creek-Klamath River**, Lower Jenny Creek**, Fall Creek-Klamath River**, Upper Cottonwood Creek, Middle Cottonwood Creek, Lower Cottonwood Creek, Bogus Creek**, Willow Creek, Cow Creek-Grouse Creek, Hungry Creek-Beaver Creek, West Fork Beaver Creek**, Horse Creek**  **Cost range ($K):** no cost data available (no data for "riparian area conservation grazing management")	0.5	1.8	2.38	4.5	4.75
Upper Klamath River 15 (13.2)	**Restore reservoir footprint to former conditions in the UKR (once four lower Klamath River hydroelectric dams are removed)** **Project Description:** Contingent on completing dam removal. Restore the former reservoir footprints for fisheries needs. This project is not costed within the IFRMP because reservoir footprint restoration is an embedded component of planned KRRC dam removal activities/scope. Refer to IFRMP report, section 2.5 - "Klamath Hydroelectric Settlement Agreement (HHSA) Definite Decommissioning Plan (DDP)" for links to package of dam removal related restoration actions. **Dependencies / Project Linkages:** This project would occur following dam removal. **Primary Action Types:** Riparian planting	0.33	1.54	2.38	3	6

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.2)*	CPI Status *(0.4)*	Stressors Addressed *(0.5)*	Scale of Benefit *(0.6)*	Implementability *(0.6)*
	Near-Term Focal Areas (map): 14 sub-watersheds, Buck Lake**, Upper Spencer Creek**, Lower Spencer Creek**, John C Boyle Reservoir**, Hayden Creek, Shovel Creek**, Deer Creek-Klamath River**, Upper Jenny Creek, Middle Jenny Creek, Lower Jenny Creek**, Camp Creek-Scotch Creek, Fall Creek-Klamath River**, Horse Creek**, Seiad Creek**  **Cost range ($K):** This cost is included within the KHSA Definite Decommissioning Plan.					
Upper Klamath River 16 (13.1)	**Replace existing culverts with bridges at priority road crossings in UKR tributaries to improve access to upstream habitats.** **Project Description:** To allow access to traditional spawning and rearing areas improve fish passage at road crossings by replacing existing culverts with bridges at the Canyon Creek tributary to Seiad Creek, Middle Creek tributary to Horse Creek, and various tributaries entering the mainstem Klamath River including Portuguese Creek, McKinney Creek, Lumgrey Creek , and Empire Creek (T. Soto, pers. comm.). **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Bridge installed or improved at road stream crossing **Near-Term Focal Areas (map):** 3 sub-watersheds, McKinney Creek-Klamath River**, Horse Creek, Seiad Creek**  **Cost range ($K):** $1,050 - 7,525 - 14,000	2	3.6	0.88	3	3.57
Upper Klamath River 17 (12.3)	**Restore upland wetlands and meadows to improve cold water storage and runoff attenuation in the UKR sub-basin.** **Project Description:** To maximize cold water quantity and duration and increase runoff attenuation for salmonid protection and recovery as well as providing a wide array of other species and ecosystem benefits, restore upland wetlands and meadows (Donald Flickinger and Jon Grunbam, pers. comm.). **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Upland wetland improvement **Near-Term Focal Areas (map):** 4 sub-watersheds, Cow Creek-Grouse Creek, West Fork Beaver Creek**, Dutch Creek-Beaver Creek, Horse Creek**  **Cost range ($K):** $3,600 - 3,600 - 3,600	0.95	2.11	0.63	4.5	4.11

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.2)*	CPI Status *(0.4)*	Stressors Addressed *(0.5)*	Scale of Benefit *(0.6)*	Implementability *(0.6)*
Upper Klamath River 7 (12.1)	**Reduce fuels and re-introduce low intensity fires to re-establish natural fire regimes across UKR sub-basin.** **Project Description:** Re-establish natural fire regime through fuel reduction and re-introduction of low intensity fires through controlled burning, managed wildfires, and planting of fire-resistant species. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Upland vegetation management including fuel reduction and burning **Near-Term Focal Areas (map):** 6 sub-watersheds, Humbug Creek, West Fork Beaver Creek**, Dutch Creek-Beaver Creek, Grider Creek**, Seiad Creek**, Horse Creek  **Cost range ($K):** $540 - 630 - 720	1.68	1.94	1.17	4.5	2.87
Upper Klamath River 14 (11.9)	**Install fish screens at diversions of priority concern within the UKR sub-basin.** **Project Description:** Assess and implement a screening program with the intent of screening all diversions. Focus first on those streams where Coho would benefit immediately (e.g., Horse, and Cottonwood). **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Fish screens installed **Near-Term Focal Areas (map):** 16 sub-watersheds, Rock Creek-Klamath River**, Shovel Creek**, Deer Creek-Klamath River**, Middle Cottonwood Creek, Lower Cottonwood Creek, Barkhouse Creek, McKinney Creek-Klamath River, Horse Creek**, Kohl Creek-Klamath River, Seiad Creek**, Buck Lake, Upper Spencer Creek, Clover Creek, John C Boyle Reservoir, Hayden Creek, Lower Jenny Creek  **Cost range ($K):** $770 – 1,680 - 2,590	0.73	2.33	0.5	4.5	3.89
Upper Klamath River 3 (11.9)	**Improve irrigation practices to increase instream flows in UKR tributaries to benefit fish and riverine processes.** **Project Description:** Improve irrigation conveyance efficiency and water conservation practices to increase instream flows in tributaries to benefit fish and riverine processes. Focus first on streams where Coho would immediately benefit (e.g.,	1.12	1.63	4.06	4.5	0.6

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)* Range Overlap *(0.2)*	CPI Status *(0.4)*	Stressors Addressed *(0.5)*	Scale of Benefit *(0.6)*	Implementability *(0.6)*
	Seiad Valley, Beaver, Hornbrook, Cottonwood, Bogus, Grider, Little Grider, Willow, Horse, Little Horse, Walker, Elliott, Shovel, and Tom Martin creeks). Possible improvements include decreasing diversions during periods of low flow, working collaboratively with water users on how to further improve water conveyance efficiency, and ensuring water is allocated according to established water rights. For tributaries with subsurface or low flow barrier conditions, reduce diversions through a combination of incentives and enforcement measures (e.g., identify and cease unauthorized water diversions). **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Instream flow project (general), Irrigation practice improvement **Near-Term Focal Areas (map):** 11 sub-watersheds, Buck Lake**, Rock Creek-Klamath River**, Shovel Creek**, Deer Creek-Klamath River**, Lower Cottonwood Creek, Bogus Creek**, Willow Creek, Horse Creek**, Kohl Creek-Klamath River, Grider Creek**, Seiad Creek**  **Cost range ($K):** $2,069 – 3,838 – 5,550 (based partly on cost data from UKL)					
Upper Klamath River 18 (11.9)	**Install BDAs in key UKR tributaries to provide improved seasonal fish rearing habitats.** **Project Description:** Install beaver dam analogues (BDAs) in lower gradient, Lower River streams to provide summer and winter rearing opportunities for juvenile Coho (SONCC Recovery Plan, NMFS 2014; USBOR 2018). **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Beavers & beaver dam analogs **Near-Term Focal Areas (map):** 18 sub-watersheds, Buck Lake**, Upper Spencer Creek**, Clover Creek, Lower Spencer Creek**, Shovel Creek**, Upper Jenny Creek, Middle Jenny Creek, Lower Jenny Creek**, Camp Creek-Scotch Creek, Fall Creek-Klamath River**, Bogus Creek**, Hungry Creek-Beaver Creek, West Fork Beaver Creek**, Dutch Creek-Beaver Creek, Horse Creek**, Grider Creek**, Seiad Creek**, Bittenbender Creek-Klamath River  **Cost range ($K):** $170 - 255 - 340	0.5	1.37	2.87	3	4.12

Project # (*Overall Score*)	Restoration Projects	Criteria Scores (*Criteria Weights*)				
		Range Overlap (*0.2*)	CPI Status (*0.4*)	Stressors Addressed (*0.5*)	Scale of Benefit (*0.6*)	Implementability (*0.6*)
Upper Klamath River 20 (11.7)	**Address restoration needs of PacifiCorp Parcel A lands** **Project Description:** This action proposes habitat restoration over approximately 11,000 acres of property within the Klamath Reservoir Reach which is owned by PacifiCorp but not directly associated with the Klamath Hydroelectric Project or within the FERC project boundary (as described within the Klamath Hydroelectric Settlement Agreement of 2016) to benefit resident and anadromous fish. Purchase of these lands aligns with the highest priority action recommended in the Klamath Reservoir Reach Restoration Plan jointly developed by NOAA, PSMFC, and Trout Unlimited and released in December 2022, and many of the other restoration actions recommended in the plan would take place on these lands (O'Keefe et al. 2022). **Dependencies / Project Linkages:** This project could occur before or after dam removal. **Primary Action Types:** Instream habitat project (general), Riparian habitat project (general) **Near-Term Focal Areas (map):** 7 sub watersheds, John C Boyle Reservoir, Big Bend-Klamath River, Rock Creek-Klamath River, Shovel Creek, Long Prairie Creek, Hayden Creek, Deer Creek-Klamath River **Cost range ($K):** $253 – 377 – 480. (NOAA estimate suggests $3 M to purchase lands, but costs of restoration have not yet been assessed)  	0.33	0.4	2.92	4.5	3.54
Upper Klamath River 6 (11.2)	**Implement upland road decommissioning in key areas of the UKR sub-basin with high fine sediment input.** **Project Description:** Prioritize and implement upland road decommissioning in areas with high fine sediment input, transport, and storage. Watersheds with highest road densities are below IGD and include: Beaver, Horse, McKinney, Doggett, O'Neil, Empire-Lumgrey, Cottonwood, the lower reaches of Grider Creek, and the upper reaches of Humbug Creek and Seiad Creek (NMFS 2014). Focus first on areas where Coho would benefit immediately. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Road closure/abandonment **Near-Term Focal Areas (map):** 17 sub-watersheds, Buck Lake**, Upper Spencer Creek**, Clover Creek, Lower Spencer Creek**, John C Boyle Reservoir**, Hayden Creek, Rock Creek-Klamath River**, Upper Jenny Creek, Middle Jenny Creek, Keene Creek, Lower Jenny Creek**, Camp Creek-Scotch Creek, Fall Creek-Klamath River**, West Fork Beaver Creek**, Horse Creek**, Grider Creek**, Seiad Creek** **Cost range ($K):** $15 – 30 - 40  	**0.26**	**1.5**	**2.25**	**4.5**	**2.73**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.2)*	CPI Status *(0.4)*	Stressors Addressed *(0.5)*	Scale of Benefit *(0.6)*	Implementability *(0.6)*
Upper Klamath River 13 (10.9)	**Remove/repair road/stream crossings to restore fish passage to upstream habitats within UKR tributaries.** **Project Description:** Restore fish passage in tributaries primarily at barriers due to road crossings. Crossings can be prioritized based on the length and quality of upstream habitat above the barrier. This action should be completed in addition to Action #1 or Action #2. **Dependencies / Project Linkages:** This project depends on anadromous fish passage above the mainstem dams which could be accomplished through either Project 1 or Project 2. **Primary Action Types:** Culvert installed or improved at road stream crossing, Road stream crossing removal **Near-Term Focal Areas (map):** 15 sub-watersheds, Buck Lake**, Upper Spencer Creek**, Clover Creek, Lower Spencer Creek**, Big Bend-Klamath River**, Rock Creek-Klamath River**, Shovel Creek**, Long Prairie Creek, Upper Jenny Creek, Middle Jenny Creek, Lower Jenny Creek**, Fall Creek-Klamath River**, Bogus Creek**, Horse Creek**, Seiad Creek**  **Cost range ($K):** No cost data available (no data from “culvert installed or improved at road stream crossing” and “road stream crossing removal”)	**0.2**	**1.41**	**1.42**	**4.5**	**3.4**
Upper Klamath River 4 (10.2)	**Implement projects to reduce warm tailwater inputs to tributaries in the UKR.** **Project Description:** Work to implement or expand tailwater reduction programs to reduce warm inputs to tributaries. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Tailwater return reuse or filtering **Near-Term Focal Areas (map):** 9 sub-watersheds, Buck Lake**, Upper Spencer Creek**, Big Bend-Klamath River**, Hayden Creek, Rock Creek-Klamath River**, Shovel Creek, Horse Creek**, Grider Creek**, Seiad Creek**  **Cost range ($K):** $120 - 240 – 400 (based on cost data from UKL)	**0.94**	**0.88**	**1.42**	**4.5**	**2.47**

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC and SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, and sub-regional working group input via surveys and webinars.

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the Upper Klamath River Sub-basin

The state and federally listed Southern Oregon/Northern California Coast (SONCC) Evolutionarily Significant Unit (ESU) of ***Coho Salmon*** is a key species identified for many restoration actions in this sub-basin, and other parts of the mid and lower Klamath basin (NMFS 2014). Spring-run Chinook Salmon are also listed under California's Endangered Species Act (CESA). The Upper Klamath River Coho are considered a core functionally independent population, and are currently listed as being at high extinction risk (NMFS 2014). Anadromous fish were removed above IGD and spring-run Chinook Salmon are eliminated throughout the sub-basin. There is a thriving population of ***Redband Trout*** below Keno dam (William T., pers. Comm; www.flyfisherman.com, 2011). This sub-basin is the focus of the Klamath River Renewal Corporation's (KRRC) plan to decommission four mainstem dams (KRRC 2018). In addition to the KRRC Definite Plan, the Coho recovery plan identifies a suite of recommended restoration actions. Fall-run ***Chinook Salmon***, spring/summer- and winter-run ***steelhead*** and ***Pacific Lamprey*** should also benefit from many of the restoration actions proposed for Coho Salmon recovery. This program presents an opportunity to take a broader ecosystem-based approach to restoration which would benefit other fish and species in addition to Coho.

Table 4-18: Summary of major restoration efforts in the Upper Klamath River sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit.

Key Restoration Activities in the Upper Klamath River Sub-basin to Date	Species Benefiting				
	RT	CO	CH	ST	PL
Road assessment: The Klamath National Forest, along with all national forests in the US, is conducting an analysis of all the roads, trails, and areas used by motor vehicles.		●	●	●	○
Flushing flows: The intent of the flushing flows is to mimic the natural hydrography, providing a spring pulse which is intended to reduce the prevalence of *Ceratonova shasta* disease in Coho. The new 2019 BiOp provides guidance for these adaptively managed releases (USFWS 2019a). The first application of this new strategy was announced by USBR April 8th, 2019.		●	●	●	
Coho habitat enhancement projects: Current projects include Humbug Creek, Empire Creek, Lumgrey Creek, Horse Creek, Tom Martin Creek, O'Neil Creek, Walker Creek, Beaver Creek, Grider Creek, Seiad Creek, and Portuguese Creek.		●	○	○	○
Klamath tributary fish passage improvement projects: There are a number of projects currently underway by the MKWC and Karuk Tribe including locations in Cottonwood Creek, Little Humbug Creek, McKinney Creek, Horse Creek, Tom Martin Creek, Walker Creek, Grider Creek, Seiad Creek, and Portuguese Creek.		●	○	○	○

*Sources: 2012_MUK Instream_KlamathCandActs_9_17_13_FINAL.xls, NMFS 2014, Klamath National Forest.

Current State of Monitoring & Data Gaps

Current Gauges

USGS measures flow, turbidity, and temperature at several mainstem and tributary sites with more to come over the next two years. The Karuk Tribe employs continuous water quality monitors at many of the same locations[14]:

Mainstem sites (now including wintertime)

- Below Keno Dam (USGS 11509500)
- Below JC Boyle Dam (USGS 11510700)
- Iron Gate (USGS 11516530)
- Seiad Valley (USGS 11520500)
- Orleans (USGS 11523000)
- Klamath, CA (USGS 11530500)

Tributary sites (primarily summer)

- Shasta R (USGS 11517500)
- Scott R (USGS 11519500)
- Salmon R (USGS (11522500)
- Trinity R (USGS 11530000)

Water Quality

Water quality on the Upper Klamath River mainstem, particularly downstream of IGD, has been a concern for a long time. In 1997, the Pacific Coast Federation of Fisherman's Association brought a suit against the Environmental Protection Agency, which led to the ruling in March 1997 for 17 California watersheds (including the Klamath Basin) to adopt Total Maximum Daily Loads (TMDLs). TMDLs for temperature, dissolved oxygen, nutrients, and cyanotoxin damages were applied for the California reaches of the Klamath River mainstem in December 2010. There are numerous water quality monitoring stations throughout the mainstem of the Klamath in this sub-basin and several tributaries (https://kbmp.ecoatlas.org/map.php), some of which provide continuous monitoring data. Data are collected by a variety of organizations, including the Karuk Tribe, USFWS, USFS, BLM, PacifiCorp, and Oregon State University. A summary is provided by the Klamath Basin Monitoring Plan.

Fish Populations

The California Department of Fisheries and Wildlife (CDFW) has been collecting population data for Coho, Chinook, and steelhead since 1978. Records for Coho spawner surveys exist for most years since 1979. Occasional monitoring of the presence of juvenile Coho has occurred throughout much of the sub-basin below IGD (NMFS 2014; ESSA 2017). Comprehensive fall Chinook spawning escapement monitoring began in 1978 to inform harvest decisions. Monitoring currently occurs along the Klamath and Trinity rivers, including Bogus Creek, Horse Creek, Beaver Creek, and Grider Creek of the Upper Klamath River sub-basin (ESSA 2017, Figure 7-8). USFWS Arcata Fish and Wildlife Office leads fall spawner surveys on Mainstem Klamath River with the support of tribal partners, including the Karuk Tribe and Yurok Tribe, while additional fall spawner surveys have been conducted by the Mid Klamath Watershed Council, CDFW, and the USFS. Run-size estimates are based on spawning beds (redds) or carcass counts, although there

[14] USGS is working on a web site summarizing their monitoring along with the Karuk-operated sondes. This is expected to be available to the public in FY2020.

is an adult fish weir in Bogus Creek on video. USFWS in Arcata, as well as the California-Nevada Fish Health Center from Red Bluff, conducts mainstem studies including juvenile outmigration, fish disease, and disease infection. Oregon State University (OSU) also completes rigorous disease monitoring including spore monitoring, sentinel exposure studies, and food abundance surveys.

Effectiveness Monitoring

A review of restoration projects found limited evidence of project effectiveness monitoring in this sub-basin (ESSA 2017). Reintroduction[15] of native anadromous fish either by way of dam removal or enabling fish passage is one of the highest profile restoration actions being considered within the Plan. ODFW and the Klamath Tribes have developed a draft reintroduction implementation plan for the Oregon part of the basin (ODFW and The Klamath Tribes, Draft 2018), and CNRA/CDFW have also developed a draft reintroduction monitoring plan for the California part of the basin (CNRA and CDFW 2021). Both are critical in informing the effectiveness monitoring for this action. The Yurok Tribe is also preparing to complete a full biological census of the Klamath River, including macroinvertebrates, for locations above and below the dams,.

When the dam removal occurs as per the Definite Plan released by the Klamath River Renewal Corporation (KRRC 2018)[16] the physical outcomes of the action need to be evaluated. The focus of the Definite Plan (KRRC 2018) is on how to decommission the dams. There is a small monitoring component to this plan, however it is focused only on the 2 years immediately following the dam-removal in the 18-mile reach where the bulk of geomorphic change is expected, between Iron Gate Dam and Cottonwood Creek (Hetrick et al. 2009). Specifically, the Definite Plan highlights the act of monitoring several tributary/mainstem confluences to ensure that connectivity isn't affected by sediment deposits after the dam removal, and evaluating spawning habitat in the hydro reach. The State of California's 401 permit should also inform monitoring associated with the Clean Water Act requirements, as should KRRC's 16 management plans for dam removal including the Aquatic Resources Management Plan (KRRC 2021b) and Reservoir Area Management Plan (KRRC 2021d), which describe specific restoration actions.

<u>Current Data Gaps:</u>

Figure 4-20 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring across agencies in the Upper Klamath River sub-basin. Location-specific agency metadata (where available) on monitoring projects is incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. The most obvious population data gap is with respect to Pacific Lamprey in the Upper Klamath River sub-basin. There are relatively strong data on salmon populations, as well as water temperature and flow, which are of particular concern below IGD. Moving forward, rigorous effectiveness monitoring will be important to inform future restoration strategies, particularly environmental responses after the dam removal. The reintroduction of anadromous fish will require a significant monitoring effort to

---

[15] Under a dam removal scenario, only spring-run Chinook will be reintroduced immediately. Other species/runs will be left to recolonize on their own at first.

[16] Note: We will update citations and related content as major parallel plans like the KRRC are released and we proceed with greater focus on plan alignment in Phase 4.

guide the application and evaluation of effectiveness. There is currently no plan for monitoring physical changes downstream of IGD beyond the limited scope described in the Definite Plan.

Upper Klamath River Sub-basin Monitoring Summary

Habitat Monitoring	Watershed Inputs	Weather	●
		Streamflow	●
		Groundwater	●
		Riparian & Landscape	●
	Fluvial-Geomorph	Sediments & Gravel	●
		Stream Morphology	●
	Habitat	Stream Temperature	●
		Water Quality	●
		Habitat Quality	●
		Barriers & Injury	●
		Marine/Estuary	NA
	Biota	Invasive Species	

			RB Trout	Salmon / Steehead	Pacific Lamprey
Population Monitoring	Abundance	Juvenile Abundance (anad)	NA	●	
		Spawner Abundance (anad)	NA	●	
		Abundance (non-anad)	●	NA	NA
	Harvest	Harvest (in-river)	●		
		Harvest (ocean)	NA		
	Distrib-ution	Temporal Distribution		●	
		Spatial Distribution	●	●	
	Demo-graphics	Stock Composition		●	
		Age Structure		●	
	Biota	Disease		●	

● Known monitoring activities (past or ongoing)

NA Monitoring not relevant to this sub-basin

Figure 4-20. Synthesis of past and ongoing monitoring activities in the Upper Klamath River sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017, Section 2.5, Appendix H):

Whole Basin

- Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (SONCC) (NMFS, 2014)
- Recovery Strategy for California Coho Salmon (CDFW 2014)

- Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)
- Klamath Basin Water Quality Monitoring Plan (KBMP 2016)
- Klamath Hydroelectric Settlement Agreement (KHSA) which included Interim Measure 15, which funds long-term baseline water quality (multi party 2010)

Regional Plans

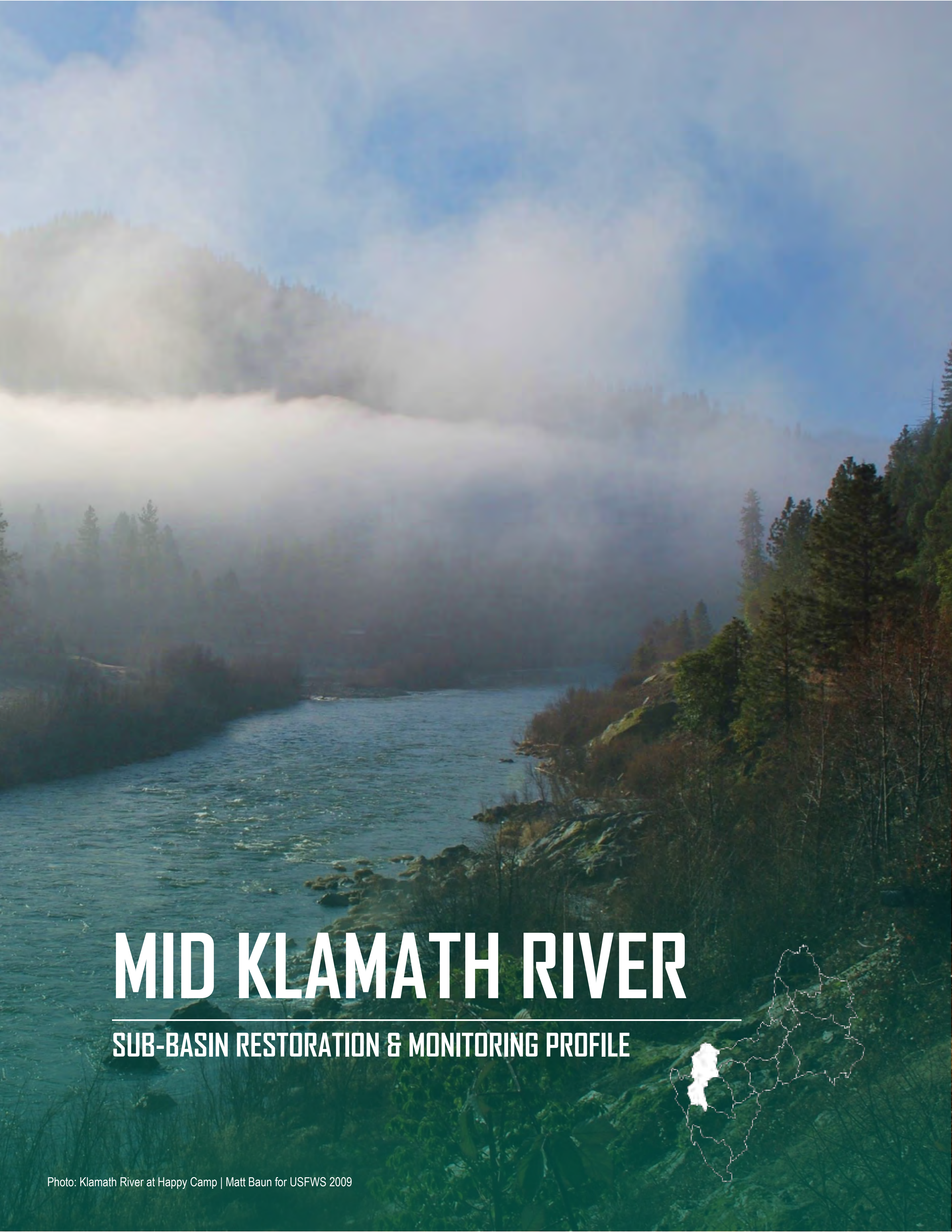
- Reintroduction of Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin – A Summary - Prepared by Oregon Department of Fish and Wildlife and The Klamath Tribes (Draft 2018)
- Definite Plan for the Lower Klamath Project (KRRC 2018)
- Klamath National Forest (KNF) Water Quality Monitoring Plan (USFS 2010)
- The Klamath National Forest Land and Resource Management Plan (Klamath National Forest 2010)
- Yurok Tribe Comprehensive Cultural Riverscape Restoration Plan (Draft)
- The 2012 Fruit Grower's Supply Habitat Conservation Plans
- Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife (CNRA and CDFW 2021, Draft)

Upper Klamath River Sub-basin Focus

- Mid-Klamath sub-basin Fisheries Resource Recovery Plan (Soto et al. 2008) – note that the upper portion of the mid-Klamath as defined by this plan includes the reach between IGD and Seiad Creek, and therefore is relevant to this section.
- Incidental Take Permit for PacifiCorp's Habitat Conservation Plan (HCP; PacifiCorp 2012)

Recent and Forthcoming Plans and Initiatives

NOAA is developing the "Klamath River Reservoir Reach Habitat Assessment and Restoration Plan" which will be finalized in May/June 2022). This plan will incorporate the area from Iron Gate Dam to Link River Dam and will include habitat assessment data, temperature data from over 20 tributaries, a diversion/screening assessment, has identified over 75 restoration actions, and a prioritized list of diversions to screen and habitat projects to implement. CDFW is also developing the "Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife."



MID KLAMATH RIVER

SUB-BASIN RESTORATION & MONITORING PROFILE

Photo: Klamath River at Happy Camp | Matt Baun for USFWS 2009

4.4.2 Mid-Klamath River Sub-basin

The boundaries of the Mid-Klamath River sub-basin conform to those defined for the Mid-Klamath River population of the Southern Oregon/Northern California Coast Coho Salmon (SONCC) Coho Salmon Evolutionary Significant Unit (ESU) (NMFS 2014). The sub-basin is characterized by heavy annual precipitation with frequent winter floods. The sub-basin has many small tributaries with highly variable flows that are often seasonally intermittent. Impacts from past mining, forestry activities, and intense fires have resulted in degraded stream riparian conditions, increased fine sediment inputs, created barriers, and reduced fish habitat. Re-establishing a natural fire regime is a key restoration action for the sub-basin. Upriver dams have altered hydrological function and high nutrient loads from upstream agriculture and associated algal blooms have impacted water quality in the Klamath mainstem throughout this reach, creating conditions for fish disease to run rampant. TMDLs have been established within this sub-basin for high nutrient load; low dissolved oxygen; cyanotoxins; high stream temperatures, and organic matter.

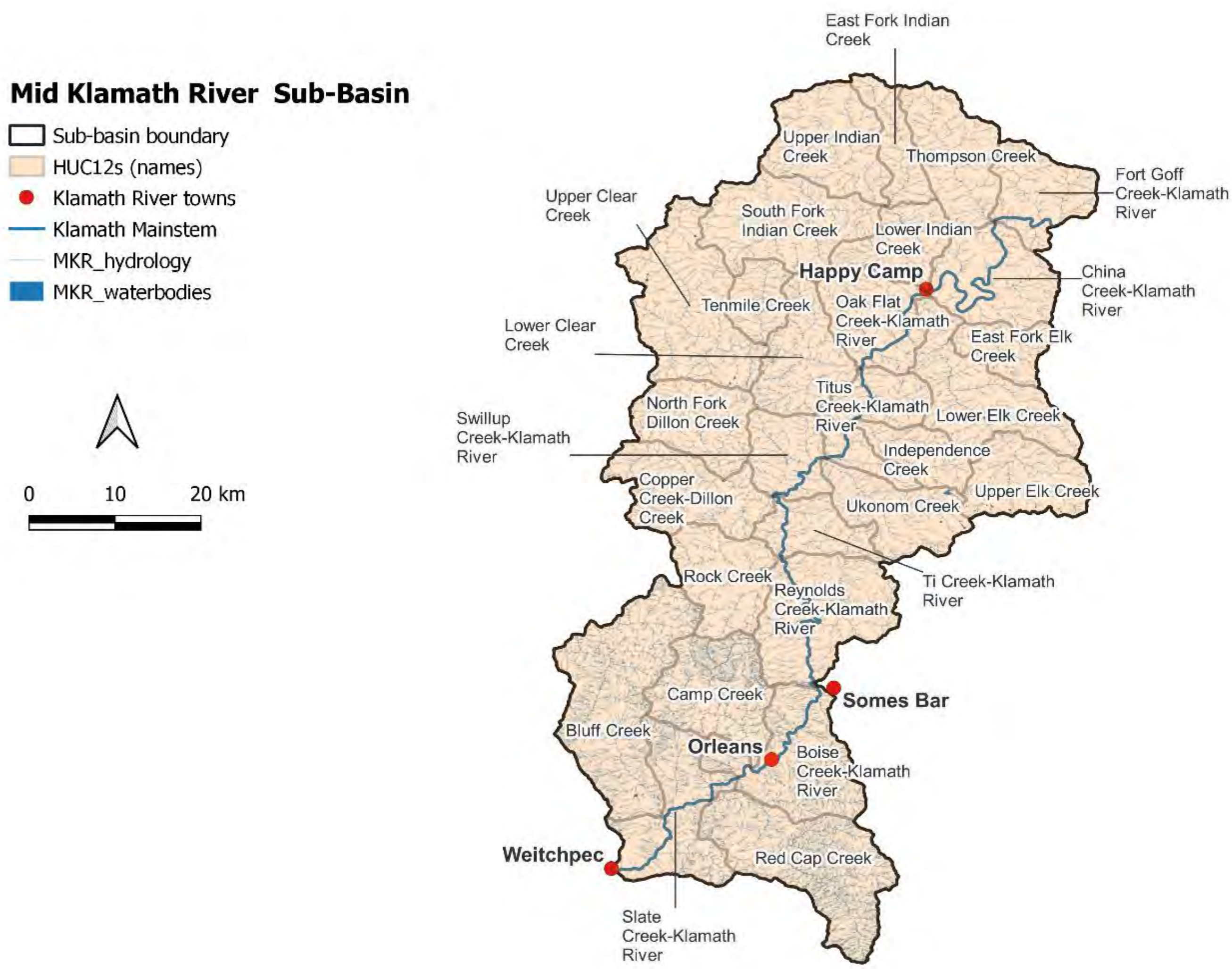


Figure 4-21: Reference map of the Mid-Klamath River Sub-Basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current**: Chinook Salmon (fall-run and spring-run), Coho Salmon, steelhead (summer and winter), Pacific Lamprey, Green Sturgeon

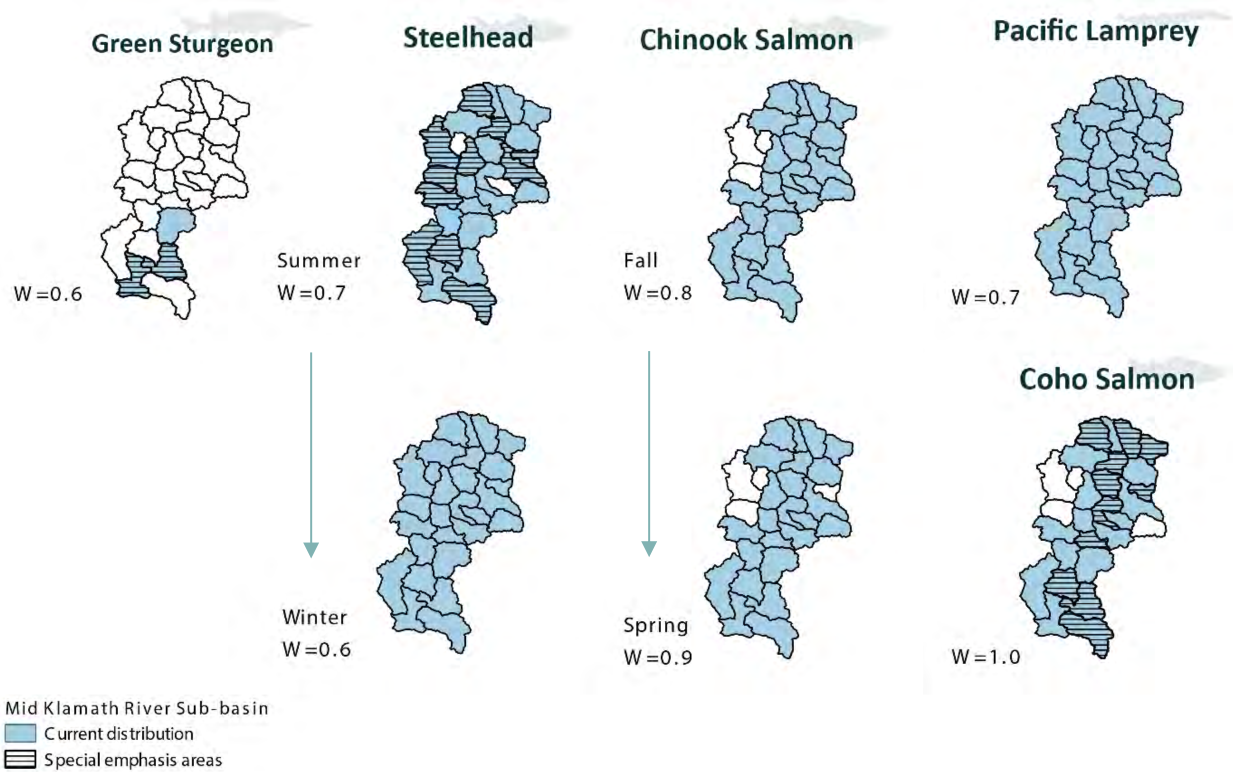


Figure 4-22: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the Mid-Klamath River sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors

Table 4-19: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the Mid-Klamath River sub-basin listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. CH = Chinook Salmon, CO = Coho Salmon, ST = steelhead, PL = Pacific Lamprey, GS = Green Sturgeon.

Key Stressors	Tier	Stressor Summary for the Mid-Klamath River Sub-basin	Species				
			GS	CH	CO	ST	PL
Klamath River flow regime	WI	Concerns related to altered hydrologic function and flow timing/magnitude as a result of managed water releases from four Klamath River hydroelectric dams. Although the impacts of the agricultural projects and hydropower decrease with distance downstream from Iron Gate Dam, adverse effects can be detected in the Middle Klamath mainstem hydrograph	●	●	●	●	●

Key Stressors	Tier	Stressor Summary for the Mid-Klamath River Sub-basin	Species				
			GS	CH	CO	ST	PL
Instream flow (tributaries)	WI	Flow impairments in tributary streams in the sub-basin are due to the diversion of water for private and municipal use. Diversions cause some tributaries to go subsurface intermittently during the summer and may eliminate or reduce thermal refugia in tributaries or tributary outlets at other times of the year. Summer water diversions can contribute to degraded habitat and/or fish passage issues in sub-basin tributaries during low water years.	○	●	●	●	●
Increased Fine Sediment Input	WI	Soils in this area are highly erodible, and in combination with the steep terrain, recent intense fires, and a legacy of past timber harvest and road-building, fine sediment loading has reduced habitat complexity in many tributaries through infilling of pools, off-channel ponds and wetlands.		●	●	●	○
Water Temperature, Dissolved Oxygen	H	Water quality issues are a primary concern in the mainstem river due to elevated water temperatures, low dissolved oxygen, and high nutrient levels resulting from upper basin agricultural practices and altered flow regimes from dams in the upper Klamath. Cool water tributary refuge habitat in the sub-basin is limited and often disconnected from the mainstem.	●	●	●	●	●
Anthropogenic Barriers	H	Low flow conditions, road-crossings, and diversions cause many seasonal and permanent barriers in the Mid-Klamath River sub-basin. Over recent years, the most critical anadromous fish passage barriers on Forest Service roads in the sub-basin have been removed. However excess fine sediment loading in this sub-basin can also cause passage issues, with the potential for alluvial deposits/dams to form at many tributary confluences. This can either physically block fish or force flows subsurface, thereby limiting or eliminating access to important refugia and spawning/rearing habitat. These alluvial deposits/dams are considered to represent the greatest number of fish passage barriers in the sub-basin.		●	●	●	●
Instream Structural Complexity (mesohabitats)	H	A legacy of past forestry and mining activities in the sub-basin has significantly reduced stream habitat complexity (e.g. pools, LWD, cover, off-channel floodplains) in tributaries throughout the sub-basin. Wood in considered inadequate in many tributaries.		●	●	●	●
Pathogens	BI	Upper River dams have altered sediment transport processes and contributed to the reduction of flow variability in the Mid Klamath, which has created river conditions that favor disease proliferation and facilitate increased fish infection rates.		●	●	○	

Stressors identified from: NMFS 2014; USFWS 2019a,b; Sub-regional working group survey responses. Note that understanding of stressors affecting juvenile Pacific Lamprey and Green Sturgeon is poor.

Sequences of Restoration Projects for the Mid-Klamath River Sub-Basin

The **summary infographic** in Figure 4-23 provides a compact overview of the Mid-Klamath River sub-basin restoration project priorities and their distribution across the sub-basin.

Figure 4-23: Summary for the Mid-Klamath River sub-basin, including key stressors, cost ranges, and projects (see next page).

Mid Klamath River Sub-basin

Sub-Basin Summary

The Mid Klamath River Sub-basin is characterized by heavy annual precipitation with frequent winter floods. The sub-basin has many small tributaries with highly variable flows that are often seasonally intermittent. Impacts from past mining and forestry activities in the sub-basin have resulted in degraded stream riparian conditions, increased fine sediment inputs, created barriers, and reduced fish habitat. Altered hydrological function due to upriver dams and high nutrient loads from upstream agriculture and associated algal blooms have impacted water quality in the Klamath mainstem throughout this reach and created conditions for fish disease proliferation. TMDLs have been established in this sub-basin for high nutrient load; low dissolved O2; microcystin; high stream temperatures, and organic matter.

Key Stressor Summary

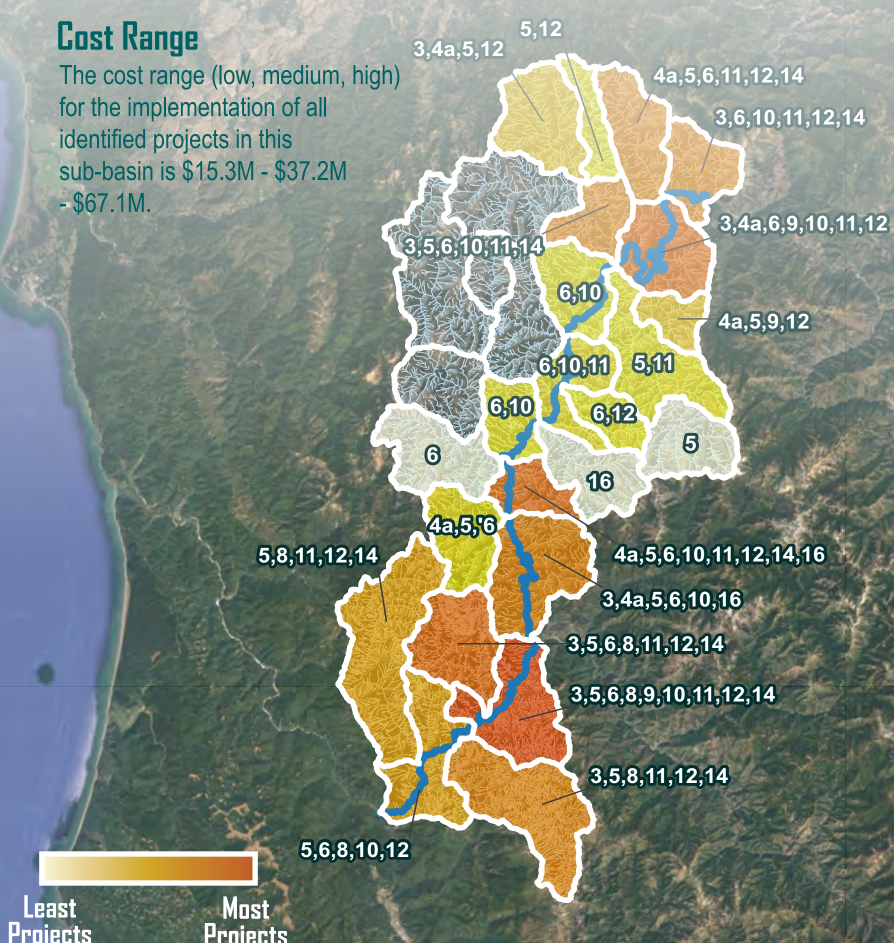
Key Stressors	Focal Species				
	CO	CH	ST	PL	GS
Klamath River flow regime					
Instream Flow (tribs)					
Increased Fine Sediment					
Anthropogenic Barriers					
Water Temperature					
Instream Structural Complexity					
Pathogens					

Restoration Summary

A total of 11 projects were identified by the sub-basin working group. Projects primarily address habitat (e.g., condition and access/connectivity) and watershed inputs (e.g., fine sediment inputs and instream flow). There was general alignment between the IFRMP tool rankings and the recommendations of the sub-basin working group. In particular, the top four IFRMP ranked projects are consistent with the sub-basin working group views, although the group noted they would rank project 6 higher than project 9 and project 10. These differences in opinion tended to be due to considerations around implementability and timing of associated benefits. A more detailed discussion of participant perspectives on the IFRMP rankings is available in the full report chapter.

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is \$15.3M - \$37.2M - \$67.1M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP Mid Klamath River sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting, and **arrows** indicate linkages between projects.

Project ID & Description	Tiers
MKR 8 - Undertake riparian planting to reduce water temperatures and improve fish habitats | **16.3**	H, FG
MKR 6_10 - Remove sediment barriers or construct low flow channels to provide access to existing cold water refugia within the Mid Klamath River Sub-basin | **15.9**	H, WI
MKR 11 - Reconnect off-channel habitats by removing or reconfiguring stream levees and dikes | **15.4**	FG
MKR 14 - Install BDAs to provide seasonal fish rearing habitats in Mid Klamath River tributaries | **14.8**	H, FG
MKR 4a - Decommission forestry roads to reduce fine sediment inputs to Mid Klamath River streams | **14.2**	WI
MKR 9 - Implement projects to provide for fish passage at identified priority tributary fish barriers across the Mid Klamath River Sub-basin | **14.0**	H
MKR 12 - Install in-channel structures such as LWD, boulders, etc. to improve conditions of fish habitats | **13.9**	H
MKR 3 - Manage water withdrawals across the Mid Klamath River Sub-basin to increase instream flows during critical low flow periods | **13.4**	WI
MKR 5 - Undertake upland vegetation management as needed to restore a fire adapted landscape across the Mid Klamath River Sub-basin | **11.9**	WI
MKR 16 - Restore upland wetlands and meadows to improve cold water storage and runoff attenuation in the Mid Klamath River Sub-basin | **9.8**	WI, FG

Table 4-20 presents the results of the 2022 iteration of the IFRMP restoration sequencing process for the Mid-Klamath River sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-20. The projects listed here have a cost range of $15.3M - $37.2M - $67.1M (low, estimated midpoint, high), and have been collated from projects proposed in prior local or regional restoration plans and studies as well as from in-depth discussions among participants in the IFRMP's Mid-Klamath River Sub-basin Working Group who represent scientists, restoration practitioners, and resource users working in the sub-basin (see Acknowledgements section). The sequences and scoring in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria.

Additional considerations such as implementability, cost and dependencies among projects may influence the ultimate sequencing of projects. Dependencies identified by the Sub-basin Working Groups are noted in the table. Sequencing of projects in terms of ecological processes will be very important for maximizing benefits in the sub-basin but determining the optimal sequencing steps for multi-project implementation requires further deliberation among the working group. To facilitate comparison across the sub-basins, results are shown assuming the four major Klamath mainstem dams have been removed, but no other changes. The Mid-Klamath River Sub-basin Working Group identified the following additional scenarios with potential to influence restoration priorities. Should any these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

- Species status
- Extreme disease condition

A total of 10 projects were identified by the Sub-basin Working Group. Projects primarily address habitat (e.g., condition and access/connectivity) and watershed inputs (e.g., fine sediment inputs and instream flow). There was general alignment between the IFRMP tool rankings and the recommendations of the Sub-basin Working Group. Differences tend to be due to considerations around implementability and timing of associated benefits.

The top four IFRMP ranked projects are consistent with the Sub-basin Working Group recommendations.

- **Projects 8, 6_10, 11, and 14.** Project 8 involves riparian planting to reduce water temperatures for fish. Project 6_10 involves protection and enhancement of current cold water refugia. Project 11 involves channel reconfiguration and improving connectivity in tributaries across the sub-basin (i.e., ten sub-watersheds). Project 14 pertains to installation of BDAs in tributaries, the Sub-basin Working Group suggests there are many opportunities where this action could provide *immediate* benefit.

    Sub-group recommendations

    - Consider lowering the rank order of Project 8 when not paired with another project.

Projects ranked as of more intermediate restoration importance by the IFRMP tool included:

- **Projects 4a, 9, 12, 3.** Project 4a involves the decommissioning of forestry roads to reduce sediment inputs into streams. Project 9 is related to fish passage improvements at priority barriers. Project 12 (channel structure placement) was ranked 7th by the IFRMP tool largely due to a low CPI score and as in other sub-basins a low 'scale of benefit' score. Project 3 involves managing water withdrawals across a number of tributaries (8 sub-watersheds).

  Sub-group recommendations

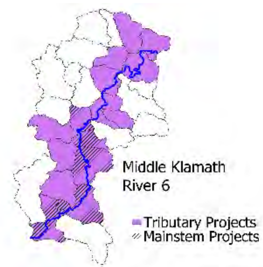
  - Consider raising the rank order of Project 12 to reflect immediate benefit.

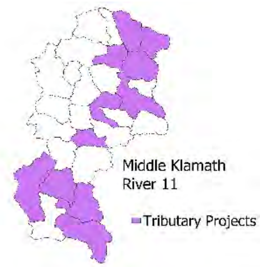
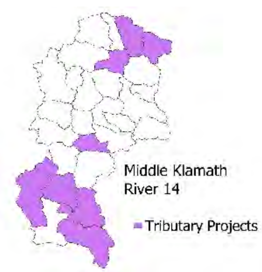
The lowest ranking restoration projects by the IFRMP tool in the Mid Klamath sub-basin were:

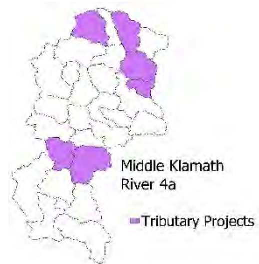
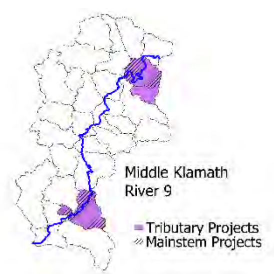
- **Projects 5, 16.** Project 5 involves broad upland vegetation management across 15 sub-watersheds. Project 16 involves upland wetland improvements in three adjacent tributaries. Both projects were ranked as an intermediate priorities by the Sub-basin Working Group.

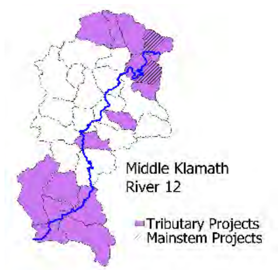
Table 4-20: Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the Mid-Klamath River sub-basin, with projects scored higher to be considered first for implementation. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name. Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-21; special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

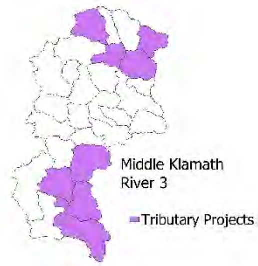
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.5)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.5)*	Implementability *(0.6)*
Mid-Klamath River 8 (16.3)	**Undertake riparian planting to reduce water temperatures and improve fish habitats.** **Project Description:** Implement riparian planting to restore forest and instream vegetation for shading with benefits for reducing water temperatures and improving instream habitat (NMFS 2014). Most riparian planting that is implemented in the MKR sub-basin is associated with channel reconfiguration and reconnection, and thermal refugia projects. There is need for stand-alone riparian planting along stream reaches in Bluff Creek, Camp Creek, and Red Cap Creek; and various sites along the mainstem Klamath River (Aikens Creek completed). Riparian planting has localized benefits and, since landslide failure response work in late 1990s, occurs primarily as an ancillary activity to primary prioritized restoration projects. Invasive vascular plant removal that often occurs concurrently and complementary to priority restoration projects are ecologically important but less so to fish and other aquatic species. **Dependencies / Project Linkages:** It was noted that riparian planting was more important as an ancillary activity to support other restoration actions. **Primary Action Types:** Riparian planting **Near-Term Focal Areas (map):** 4 sub-watersheds, Camp Creek**, Boise Creek-Klamath River**, Red Cap Creek**, Slate Creek-Klamath River**, Bluff Creek** **Cost range ($K):** $125 - 138 – 150 (based on cost data from Shasta, UKR) 	**4**	**0.67**	**3.11**	**2.5**	**6**

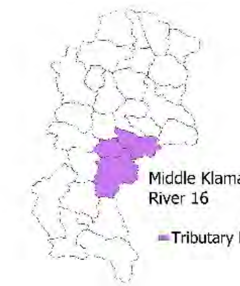
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.5)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.5)*	Implementability *(0.6)*
Mid-Klamath River 6_10 (15.9)	**Remove sediment barriers or construct low flow channels to provide access to existing cold water refugia within the MKR sub-basin.** **Project Description:** Ensure there is fish passage to cold water refugia and habitat in Klamath River tributaries by removing sediment barriers formed by alluvial deposits or construct low flow channels and reduce gradient to provide fish passage over deposits (NMFS 2014). Fish passage improvements (e.g., removal of sediment barriers) are most often needed at the confluence of lower reaches of Klamath River tributaries. This will enhance access to existing cold-water habitat and potentially expand thermal refugia habitat by construction off of-channel ponds for Coho salmon that would be fed by cool groundwater. Other specific sub-activities include protecting and restoring instream flow and water quality e.g., by relocating Indian Creek River access from the mouth of Indian Creek to protect rearing salmonids from being harassed and displaced from this critical thermal refugia. **Dependencies / Project Linkages:** No dependencies indicated.  **Primary Action Types:** Fish passage improvement (gen.), Minor fish passage blockages removed or altered, Instream flow project (gen.), Water quality project (gen.) **Near-Term Focal Areas (map):** 18 sub-watersheds, Lower Indian Creek, Thompson Creek**, Fort Goff Creek-Klamath River**, China Creek-Klamath River, East Fork Elk Creek**, Upper Clear Creek**, North Fork Dillon Creek**, Copper Creek-Dillon Creek**, Oak Flat Creek-Klamath River**, Independence Creek**, Titus Creek-Klamath River, Swillup Creek-Klamath River, Rock Creek, Ti Creek-Klamath River**, Reynolds Creek-Klamath River, Camp Creek**, Boise Creek-Klamath River**, Slate Creek-Klamath River** **Cost range ($K):** $5,858 - 12,494 - 19,105 (based partly on cost data from Shasta, SF Trinity, Trinity, UKR)	**0.4**	**1.25**	**8**	**2.5**	**3.73**
Mid-Klamath River 11 (15.4)	**Reconnect off-channel habitats by removing or reconfiguring stream levees and dikes.** **Project Description:** Reconnect channels to existing off-channel ponds, wetlands, and side channels. Remove, set back, or reconfigure levees and dikes (NMFS 2014). Implement projects to reverse channel incision or prevent further incision. Restore, expand and/or create off-channel and floodplain habitats and re-establish hydrologic connectivity to those habitats. Projects are being planned or implemented in the following watersheds: Bluff Creek; Red Cap Creek: Schnable and Larsons; Camp Creek; Lower Ti Creek; Indian Creek; China Creek (off-channel pond projects have been completed in China Creek). Restore hydrologic connection to floodplain and off-channel habitat in mainstem Klamath River reaches including those that are	**2.39**	**2**	**6.74**	**2.5**	**1.76**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.5)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.5)*	Implementability *(0.6)*
	impacted by tailings from historical industrial-scale mining (sites along the MKR and UKR have been assessed in the MKR Floodplain Habitat Enhancement and Mine Tailing Remediation study). **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Mechanical channel modification, reconfiguration, Dike or berm modification/removal **Near-Term Focal Areas (map):** 10 sub-watersheds, Lower Indian Creek, Thompson Creek**, Fort Goff Creek-Klamath River**, China Creek-Klamath River, Lower Elk Creek, Titus Creek-Klamath River, Ti Creek-Klamath River**, Camp Creek**, Boise Creek-Klamath River**, Red Cap Creek**, Bluff Creek  **Cost range ($K):** $3,444 – 10,961 – 27,050					
Mid-Klamath River 14 (14.8)	**Install BDAs to provide seasonal fish rearing habitats in MKR tributaries.** **Project Description:** Install beaver dam analogues (BDAs) in lower gradient streams to provide summer and winter rearing opportunities for juvenile (SONCC Recovery Plan, NMFS 2014; USBOR 2018). Planned and potential projects in the Red Cap Creek; Camp Creek; Stanshaw Creek; Sandy Bar Creek, Titus Creek, Independence Creek, China Creek, Bluff Creek, and Thompson Creek watersheds (Boise Creek completed). Potential mainstem projects in the China Creek-Klamath River and Fort Goff Creek-Klamath River HUC12s. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Beavers & beaver dam analogs **Near-Term Focal Areas (map):** 7 sub-watersheds, Lower Indian Creek, Thompson Creek**, Fort Goff Creek-Klamath River**, Ti Creek-Klamath River**, Camp Creek**, Boise Creek-Klamath River**, Red Cap Creek**, Bluff Creek**  **Cost range ($K):** $91 – 137 – 183	**2.87**	**0.58**	**3.65**	**2.5**	**5.23**
Mid-Klamath River 4a (14.2)	**Decommission forestry roads to reduce fine sediment inputs to MKR streams.** **Project Description:** West Ishi Pishi road upgrading and/or decommissioning in the Rock Creek (180102090701) and Reynolds Creek-Klamath River (180102090703) HUC12s. Storm proofing roads in the Elk Creek, Indian Creek and Thompson Creek watersheds. The Dillon Creek to Salmon River (aka West Ishi Pish i) have a hand-full of roads still needing	**1.09**	**1.92**	**4.32**	**3.75**	**3.17**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)* Range Overlap *(0.4)*	CPI Status *(0.5)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.5)*	Implementability *(0.6)*
	stormproofing or decommissioning. There are currently few roads proposed for decommissioning treatment elsewhere in the MKR sub-basin and road stormproofing is being implemented at relatively small scales. Sites for treatment are few. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Road closure/abandonment, Planting for erosion and sediment control, Slope stabilization **Near-Term Focal Areas (map):** 6 sub-watersheds, Upper Indian Creek**, Thompson Creek**, China Creek-Klamath River, East Fork Elk Creek**, Rock Creek, Reynolds Creek-Klamath River **Cost range ($K):** $1,370 - 1,820 - 2,270 (incomplete – no cost data for "slope stabilization") (based partly on cost data from Trinity) 					
Mid-Klamath River 9 (14.0)	**Implement projects to provide for fish passage at identified priority tributary fish barriers across the MKR sub-basin.** **Project Description:** This is an infrequent activity that provides long-term access to cold water refugia and to suitable aquatic habitats, extending the range of target fish species. Numerous stream crossing fish passage barriers overlapping with Forest Service and County jurisdictions have been removed or modified over the past 30 years in this subbasin . These fish passage projects normally require heavy machinery, jackhammering, and/or expansion agents in addition to hand crew labor. There are currently three sites proposed for treatment (Cade Creek - road/stream crossing; East Fork Elk Creek - natural barrier; and Portuguese Creek - road/stream crossing). **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Fish passage improvement (general) **Near-Term Focal Areas (map):** 3 sub-watersheds, China Creek-Klamath River, East Fork Elk Creek**, Boise Creek – Klamath River **Cost range ($K):** $550 – 4,775 – 9,000 (based partly on cost data from Shasta, and SF Trinity) (the "fish passage blockage removed or altered" action type for this project uses cost data from MKR Project #6). 	**1.64**	**5**	**1.04**	**2.5**	**3.84**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.5)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.5)*	Implementability *(0.6)*
Mid-Klamath River 12 (13.9)	**Install in-channel structures such as LWD, boulders, etc. to improve condition of fish habitats.** **Project Description:** Implement habitat restoration projects including large woody debris, boulders, and other instream structures (NMFS 2014). Planned or good potential projects in: Bluff Creek, Red Cap Creek, Camp Creek, Ti Creek; King Creek, Independence Creek, China Creek; Indian Creek, Bluff Creek, and the Klamath River mainstem in the China-Klamath River and Fort Goff Creek-Klamath River HUC12s (projects have been completed in Aikens Creek and China Creek). Channel structure placement is often a component of channel reconfiguration and reconnection projects, and in thermal refugia restoration/enhancement/creation projects. Channel structure placement can occur independently as a single action (such as the Horse Creek Helicopter Large Wood Loading project that is set to be implemented). **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Channel structure placement, Addition of large woody debris **Near-Term Focal Areas (map):** 12 sub-watersheds, Upper Indian Creek**, East Fork Indian Creek, Thompson Creek**, Fort Goff Creek-Klamath River**, China Creek-Klamath River, East Fork Elk Creek**, Independence Creek**, T i Creek-Klamath River**, Camp Creek**, Boise Creek-Klamath River**, Red Cap Creek**, Slate Creek-Klamath River**, Bluff Creek**  **Cost range ($K):** $2,481 – 5,037 – 6,917 (based partly on cost data from Trinity)	**1.54**	**0.5**	**6.11**	**1.25**	**4.5**
Mid-Klamath River 3 (13.4)	**Manage water withdrawals across the MKR sub-basin to increase instream flows during critical low flow periods.** **Project Description:** Improve flow timing or volume by assessing diversion impacts and developing an incentives and enforcement program to increase flow during critical low flow periods (NMFS 2014). Identify and cease any unauthorized water diversions (NMFS 2014). No specific projects identified to address current situation to assess private landowners water usage, rights, diversion, and storage. These projects often take many years to implement/adjudicate, and/or usually do not result in significant increases in flow. There are few opportunities to manage water withdrawals where more than just fractions of a cfs can be dedicated to instream flows. These are also highly controversial with the public, and documenting/tracking them is difficult.	**3.36**	**3.08**	**2.57**	**3.75**	**0.6**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.5)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.5)*	Implementability *(0.6)*
	Dependencies / Project Linkages: No dependencies indicated. **Primary Action Types:** Manage water withdrawals **Near-Term Focal Areas (map):** 8 sub-watersheds, Upper Indian Creek**, Lower Indian Creek, Fort Goff Creek-Klamath River**, China Creek-Klamath River, Reynolds Creek-Klamath River, Camp Creek**, Boise Creek-Klamath River**, Red Cap Creek** **Cost range ($K):** $82 - 587 - 1,083 (based on cost data from Shasta, SF Trinity, Trinity) 					
Mid-Klamath River 5 (11.9)	**Undertake upland vegetation management as needed to restore a fire adapted landscape across the Middle Klamath River sub-basin.** **Project Description:** Vegetation and fuel reduction treatments to reduce risk of largescale high severity wildfire and to restore fire resiliency at the watershed and landscape level. Projects include: Orleans Community Fuel Reduction; Somes Bar Integrated Fire Management Project; Leary Creek Project; Offield Thinning and Fuels Reduction; Elk Creek Fuels and Vegetation Management; Indian Creek Community Protection. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Upland vegetation management including fuel reduction and burning **Near-Term Focal Areas (map):** 15 sub-watersheds, Upper Indian Creek**, East Fork Indian Creek, Lower Indian Creek, Thompson Creek**, Upper Elk Creek, East Fork Elk Creek**, Lower Elk Creek, Rock Creek, Ti Creek-Klamath River**, Reynolds Creek-Klamath River, Camp Creek**, Boise Creek-Klamath River**, Red Cap Creek**, Bluff Creek**, Slate Creek-Klamath River**  **Cost range ($K):** $100 – 100 – 150	**1.69**	**1**	**1.47**	**3.75**	**3.95**
Mid-Klamath River 16 (9.8)	**Restore upland wetlands and meadows to improve cold water storage and runoff attenuation in the Middle Klamath River sub-basin.** **Project Description:** To maximize cold water quantity and duration and increase runoff attenuation for salmonid protection and recovery as well as providing a wide array of other species and ecosystem benefits restore upland wetlands and meadows (Donald Flickinger and Jon Grunbam, pers. comm.). Klamath Mountains Meadow Project:	**1.19**	**1.08**	**0.8**	**3.75**	**2.96**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.5)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.5)*	Implementability *(0.6)*
	restore degraded meadows to restore water holding capacity and improve water quality. Projects are in initial stages of planning. Meadows in the headwaters of Stanshaw Creek, Sandy Bar Creek, and Ti Creek. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Upland wetland improvement **Near-Term Focal Areas (map):** 3 sub-watersheds, Ukonom Creek, Ti Creek-Klamath River**, Reynolds Creek-Klamath River **Cost range ($K):** $1,200 - 1,200 - 1,200  					

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC and SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, and sub-regional working group input via surveys and webinars.

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the Mid-Klamath River Sub-basin

The state and federally listed SONCC ESU of ***Coho Salmon*** is a key species identified for many restoration actions in this sub-basin and in other parts of the mid and lower Klamath basin (NMFS 2014). Spring-run ***Chinook Salmon*** are also listed under California's Endangered Species Act (CESA). ***Steelhead, Pacific Lamprey,*** and ***Green Sturgeon*** populations are also of significant conservation concern as these are Tribal Trust species that have experienced notable long-term declines in the Basin.

The Mid-Klamath Watershed Council (MKWC) is a leading group in planning, coordinating, and implementing restoration projects in this section of the Klamath Basin. The MKWC and the Salmon River Restoration Council have worked with governmental, Tribal, and NGO partners to create a detailed Candidate Action Table for in-stream restoration of ecological processes and fish populations in the Mid-Klamath River and Salmon River sub-basins. Fish passage improvement projects are generally concentrated in sub-basins below the dams, where they provide greater benefit to anadromous fish, and are particularly dense in the Mid-Klamath River sub-basin. The MKWC collaborates with the Karuk Tribe and Six Rivers National Forest on local habitat restoration projects in the sub-basin (i.e., Mid-Klamath Tributary Fish Passage Improvement Project; Mid Klamath Coho Rearing Habitat Enhancement Project). Alongside the Karuk Tribe, the Klamath and Six Rivers National Forests, and the California Department of Fish and Game, MKWC conducts yearly spawning surveys for fall Chinook and Coho salmon. The Karuk Tribe's Water Pollution Control Program also evaluates mainstem water quality issues in this section of the river, while the Karuk Tribe's Watershed Restoration Department works in partnership with the Klamath and Six Rivers National Forest to dismantle roads, stabilize road-stream crossings, and re-establish natural hillslope drainage patterns. The Karuk Tribe and Six Rivers National Forest jointly implement juvenile salmon surveys, and the Karuk Tribe tracks the life history movements and habitat use of juvenile salmon using PIT tags and sensor arrays. In addition, the USFWS and Yurok Tribal Fisheries Department (YTFD) monitor juvenile salmon on the mainstem Klamath River at Weitchpec.

The following table summarizes selected major restoration activities in this sub-basin and those species which these activities have benefited.

Table 4-21: Summary of major restoration efforts in the Mid-Klamath River sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit.

Key Restoration Activities in the Mid-Klamath River Sub-basin to Date	Species Benefiting				
	CO	CH	ST	*PL*	GS
The MKWC's Mid-Klamath Tributary Fish Passage Improvement Project (with the support of other sub-basin river restoration councils) implements actions to restore and maintain salmonid fish passage to over 70 tributaries in the Middle Klamath, Salmon and lower Scott River systems. Cold-water tributaries provide critical habitat for both juvenile and adult salmonids, especially during high water temperature, low flow periods. Tributary streams within the Mid-Klamath River sub-basin that have been targeted for passage improvements within this Project include Fort Goff, Thompson, Little Horse, China, Cade, Indian, Little Grider, Elk, Clear, Titus, King, Ukonom, Swillup, Elliot, Aubrey, Dillon, Ti,	●	○	○	○	

Key Restoration Activities in the Mid-Klamath River Sub-basin to Date	Species Benefiting				
	CO	CH	ST	*PL*	*GS*
Rock, Sandy Bar, Stanshaw, Irving, Rogers, Whitmore, Wilson, Camp, Boise, Slate, Bluff, Aitkens, and Hopkins Creeks, as well as the Klamath mainstem from RM 43-127.					
The MKWC's Mid Klamath Coho Rearing Habitat Enhancement Project implements restoration actions designed to enhance off-channel refuge habitats for Coho along the Mid-Klamath River corridor. These projects include a range of habitat restoration actions in the Mid Klamath mainstem and within sub-basin tributaries such as construction of off-channel habitats, removal of sediment from creek mouths, construction of step pools, riparian planting, mine tailing reclamation (above Happy Camp to China Creek), re-introduction or encouragement of beavers, diversion screening, addition of LWD, and removal of invasive vegetation. Tributary streams within the Mid-Klamath River sub-basin targeted for habitat improvements within this Project include Fort Goff, Thompson, Little Horse, China, Cade, Little Grider, Elk, Clear, Titus, Independence, King, Swilllup, Aubrey, Dillon, Ti, Rock, Sandy Bar, Stanshaw, Irving, Whitmore, Wilson, Camp, Boise, Red Cap, Slate, Aikens, and Hopkins Creeks, as well as the Klamath mainstem from RM 43-127.	●	○	○	○	
Since 2014, the Western Klamath Restoration Partnership (WKRP) has been implementing the National Cohesive Wildland Fire Management Strategy within Six Rivers National Forest. The strategy seeks to address fire management challenges by working collaboratively with stakeholders, using best science to achieve resilient landscapes, fire-adapted communities, and safe and effective wildfire response. Projects undertaken by WKRP within this strategy to date are the Somes Bar Integrated Fire Management Project that has been developing landscape level fuels reduction treatments, the Happy Camp Integrated Community Protection and Workforce Development Project which has been working to accelerate the development of fire-adapted communities, and the Salmon River Integrated Large Fire Management Project which is creating strategic fire breaks to develop appropriate conditions for managed wildfire use.	○	○	○	○	
The USFS-Six Rivers National Forest's Instream and Riparian Enhancement Project implements actions to improve spawning/rearing habitats for fish and accelerate restoration of riparian vegetation. Tributary streams within the Mid-Klamath River sub-basin currently targeted for habitat improvements within this Project include Camp, Boise, Red Cap, Slate, Bluff, Aikens, and Hopkins Creeks.	●	○	○	○	
The Klamath and Six Rivers National Forests have eliminated or modified most high and medium fish passage barriers on National Forest lands	○	○	○	○	

*Sources for this table include: 2012_MUK_InstreamCandActs_9_17_13_final Excel spreadsheet (From Toz Soto – Karuk Tribe, updated 2016), MKWC website, Six Rivers National Forest website.

Current State of Monitoring & Data Gaps

Past and Ongoing Monitoring:

NOAA Fisheries' Pacific Coastal Salmon Recovery Fund (PCSRF) supports numerous flow monitoring projects within the Mid-Klamath River sub-basin.

The U.S. Forest Service (USFS) conducts ongoing monitoring of water quality (sediment and temperature) in USFS designated reference streams and managed streams across the Klamath National Forest (KNF), as well as base flow conditions in Mid Klamath tributaries (more information at this link). USFS designated reference streams show very little sign of human management and serve as a baseline for comparison against managed stream conditions. In addition to water quality monitoring, the Forest Service opportunistically conducts habitat reach surveys, which include multiple physical parameters. The Klamath and Six Rivers National Forests with the Karuk Tribe have also conducted juvenile presence/absence surveys for Coho Salmon in select Mid-Klamath River sub-basin tributaries, and for summer steelhead in the tributaries where they still remain (Elk Creek, Clear Creek, Indian Creek, Dillon Creek, Thompson Creek, and Independence Creek). The two National Forests with the Mid Klamath Watershed Council, Karuk Tribe, and California Department of Fish and Game conduct annual spawning surveys for adult Chinook salmon. The Mid Klamath Watershed Council, Karuk Tribe, and Six Rivers National Forest conduct spawning surveys for Coho salmon. The USFWS and partners conduct water quality monitoring along the Klamath mainstem (Ward and Armstrong 2010; Armstrong and Ward 2008) as well as fish passage barrier surveys in mid-Klamath River tributaries.

Two programs at the Karuk Tribe Department of Natural Resources conduct habitat monitoring: Fisheries and Water Quality. The Fisheries program focuses on monitoring base flows and temperatures in mid-Klamath tributaries, coordinating with USFS. The Water Quality program monitors over 130 miles of the mainstem Klamath and the mouths of the Salmon, Scott, and Shasta Rivers. At three mainstem sites and the three tributary sites, this program runs real-time sondes that collect continuous water quality data (temperature, DO, pH, conductivity, turbidity) (Karuk Tribe 2013). The Karuk Tribe also sample nutrients, phytoplankton, and algal toxins, which assist in fish disease monitoring through the Oregon State University as well as baseline public health monitoring. The Karuk Tribe is also involved in monitoring of flows, fish passage barriers, fish utilizing pockets in the river with cooler temperatures, and fish health. In collaboration with USFS, the Tribe measures summer low-flow discharge rates annually on all major and most minor tributaries to the mainstem Mid-Klamath River (Soto et al. 2008). Fish use of thermal refugia and fish health is assessed in collaboration with USFWS, Yurok Tribe and the Mid-Klamath Watershed Council. The Karuk Tribe also conducts Mid Klamath spawner surveys, carcass surveys, out-migrating juvenile trapping, fish disease monitoring, and runs PIT-tag arrays for Coho Salmon and lamprey. The Tribe also conducts monitoring of cold-water refugia and off channel ponds for Coho use/abundance.

The Mid-Klamath Watershed Council collaborates with the Karuk Tribe Fisheries Program to survey for spring Chinook, summer steelhead, winter steelhead, as well as Green Sturgeon, and participates in multi-agency fish kill monitoring efforts throughout the summer months. The Mid-Klamath Watershed Council has participated in restoration projects in the Mid-Klamath River sub-basin since 2001. Effectiveness monitoring for these efforts include tracking recovery of restored off-channel pond habitat and monitoring use of restored thermal refugia by juvenile fish.

Current Data Gaps:

Figure 4-24 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring across agencies in the Mid-Klamath River sub-basin. Location-specific agency metadata (where available) on monitoring projects is incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. There is relatively strong data on focal fish species using this sub-basin, particularly for Chinook salmon and Coho salmon. Strong data are also available for water temperature and flow, which is of particular importance for evaluating the broad effects of landscape level restoration actions in the sub-basin. Moving forward, rigorous and expanded effectiveness monitoring will be important to inform future restoration strategies, particularly responses of fish habitat to riparian restoration, stream channel restoration, and increased access to thermal refugia and off-channel habitats.

Mid Klamath River Sub-basin Monitoring Summary

Habitat Monitoring			
Watershed Inputs	Weather	●
	Streamflow	●
	Groundwater	●
	Riparian & Landscape	●
Fluvial-Geomorph	Sediments & Gravel	●
	Stream Morphology	●
Habitat	Stream Temperature	●
	Water Quality	●
	Habitat Quality	●
	Barriers & Injury	●
	Marine/Estuary	NA
Biota	Invasive Species	

Population Monitoring		Salmon / Steelhead	Pacific Lamprey	Green Sturgeon
Abundance	Juvenile Abundance (anad)	●		
	Spawner Abundance (anad)	●		
	Abundance (non-anad)	NA	NA	NA
Harvest	Harvest (in-river)	●		
	Harvest (ocean)			
Distrib-ution	Temporal Distribution	●		
	Spatial Distribution	●	●	●
Demo-graphics	Stock Composition	●		
	Age Structure	●		
Biota	Disease	●		

● Known monitoring activities (past or ongoing)

NA Monitoring not relevant to this sub-basin

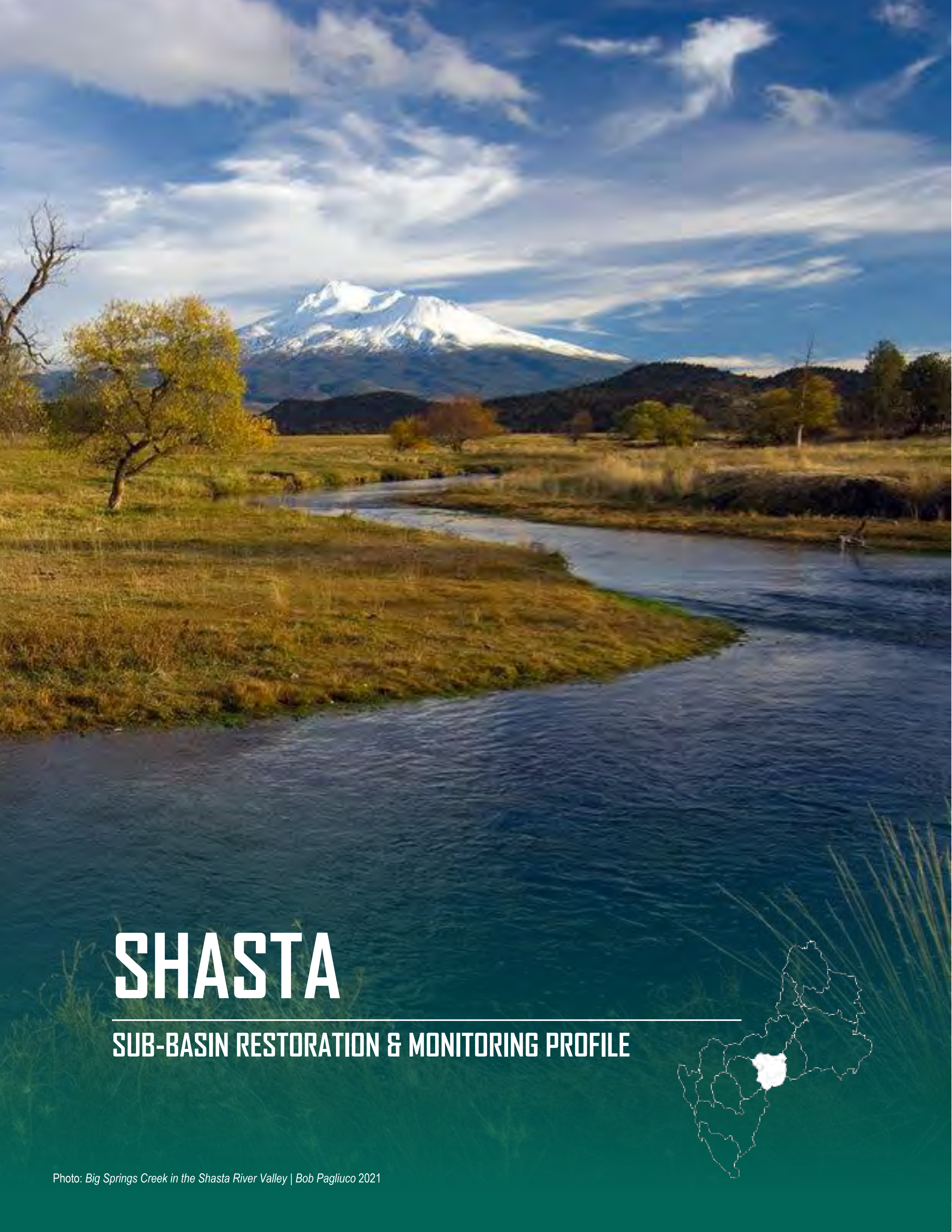
Figure 4-24. Synthesis of past and ongoing monitoring activities in the Mid-Klamath River sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017, Section 2.5, Appendix H):

- Northwest Forest Plan – Aquatic Conservation Strategy (USFS 1994)
- Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)
- Record of Decision and Land and Resource Management Plan Ammendment for Management of Port-Orford-Cedar in Southwest Oregon, Siskiyou National Forest (USDA Forest Service 1995)

- Steelhead Restoration and Management Plan for California (CDFG 1996)
- Record of Decision for Amendments to the Survey and Manage, Protection Buffer, and other Mitigation Measures Standards and Guidelines in the Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl (USDA and USDI 2001)
- Recovery Strategy for California Coho Salmon (CDFG 2004)
- Forest Service Manual. FSM 2600, Wildlife, Fish, and Sensitive Plant Habitat Management, Chapter 2670 FSM, Threatened, Endangered, and Sensitive Plants and Animals (USDA Forest Service 2005)
- Mid Klamath sub-basin Fisheries Resource Recovery Plan (Soto et al. 2008)
- National Best Management Practices for Water Quality Management on National Forest System Lands (USDA Forest Service 2010)
- Karuk Eco-cultural Resources Management Plan (Karuk Tribe 2010)
- Klamath National Forest Land and Resource Management Plan (USFS 2010)
- Six Rivers National Forest Land and Resource Management Plan (USFS 2010)
- North Coast Region Water Quality Control Plan (2011)
- Assessing the Vulnerability of Watersheds to Climate Change: Results of National Forest Watershed Vulnerability Pilot Assessments (Furniss et al. 2013)
- Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (NFMS 2014)
- Western Klamath Restoration Partnership – Plan for Restoring Fire Adapted Landscapes (Klamath National Forest 2014)
- Karuk Tribal Water Quality Plan (2014)
- Karuk Department of Natural Resources Strategic Plan for Organizational Development (Karuk DNR 2015)
- Eco-cultural Resources Management Plan (draft) (Karuk Tribe 2015)
- The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains (Pollock et al. 2015)
- Coastal Multispecies Recovery Plan (NMFS 2016)
- Middle Klamath Restoration Candidate Actions Plan (KRITFWC 2016, unpubl.)
- Mid-Klamath River Instream Candidate Actions Table (CAT) (Mid-Klamath Watershed Council, unpubl.). Creation of this “living” document has been a collaborative effort between the Mid Klamath Watershed Council, the Karuk Tribe, Klamath National Forest, Six Rivers National Forest, NOAA Fisheries, the California Department of Fish and Wildlife, the US Fish and Wildlife Service, and others, and is now under the umbrella of the Western Klamath Restoration Partnership (WKRP).
- Six Rivers National Forest Aquatic Restoration Plan (USFS 2018)
- Karuk Climate Adaptation Plan (KTDNR 2019)
- Yurok Tribe Comprehensive Cultural Riverscape Restoration Plan (draft)
- Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife (in draft form at the time of writing)
- USGS is currently working with the Karuk and Yurok Tribes and other agencies on a baseline sediment budget for the mainstem of the Klamath, from Iron Gate dam to the estuary, and including upstream inputs at Keno (C. Anderson, pers. comm.). The intent is to develop a website that provides sediment and other data including in real-time.



SHASTA

SUB-BASIN RESTORATION & MONITORING PROFILE

Photo: *Big Springs Creek in the Shasta River Valley* | *Bob Pagliuco* 2021

4.4.3 Shasta Sub-basin

This 880 square mile sub-basin is notable for the Shasta River, which is fed by a series of large, cold-water spring complexes and snowmelt from Mt. Shasta, providing important cold-water refuges for salmonids. The river is surrounded by wide alluvial valleys on its route to join the Klamath River mainstem. This sub-basin supports extensive ranching and agricultural operations with many irrigation diversions and dams, including the two permanent Dwinnell Dam and Greenhorn Dam. This sub-basin also encompasses parts of the Klamath and Shasta-Trinity National Forests.

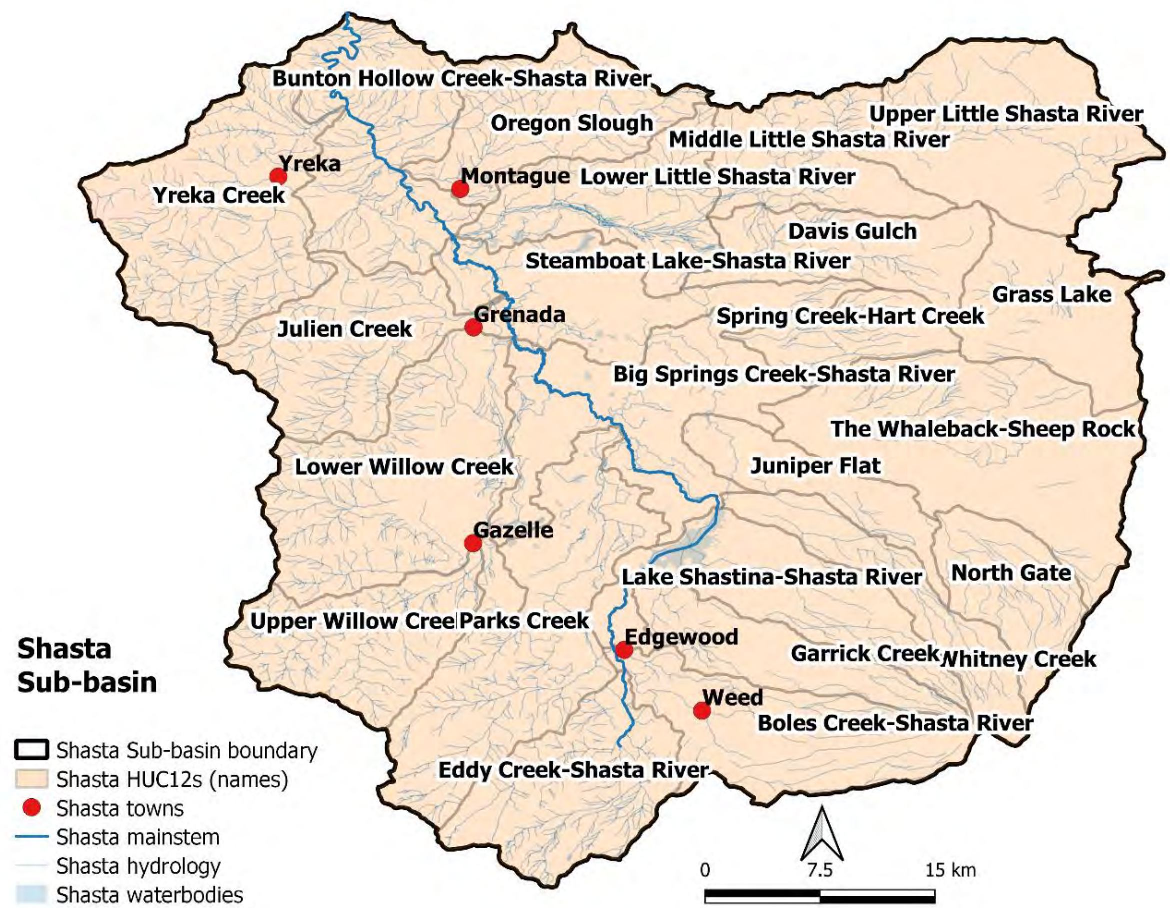


Figure 4-25: Reference map of the Shasta Sub-Basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current**: Coho and Chinook Salmon (fall-run), winter steelhead, Pacific Lamprey
- **Historical**: Summer steelhead, Chinook Salmon (spring-run)

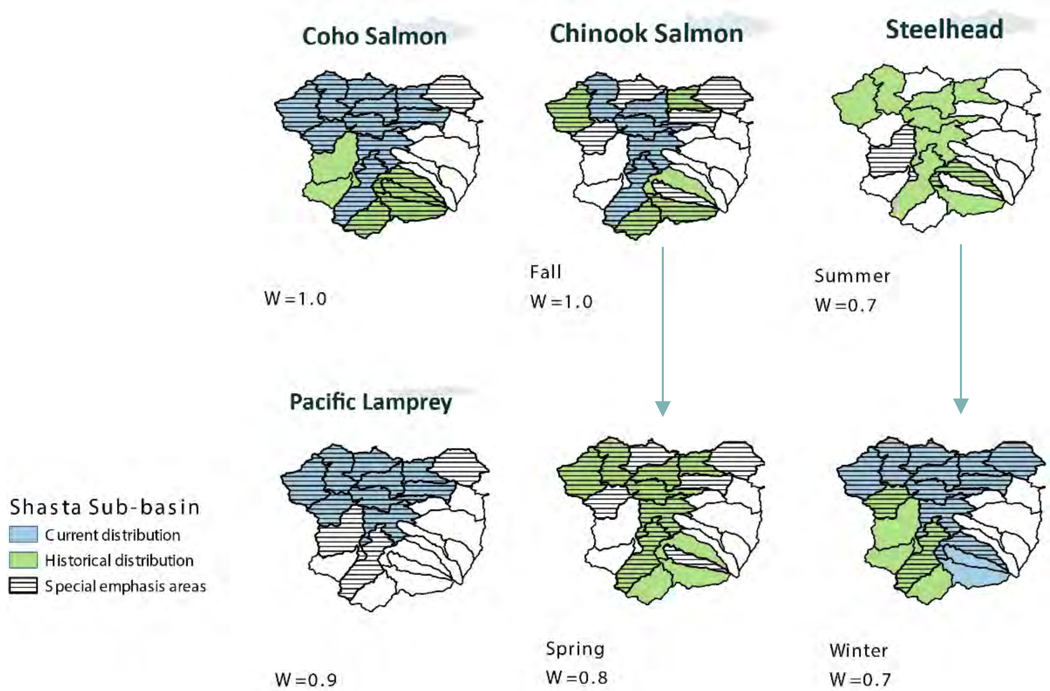


Figure 4-26: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the Shasta sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors

Table 4-22: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the Shasta sub-basin listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. CO = Coho Salmon, CH = Chinook Salmon (all run types), ST = steelhead, PL = Pacific Lamprey.

Key Stressors	Tier	Stressor Summary for the Shasta Sub-basin	Species			
			CH	CO	ST	PL
Instream Flow	WI	A large number of irrigation diversions as well as the Dwinnell Dam supply an overallocated quantity of irrigation flows for roughly 52,000 acres of land in the sub-basin, leaving inadequate streamflow (5-20 cfs) for fish during summer months. Flows decline towards the confluence with the Klamath River mainstem as the number of diversions increases. Low flows reduce water quality, reduce transport of spawning gravels, reduce flushing of fine sediment, limit migratory passage, and interfere with flow cues for juvenile outmigration (Willis et al. 2013, NMFS 2014, Goodman et al. 2015). In addition to low base flows, the Shasta River experiences wild fluctuations in flow every year in which the flow plummets by as much as 80% in the span of a day or two. Such rapid flow reductions cause	●	●	●	●

Key Stressors	Tier	Stressor Summary for the Shasta Sub-basin	Species			
			CH	CO	ST	PL
		desiccation of macroinvertebrate and fish habitat, direct fish stranding, increased predation, and fish relocation to less suitable habitats.				
Water Temperature, Dissolved Oxygen (DO)	WI	Elevated water temperatures are a significant stressor for salmonids throughout this sub-basin, especially juvenile Coho below Dwinnell Dam. Low dissolved oxygen is an additional stress driven by many of the same factors that increase water temperatures. Contributors to warm waters include solar radiation, diversions reducing instream flow, lack of riparian shading driven by livestock grazing practices and hydrologic modification, instream impoundments (i.e., the flashboard dam upstream of the A-12 road bridge) that decrease stream velocity, and increase residence time, thus increasing solar radiation loading, and warm air temperatures. Routinely in the summer months water temperatures in Shasta sub-basin streams become lethal for anadromous fish (NCRWQCB 2006, Biostream Environmental 2012, Stenhouse et al. 2012; Willis et al. 2013, NMFS 2014, SVRCD et al. 2018).	●	●	●	●
Anthropogenic Barriers	H	This sub-basin contains numerous small fish passage barriers from small irrigation diversion structures as well as two larger barriers, the Dwinnell Dam and the Greenhorn Dam, which block access to high quality upstream spawning and rearing habitats. The Dwinnell Dam is estimated to restrict access to 22% of salmonid habitat in the Shasta sub-basin, while the Greenhorn blocks access to upstream areas and blocks downstream transport of spawning gravels from Yreka Creek (NMFS 2014, Goodman et al. 2015).	●	●	●	●
Channelization and Habitat Complexity (mesohabitats)	FGH	Lack of floodplain and channel structure in this sub-basin due to regulated flows from Dwinnell Dam, loss of riparian vegetation and wetland habitat, and associated channel margin degradation, sedimentation, and loss of spawning gravels, pools, and off-channel rearing habitats presents a stressor for all life stages. Channelization is of greatest concern primarily along many reaches of Parks Creek, Willow Creek, the Little Shasta River, and the urban reach of Yreka Creek (NMFS 2014).	●	●	●	○

Spatial stressor hotspots identified from (1) Trout Unlimited Conservation Success Index (Fesenmeyer et al 2013) data, (2) CDFW BIOS Map of USFWS Species Critical Habitats

Sequences of Restoration Projects for the Shasta Sub-Basin

The **summary infographic** in Figure 4-27 provides a compact overview of the Shasta sub-basin restoration project priorities and their distribution across the sub-basin. Table 4-23 presents the results of the 2022 iteration of the IFRMP restoration sequencing process for the Shasta sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-23.

Figure 4-27: Summary for the Shasta sub-basin, including key stressors, cost ranges, and projects (see next page).

Shasta River Sub-basin

Sub-Basin Summary

This small sub-basin is notable for the Shasta River, which is fed by a series of large cold-water spring complexes and snowmelt from Mt. Shasta that provide important cold-water refuges for salmonids. The river is surrounded by wide alluvial valleys on its route to join the Klamath River mainstem. This sub-basin supports extensive ranching and agricultural operations featuring many irrigation diversions and dams including two permanent dams, the Dwinnell Dam and Greenhorn Dam. This sub-basin and also encompasses parts of the Klamath and Shasta-Trinity National Forests.

Restoration Summary

A diverse variety of projects were identified by the working group for the Shasta Sub-basin. The project that rated most highly (Project 11) would have major ecological benefits but would require considerable planning before any actual implementation. Other highly rated projects for the Shasta Sub-basin were primarily focused on riparian rehabilitation (Project 6), improving instream flows (Project 1), improving water quality in the upper Shasta (Project 3), and restoring fish passage by removing Dwinnell Dam (Project 8a).

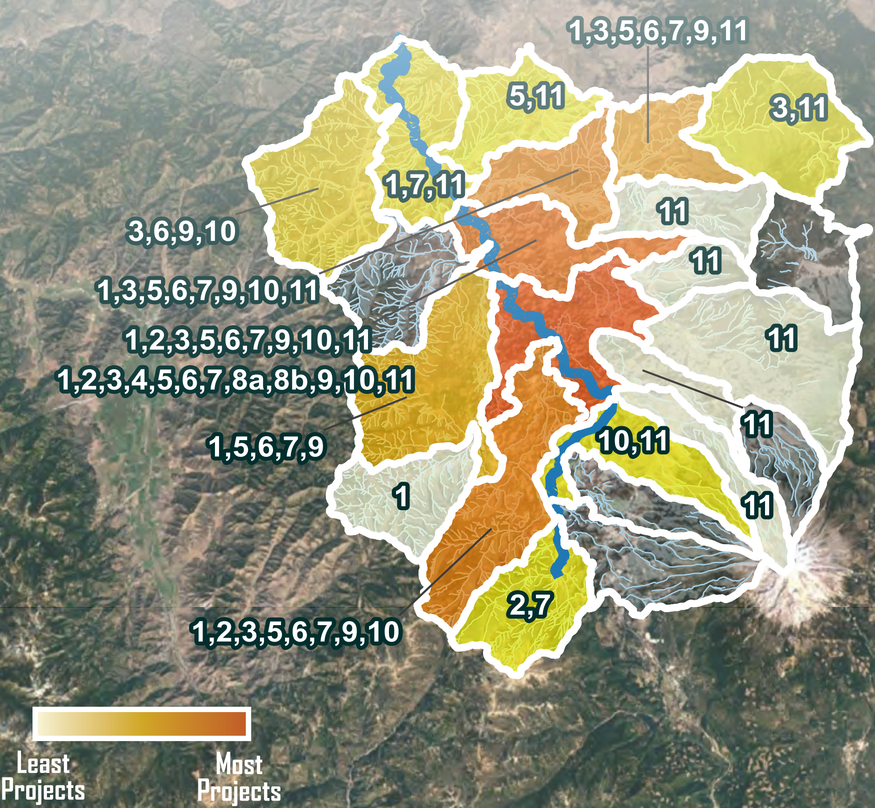
Projects ranked as of more intermediate importance relate to reducing warm tailwater inputs into streams, restoring floodplain connectivity, improving stream flows, providing for fish passage at small barriers, and improving mainstem water quality by adjusting discharges from Dwinnell Dam. Projects ranking lower on the list are focused on adding spawning gravels to streams and restoring passage above Dwinnell Dam through bypass infrastructure.

Key Stressor Summary

Key Stressors	Focal Species (Current)				
	GS	CH	CO	ST	PL
Klamath River Flow Regime					
Instream Flow (tributaries)					
Fine Sediment Delivery					
Water Temperature and Quality (DO, pH)					
Anthropogenic Barriers					
Instream Structural Complexity (mesohabitats)					
Mesohabitats					

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is \$16.3M - \$22.2M - \$27.7M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP Shasta sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting, and **arrows** indicate linkages between projects.

Project ID & Description	Tiers
Shasta 6 - Undertake riparian rehabilitation actions to maintain shading, reduce water temperatures and improve instream habitat within priority mainstem Shasta River sites | **29.4**	H FG
Shasta 3 - Increase cold water refuge habitats for fish in the upper Shasta Sub-basin through improved irrigation and groundwater management and secured water rights | **25.2**	H WI
Shasta 9 - Undertake habitat restoration projects in streams across the Shasta Sub-basin to restore floodplain connectivity and create new rearing habitats | **23.4**	H FG
Shasta 1 - Manage water withdrawals across the Shasta Sub-basin to maintain instream flows and to overcome low water barriers to upstream habitats | **22.3**	H WI
Shasta 5 - Implement projects to reduce warm tailwater inputs in prioritized implementation areas as guided by the Shasta Sub-basin's Tailwater Reduction Pla | **22.0**	H WI
Shasta 10 - Add spawning gravels to priority sediment impoverished river reaches as guided by the Shasta's Spawning Gravel Evaluation and Enhancement Plan | **21.4**	H
Shasta 7 - Implement projects to provide for fish passage at identified priority fish passage barriers across the Shasta Sub-basin | **20.2**	H
Shasta 2 - Relocate, redesign, or eliminate the Parks Creek diversion to improve instream flows for fish | **17.2**	FG WI
Shasta 8a - Restore fish passage above Dwinnell Dam through removal of the dam | **15.1**	H
Shasta 4 - Adjust discharges from Dwinnell Dam to improve water temperatures and dissolved oxygen concentrations downstream of the dam | **13.2**	H WI
Shasta 8b - Restore fish passage above Dwinnell Dam through construction of dam bypass infrastructure | **11.3**	H

The projects listed here have a cost range of $16.3M - $22.2M - $27.7M (low, estimated midpoint, high), and have been collated from projects proposed in prior local or regional restoration plans and studies as well as from in-depth discussions among participants in the IFRMP's Shasta Sub-basin Working Group who represent scientists, restoration practitioners, and resource users working in the sub-basin (see Acknowledgements section). The sequences and scoring in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria. Additional considerations such as implementability, cost, and dependencies among projects may influence the ultimate sequencing of projects. Any dependencies identified by the Sub-basin Working Groups to date are noted in the table and will be further scrutinized during review of this draft document and further refined during Phase 4. Sequencing of projects will be very important for maximizing benefits in the sub-basin. Discussion of this topic has been initiated but determining the optimal sequencing steps for multi-project implementation across the Shasta sub-basin will require further deliberation by the working group.

To facilitate consistent comparison across the sub-basins, results in Table 4-23 are shown for the Shasta sub-basin assuming a scenario where the four lower Klamath River hydroelectric dams have been removed, but no other significant changes from current conditions in the Klamath Basin. The Sub-basin Working Group also identified the following additional scenarios with potential to influence restoration priorities. Should any these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

- Removal of Dwinnell Dam
- Improved fish passage at Dwinnell Dam
- Changes in minimal flow requirements with improved enforcement
- Consolidation of diversion points
  Changes in groundwater regulation

A diverse variety of projects were identified by the working group for improving habitat conditions in the Shasta sub-basin. Note that Shasta 11 (diverting water from mainstem Klamath River by constructing a 70-mile gravity flow conduit below Keno Dam) would require agreement by water rights holders to give up these rights for an ostensibly new Federally run project, which is highly improbable. Participants noted that the benefits of the contemplated Shasta 11 project can also more feasibly be achieved through efforts considered in Shasta 1 - demand reduction, enforcing water rights and better efforts to coordinate water management. Given these points and the large cost of Shasta 11, Shasta 11 was removed. Top-scoring projects include:

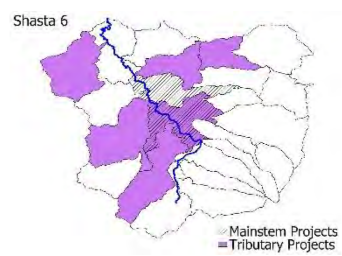
- **Projects 6, 3, 9, 1.** Highly rated projects for the Shasta sub-basin were primarily focused on riparian rehabilitation (Project 6), improving water quality in the upper Shasta (Project 3), floodplain restoration and connectivity (Project 9), and improving instream flows (Project 1).

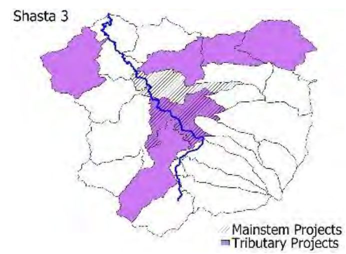
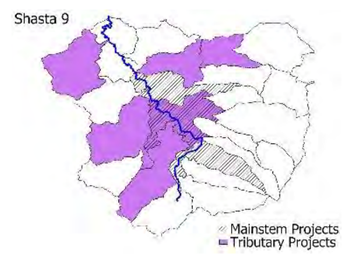
Projects ranked as of more intermediate restoration importance included:

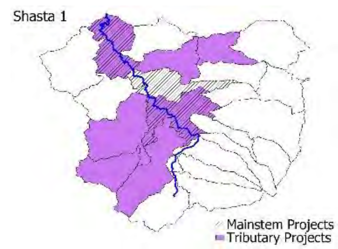
- **Projects 5, 10, 7, 2, and 8a.** These covered a range of mitigations/restorations relating to reducing warm tailwater inputs into streams, adding spawning gravels to streams, and providing for fish passage at small barriers and at Dwinnell Dam (Project 8a). This latter project (i.e. removing the dam) would also being highly beneficial but would require a long planning timeline for any potential implementation.

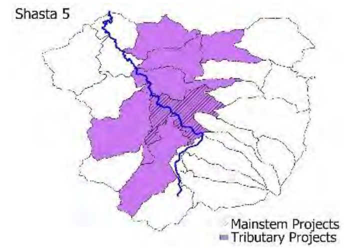
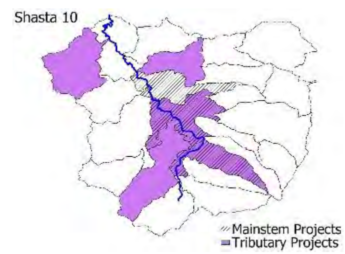
- **Projects 4, and 8b** were the lowest ranking restoration projects in the Shasta sub-basin. Project 4 is focused on adjusting discharges from Dwinnell Dam to improve water temperatures. And Project 8b is focused on restoring passage above Dwinnell Dam through bypass infrastructure.

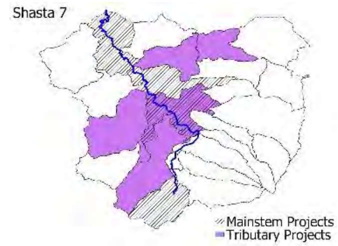
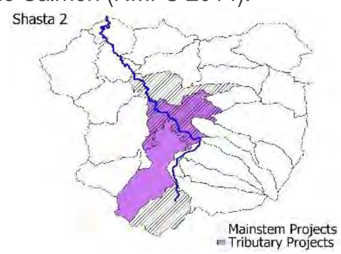
Table 4-23: Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the Shasta sub-basin, with projects scored higher to be considered first for implementation. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name. Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-25, while special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin IFRMP planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

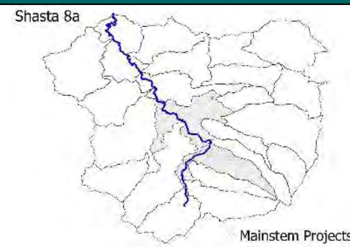
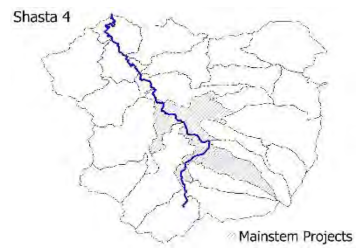
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
Shasta 6 (29.4)	**Undertake riparian rehabilitation actions to maintain shading, reduce water temperatures, and improve instream habitat within priority mainstem Shasta River sites.** **Project Description:** Riparian fencing and planting to restore riparian and instream vegetation and shading with benefits for reducing water temperatures and improving instream habitat (NCRWQCB 2006, Biostream 2012, NMFS 2014, SVRCD et al. 2018). According to the Shasta River Riparian Planting Model, priority sites for future planting include the mainstem Shasta River above Grenada, the lowermost and uppermost reaches of Parks Creek, and the mainstem Shasta River downstream of the Dwinnell Dam (SVRCD et al. 2018). This action would have benefits for temperature and water quality, but also for instream habitat and is related to Action # 9. **Dependencies / Project Linkages:** Should by implemented simultaneously with Projects #9, 1, 3, and 5 for an integrated ecological benefit.  **Primary Action Types:** Riparian planting, Fencing **Near-Term Focal Areas (map):** 7 sub-watersheds, Lower Willow Creek**, Middle Little Shasta River**, Lower Little Shasta River**, Parks Creek**, Big Springs-Shasta River**, Middle Shasta River**, Yreka Creek** **Cost range ($K):** $100 – 175 – 225	**4.43**	**7**	**6.94**	**4**	**7**
Shasta 3 (25.2)	**Increase cold water refuge habitats for fish in the upper Shasta sub-basin through improved irrigation and groundwater management and secured water rights.** **Project Description:** Increase cold water in the Upper Shasta basin by evaluating quantity and quality of refuge habitats, conducting water rights assessments at spring complexes, encouraging tailwater reuse rather than irrigation with cold spring water (groundwater), relocating of points of diversion from cold springs to warm river water (e.g., as done at Cardoza Ranch), and securing water rights to dedicate cold water to instream flows. Priority areas of focus for	**5.57**	**1.4**	**9**	**6**	**3.27**

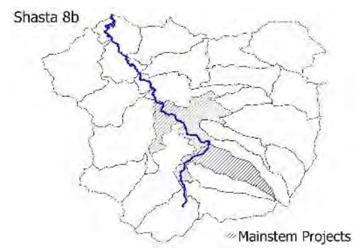
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)* Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
	this work include Big Springs Irrigation District and Big Springs Lake Dam, Parks Creek, Kettle Springs, Bridge Field Springs Complex, Little Shasta River, and the upper Shasta River (NMFS 2014). **Dependencies / Project Linkages:** Should by implemented simultaneously with Projects #9, 1, 6, and 5 for an integrated ecological benefit.  **Primary Action Types:** Water leased or purchased, Tailwater return reuse or filtering, Irrigation practice improvement, Manage water withdrawals. **Near-Term Focal Areas (map):** 7 sub-watersheds, Upper Little Shasta River**, Middle Little Shasta River**, Lower Little Shasta River**, Parks Creek**, Big Springs-Shasta River**, Middle Shasta River**, Yreka Creek** **Cost range ($K):** $395 - 1,090 - 1,750 (based partly on cost data from UKL)					
Shasta 9 (23.4)	**Undertake habitat restoration projects in streams across the Shasta sub-basin to restore floodplain connectivity and create new rearing habitats.** **Project Description:** Identify and implement restoration projects that restore floodplains through improving or creating refugia and rearing habitat through the construction of off-channel or side-channel habitat, alcoves, backwaters, in areas where Coho Salmon would benefit immediately (Biostream 2012, NMFS 2014). Because these projects may involve riparian restoration, this action is related to Action #6. **Dependencies / Project Linkages:** Should by implemented simultaneously with Projects #1, 6, 3 and 5 for an integrated ecological benefit.  **Primary Action Types:** Mechanical channel modification and reconfiguration **Near-Term Focal Areas (map):** 8 sub-watersheds, Lake Shastina-Shasta River**, Lower Willow Creek**, Middle Little Shasta River**, Lower Little Shasta River**, Parks Creek**, Big Springs-Shasta River**, Middle Shasta River**, Yreka Creek** **Cost range ($K):** $3,042 - 5,617 - 7,914 (based on cost data from MKR, Scott, Trinity, UKR)	**2.83**	**4.67**	**3.81**	**6**	**6.12**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
Shasta 1 (22.3)	**Work with agriculture interests and others to manage water withdrawals across the Shasta sub-basin to maintain instream flows and to overcome low water barriers to upstream habitats.** **Project Description:** Increase and maintain adequate flows across the sub-basin to levels needed to support all life stages of fish species in the Shasta River by providing sufficient instream flows for spawning and rearing habitat (NMFS 2014) and to overcome low-water barriers to already suitable upstream habitat (e.g., as in the Little Shasta River) (Nichols et al. 2017). Minimize flow fluctuations that impact salmonids through coordinated water management. Through its relationship to fish passage, this action is related to Action #7.  **Dependencies / Project Linkages:** Should by implemented simultaneously with Projects #9, 6, 3 and 5 for an integrated ecological benefit. **Primary Action Types:** Instream flow project (general), Manage water withdrawals **Near-Term Focal Areas (map):** 8 sub-watersheds, Upper Willow Creek, Lower Willow Creek**, Middle Little Shasta River**, Lower Little Shasta River**, Parks Creek**, Big Springs-Shasta River**, Middle Shasta River**, Bunton Hollow Creek-Shasta River** **Cost range ($K):** $6,100 – 6,100 – 6,100	0.7	6.07	7.61	6	1.92
Shasta 5 (22.0)	**Implement projects to reduce warm tailwater inputs in prioritized implementation areas as guided by the Shasta sub-basin's Tailwater Reduction Plan.** **Project Description:** Identify and implement projects to reduce warm tailwater inputs into streams, with priority implementation areas including Bridge Field Springs Complex, Kettle Springs, Upper Shasta River, and Parks Creek (NCRWQCB 2006, NMFS 2014, SVRCD et al. 2018). A Tailwater Reduction Plan has been developed for this sub-basin to prioritize tailwater "neighbourhoods" for restoration work and recommend projects in each neighbourhood (AquaTerra Consulting 2011). Priority areas for tailwater reduction highlighted by this plan include the Shasta mainstem from Dwinnell Dam to downstream of Big Springs confluence, Parks Creek, and Big Springs Creek. Proposed tailwater projects include tailwater reduction through increased irrigation efficiency, tailwater reuse by downstream irrigators, tailwater treatment before return to stream, and encouraging transition to using Dwinnell Reservoir water for irrigation rather than cold spring water that would be more beneficial in streams (AquaTerra Consulting 2011).	7	3.03	2.59	6	3.4

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)* Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
	Dependencies / Project Linkages: Should by implemented simultaneously with Projects #9, 1, 3, and 6 for an integrated ecological benefit **Primary Action Types:** Tailwater return reuse or filtering **Near-Term Focal Areas (map):** 6 sub-watersheds, Middle Little Shasta River**, Lower Little Shasta River**, Parks Creek**, Big Springs-Shasta River**, Middle Shasta River**, Oregon Slough** **Cost range ($K):** $120 – 240 – 400 (based partly on cost data from UKL) 					
Shasta 10 (21.4)	**Add spawning gravels to priority sediment impoverished river reaches as guided by the Shasta's Spawning Gravel Evaluation and Enhancement Plan.** **Project Description:** Enhance spawning substrate at critical parts of the sub-basin where Coho Salmon would benefit immediately, including the reach downstream of Dwinnell Dam and Parks Creek, guided by the Spawning Gravel Evaluation and Enhancement Plan for this sub-basin (McBain and Trush 2010, SVRCD and McBain and Trush 2013, NMFS 2014). **Dependencies / Project Linkages:** Project 10 should be completed after projects #9, 6, 3, 1, and 5 are planned/implemented **Primary Action Types:** Spawning gravel placement **Near-Term Focal Areas (map):** 6 sub-watersheds, Lake Shastina-Shasta River**, Lower Little Shasta River**, Parks Creek**, Big Springs-Shasta River**, Middle Shasta River**, Yreka Creek** **Cost range ($K):** $99 - 278 – 528 (based on cost data from UKL) 	**6.61**	**3.73**	**0.9**	**4**	**6.12**
Shasta 7 (20.2)	**Implement projects to provide for fish passage at identified priority fish passage barriers across the Shasta sub-basin.** **Project Description:** Identify and prioritize fish passage barriers across the sub-basin including low-water barriers and leveraging the existing California Fish Passage Assessment Database, develop a plan to provide short and long-term passage, and implement the plan (NMFS 2014). One current fish passage priority in the 2017 CDFW Fish Passage Priority Assessment is the barrier on Little Springs Creek near Louie Road, and additional fish passage priorities in the Shasta sub-basin, including at Montague-Grenada Weir and Parks Creek, are described in recent sub-basin watershed assessments (SVRCD and McBain and Trush 2013, SVRCD et al. 2018).	**2.12**	**6. 3**	**4.7**	**4**	**3.12**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
	Dependencies / Project Linkages: No dependency indicated **Primary Action Types:** Fish passage improvement (general), Minor fish passage blockages removed or altered **Near-Term Focal Areas (map):** 8 sub-watersheds, Dale-Eddy-Shasta River**, Lower Willow Creek**, Middle Little Shasta River**, Lower Little Shasta River**, Parks Creek**, Big Springs-Shasta River**, Middle Shasta River**, Bunton Hollow Creek-Shasta River** **Cost range ($K):** $720 - 2,220 - 3,720 					
Shasta 2 (17.2)	**Relocate, redesign, or eliminate the Parks Creek diversion to improve instream flows for fish.** **Project Description:** Increase instream flows and improve flow timing by assessing and relocating, redesigning, or eliminating the Parks Creek "cross channel" diversion to decrease impacts to Coho Salmon (NMFS 2014). **Dependencies / Project Linkages:** No dependency indicated **Primary Action Types:** Instream flow project (general) **Near-Term Focal Areas (map):** 4 sub-watersheds, Dale-Eddy-Shasta River**, Parks Creek**, Big Springs-Shasta River**, Middle Shasta River** **Cost range ($K):** $1,200 - 1,200 - 1,200 	**2.49**	**4.43**	**5.07**	**4**	**1.17**
Shasta 8a (15.1)	**Restore fish passage above Dwinnell Dam through removal of the dam.** **Project Description:** Restoring upstream fish passage at Dwinnell Dam to open large areas of suitable Coho, steelhead, and Chinook spawning and rearing habitats in headwaters via fish ladders, a constructed channel bypass alternative, or dam removal (NMFS 2014). Dam removal is anticipated to yield large benefits for salmon in the basin (Null and Lund 2012). However, a series of studies evaluating these alternatives suggests that the bypass alternative is the most feasible and beneficial at this time (see Shasta 8b)(Cannon 2011, Biostream 2012, McBain Associates 2015), although successful operation of the bypass alternative is contingent on landowner agreements and on changes to water allocation that would permit adequate instream flows to the bypass during migratory periods (McBain Associates 2015). **Dependencies / Project Linkages:** No dependency indicated	**1.83**	**0.7**	**5.92**	**6**	**0.7**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
	Primary Action Types: Major dams removed **Near-Term Focal Areas (map):** 2 sub-watersheds, Lake Shastina-Shasta River**, Big Springs-Shasta River** **Cost range ($K):** $1,500 - 1,500 - 1,500 					
Shasta 4 (13.2)	**Adjust discharges from Dwinnell Dam to improve water temperatures and dissolved oxygen concentrations downstream of the dam.** **Project Description:** Control discharges from Dwinnell Dam to maximize cold water and dissolved oxygen (NCRWQCB 2006, NMFS 2014). This project is being implemented right now (2022) as a result of the Shasta River Safe Harbor Agreements. **Dependencies / Project Linkages:** No dependency indicated **Primary Action Types:** Instream flow project (general) **Near-Term Focal Areas (map):** 2 sub-watersheds, Lake Shastina-Shasta River**, Big Springs-Shasta River** **Cost range ($K):** $1,200 - 1,200 - 1,200 	**1.83**	**0.7**	**5.07**	**4**	**1.57**
Shasta 8b (11.3)	**Restore fish passage above Dwinnell Dam through construction of dam bypass infrastructure.** **Project Description:** Consider restoring upstream fish passage at Dwinnell Dam to open large areas of suitable Coho, steelhead, and Chinook spawning and rearing habitats in headwaters via fish ladders, a constructed channel bypass alternative, or dam removal (NMFS 2014). A series of studies evaluating these alternatives suggests that the bypass alternative is the most feasible and beneficial at this time (Cannon 2011, Biostream 2012, McBain Associates 2015), although successful operation of the bypass alternative is contingent on landowner agreements and on changes to water allocation that would permit adequate instream flows to the bypass during migratory periods (McBain Associates 2015).	**1.83**	**0.7**	**2.05**	**6**	**0.7**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
	Dependencies / Project Linkages: No dependency indicated **Primary Action Types:** Fish ladder installed/improved **Near-Term Focal Areas (map):** 2 sub-watersheds, Lake Shastina-Shasta River**, Big Springs-Shasta River** **Cost range ($K):** $25 – 35 – 45 					

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC and SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, and sub-regional working group input via surveys and webinars.

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the Shasta Sub-basin

The state and federally listed SONCC ESU of ***Coho Salmon*** is a key species identified for many restoration actions in this sub-basin and in other parts of the mid and lower Klamath basin (NMFS 2014). Spring-run ***Chinook Salmon*** are also listed under California's Endangered Species Act (CESA). Winter-run ***steelhead***, and ***Pacific Lamprey*** are also present in this sub-basin and are anticipated to benefit from many of the restoration actions proposed for Coho Salmon recovery. At this time, neither steelhead nor Pacific Lamprey ESA-listed, although steelhead are a species of Special Concern.

The following table summarizes select major past restoration activities in this sub-basin and the species which these activities have benefited.

Table 4-24: Summary of major restoration efforts in the Shasta sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit.

Key Restoration Activities in the Shasta Sub-basin to Date	Species Benefiting			
	CO	CH	ST	PL
MWCD settlement in 2013 resulting in 2,250 to 11,000 acre-feet of environmental water released from Dwinnell Dam for fish benefits each year (NMFS 2014).	●	●	○	○
Since 2012 The Nature Conservancy's Shasta River Water Transaction Program has worked with partners to lease surface water and undertake permanent water transfers to improve instream flows in the Shasta River (https://www.casalmon.org/Shasta-Water-Transaction-Program).	●	●	●	○
Acquisition in 2019 of Shasta Big Springs Ranch by the CDFW. The land was originally purchase by the Nature Conservancy in 2009. Intent is for CDFW to use the property to protect critical cold-water aquatic habitat for anadromous fish species, including state and federally-listed Coho Salmon, and to protect migration corridors for plants, birds, and mammals.	●	●	○	○
Removal of several fish passage barriers including the Shasta River Water Association Flashboard Dam and Araujo Flashboard Dam (SVRCD et al. 2018).	●	●	●	●
Development of a sub-basin-wide Tailwater Reduction Plan to assess and prioritize sites for tailwater reduction according to potential benefits to fish (SVRCD et al. 2018).	●	●	●	●
Extensive riparian fencing and planting projects to restore riparian vegetation and shading, including (1) fencing and planting across Big Springs Ranch, (2) an inventory of streambanks protected from livestock through fencing or other features in 2016, except for smaller tributaries above Lake Shastina, and (3) collaborative development of a riparian planting site prioritization model by TNC, SCRCD, and the USFWS that is currently being validated (SVRCD et al. 2018).	●	●	●	●

Current State of Monitoring & Data Gaps

Past and Ongoing Monitoring:

Instream flows have been monitored at several stations along the Shasta River since 1957, operated by the USGS and the California Department of Water Resources (DWR)(SWRCB 2018). Streamflow has been monitored along the Shasta River, Big Springs Creek, and the Little Shasta River by The University of California at Davis Center for Watershed Science, The Nature Conservancy, and Watercourse Engineering (SWRCB 2018). Water temperatures have been and are continuously monitored along the Shasta River at over 100 monitoring stations operated by the CDFW, the Shasta River Water Association Flashboard Dam and Araujo Flashboard Dam (SVRCD), TNC, the Karuk Tribe, the Yurok Tribal Fisheries Program, and the US Forest Service (USFS). A massive amount of water quality data have been collected between 1991 and 2012 at 160 locations along the Shasta River (SVRCD et al. 2018).

The North Coast Regional Water Quality Control Board (NCRWQCB) developed an action plan for the Shasta River Watershed, outlining the monitoring needed to measure the effectiveness of establishing water temperature and dissolved oxygen total maximum daily loads (TMDLs) (NCRWQCB 2006). A Shasta River Tailwater Reduction project, which began in 2010 and wrapped up in 2013, undertook extensive pre- and post-project monitoring of the Shasta River in order to evaluate the effectiveness of tailwater reduction projects (SVRCD 2013). Another similar project monitored water temperature, dissolved oxygen, discharge, and storage at Dwinnell Dam in 2017 to evaluate the effects of tailwater reduction efforts (SVRCD et al. 2018). The NCRWQCB also manages the Shasta River TMDL Conditional Waiver of Waste Discharge Requirements to address dissolved oxygen and temperature impairments in the Shasta River watershed. The waiver requires landowners to implement BMPs that minimize, control, and prevent the discharge of tailwater into the Shasta River and so that native riparian vegetation can naturally re-establish. The waiver also prohibits discharging nutrients into the Shasta River and its tributaries. Site-specific monitoring is required to confirm the effectiveness of the BMPs implemented on ranches where a Ranch Management and Monitoring Plan is requested by the Regional Water Board.

Two programs at the Karuk Tribe Department of Natural Resources conduct habitat monitoring: Fisheries and Water Quality. The Fisheries program focuses on monitoring base flows and temperatures in mid-Klamath tributaries in coordination with USFS. The Water Quality program monitors over 130 miles of the mainstem Klamath and the mouths of the Salmon, Scott, and Shasta Rivers. At three mainstem sites and the three tributary sites, this program runs real-time sondes that collect continuous water quality data (temperature, DO, pH, conductivity, turbidity)

The SVRCD's Watershed Stewardship Action Plan (2018) is intended to be regularly updated, with these updates being supported by ongoing monitoring initiatives delineated in the multi-agency monitoring program (SVRCD et al. 2018).

CDFW's Klamath River Project (KRP) conducts population monitoring in the Shasta sub-basin . The KRP collects information on population abundance, hatchery composition, run timing, spawning distribution, fork length frequency, age composition, and sex ratios for salmonids (primarily Klamath River Fall Chinook (KRFC), but also Coho and steelhead). Run-size estimates within the Shasta River are acquired via an adult fish video counting facility and, downstream of that facility, during spawning ground surveys.

CDFW's Yreka Fisheries Program has operated rotary screw traps since 2000 in the Shasta River for the purpose of generating population estimates for out-migrating juvenile salmon (Stenhouse et al. 2016a,b). Using rotary screw traps, all age classes of out-migrating Chinook Salmon, Coho Salmon, and steelhead trout, as well as a variety of native and non-native fish species are sampled. PIT tags are also used to monitor juvenile Coho movements and survival (Chesney et al. 2009; CDFW 2016b).

While there has not historically been much monitoring for Pacific Lamprey in this sub-basin, recent coast-wide restoration planning efforts for this species have included initiatives to assess lamprey passage issues at the Grenada water diversion dam. The USFWS also aims to develop a general monitoring plan for out-migrating macrophthalmia (juvenile lamprey) with screw trap programs telemetry studies to assess lamprey habitat use and migration behavior across the Klamath Basin

(USFWF 2019). These initiatives are currently underway and will help to improve informed decision-making for restoration of this species.

<u>Current Data Gaps</u>:

Figure 4-28 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken across agencies in Shasta River sub-basin. Location-specific agency metadata (where available) on monitoring projects is incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. While an extensive number of monitoring stations are currently in operation along the Shasta River and within its tributaries, some parameters are not being monitored across all locations (e.g., temperature monitoring at the lower reach of Parks Creek).

Shasta Sub-basin Monitoring Summary

Habitat Monitoring	Watershed Inputs	Weather	●
		Streamflow	●
		Groundwater	●
		Riparian & Landscape	●
	Fluvial-Geomorph	Sediments & Gravel	●
		Stream Morphology	●
	Habitat	Stream Temperature	●
		Water Quality	●
		Habitat Quality	●
		Barriers & Injury	●
		Marine/Estuary	NA
	Biota	Invasive Species	

			Salmon / Steelhead	Pacific Lamprey
Population Monitoring	Abundance	Juvenile Abundance (anad)	●	●
		Spawner Abundance (anad)	●	
		Abundance (non-anad)	NA	NA
	Harvest	Harvest (in-river)		
		Harvest (ocean)		
	Distrib-ution	Temporal Distribution	●	●
		Spatial Distribution	●	●
	Demo-graphics	Stock Composition	●	
		Age Structure	●	
	Biota	Disease		

● Known monitoring activities (past or ongoing)
NA Monitoring not relevant to this sub-basin

Figure 4-28. Synthesis of past and ongoing monitoring activities in the Shasta sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017, Section 2.5, Appendix H):

Whole Basin

- Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (SONCC) (National Marine Fisheries Service, Arcata, CA, 2014)
- Recovery Strategy for California Coho Salmon (CDFW 2004)
- Regional Implementation Plan for Measures to Conserve Pacific Lamprey (*Entosphenus tridentatus*), California - North Coast Regional Management Unit (Goodman and Reid 2015)
- Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)

Regional Plans

- Western Klamath Restoration Partnership - Plan for Restoring Fire Adapted Landscapes (Klamath National Forest 2014)
- Shasta-Trinity, and Klamath, National Forest Land and Resource Management Plans
- Klamath National Forest (KNF) Water Quality Monitoring Plan (USFS 2010)
- Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife (in draft form at the time of writing)

Shasta Sub-basin Focus

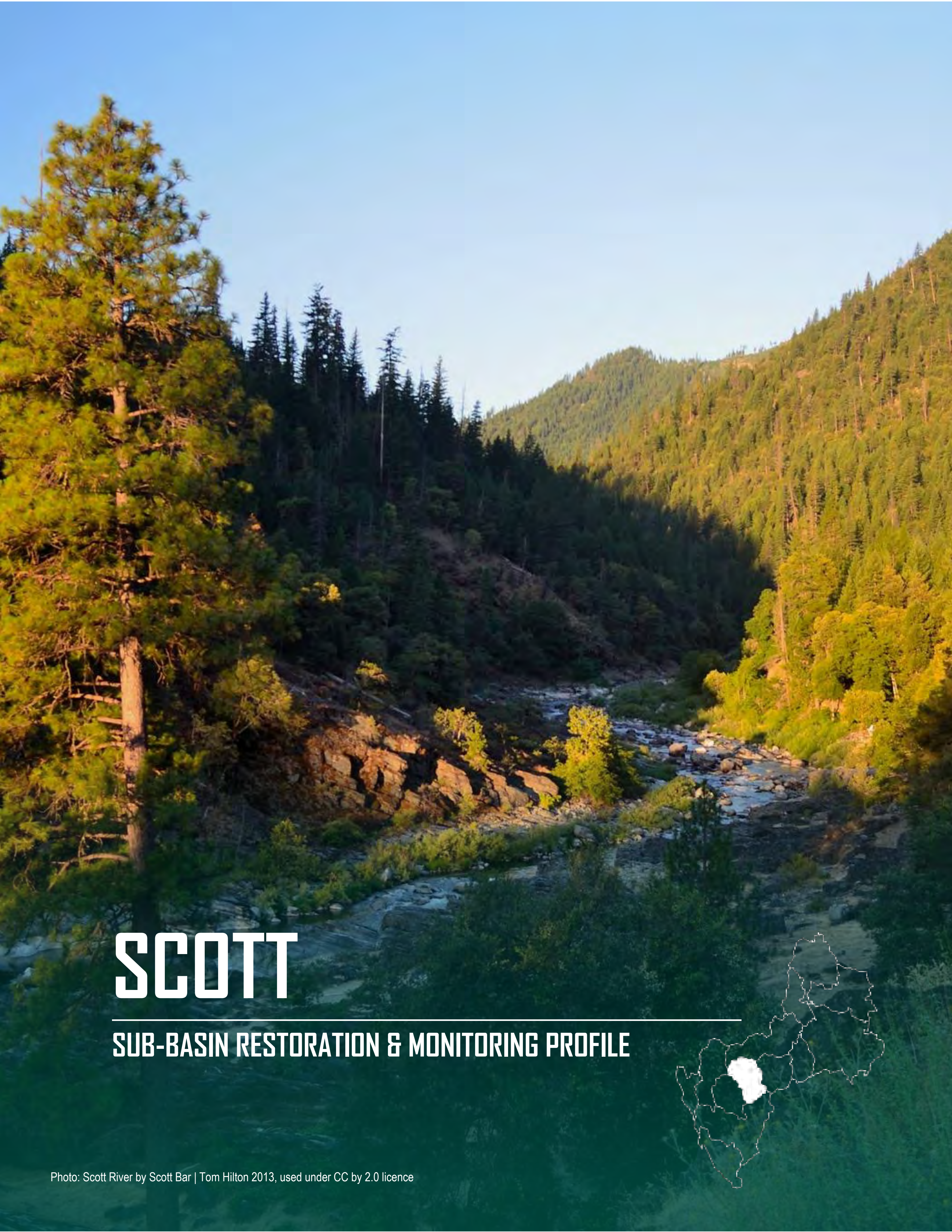
- Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen TMDLs (NCRWQCB 2006)
- Shasta Valley Tailwater Reduction Plan (AquaTerra Consulting 2011)
- Spawning Gravel Evaluation and Enhancement Plan (McBain and Trush 2010)
- Study Plan to Assess Shasta River Salmon and Steelhead Recovery Needs (SVRCD and McBain & Trush 2013).
- Shasta River Watershed Characterization and Model Study Plan (Paradigm 2018)
- Shasta River Watershed Stewardship Report & Action Plan (SVRCD et al. 2018).

At the time of writing, there was at least one ***forthcoming plan*** specific to this sub-basin under development, recently completed, or soon to proceed to implementation.

- Siskiyou County Flood Control and Water Conservation District

  Per California's Sustainable Groundwater Management Act (SGMA), Siskiyou County has developed draft Groundwater Sustainability Plan (GSP) to assess the current and projected future conditions of three basins (Shasta, Scott, and Butte), and establish management and monitoring activities and long-term goals. Plans were submitted to the California Department of Water Resources in January 2022 are currently being reviewed (Shasta GSP Information: https://sgma.water.ca.gov/portal/gsp/preview/90).

The Shasta Safe Harbor Agreement seeks to improve conditions for coho salmon on more than 30,000 acres of the Shasta River watershed. Private property owners agree to improve habitat to help recover Southern Oregon/Northern California Coast coho salmon listed under the Endangered Species Act. In exchange, they receive regulatory assurances removing the risk of additional regulation and penalty under the Endangered Species Act. These assurances remain as long as they maintain and improve important coho salmon habitat on their lands. The agreement outlines more than 100 restoration actions to improve water quality and habitat conditions over 37 river miles in the next 20 years. The actions include removing fish passage barriers and improving irrigation systems so that cold water can remain in the stream. Other steps include adding off-channel ponds where juveniles can grow, and protecting riparian corridors by fencing out cattle and planting native species. The Shasta River Safe Harbor Agreements have been completed and can be located here: https://www.fisheries.noaa.gov/resource/document/shasta-river-template-safe-harbor-agreement-and-site-plans.



SCOTT

SUB-BASIN RESTORATION & MONITORING PROFILE

4.4.4 Scott Sub-basin

The Scott River flows through a valley which was likely once dominated by sloughs, marshy meadows, and wetlands including numerous beaver ponds that would have slowed flows and created extensive habitat for rearing fish and riparian vegetation. The historical hydrology of this watershed has since been significantly altered by extensive beaver trapping, hydraulic gold mining, flood control structures, and irrigation canals. Direct impacts include scouring, channel simplification, degradation of floodplains and riparian areas, changes to upland stand composition and density, fire regime, loss of slow-water rearing habitat and reduced groundwater recharge contributing to dewatering, disconnection, and sometimes fish strandings in large portions of the mainstem river and some tributaries (NMFS 2014, SRWC & SRCD 2014, CDFW et al. 2015, Yokel et al. 2016).

Today, the valley floor supports extensive agricultural lands cultivating hay and cattle production, which are dependent on both ground water and surface water irrigation, while the surrounding mountainous slopes support timber production. These activities occur on private lands, which contribute to the majority of land ownership in the sub-basin (Yokel et al. 2016). This sub-basin also contains the Quartz Valley Indian Reservation as well as portions of the Klamath National Forest. The Scott watershed continues to support significant populations of steelhead, Chinook Salmon, and Coho Salmon, primarily in tributaries on the western side of the valley as well as the East and South forks of the Scott River. The Scott River population of Coho in particular is considered a Core, Functionally Independent Population of this species that represents one of the most productive natural stocks in the Klamath basin (Yokel et al. 2016).

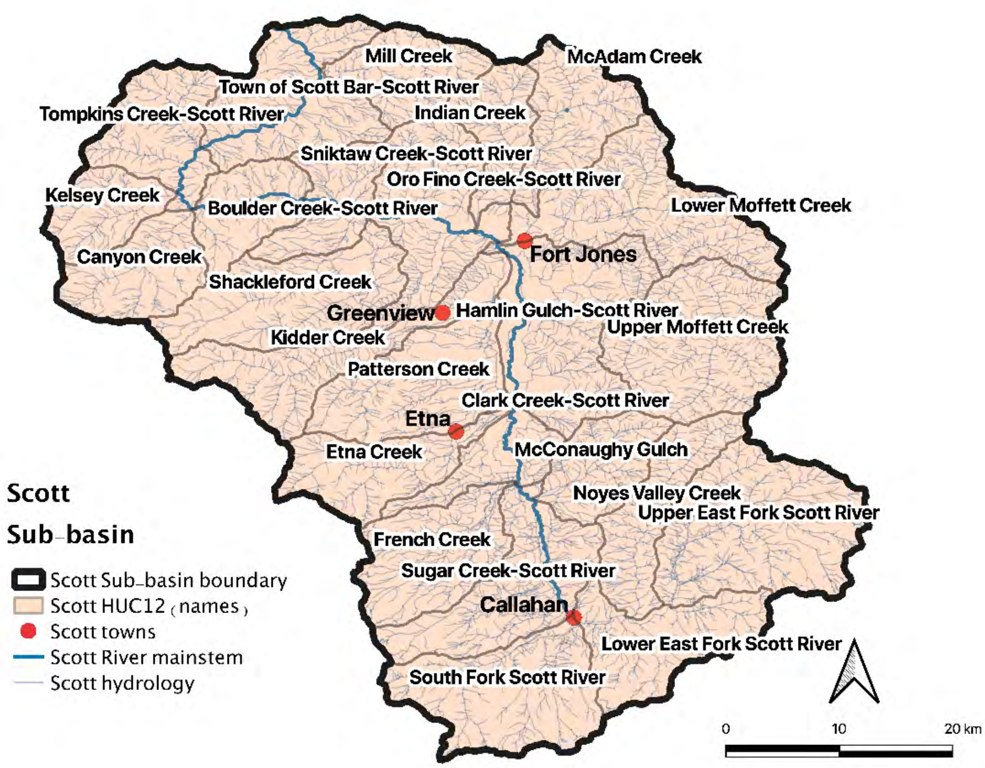


Figure 4-29: Reference map of the Scott Sub-Basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current:** Chinook Salmon (fall-run), Coho Salmon, winter steelhead and Pacific Lamprey
- **Historical**: Chinook Salmon (spring-run), summer steelhead

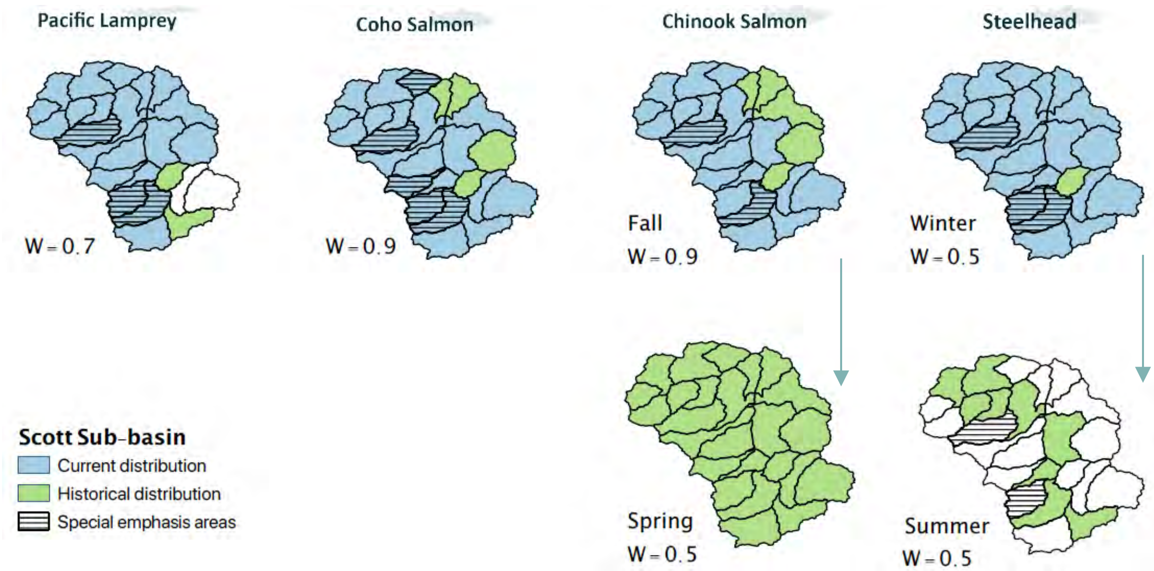


Figure 4-30: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the Scott sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data across Klamath sub-basins is based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors

Table 4-25: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the Scott sub-basin listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. CH = Chinook Salmon, CO = Coho Salmon, ST = steelhead, PL = Pacific Lamprey.

Key Stressors	Tier	Stressor Summary for the Scott Sub-basin	Species			
			CH	CO	ST	PL
Instream Flow and Groundwater Interactions	WI	Extensive use of surface water and groundwater for irrigation, combined with reduced groundwater recharge due to loss of beaver dams, has contributed to low summer flows and disconnection or dewatering of some spawning and rearing habitats for salmonids and Pacific Lamprey (NMFS 2014, Foglia et al. 2018). Most alfalfa production in the valley is irrigated by center-pivots, which withdraw groundwater. This shift occurred in the 1970s. Cattle production is primarily dependent on surface water in this valley. Low flows are of concern throughout the valley. Low flow conditions cause tributaries to disconnect from the mainstem, trapping and killing large numbers of fish every year including ESA Coho. Low flows have repeatedly blocked passage for fall-run Chinook Salmon through the canyon reach of the Scott River. Fish that are forced to spawn in the canyon reach face redd superimposition, flood scour risk, and early entry into the Klamath mainstem. In fall 2018, the Yurok Tribe documented a	●	●	●	●

Key Stressors	Tier	Stressor Summary for the Scott Sub-basin	Species			
			CH	CO	ST	PL
		100% and total blockage of the fall-run migration below Boulder Creek in the canyon reach of the Scott River. Low flows are anticipated to be more frequent as groundwater withdrawals extend farther into the fall and as there are further climate-related snowpack reductions (Van Kirk and Naman, 2008).				
Water Temperature	WI	Reduced instream flows, loss of riparian vegetation, and loss of fish passage to thermal refugia pools along the mainstem and some tributaries in low water years has contributed to increased thermal stress, thermal barriers, or acute lethality throughout summers and much of the fall, especially in the mainstem Scott River as well as Wildcat Creek, Patterson Creek, and lower French Creek (NMFS 2014, USFWS 2019b), as well as Shackleford and East Fork Scott (Betsy Stapleton, pers. Comm. 2022)	●	●	●	●
Fine Sediment Inputs	WI	A high density of unpaved and unmaintained roads as well as streambank erosion contribute excessive fine sediment inputs in this watershed, resulting in 303d listing for sediment (Fesenmeyer et al. 2013). Fine sediment inputs are of greatest concern in mainstem Scott River as well as West Canyon tributaries including French Creek, Miners Creek, Sugar Creek, Moffett Creek and Kidder Creek, South and East forks (Note: not all of these tributaries are on West Canyon). In these areas, sediment may prevent spawning and smother eggs (NCRWQCB 2006, Table 7 and Figure 30 in Cramer et al. 2010, NMFS 2014).	●	●	●	
Impaired Channel and Floodplain Hydrology	FG	Channelization, levee construction, and addition of rip-rap[17] along the mainstem Scott River and some tributaries for flood control have contributed to channel simplification, channel incision, streambank instability, loss of riparian vegetation, and accumulation of coarse sediment that may diminish stream flow and pose barriers to fish passage (NMFS 2014). Moreover, channelization contributes to confined flows that can scour the redds of salmonids spawning in the mainstem Scott River (Yokel et al. 2016). Channelization with subsequent incision is a contributor groundwater lowering that can have subsequent impacts to flow and groundwater dependent ecosystems.	●	●	●	●
Instream Structural Complexity	H	Loss of beavers, historic management of grazing activities, channelization, and deposition of tailing piles from hydraulic mining has resulted in reduced habitat complexity including loss of riparian vegetation, large woody debris, and access to off-channel rearing habitats (SRWC 2006, NMFS 2014). Channel structure is particularly degraded along former mining sites on the mainstem Scott River near Callahan, Oro Fino Creek and in lower Kidder Creek (NMFS 2014). Large woody debris is considered lacking throughout the basin, but particularly in the upper mainstem Scott River, upper Kidder Creek (Fig 25 in Cramer et al. 2010).	●	●	●	○

Stressors identified from: USFWS 2019b, NOAA 2014, SRWC 2006, SRWC 2018, and sub-regional working group survey responses.

Sequences of Restoration Projects for the Scott Sub-Basin

The **summary infographic** in Figure 4-31 provides a compact overview of the Scott sub-basin restoration project priorities and their distribution across the sub-basin.

Figure 4-31: Summary for the Scott sub-basin, including key stressors, cost ranges, and projects (see next page).

[17] Groundwater removal may also contribute to stress as the ground water table retreat and with overgrazing in Moffett Creek, the mainstem Scott, and some of the drier east side tributaries, has caused cottonwoods and willows to die off, increasing bank erosion and flooding.

Scott Sub-Basin

Sub-Basin Summary

The Scott River flows through a valley once dotted with grassy prairies and numerous beaver ponds that would have slowed flows and created extensive habitat for rearing fish and riparian vegetation. The historical hydrology of this watershed has since been significantly altered by extensive beaver trapping, hydraulic gold mining, forestry, flood control structures, and extensive use of surface water irrigation for agriculture. The resulting low flows contribute to poor water quality as well as dewatering, disconnection, and sometimes fish strandings in large portions of the mainstem river and some tributaries, especially in low water years.

Key Stressor Summary

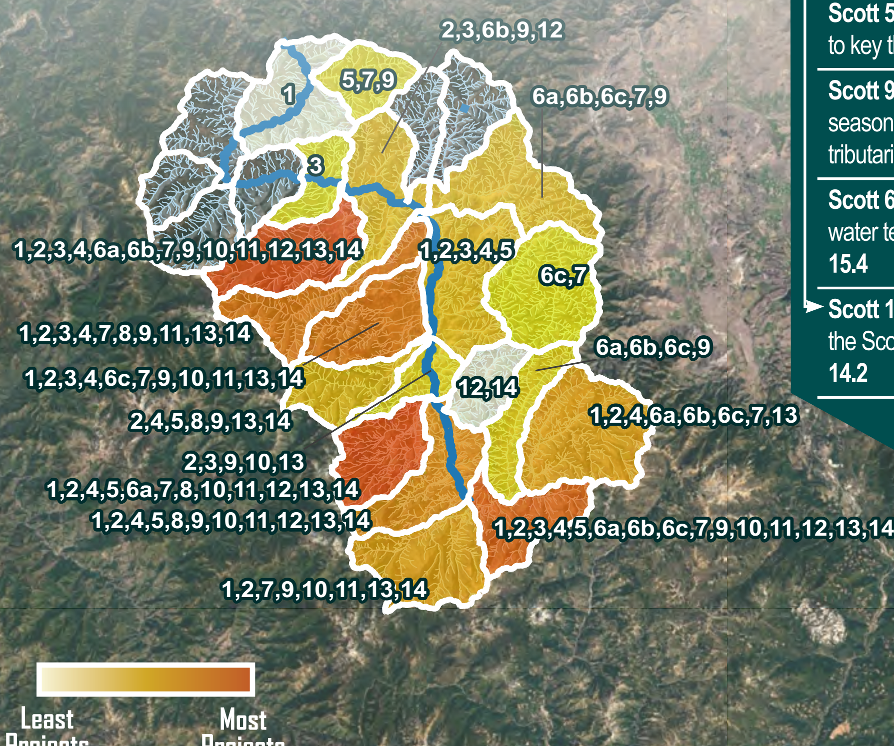
Key Stressors	Focal Species			
	CO	CH	ST	PL
Instream Flow and Groundwater				
Water Temperature				
Fine Sediment Inputs				
Impaired Channel and Floodplain Hydrology				
Instream Structural Complexity				

Restoration Summary

The major focus in the sub-basin has historically been on riparian fencing and restoration. More recently, restoration activities have focused on increasing instream flow through acquisition of water rights and restoring floodplain and channel hydrology through the reintroduction of beavers and the installation of beaver dam analogues. Top priority stressors (limiting factors) currently identified for the Scott Sub-basin by working group participants included channel and floodplain connectivity and reconfiguration, and projects that restore these functions were indeed ranked higher by the IFRMP Tool and are among the top group of restoration projects to be considered first for implementation.

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is $39.0M – $81.6M - $133.4M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP Scott sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting, and **arrows** indicate linkages between projects.

Project ID & Description	Tiers
Scott 14 - Restore upland wetlands and meadows to improve cold water storage and runoff attenuation in the Scott River Sub-basin | **24.0**	WI H
Scott 15 - Callahan Dredge Tailings Remediation | **21.4**	FG
Scott 11 - Install appropriate in-channel structures such as LWD, boulders, etc. to improve condition of fish habitat in priority tributaries | **17.2**	H
Scott 7 - Improve/decommission priority roads identified in the Five Counties Road Erosion Inventory to reduce fine sediment inputs to Scott Sub-basin streams | **17.1**	WI H
Scott 3 - Implement winter flooding of agriculture land in the Scott River Sub-basin as a method of groundwater recharge | **16.4**	WI FG
Scott 10 - Restore floodplain connectivity and create refuge habitats across Scott River Sub-basin streams as identified in the SRWC plan | **16.3**	FG
Scott 13 - Reduce fuel loads, undertake prescribed burns across the SW Scott River Sub-basin to reduce wildfire risks | **15.9**	WI
Scott 2 - Ensure compliance with existing water and environmental laws and regulations for ensuring instream flows within the Scott River Sub-basin | **15.8**	WI H
Scott 4 - Improve irrigation system water use efficiencies and associated monitoring within the Scott River Sub-basin to benefit fish and riverine processes | **15.6**	WI
Scott 1 - Acquire water rights from willing sellers within priority areas of the Scott River Sub-basin to help maintain instream flows for fish | **15.5**	WI H
Scott 5 - Remove physical and hydrologic barriers blocking fish passage to key thermal refuge areas within the Scott River Sub-basin | **15.5**	H
Scott 9 - Encourage beaver colonization and/or install BDAs to provide seasonal fish rearing habitats in the mainstem Scott River and key tributaries | **15.4**	WI H
Scott 6b - Undertake riparian planting to increase shading, help reduce water temperatures and improve fish habitats within priority streams | **15.4**	H
Scott 12 - Establish conservation easements adjacent to key areas of the Scott River mainstem to allow for levee, dike, and berm removal | **14.2**	FG
Scott 6a - Improve grazing management of riparian areas to maintain shading, reduce water tempertures and improve fish habitats within priority streams | **13.9**	WI H
Scott 8 - Remove or reconfigure priority river/stream levees and dikes identified in the SRWC plan to restore channel form and floodplain connectivity | **12.0**	FG
Scott 6c - Install fencing along riparian corridors to reduce grazing damage to riparian habitats within priority streams | **11.2**	WI H

Table 4-26 presents the results of the 2022 iteration of the IFRMP restoration sequencing process for the Scott sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-26. The projects listed here have a cost range of $39.0M – $81.6M - $133.4M (low, estimated midpoint, high), and have been collated from projects proposed in prior local or regional restoration plans and studies as well as from in-depth discussions among participants in the IFRMP's Scott Sub-basin Working Group who represent scientists, restoration practitioners, and resource users working in the sub-basin (see Acknowledgements section). The scores and sequences in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria.

Additional considerations such as implementability, cost, and dependencies among projects may influence the ultimate sequencing of projects. Any dependencies identified by the Sub-basin Working Groups to date are noted in the table and will be further scrutinized during review of this draft document and further refined during Phase 4. Sequencing of projects will also be very important for maximizing benefits in the sub-basin. Discussion of this topic has been initiated but determining the optimal sequencing steps for multi-project implementation across the Scott sub-basin will require further deliberation by the working group. Sequencing of projects will be very important for maximizing benefits in the sub-basin but determining the optimal sequencing steps for multi-project implementation requires further deliberation among the working group.

We anticipate Scott (and many other) sub-basin experts will focus on the default **HUC12 CPI impairment scores** during review of the current prioritization rankings. During later phases of the IFRMP development, participants will be able to **override proxy CPIs** with site specific CPIs that have been developed as part of regional or local planning efforts or project design and implementation plans. This process is significantly streamlined through design of the Klamath IFRMP Restoration Prioritization Tool (https://ifrmp.net) and will lead to further honing and improvement of the rank order accuracy of priority lists.

Interim Results

To facilitate consistent comparison across the sub-basins, results in Table 4-26 are shown for the Scott sub-basin assuming a scenario where the four major Klamath mainstem dams have been removed, but no other significant changes from current conditions in the Klamath Basin. The Sub-basin Working Group identified the following additional scenarios with the potential to influence restoration priorities in the Scott sub-basin. Should any these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

- Additional species ESA listings
- Accelerating climate change
- Landowner access permissions
- Changing minimum flow requirements
- Significant inflow of funds
- Fish species extirpations
- Mitigation of annual juvenile kills in mainstem

During participant component and criteria weighting exercises, Scott sub-basin participants rated actions that alleviated impairments / restored conditions at the watershed input, fluvial geomorphic process and fish habitat biophysical tiers as the most important. Thinking in terms of desired future restored conditions, the key target fish species were fall chinook, coho and pacific lamprey, followed by spring chinook, summer steelhead and winter steelhead in relative terms, of secondary importance (over the next 2-5 years).Top priority stressors in the Scott sub-basin included channel and floodplain connectivity and reconfiguration, and projects that restore these functions were indeed ranked in the top tranche of restoration projects that should be considered first:

- **Projects 14, 15, 11, 7, 3** which provide upland wetland restoration for improved cold water storage, tailing remediation, installation of LWD, improve or decommission priority roads identified in the Five Country's Road Erosion Inventory to reduce fine sediment inputs, and to implement winter flooding of agricultural areas to support groundwater recharge. Details of these projects vary, but include refuge habitats through improvements to cold water storage.

These projects were closely followed in importance by a second suite of restoration projects:

- **Projects 10, 13, 2, and 4** which include floodplain connectivity restoration to create refuge habitat as identified in the SRWC plan, reduce fuel loads to reduce wildfire risks, and enforcing compliance with existing water laws to ensure instream flows, and improve irrigation efficiencies. Working group participants noted that to actually get more water instream from such projects there will need to be changes in water right structures and enforcement practices in California.

Projects ranked as of more intermediate restoration importance included:

- **Projects 1, 5, 9, 6b and 12** which include acquiring water rights to help maintain fish flows, removal of barriers to fish passages, encourage beaver colonization[18], undertake riparian planting to help reduce water temperatures, and establish conservation easements. Although not direct restoration actions in themselves conservation easements provide an important management tool to allow permission to access areas in need of dike and berm removal or repair.

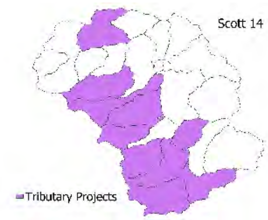
The lowest ranking restoration projects in the Scott sub-basin were:

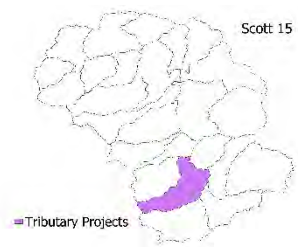
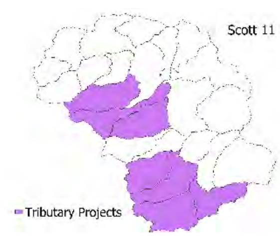
- **Projects 6a, 8 and 6c** involve improving grazing management, removal or reconfiguration of levees and dikes, and installing fencing along riparian corridors to maintain riparian shading along priority streams. If these individual projects could be further bundled and implemented together within 2-5 years, they would likely provide similar levels of benefits to the restoration projects currently ranked as intermediate importance in the Scott sub-basin.

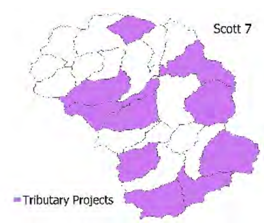
---

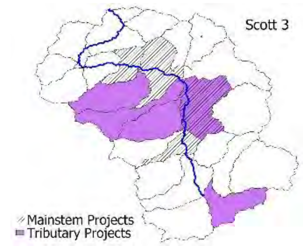
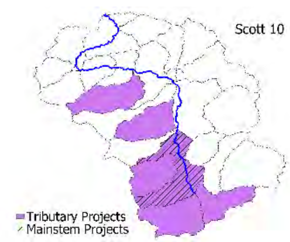
[18] Note: At this time, beaver relocation is not legal and has not been undertaken. At the time of writing, implementability (or feasibility) of various restoration project concepts is the subject of focus group efforts that will further help refine future project rankings. The term 'implementability' can encompass many considerations such as technical feasibility, permitting complexity, and willingness of implementation partners including management agencies, restoration organizations, and landowners to cooperate on a given type of project.

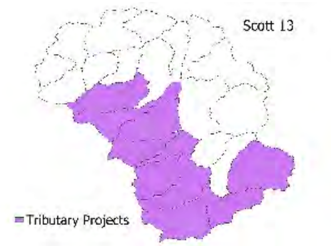
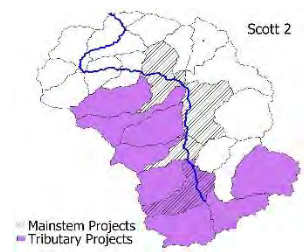
Table 4-26: Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the Scott sub-basin, with projects scored higher to be considered first for implementation. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name. Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-29, while special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin IFRMP planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

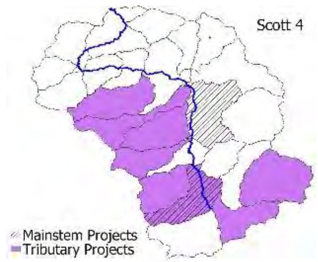
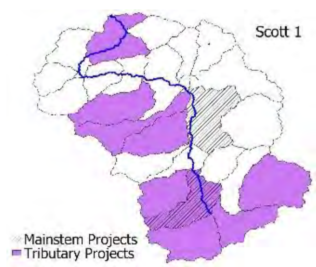
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.6)*
Scott 14 (24.0)	**Restore upland wetlands and meadows to improve cold water storage and runoff attenuation in the Scott River sub-basin.** **Project Description:** Implement package of nature-based solutions to maximize cold water quantity and duration and increase runoff attenuation for salmonid protection and recovery as well as providing a wide array of other species and ecosystem benefits (especially with increasing climate change), restore both wet and dry mountain meadows and their surrounding forests in upper montane and some mid montane areas of the Scott sub-basin, through channel restoration (e.g., grade control structures, channel reconfiguration), riparian vegetation management, forest thinning for snowpack enhancement, grazing management, and recreation and road infrastructure enhancement, with a particular focus on the headwaters to fish bearing and cold water refuge streams (Stillwater Science 2012). (SRRC communication) **Dependencies / Project Linkages:** No dependency indicated **Primary Action Types:** Addition of large woody debris, Beavers & beaver dam analogs, Mechanical channel modification and reconfiguration, Riparian area conservation grazing management, Riparian Forest Management (RFM), Road drainage system improvements and reconstruction, Upland wetland improvement, and Wetland project (general).  **Near-Term Focal Areas (map):** 10 sub-watersheds, Lower East Fork Scott River, South Fork Scott River, McConaughy Gulch, French Creek**, Kidder Creek, Shackleford Creek**, Scott Bar-Scott River, Sugar Creek-Scott River, Etna Creek, Patterson Creek **Cost range ($K):** $8,748 – 17,749 – 26,822 (incomplete – no cost data for "riparian area conservation grazing management" and "streambank stabilization")	**2.89**	**2.78**	**9**	**5.25**	**4.09**

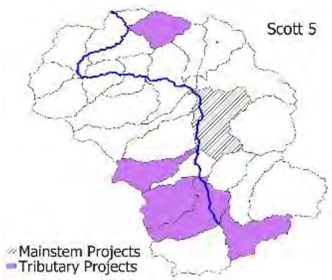
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.6)*
Scott 15 (21.4)	**Callahan Dredge Tailings Remediation** **Project Description:** Remediation of the Callahan Dredge Tailings requires downscaling of the Scott Valley Integrated Hydrologic Model to evaluate the streamflow and water temperature effects of potential restoration actions. The Tailings dewater every year, increasingly extending into the spawner migration season with climate change, which blocks passage to the upper 20% of the basin for spawning. The Tailings are severely degraded with highly altered and complex geomorphology, extensive analysis is needed to ensure that proposed restoration actions will be effective and avoid unintended consequences. **Dependencies / Project Linkages:** Establishment of conservation easements by purchasing select agricultural land parcels adjacent the mainstem Scott River downstream of Callahan would allow for removal of channel confining levees, dikes, berms required for this project.  **Primary Action Types:** Minor fish passage blockages removed or altered, Mechanical channel modification and reconfiguration **Near-Term Focal Areas (map):** One sub-watershed, Sugar Creek Scott River. **Cost range ($K):** $4,665 – 8,890 – 13,275	7	7	2.65	3.5	1.2
Scott 11 (17.2)	**Install appropriate in-channel structures such as LWD, boulders, etc. to improve condition of fish habitat in priority tributaries.** **Project Description:** Placement of appropriate instream structures, most likely large woody debris (given that large boulders are not native to the lower Scott River) to provide cover for rearing salmonids at streams identified as priorities for this purpose (NMFS 2014). These activities may be further guided by the Scott River Water Shed Council's new plan: Restoring Priority Coho Habitat in the Scott River Watershed: Modeling and Planning Report (SRWC 2018) with the potential for increased floodplain connectivity with groundwater recharge and water quality benefits.  **Dependencies / Project Linkages:** No dependency indicated **Primary Action Types:** Channel structure placement, Addition of large woody debris	3.64	4.49	2.86	1.75	4.49

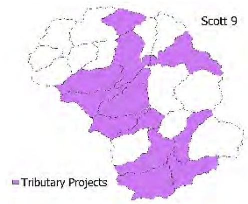
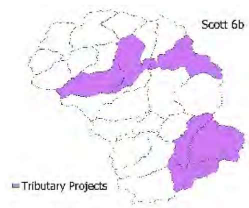
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.6)*
	Near-Term Focal Areas (map): 7 sub-watersheds, South Fork Scott River, French Creek**, Sugar Creek-Scott River**, Patterson Creek, Kidder Creek, Shackleford Creek**, Lower East Fork Scott River **Cost range ($K):** $800 – 1,675 – 2,433 (based partly on cost data from Trinity)					
Scott 7 (17.1)	**Improve/decommission priority roads identified in the Five Counties Road Erosion Inventory to reduce fine sediment inputs to Scott sub-basin streams.** **Project Description:** Pursue road upgrades and decommissioning at high-priority sites of roadside erosion identified as part of the Scott and Salmon River Watersheds Road Erosion Inventory and Assessment (Five Counties 2008), to help meet established TMDLs for sediment loads in this sub-basin (NCRWQCB 2006). Riparian restoration and riparian grazing management (Action 5) will also reduce sediment inputs. Actions should focus on those reaches where the most significant sources of sediment production are found and have been noted to limit salmonid spawning potential, particularly in the South Fork Scott River, East Fork Scott River, French/Miners, Johnson, Patterson, Kidder, Moffett, McAdams, Shackleford/Mill, Boulder, Scott Bar and Mill creeks (Cramer et al. 2010, NMFS 2014). **Dependencies / Project Linkages:** No dependency indicated  **Primary Action Types:** Road drainage system improvements and reconstruction, Road closure/abandonment, Planting for erosion and sediment control **Near-Term Focal Areas (map):** 10 sub-watersheds, Upper East Fork Scott River, Lower East Fork Scott River, South Fork Scott River, French Creek**, Upper Moffett Creek, Lower Moffett Creek, Patterson Creek, Kidder Creek, Shackleford Creek**, Mill Creek** **Cost range ($K):** $1,992 - 2,760 - 3,526 (based on cost data from MKR, Trinity, UKR) (the "road drainage system improvements and reconstruction" action type utilized cost data from Project #14)	**2.18**	**1.85**	**2.93**	**5.25**	**4.94**
Scott 3 (16.4)	**Implement winter flooding of agriculture land in the Scott River sub-basin as a method of groundwater recharge.** **Project Description:** UC Davis recently conducted an experiment in the Davis and Scott Valleys researching the effects of winter flooding of alfalfa on groundwater recharge. This method of groundwater recharge has been proposed by producers in the Scott Valley who see the benefit to the river and the groundwater table. In theory, this management tool could prolong the Scott River baseflows by slowly releasing stored water late in the summer during the critical period for juvenile Coho rearing. The study showed up to 90% of the applied water percolated deep past the root zone toward the groundwater table (Dahlke et al. 2018). This management action utilizes the naturally occurring runoff to recharge	**2.82**	**4.92**	**0.93**	**5.25**	**2.44**

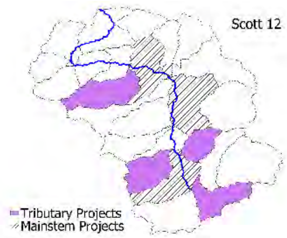
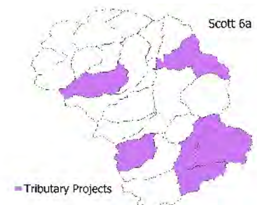
Project # *(Overall Score)*	Restoration Projects	Criteria Scores (*Criteria Weights*) Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.6)*
	the groundwater table during non-critical periods. Use of the Hater Groundwater model provides potential to model project effects for further understanding. Note: the actual calculations on what this can contribute to steam flow may be minimal, on the order of 3 CFS in the fall when needed for fish migration.  **<u>Dependencies / Project Linkages:</u>** No dependency indicated **<u>Primary Action Types:</u>** Irrigation practice improvement **<u>Near-Term Focal Areas (map):</u>** 8 sub-watersheds, Lower East Fork Scott River, Clark Creek-Scott River, Patterson Creek, Kidder Creek, Hamlin Gulch-Scott River, Shackleford Creek**, Oro Fino Creek-Scott River, Sniktaw Creek-Scott River **<u>Cost range ($K):</u>** $25 – 350 – 600 (based on cost data from Lost and UKL)					
Scott 10 (16.3)	**Restore floodplain connectivity and create refuge habitats across Scott River sub-basin streams as identified in the SRWC plan.** **<u>Project Description:</u>** Enhance refugia habitats and construct off channel-ponds, alcoves, backwater habitat, floodplain reconnection, and stream oxbows as per SRWC 2018 plan. This action is also a high priority within the NOAA SONCC recovery plan (NMFS 2014) as it will contribute to groundwater recharge and water quality.  **<u>Dependencies / Project Linkages:</u>** No dependency indicated **<u>Primary Action Types:</u>** Mechanical channel modification and reconfiguration **<u>Near-Term Focal Areas (map):</u>** 7 sub-watersheds, South Fork Scott River, French Creek**, Sugar Creek-Scott River**, Patterson Creek, Shackleford Creek**, Clark Creek-Scott River, Lower East Fork Scott River **<u>Cost range ($K):</u>** $6,429 – 12,143 – 17,858 (based on cost data from Scott, Trinity, MKR, UKR)	**3.78**	**5.42**	**1.53**	**3.5**	**2.1**
Scott 13 (15.9)	**Reduce fuel loads, undertake prescribed burns across the SW Scott River sub-basin to reduce wildfire risks.** **<u>Project Description:</u>** To reduce wildfire risk, conduct upland vegetation management and prescribed burning to reduce fuel loads throughout south west rim of the valley from Schackleford Creek to Upper East Fork Scott River east of Callahan. (B. Stapleton, pers. comm.) **<u>Dependencies / Project Linkages:</u>** No dependency indicated	**3.08**	**3.64**	**0.9**	**5.25**	**3.03**

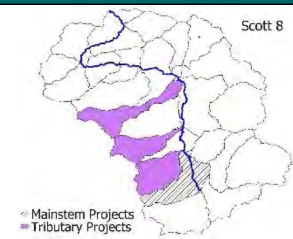
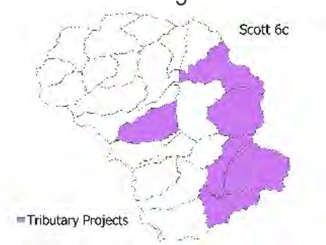
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.6)*
	Primary Action Types: Upland vegetation management including fuel reduction & burning **Near-Term Focal Areas (map):** 10 sub-watersheds, Upper East Fork Scott River, Lower East Fork Scott River, South Fork Scott River, French Creek**, Sugar Creek-Scott River**, Etna Creek**, Clark Creek-Scott River, Patterson Creek, Kidder Creek, Shackleford Creek** **Cost range ($K):** $250 - 413 – 738 (based on cost data from Trinity and UKR) 					
Scott 2 (15.8) Policy Focused Action	**Ensure compliance with existing water and environmental laws and regulations for ensuring instream flows within the Scott River sub-basin.** **Project Description:** Ensuring existing water and environmental laws are enforced. Manage groundwater extraction and ensure that GWSP includes sufficient understanding of GWDE and appropriate management of groundwater to support them. This action relates to the monitoring of Action #1 specifically but is separated out as its own action given that only two streams in the Scott are currently 'water-mastered', so it is difficult to know the level of compliance for existing regulations. Ensuring sufficient water is fundamental; all other restoration actions depend on this. **Dependencies / Project Linkages:** No dependency indicated **Primary Action Types:** Manage water withdrawals **Near-Term Focal Areas (map):** 12 sub-watersheds, Upper East Fork Scott River, Lower East Fork Scott River, South Fork Scott River, French Creek**, Sugar Creek-Scott River**, Etna Creek**, Clark Creek-Scott River, Patterson Creek, Kidder Creek, Hamlin Gulch-Scott River, Shackleford Creek**, Oro Fino Creek-Scott River **Cost range ($K):** $1,561 - 3,690 - 5,813 (based on cost data from Shasta, SF Trinity and Trinity) 	**3.03**	**3.85**	**1.4**	**5.25**	**2.22**
Scott 4 (15.6)	**Improve irrigation system water use efficiencies and associated monitoring within the Scott River sub-basin to benefit fish and riverine processes.** **Project Description:** Assess irrigation system water use efficiency and implement water use efficiency improvements through measures such as lining or piping irrigation ditch systems to reduce water loss and increase flows in the river, making revenue-neutral changes to water pricing to promote conservative water use, and monitoring allocations through a	**3.22**	**3.13**	**0.93**	**5.25**	**3.1**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.6)*
	watermaster program (NMFS 2014). Additionally implement actions to improve municipal and domestic water use efficiencies. **Dependencies / Project Linkages:** No dependency indicated **Primary Action Types:** Irrigation practice improvement **Near-Term Focal Areas (map):** 9 sub-watersheds, Upper and Lower East Fork Scott River, French Creek**, Sugar Creek-Scott River**, Etna Creek**, Patterson Creek, Kidder Creek, Hamlin Gulch-Scott River, Shackleford Creek**  **Cost range ($K):** $25 – 350 – 600 (based on cost data from Lost and UKL)					
Scott 1 (15.5)	**Acquire water rights from willing sellers within priority areas of the Scott River sub-basin to help maintain instream flows for fish.** **Project Description:** Acquire water rights from willing sellers to instream uses through the CA Water Code Section 1707 process and implement these transfers to avoid dewatering events and help to meet or exceed minimum instream flows outlined in planned studies of environmental flow needs for both Coho and Pacific Lamprey in this sub-basin (NMFS 2014, USFWS 2019b). Acquire strategic short-term leases and SVID and Farmer's ditch which are off of the mainstem Scott and represent large contributions. Purchase groundwater from interconnected zone. Priority areas for implementation of these activities to benefit Coho Salmon include the East Fork Scott River, the South Fork Scott River mainstem as well as tributaries to mainstem, including Kidder Creek, Patterson Creek, Moffett Creek, Shackleford/Mill Creek, Sugar Creek, Noyes Valley Creek, Meadow Gulch, and McConnaughy Gulch (NMFS 2014, SRWT 2019). This work would also yield improvements for water quality and temperature. **Dependencies / Project Linkages:** No dependency indicated **Primary Action Types:** Water leased or purchased, Manage water withdrawals **Near-Term Focal Areas (map):** 10 sub-watersheds, Upper East Fork Scott River, Lower East Fork Scott River, South Fork Scott River, French Creek**, Sugar Creek-Scott River**, Patterson Creek, Kidder Creek, Hamlin Gulch-Scott River, Shackleford Creek**, Scott Bar-Scott River  **Cost range ($K):** $1,711 - 4,090 - 6,463 (based on cost data from Shasta, SF Trinity, and Trinity)	**3.09**	**3.28**	**2. 4**	**5.25**	**1.5**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.6)*
Scott 5 (15.5)	**Remove physical and hydrologic barriers blocking fish passage to key thermal refuge areas within the Scott River sub-basin.** **Project Description:** In addition to general improvements in water quantity and flows to reduce hydrologic disconnection, there is a need to address various types of physical fish passage barriers including dams, diversions (where gravel push-up dams are often used resulting in inadequate flow downstream), and alluvial sills at a number of key locations in this sub-basin where they limit or prevent access to key thermal refugia for rearing juvenile salmonids. These locations include sites in both the Scott Valley (French Creek, Patterson Creek, Kidder Creek, Shackleford/Mill Creek, South Fork and East Fork Scott River) and the Scott Bar (mainstem Boulder Creek to Tompkins Creek, Canyon Creek, and Kelsey Creek) (Table 36-5 in NMFS 2014). **Dependencies / Project Linkages:** No dependency indicated  **Primary Action Types:** Fish passage improvement (general), Minor fish passage blockages removed or altered **Near-Term Focal Areas (map):** 6 sub-watersheds, Lower East Fork Scott River, French Creek**, Sugar Creek-Scott River**, Etna Creek**, Hamlin Gulch-Scott River, Mill Creek** **Cost range ($K):** $765 - 2,190 - 3,757 (based on cost data from MKR, Shasta, and Trinity)	**3.68**	**2.42**	**1.87**	**3.5**	**4.02**
Scott 9 (15.4)	**Encourage beaver colonization and/or install BDAs to provide seasonal fish rearing habitats in the mainstem Scott River and key tributaries.** **Project Description:** Increase abundance of beavers and/or pursue installation of beaver dam analogues where the environment is not yet suitable for reintroduction of beaver. Proposed actions involve improving conservation regulations and relocation guidelines for beaver as well as developing and implementing a beaver conservation plan including outreach activities, landowner assistance program, and a reintroduction or relocation program as guided by the plan (NMFS 2014). Areas where beaver dams are already locally abundant include the Mill-Shackleford and French-Miners Creeks systems, and additional sites that are of interest for the installation of BDAs have included the mainstem Scott River and Sugar Creek (Yokel et al. 2018, Charnley 2018). In addition to improving channel and habitat complexity, these projects are also expected to contribute to groundwater recharge. These activities may be further guided by the Scott River Water Shed Council's new plan: Restoring Priority Coho Habitat in the Scott River Watershed: Modeling and Planning Report (SRWC 2018).	**2.66**	**3.35**	**1.79**	**3.5**	**4.09**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.6)*
	Dependencies / Project Linkages: No dependency indicated **Primary Action Types:** Beavers & beaver dam analogs **Near-Term Focal Areas (map):** 12 sub-watersheds, Noyes Valley Creek, Lower East Fork Scott River, South Fork Scott River, Sugar Creek-Scott River**, Clark Creek-Scott River, Lower Moffett Creek, Patterson Creek, Kidder Creek, Shackleford Creek**, Oro Fino Creek-Scott River, Mill Creek**, Etna Creek  **Cost range ($K):** $369 – 738 – 1,108					
Scott 6b (15.4)	**Undertake riparian planting to increase shading, help reduce water temperatures and improve fish habitats within priority streams.** **Project Description:** Riparian fencing and planting are called for in both the SONCC Coho Recovery Plan and the Scott River TMDL action plan to improve stream shading and contribute to lower stream temperatures, in addition to providing additional benefits for instream habitat (NCRWQCB 2006, NMFS 2014). Priority areas for these activities are low-gradient private lands in the Scott Valley where high temperatures coincide with suitable Coho spawning habitat (NMFS 2014). These activities may be further guided by the Scott Riparian Planting Strategy. **Dependencies / Project Linkages:** No dependency indicated **Primary Action Types:** Riparian planting **Near-Term Focal Areas (map):** 6 sub-watersheds, Upper East Fork Scott River, Noyes Valley Creek, Lower East Fork Scott River, Lower Moffett Creek, Shackleford Creek**, Oro Fino Creek-Scott River  **Cost range ($K):** $125 – 138 – 150 (based on cost data from Shasta, UKR)	**1.88**	**2.49**	**1.52**	**3.5**	**6**
Scott 12 (14.2)	**Establish conservation easements adjacent to key areas of the Scott River mainstem to allow for levee, dike, and berm removal.** **Project Description:** Create conservation easements by purchasing select agricultural land parcels adjacent the mainstem Scott River downstream of Callahan through to the Oro Fino Valley in key areas to allow for removal of channel confining levees, dikes, berms. Any such purchases should include the requirement to implement a river migration corridor or perform other beneficial active restoration actions (e.g., as noted, berm and dike removal). (B.Stapleton, pers. comm 2021). While the purchase of easements is a distinct action and may happen on its own, conditions of the easements should lead to subsequent berm and dike removal or repair which can be an restoration action on its own.	**3.37**	**3.64**	**3.12**	**3.5**	**0.6**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)* Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.6)*
	Dependencies / Project Linkages: Establishment of conservation easements allows for subsequent berm and dike removal or repair. This project assumes that berm and dike removal or repair happens in concert with the establishment of the conservation easement. **Primary Action Types:** Conservation easement, Dike or berm modification / removal **Near-Term Focal Areas (map):** 7 sub-watersheds, Sugar Creek-Scott River**, Hamlin Gulch-Scott River, Oro Fino Creek-Scott River, Lower East Fork Scott River, French Creek, McConaughy Gulch, Shackleford Creek  **Cost range ($K):** $4,800 – 4,800 – 4,800					
Scott 6a (13.9)	**Improve grazing management of riparian areas to maintain shading, reduce water temperatures and improve fish habitats within priority streams.** **Project Description:** Conservation management as well as riparian fencing and planting are called for in both the SONCC Coho Recovery Plan and the Scott River TMDL action plan to improve stream shading and contribute to lower stream temperatures, in addition to providing additional benefits for instream habitat (NCRWQCB 2006, NMFS 2014). Priority areas for these activities are low-gradient private lands in the Scott Valley where high temperatures coincide with suitable Coho spawning habitat (NMFS 2014). These activities may be further guided by the Scott Riparian Planting Strategy. **Dependencies / Project Linkages:** No dependency indicated **Primary Action Types:** Riparian area conservation grazing management **Near-Term Focal Areas (map):** 6 sub-watersheds, Upper East Fork Scott River, Noyes Valley Creek, Lower East Fork Scott River, French Creek**, Lower Moffett Creek, Shackleford Creek**  **Cost range ($K):** no cost data available (no cost data for "riparian area conservation grazing management")	**2.29**	**1.85**	**1.52**	**3.5**	**4.75**
Scott 8 (12.0)	**Remove or reconfigure priority river/stream levees and dikes identified in the SRWC plan to restore channel form and floodplain connectivity.** **Project Description:** Remove, setback, or reconfigure levees / dikes to restore channel form, floodplain connectivity as per SRWC 2018 plan. Activity is expected to focus on those areas with the greatest concentration of flood-control levees, including the mainstem Scott River and along lower Etna, Kidder and Moffett creeks (NMFS 2014). In addition to improving hydrologic function and groundwater recharge, this action is expected to increase habitat complexity.	**3.22**	**1.2**	**2.97**	**3.5**	**1.12**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.7)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.6)*
	Dependencies / Project Linkages: No dependency indicated **Primary Action Types:** Mechanical channel modification / reconfiguration, Dike or berm modification/removal **Near-Term Focal Areas (map):** 3 sub-watersheds, French Creek**, Etna Creek**, Kidder Creek **Cost range ($K):** $7,072 - 20,024 - 42,108 (based on cost data from MKR, UKR, Trinity)  					
Scott 6c (11.2)	**Install fencing along riparian corridors to reduce grazing damage to riparian habitats within priority streams.** **Project Description:** Fencing (often in conjunction with riparian planting) to exclude cattle from streams is called for in both the SONCC Coho Recovery Plan and the Scott River TMDL action plan to improve stream shading and contribute to lower stream temperatures, in addition to providing additional benefits for instream habitat (NCRWQCB 2006, NMFS 2014). Priority areas for these activities are low-gradient private lands in the Scott Valley where high temperatures coincide with suitable Coho spawning habitat (NMFS 2014). These activities may be further guided by the Scott Riparian Planting Strategy. Almost all of the anadromous fish streams in the Scott sub-basin now have existing fencing- so that a large percentage of this required fencing work has been accomplished.  **Dependencies / Project Linkages:** No dependency indicated **Primary Action Types:** Fencing **Near-Term Focal Areas (map):** 6 sub-watersheds, Upper East Fork Scott River, Noyes Valley Creek, Lower East Fork Scott River, Upper Moffett Creek, Lower Moffett Creek, Patterson Creek **Cost range ($K):** $385 – 770 – 963 (based on cost data from Shasta, UKR)	**0.7**	**0.7**	**1.52**	**3.5**	**4.76**

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC and SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, and sub-regional working group input via surveys and webinars.

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the Scott Sub-basin

All anadromous fish are acknowledged to have significantly declined from historical levels in the Scott sub-basin (QVIR 2016).

The state and federally listed SONCC ESU of ***Coho Salmon*** is a key species identified for many restoration actions in the Scott sub-basin and in other parts of the mid and lower Klamath basin (NMFS 2014). The Scott River population of Coho is considered a core, functionally independent population of this species, representing one of the most productive natural stocks in the Klamath Basin (NMFS 2014, Yokel et al. 2016). Nonetheless, given the wide range of pressures they experience, Scott River Coho are currently listed as being at moderate risk of extinction (NMFS 2014).

Fall-run Chinook Salmon abundance has remained relatively stable since the late 1970s but has begun to rapidly decline at a faster rate than that across the entire Klamath Basin. From the late 1970s until the present, the Scott River has contributed an average of 9% of the remaining total salmon from across the Klamath Basin, but this figure has dipped as low as 2% in the last 5 years (Knechtle and Chesney 2016, Knechtle and Giudice 2021). While ***Pacific Lamprey*** have thus far maintained an abundance similar to historical levels in this sub-basin, they are now also rapidly declining (USFWS 2019b). The population trajectory for ***steelhead*** is less certain as run size was not monitored prior to 2007, and runs are thought to occur outside the primary salmonid abundance monitoring window since 2007 but appear to be relatively stable in the years since monitoring began (Knechtle and Chesney 2016). These species are also anticipated to benefit from many of the restoration actions proposed for Coho Salmon recovery.

Extensive restoration efforts in this sub-basin began around the 1990s with a strong focus on rangeland management and riparian restoration. Since then, efforts have more recently transitioned into restoring floodplain structure and function with a focus on beaver restoration, channel reconstruction and levee setbacks, and restoring instream flows (Table 4-27).

Table 4-27: Summary of major restoration efforts in the Scott sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit.

Key Restoration Activities in the Scott Sub-basin to Date	Species Benefiting			
	CO	CH	ST	PL
Beaver dam analogues: The Scott River Watershed Council led a beaver dam analog project that expanded on existing landowner efforts to work with beaver to create more juvenile Coho Salmon rearing habitat in the Scott Valley. Under this project, 17 beaver dam analogs (BDAs) have been installed on French, Miners, Sugar, and Rattlesnake Creeks as well as the mainstem Scott River (Yokel 2018; Charnley 2018). Notably, these were the first BDAs constructed in California. Preliminary results are promising with monitoring demonstrating that adult Chinook and Coho spawned above the BDAs while the resulting pools were extensively used by juvenile Coho, steelhead and, to a lesser extent, Chinook Salmon, supporting the benefits of these structures for salmonids. In addition, significant groundwater storage was documented. BDAs constructed in the mainstem were washed out or damaged and so current and future efforts are focused on the tributaries (Charnley 2018). The program continues within an adaptive management framework and in 2018 SRWC.	●	○	●	

Key Restoration Activities in the Scott Sub-basin to Date	Species Benefiting			
	CO	CH	ST	PL
Riparian restoration program: Extensive livestock exclusion fencing and riparian restoration efforts began in the 1990s. More recent efforts towards stream bank stabilization, bio-engineering, riparian planting, and beaver habitat enhancement are all contributing to progressive improvement of riparian habitat conditions (NMFS 2014). Most of the mainstem Scott River and the west side tributaries have riparian fencing. Riparian restoration efforts to date have been informed in part by a Scott River Riparian Restoration Analysis Prepared by the Siskiyou RCD For the United States Fish and Wildlife Service (SRCD 2009).	●	●	●	○
Scott River Water Trust: Created in 2007, this is the first water trust established in California with the objective of supplementing instream flows in critical habitat reaches of the Scott River and its tributaries where salmonids migrate or spawn. The trust undertakes voluntary leases with water users to forego water use for irrigation or livestock in the summer and fall, and then carries out spawning surveys to help inform water leasing priorities in the next year (NMFS 2014, Watson 2016).	●	●	●	○
Instream restoration: The Scott River Watershed Council has augmented large wood on an 800 ft reach of Patterson Creek, with plans to do so over a 1 mile reach over the next 4 years. SRWC has also augmented wood in French Creek and Rattlesnake Creek. SRWC has constructed a side channel slow water habitat in French Creek. SRWC has funded a planning and design project on a 1 mile reach of French Creek. SRWC has funding and will implement to connect a side channel in the Callahan Tailings, as well as do riparian planting and place ELJs. SRWC has done riparian planting on French Creek and Sugar Creek. SRWC, in collaboration with USFS (Klamath National Forest), QVIR and NOAA is undertaking a Stage 0 geomorphic grade line project on Grouse Creek (in design). SRWC augmented gravel in French Creek and had a significant spawning response. SRWC is funded to augment additional gravel in French Creek. SRWC, in collaboration with EFMI_(Eco Forest Management) and QVIR will undertake fuels reduction and road improvements above Etna and QVIR. Siskiyou Land Trust has worked with multiple landowners to place permanent conservation easements on multiple properties, most notably placing approximately 30,000 acres of EFM lands in an easement. SRWC has a planned floodplain connection project in Sugar Creek (funded, awaiting NEPA clearance).	●	●	●	○

Current State of Monitoring & Data Gaps

The CDFW monitors salmonids in the Scott sub-basin including adult spawning migration counts, spawning ground surveys, and rotary screw trap sampling out-migrating salmonid juveniles. Incoming migrants are counted at a video counting weir on the Scott River 29.3 km upstream of its confluence with the mainstem Klamath River from October through December of each year (Manhard et al. 2018). While some steelhead are counted, their run timing does not perfectly align with the weir's operational window. Therefore, estimates of steelhead escapement from this source are considered minimum estimates only (Manhard et al. 2018). Spawning success is measured through spawning ground surveys of fish carcasses, carried out in cooperation with the Siskiyou Resource Conservation District (Knechtle and Chesney 2016). Finally, juvenile out-migration success is monitored via a rotary screw trap 7.6 km upstream of the confluence with the Klamath River (Manhard et al. 2018).

While there has not historically been much monitoring for Pacific Lamprey in this sub-basin, recent coast-wide restoration planning efforts have included initiatives to carry out distribution surveys on mainstems and principal tributaries in the Scott River. It is highly desirable to have a monitoring plan for out-migrating macrophthalmia using screw trap programs and to carry out telemetry studies to assess habitat use and migration behavior across the Klamath Basin (USFWF 2019). These initiatives are currently underway and help to improve informed decision-making for restoration of this species.

The Quartz Valley Indian Reservation has carried out a water quality monitoring program since 2007. This program includes monitoring on the mainstem Scott River at the site of an existing USGS flow gauge near Shackleford Creek, which records temperature, specific conductivity, dissolved oxygen, pH and turbidity (Asarian et al. 2021). This program also monitors groundwater, nutrients, water temperature, bacterial contamination of surface water, and fish populations at over 30 other sites across the sub-basin (QVIR 2016), and periodically produces monitoring reports (QVIR 2008, 2009). QVIR's Scott River monitoring data are now available in real-time through the Karuk Tribe's water quality portal.

There has also been a significant investment in restoration and associated effectiveness monitoring through implementation of the action plan for the Scott River TMDLs[19], the Scott River Watershed Restoration Strategy, and the Recovery Plan for SONCC Salmon. Each of these plans includes a section on monitoring and the TMDL plan requires periodic updates to the Action Plan and associated implementation programs and permits.

Current Data Gaps:

Figure 4-32 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring across agencies in the Scott sub-basin. Location-specific agency metadata (where available) on monitoring projects has been incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. There is relatively strong data on salmonid populations (with the exception of steelhead) and sediment, water temperature, and flow, which is of particular importance for evaluating landscape level restoration actions. In addition, new monitoring and ongoing assessment data on Pacific Lamprey is helping to fill important historical data gaps for this species. Moving forward, rigorous effectiveness monitoring will be important to inform future restoration strategies, particularly responses to instream flow and floodplain restoration measures.

[19] The Conditional Waiver of Waste Discharge Requirements is particularly relevant as it drives most of the on-the-ground TMDL compliance on ranches and requires site-specific effectiveness monitoring from those properties where Grazing and Riparian Management Plans are required to guide the implementation of best management practices.

Scott Sub-basin Monitoring Summary

Habitat Monitoring	Watershed Inputs	Weather	●
		Streamflow	●
		Groundwater	●
		Riparian & Landscape	●
	Fluvial-Geomorph	Sediments & Gravel	●
		Stream Morphology	●
	Habitat	Stream Temperature	●
		Habitat Quality	●
		Water Quality	●
		Barriers & Injury	●
		Marine/Estuary	NA
	Biota	Invasive Species	

			Salmon /Steelhead	Pacific Lamprey
Population Monitoring	Abundance	Juvenile Abundance (anad)	●	●
		Spawner Abundance (anad)	●	
		Abundance (non-anad)	NA	NA
	Harvest	Harvest (in-river)		
		Harvest (ocean)		
	Distrib-ution	Temporal Distribution	●	●
		Spatial Distribution	●	●
	Demo-graphics	Stock Composition	●	
		Age Structure	●	
	Biota	Disease		

● Known monitoring activities (past or ongoing)

NA Monitoring not relevant to this sub-basin

Figure 4-32. Synthesis of past and ongoing monitoring activities in the Scott sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species (note that here, salmon includes steelhead) is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017, Section 2.5, Appendix H):

Whole Basin

- Recovery Plan for Southern Oregon/Northern California Coast Coho salmon (SONCC) (National Marine Fisheries Service, Arcata, CA, 2014)
- Recovery Strategy for California Coho Salmon (CDFW 2004)

- Regional Implementation Plan for Measures to Conserve Pacific Lamprey (*Entosphenus tridentatus*), California – North Coast Regional Management Unit (Goodman and Reid 2015)
- Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)

Regional Plans

- Western Klamath Restoration Partnership – Plan for Restoring Fire Adapted Landscapes (Klamath National Forest 2014)
- Klamath National Forest (KNF) Water Quality Monitoring Plan (USFS 2010)
- The Klamath National Forest Land and Resource Management Plan (Klamath National Forest 2010)
- Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife (in draft form at the time of writing)

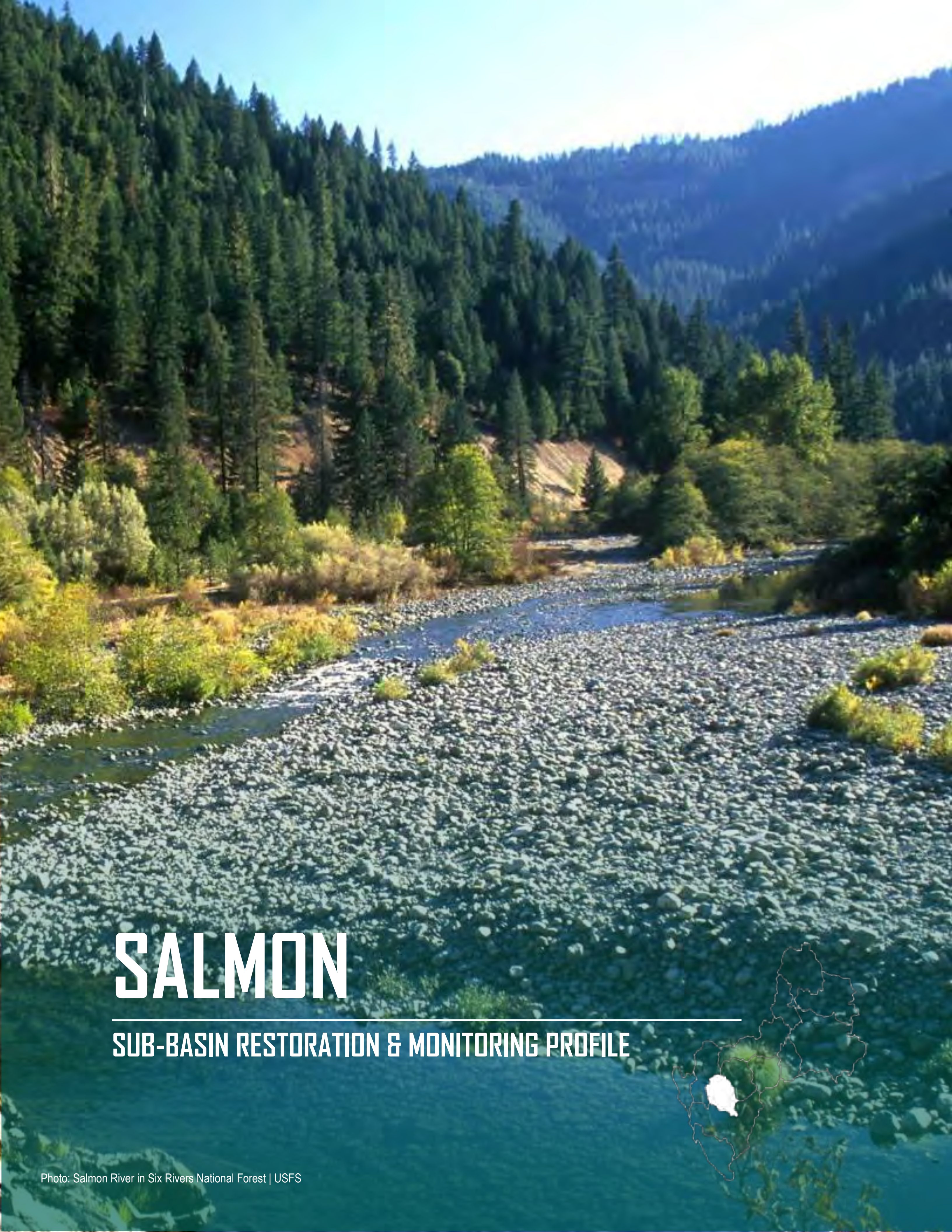
Scott Sub-basin Focus

- Scott River TMDL which specifies implementation of the:
    - Action Plan for the Scott River Watershed Sediment and Temperature Total Maximum Daily Loads (NCRWQCB 2006)
    - Conditional Waiver of Waste Discharge Requirements
    - Scott River Watershed Water Quality Compliance and Trend Monitoring Plan (NCRWQCB 2011)
    - Scott Valley Community Groundwater Study Plan (Harter et al. 2008)
- Scott River Watershed Council and Siskiyou Resource Conservation District
    - Restoring Priority Coho Habitat in the Scott River Watershed Modeling and Planning Report (SRWC 2018)
    - Scott River Watershed Restoration Strategy & Schedule (SRWC and SRCD 2014)
    - Initial Phase of the Scott River Watershed Council Strategic Action Plan (SRCD 2005)
    - Scott Valley Community Groundwater Study Plan (Harter et al. 2008; Foglia et al. 2018)
    - Voluntary Groundwater Management and Enhancement Plan (Siskiyou County 2013)
    - Ranch Water Quality Plan and Monitoring Template for Landowners (SRCD 2015)
- Scott River Spawning Gravel Evaluation and Enhancement Plan (Cramer et al. 2010)

At the time of writing, there was at least one ***forthcoming plan*** specific to this sub-basin under development, recently completed, or soon to proceed to implementation.

- Siskiyou County Flood Control District

  Per California's Sustainable Groundwater Management Act (SGMA), Siskiyou County has developed draft Groundwater Sustainability Plan (GSP) to assess the current and projected future conditions of three basins (Shasta, Scott, and Butte), and establish management and monitoring activities and long-term goals. Plans were submitted to the California Department of Water Resources in January 2022 are currently being reviewed (Scott GSP Information: Scott is https://sgma.water.ca.gov/portal/gsp/preview/89).



SALMON

SUB-BASIN RESTORATION & MONITORING PROFILE

Photo: Salmon River in Six Rivers National Forest | USFS

4.4.5 Salmon Sub-basin

The Salmon River has natural, unregulated flow without significant diversions, notable for hosting the only remaining viable wild spring Chinook run in the Klamath Basin (i.e., not heavily influenced by hatchery fish, per Moyle et al. 2008). Over 97% of the lands are managed by USFS with over 70% designated as Wilderness Area, Late Successional Reserve, or other management constrained allocations. The relatively pristine Salmon River also provides rearing, migratory, and refugia habitat to other Interior Klamath River populations and is identified as a key watershed by the Northwest Forest Plan. There has been extensive historical disturbance from gold mining and forestry activities, resulting in direct impacts such as scouring and simplification of the channel and degradation of floodplains and riparian areas. Road development associated with forestry and mining activity combined with the naturally steep terrain and unstable geology has resulted in an increase in disturbance events such as: flooding, debris torrents, and landslides. Land management practices such as clearcutting and fire suppression have resulted in a high fuel load and an increase in frequency and intensity of fires in the watershed. Between 2000 and 2017, over 50% of the watershed has burned in wildfires (SRRC [online] a).

Figure 4-33: Reference map of the Salmon Sub-Basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current:** Chinook Salmon (fall-run and spring-run), Coho Salmon, steelhead (summer and winter), Pacific Lamprey, Green Sturgeon (present in lower reaches of mainstem Salmon and Wooley Creek)

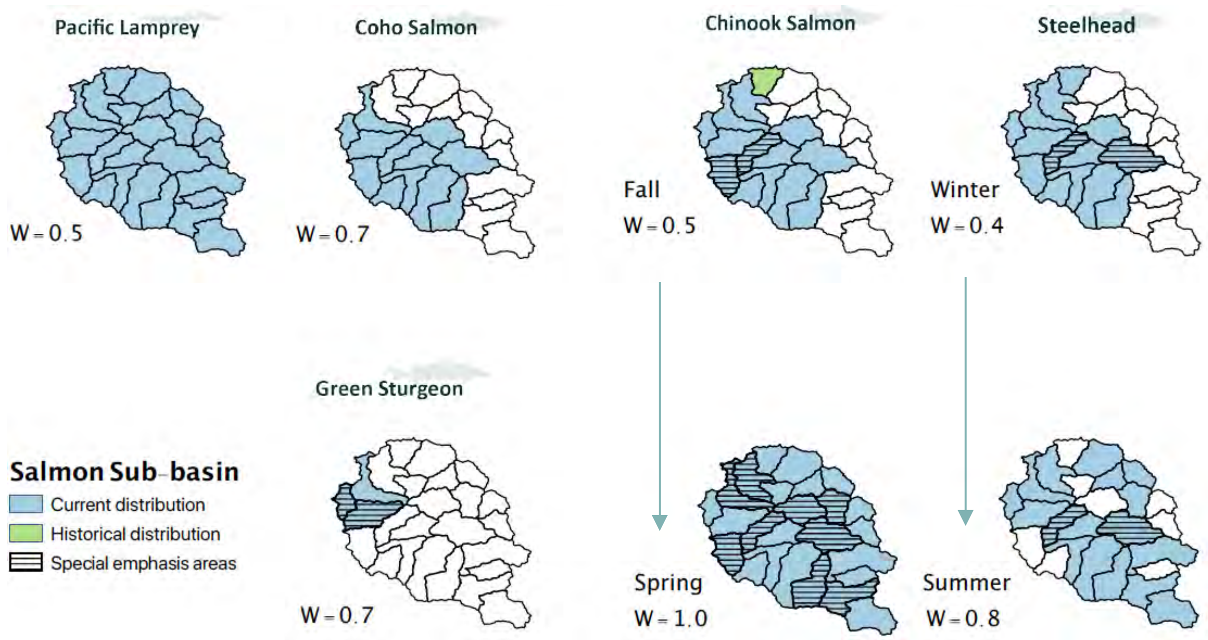


Figure 4-34: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the Salmon sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors

Table 4-28: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the Salmon sub-basin listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. CH = Chinook Salmon, CO = Coho Salmon, ST = steelhead, PL = Pacific Lamprey, GS = Green Sturgeon.

Key Stressors	Tier	Stressor Summary for the Salmon Sub-basin	Species				
			CH	CO	ST	PL	GS
Channelization	FG	Historical mining scoured and simplified the channel. Legacy tailings constrain the channel and cover the floodplain. The bulk of the mining impacts occur along the mainstem of the North and South Forks.	●	●	●	●	
Fine Sediment Retention	FG	Fine sediment retention is limited due to a decrease in slow water habitat resulting from channelization combined with an increased frequency of flood events which may flush sediments out of the system.	○	○	○	●	○

Key Stressors	Tier	Stressor Summary for the Salmon Sub-basin	Species				
			CH	CO	ST	PL	GS
Instream Structural Complexity (includes LWD)	H	Channelization due to mining as well as increased flooding and mass wasting events has resulted in reduction in habitat complexity including loss of connectivity to off-channel habitat, reducing slow water habitats, infilling pools (important for sturgeon as well), and flushing LWD from the system. Degradation of riparian areas limits new sources of LWD.	●	●	●	●	○
Water Temperature	H	High elevation headwaters in the South Fork provide late-melting snowpack and cooler waters. Climate model predictions suggest that the summer snowpack will be reduced and temperatures will increase (Asarian et al. 2019). Riparian areas in smaller tributaries are important in moderating temperatures throughout the sub-basin. Legacy mine tailings directly impact riparian areas in the mainstem of the North and South Forks. In addition, landslides, debris torrents and increased severity and frequency of fires have impacted significant portions of the riparian forests in the Salmon River.	●	●	●	●	●

Stressors identified from: NMFS 2014; Salmon River Sub-basin Restoration Strategy (Elder et al. 2002); Salmon River Restoration Council; Sub-regional working group survey responses.

Sequences of Restoration Projects for the Salmon Sub-Basin

The **summary infographic** in Figure 4-35 provides a compact overview of the Salmon sub-basin restoration project priorities and their distribution across the sub-basin.

Table 4-29 presents the results of the 2022 iteration of the IFRMP restoration sequencing process for the Salmon sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-29. The projects listed here have a cost range of $20.7M - $43.5M - $64.6M (low, estimated midpoint, high), and have been collated from projects proposed in prior local or regional restoration plans and studies as well as from in-depth discussions among participants in the IFRMP's Salmon Sub-basin Working Group who represent scientists, restoration practitioners, and resource users working in the sub-basin (see Acknowledgements section). The sequences and scoring in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria. Additional considerations such as implementability, cost, and dependencies among projects may influence the ultimate sequencing of projects. The working group did not identify any specific dependencies between projects but indicated that implementation of the proposed projects should be integrated as much as possible. Sequencing of projects will be very important for maximizing benefits in the sub-basin but hard at this point to say which projects should be highest in sequencing order.

Figure 4-35: Summary for the Salmon sub-basin, including key stressors, cost ranges, and projects (see next page).

Salmon Sub-basin

Sub-Basin Summary

The Salmon River has natural, unregulated flow without significant diversions and is notable for hosting the only remaining viable wild Spring Chinook run in the Klamath Basin. The relatively pristine Salmon River also provides rearing, migratory and refugia habitat to other Interior Klamath River populations and is identified as a key watershed by the Northwest Forest Plan. There has been extensive historical disturbance from gold mining and forestry activities in the sub-basin. Direct impacts include scouring and simplification of the channel and degradation of floodplains and riparian areas. Road development associated with forestry and mining activity combined with the naturally steep terrain and unstable geology has resulted in an increase in disturbance events such as: flooding, debris torrents, and landslides. Land management practices such as clearcutting and fire suppression have resulted in a high fuel load and increase in frequency and intensity of fires in the watershed.

Key Stressor Summary

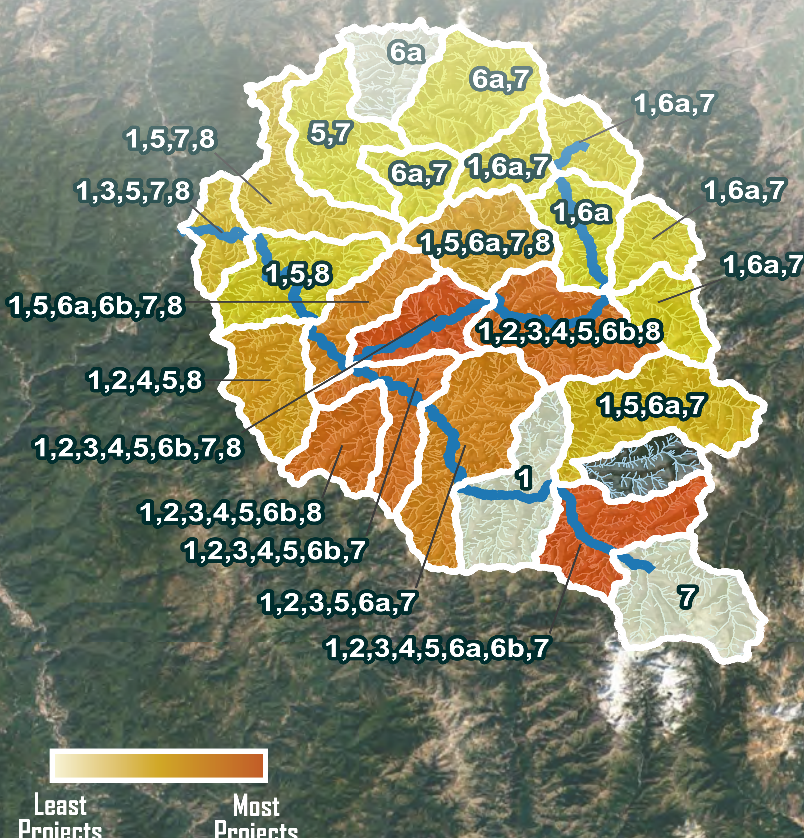
Key Stressors	Focal Species				
	CO	CH	ST	PL	GS
Channelization					
Fine Sediment Retention					
Water Temperature					
Instream Structural Complexity					

Restoration Summary

Since the Salmon River Sub-basin Restoration Strategy was published (Elder et al. 2002), many of the high priority fish passage barriers and treatable sediment sources in the watershed have been addressed. The highest ranked projects identified by the working group for improving habitat conditions in the Salmon Sub-basin were focused on restoring upland wetlands and meadows to improve cold water storage and flood attenuation (Project 7), protecting existing cold-water refugia (Project 5), and reconnecting floodplains and channels while remediating past mine tailing impacts (Projects 2 and 3). Projects ranked as of more intermediate restoration importance covered a range of mitigations/restorations relating to riparian planting to reduce water temperatures/improve habitat, removal of small passage barriers, installation of LWD and other structures to improve habitat, and upland vegetation management to restore natural fire regimes.

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is \$20.7M - \$43.5M - \$64.6M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP Sprague sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting, and **arrows** indicate linkages between projects.

Project ID & Description	Tiers
Salmon 7 - Restore upland wetlands and meadows to improve cold water storage and runoff attenuation in the Salmon River Sub-basin | **22.2**	H FG
Salmon 5 - Protect and enhance existing cold-water refugia through improved maintenance and management of existing riparian areas in the sub-basin | **22.1**	H FG
Salmon 3 - Build and improve connection to off-channel rearing habitats in Salmon Sub-basin tributaries | **21.3**	H FG
Salmon 2 - Undertake mine tailing remediation in priority reaches of the Salmon River and North and South Forks mainstems and reconnect floodplains | **21.3**	FG WI
Salmon 4 - Install LWD, boulders and other in-channel structures to improve fish habitats within the Salmon River and sub-basin tributaries | **17.6**	H
Salmon 8 - Remove physical barriers blocking fish passage to key thermal refuge areas within the Salmon River Sub-basin | **16.5**	H
Salmon 6_6b - Undertake riparian planting and management to reduce water temperatures within priority reaches of NF and SF Salmon River | **16.0**	H FG
Salmon 1 - Undertake upland vegetation management as needed to restore a fire adapted landscape across the Salmon River Sub-basin | **12.8**	WI

Discussion of this topic has been initiated but determining the optimal sequencing steps for multi-project implementation across the Salmon sub-basin will require further deliberation by the working group. Sequencing of projects will be very important for maximizing benefits in the sub-basin but determining the optimal sequencing steps for multi-project implementation requires further deliberation among the working group.

To facilitate consistent comparison across the sub-basins, results in Table 4-29 are shown for the Salmon sub-basin assuming a scenario where the four major Klamath mainstem dams have been removed, but no other significant changes from current conditions in the Klamath Basin. The Sub-basin Working Group identified the following additional scenarios with the potential to influence restoration priorities in the Salmon sub-basin. Should any these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

- Additional federal or state ESA listings
- Major 100 year flood events
- Large wildfire events
- Reduced snowpack
- Increase in general climate change effects

The highest ranked projects identified by the working group for improving habitat conditions in the Salmon sub-basin included:

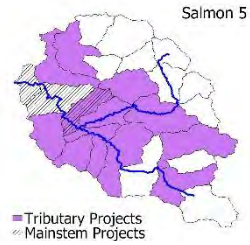
- **Projects 7, 5, 3, 2.** Project 7 is focused on restoring upland wetlands and meadows to improve cold water storage and flood attenuation**,** Project 5 is focused on protecting existing cold-water refugia, and Projects 3 and 2 are about reconnecting floodplains and channels while remediating past mine tailing impacts.

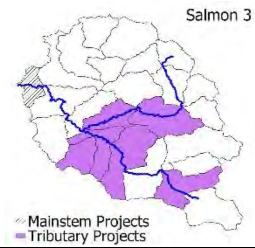
Projects ranked as of more intermediate restoration importance included:

- **Projects 4, 8, and 6a_6b.** These covered a range of mitigations/restorations relating to installation of LWD and other structures to improve habitat, removal of small passage barriers, and riparian planting to reduce water temperatures/improve habitat.
- **Projects 1** was the lowest ranked restoration projects in the Salmon sub-basin. This project pertains to upland vegetation management to restore fire adapted landscapes across the sub-basin.

Table 4-29: Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the Salmon sub-basin, with projects scored higher to be considered first for implementation. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name. Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-33, while special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin IFRMP planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.5)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.9)*	Implementability *(0.7)*
Salmon 7 (22.2)	**Restore upland wetlands and meadows to improve cold water storage and runoff attenuation in the Salmon River sub-basin.** **Project Description:** To maximize cold water quantity and duration and increase runoff attenuation for salmonid protection and recovery as well as providing a wide array of other species and ecosystem benefits (especially with increasing climate change), restore both wet and dry mountain meadows and their surrounding forests in upper montane and some mid montane areas of the Salmon sub-basin, through channel restoration (e.g., grade control structures, bank stabilization, channel reconfiguration), riparian vegetation management, forest thinning for snowpack enhancement, grazing management, and recreation and road infrastructure enhancement, with a particular focus on the headwaters to fish bearing and cold water refuge streams (Stillwater Science 2012). (SRRC communication) **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Mechanical channel modification and reconfiguration, Streambank stabilization, Riparian area conservation grazing management, Riparian Forest Management (RFM), Road drainage system improvements and reconstruction, Upland wetland improvement **Near-Term Focal Areas (map):** 17 sub-watersheds, Big Bend Creek-South Fork Salmon River, Main East Fork South Fork Salmon River, Garden Gulch-South Fork Salmon River**, Black Bear Creek-South Fork Salmon River, Methodist Creek-South Fork Salmon River**, Right Hand Fork North Fork Salmon River, Grant Creek-North Fork Salmon River, South Russian Creek, North Russian Creek, Little North Fork Salmon River**, Olsen Creek-North Fork Salmon River, Upper Wooley Creek, Hancock Creek, Middle Wooley Creek**, Lower Wooley Creek**, Crapo Creek-Salmon River**, Somes Creek-Salmon River**  **Cost range ($K):** $5,172 – 11,459 – 17,120 (incomplete – no cost data available for "riparian area conservation grazing management" and streambank stabilization") (based on cost data from Scott, Trinity, MKR)	**1.07**	**0.85**	**9**	**6.75**	**4.52**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.5)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.9)*	Implementability *(0.7)*
Salmon 5 (22.1)	**Protect and enhance existing cold-water refugia through improved maintenance and management of existing riparian areas in the sub-basin.** **Project Description:** Protect and enhance existing or potential cold-water refugia. The Salmon River is listed as impaired due to high temperatures under the TMDL. The riparian areas in Wooley Creek are considered in very good condition (NMFS 2014 cited USFS 2000c). Riparian areas in the Salmon sub-basin are protected through the Memorandum of Understanding between the Regional Water Board and the US Forest Service (RWMG 2009). However, riparian areas are still at risk of catastrophic fires and so this action is related to Action #1, re-establish a natural fire regime. Participants who reviewed this project noted that the relatively high score for this project is only valid if there is strong enforcement by the US Forest Service and the Regional Water Board. **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Riparian Forest Management (RFM)  **Near-Term Focal Areas (map):** 14 sub-watersheds, Main East Fork South Fork Salmon River, Garden Gulch-South Fork Salmon River**, Black Bear Creek-South Fork Salmon River, Knownothing Creek**, Methodist Creek-South Fork Salmon River**, Little North Fork Salmon River**, Whites Gulch-North Fork Salmon River**, Olsen Creek-North Fork Salmon River, Middle Wooley Creek**, Lower Wooley Creek**, Nordheimer Creek**, Crapo Creek-Salmon River**, Butler Creek-Salmon River**, Somes Creek-Salmon River** **Cost range ($K):** $1,674 – 3,940 – 6,166 (based on cost data from Scott and UKR)	**4.53**	**2.75**	**3.83**	**6.75**	**5.26**
Salmon 3 (21.3)	**Build and improve connection to off-channel rearing habitats in Salmon sub-basin tributaries.** **Project Description:** Increase channel complexity by constructing off-channel habitats, alcoves, back water habitat and old stream oxbows. Improve amount of and connection to lower velocity off-channel habitat to provide juvenile salmonids with refuge habitat against warmer temperatures in the summer and high flow events in the winter. Increased off-channel habitat may also improve fine sediment retention in some areas supporting Pacific Lamprey habitat needs. Some of these projects will occur at sites impacted by mine tailings (e.g., projects in progress at Kelly Gulch and Red Bank in the North Fork downstream of Sawyers Bar) and so are related to (but not necessarily dependent on) Action #2. Because constructing off-channel habitats may also involve instream structure placement and riparian restoration, this action enhances the value of Action #4 and Action #6.	**4.42**	**5**	**2.07**	**4.5**	**5.35**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.5)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.9)*	Implementability *(0.7)*
	Dependencies / Project Linkages: This action could occur in conjunction with Action #2 but does not have to. The kinds of off-channel design (alcoves, backwater oxbow restoration) in Action #3 are more elaborate than Action #2's more fundamental grading and contouring to reconnect areas to floodplains following mine tailing remediation. Could be packaged with Action #2 (installing LWD and in-channel structures) but not dependent on doing so._Also, often, constructing off-channel habitats also logically would precede riparian planting and in channel placement actions where sites were in common. This project would logically happen prior to Action #6. **Primary Action Types:** Mechanical channel modification and reconfiguration  **Near-Term Focal Areas (map):** 7 sub-watersheds, Garden Gulch-South Fork Salmon River**, Black Bear Creek-South Fork Salmon River, Knownothing Creek**, Methodist Creek-South Fork Salmon River**, Whites Gulch-North Fork Salmon River**, Olsen Creek-North Fork Salmon River, Somes Creek-Salmon River** **Cost range ($K):** $2,465 – 5,730 – 8,520 (based on cost data from Scott, Trinity, MKR)					
Salmon 2 (21.3)	**Undertake mine tailing remediation in priority reaches of the Salmon River and North and South Forks mainstems and reconnect floodplains.** **Project Description:** Address historical mining impacts in riparian areas. Activities may include removing or setting back tailings piles, providing soil where sites were mined to the bedrock (Petersburg and Summerville) and reconnection to the floodplain. Legacy mine tailings occur primarily in the mainstem of the North and South Forks. A recent LiDAR analysis identified 14 candidate reaches with high potential for restoration (i.e., not bedrock constrained and have legacy mine tailings) (Stillwater 2014). The benefits of this action may be further enhanced with riparian restoration (Action #6) and increasing channel complexity (Actions #3 and #4). Removal and setting back tailings piles and providing/grading and contouring soil would be a logical pre-cursor to these other riparian and in-channel actions that together provide cumulative benefits. However, mine tailing pile setbacks and provision of soil to reconnect floodplains is a distinct project action that does not have to occur simultaneously with other riparian and in-channel restoration actions. **Dependencies / Project Linkages:** May be preferable for this action to occur prior to riparian and in-channel actions at the same common sites. Could be combined with Action #3 (but Action #2 and Action #3 may not always occur at the same sites and can be completed in a staged fashion). **Primary Action Types:** Instream habitat project (general), Mechanical channel modification and reconfiguration	**4.51**	**3.79**	**4.5**	**4.5**	**4.88**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.5)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.9)*	Implementability *(0.7)*
	Near-Term Focal Areas (map): 8 sub-watersheds, Garden Gulch-South Fork Salmon River**, Black Bear Creek-South Fork Salmon River, Knownothing Creek**, Methodist Creek-South Fork Salmon River**, Whites Gulch-North Fork Salmon River**, Olsen Creek-North Fork Salmon River, Nordheimer Creek**, Somes Creek-Salmon River** **Cost range ($K):** $7,840 – 12,199 – 15,945 (based on cost data from MKR, Scott, Trinity, UKR, SF Trinity, Shasta)  					
Salmon 4 (17.6)	**Install LWD, boulders and other in-channel structures to improve fish habitats within the Salmon River and sub-basin tributaries.** **Project Description:** Instream habitat enhancement. Increase large woody debris, boulders, and other instream structures to improve the quality and quantity of adult spawning habitat and juvenile rearing habitat for salmonids, particularly Coho and spring Chinook In-channel structure helps trap sediment, alleviate incision, creates refugia and improves habitat quality. Increasing the instream complexity will also promote a more natural heterogeneous stream structure which may improve the fine sediment retention in some areas (e.g., deep pools), thus also supporting Pacific Lamprey habitat needs. This action is related to Action 3 and will often be employed together at the same restoration sites. The focus of these restoration actions may be broader than for Action 3 which is primarily focused on areas with legacy mine tailing impacts. For example, there is a plan to enhance habitat in Nordheimer Creek, a tributary to the mainstem Salmon River just below the Forks of Salmon. This project is considered highly implementable by participants. **Dependencies / Project Linkages: :** No dependencies indicated. Could be packaged with Action #3 (constructing alcoves, backwater habitats, oxbow reconnection) but not dependent on doing so. **Primary Action Types:** Channel structure placement, Addition of large woody debris **Near-Term Focal Areas (map):** 6 sub-watersheds, Garden Gulch-South Fork Salmon River**, Knownothing Creek**, Methodist Creek-South Fork Salmon River**, Whites Gulch-North Fork Salmon River**, Olsen Creek-North Fork Salmon River, Nordheimer Creek** **Cost range ($K):** $1,225 – 2,608 – 3,933 (based on cost data from Scott, Trinity, MKR)  	**4.02**	**3.1**	**3.66**	**2.25**	**4.58**
Salmon 8 (16.5)	**Remove physical barriers blocking fish passage to key thermal refuge areas within the Salmon River sub-basin.** **Project Description:** Address various types of physical fish passage barriers at key locations in this sub-basin to protect and provide access to existing cold water refugia (SRRC communication)	**6**	**2.32**	**2.4**	**4.5**	**1.26**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.5)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.9)*	Implementability *(0.7)*
	Dependencies / Project Linkages: No dependencies indicated  **Primary Action Types:** Fish passage improvement (general), Minor fish passage blockages removed or altered **Near-Term Focal Areas (map):** 9 sub-watersheds, Knownothing Creek**, Little North Fork Salmon River**, Whites Gulch-North Fork Salmon River**, Olsen Creek-North Fork Salmon River, Lower Wooley Creek**, Nordheimer Creek**, Crapo Creek-Salmon River**, Butler Creek-Salmon River**, Somes Creek-Salmon River** **Cost range ($K):** $588 – 1,825 – 3,275 (based on cost data from MKR, Trinity, Shasta, SF Trinity)					
Salmon 6_6b (16.0)	**Undertake riparian planting and management to reduce water temperatures within priority reaches of NF and SF Salmon River.** **Project Description:** Riparian vegetation provides shade reducing water temperatures and improving instream habitat (NMFS 2014). The North Fork and South Fork are the priority areas for riparian restoration in the Salmon River (NMFS 2014). This action would have benefits for reducing local water temperatures which in conjunction with instream habitat enhancement (Action #4, placing LWD, boulders) further enhance instream habitat (Actions #4 and #6 are synergistic but not linked). A riparian assessment was completed in 2008 to prioritize riparian restoration sites. The majority of the high priority sites are clustered within three reaches of the North and South Forks (Cressey and Greenberg 2008). The prioritization criteria included impacts (e.g., due to mine tailings) and so there is substantial overlap with the sites identified as high potential for Actions #2 and #3. The TMDL also requires that the Salmon River "be managed for increasing vegetation cover and increasing vegetation height within the riparian zones". Once planted or naturally colonized, these riparian vegetation areas needs to be managed to ensure seedlings grow and reach sustained heights capable of providing shade.  **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Riparian planting, Riparian Forest Management (RFM) **Near-Term Focal Areas (map):** 17 sub-watersheds: Black Bear Creek-South Fork Salmon River, Crapo Creek-Salmon River**, Garden Gulch-South Fork Salmon River**, Grant Creek-North Fork Salmon River, Hancock Creek, Knownothing Creek**, Little North Fork Salmon River**, Main East Fork South Fork Salmon River, Methodist Creek-South Fork Salmon River**, North Fork Wooley Creek, North Russian Creek,	**0.6**	**0.5**	**3.43**	**4.5**	**7**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.5)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.9)*	Implementability *(0.7)*
	Olsen Creek-North Fork Salmon River, Right Hand Fork North Fork Salmon River, South Russian Creek, Upper Wooley Creek, Whites Gulch-North Fork Salmon River**, Yellow Dog Creek-North Fork Salmon River**. **Cost range ($K):** $125 – 138 – 150 (based on cost data Shasta, UKR)					
Salmon 1 (12.8)	**Undertake upland vegetation management as needed to restore a fire adapted landscape across the Salmon River sub-basin.** **Project Description:** Upland vegetation management to re-establish a natural fire regime. High fuel loading resulting from past timber harvest practices and fire suppression is a concern throughout the Western Klamath. The Western Klamath Restoration Partnership (WKRP) describes a regional plan for restoring fire adapted landscapes (Harling and Tripp 2014). The Karuk Tribe and other federal, state, and NGO's are partners in the WKRP with regional interests including the Salmon sub-basin. The Salmon River Restoration Council (SRRC) and Salmon River Fire Safety Council are Salmon sub-basin focused partners in the regional plan. The plan identifies three key components: Restoring and maintaining resilient landscapes, creating fire-adapted communities, and responding to wildfires. WKRP efforts currently address the first two components and are working with Federal agencies to begin to address the third. Fuel reduction and re-introduction of low intensity fires through controlled burning, managed wildfires, and planting of fire-resistant species are key actions towards re-establishing a natural fire regime. Recent large fires in the Salmon River may enable prescribed burning to be safely reintroduced adjacent to fire footprints. **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Upland vegetation management including fuel reduction and burning **Near-Term Focal Areas (map):** 19 sub-watersheds, Main East Fork South Fork Salmon River, Garden Gulch-South Fork Salmon River**, Crawford Creek-South Fork Salmon River**, Black Bear Creek-South Fork Salmon River, Knownothing Creek**, Methodist Creek-South Fork Salmon River**, Right Hand Fork North Fork Salmon River, Grant Creek-North Fork Salmon River, South Russian Creek, North Russian Creek, Yellow Dog Creek-North Fork Salmon River**, Little North Fork Salmon River**, Whites Gulch-North Fork Salmon River**, Olsen Creek-North Fork Salmon River, Lower Wooley Creek**, Nordheimer Creek**, Crapo Creek-Salmon River**, Butler Creek-Salmon River**, Somes Creek-Salmon River**  **Cost range ($K):** $50 – 300 – 875 (based on cost data from Trinity)	**2.69**	**1.8**	**0.9**	**6.75**	**0.7**

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC and SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, and sub-regional working group input via surveys and webinars.

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the Salmon Sub-basin

The state and federally listed SONCC ESU of ***Coho Salmon*** is a key species identified for many restoration actions in the Salmon sub-basin, and in other parts of the mid and lower Klamath basin (NMFS 2014). Spring-run ***Chinook Salmon*** are also listed under California's Endangered Species Act (CESA). Salmon River Coho are considered a potentially independent population and are currently listed as being at high extinction risk (NMFS 2014). In February 2018 NOAA Fisheries announced that they would evaluate a petition by the Karuk Tribe and Salmon River Restoration Council (SRRC) to list the Upper Klamath – Trinity River Chinook ESU or establish a new ESU for Klamath spring-run Chinook (NOAA 2018). Currently, Upper Klamath Spring Chinook are warranted all the protections of a state-listed species (listed as threatened by the State of California in 2016) while the review process takes place. The Salmon River hosts the last remaining viable wild population of spring-run Chinook in the Klamath basin. Fall- and spring-run Chinook Salmon, spring/summer- and winter-run ***steelhead***, and ***Pacific Lamprey*** are anticipated to benefit from many of the restoration actions proposed for Coho Salmon recovery. ***Green Sturgeon*** are also known to be found in the lower reaches of the mainstem Salmon River and is the site of a confirmed spawning location (Karuna Greenburg, pers. Comm.). Their distribution is thought to extend up to the confluence with Nordheimer Creek on the mainstem and up to and including Haypress Creek on Wooley Creek (Northern Green Sturgeon Range – FSSC, CDFW Spatial Dataset 1204). Fall-run Chinook, Pacific Lamprey, and steelhead are either much declined or declining and are Tribal Trust Species.

Since the Salmon River Sub-basin Restoration Strategy was published (Elder et al. 2002) many of the high priority fish passage barriers and treatable sediment sources in the watershed have been addressed (Table 4-5). A variety of restoration efforts have occurred to re-establish a natural fire regime, and this remains a priority. More recent restoration efforts focus on instream or riparian habitat enhancement.

Table 4-30: Summary of major restoration efforts in the Salmon sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit.

Key Restoration Activities in the Salmon Sub-basin to Date	Species Benefiting				
	CO	CH	ST	PL	GS
Restore natural fire regime: Fuel reduction efforts began in 1995 through the SRRC. The Salmon River Fire Safety Council was established in 2000 to *"help plan, implement and monitor the reinstatement of natural fire regimes in the Salmon River ecosystem"*. A variety of fuel reduction strategies have been used including: creating shaded fuel breaks, Late Successional Reserves (e.g., Eddy Gulch) and more recently prescribed burns and managed wildfires. Due to planning, budget, and regulatory constraints, it is only possible to do thinning and prescribed burns on a relatively limited number of acres. To affect large portions of the landscape, it is necessary to also use the opportunities created by naturally occurring fires.	●	●	○	○	○
Barrier removal: Most of the fish passage barriers in the sub-basin have been identified (Barrier Removal Forest-wide assessment at road stream crossings during 2003-2004) and addressed. These include the White gulch project which involved removing two small dams in 2008 and replacing a culvert with a bridge at a downstream road crossing in 2010. In addition, the Klamath National Forest has upgraded 7 crossings and the fish barrier in Hotelling Gulch, tributary to the South Fork Salmon River, is slated for removal in 2020.	●	●	●	○	

Key Restoration Activities in the Salmon Sub-basin to Date	Species Benefiting				
	CO	CH	ST	PL	GS
Road upgrades or decommissioning may reduce sediment inputs via landslides and surface erosion. The Klamath National Forest has an active road decommissioning and storm proofing program which has decommissioned 84.4 miles and storm proofed another 76.2 miles of highest risk roads (out of 766 federally maintained roads) and continues to mitigate road-related hydrologic connection on public land in the Salmon River. Salmon River Private Roads Sediment Reduction Project (PWA 2011) has upgraded and decommissioned approximately 3.1 miles of roads in the Salmon River basin.	●	●	○	○	
Instream habitat enhancement. The SRRC Habitat Restoration Program was initiated in 2015 to improve habitat for aquatic species, particularly for juvenile salmonids. Enhancement projects focus on increasing instream complexity (e.g., incorporating large woody debris) and slow water habitat (e.g., reconnecting floodplains and creating off-channel habitat). Enhancement has occurred in Methodist and Knownothing Creeks, other projects are in progress or in the planning stages. The SRRC conducts ongoing annual efforts to enhance cold-water refugia and increase access into cold-water tributaries through manual manipulation of rocks and boulders as well as increasing cover for fish using the refugia through addition of brush bundles.	●	●	○	○	
Riparian restoration. Salmon River Riparian Assessment was completed to identify priority areas for riparian restoration to meet target TMDL water temperatures.	●	●	●	○	○

*Sources for this table include: http://www.srrc.org/programs/restoration.php, NMFS 2014; ESSA 2017.

Current State of Monitoring & Data Gaps

Yearly adult population counts of spring Chinook and summer steelhead have occurred since 1995 in an effort coordinated by the SRRC and USFS, with cooperation from and participation by local Tribes, NOAA Fisheries, USFWS, CDFW, MKWC, and community volunteers. Some juveniles originating from other sub-basins may rear in the lower reaches of the Salmon, creating a potential complication in interpreting presence or abundance of juveniles specific to this sub-basin. The SRRC, in coordination with the Klamath National Forest and the Karuk Tribe, has also conducted water temperature monitoring since the early 1990s at over 50 sites, and flow monitoring since 2001 at 20 sites. The focus is on cold-water tributaries. There has been a significant investment in restoration through the Salmon River Sub-basin Restoration Strategy and the Klamath National Forest Land and Resource Management Plan. Each of these plans includes a section on monitoring and the Salmon TMDL plan requires periodic updates to the Action plan. While detailed effectiveness monitoring reports are not readily available, the plans have been periodically updated incorporating new knowledge and updating priorities. The SRRC initiated a habitat restoration program in 2015 and new projects include an effectiveness monitoring component. Likewise, the Western Klamath Restoration Partnership Plan includes a project level effectiveness monitoring component.

Current Data Gaps:

Figure 4-36 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken across agencies in the Salmon sub-basin. Location-specific agency metadata (where available) on monitoring projects is incorporated into an Integrated

Tracking Inventory Excel spreadsheet internal to the project. The most obvious population data gap is with respect to Green Sturgeon in the Salmon sub-basin. Distribution assessments for Pacific Lamprey were initiated in the Salmon River in 2015 and as of 2019 are ongoing. There is relatively strong data on salmon populations as well as water temperature and flow, which is of particular importance for evaluating landscape level restoration actions in the Salmon sub-basin. One information gap is the degree of spawning overlap between spring-run Chinook and fall-run Chinook, and the associated proportion of spring-run/fall-run heterozygotes in the system. Moving forward, rigorous effectiveness monitoring will be important to inform future restoration strategies, particularly responses to riparian restoration and fire management practices.

Salmon Sub-basin Monitoring Summary

Habitat Monitoring			
Watershed Inputs	Weather	●
	Streamflow	●
	Groundwater	●
	Riparian & Landscape	●
Fluvial-Geomorph	Sediments & Gravel	●
	Stream Morphology	●
Habitat	Stream Temperature	●
	Habitat Quality	●
	Water Quality	●
	Barriers & Injury	●
	Marine/Estuary	NA
Biota	Invasive Species	

Population Monitoring		Green Sturgeon	Salmon / Steelhead	Pacific Lamprey
Abundance	Juvenile Abundance (anad)		●	
	Spawner Abundance (anad)		●	
	Abundance (non-anad)	NA	NA	NA
Harvest	Harvest (in-river)			
	Harvest (ocean)			
Distrib-ution	Temporal Distribution		●	●
	Spatial Distribution		●	●
Demo-graphics	Stock Composition		●	
	Age Structure		●	
Biota	Disease			

● Known monitoring activities (past or ongoing)

NA Monitoring not relevant to this sub-basin

Figure 4-36. Synthesis of past and ongoing monitoring activities in the Salmon sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017, Section 2.5, Appendix H):

Whole Basin

- Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (SONCC) (National Marine Fisheries Service, Arcata, CA, 2014)
- Recovery Strategy for California Coho Salmon (CDFW 2004)
- Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)

Regional Plans

- Western Klamath Restoration Partnership ñ Plan for Restoring Fire Adapted Landscapes (Klamath National Forest 2014)
- Klamath National Forest (KNF) Water Quality Monitoring Plan (USFS 2010)
- Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife (in draft form at the time of writing)

Salmon Sub-basin Focus

- Salmon River TMDL and Implementation Plan which specifies implementation of:
  - Klamath National Forest Land and Resources Management Plan (2010 is latest version)
  - Salmon River Sub-basin Restoration Strategy (Elder et al. 2002)

- Salmon River Restoration Council
  - Habitat Restoration Program (initiated in 2015)
  - Salmon River Fire Safe Council (initiated in 2000)
  - Water quality monitoring program (initiated in 1992, stream temperature and stream flow)
  - Fisheries Program (initiated in 1992 to assess, maintain, and restore the Salmon Riverís fishery and aquatic ecosystems)
- Salmon River Floodplain Habitat Enhancement and Mine Tailing Remediation Project Technical Memo (Stillwater Sciences 2018)
- Salmon River Candidate Action Table

At the time of writing, there were no ***forthcoming plans and initiatives*** specific to this sub-basin under development, recently completed, or soon to proceed to implementation.

4.5 Lower Klamath River Sub-region & Klamath Estuary

The Lower Klamath River sub-region includes the mainstem Klamath River (from its estuary on the Pacific Ocean to the confluence with the Trinity River), the Trinity River, and the South Fork Trinity (California's largest unregulated watershed). Cool streams entering the lower reach of the Klamath River mainstem below the Trinity confluence represent important refugia habitat for fish in the sub-region (Vanderkooi et al. 2011) but can be prone to excessive sediment input due to unstable soils, heavy logging activity, and associated high road densities in the area (Stanford et al. 2011). The history of extensive logging in the region has led to a low supply of large wood, which is a primary stressor in this sub-basin. Low densities of large wood also compound sediment-related issues: the lack of in-stream obstructions leads to poor retention of spawning gravels and the persistence coarse-grained material results from logging legacies and hillslope mass-movements. Lack of local wood availability also inhibits restoration efforts and increases costs for projects that aim to add wood to the system. Inter-basin diversion of water into California's Central Valley can divert a significant amount of the Trinity River's historical annual flow (NRC 2008). The largest effect of this diversion is on spring flows with reduced flows having caused channel degradation and floodplain disconnection (Vanderkooi et al. 2011). Other issues in the sub-region include inaccessible salmon habitat in the upper Trinity, lack of gravel recruitment, and erosion of fine sediments into streams from logging, grazing, and past placer mining (Stanford et al. 2011).

The estuary at the mouth of the Klamath is relatively small (although it may have been larger historically) and is similar to a pulsating or protected lagoon (Vanderkooi et al. 2011). Within the estuary, wetland, slough, and off-channel habitats provide important foraging areas for juvenile salmon and other brackish water fish (Patterson 2009; Vanderkooi et al. 2011). Although the Klamath River estuary is located far downstream of Klamath River dams, water quality in the estuary can be affected by dam operations and water diversions on the Klamath and Trinity Rivers can affect mouth closure dynamics in the Klamath River estuary (Stillwater Sciences 2009, Lowe et al. 2018). Mouth closure can reduce the size of the estuary's saltwater wedge, decrease overall salinity, and subsequently increase water temperatures in the estuary to levels detrimental to out-migrating salmonids (Hiner 2006, Stillwater Sciences 2009, Lowe et al. 2018). Additional stressors in this sub-region that are not yet fully understood include the impacts of downstream transmission of fine sediments and pathogens, impacts of sedimentation from timber practices and historical mining upstream, and the potential influence of climate change-induced sea level rise, which could have profound effects on the estuary and Lower River habitats (Adams et al. 2011).

- **Sub-basins:** Lower Klamath River (Klamath Estuary), Trinity, South Fork Trinity
- **Key Species:** Chinook Salmon, Coho Salmon, Steelhead, Pacific Lamprey, Green Sturgeon, and Eulachon

Header Image: Wild and Scenic Trinity River, 2009 | BLM

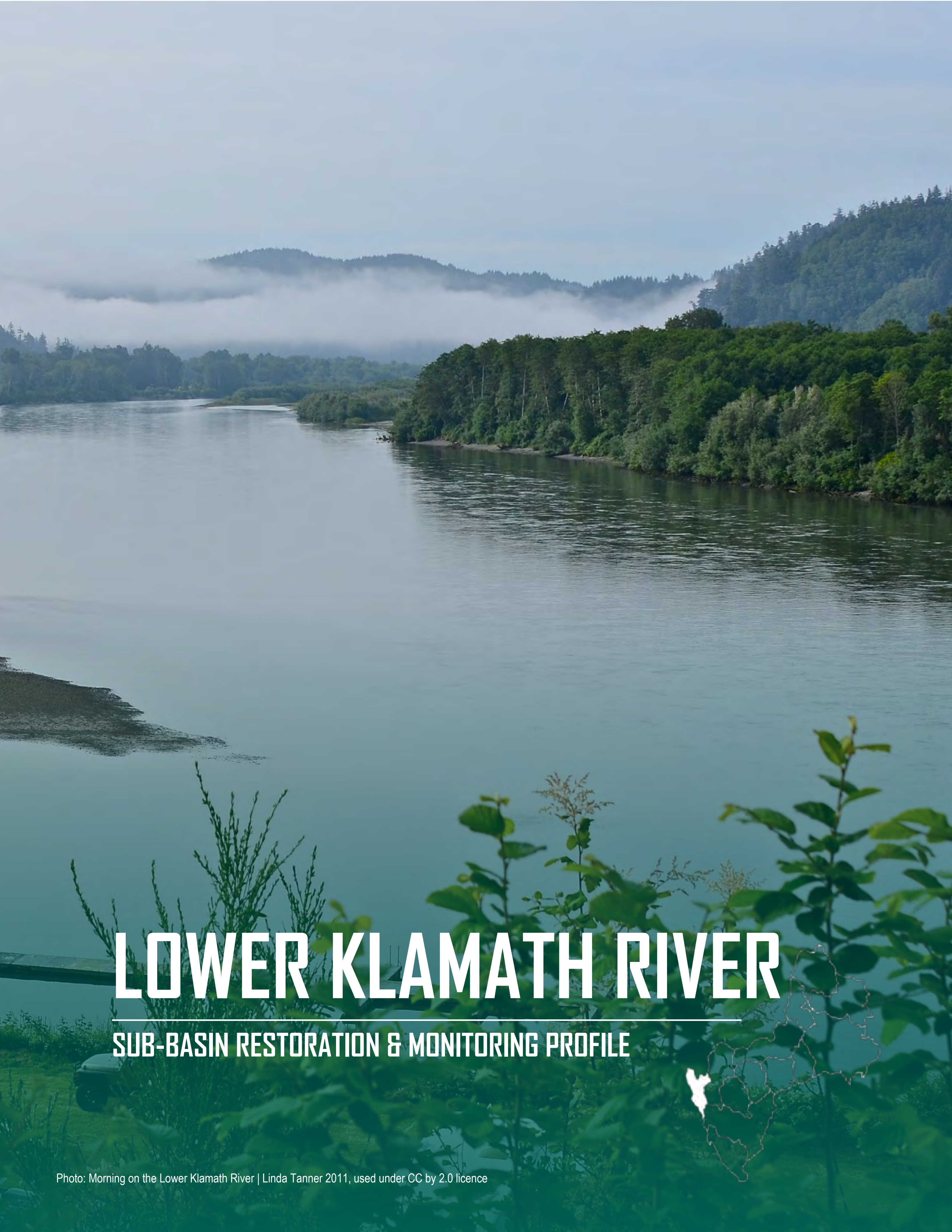
Table 4-31: Synthesis of stressors (X) and key stressors (yellow highlighted) affecting focal fish species/functional groups across the Lower Klamath River (LKR) sub-region (includes Klamath Estuary) (as identified through IFRMP Synthesis Report and technical group conceptual modeling exercises). Yellow highlighted cells represent suggested key stressors for a focal species or species group within a particular sub-region.

Lower Klamath River (LKR) sub-region							
Stressor Tier	Stressor	Focal Fish Species					
		GS	EU	CH	CO	ST	PL
Watershed inputs (WI)	9.3.1 Klamath River flow regime	X	X	X	X	X	X
	7.2.1 Increased fine sediment input/delivery	X	X	X	X	X	
	3.1.2 Marine nutrients			X	X	X	X
	8.7 Chemical contaminants	X	X				
	3.3.3 Nutrient influx		X				
	3.1.2 Marine nutrients			X	X	X	X
	4.2 Large woody debris			X	X	X	X
	9.2.2. Instream flows (tributaries)			X	X	X	X
	7.1.1 Decreased coarse sediment input/delivery			X	X	X	X
Fluvial-geomorphic Processes (FG)	8.4 Total suspended sediments	X	X				
	6.1.1 Channelization			X	X	X	X
	9.2.1 Groundwater interactions			X	X	X	X
Habitat (H)	8.1 Water temperature	X	X	X	X	X	X
	8.2 Dissolved oxygen	X		X	X	X	X
	8.5 pH			X	X	X	X
	1.1. Anthropogenic barriers			X	X	X	X
	6.2.1 Deep pools	X					
	6.2.2 Suitable (cobble) substrate	X					
	2.3.1 Fish entrainment (larvae/juveniles)	X	X				
	7.3.1 Contaminated sediment	X	X				
	6.2 Instream structural complexity			X	X	X	X
	6.2.3. Fine sediment retention			X	X	X	X
Biological Interactions (BI)	2.1.2 Predation (fish)	X	X	X	X	X	X
	2.1.2 Predation (mammals/birds)	X		X	X	X	X
	3.3.2 Abundance of invertebrate prey	X					
	10.1 Hybridization			X			
	2.2 Pathogens			X	X		
	3.2 Competition			X	X	X	

Klamath River Estuary (KRE) sub-region		
Stressor Tier	Stressor	All focal species in sub-region
Watershed inputs (WI)	9.3.1 Klamath River flow regime	X
	7.2.1 Increased fine sediment input/delivery	X
	8.7 Chemical contaminants	X
	3.3.3a Nutrients	X
	3.3.3.b Particulate organic matter	X
	9.2.2 Instream flows (estuarine tributaries)	X
	4.1 Riparian vegetation	X
Fluvial-geomorphic Processes (FG)	6.2.3 Fine sediment retention	X
Habitat (H)	8.1 Water temperature	X
	8.6 Salinity	X

Klamath River Estuary (KRE) sub-region		
Stressor Tier	**Stressor**	**All focal species in sub-region**
	8.5 pH	X
	8.4 Total suspended solids (TSS) (deposits/turbidity)	X
	8.2 Dissolved oxygen	X
	7.3.1 Contaminated sediment	X
	2.4 Toxins (e.g. cyanotoxins)	X
	4.2 LWD	X
	3.1 Altered primary productivity	X
	6.2 Instream structural complexity	X
	5.1 Wetland condition (estuarine wetlands)	X
	5.3.1 Estuary size	X
	5.3.2 Estuary lagoon depth	X
	5.3.3 Macro algae/macrophyte abundance & distribution	X
	5.5.3 Salt wedge (size & location)	X
	5.3.5 Estuary "perching" (frequency & duration)	X
	5.3.6 Estuary mouth closure (frequency & duration)	X
	5.3.7 Estuary plume (size)	X
	5.4 Nearshore conditions	X
Biological Interactions (BI)	2.1.1 Predation (fish)	X
	2.1.2 Predation (aquatic mammals)	X
	2.2 Pathogens	X
	3.2.2a Abundance of invertebrate prey	X
	3.3.2b Abundance of forage fish	X
	3.2 Competition	X

GS = Green Sturgeon, EU = Eulachon, CH = Chinook Salmon, CO = Coho Salmon, ST = steelhead, PL = Pacific Lamprey. Stressor numbering is adapted from NOAA's Pacific Coastal Salmon Recovery Fund 'Ecological Concerns Data Dictionary' available from: https://www.webapps.nwfsc.noaa.gov/apex/f?p=309:13::::::



LOWER KLAMATH RIVER

SUB-BASIN RESTORATION & MONITORING PROFILE

Photo: Morning on the Lower Klamath River | Linda Tanner 2011, used under CC by 2.0 licence

4.5.1 Lower Klamath River Sub-basin (includes Klamath Estuary)

The Lower Klamath River sub-basin has a mix of forestry and agriculture use with subsequent degraded riparian forest. High nutrient loads from upstream agriculture can be an issue with potential for low dissolved oxygen, high pH, high stream temperatures and harmful algal blooms. Many small tributary streams in the sub-basin appear seasonally. Altered sediment supply and flows due to upstream dam operations in the Klamath and Trinity Rivers has impacted lower Klamath River fish habitat by simplifying floodplain and channel structure and impairing estuary/mainstem functions.

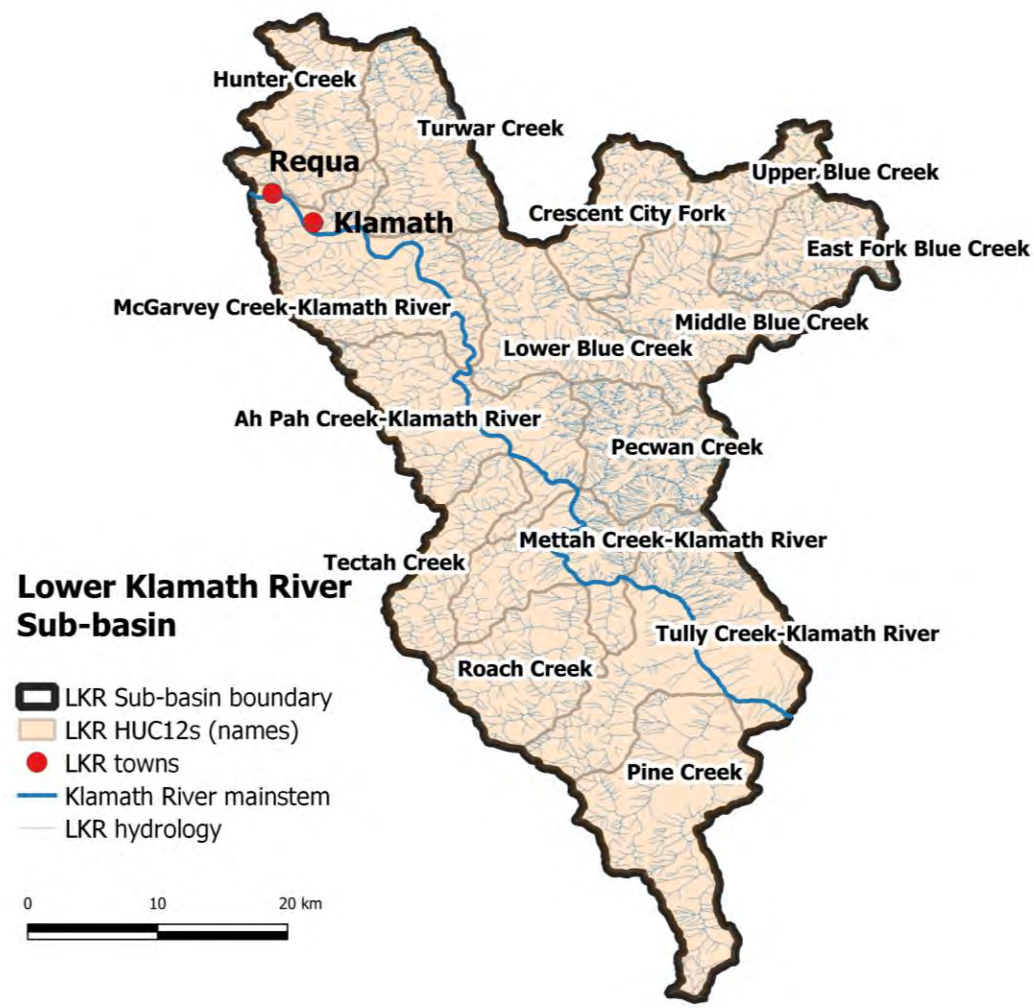


Figure 4-37: Reference map of the Lower Klamath River (LKR) Sub-Basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current:** Chinook Salmon (fall-run and spring-run), Coho Salmon, steelhead (winter-run and summer-run), Pacific Lamprey, Green Sturgeon, and Eulachon

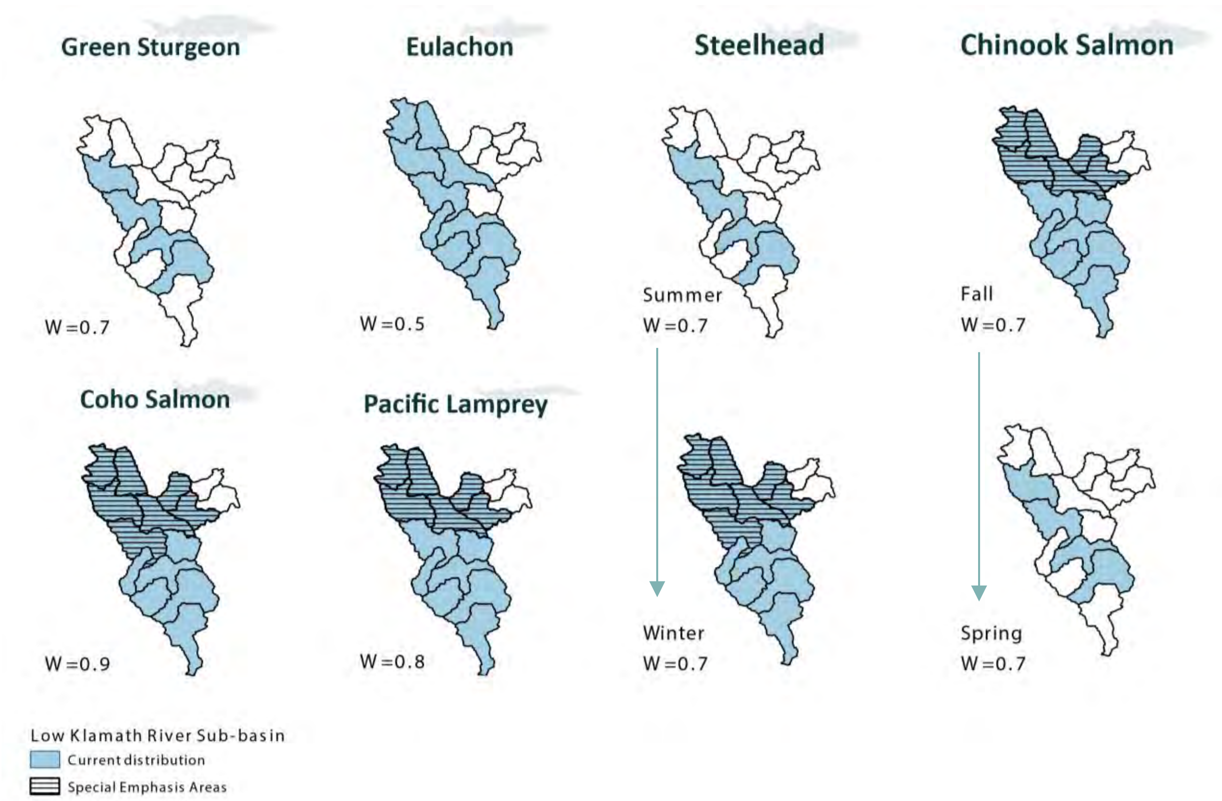


Figure 4-38: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the Lower Klamath River (LKR) sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors:

Table 4-32: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the Lower Klamath River sub-basin (including the Klamath Estuary) listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. CH = Chinook Salmon, CO = Coho Salmon, ST = steelhead, PL = Pacific Lamprey, GS = Green Sturgeon, EU = Eulachon.

Key Stressors	Tier	Stressor Summary for the Lower Klamath River Sub-basin	Species					
			GS	EU	CH	CO	ST	PL
Klamath River Flow Regime	WI	Concerns related to altered hydrologic function and flow timing/magnitude in the lower mainstem Klamath River and estuary due to combined managed water releases from dams in both the Klamath River and the Trinity River.	●	●	●	●	●	●
Fine Sediment Inputs	WI	Many small streams in the sub-basin are 303d listed for sediment (e.g. Terwer, Hunter, McGarvey, Blue Creeks).			●	●	●	○

Key Stressors	Tier	Stressor Summary for the Lower Klamath River Sub-basin	Species					
			GS	EU	CH	CO	ST	PL
Instream Flows (tributaries)	WI	Concerns that the extensive timber road network in the lower basin creates quick flow on road surfaces and cutbanks that causes loss of groundwater and reduces base flows in tributary streams.			●	●	●	●
Water Temperature	H	Elevated water temperatures in the lower Klamath mainstem and in small tributary streams is a concern, as is disconnection from potential thermal refugia.	●	●	●	●	●	○
Contaminated Sediments	H	Concerns that a past legacy of upstream mining and other activities has introduced contaminants to downstream sediments that could be released through bottom disturbance.	●	●	○	○	○	○
Habitat Conditions	H	Physical condition of and water quality within lower Klamath wetlands, sloughs, and off-channel habitats is critical for providing suitable foraging areas for juvenile salmon and other fish (Vanderkooi et al. 2011).	●	●	●	●	●	●

Stressors identified from: NMFS 2014; Yurok Tribal Environmental Program, Sub-regional working group survey responses.

Sequences of Restoration Projects for the Lower Klamath River Sub-Basin

The **summary infographic** in Figure 4-39 provides a compact overview of the Lower Klamath River sub-basin restoration project priorities and their distribution across the sub-basin.

Table 4-33 presents the results of the 2022 iteration of the IFRMP restoration sequencing process for the Lower Klamath River (LKR) sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-33. The projects listed here have a cost range of $5.2M - $10.8M - $16.0M (low, estimated midpoint, high), and have been collated from projects proposed in prior local or regional restoration plans and studies as well as from in-depth discussions among participants in the IFRMP's LKR Sub-basin Working Group who represent scientists, restoration practitioners, and resource users working in the sub-basin (see Acknowledgements section). The sequences and scoring in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria. Additional considerations such as implementability, cost, and dependencies among projects may influence the ultimate sequencing of projects. Any dependencies identified by the Sub-basin Working Group to date are noted in the table. Sequencing of projects will be very important for maximizing benefits in the sub-basin but determining the optimal sequencing steps for multi-project implementation requires further deliberation among the working group.

Figure 4-39: Summary for the Lower Klamath River sub-basin, including key stressors, cost ranges, and projects (next page).

Lower Klamath River Sub-basin

Sub-Basin Summary

The Lower Klamath River sub-basin has a mix of forestry and agriculture use and a legacy of past logging activity that has seriously depleted the riparian wood supply along tributary streams. High nutrient loads from upstream agriculture can be an issue with potential for low dissolved O_2, high pH, high stream temperatures and microcystin blooms. Many small tributary streams in the sub-basin are seasonally intermittent. Altered sediment supply and flows due to upstream dam operations in the Klamath and Trinity Rivers has impacted lower Klamath River fish habitat by simplifying floodplain and channel structure and impairing estuary/mainstem functions.

Restoration Summary

Projects that rated most highly in the IFRMP Tool were consistent with addressing the lack of riparian wood supply, with the highest ranked projects being those focused on improving physical instream habitat quality through installation of wood and other structures to slow down water flows (Projects 11 and 10), mechanical restoration to establish reconnections to thermal refugia within temperature sensitive streams (Project 6), and enhancement and protection of stream riparian vegetation through riparian planting efforts on logged streams (Project 7) and removal of grazing feral cattle (Project 13).These should be considered among the top group of restoration projects to be considered first for implementation.

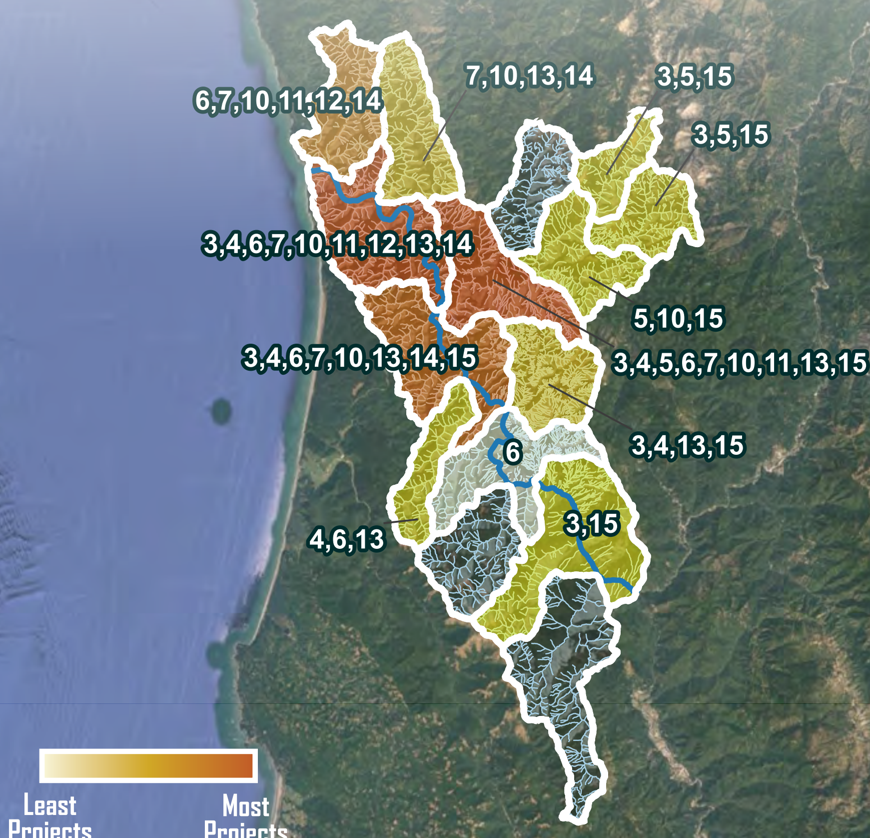
Projects ranked as of more intermediate importance related to removing non-native estuary plants, conducting juvenile fish rescues and relocations, and road decommissioning or improvement to reduce sediment inputs and promote hydrologic restoration. Projects ranking lower focused on forest management to maintain prairie habitats and restricting forest harvest to protect the few remaining tracts of undisturbed riparian.

Key Stressor Summary

Key Stressors	Focal Species					
	GS	EU	CO	CH	ST	PL
Klamath River Flow Regime						
Fine Sediment Inputs						
Instream Flows (tributaries)						
Water Temperature						
Contaminated Sediments						
Habitat Conditions						

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is $5.2M - $10.8M - $16.0M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP LKR sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting, and **arrows** indicate linkages between projects.

Project ID & Description	Tiers
LKR 11 - Install BDAs in key tributaries in the Lower Klamath to promote increased base flows and provide improved rearing habitats | **25.2**	H, WI
LKR 7 - Plant riparian vegetation along key Lower Klamath River tributaries to reduce water temperatures | **24.9**	H, FG
LKR 6 - Increase habitat connectivity and enhance floodplain habitats in key Lower Klamath River streams | **23.6**	H, FG
LKR 10 - Install LWD to increase floodplain connectivity and provide cover for spawning and rearing fish in key Lower Klamath River tributaries | **23.1**	H, FG
LKR 3_4 - Upland road decommissioning and drainage system improvements to reduce sediment inputs and promote hydrologic restoration throughout the Lower Klamath River Sub-basin | **23.0**	FG, WI
LKR 13 - Remove feral cattle from key Lower Klamath River tributaries where wild herds exist | **18.4**	FG, WI
LKR 12 - Remove non-native estuary plants from key Lower Klamath River estuary and off-estuary tributary habitats | **16.1**	FG
LKR 14 - Conduct juvenile fish rescues and relocation in key Lower Klamath River tributaries prone to seasonal drying | **15.2**	FP
LKR 15 - Seek opportunities to conduct thinning of forest stands and cultural and prescribed burns to restore historic prairie habitats within key Lower Klamath River tributary watersheds | **10.1**	WI

To facilitate consistent comparison across the sub-basins, results in Table 4-33 are shown for the Lower Klamath River sub-basin assuming a scenario where the four major Klamath mainstem dams have been removed, but no other significant changes from current conditions in the Klamath Basin. The Sub-basin Working Group identified the following additional scenarios with the potential to influence restoration priorities in the Lower Klamath River sub-basin. Should any these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

- Extirpation of focal fish species from the system
- Persistent drought
- Change in land ownership (Tribal vs. commercial timber)
- Large scale storm event (e.g. 1000 year flood)
- New legislation

A diverse variety of projects was identified by the working group for improving habitat conditions in the Lower Klamath River sub-basin. The Sub-basin Working Group noted that a legacy of past logging has seriously depleted wood supply in tributary streams throughout the sub-basin. Projects that rated most highly in the IFRMP Tool were consistent with addressing this general restoration need:

- **Projects 11, 7, 6, 10, and 3_4** which focus on improving physical instream habitat quality through installation of wood or other structures to slow down water flows, enhancement and protection of stream riparian vegetation through riparian planting efforts on logged streams, increased habitat connectivity, installation of LWD, and upland road decommissioning and drainages to promote hydrologic processes. These projects should be considered among the top group of restoration projects to be considered first for implementation.

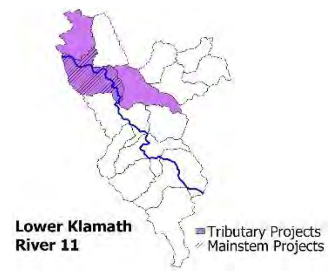
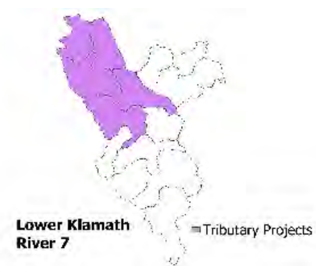
Projects ranked as of more intermediate restoration importance included:

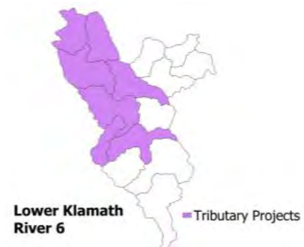
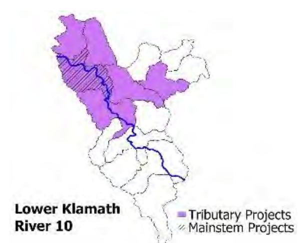
- **Projects 13, 12, and 14** which cover a range of mitigations/restorations related to removal of feral cattle from key tributaries, removing non-native estuary plants, and conducting juvenile fish rescues and relocations.

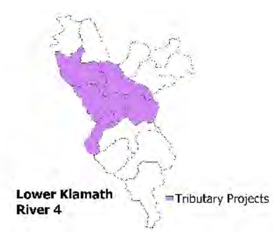
The lowest ranking restoration projects in the Lower Klamath River sub-basin were:

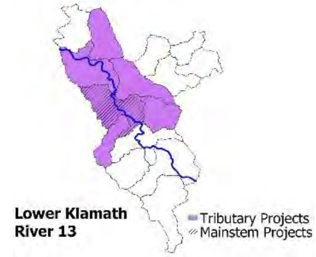
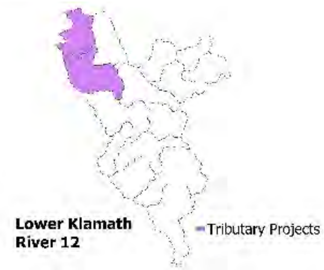
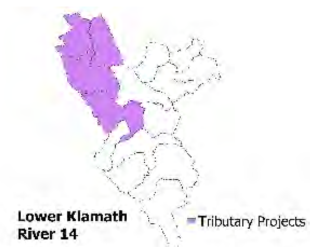
- **Projects 15** which focuses on forest management to maintain prairie habitats.

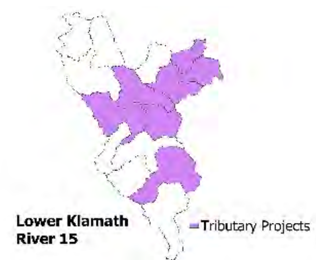
Table 4-33: Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the Lower Klamath River (LKR) sub-basin, with projects scored higher to be considered first for implementation. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name. Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-37, while special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin IFRMP planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.5)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
LKR 11 (25.2)	**Install BDAs in key tributaries in the Lower Klamath to promote increased base flows and provide improved rearing habitats.** **Project Description:** Install beaver dam analogues (BDAs) in lower gradient, Lower River streams to provide summer and winter rearing opportunities for juvenile salmonids, specifically in McGarvey, Salt, Hoppaw, Mynot, Terwer, Waukell Creeks (SONCC Recovery Plan, NMFS 2014; USBOR 2018). **Dependencies / Project Linkages:** BDAs and project sequencing should be considered alongside other methods targeting instream flows, such as floodplain reconnection or installation of large wood jams, which may decrease stream power and improve success and longevity of BDAs and vice versa. **Primary Action Types:** Beavers & beaver dam analogs **Near-Term Focal Areas (and average CPI scores):** Covers 3 sub-watersheds – Lower Blue Creek**, Hunter Creek**, McGarvey Creek-Klamath River** **Cost range ($K):** $190 – 367 – 543 (based on cost data from MKR, Scott, Trinity) 	6	4.13	7.76	3.5	3.81
LKR 7 (24.9)	**Plant riparian vegetation along key Lower Klamath River tributaries to reduce water temperatures.** **Project Description:** Plant riparian vegetation in key Lower Klamath tributaries to protect and enhance vitally important riparian forests for increased shade benefits (i.e. reduction in solar heating). **Dependencies / Project Linkages:** Riparian planting success may be improved following implementation of actions LKR6, LKR10, and LKR11 **Primary Action Types:** Riparian planting **Near-Term Focal Areas (and average CPI scores):** Covers 5 sub-watersheds – Lower Blue Creek**, Ah Pah Creek-Klamath River**, Turwar Creek**, Hunter Creek**, McGarvey Creek-Klamath River** **Cost range ($K):** $125 – 138 – 150 (based on cost data from Shasta, UKR) 	5.02	2.94	6.46	3.5	7

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.5)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
LKR 6 (23.6)	**Increase habitat connectivity and enhance floodplain habitats in key Lower Klamath River streams.** **Project Description:** Mechanical restoration (e.g., adjusting bed/bank elevations or installing in-channel features) / reconnection of aquatic habitats in lower Klamath streams to improve fish access to and enhancement of vital habitats such as thermal refugia, velocity refugia, floodplain and off-channel habitats (e.g., wetlands, alcoves, side channels, and back-water pools), and other spawning or rearing zones. **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Mechanical channel modification and reconfiguration, Water quality project (general) **Near-Term Focal Areas (and average CPI scores):** Covers 7 sub-watersheds – Hunter Creek, Lower Blue Creek**, Mettah Creek-Klamath River**, Tectah Creek**, Ah Pah Creek-Klamath River**, McGarvey Creek-Klamath River**, Turwar Creek**  **Cost range ($K):** $3,012 – 6,274 – 9,148 (based on cost data from Trinity, MKR, Scott, UKR)	**4.55**	**2.52**	**9**	**3.5**	**4.06**
LKR 10 (23.1)	**Install LWD to increase floodplain connectivity and provide cover for spawning and rearing fish in key Lower Klamath River tributaries.** **Project Description:** Install complex wood jams in mainstems, side channels, and off channel ponds in Klamath River and all anadromous Lower River tributaries (especially Hunter, Turwar, McGarvey, Blue, Ah Pa, Bear, and Tectah Creeks) (SONCC Recovery Plan, NMFS 2014; Beesley and Fiori, 2016) to provide rearing and spawning cover for fish, increase floodplain connectivity, improve protection of riparian forests and enhance carbon sequestration. **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Addition of large woody debris **Near-Term Focal Areas (and average CPI scores):** Covers 6 sub-watersheds – Middle Blue Creek**, Lower Blue Creek**, Ah Pah Creek-Klamath River**, Turwar Creek**, Hunter Creek**, McGarvey Creek-Klamath River**  **Cost range ($K):** $450 – 975 – 1,500 (based on cost data from Trinity)	**4.57**	**2.28**	**7.76**	**3.5**	**4.96**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.5)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
LKR 3_4 (23.0)	**Upland road decommissioning and drainage system improvements to reduce sediment inputs and promote hydrologic restoration throughout the Lower Klamath River sub-basin.** **Project Description:** Prioritize and implement upland road decommissioning in Lower Klamath River tributaries to reduce sediment delivery impacts (from both fine and coarse grained materials) and promote hydrological restoration (especially for Ah Pah, Surpur, Pecwan, Blue, McGarvey, Hoppaw, Mynot, Hunter, Turwar, and Tarup creeks) (McEwan et al. 1996; Fesenmeyer et al. 2013; as noted by participants at IFRMP Workshop 2018). Remove cut banks and other hydrologic alterations resulting from the extensive timber road network in the sub-basin to reduce quick flow on road surfaces and prevent the loss of ground water through cut banks to help recharge the mountain aquifers and help boost base flow (Yurok Tribe pers. comm.). Drainage improvements to non-forestry roads should also be considered (e.g. Klamath Beach Road, Resighini Rancheria pers. comm.). **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Road closure / abandonment, Road drainage system improvements and reconstruction **Near-Term Focal Areas (and average CPI scores):** Covers 8 sub-watersheds – East Fork Blue Creek, Upper Blue Creek, Lower Blue Creek**, Pecwan Creek, Tectah Creek**, Ah Pah Creek-Klamath River**, McGarvey Creek-Klamath River**, Tully Creek-Klamath River**  **Cost range ($K):** $914 – 1,900 – 2,886 (based on cost data from MKR, Trinity)	**1.41**	**1.49**	**8.09**	**5.25**	**6.79**
LKR 13 (18.4)	**Remove feral cattle from key Lower Klamath River tributaries where wild herds exist.** **Project Description:** To improve riparian habitat function (i.e. regrowth of impacted native shrubs and trees, increased canopy coverage & future wood recruitment) and decrease water quality impacts (i.e. reduce sediment and fecal inputs) remove feral cattle throughout the Lower Klamath sub-basin where herds exist, with priority areas for removal being Blue Creek, Bear Creek, Pecwan Creek, Terwer Creek, and Tectah Creek (S. Beesley, pers. Comm.). The Yurok Tribe Wildlife Department is currently working to assess feral cattle populations throughout the Lower Klamath and are currently conducting various removal efforts. **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Remove feral cattle	**3.68**	**2.11**	**5.59**	**3.5**	**3.56**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.5)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
	Near-Term Focal Areas (and average CPI scores): Covers 6 sub-watersheds – Lower Blue Creek, Pecwan Creek**, Tectah Creek, Ah Pah Creek-Klamath River**, Turwar Creek**, McGarvey Creek-Klamath River** **Cost range ($K):** no cost data available (no cost data for "remove feral cattle") 					
LKR 12 (16.1)	**Remove non-native estuary plants from key Lower Klamath River estuary and off-estuary tributary habitats.** **Project Description:** Remove non-native estuary vegetation such as Reed Canary Grass from Salt, Panther, and Waukell Creeks (Yurok Tribe communication). **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Estuarine plant removal / control **Near-Term Focal Areas (and average CPI scores):** Covers 2 sub-watersheds – Hunter Creek**, McGarvey Creek-Klamath River** **Cost range ($K):** no cost data available (no cost data for "estuarine plant removal / control") 	5.26	5	0.9	3.5	1.48
LKR 14 (15.2)	**Conduct juvenile fish rescues and relocation in key Lower Klamath River tributaries prone to seasonal drying.** **Project Description:** To increase juvenile salmonid survival in priority areas of the Lower Klamath (i.e. McGarvey Creek, Hunter Creek, Terwer Creek, and Ah Pah Creek) conduct seasonal fish rescues using juvenile salmonid capture techniques (e.g. fyke/seine nets, electrofishing equipment) to collect juvenile salmonids from drying habitats and relocate them to perennial habitats capable of supporting additional fish (S. Beesley, pers. Comm.). Care must be taken to reduce travel time for rescued fish and to maintain adequate DO levels and water temperatures during their travel. Survival of rescued fish should be assessed whenever feasible to help document the effectiveness of this approach. **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Fish translocation 	5.34	3.47	2.22	3.5	0.7

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.6)*	CPI Status *(0.5)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.7)*	Implementability *(0.7)*
	Near-Term Focal Areas (and average CPI scores): Covers 4 sub-watersheds – Ah Pah Creek-Klamath River**, Turwar Creek**, Hunter Creek**, McGarvey Creek-Klamath River** **Cost range ($K):** no cost data available (no cost data for "fish translocation")					
LKR 15 (10.1)	**Seek opportunities to conduct thinning of forest stands and cultural and prescribed burns to restore historic prairie habitats within key Lower Klamath River tributary watersheds.** **Project Description:** To reduce risk of catastrophic wildfire and potentially reduce upslope water demands and/or loss via evapotranspiration of young, overcrowded forest stands conduct forest thinning, cultural and prescribed burns, and/or restore historic prairie habitats that had been converted to timberlands throughout the Lower Klamath, with priority areas including Blue Creek, Bear Creek, and Pecwan Creek where the Yurok Tribe has ownership and desire to conduct this type of work (S. Beesley, pers. Comm.). **Dependencies / Project Linkages:** No dependencies indicated **Primary Action Types:** Upland vegetation management,fuel reduction, burning **Near-Term Focal Areas (and average CPI scores):** Covers 7 sub-watersheds – East Fork Blue Creek, Upper Blue Creek, Middle Blue Creek**, Lower Blue Creek**, Tully Creek-Klamath River**, Pecwan Creek, Ah Pah, Creek-Klamath River** **Cost range ($K):** $75 – 200 – 513 (based on cost data from MKR, Trinity)  	**0.6**	**0.5**	**1.77**	**5.25**	**1.94**

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC and SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, and sub-regional working group input via surveys and webinars.

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the Lower Klamath River Sub-basin

Coho Salmon, and Eulachon are of the greatest immediate conservation concern in this sub-basin as all are federally ESA listed as Threatened. ***Chinook, steelhead, Pacific Lamprey, and Green Sturgeon*** populations are also of significant conservation concern as these are Tribal Trust species that have experienced notable long-term declines in the Basin. All anadromous fish populations must at least pass through the estuary and lower basin as part of their lifecycles and the Lower River is considered to serve an essential role to many Klamath River fish as nursery and rearing habitat.

The federally listed SONCC ESU of ***Coho Salmon*** is a key species identified for many restoration actions in the lower Klamath (NMFS 2014). The Yurok Tribal Fisheries Department's (YTFD) Lower Klamath Program has a major focus on restoring mainstem, estuary, and tributary habitats in the Lower Klamath River sub-basin. The program identifies factors currently limiting salmonid production and integrates past and present data to further develop meaningful process-based restoration in the Lower Klamath River sub-basin.

The following table summarizes selected major restoration activities in this sub-basin and those species which these activities have benefited.

Table 4-34: Summary of major restoration efforts in the Lower Klamath River sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit.

Key Restoration Activities in the Lower Klamath River Sub-basin to Date	Species Benefiting					
	CO	CH	ST	*PL*	*EU*	*GS*
The Yurok Tribe's Lower Klamath Restoration Plan guides restoration actions in the lower basin and has focused on watershed assessment and process-based approaches to lower basin restoration such as riparian planting, instream structure placement, road-crossing removals, and road improvement or decommissioning within priority Lower Klamath tributaries (Gale and Randolph 2000).	●	●	●	●		
The Yurok Tribe's Lower Klamath Division of Fisheries (with Fiori GeoSciences) has conducted extensive wood loading (i.e. installation of constructed/engineered log jams and whole tree materials) within Hunter, Turwar, McGarvey, and Tectah Creeks (Beesley and Fiori 2009, 2012, 2013a,b,c, 2018, 2019, Gale 2008, Gale 2009, Yurok Tribal Fisheries Program 2010).	●	●	●	●		
The Yurok Tribe has recently implemented riparian habitat restoration along Turwar, McGarvey, and Hunter Creeks, key Lower Klamath tributaries that have been heavily impacted by historic logging and road-building (Hiner et al. 2011, Yurok Tribal Fisheries Program 2011).	●	●	●	●		
From 2010-2016, the Yurok Tribal Fisheries Department (YTFD) (with Fiori GeoSciences) constructed eight off-channel habitat features within priority Lower Klamath tributaries (Beesley and Fiori 2012, Beesley and Fiori 2016).	●	●	●	●		
In August 2019, 50,000 acres of forest surrounding four tributary streams in the Lower Klamath (including Blue Creek) were acquired from Green Diamond Resource Company and placed into Yurok Tribal ownership for the establishment of a Blue Creek Salmon Sanctuary. In addition to Blue Creek, parcels in the Pecwan, Ke'pel and Weitchpec Creek drainages are included in the project. The latter three properties will become part of the Tribe's Community Forest (Lost Coast Outpost Newsletter 2019).	●	●	●	●		

Current State of Monitoring & Data Gaps

Past and Ongoing Monitoring:

The USFWS funds Tribal and agency research and monitoring for anadromous fish restoration in the Klamath Basin, which includes both habitat and population monitoring. Since the late 1990s, the Yurok Tribal Fisheries Department's (YTFD) Lower Klamath Program has conducted thorough watershed and physical habitat assessments to guide watershed restoration and species recovery efforts in the Lower Klamath River. As part of the program, YTFD monitors salmonid smolt outmigration in Blue Creek (1999-present) and McGarvey Creek (1997-present) and conducts late fall Chinook spawner surveys in Blue Creek (1999-present). Additionally, YTFD and the Karuk Tribe are the leads on the Klamath Coho and Salmon Ecology Study (2006-present). This study assesses Coho Salmon life history patterns, habitat use, growth, survival, movement, distribution, and other parameters throughout the Mid- and Lower Klamath Sub-regions. The partnership has grown to include various other state and federal agencies and NGOs, including the Scott River Watershed Council and has led to the development of the Klamath Basin Pit Tag Database. These efforts grew out of the Lower Klamath Sub-basin Watershed Restoration Plan, which prioritized upslope restoration and identified tributary-specific restoration objectives for each Lower Klamath tributary (Gale and Randolph 2000). Using the habitat assessment data, YTFD works closely with the California Department of Fish and Wildlife (CDFW) and the National Marine Fisheries Service (NMFS) to identify, implement, and assess priority SONCC Coho Salmon recovery actions for the sub-basin (CDFW 2004; NMFS 2014). Since the early 2000s, Yurok Fisheries staff also conduct summer monitoring of thermal refugia in the Lower Klamath River sub-basin and complete periodic surveys that note use of refuge areas by juvenile and adult salmonids. This information permits identification of temperature thresholds leading to the use of thermal refugia and enables monitoring of fish behavior at thermal refuge areas during warm summer months. The Yurok Tribe Environmental Program (YTEP) monitors nutrients, phytoplankton (including toxic cyanobacteria for public health purposes), and continuous water quality (water temperature, D.O., pH, and conductivity) at several sites on the lower mainstem Klamath River (YTEP 2013a, b). YTEP also operates streamflow gauges in several lower Klamath tributaries.

Current Data Gaps:

Figure 4-40 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken across agencies in the Lower Klamath River sub-basin. Location-specific agency metadata (where available[20]) on monitoring projects is incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. Habitat monitoring appears generally well covered in the Lower Klamath River sub-basin, with gauging in place for water quality, flow and sediment monitoring in the mainstem and an extensive network of monitoring sites for water temperature in the Klamath mainstem and Lower River tributary streams. More detailed habitat assessment is well coordinated by the Yurok Tribal Fisheries Program. Current monitoring gaps relate principally to detailed assessment of habitat dynamics within the Klamath River estuary and evaluations of the full extent of use of habitats by the different fish species rearing or migrating through the estuary.

[20] Note that only some available information on past monitoring activities across sub-basins provides specific location information (i.e. beyond indicating that it occurs somewhere within a sub-basin) and can be found in existing spatially-referenced databases that would allow for reliable transfer to the project's Integrated Tracking Inventory.

Lower Klamath River Sub-basin Monitoring Summary

Habitat Monitoring	Watershed Inputs	Weather	●
		Streamflow	●
		Groundwater	●
		Riparian & Landscape	●
	Fluvial-Geomorph	Sediments & Gravel	●
		Stream Morphology	●
	Habitat	Stream Temperature	●
		Water Quality	●
		Habitat Quality	●
		Barriers & Injury	●
		Marine/Estuary	●
	Biota	Invasive Species	●

			Eulachon	Green Sturgeon	Salmon / Steelhead	Pacific Lamprey
Population Monitoring	Abundance	Juvenile Abundance (anad)			●	
		Spawner Abundance (anad)			●	
		Abundance (non-anad)	NA	NA	NA	NA
	Harvest	Harvest (in-river)		●	●	○
		Harvest (ocean)				
	Distrib-ution	Temporal Distribution	●	●	●	●
		Spatial Distribution	●	●	●	●
	Demo-graphics	Stock Composition			●	
		Age Structure			●	
	Biota	Disease			●	

● Known monitoring activities (past or ongoing)
NA Monitoring not relevant to this sub-basin

Figure 4-40. Synthesis of past and ongoing monitoring activities in the Lower Klamath River sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017, Section 2.5, Appendix H):

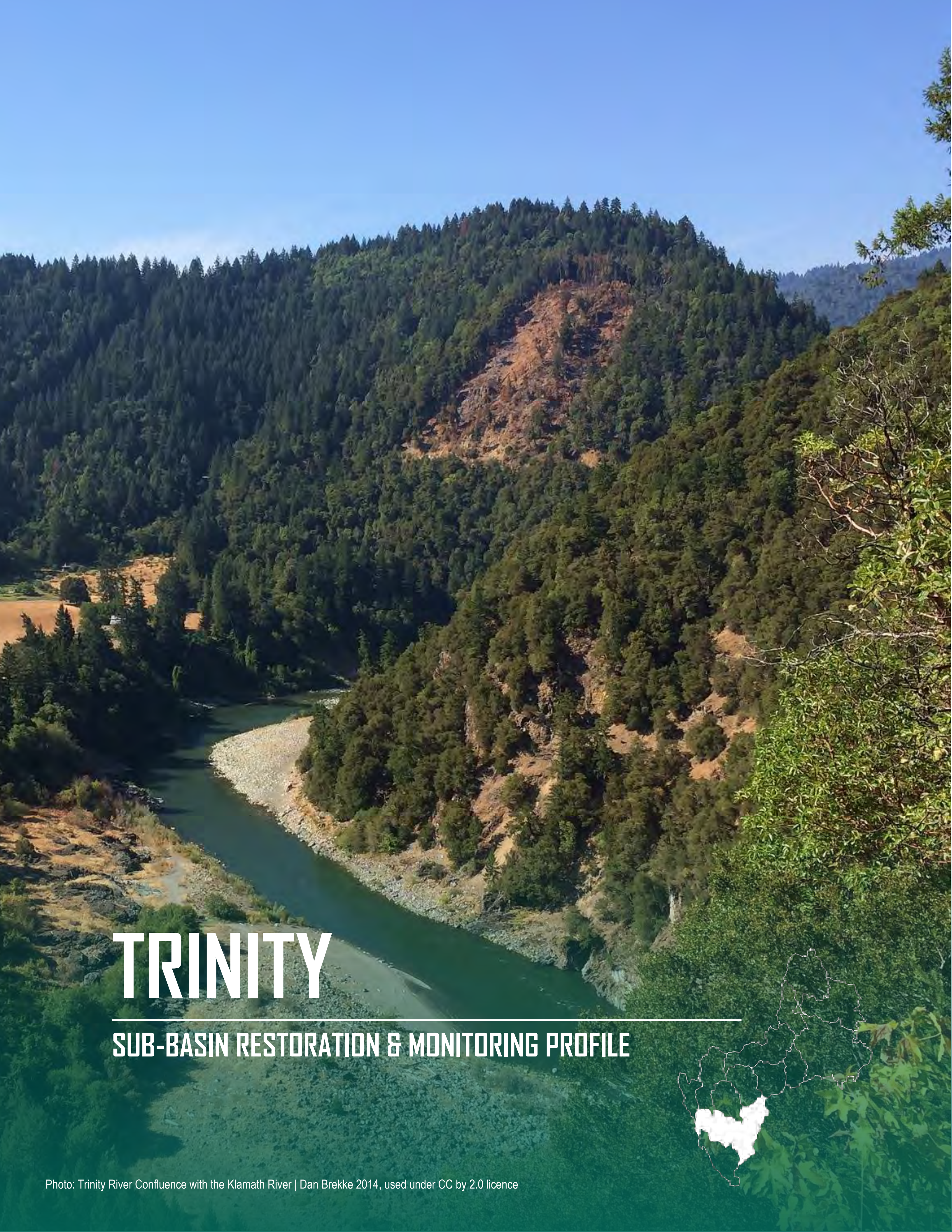
- Blue Creek Sanctuary and Yurok Community Forest Conservation and Management Plan. Yurok Tribe and Western Rivers Conservancy (Yurok Tribe 2015)
- Blue Creek Sanctuary & Yurok Community Forest Phase II: Management Requirements, Use Restrictions, and Management Activities/Work Plan. Yurok Tribe and Western Rivers Conservancy (Yurok Tribe 2018)
- Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)
- Habitat Assessment and Restoration Planning in the Salt Creek Watershed, Lower Klamath River sub-basin, California (Beesley and Fiori 2004)

- Green Diamond Resource Company Aquatic Habitat Conservation Plan and Candidate Conservation Agreement with Assurances (applied to privately owned land in the Lower Klamath sub-basin) (Green Diamond Resource Company 2006)
- Cooperative Restoration of Tribal Trust Fish and Wildlife Habitat in Lower Klamath River Tributaries (Yurok Tribal Fisheries Program. Beesley and Fiori 2008)
- Restoration Planning in Lower Blue Creek, Lower Klamath River: Phase I (Yurok Tribal Fisheries Program. Beesley and Fiori 2008b)
- Instream Habitat Enhancement of Tectah Creek, Lower Klamath River: Year 1 (Yurok Tribal Fisheries Program. Beesley and Fiori 2009)
- Lower Klamath River Sub-basin Watershed restoration Plan (Yurok Tribal Fisheries Program. Gale and Randolph 2000)
- Restoration and Feasibility Planning in Blue Creek, Lower Klamath River (Yurok Tribal Fisheries Department. Beesley and Fiori 2020)
- Lower Blue Creek Restoration Planning and Basis of Design Report: Fall 2021 (Yurok Tribal Fisheries Department. Beesley and Fiori 2021).
- Feral Cattle Management Plan (Yurok Tribe Wildlife Department 2020).
- Yurok Tribe Environmental Program Wetlands Program Plan (YTEP 2013c)
- Partners for Fish and Wildlife & Coastal Programs Strategic Plan – California/Nevada Operations incl Klamath Basin (USFWS 2012)
- Klamath River Basin Conservation Area Restoration Plan (in fulfillment of the Klamath Act) (USFWS 2006)
- Work Plan for Adaptive Management, Klamath River Basin Oregon & California (USDA-NRCS 2004)
- Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River (BOR 2017)
- Steelhead Restoration and Management Plan for California (CDFW 1996)
- Recovery Strategy for California Coho Salmon (CDFW 2004)
- Klamath Hydroelectric Settlement Agreement (KHSA) (2010, Amended 2016)
- Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (SONCC) (National Marine Fisheries Service, Arcata, CA, 2014)
- Endangered Species Act Recovery Plan for the Southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*) (NMFS 2016)
- North Coast Regional Water Quality Control Board Watershed Planning Chapter – Klamath Watershed Management Area (CA NC RWQCB 2011)
- Klamath Basin Water Quality Monitoring Plan (KBMP 2016)
- Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife (in draft form at the time of writing)

Forthcoming plans and initiatives affecting this sub-basin are under development, have recently been completed, or will soon proceed to implementation and will contribute to meeting overall restoration needs in this area. These include:

- Coastal Resource Planning within the Klamath River Estuary is being developed by the Yurok Tribe to assist the Tribe with coastal resource and climate change adaptation planning for the Klamath River Estuary (Lowe et al. 2018).

- Fisheries Restoration Planning for the Resighini Rancheria: Junior Creek Watershed is an ongoing project to investigate baseline conditions and restoration potential in Junior Creek and Waukell Creek watersheds (Voight et al. 2021)



TRINITY

SUB-BASIN RESTORATION & MONITORING PROFILE

Photo: Trinity River Confluence with the Klamath River | Dan Brekke 2014, used under CC by 2.0 licence

4.5.2 Trinity Sub-basin

The Trinity sub-basin has been significantly altered by a wide range of human activities. Of note are the Lewiston and Trinity Dams completed in 1964, which are impassible to anadromous fish and prevent access to over 100 miles of historical habitat in the upper Trinity River. The dams have also substantially altered the hydrology of the system. For 36 years, as much as 90% of the river's water was diverted by these dams to California's Central Valley for agriculture. The dams created direct impacts on salmon populations due to low flows and high temperature, while the lack of flows sufficient to move sediment also resulted in channelization and a loss of floodplain and off-channel habitat (USFWS and HVT 1999). There were also substantial historical impacts in the sub-basin associated with gold and placer mining, timber harvest, roads, and agriculture. Legacy mining impacts exist today, including contaminants and levees which add to the channel confinement issues in the Trinity. There is still timber harvest activity throughout the watershed although roughly 78% of the Trinity is under Federal management as part of the Shasta-Trinity National Forest, (NMFS 2014) which encompasses nearly the entire Trinity River watershed with the exception of private inholdings and a small area in Humboldt County. Agriculture is more prevalent in the lower sub-basin and recreational activities such as rafting and fishing are prevalent in the upper portion (NMFS 2014).

The Trinity River was officially designated a Wild and Scenic River in 1981. In 2000 a Record of Decision (ROD) was signed which included a suite of actions: increased flow regime, mechanical channel rehabilitation, sediment management, and watershed restoration. The Trinity River Restoration Program (TRRP) was born of the ROD and employs Adaptive Management as a fundamental principle. A unique aspect of this sub-basin is the cold-water reservoir above Trinity River Dam which may be used to help achieve temperature targets for salmonids in the Trinity River, Klamath River, and Sacramento Rivers. Use of the reservoir in this way depends on a sufficient volume of water and may be threatened if there are too many dry years in a row.

Figure 4-41: Reference map of the Trinity Sub-Basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current:** Green Sturgeon, Chinook Salmon (fall-run and spring-run), Coho Salmon, steelhead (spring/summer and winter-run), Pacific Lamprey
- **Historical:** All the current populations are extirpated above Lewiston Dam: Green Sturgeon, Chinook Salmon (fall-run and spring-run), Coho Salmon, steelhead (spring/summer and winter-run), Pacific Lamprey

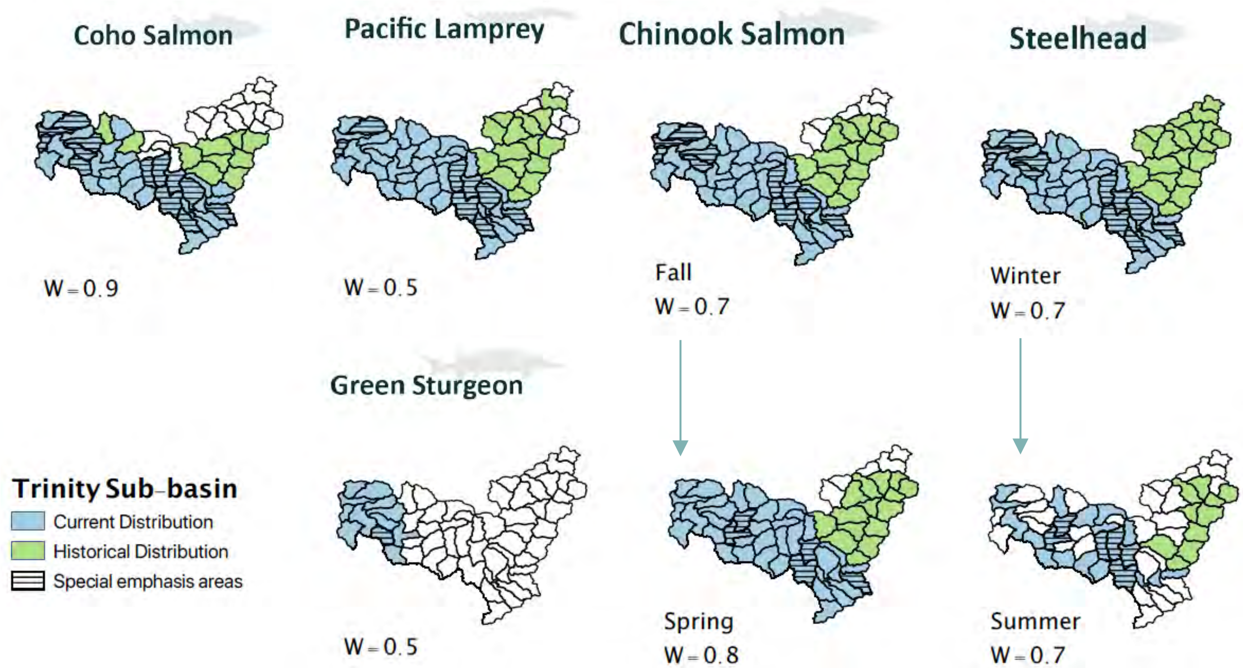


Figure 4-42: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the Trinity sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors

Table 4-35: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the Trinity sub-basin listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. GS = Green Sturgeon, CH = Chinook Salmon, CO = Coho Salmon, ST = steelhead, PL = Pacific Lamprey.

Key Stressors	Tier	Stressor Summary for the Trinity Sub-basin	Species				
			GS	CH	CO	ST	PL
Trinity River Flow Regime	WI	The construction of Trinity and Lewiston dams in the early 1960s and water diversion to the Sacramento Valley had major impacts on the flow and function of the Trinity River. The 2000 ROD (USDI 2000) provides for implementation of a variable annual flow regime from the dams to	●	●	●	●	●

Key Stressors	Tier	Stressor Summary for the Trinity Sub-basin	Species				
			GS	CH	CO	ST	PL
		maintain conditions for fish in Trinity River below the dams. However, roughly half of the mainstem Trinity River flow is diverted to the Sacramento River Valley and remaining flows and variability are reduced downstream of the Trinity dam.					
Instream Flows (tributaries)	WI	There are many stream diversions in the Trinity sub-basin for human uses that can reduce baseflows in the summer and fall. There are almost 400 diversions listed in CDFG's Fish Passage Assessment Database (CalFish), and this does not include unpermitted or illegal diversions or groundwater use. Many streams are impacted by illegal diversions and water use for marijuana cultivation, which has a growing and substantial impact to streamflow in the area.		●	●	●	●
Channelization	FG	Diking and channelization in many streams has reduced habitat complexity, connectivity with the floodplain, and increased water velocity. Historic floodplains in the area have been disconnected from tributary streams and converted to agricultural, grazing, or residential lands.		●	●	●	●
Decreased Coarse Sediment Delivery	FG	Changes in coarse sediment supply, storage, and transport, in combination with altered mainstem flow, which resulted from construction of the Trinity River Dam, and caused alterations to the channel geomorphology of the lower Trinity River. Larger particles that were commonly transported during pre-dam floods were no longer mobilized, such that only finer gravels and sands were transported downstream (USFWS and HVT 1999). This has caused the riverbed to become armored. Despite flow re-regulation, processes associated with geomorphic self-sustainability have been severely altered.	●	●	●	●	○
Increased Fine Sediment Input	FG	Water quality of the Trinity River is 303d listed as sediment impaired throughout its length by the California State Water Resources Control Board. Most fine sediment in the tributaries originates from roads and landslides. The mainstem has an oversupply of sediments from a mix of past hydraulic mining, dredging, timber harvest, and road building.	●	●	●	●	
Anthropogenic Barriers*	H	The Trinity and Lewiston Dams completely block access to fish habitats in the upper basin. Lewiston Dam is now the upper limit of anadromous fish migration on the Trinity River. The loss of this habitat has led to reliance on a limiting amount of spawning and rearing habitat downstream. Additionally, many road-related barriers preclude access to potential Coho Salmon habitat. The total extent of impact from barriers on tributary streams is largely unknown due to the large number of private diversions in the sub-basin, but the potential impact could be significant.	●	●	●	●	●
Water Temperature *	H	Mainstem and tributary habitats are often impaired by high summer temperatures and thermal barriers that restrict access to refuge areas. Releases from Lewiston Dam to support NCRWQCB and ROD temperature criteria have substantially improved conditions in the lower mainstem river (USFWS and HVT 1999). However, these criteria do not prohibit temperature increases after July 9 (or June 15 in Dry and Critically Dry Water Years). NCRWQCB temperature targets for rearing salmonids take effect after July 1st and are located in above the North Fork Trinity	●	●	●	●	●

Key Stressors	Tier	Stressor Summary for the Trinity Sub-basin	Species				
			GS	CH	CO	ST	PL
		River confluence, these are adopted by the ROD. Additional targets for outmigration prior to July 9th, are also established in the ROD. There is also extreme hypolimnal thermal pollution that is experienced below the dams. In many years the water temperature is <50 F0 in May, which can suppress growth in the Upper River during the critical rearing period (Yurok Tribe communication). Temperatures in the mainstem can exceed the thermal tolerances of Coho Salmon in the summer and early fall (USFS 2003) despite base flows in the summer that are now 3-5 time higher than they were historically. The mainstem likely never provided over summering habitat for Coho, excluding thermal refugia, and base flows in winter are 3-5 time smaller than they were historically, providing virtually no seasonally inundated habitats in the Upper River during the early rearing period (Yurok Tribe communication). In some smaller tributary streams, water temperatures can also increase to levels stressful for rearing Coho Salmon in the summer months.					
Instream Structural Complexity	H	Tributary and mainstem habitat complexity is limited by a lack of coarse sediment and wood, modified flows, remnant dredge piles, and impaired riparian function. Fine sediment loading in many streams has also led to the filling of pools, disconnection from the floodplain, and the overall loss of stream complexity.		●	●	●	●
Predation*	BI	Predation and competition from non-native German Brown Trout present in the river below the dams is a concern for native Coho and other salmonids (Alveraz and Ward 2019).		○	○	○	

Stressors identified from: NMFS 2014; Trinity River Restoration Program website (http://www.trrp.net/); Sub-regional working group survey responses.

Sequences of Restoration Projects for the Trinity Sub-Basin

The **summary infographic** in Figure 4-43 provides a compact overview of the Trinity sub-basin restoration project priorities and their distribution across the sub-basin. Table 4-36 presents the results of the 2022 iteration of the IFRMP restoration sequencing process for the Trinity sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-36. The projects listed here have a cost range of $46.9M – $88.9M - $148.4M (low, estimated midpoint, high), and have been collated from projects proposed in prior local or regional restoration plans and studies as well as from in-depth discussions among participants in the IFRMP's Trinity Sub-basin Working Group who represent scientists, restoration practitioners, and resource users working in the sub-basin (see Acknowledgements section). The sequences and scoring in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria. Additional considerations such as implementability, cost and dependencies among projects may influence the ultimate sequencing of projects.

Figure 4-43: Summary for the Trinity sub-basin, including key stressors, cost ranges, and projects (see next page).

Trinity Sub-basin

Sub-Basin Summary

The Trinity River Sub-basin has been substantially altered by a wide range of human activities. Of note are the Lewiston and Trinity Dams completed in 1964. The dams are impassible to anadromous fishes and have also substantially altered fish habitats downstream. In addition to the dams, there have been substantial historical impacts in the sub-basin associated with gold and placer mining, timber harvest, roads, and agriculture. A unique aspect of this sub-basin is the cold-water reservoir maintained above Trinity River Dam which may be used to help achieve temperature targets for salmonids in both the Trinity River and the Sacramento River.

Key Stressor Summary

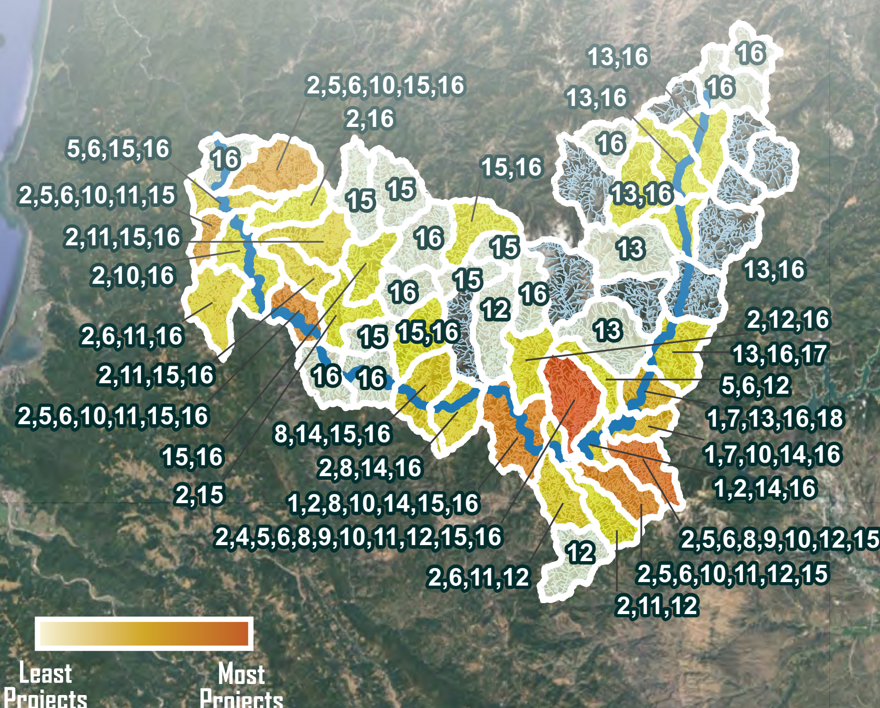
Key Stressors	Focal Species				
	GS	CO	CH	ST	PL
Trinity River Flow Regime	●	●	●	●	●
Instream Flows (Tributaries)		●	●	●	●
Channelization		●	●	●	●
Decreased Coarse Sediment Delivery	●	●	●	●	○
Increased Fine Sediment Inputs	●	●	●	●	
Anthropogenic Barriers	●	●	●	●	●
Water Temperature	●	●	●	●	●
Instream Structural Complexity		●	●	●	●
Predation		○	○	○	

Restoration Summary

Key restoration actions focus on continuing the elements of the Trinity River Restoration Project (TRRP) that include implementing ROD mandated flows from Trinity and Lewiston dams, improving instream flows in tributaries, removing fish passage barriers, undertaking mainstem channel rehabilitation projects, and directly augmenting coarse sediment in the river to increase salmon spawning habitat. Projects identified as priorities by the IFRMP Trinity Sub-basin working group focused on restoring mainstem processes resulting from past anthropogenic disturbances including the Lewiston and Trinity mainstem dams and gold and placer mining were ranked higher by the IFRMP Tool and should be considered among the top group of restoration projects to be considered first for implementation.

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is $46.9M - $88.9M - $148.4M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP Trinity sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting, and **arrows** indicate linkages between projects.

Project ID & Description	Tiers
Trinity 1 - Implement managed flows from Trinity and Lewiston dams, gravel augmentation, and reconnect floodplains by removing levees and constructing off-channel habitats | **26.2**	FG, H, WI
Trinity 5 - Reconnect floodplains in the mainstem Trinity River below the North Fork confluence and key tributaries by removing levees and constructing off-channel habitats | **21.8**	H, FG
Trinity 4 - Maintain flows in Weaver Creek by alternatively using Trinity River to provide summer water to the Weaverville Community Services District | **21.3**	WI
Trinity 6 - Install in-channel structures such as LWD, boulders, etc. to improve fish habitats in priority tributaries | **19.9**	H
Trinity 8 - Implement projects to provide for fish passage at identified priority fish passage barriers across the Trinity River sub-basin | **19.6**	H
Trinity 17_18 - Install temperature control device for Trinity Reservoir and evaluate and develop a new conveyance system from Trinity Reservoir to the Carr tunnels to improve temperature management | **18.6**	
Trinity 16 - Undertake upland vegetation management as needed to thin forest and reduce fuels across the Trinity River sub-basin | **18.5**	WI
Trinity 15 - Translocate beaver and install BDAs to impound water and create seasonal fish rearing habitats in Trinity River tributaries, particularly in the Weaver basin | **16.9**	H, FG
Trinity 2_11 - Implement projects in Trinity River tributary streams to improve flows to decrease water temperatures and increase dissolved oxygen | **16.2**	H, WI
Trinity 14 - Increase Trinity recreational harvest of introduced Brown Trout and adjust hatchery release practices to minimize trout predation on juvenile salmon | **15.6**	BI
Trinity 12 - Stocking of spring Chinook and summer steelhead into Trinity streams where currently extirpated and carcasses where populations still exist | **15.6**	FP
Trinity 7 - Install fish passage infrastructure at Lewiston and Trinity Dams to allow access to upstream habitats | **14.8**	H
Trinity 13 - Stock Trinity and Lewiston lakes to establish landlocked salmon and/or trout runs, using only fish of Trinity Basin genetic stock | **10.1**	FP

Dependencies identified by the Sub-basin Working Groups are noted in the table. Sequencing of projects will be very important for maximizing benefits in the sub-basin but determining the optimal sequencing steps for multi-project implementation requires further deliberation among the working group. To facilitate comparison across the sub-basins, results are shown assuming the four major Klamath mainstem dams have been removed, but no other changes. The Trinity Sub-basin Working Group identified the following additional scenarios of potential interest. Should any these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

- Large flood
- Trinity and Lewiston dam removals
- Extirpation of stocks
- Regulatory actions on cannabis
- Significant increase in water released from Trinity dams

Projects focused on restoring mainstem processes resulting from past anthropogenic disturbances including the Lewiston and Trinity mainstem dams and gold and placer mining were ranked higher by the IFRMP Tool and should be considered among the top group of restoration projects to be considered first for implementation:

- **Projects 1, 5** which focus on Trinity River processes and connectivity were identified as the top priorities for the Trinity sub-basin. Project 1 includes the suite of mainstem actions currently underway through the Trinity River Restoration Program (TRRP) including: managed flow releases, gravel augmentation, and channel reconfiguration in the upper 40 miles of the mainstem Trinity. Related Project 5 identifies opportunities for additional channel reconfiguration in the mainstem below the North Fork confluence and in key tributaries.

These projects were closely followed in ranking by the following second suite of restoration projects focused in tributaries:

- **Projects 4, 6, and 8** which represent a range of action types (maintaining flows at Weaver Creek, installing LWD, and fish passage) at a variety of tributary locations (9, 10, and 5 HUCs per project respectively) within the sub-basin.

Projects ranked as of more intermediate restoration importance included:

- **Projects 17_18, 16, 15, and 2_11** again represent a range of action types (installation of temperature control devices, upland vegetation management, translocate beaver and install BDAs, improve flows and decrease water temperature).

The lowest ranking restoration projects in the Trinity sub-basin were:

- **Projects 14, 12, 7, and 13.** Action types include: increase recreational harvest of Brown Trout and minimize trout predation, stock spring Chinook and summer steelhead, install fish passage at Lewiston and Trinity Dams, and ensure Lewiston and Trinity lakes use stock of Trinity genetic origin.

Table 4-36: Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the Trinity sub-basin, with projects scored higher to be considered first for implementation. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name. Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-41, while special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin IFRMP planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

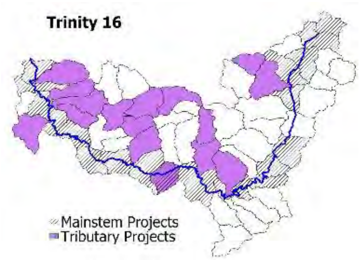
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
Trinity 1** (26.2)	**Implement managed flows from Trinity and Lewiston dams, gravel augmentation, and reconnect floodplains by removing levees and constructing off-channel habitats.** **Project Description:** Implement adaptive management of the Trinity River flows from the Trinity and Lewiston Dams, Coarse sediment augmentation, and reconnect floodplains in the mainstem Trinity River by removing levees and constructing off-channel habitats through implementation of the Trinity River Restoration Program (TRRP) as mandated by the Department of Interior Record of Decision (ROD). The ROD (USDI 2000) proscribes a variable flow regime for the Trinity River mainstem based on five (5) water year types to mimic more natural flows, the long-term augmentation of coarse sediment, and the reconfiguration of the channel at 47 sites. This strategy does not strive to recreate pre-dam conditions; rather, the goal is to create a dynamic alluvial channel exhibiting all the characteristics of the pre-dam river, but at a smaller scale.  **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Manage Dam releases (Trinity and Lewiston Dams), Mechanical channel modification and reconfiguration, Augment coarse sediment, Dike or berm modification / removal **Near-Term Focal Areas (map):** 4 sub-watersheds – Mooney Gulch-Trinity River, Deadwood Creek-Trinity River, Dutton Creek-Trinity River, Conner Creek Trinity River** **Cost range ($K):** **This project refers to the Trinity River Restoration Program (TRRP) which has a separate funding stream. Based on action types, the cost range may be $1,732 – 21,428 – 56,760	**3.21**	**4.19**	**9**	**6**	**3.83**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
Trinity 5 (21.8)	**Reconnect floodplains in the mainstem Trinity River below the North Fork confluence and key tributaries by removing levees and constructing off-channel habitats.** **Project Description:** Undertake actions to reconnect the channel to the floodplain by removing levees and constructing off-channel habitats, backwater habitat, and old stream oxbow in key tributary streams. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Mechanical channel modification and reconfiguration, Dike or berm modification / removal **Near-Term Focal Areas (and average CPI scores):** Covers 8 sub-watersheds – Rush Creek, Grass Valley Creek**, Indian Creek, Weaver Creek**, Sharber Creek-Trinity River**, Supply Creek**, Mill Creek**, Soctish Creek-Trinity River**  **Cost range ($K):** $963 – 3,120 – 6,510	4	2.78	6.26	6	2.79
Trinity 4 (21.3)	**Maintain flows in Weaver Creek by alternatively using Trinity River to provide summer water to the Weaverville Community Services District.** **Project Description:** Provide funding for the Weaverville Community Services District to use the Trinity River for their summer water supply instead of East/West Weaver Creek (TRRP, Weaverville Community Services District, 5 Counties Salmonid Conservation Program). **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Manage water withdrawals **Near-Term Focal Areas (and average CPI scores):** Covers 1 sub-watershed – Weaver Creek**  **Cost range ($K):** $25 – 100 – 150	3.83	7	2.01	4	4.47
Trinity 6 (19.9)	**Install in-channel structures such as LWD, boulders, etc. to improve fish habitats in priority tributaries.** **Project Description:** Increase instream complexity through addition of LWD, boulders, or other instream structures to key Trinity River tributary streams. **Dependencies / Project Linkages:** No dependencies indicated.	3.86	2.64	6.3	2	5.12

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
	Primary Action Types: Channel structure placement, Addition of large woody debris **Near-Term Focal Areas (and average CPI scores):** Covers 10 sub-watersheds – Lower Browns Creek**, Rush Creek, Grass Valley Creek**, Indian Creek, Weaver Creek**, Sharber Creek-Trinity River**, Willow Creek, Supply Creek**, Mill Creek**, Soctish Creek-Trinity River**  **Cost range ($K):** $600 – 1,525 – 3,000					
Trinity 8 (19.6)	**Implement projects to provide for fish passage at identified priority fish passage barriers across the Trinity River sub-basin.** **Project Description:** Assess barriers in tributary streams and prioritize for removal leveraging the existing California Fish Passage Assessment Database. Based on evaluation remove highest priority road-stream and diversion related barriers to fish passage. A key barrier that should be considered for removal is the Weaverville Community Services District diversion dam on East Weaver Creek. (Eli-Asarian, pers. Comm.) **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Fish passage improvement (general), Minor fish passage blockages removed or altered **Near-Term Focal Areas (and average CPI scores):** Covers 5 sub-watersheds – Grass Valley Creek**, Weaver Creek**, Conner Creek Trinity River**, Big Bar Creek-Trinity River, Little French Creek-Trinity River  **Cost range ($K):** $425 – 1,850 – 3,700 (based partly on cost data from Shasta and SF Trinity)	**3.97**	**3.82**	**3.37**	**4**	**4.4**
Trinity 17_18 (18.6)	**Install temperature control device for Trinity Reservoir and evaluate and develop a new conveyance system from Trinity Reservoir to the Carr tunnels to improve temperature management** **Project Description:** With current infrastructure, water can only be released from the depths of Trinity Reservoir. During spring, this water is too cold for optimal growth of juvenile salmonids. A temperature control device would allow release of warmer near-surface reservoir water during spring, benefiting salmonid growth and conserving the reservoir's cold water pool. During multi-year droughts when the reservoir is drawn down to low levels, the cold water pool can become depleted, resulting in the release of warm water during the fall when salmon are	**0.83**	**2.14**	**7.05**	**6**	**2.62**

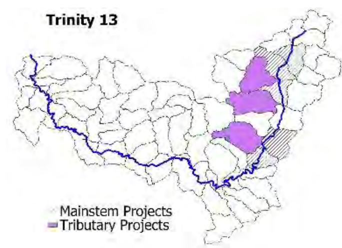
Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
	spawning and incubating. As climate change increases drought frequency and severity, it will become increasingly important to preserve the cold water pool (Naman 2021). A new conveyance system could include dam removal, a canal, or pipeline. With current infrastructure, when flow releases are low and air temperatures are high, water released from Trinity Reservoir can warm substantially while flowing through Lewiston Reservoir en route to the Trinity River and the Carr diversion tunnel that transfers water to Sacramento River Basin. The ability to convey water around Lewiston Reservoir would enhance the ability to control temperatures in both the Trinity River and Sacramento River (USBR 2012). This project should be coordinated with the Trinity Dam temperature control device project proposed above. **Dependencies / Project Linkages:** No dependencies identified. **Primary Action Types**: Instream flow project (general), Water flow gauges, Manage dam releases (Trinity and Lewiston) **Near-Term Focal Areas (and average CPI scores):** Papoose Creek watershed, Mooney Gulch watershed (180102110505)  **Cost range ($K):** These infrastructure improvements were costed in 2012 (USBR 2012) Converted to 2022 dollars using the government's official inflation calculator [21] these projects are estimated at: $299 million for the Trinity temperature control device and $439-862 million for the conveyance improvements.					
Trinity 16 (18.5)	**Undertake upland vegetation management as needed to thin forest and reduce fuels across the Trinity River sub-basin.** **Project Description:** Upland vegetation management including fuel reduction and burning. Several sub-watersheds have a history of high intensity and severity fire. Treatments to thin forest and reduce fuels are underway with Local Tribes, Cal Fire, US Forest Service- Shasta-Trinity National Forest & Six Rivers National Forest, Fire Districts and local communities. **Dependencies / Project Linkages:** Consider implementing along with project 10 (road decommissioning). Afterwards access may be an issue. **Primary Action Types:** Upland vegetation management including fuel reduction and burning	**2.63**	**1.4**	**1.42**	**6**	**7**

[21] https://www.bls.gov/data/inflation_calculator.htm

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
	Near-Term Focal Areas (and average CPI scores): Covers 33 sub-watersheds – North Fork Coffee Creek, Lower Coffee Creek, High Camp Creek-Trinity River, Picayune Creek-Trinity River, Bear Creek-Trinity River, Eagle Creek-Trinity River, Buckeye Creek-Trinity River, Papoose Creek-Trinity River, Mooney Gulch-Trinity River, Deadwood Creek-Trinity River, Weaver Creek**, Dutton Creek-Trinity River, Upper Canyon Creek, Lower Canyon Creek**, Upper North Fork Trinity River, East Fork New River, Devils Canyon, Quinby Creek-New River**, Conner Creek Trinity River**, Big Bar Creek-Trinity River, Big French Creek, Little French Creek-Trinity River, Don Juan Creek-Trinity River, McDonald Creek-Trinity River, Sharber Creek-Trinity River**, Willow Creek, Cedar Creek**, Horse Linto Creek**, Tish Tang A Tang Creek, Campbell Creek-Trinity River, Mill Creek**, Soctish Creek-Trinity River**, Deerhorn Creek-Trinity River  **Cost range ($K):** $50 – 300 – 875					
Trinity 15 (16.9)	**Translocate beaver and install BDAs to impound water and create seasonal fish rearing habitats in Trinity River tributaries, particularly in the Weaver basin.** **Project Description:** Translocate beaver and implement Beaver Dam Analog (BDA) projects to impound water, increasing water residence time with benefits for maximizing groundwater recharge, improving base flows, and creation of fish habitat. Emphasis is in small tributaries in the Weaver basin with large drainages which are heavily impacted by mining. **Dependencies / Project Linkages:** Consider in the context of other instream flow actions (project 11). **Primary Action Types:** Beavers & beaver dam analogs **Near-Term Focal Areas (and average CPI scores):** Covers 20 sub-watersheds – Grass Valley Creek**, Indian Creek, Weaver Creek**, Rattlesnake Creek, Upper North Fork Trinity River, Middle North Fork Trinity River, Virgin Creek, Slide Creek, Quinby Creek-New River**, Big Creek, Bell Creek-New River**, Conner Creek Trinity River**, Big French Creek, Little French Creek-Trinity River, Sharber Creek-Trinity River**, Cedar Creek**, Horse Linto Creek**, Supply Creek**, Mill Creek**, Soctish Creek-Trinity River**  **Cost range ($K):** $90 – 180 – 270	3.57	0.7	3.88	4	4.79

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
Trinity 2_11 (16.2)	**Implement projects in Trinity River tributary streams to improve flows to decrease water temperatures and increase dissolved oxygen.** **Project Description:** Reduce water temperatures and increase dissolved oxygen in tributary streams by taking actions to increase stream flow. Actions include identifying and ceasing unauthorized water diversions, and regulatory mechanisms, improving water management techniques and developing/implementing plans to reduce effects of legal water users (e.g., legal marijuana cultivation, ranchers etc.)..  **Dependencies / Project Linkages:** Beaver translocation and beaver dam analogue (BDA) installation (project 15) will also affect instream flows. **Primary Action Types:** Instream flow project (general) **Near-Term Focal Areas (and average CPI scores):** Covers 21 sub-watersheds – Lower Coffee Creek, East Fork Stuart Fork, Lower Stuart Fork, Lower Browns Creek**, Indian Creek, Weaver Creek**, Reading Creek, Lower Canyon Creek**, Sharber Creek-Trinity River**, Willow Creek, Cedar Creek**, Horse Linto Creek**, Supply Creek** Grass Valley Creek, Dutton Creek-Trinity River, Bell Creek-New River**, Conner Creek Trinity River**, Big Bar Creek-Trinity River, Tish Tang A Tang Creek, Campbell Creek-Trinity River, Mill Creek** **Cost range ($K):** $13,000 – 15,275 – 16,900	**3.42**	**1.84**	**4.03**	**4**	**2.92**
Trinity 14 (15.6)	**Increase Trinity recreational harvest of introduced Brown Trout and adjust hatchery release practices to minimize trout predation on juvenile salmon.** **Project Description:** Minimizing the impacts of brown trout predation on juvenile salmon. Brown trout were intentionally introduced in the Trinity River until 1932. Alvarez and Ward (2018) found substantial predation by brown trout on wild and hatchery-produced salmon and trout in the Trinity River. Actions could include increased bag limits for recreational fishers as well as altered hatchery release practices to minimize predation (Alvarez and Ward 2018).  **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Predator/competitor non-native fish species removal, Hatchery reform and assessment (general)	**3.63**	**3.58**	**1.45**	**6**	**0.97**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
	Near-Term Focal Areas (and average CPI scores): Covers 5 sub-watersheds – Deadwood Creek-Trinity River, Dutton Creek-Trinity River, Conner Creek Trinity River**, Big Bar Creek-Trinity River, Little French Creek-Trinity River **Cost range ($K):** $10,005 – 15,080 – 20,165 (based partly on cost data from Project #12)					
Trinity 12 (15.6)	**Stocking of spring Chinook and summer steelhead into Trinity streams where currently extirpated and carcasses where populations still exist.** **Project Description:** Stocking spring Chinook and summer steelhead in suitable habitat where they have been extirpated (e.g. Canyon Creek) or at risk of extirpation, and addition of carcasses where populations still exist. This is likely to be a recommendation out of the Federal and State status reviews currently underway. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Hatchery reform and assessment (general) **Near-Term Focal Areas (and average CPI scores):** Covers 9 sub-watersheds –Upper Browns Creek, Lower Browns Creek**, Rush Creek, Grass Valley Creek**, Indian Creek, Weaver Creek**, Reading Creek, Lower Canyon Creek**, East Fork North Fork Trinity River** **Cost range ($K):** $10,000 – 15,000 – 20,000 	3.48	2.27	0.9	6	2.96
Trinity 7 (14.8)	**Install fish passage infrastructure at Lewiston and Trinity Dams to allow access to upstream habitats.** **Project Description:** Provide for fish passage at Lewiston and Trinity Dams. **Dependencies / Project Linkages:** Would influence related project 13 **Primary Action Types:** Fish ladder Installed / improved **Near-Term Focal Areas (and average CPI scores):** Covers 2 sub-watersheds – Mooney Gulch-Trinity River, Deadwood Creek-Trinity River **Cost range ($K):** $38 – 53 – 68 	2.11	4.32	1.39	6	1.01

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.4)*	CPI Status *(0.7)*	Stressors Addressed *(0.9)*	Scale of Benefit *(0.8)*	Implementability *(0.7)*
Trinity 13 (10.1)	**Stock Trinity and Lewiston lakes to establish landlocked salmon and/or trout runs, using only fish of Trinity Basin genetic stock.** **Project Description:** Any stocking of Trinity and Lewiston Lakes for the purpose of establishing land locked runs of kings, rainbows, and Coho should only use fish of Trinity Basin genetic origin. Do not allow out of basin stocking to occur as there is potential for some downstream movement from the lakes to the Trinity River. The current status of CDFW is that Trinity and Lewiston Lakes shouldn't be stocked due to disease exposure potential. **Dependencies / Project Linkages:** Passage at Lewiston and Trinity dams (project 7) would influence hatchery stocking strategies.  **Primary Action Types:** Hatchery reform and assessment (general) **Near-Term Focal Areas (and average CPI scores):** Covers 8 sub-watersheds – Lower Coffee Creek, Bear Creek-Trinity River, Eagle Creek-Trinity River, Lower Stuart Fork, Swift Creek, Buckeye Creek-Trinity River, Papoose Creek-Trinity River, Mooney Gulch-Trinity River **Cost range ($K):** $10,000 – 15,000 – 20,000 (based on cost data from Project #12)	**0.4**	**2.14**	**0.9**	**6**	**0.7**

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC and SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, and sub-regional working group input via surveys and webinars.

**This project refers to the Trinity River Restoration Program (TRRP) which has a separate funding stream.

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the Trinity Sub-basin

The federally listed Southern Oregon/Northern California Coast Evolutionarily Significant Unit of ***Coho Salmon*** is a key species identified for many restoration actions in the Trinity River (NMFS 2014). Two populations of Coho are found in the Trinity – a Lower Trinity River Population which is considered at high extinction risk and likely below the depensation threshold, and an Upper Trinity River Population which is considered at moderate extinction risk and could also sustain itself if given the chance. ***Chinook, steelhead and Pacific Lamprey*** populations are also of significant conservation concern as these are Tribal Trust Species that have experienced notable long-term declines in the Basin. Fall-run Chinook are the most numerous salmonid in the Trinity River, followed by steelhead. Restoration activities in the Trinity sub-basin are also driven by the needs of the Trinity River Restoration Program (TRRP), which focuses substantial resources on restoration of the upper 40-mile mainstem reach of the Trinity River between Lewiston Dam and the North Fork Trinity River. The TRRP implements the 2000 Department of Interior (DOI) Record of Decision (ROD), which directs DOI to restore the fisheries (***spring and fall Chinook Salmon, Coho Salmon, Steelhead***) of the Trinity River impacted by dam construction and related diversions of the Trinity River Division (TRD). The TRRP also has an active watershed restoration program that focuses on undertaking restoration work in Trinity tributaries. The TRRP is a multi-agency program with eight Partners (i.e., USBOR, USFWS, Hoopa Valley Tribe, Yurok Tribe, CNRA, NMFS, USFS and Trinity County) forming the Trinity Management Council (TMC), plus numerous other collaborators.

The following table summarizes selected major restoration activities in this sub-basin and those species which these activities have benefited.

Table 4-37: Summary of major restoration efforts in the Trinity sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit.

Key Restoration Activities in the Upper Klamath Sub-basin to Date	Species Benefiting				
	GS	CO	CH	ST	PL
Since 2001, the TRRP has implemented variable flows mandated by the ROD. Restoration flows are intended to clean spawning gravels, build gravel/cobble bars, scour sand out of pools, provide adequate temperature and habitat conditions for fish and wildlife at different life stages, control riparian vegetation, and perform many other ecological functions. In order to mimic some of the inter-annual variation that is naturally found within the Trinity sub-basin the ROD defines five water-year types along with a minimum volume of water to be released from the dams into the Trinity River within each water year (and not diverted to the Central Valley).	○	●	●	●	○
The TRRP undertakes or supports a variety of watershed restoration actions including road maintenance, road rehabilitation and road decommissioning on private and public lands within the Trinity sub-basin below Lewiston Dam. To date 87 watershed restoration projects in the Trinity sub-basin have been funded through the TRRP.	○	●	●	●	○
The USFS maintains an active road decommissioning and sediment abatement program that aims to minimize fine sediment delivery to streams within their jurisdiction. Approximately 80 percent of the lands within the Trinity basin are federally managed of which the USFS administers approximately 95%. Fuels reductions programs implemented	○	●	●	●	○

Key Restoration Activities in the Upper Klamath Sub-basin to Date	Species Benefiting				
	GS	CO	CH	ST	PL
by the USFS are also activities that help reduce the risk of catastrophic forest fires and subsequent fine sediment deposition from erosion.					
The TRRP has implemented a phased sequence of channel rehabilitation actions along the upper 40 miles of river below Lewiston Dam. TRRP channel rehabilitation projects include construction of natural riverine features such as floodplains, point bars, forced meanders, mid-channel islands, side channels, and alcoves. These channel rehabilitation projects (of which 34 of a planned 47 have now been completed) are intended in composite to help reshape the river channel form so that it can work with flows over time to restore the river and its fisheries. This combination of channel rehabilitation and river flow is expected to reconnect the river to its floodplains, promote alternate bar sequences and low-velocity habitat for salmonid fry; increase habitat complexity; and allow the river to maintain itself as an alluvial system in both treated and untreated areas. Information on the range of channel rehabilitation sites constructed in the Trinity River by the TRRP beginning in 2005 is provided at http://www.trrp.net/restoration/channel-rehab/sites/.	○	●	●	●	○
The TRRP adds gravel to the river at several locations in the Trinity River above the confluence of Weaver Creek to make up for the deficit caused by the dams. The amount gravel injected into the river is based on scientific analyses and calculation of a gravel budget for the river. Gravels injected are of a size appropriate for use by spawning salmon. Gravel may also be added at constructed rehabilitation sites for specific purposes. Gravel augmentation may occur during high flow releases or by placement during summer and early fall, typically at rehabilitation sites.	○	●	●	●	○
The Five Counties Salmonid Conservation Program (covering Del Norte, Humboldt, Mendocino, Siskiyou, and Trinity counties) undertakes replacement of stream crossings in the sub-basin that are barriers to fish migration. Find more information at this link: *https://www.5counties.org/migbaremov.htm*		●	●	●	○

*Sources for this table include: Trinity River Restoration Program website (http://www.trrp.net/); NMFS 2014.

Current State of Monitoring & Data Gaps

Past and Ongoing Monitoring:

The USFWS and partners conduct flow and water temperature monitoring and integrated habitat assessments throughout the Trinity sub-basin. The USFWS also undertakes comprehensive fall Chinook spawning escapement monitoring, including red counts, carcass tag-recovery, and juvenile salmonid and non-salmonid trap monitoring in the Trinity River. The USFWS also funds project effectiveness monitoring which includes effects assessment of Coho and Chinook rearing habitat restoration in the Trinity River (Goodman et al. 2016).The Yurok Tribe Environmental Program (YTEP) monitors nutrients, phytoplankton (including toxic cyanobacteria for public health purposes), and continuous water quality (water temperature, DO, pH, and conductivity) at the mouth of the Trinity River. The Yurok Tribe monitors juvenile salmonids to evaluate abundance, timing, health, and size of juveniles emigrating from key tributaries and the Trinity River. The Yurok also undertake harvest and escapement monitoring for fall run Chinook and Coho salmon. The Hoopa Valley Tribe is active in stream flow, temperature, and water quality monitoring in several tributaries of the Trinity sub-basin. More generally, under the umbrella of the TRRP, much of the monitoring in the sub-basin involves co-managed efforts between the Hoopa Valley Tribe, the Yurok, USFWS, CDFW, and USFS. **The TRRP represents the best example of collaborative**

effectiveness monitoring in the Klamath Basin. The TRRP's Fish Work Group coordinates regular tracking of Trinity salmon metrics (e.g., redd distribution and abundance, juvenile fish habitat condition, juvenile density, juvenile salmonid outmigrants, Coho survival and migration, hatchery straying, Chinook genetics, adult and juvenile fish disease, adult run-size estimation, and adult fall-Chinook harvest). The TRRP's Physical Work Group monitors sediment transport processes in the Trinity River during the spring flow release and monitor bed scour and bed mobility using a combination of painted tracer rocks, scour chains, and topographic surveys. Sediment transport information is used for numerous aspects of Trinity River management and contributes to flow scheduling decisions. The Trinity River Restoration Program Integrated Assessment Plan (IAP) (TRRP and ESSA 2009) provides a useful summary of TRRP restoration goals for the river and associated monitoring efforts/performance measures. TRRP effectiveness monitoring objectives and methods for channel rehabilitation sites were reviewed post Phase 1 of the Program (Buffington et al. 2014).

Current Data Gaps:

Figure 4-44 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken across agencies in the Trinity sub-basin. Location-specific agency metadata (where available) on monitoring projects is incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. The TRRP already provides extensive data management support for fish habitat and fish population information in this sub-basin. The TRRP manages the Trinity River DataPort (http://www.trrp.net/dataport/) with the support of DOI. The DataPort provides an online library for Trinity related documents and data, a mapping application, and a time series data explorer. In addition, the TRRP maintains a Restoration Action Database (RAD) (http://www.trrp.net/dataport/rad/) which provides detailed information about the actions implemented to date as part of the TRRP. Given the already existing TRRP data management infrastructure in place there has been minimal effort to date to pull the extensive monitoring data available for the Trinity into this project's Internal Integrated Tracking Inventory.

A great deal of data is available for salmonids in the Trinity sub-basin, although there are gaps in information on ecological interactions and hatchery impacts. There is further deficiency of information related specifically to Green Sturgeon and Pacific Lamprey populations in the sub-basin.

Trinity Sub-basin Monitoring Summary

Habitat Monitoring			
Watershed Inputs	Weather	●
Watershed Inputs	Streamflow	●
Watershed Inputs	Groundwater	●
Watershed Inputs	Riparian & Landscape	●
Fluvial-Geomorph	Sediments & Gravel	●
Fluvial-Geomorph	Stream Morphology	●
Habitat	Stream Temperature	●
Habitat	Water Quality	●
Habitat	Habitat Quality	●
Habitat	Barriers & Injury	●
Habitat	Marine/Estuary	NA
Biota	Invasive Species	●

Population Monitoring		Salmon / Steelhead	Pacific Lamprey	Green Sturgeon
Abundance	Juvenile Abundance (anad)	●	●	
Abundance	Spawner Abundance (anad)	●		
Abundance	Abundance (non-anad)	NA	NA	NA
Harvest	Harvest (in-river)	●		
Harvest	Harvest (ocean)			
Distrib-ution	Temporal Distribution	●	●	
Distrib-ution	Spatial Distribution	●	●	
Demo-graphics	Stock Composition	●		
Demo-graphics	Age Structure	●		
Biota	Disease	●		

● Known monitoring activities (past or ongoing)
NA Monitoring not relevant to this sub-basin

Figure 4-44. Synthesis of past and ongoing monitoring activities in the Trinity sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017, Section 2.5, Appendix H):

- Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (SONCC) (National Marine Fisheries Service, Arcata, CA, 2014)
- Recovery Strategy for California Coho Salmon (CDFW 2004)
- Trinity River Flow Evaluation Final Report (USFWS and HVT 1999)
- Secretarial Record of Decision (ROD) (USDI 2000)
- Trinity River Restoration Program (TRRP) (http://www.trrp.net/)

- Review of the Trinity River Restoration Program following Phase 1, with emphasis on the Program's rehabilitation strategy (Buffington et al. 2014).
- Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)
- FISHPass optimization tool. https://www.cafishpassageforum.org/fishpass
- Klamath Basin Water Quality Monitoring Plan (KBMP 2016)
- Water Quality Control Plan Hoopa Valley Indian Reservation (Hoopa Valley Tribe 2020)
- Hoopa Tribal Forestry Forest Management Plan (Hoopa Valley Tribe 2014)
- Trinity River Restoration Program Restoration Action Database (RAD) http://www.trrp.net/library/
- Trinity River Restoration Program Online DataPort Document and Data Library http://www.trrp.net/library/
- Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife (in draft form at the time of writing)

Forthcoming plans and Initiatives

- The TRRP is currently undergoing a synthesis reporting effort of all major monitoring efforts over the last 15 years since full implementation of the ROD in 2004.
- Federal and State status reviews for Spring Chinook are underway.

SOUTH FORK TRINITY

SUB-BASIN RESTORATION & MONITORING PROFILE

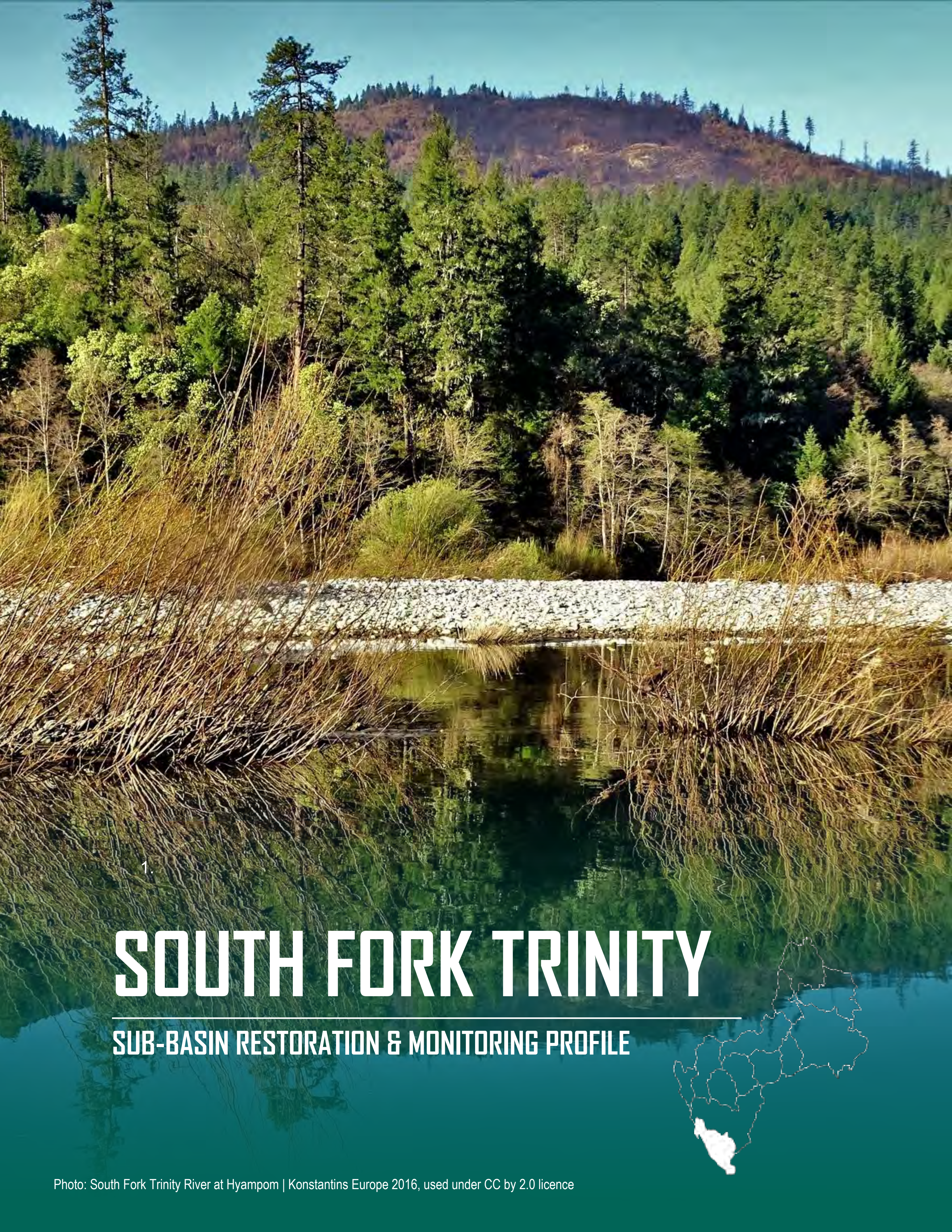


Photo: South Fork Trinity River at Hyampom | Konstantins Europe 2016, used under CC by 2.0 licence

4.5.3 South Fork Trinity Sub-basin

The South Fork Trinity is the largest tributary of the Trinity River and is the longest undammed river remaining in California. The Shasta–Trinity National Forest covers the vast majority of the South Fork Trinity sub-basin such that nearly 70 percent of the South Fork Trinity is under federal management. The sub-basin has experienced extensive past placer mining, timber harvest, and road construction. Agriculture and grazing occurs within the low lying areas of the sub-basin. Since the mid 1970's, marijuana cultivation is also practiced in more remote areas (WRTC 2016). Extensive land management and associated water withdrawals in the sub-basin have modified streamflow and natural erosion processes, resulting in sediment loading, elevated temperatures, altered stream channels, and migration barriers that have impacted fish populations (USFS 2008). Fire is a significant disturbance factor within the South Fork Trinity sub-basin and accelerated sediment production is found in many areas of the sub-basin where large scale forest fires have burned (USFS 2008). In the summer, many tributaries in the sub-basin go dry or subsurface, the extent of which has increased in recent years (WRTC 2016). The South Fork Trinity has been listed for stream temperature and sediment impairment under Section 303(d)) and has a TMDL established for sediment impairment.

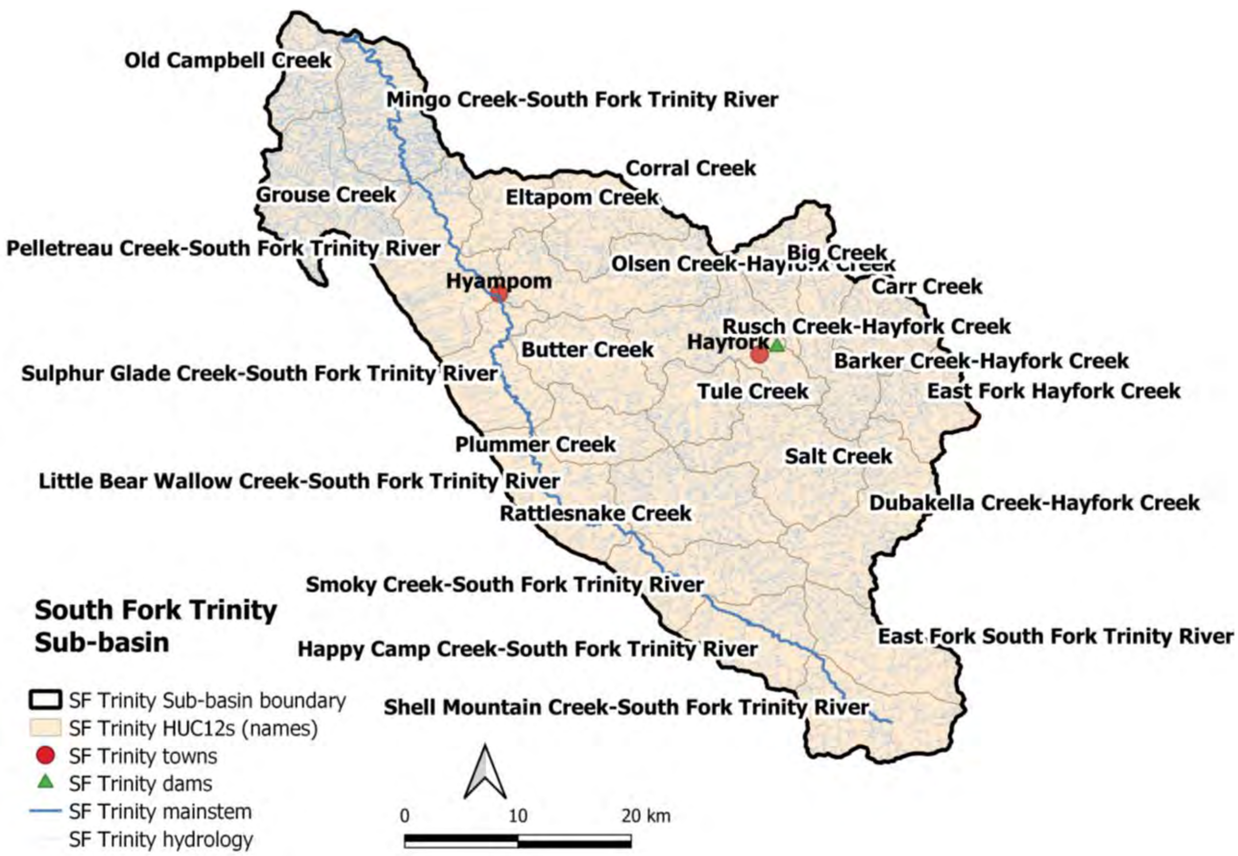


Figure 4-45: Reference map of the South Fork Trinity Sub-Basin, showing major settlements, waterways, and the names for HUC12 sub-watersheds referred to later on in this section.

Key Species

- **Current:** Chinook Salmon (fall-run and spring-run), Coho Salmon, steelhead (summer and winter runs), Pacific Lamprey, Green Sturgeon

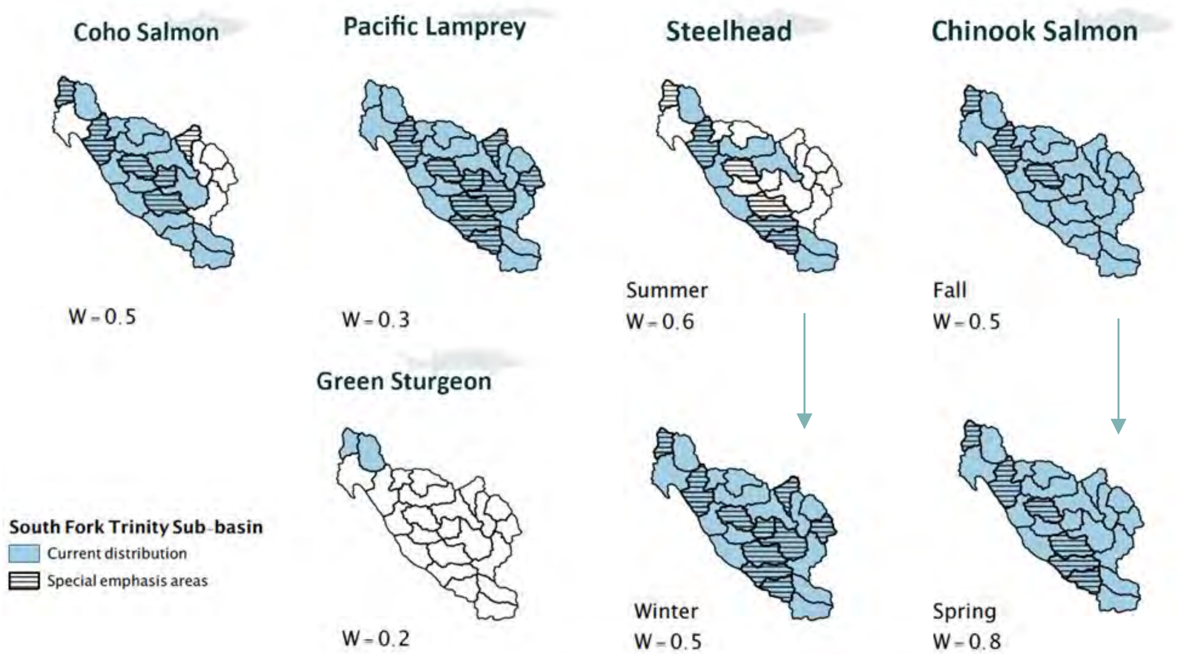


Figure 4-46: Reference maps of the current, historical, and special emphasis distributions as well as prioritization weights of focal fish species native to the SF Trinity sub-basin across HUC12 sub-watersheds. Note that special emphasis areas are areas identified by participants in the planning process as deserving of additional emphasis for a variety of reasons (e.g., key population, stronghold habitat, etc.). Species range data based on the UC Davis PISCES Fish Range and Occurrence Database, the ODFW Oregon Fish Habitat Distribution Data Layers, and USFWS Species Range and Critical Habitat Designation data, followed by region-specific updates to these layers based on expert consultation. W indicates the importance weight assigned to each species in this sub-basin for prioritization. W indicates the importance weight assigned to each species in this sub-basin for prioritization.

Key Stressors:

Table 4-38: Hypothesized stressors (○) and key stressors (●) affecting focal fish species/functional groups across the South Fork Trinity sub-basin listed in approximate order of importance based on conceptual models, stakeholder surveys, and workshop input. CH = Chinook Salmon, CO = Coho Salmon, ST = steelhead, PL = Pacific Lamprey, GS = Green Sturgeon.

Key Stressors	Tier	Stressor Summary for the South Fork Trinity Sub-basin	Species				
			GS	CH	CO	ST	PL
Instream Flows (tributaries)	WI	Altered hydrologic function represents a high stress for fish populations in the South Fork sub-basin. Flows are naturally low during the summer due to the low elevations in the basin, the bedrock geology and the low water holding capacity. The summers are hot and dry for several months and there is often little water flowing in most creeks during the summer. Exacerbating this concern is the substantial water utilization in the South Fork Trinity River which has caused reductions in the amount of rearing habitat available in the summer and restricted access to spawning grounds in the fall (NMFS 2014). Water uses within the sub-basin include numerous withdrawals for domestic, agricultural and livestock watering purposes (WRTC 2016). Water diversions for marijuana cultivation also likely has a significant impact on the hydrologic function of tributary streams during critical low-flow periods in the summer and fall (NMFS 2014, McFadin 2019). The effects of diversion are particularly acute in the Hyampom and Hayfork Valleys as well as the Forest Glenn area where		●	●	●	●

Key Stressors	Tier	Stressor Summary for the South Fork Trinity Sub-basin	Species				
			GS	CH	CO	ST	PL
		summer low flows lead to elevated water temperatures and a constriction of summer rearing habitat (NMFS 2014)					
Fine Sediment Inputs	WI	The South Fork Trinity experiences high sediment loads resulting from the latent effects of past land use practices (e.g., logging, high density of roads, placer mining) and generally unstable substrate in the sub-basin combining to generate elevated quantities of sediment to the mainstem and smaller tributaries. Sediment loading is greatest in the Hyampom Valley, with most of the sediment being delivered from South Fork Mountain tributaries (NMFS 2014).		●	●	●	○
Water Temperature	H	Water temperatures within the lower South Fork Trinity mainstem and in some tributary streams can often reach lethal levels for fish in the summer, with such high temperatures resulting from natural conditions exacerbated by water diversions, loss of riparian vegetation, and excess sedimentation that has resulted in channel widening and decreased water depths (USEPA 1998, Asarian 2016). Tributaries with the potential to act as thermal refugia often lack adequate flows during the summer.	●	●	●	●	●
Instream Structural complexity	H	Past and present activities such as mining, road construction, stream diversion, and timber harvest have modified streamflow and natural erosion processes and altered the dynamic equilibrium of stream channels in areas of the South Fork Trinity sub-basin. Piles of mine tailings still line the channels of some streams constricting flows in places, producing sediment sources, limiting floodplain connectivity, and reducing the proper functioning condition of the stream and associated riparian zone. A lack of LWD resulting from decades of grazing, timber harvest, and intense fire that has impacted the riparian plant and forest communities is likely adding to lack of instream complexity.		●	●	●	●
Anthropogenic Barriers	H	While there are no large dams in the South Fork Trinity sub-basin, numerous small barriers are scattered across the sub-basin and could potentially block a access to available habitat (WRTC 2016). According to CalFish (as of 2009), there are potentially 4 small dams and 147 road-stream crossing barriers in the sub-basin.		●	●	●	●
Fish Entrainment (juveniles)	H	The number of diversions is unknown but presumed to be large given the amount of agriculture in the sub-basin. There are concerns that unscreened diversions may act to trap juveniles and may prevent upstream or downstream movement (NMFS 2014). It is considered likely that many if not all of the illegal diversions in the watershed are unscreened. Although there is a need for more recent assessments, there is a need for fish screens on diversions in Barker, Big, E. Fork Hayfork, Upper Hayfork, Little, Olsen, Salt, and Tule creeks was identified by PWA (1994). Because of impacts on summer rearing, diversions are considered to be very high threat to juvenile Coho (NMFS 2014).	●	●	●	●	●

Stressors identified from: NMFS 2014; WRTC 2016; Sub-regional working group survey responses.

Sequences of Restoration Projects for the South Fork Trinity Sub-Basin

The **summary infographic** in Figure 4-47 provides a compact overview of the South Fork Trinity sub-basin restoration project priorities and their distribution across the sub-basin. Table 4-39 presents the results of the 2022 iteration of the IFRMP restoration sequencing process for the South Fork (SF) Trinity sub-basin. The 2023-2024 Restoration Action Agenda (RAA) project list include what participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon felt were the highest priority project concepts that should be funded soon. That RAA list (see https://ifrmp.net/) is only a small subset of what is shown in the summary infographic and Table 4-39.

Figure 4-47: Summary for the South Fork Trinity Sub-basin, including key stressors, cost ranges, and projects (see next page)

South Fork Trinity Sub-basin

Sub-Basin Summary

The South Fork Trinity is the longest undammed river in California. Extensive land management and associated water withdrawals in the sub-basin have modified streamflow and natural erosion processes, resulting in sediment loading, elevated temperatures, altered stream channels, and fish migration barriers. Fire is a significant disturbance factor and accelerated sediment production is found in many areas of the sub-basin. In the summer many tributaries in the sub-basin go dry or subsurface. The sub-basin is 300d listed for stream temperature and sediment impairment and has a TMDL for sediment impairment.

Key Stressor Summary

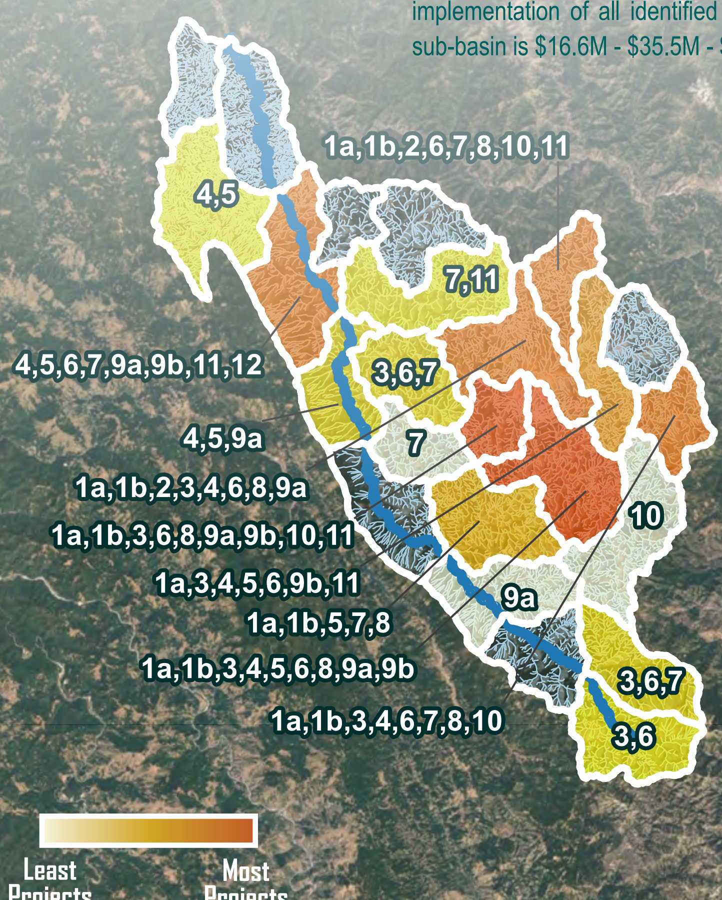
Key Stressors	Focal Species				
	GS	CH	CO	ST	PL
Instream Flow (tributaries)					
Fine Sediment Inputs					
Water Temperature					
Instream Structural Complexity					
Anthropogenic Barriers					
Fish Entrainment (juveniles)					

Restoration Summary

Projects identified as priorities for the South Fork Trinity Sub-basin through the IFRMP process are located in the North East portion of the sub-basin. The top three ranked projects in the South Fork address water availability in some capacity, reflecting the heavy agricultural presence in the region. These projects were followed closely by those involve protection of riparian areas through grazing management and fencing as well as direct fish habitat improvements through placement of in-channel structures. Other projects ranked lower included those related to reducing sediment inputs and improving channel configuration and connectivity.

Cost Range

The cost range (low, medium, high) for the implementation of all identified projects in this sub-basin is $16.6M - $35.5M - $58.9M.



Restoration Sequencing Results

This list reflects the results of the Klamath IFRMP Restoration Sequencing Planning Process, drawing on existing species recovery plans, regional restoration plans and strategies, and input from the IFRMP South Fork Trinity sub-basin working group. The **number** at the end of each entry reflects project benefit scores, **circles** indicate the relevant watershed process tiers benefiting, and **arrows** indicate linkages between projects.

Project ID & Description	Tiers
SF Trinity 5 - Decommission roads and improve road drainage systems to reduce fine sediment delivery to South Fork Trinity streams | **16.2**	WI
SF Trinity 3 - Increase groundwater storage in the South Fork Trinity Sub-basin through upland wetland restoration actions | **16.0**	WI H FG
SF Trinity 2 - Increase storage capacity and delivery capability of Ewing Reservoir to allow increased seasonal water flows in Hayfork Creek | **15.8**	WI
SF Trinity 6 - Reduce cattle grazing and install fencing in riparian areas to reduce fine sediment inputs into sub- basin streams | **15.3**	WI
SF Trinity 9a - Install LWD, boulders and other in-channel structures to increase habitat complexity in key South Fork Trinity tributaries | **12.4**	H
SF Trinity 1a - Identify diversion flow impacts and cease unauthorized water diversions across the Trinity River sub-basin | **12.2**	WI
SF Trinity 7 - Improve planning and oversight of diversions to protect thermal refugia in tributaries of the South Fork Trinity sub-basin | **12.2**	H
SF Trinity 1b - Work with agricultural irrigators to reduce diversions by developing an incentives and enforcement program to increase flows | **12.0**	WI
SF Trinity 12 - Repair the levee in Hyampom Valley by the municipal airport to reduce downstream erosion | **11.7**	WI
SF Trinity 9b - Reconnect channels to increase habitat complexity in key South Fork Trinity tributaries | **10.7**	H FG
SF Trinity 4 - Stabilize slopes and revegetate vulnerable areas to reduce fine sediment delivery to South Fork Trinity streams through mass wasting events | **10.5**	WI
SF Trinity 10 - Implement projects to provide for fish passage at identified priority fish passage barriers across the South Fork Trinity Sub-basin | **10.2**	H
SF Trinity 11 - Identify priority screening needs at diversions within the South Fork Trinity Sub-basin | **6.8**	H

The projects listed here have a cost range of $16.6M - $35.5M - $58.9M (low, estimated midpoint, high), and have been collated from projects proposed in prior local or regional restoration plans and studies as well as from in-depth discussions among participants in the IFRMP's SF Trinity Sub-basin Working Group who represent scientists, restoration practitioners, and resource users working in the sub-basin (see Acknowledgements section). The sequences and scoring in this table were the result of multiple rounds of participant input and discussion on project details, activity types, stressors addressed, and species benefitting for each project as well as participant judgements of the relative weights on biophysical tiers, species, and criteria. Additional considerations such as implementability, cost and dependencies among projects may influence the ultimate sequencing of projects. Dependencies identified by the Sub-basin Working Groups are noted in the table. Sequencing of projects will be very important for maximizing benefits in the sub-basin but determining the optimal sequencing steps for multi-project implementation requires further deliberation among the working group. To facilitate comparison across the sub-basins, results are shown assuming the four major Klamath mainstem dams have been removed, but no other changes.

Trinity Sub-basin Working Group identified the following additional scenarios with potential to influence restoration priorities. Should any these scenarios become a reality at some future point in time, it may be prudent to re-address restoration priorities in light of the changed conditions:

- Large flood
- Extirpation or extinction of species
- Re-introduction of species
- Listing of new species (e.g., Spring Chinook)

Many of the restoration actions identified for the South Fork sub-basin are located in the North East portion of the sub-basin. The top three ranked projects in the South Fork address water availability in some capacity, reflecting the heavy agricultural presence.

- **Projects 5, 3** pertain to road decommissioning and improvements to road drainage systems to reduce sediment inputs, and increasing groundwater storage.

These projects were closely followed in ranking by the following second suite of restoration projects:

- **Projects 2, 6** which involve increasing storage capacity and delivery capabilities of Ewing Reservoir to allow for seasonal flows, and protection of riparian areas through grazing management.

Projects ranked as of more intermediate restoration importance included:

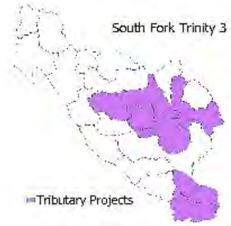
- **Projects 9a, 1a, 7, 1b, 12.** Broadly speaking these projects address installation of LWD, identification of diversion flow impacts, improved oversight and planning for diversions, create programs to increase flows, and repair a levee at Hyampom Valley.

The lowest ranking restoration projects in the SF Trinity sub-basin were:

- **Projects 9b, 4, 10, 11.** These projects include additional channel reconfiguration and fine sediment reduction as well as removal of fish passage barriers and diversion screening. These projects are primarily focused on tributaries.

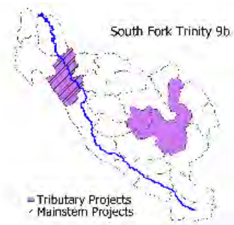
Table 4-39: Scored and sequenced restoration projects intended to reduce key stressors affecting focal fish species/functional groups across the SF Trinity sub-basin, with projects scored higher to be considered first for implementation. Purple shading on associated project location maps indicates projects to be undertaken on sub-watershed tributary streams, whereas black cross-striations indicate where projects would be undertaken on the sub-basin's mainstem river. Criteria weights are listed under each criterion name. Near-term focal area names for sub-watersheds correspond to those on the reference map in Figure 4-45, while special marks indicate focal sub-watersheds designated as critical habitat by the USFWS (*) or sub-watersheds designated as being of "special emphasis" (**) by sub-basin IFRMP planning participants. Project area maps also available interactively from within the Klamath IFRMP Prioritization Tool (https://ifrmp.net/).

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.6)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.6)*	Implementability *(0.5)*
SF Trinity 5 (16.2)	**Decommission roads and improve road drainage systems to reduce fine sediment delivery to South Fork Trinity streams.** **Project Description:** Reduce delivery of sediment to streams by reducing road-stream hydrologic connection through decommissioning or upgrading of roads in the South Fork Trinity sub-basin. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Road drainage system improvements and reconstruction, Road closure / abandonment **Near-Term Focal Areas (and average CPI scores):** Covers 6 sub-watersheds – Barker Creek-Hayfork Creek, Salt Creek**, Rattlesnake Creek**, Sulphur Glade Creek-South Fork Trinity River, Grouse Creek, Pelletreau Creek-South Fork Trinity River**  **Cost range ($K):** $60 – 180 – 390	**0.93**	**1.59**	**4.19**	**4.5**	**5**
SF Trinity 3 (16.0)	**Increase groundwater storage in the South Fork Trinity sub-basin through upland wetland restoration actions.** **Project Description:** Undertake efforts to store and meter out water in higher elevations and valley floors through increasing ground water storage. Large wood augmentation, Beavers, BDA's, meadow and stage "0" valley restoration are techniques being considered for various areas in the South Fork Trinity River (Yurok Tribe communication) **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Beavers & beaver dam analogs, Upland wetland improvement, Addition of large woody debris	**0.84**	**1.77**	**8**	**4.5**	**0.85**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.6)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.6)*	Implementability *(0.5)*
	Near-Term Focal Areas (map): Covers 8 sub-watersheds – East Fork South Fork Trinity River, Shell Mountain Creek-South Fork Trinity River, East Fork Hayfork Creek**, Barker Creek-Hayfork Creek, Salt Creek**, Tule Creek**, Rusch Creek-Hayfork Creek, Butter Creek** **Cost range ($K):** $6,460 – 12,470 – 18,480 					
SF Trinity 2 (15.8)	**Increase storage capacity and delivery capability of Ewing Reservoir to allow increased seasonal water flows in Hayfork Creek.** **Project Description:** Increase storage capacity or delivery capability for Ewing Reservoir in the Hayfork Valley of the South Fork Trinity sub-basin. In order to increase water available during low summer flow periods in the potentially productive Hayfork Creek watershed, it will be important to increase water storage and increase and improve water delivery from Ewing Reservoir (NMFS 2014, WRTC 2016). **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Instream flow project (general) **Near-Term Focal Areas (map):** Covers 2 sub-watersheds – Big Creek**, Rusch Creek-Hayfork Creek **Cost range ($K):** $500 – 1,200 – 2,000 	**0.7**	**6**	**4.42**	**3**	**1.69**
SF Trinity 6 (15.3)	**Reduce cattle grazing and install fencing in riparian areas to reduce fine sediment inputs into sub- basin streams.** **Project Description:** Reduce delivery of fine sediment to streams by improving grazing practices and fencing livestock out of riparian areas. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Fencing, Riparian area conservation grazing management **Near-Term Focal Areas (and average CPI scores):** Covers 10 sub-watersheds – East Fork South Fork Trinity River, Shell Mountain Creek-South Fork Trinity River, East Fork Hayfork Creek**, Big Creek**, Barker Creek-Hayfork Creek, Salt Creek**, Tule Creek**, Rusch Creek-Hayfork Creek, Butter Creek**, Pelletreau Creek-South Fork Trinity River**  **Cost range ($K):** $188 – 525 – 900 (incomplete – no cost data available for "riparian area conservation grazing management")	**1.02**	**1.77**	**6.49**	**3**	**3.03**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.6)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.6)*	Implementability *(0.5)*
SF Trinity 9a (12.4)	**Install LWD, boulders and other in-channel structures to increase habitat complexity in key South Fork Trinity tributaries.** **Project Description:** Increase habitat complexity in key tributary streams by adding LWD, boulders, and/or other instream structures **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Channel structure placement, Addition of large woody debris **Near-Term Focal Areas (and average CPI scores):** Covers 6 sub-watersheds – Salt Creek**, Tule Creek**, Rusch Creek-Hayfork Creek, Smoky Creek-South Fork Trinity River**, Sulphur Glade Creek-South Fork Trinity River, Pelletreau Creek-South Fork Trinity River**  **Cost range ($K):** $720 – 1,605 – 2,850	**1.55**	**2.04**	**6.85**	**1.5**	**0.5**
SF Trinity 1a (12.2) Policy Focused Action	**Identify diversion flow impacts and cease unauthorized water diversions across the Trinity River sub-basin** **Project Description:** Improve flow timing or volume by assessing diversion impacts and developing an enforcement program to increase flow during critical low flow periods. Identify and cease any unauthorized water diversions **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Manage water withdrawals **Near-Term Focal Areas (map):** 7 sub-watersheds – East Fork Hayfork Creek**, Big Creek**, Barker Creek-Hayfork Creek, Salt Creek**, Tule Creek**, Rusch Creek-Hayfork Creek, Rattlesnake Creek**  **Cost range ($K):** $120 – 1,560 – 3,000 (based on cost data from Project #1b)	**0.7**	**3.12**	**2.55**	**4.5**	**1.35**
SF Trinity 7 (12.2)	**Improve planning and oversight of diversions to protect thermal refugia in tributaries of the South Fork Trinity sub-basin.** **Project Description:** Identify and protect existing and potential cold-water thermal refugia areas in tributary streams during warm periods though improved planning and regulatory oversight over diversions affecting these areas. Improve flow timing or volume by assessing diversion impacts and developing an incentives and enforcement program to increase flow during critical low flow periods (NMFS 2014).	**1.22**	**0.87**	**6.17**	**3**	**0.89**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.6)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.6)*	Implementability *(0.5)*
	Dependencies / Project Linkages: This project relates to SF Project 1, 2, and 3, which strives to improve in-stream flows, storage, and delivery. Project 7 involves strategically managing flows to benefit thermal refugia. **Primary Action Types:** Instream flow project (general), Manage water withdrawals  **Near-Term Focal Areas (and average CPI scores):** Covers 8 sub-watersheds – East Fork South Fork Trinity River, East Fork Hayfork Creek**, Big Creek**, Olsen Creek-Hayfork Creek, Rattlesnake Creek**, Plummer Creek, Butter Creek**, Pelletreau Creek-South Fork Trinity River** **Cost range ($K):** $6,120 – 8,610 – 10,800 (based partly on cost data from Project #1b)					
SF Trinity 1b (12.0) Policy Focused Action	**Work with agricultural irrigators to reduce diversions by developing an incentives and enforcement program to increase flows.** **Project Description:** Improve flow timing or volume by assessing diversion impacts and developing an incentives and enforcement program to increase flow during critical low flow periods. Work with agricultural irrigators who have legal diversion rights to reduce their overall system impacts to the extent possible while achieving beneficial uses. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Instream flow project (general), Manage water withdrawals  **Near-Term Focal Areas (and average CPI scores):** Covers 6 sub-watersheds – East Fork Hayfork Creek**, Big Creek**, Salt Creek**, Tule Creek**, Rusch Creek-Hayfork Creek, Rattlesnake Creek** **Cost range ($K):** $120 – 1,560 – 3,000	**0.92**	**3.12**	**2.55**	**4.5**	**0.89**
SF Trinity 12 (11.7)	**Repair the levee in Hyampom Valley by the municipal airport to reduce downstream erosion.** **Project Description:** Set back the levee in Hyampom Valley associated with the municipal airport. This levee is in disrepair and is directly adjacent to Pellatreau Creek, which has an extremely high sediment load. The constriction in the valley is resulting in serious bank and terrace erosion downstream of the levee. **Dependencies / Project Linkages:** No dependencies indicated.	**3**	**0.6**	**4.35**	**3**	**0.78**

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.6)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.6)*	Implementability *(0.5)*
	Primary Action Types: Dike or berm modification / removal **Near-Term Focal Areas (and average CPI scores):** Covers 1 sub-watershed – Pelletreau Creek-South Fork Trinity River** **Cost range ($K):** $50 – 3,025 – 10,000 					
SF Trinity 9b (10.7)	**Reconnect channels to increase habitat complexity in key South Fork Trinity tributaries.** **Project Description:** Increase habitat complexity in key tributary streams by constructing such features as off-channel habitats, alcoves, backwater habitats, and old stream oxbows. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Mechanical channel modification and reconfiguration **Near-Term Focal Areas (and average CPI scores):** Covers 4 sub watersheds – Barker Creek-Hayfork Creek, Salt Creek**, Tule Creek**, Pelletreau Creek-South Fork Trinity River** **Cost range ($K):** $625 – 1,650 – 2,700 	1.13	1.95	3.28	3	1.33
SF Trinity 4 (10.5)	**Stabilize slopes and revegetate vulnerable areas to reduce fine sediment delivery to South Fork Trinity streams through mass wasting events.** **Project Description:** Reduce delivery of sediment to streams by assessing and reducing mass wasting hazards by stabilizing slopes and revegetating vulnerable areas. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Planting for erosion and sediment control, Slope stabilization **Near-Term Focal Areas (and average CPI scores):** Covers 6 sub-watersheds – East Fork Hayfork Creek**, Barker Creek-Hayfork Creek, Rusch Creek-Hayfork Creek, Sulphur Glade Creek-South Fork Trinity River, Grouse Creek, Pelletreau Creek-South Fork Trinity River** **Cost range ($K):** $1,170 – 1,170 – 1,170 (incomplete – no cost data available for "slope stabilization") 	0.65	2.04	1.46	4.5	1.84

Project # *(Overall Score)*	Restoration Projects	Criteria Scores *(Criteria Weights)*				
		Range Overlap *(0.3)*	CPI Status *(0.6)*	Stressors Addressed *(0.8)*	Scale of Benefit *(0.6)*	Implementability *(0.5)*
SF Trinity 10 (10.2)	**Implement projects to provide for fish passage at identified priority fish passage barriers across the South Fork Trinity sub-basin.** **Project Description:** Assess barriers and prioritize for removal leveraging the existing California Fish Passage Assessment Database, remove barriers based on evaluation (NMFS 2014). An appendix to WRTC (2016) provides information on additional barriers that are not yet included in the state database. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Fish passage improvement (general), Minor fish passage blockages removed or altered **Near-Term Focal Areas (and average CPI scores):** 4 sub-watersheds ñ East Fork Hayfork Creek**, Dubakella Creek-Hayfork Creek, Big Creek**, Tule Creek** **Cost range ($K):** $360 ñ 1,660 ñ 2,960 	**0.3**	**1.68**	**3.34**	**3**	**1.86**
SF Trinity 11 (6.8)	**Identify priority screening needs at diversions within the South Fork Trinity sub-basin.** **Project Description:** Carry out an assessment of entrainment risk and a screening prioritization study on diversions (per the California Fish Passage Assessment Database) in the South Fork Trinity sub-basin to determine screening needs. **Dependencies / Project Linkages:** No dependencies indicated. **Primary Action Types:** Fish screens installed **Near-Term Focal Areas (and average CPI scores):** Covers 5 sub-watersheds ñ Big Creek**, Barker Creek-Hayfork Creek, Tule Creek**, Olsen Creek-Hayfork Creek, Pelletreau Creek-South Fork Trinity River** **Cost range ($K):** $125 ñ 375 ñ 688 	**1.01**	**1.5**	**0.8**	**1.5**	**1.97**

Sources for restoration actions: NCRWQCB 2006, NMFS 2014; SRWC and SRCD 2014, SRWC 2018, Yokel et al. 2018, USFWS 2019b, and sub-regional working group input via surveys and webinars.

Current & Future State of Species, Restoration, and Monitoring:

Species Status & Current Restoration Efforts in the South Fork Trinity Sub-basin

The federally listed Southern Oregon/Northern California Coast Evolutionarily Significant Unit of ***Coho Salmon*** is a key species identified for many restoration actions in the South Fork Trinity (NMFS 2014). ***Chinook, steelhead, and Pacific Lamprey*** populations are also of significant conservation concern as these are Tribal Trust Species that have experienced long-term declines in the Basin. The South Fork Trinity sub-basin is considered to hold vast potential for restoration and wild salmonid recovery, having once supported large runs of Coho and both spring and fall Chinook. Spring Chinook once had runs of over 10,000 a year but have since been less than 50 fish a year since 2015 (Yurok Tribes communication).

The Trinity County Resource Conservation District has undertaken a number of large-scale watershed restoration projects in the South Fork Trinity sub-basin in recent years, involving road removal, slope stabilization, riparian planting and landowner education in cooperation with the South Fork Trinity River Coordinated Resources Management Planning group (CRMP). Additionally, while the river is beyond the ancestral territory of the Yurok, the Tribe has recently entered into partnership with the US Forest Service, the Watershed and Fisheries Restoration Program of the Watershed and Research Training Center, and local landowners in order to rebuild the river through various targeted restoration activities (Yurok Tribe press release, 2018).

The following table summarizes selected major restoration activities in the South Fork Trinity sub-basin and those species which these activities have benefited.

Table 4-40: Summary of major restoration efforts in the South Fork Trinity sub-basin to date. (●) indicates target focal species for each restoration activity, (○) indicates non-target species that will also benefit.

Key Restoration Activities in the South Fork Trinity Sub-basin to Date	Species Benefiting				
	CO	CH	ST	*PL*	*GS*
The Trinity County Resource Conservation District has undertaken numerous large-scale watershed restoration projects in the South Fork Trinity sub-basin where roads have been decommissioned to reduce the amount of sediment going into the river.	●	●	●	○	○
The Trinity River Restoration Program (TRRP) supports a variety of watershed restoration actions including road maintenance, rehabilitation and decommissioning on private and public lands below Lewiston Dam, including the South Fork Trinity River basin.	●	●	●	○	○
The Yurok Tribe (with funding from the Trinity River Restoration Program) have recently undertaken a large woody debris helicopter-loading pilot project in the South Fork Trinity River where approx. 300 whole trees (up to 150 feet in length) have been installed in various configurations at locations within a 5-mile reach of the river. The intent is for the trees to provide the functional of LWD now missing from the river and facilitate the formation of habitats that can be used by fish (e.g., pools, side channels, wetlands)	●	●	●	○	
The Trinity Fisheries Improvement Association has undertaken projects to improve fish passage at numerous streams throughout the South Fork Trinity sub-basin.	●	●	●	○	
The Trinity County Resource Conservation District has undertaken a number of projects involving installation of livestock exclusion fencing and riparian planting in a number of key streams in the sub-basin.	●	●	●	○	

Current State of Monitoring & Data Gaps

Past and Ongoing Monitoring:

The USGS has a gauging station located at Hyampom on the South Fork Trinity River below the confluence with Hayfork Creek with flow discharge records dating back to 1965. This represents the only continuous discharge data for the river. Historically, the USGS gauged Big Creek (Hayfork Creek tributary) from 1961-1967 and Hayfork Creek from 1956-1965 (WRTC 2016). Limited gauging data has also been collected from small monitoring projects within the sub-basin by the USFS, Trinity County Resource Conservation District, and the Watershed Research and Training Center (WRTC 2016). These efforts, however, have been short term measures (WRTC 2016). The Watershed Research and Training Center, in coordination with the California State Water Resources Control Board, has recently initiated a discharge monitoring program on select streams in the sub-basin to better assess the impacts of water diversions on flow (WRTC 2016, McFadin 2019). Multiple agencies/organizations have collected short term water temperature datasets from smaller monitoring projects in the sub-basin in recent decades (WRTC 2016). The USFS has undertaken long-term monitoring of sediment transport in the South Fork Trinity River and has documented the restoration history in the Lower River. The Trinity County Resource Conservation District has also undertaken water quality monitoring in the past in the lower South Fork Trinity River.

Current Data Gaps:

Figure 4-48 provides a general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken across agencies in the South Fork Trinity sub-basin. Location-specific agency metadata (where available[22]) on monitoring projects is incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. Further investigation is needed to confirm whether or not the current data available can help answer key monitoring questions for the South Fork Trinity sub-basin (i.e., species relevance, spatial and temporal extent, data quality) and isolate any existing monitoring gaps.

Gauging and flow information for the South Fork Trinity is considered very limited (WRTC 2016). Due to resource availability and agency staff turnover, there are only a few sites in the sub-basin where water temperature is monitored nearly every year (Asarian 2016, WRTC 2016). There do not appear to be any active gauges in the sub-basin for monitoring of sediment inputs/transport processes.

[22] Note that only some available information on past monitoring activities across sub-basins provides specific location information (i.e. beyond indicating that it occurs somewhere within a sub-basin) and can be found in existing spatially-referenced databases that would allow for reliable transfer to the project's Integrated Tracking Inventory.

South Fork Trinity Sub-basin Monitoring Summary

Habitat Monitoring	Watershed Inputs	Weather	●
		Streamflow	●
		Groundwater	
		Riparian & Landscape	
	Fluvial-Geomorph	Sediments & Gravel	●
		Stream Morphology	●
	Habitat	Stream Temperature	●
		Water Quality	●
		Habitat Quality	●
		Barriers & Injury	●
		Marine/Estuary	NA
	Biota	Invasive Species	

			Salmon /Steelhead	Pacific Lamprey
Population Monitoring	Abundance	Juvenile Abundance (anad)	●	
		Spawner Abundance (anad)	●	
		Abundance (non-anad)	NA	NA
	Harvest	Harvest (in-river)		
		Harvest (ocean)		
	Distrib-ution	Temporal Distribution		
		Spatial Distribution	●	
	Demo-graphics	Stock Composition		
		Age Structure		
	Biota	Disease		

● Known monitoring activities (past or ongoing)

NA Monitoring not relevant to this sub-basin

Figure 4-48. Synthesis of past and ongoing monitoring activities in the South Fork Trinity sub-basin. Figure rows indicate general types of information collected (for habitat and population monitoring) within the sub-basin. More detailed information on agency monitoring by monitoring type and species is available in a supporting Excel table (the project's Integrated Tracking Inventory). This summary does not provide any detail in terms of the quality of the various assessments undertaken.

Recent and Forthcoming Plans and Initiatives

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017, Section 2.5, Appendix H):

- Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (SONCC) (NMFS 2014)
- Action Plan for Restoration of the South Fork Trinity River Watershed and its Fisheries (PWA 1994)
- North Coast Regional Water Quality Control Board Watershed Planning Chapter ñ Klamath Watershed Management Area (CA NC RWQCB 2011)
- Recovery Strategy for California Coho Salmon (CDFW 2004)

  - Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA and USDI 1994)
- Trinity County Resource Conservation District programs (Watershed Management, Native Habitat Restoration, Forest Health, Agriculture) http://www.tcrcd.net/
- Fish passage prioritization tool (https://www.cafishpassageforum.org/fishpass)
- Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife (in draft form at the time of writing)

At the time of writing, there were no new ***forthcoming plans and initiatives*** specific to this sub-basin under development, recently completed, or soon to proceed to implementation.

5 Recommended Monitoring Actions & Costs

This Section

- Summarizes priority monitoring actions, current state of monitoring, and detailed recommendations for continued or further monitoring.

5.1 Overview

5.1.1 Approach

As identified in Section 2.2 the goals and objectives of **the Integrated Fisheries Restoration and Monitoring Plan (IFRMP) have been collated from existing plans (details in ESSA 2017 and Appendix H) to ensure compatibility with ongoing work**, updated with input from regional stakeholders to ensure they still meet practitioners' needs, and organized into a hierarchy which reflects the major tiers of watershed function (see Table 2-1). Under this framework, watershed inputs and fluvial and geomorphic processes form the base of the hierarchy and support functions in all tiers above them, like a pyramid, such that improvements in function of these lower tiers are also expected to benefit habitat and biological functions in all tiers above.

Each of the IFRMP objectives is linked to associated core performance indicators (CPIs) that will be monitored across the Klamath Basin to **track and communicate progress towards basin-wide recovery** per desired states of these CPIs that achieve objectives within each of the biophysical tiers (Table 2-2). CPIs selected for IFRMP monitoring were developed through literature review of common watershed status indicators and further refined though review, preference surveys, and follow-up webinar discussions with IFRMP participants across Sub-basin Working Groups.

IFRMP monitoring is intended to provide broad-scale, ongoing tracking of CPI status and trends to confirm that whole-basin recovery across all biophysical tiers is occurring and is being maintained over time. Any worrisome signals in monitoring of CPIs could indicate the need for further diagnostic investigation through additional, more detailed monitoring or special studies to evaluate causes. These shifts in CPI state will also influence the future rank order of restoration action priorities identified by the Klamath IFRMP Restoration Action Prioritization Tool. While the IFRMP will focus on evaluating basin-wide status and trends, additional support and funding are also needed to ensure that other ongoing monitoring programs across the Basin will be able to continue to evaluate local project implementation and effectiveness.

It is anticipated that it will be possible in many cases to integrate local monitoring infrastructure/information from ongoing programs into the broader IFRMP assessments of basin-wide CPI status and trend. Past and ongoing monitoring programs/activities within each of the Klamath sub-basins were described generally in Section 4.

5.1.2 Summary

Through a series of webinars convened by the IFRMP in June-August 2021 subject-area experts (Appendix F) discussed in detail the current monitoring infrastructure in place across the Klamath Basin, evaluated the strength of existing monitoring for providing broad evaluations of the status

Header Image: Klamath Mainstem Chinook Salmon Monitoring 2015 | USFWS of CPIs within the different biophysical tiers (see Figure 2-1), **identified important monitoring gaps**, and made **recommendations as to where/how the IFRMP could best supplement existing monitoring** information to improve basin-scale assessments of CPI status and trends. These recommendations were vetted through additional literature review where possible. **Several crosscutting monitoring needs emerged** from the webinar discussions including the:

- need for improved **standardization of data collection and storage**.
- need for coarse basin-wide approaches to support **system-wide assessments** of multiple CPIs (e.g., repeat bathymetric LiDAR over time).
- need for **event driven monitoring** (i.e., real-time data) to understand the relationship between significant precipitation events and CPIs.

There were also commonalities across CPIs in terms of the spatial allocation of sampling effort. In many cases the proposed stratification variables were the same, providing the **opportunity to co-locate sites** thus minimizing effort and providing additional information for individual CPIs. This resulted in the recommendation for three common approaches to allocating samples across the basin (Figure 5-1) which are employed in some combination by each of the CPIs.

- Approach A) **Basin-wide census** (e.g., LiDAR, TIR);
- Approach B) **Point locations** in the mainstem Klamath River and just above the confluence (subject to logistical and access constraints) of each major sub-basin (e.g., water quality sampling, eDNA etc.); and
- Approach C) **CPI specific stratification** as necessary (e.g., key refugia, areas of special emphasis, tributaries, areas with high agricultural pressures etc.).

Costs for each monitoring activity and CPI/recommendation were generated from individual requests to practitioners and experts from organizations in the Klamath region, communication with commercial providers, literature searches for monitoring activity costs from similar watershed monitoring applications, and assumptions about general fieldwork costs. Costing calculators were then generated to scale up cost estimates by the recommended sample design in terms of number of sites, spatial extent, data collection and analysis frequency, inflation, and changes in funding over 1, 5, 10, 15, and 20-year time frames. In this section, 1- and 10-year costs are presented for each individual CPI in isolation in the body text for each CPI. Portraying the costs individually shows what it would take to fund a certain CPI, without accounting for synergies between monitoring activities that inform multiple CPIs. However, many CPIs will not be treated in isolation, as certain monitoring activities will inform multiple CPIs. There are strategic opportunities to leverage site co-location for many CPIs. To account for these synergies, we examined the effects of overlapping coverage for monitoring activities in terms of a ‘gestalt prioritization’ where we ranked individual CPI/recommendations with our own judgement and workshop participant input on a scale from 1 (most important) to 5 (least important) and summarized total costs for the monitoring activities to cover each tier of priority (see details of priorities in Appendix G). These rankings focus first on high priority basin-wide monitoring that is difficult for an individual organization to tackle or on activities that inform many CPIs; lower tier priorities target supplemental monitoring in specific areas, or monitoring activities that are informative but not necessary to the functioning of the monitoring program. Costs accounting for the gestalt prioritization tiers are summarised in Table 5-1.

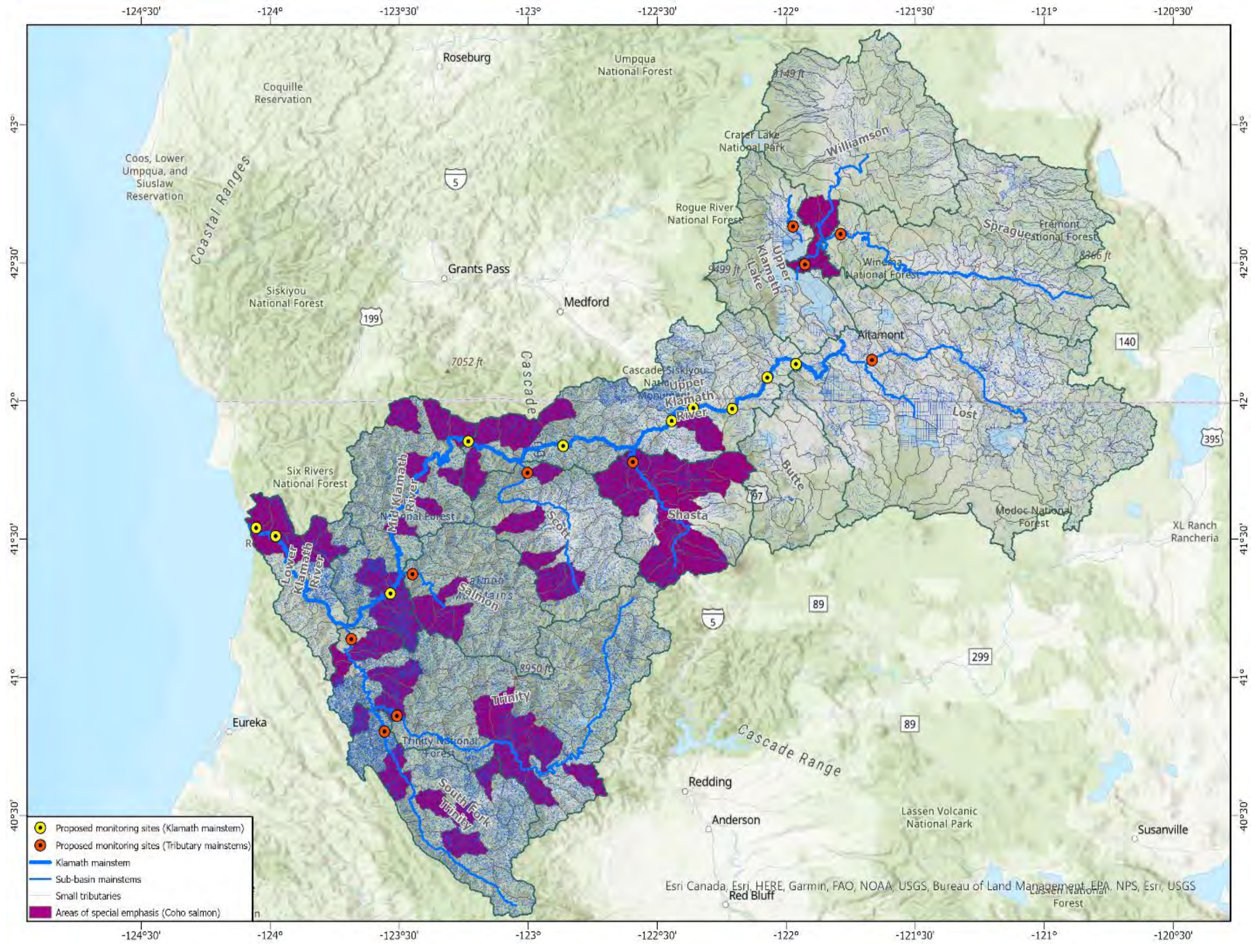


Figure 5-1: Conceptual map of the three common sampling approaches employed across the CPIs at the basin-wide scale. Approach A is illustrated by the blue stream network (Klamath River mainstem, sub-basin tributary mainstems, smaller tributaries). Approach B is illustrated by the yellow (Klamath River mainstem) and red (sub-basin tributary mainstems) point locations. Approach C is illustrated by the purple shaded HUC12 polygons representing an example stratification (i.e., areas of special emphasis for coho as identified by IFRMP sub-basin experts).

Table 5-1. Cost totals to fully cover all CPI/recommendations in each tier of gestalt prioritization, accounting for synergies in site co-location and monitoring activities that informs multiple CPIs.

Gestalt Priority Tier	Cost: 1-Year	Cost: 10-Year
1	1,578,000	12,230,000
2	4,583,000	16,565,000
3	1,443,000	3,848,000
4	4,969,000	13,788,000
5	5,613,000	25,194,000

Table 5-2 provides a summary of our recommendations as to where the IFRMP could best contribute to consolidating or improving Klamath basin-wide monitoring of individual CPIs within each of the defined biophysical tiers, including potentially developing new monitoring activities or else helping to support or expand existing monitoring programs/activities already in place. As noted in Table 5-2 there are many cases where a particular recommended monitoring activity could potentially support evaluation of multiple CPIs within or across biophysical tiers. More detailed descriptions of monitoring recommendations for individual CPIs including where and when sampling should occur are provided in subsequent subsections. In addition, maps of recommended IFRMP monitoring locations and/or sampling strata[23] for each of the CPIs have been developed and are available at https://arcg.is/WWvDH.

[23] Strata are defined as groups from within the total population that are organized based on their shared characteristics or attributes. The process of classifying the population into groups is called stratification. Stratification thus consists of dividing the population into strata within each of which an independent sample can be chosen.

Table 5-2: Activities that could support/improve Klamath basin-wide monitoring of biophysical tier core performance indicators (CPIs) as identified by IFRMP monitoring workgroup webinar participants. Note that these include maintenance of existing infrastructure/activities, expansion of existing infrastructure/activities, and new infrastructure/activities. (11x17 page layout is intentional).

					CPIs across Biophysical Tiers																			
					Watershed Inputs			Fluvial Geomorphology					Habitat								Biotic Interactions		Fish Populations	CPI Totals
		Current status of recommended infrastructure / activities			Instream flow	Nutrient loads	Fine sediment loads and turbidity	Large wood recruitment/retention	Geomorphic flushing/scouring flows	Floodplain connectivity/ Inundation	Channel complexity	Sediment distributions	Water temperature	Water chemistry (DO, pH, conductivity)	Turbidity	Thermal refugia	Nutrients (P, N)	Nuisance phytoplankton and toxins	Stream habitat condition	Riparian condition	Disease	Invasive aquatic species	Focal Species Population Indicators	
		Maintain existing infrastructure	Expand existing infrastructure	New infrastructure/approach																				
Monitoring Activities	Sondes	X	X				X						X	X	X	X		X						6
	Water samplers (e.g. ISCO)	X	X	X		X											X	X			X	X[24]	X[25]	6
	Drone surveys			X												X							X	2
	Topographic[26] LiDAR surveys	X						X		X									X	X				4
	Bathymetric[27] LiDAR surveys		X	X							X	X												2
	Air photos		X	X							X	X				X			X	X				5
	Satellite imagery		X	X						X	X								X	X				4
	Thermal infrared (TIR) surveys		X	X												X								1
	Temperature sensors															X								1

[24] eDNA analysis
[25] eDNA analysis
[26] Topographic LiDAR is applicable for efficient characterization of landforms and vegetation over broad (basin-wide) extents but does not provide information about wetted channel elevations.
[27] Bathymetric LiDAR penetrates the water column to measure submerged bed elevations in addition to nearby dryland elevations but requires more targeted surveys over smaller extents to ensure adequate resolution and sufficient water penetration.

		Current status of recommended infrastructure / activities			CPIs across Biophysical Tiers																			
					Watershed Inputs			Fluvial Geomorphology					Habitat								Biotic Interactions		Fish Populations	CPI Totals
		Maintain existing infrastructure	Expand existing infrastructure	New infrastructure/approach	Instream flow	Nutrient loads	Fine sediment loads and turbidity	Large wood recruitment/retention	Geomorphic flushing/scouring flows	Floodplain connectivity/ Inundation	Channel complexity	Sediment distributions	Water temperature	Water chemistry (DO, pH, conductivity)	Turbidity	Thermal refugia	Nutrients (P, N)	Nuisance phytoplankton and toxins	Stream habitat condition	Riparian condition	Disease	Invasive aquatic species	Focal Species Population Indicators	
Monitoring Activities	Flow gages	X	X		X	X			X	X			X		X		X							7
	Groundwater wells	X	X		X																			1
	Stage loggers	X	X							X														1
	Field-based surveys	X	X			X		X								X	X	X	X	X				7
	Carcass surveys	X	X																		X		X	2
	Electrofishing	X	X													X							X	2
	Snorkel surveys	X	X													X							X	2
	Screw traps	X	X																		X		X	2
	Weirs	X	X																		X		X	2
	PIT tag arrays	X	X																				X	1
	Redd counts (foot/aerial)	X	X																				X	1
	Telemetry (fixed arrays & mobile surveys)	X	X													X							X	2
	Sentinel fish cages	X	X																		X			1

5.2 Watershed Inputs

5.2.1 Instream Flow

Why

River/stream flows create and maintain aquatic, floodplain, and riparian habitats. Flows also transport other key watershed inputs (e.g., sediment, large woody debris). Streamflow in the Klamath Basin is driven by snowmelt and rainfall, while groundwater discharges can also contribute significantly to baseflows in many reaches. A wide range of historical and ongoing human activities have contributed to reduced flows in many areas of the Klamath Basin. Extensive use of surface water and groundwater for irrigation (legal and illegal withdrawals), combined with reduced groundwater recharge, has contributed to low summer flows and disconnection or complete dewatering of some spawning and rearing habitats important for focal fish species (NMFS 2015, Foglia et al. 2018). It is important to monitor stream discharges to ensure that year-round instream ecological flows that support focal fish species are being maintained across the Klamath Basin, especially given the increasing impact that climate change could have on regional flow patterns. Discharge is also necessary to estimate other CPIs including nutrient and sediment loads. Additional monitoring focusing on groundwater levels can inform this CPI by providing insights into future water availability that may impact surface flows.

Current Status of Associated Monitoring

The current network of streamflow gages maintained by a variety of Klamath agencies provides good spatial coverage of seasonal stream flows across the Klamath Basin, particularly within the Klamath River mainstem. Some monitoring gaps do exist and it would be useful to add additional streamflow monitoring at tributary mouths and within key fish production areas. While there are gages throughout the basin, real-time publicly accessible flow data to provide insights into unpredictable flow events is a key monitoring gap. Groundwater monitoring is also conducted in throughout the Basin, but coverage is not systematic or comprehensive.

Detailed Recommendations

Recommendation 1 – Expand network of streamflow gaging stations

How – Expand the existing network of real-time, publicly accessible telemetered streamflow gaging stations (as possible). Recommended techniques and methods to be employed for streamflow measurements at gaging stations are described in Turnipseed and Sauer 2010.

What – Hourly or sub-hourly discharge, which can also be used to calculate metrics such as mean monthly discharge, peak annual flow, or annual discharge.

Where – It will be important to maintain the existing network of Klamath Basin streamflow monitoring as well as adding more flow gages at sub-basin confluences as well as tributaries known to have historically high fish productivity. Known locations of spawning/rearing for focal species (or the Special Emphasis Areas identified within each sub-basin during Phase 3 of the IFRMP) could be used as strata for selecting sites for installation of new flow gages. This is seen as particularly important in the Scott River sub-basin where monitoring flows at tributary mouths is needed to evaluate condition of potential seasonal passage barriers. Adding more gage sites in the Scott River sub-basin would also help in evaluating flow restoration efforts, with flow monitoring in over-summering coho habitat in the tributaries to the Scott River especially needed. Key flow monitoring sites within the Scott River sub-basin would be at Shackleford and French Creeks. Flow gaging within the Shasta River sub-basin has increased recently with Safe Harbor Agreements but may not provide sufficient coverage across highest priority fish habitats and further supplementation would be beneficial

Top priority (1a)

- Adopt the six flow gage sites corresponding to Definite Plan water quality monitoring sites (Section 3.1.1 of Exhibit O) and **maintain after the Definite Plan is completed**.
- Ensure that a mainstem Klamath site is installed between Seiad Creek and Iron Gate Dam. This reach is currently a data gap despite expectation that it will be influenced by dam removal.
- Ensure the 3 additional tributary sites identified in the Definite Plan for water quality monitoring have a flow gage installed (i.e., Shasta River, Scott River and Salmon River).
- Ensure a site is installed at the mouth of each of the remaining sub-basins (Upper Klamath Lake, Williamson, Sprague, Lost, Upper Klamath River, Mid-Klamath River, Lower Klamath River, Trinity, South Fork Trinity). If applicable adopt / integrate existing monitoring efforts from each sub-basin.

Second priority (1b)

- If possible, supplement the network further by placing flow gage sites in areas identified as critical fish habitat (e.g., key spawning and winter rearing areas) to assess the condition of critical fish habitats over time.

When – Flow monitoring would ideally be continuous year-round at all gage sites but where this is not possible (for logistical or other reasons) then monitoring should be for as much of the year as possible and be targeted at evaluating flows at critical fish life history periods: spring outmigration, fry emergence and redistribution, summer rearing refugial conditions, winter base flows.

Other considerations – Continuous measurement of stream flows is also critical for tracking/understanding the status of Basin "loading" CPIs (i.e., sediment loads, nutrient loads), so co-location of flow gages with other monitoring sites (e.g. Definite Plan water quality monitoring sites) is important.

Recommendation 2 – Track groundwater levels at monitoring wells

How – Leverage existing groundwater wells and expand on the current network to anticipate changes in groundwater dynamics that may result in disruptions to surface flow. Recommended techniques and methods can be found in CDFW 2016.

What – Hourly groundwater level data from monitoring wells, which can be used to calculate summary statistics by season or analysis period relative to surface streamflow data.

Where – It is important to incorporate the existing network of index wells in the Basin as well as adding additional sites in areas where groundwater plays a key role in surface flows. Particular sub-basins where a need for more loggers on existing wells and additional wells exists include: Shasta, Scott, Butte, and Sprague.

When – Groundwater monitoring would ideally be continuous year-round at all well sites but where this is not possible (for logistical or other reasons) then monitoring should be for as much of the year as possible and be targeted at predicting surface flows prior to critical fish life history periods, and especially springtime flows.

Other considerations – Related relevant plans or guidance include the Shasta Groundwater Sustainability Plan (Siskiyou County Flood Control and Water District Groundwater Sustainability Agency 2021) and the CDFW Sustainable Groundwater Management Act (SGMA).

Costs

Costs for this CPI are based on flow gage/groundwater sensor equipment and upkeep costs, and whether gage sites exist already or need to be installed. For specifics of cost estimation, see Appendix G.

Table 5-3. Monitoring costs for instream flow.

Recommendation	1-Year Cost	10-Year Cost
1a: Streamflow stations (top priority sites)	685,000	5,326,000
1b: Streamflow stations (second priority sites)	847,000	5,395,000
2: Groundwater stations	85,000	192,000

Related Activities

There are at least 12 different organizations collecting flow or groundwater data across the Klamath Basin currently including: Scott River Watershed Council, U.S. Geological Survey, Quartz Valley Indian Reservations, Oregon Water Resources Department, Klamath Tribes, Salmon River Restoration Council, Department of Water Resources, Green Diamond Resource Company, UCD Watershed Science/CalTrout, Karuk Tribe, The Watershed Research and Training Center, and Shasta Valley RCD.

5.2.2 Nutrient Loads

Why

Annual cycles of flooding, draining, and agricultural activities associated with grazing and irrigated cropland have oxidized the peaty soils, caused land subsidence, increased erosion and exported large nutrient loads to Upper Klamath Lake and the downstream river for nearly a century (Carpenter et al. 2009; Snyder and Morace 1997, as cited in NMFS 2013; Walker et al. 2012). Inputs of nutrients from these sources as well as from non peat areas (Williamson and Sprague) where erosion by natural processes (and enhanced in some places by human activities) cause seasonal cyanobacteria blooms that have been linked to degradation of water quality (e.g., low dissolved oxygen, high pH, and toxic levels of un-ionized ammonia) in Upper Klamath Lake and the Klamath River (Walker et al. 2012; NMFS 2013). The Klamath River is currently listed as a

Clean Water Act (CWA) impaired waterway (on the "303(d)" list) in both California and Oregon due to water temperature, sedimentation, pH, organic enrichment/low dissolved oxygen, nutrients, ammonia, chlorophyll-a, and cyanotoxins.

Monitoring nutrients is important to evaluate the magnitude of the stress on the system over time in response to the suite of restoration actions implemented throughout the Klamath Basin. This CPI may provide an earlier signal (i.e., it is expected to improve before fish populations respond) as to the benefits of upstream restoration actions. This CPI may also be useful to identify where and when nutrient inputs are occurring to inform restoration activities.

Current Status of Associated Monitoring

There is broad spatial coverage for this CPI in the tributaries of the Upper Klamath River sub-basins. There is also good coverage in the mainstem Klamath River through the hydroelectric reach and below IGD. There are a few focused locations for nutrient monitoring in other sub-basins including the Scott, Shasta, and Trinity. Nutrient concentration at individual sites is assessed through water samples collected up to 12 times per year and sent for lab analysis. A key information gap is the lack of good data to understand how large precipitation events or flow management changes contribute nutrients to the system.

"*A combination of scheduled and storm-event sampling would better characterize the range of constituent concentrations, loads and stream flow at the sample sites*." – Schenk et al. 2018

Detailed Recommendations

Recommendation 1 – Establish network of automated water samplers

What – Nutrient concentration and load, where the primary nutrients of interest are phosphorous and nitrogen. Note that estimates of load require associated estimates of discharge.

How – Water samples followed by lab analysis are necessary for direct measures of phosphorous and nitrogen. 24-hour ISCO samplers are recommended to minimize within day variability, supplemented with periodic manual sample collection for data QA/QC and to provide redundancy in the event of ISCO sampler failure. Estimates of nutrient loads can be obtained through site level nutrient concentrations and discharge using existing tailored statistical software packages. Schenk et al. (2016) found strong correlations between turbidity and total phosphorous in the Williamson River below the confluence with the Sprague, suggesting there is potential to use turbidity as a proxy for total phosphorous, although associations are likely site or at least system specific (i.e. this same relationship was not found to exist higher in the system) and may also vary by season. This could however provide the possibility of a lower cost option by reducing the number of samples sent to the lab for analysis (although initially a considerable number of samples would be required to develop a useable regression relationship). Guidelines for establishing relationships between turbidity and concentrations of other water constituents are provided in Rasmussen et al. (2009).

Where – Monitoring sites should include a combination of mainstem and tributary sites. Mainstem sites should coincide with the fixed continuous sonde network recommended for Water Temperature, Water Chemistry, and Turbidity CPIs. Additional tributary sites should focus on areas where nutrient inputs are expected to be or have traditionally been high given land use activities to inform and evaluate restoration efforts. Tributaries could be stratified by agricultural intensity (e.g., more sites in Wood River and Williamson) and possibly by critical rearing habitat in the lower basin (e.g., more sites in the Shasta). Discharge, turbidity, and standard water chemistry should be recorded at the tributary sites to ensure loads can be estimated if necessary and to provide additional insights into associations between turbidity, water chemistry, and nutrients

Top priority (1a)

- Adopt the ten mainstem water quality sites identified in the Definite Plan (Section 3.1.1 of Exhibit O) and **maintain after the Definite Plan is completed**.
- Ensure that a mainstem Klamath site is installed between Seiad Creek and Iron Gate Dam. This reach is currently a data gap despite expectation that it will be influenced by dam removal.
- Adopt the 3 tributary sites identified in the Definite Plan (i.e., Shasta River, Scott River and Salmon River) **and maintain after the Definite Plan is completed**.
- Ensure a site is installed at the mouth of each of the remaining sub-basins (Upper Klamath Lake, Williamson, Sprague, Lost, Upper Klamath River, Mid-Klamath River, Lower Klamath River, Trinity, South Fork Trinity). If applicable adopt / integrate existing monitoring efforts from each sub-basin.

Second priority (1b)

- If possible, supplement the network further by placing water samplers in areas identified as critical fish habitat (e.g., key spawning and winter rearing areas) to assess the condition of critical fish habitats over time.

Monitoring sites should include a combination of mainstem and tributary sites. Mainstem sites should coincide with the fixed continuous sonde network recommended for Water Temperature, Water Chemistry, and Turbidity CPIs. Additional tributary sites should focus on areas where nutrient inputs are expected to be or have traditionally been high given land use activities to inform and evaluate restoration efforts. Tributaries could be stratified by agricultural intensity (e.g., more sites in Wood River and Williamson) and possibly by critical rearing habitat in the lower basin (e.g., more sites in the Shasta). Discharge, turbidity, and standard water chemistry should be recorded at the tributary sites to ensure loads can be estimated if necessary and to provide additional insights into associations between turbidity, water chemistry, and nutrients.

Please refer to the maps of recommended IFRMP monitoring locations and/or sampling strata for nutrient loads at https://essa.maps.arcgis.com/apps/MapSeries/index.html?appid=074698d7813647aa9870f235334a9a2d&entry=3.

When – Seasonal monitoring throughout the water sampling network will provide valuable estimates of status and trend over time as restoration progresses. Ideally, nutrient load during precipitation events or flow management events can be captured.

Other considerations – Discharge, turbidity, and standard water chemistry should be recorded at sites where possible to ensure loads can be estimated if necessary and to provide additional insights into associations between turbidity, water chemistry, and nutrients. At each site, the location of the water sampler should be chosen to avoid poorly mixed flow conditions to ensure a representative sample. While storm events are particularly important, they are difficult to predict, however some automated samplers are able trigger a water sample if a real-time turbidity threshold is exceeded which may provide real-time data on nutrient concentration[1]. Alternatively, discharge and turbidity from continuous sondes could be used to estimate total phosphorous load during precipitation events, leveraging the co-located samples for nutrient concentration and turbidity to calibrate the site level relationships over time. However, factors such as algal blooms may confound the generalizability of calibrated relationships, highlighting the need for the development of site-specific regressions (C. Anderson pers. comm).

Costs

Costs for this CPI are based on water sampler equipment and upkeep costs, lab analyses, and whether sites exist already or need to be installed. For specifics of cost estimation, see Appendix G.

Table 5-4. Monitoring costs for nutrient loads.

Recommendation	1-Year Cost	10-Year Cost
1a: Water samplers, top priority sites	298,000	3,091,000
1b: Water samplers, second priority sites	305,000	2,774,000

Related Activities

There are a number of linkages between the proposed monitoring for nutrients and other CPIs including: invasive species and pathogens which both require water samples, and turbidity which has potential as a surrogate for many other water quality constituents. Discharge is required to estimate nutrient load.

5.2.3 Fine Sediment Loads and Turbidity

Why

Water quality is cross-cutting issue affecting habitat conditions for all focal fish species in the Klamath Basin. Many restoration activities are currently underway or are being considered for the future to improve water quality throughout the Klamath Basin.

Levels of suspended sediment concentrations are a concern in the mainstem Klamath River and basin tributaries, especially where fires (NRC 2008) or wide-scale timber harvest has occurred (NMFS and USFWS 2013). Although sediment transport is an integral part of a functioning river system, excess suspended sediment can cause problems for aquatic habitat. Mainstem Klamath areas of concern center on sections downstream of Iron Gate and Keno Dams, where sediment transport has been disrupted and remobilization of accumulated sediments may occur with dam removal. Sub-basins where suspended sediment has been identified as a key stressor include the Williamson, Sprague, Mid-Klamath River, Scott, Lower Klamath River, Trinity, and South Fork Trinity sub-basins. High concentrations of fine sediment are a concern because sediment can fill

[1] Excerpt from Definite Plan Exhibit O, page 57. “The Teledyne ISCO automated pump samplers … Major attributes include the ability to program the sampler to collect samples at specified temporal frequencies and at specified turbidity thresholds. An SDI-12 interface allows connection with the YSI EXO2 sondes via the data logger to trigger the samples at specified turbidity thresholds without disrupting the transmission of continuous water quality data from the sondes.”

pools and simplify instream habitats used by fish (NRC 2008), disrupt normal feeding behavior by fish, reduce growth rates, and affect survival of juvenile salmonids by interfering with normal development and emergence (Berg and Northcote 1985; Chapman 1988). Sedimentation arising from harvest-related landslides and extensive road networks continues to impact habitat even from modern-day harvesting operations, although at much reduced levels compared to early logging in the Klamath Basin (NMFS and USFWS 2013). Large-scale high intensity fires can also contribute to increased downslope fine sediment deposition into rivers and streams (Moody and Martin 2009; James 2014). Post-fire “salvage logging” (harvest of trees damaged or killed by fire soon after to recover their economic value) can also compound the disturbance and contribute to altered runoff and hydrological patterns (Silins et al. 2008; Wegenbrenner et al. 2015).

Relationships between turbidity and suspended sediment combined with information on discharge can be used to estimate fine sediment loads. Monitoring turbidity/suspended sediment is also important to document conditions relative to TMDLs, as well as to be able to demonstrate basin-wide improvements resulting from the suite of restoration actions implemented throughout the Klamath Basin. Turbidity has potential value as a proxy for concentrations of nutrients and other constituents. This CPI may also be useful to identify where and when fine sediment inputs are occurring to inform restoration activities.

Current Status of Associated Monitoring

There is a good longitudinal monitoring network from Keno to the estuary for this CPI. There is limited information in the tributaries. Specific gaps were noted by sub-basin experts in the Scott River where TMDL listings exist; the South Fork Salmon River; the Sprague and the Wood River systems. Like the water quality CPIs, event-based monitoring is desired to better understand how large precipitation events contribute fine sediment to the system.

Detailed Recommendations

Recommendation 1 – Expand /maintain the network of continuous sondes with real-time data transmission

What – Fine sediment loads estimated using relationships between turbidity and suspended sediment as well as information on discharge. (https://nrtwq.usgs.gov/explore/dyplot?site_no=11502500&pcode=99409&period=2020_all&timestep=uv&modelhistory=&units=load).

How – Continuous sondes with real-time data transmission. Reference instrument specifications and quality assurance measures from the Definite Plan (Exhibit O).

Where –

Top priority (1a)

- Adopt the ten mainstem sondes identified in the Definite Plan (Section 3.1.1 of Exhibit O) and **maintain after the Definite Plan is completed**. Six of these sondes have real-time data transmission.
- Ensure that a mainstem Klamath site is installed between Seiad Creek and Iron Gate Dam (there is one proposed in the Definite Plan). This reach is currently a data gap despite expectation that it will be influenced by dam removal.

- Adopt the 3 tributary sites identified in the Definite Plan (i.e., Shasta River, Scott River and Salmon River) **and maintain after the Definite Plan is completed**.
- Ensure a site is installed at the mouth of each of the remaining sub-basins (Upper Klamath Lake, Williamson, Sprague, Lost, Upper Klamath River, Mid-Klamath River, Lower Klamath River, Trinity, South Fork Trinity). If applicable adopt / integrate existing monitoring efforts from each sub-basin.

Second priority (1b)

- If possible, supplement the network further by placing continuous sondes in areas identified as critical fish habitat (e.g., key spawning and winter rearing areas) to assess the condition of critical fish habitats over time.

When – Continuous data with real-time data transmission provide the best opportunity for assessment of conditions, particularly those associated with unpredictable events such as storms.

Other considerations – There are logistical challenges to continuous sampling during the winter and storm events. USGS has done work to 'harden' sites and equipment but there is potential for damage or theft which should be considered. This recommendation relates closely to the recommendations for Water Temperature and Water Chemistry CPIs.

Recommendation 2 – Standardize data collection and sharing across organizations

Turbidity is measured by numerous different organizations for different purposes. Turbidity measures are not readily comparable across different gage types. Currently data collection, reporting, and storage is not standardized making it difficult to leverage the available data to its fullest potential.

It would be useful to complete a collaborative study to:

- Agree upon standard Quality Assurance practices and data summaries to be shared across the basin (e.g., through the KBMP database).
- Identify best practices moving forward so that future data collection is standardized (e.g., methods and equipment, site specific consistency).

Compare and contrast objectives and identify potential redundancies or key gaps.

Costs

Costs for this CPI are based on sonde equipment and upkeep costs, and whether sites exist already or need to be installed. For specifics of cost estimation, see Appendix G.

Table 5-5. Monitoring costs for fine sediment loads and turbidity.

Recommendation	1-Year Cost	10-Year Cost
1a: Continuous sondes: top priority sites	594,000	3,812,000
1b: Continuous sondes: second priority sites	839,000	3,571,000
2: Standardize data practices	Workshop, TBD	Workshop, TBD

Related Activities

Proposed monitoring for this CPI piggybacks on the proposed monitoring within the Definite Plan (Recommendation 1).

5.3 Fluvial Geomorphology

5.3.1 Large Wood Recruitment and Retention

Why

Large wood is an important part of the physical template that structures aquatic ecosystems. In-stream wood delivered from hillslopes and stream banks mediates sediment transport processes and flow dynamics to trap and store sediment, creating hydro-geomorphic diversity and new stable alluvial features that provide a variety of habitat types (Wohl 2017; Kasprak et al. 2012). In the Klamath Basin, large wood supply and transport has been altered by degradation of riparian forests, interception of wood at mainstem dams, channel physical modifications, and widespread removal of fluvial deposited wood and wood jams (NMFS and USFWS 2013). Due to downstream channel simplification from straightening, levees, and armoring, the large wood that is available along mainstem corridors is highly mobile during high flow events, further decreasing retention of the large wood that does get recruited (NMFS and USFWS 2013). Impacts from reduced large wood supply and retention include poorer spawning habitat quality, loss of pool volume and complexity for adult holding and juvenile rearing, reduced shading, and loss of velocity refugia (NMFS and USFWS 2013).

Current Status of Associated Monitoring

Large wood monitoring is a component of existing programs in the Klamath Basin, but consistent basin-wide approaches are lacking. Most wood inventories are associated with site-specific habitat assessments or individual restoration project effectiveness monitoring (ESSA 2017), typically applying field-based approaches such as CDFW habitat inventory methods. Large wood inventories need to be standardized and applied to a broad scale for basin-wide monitoring; process-focused assessments should also be included in monitoring to develop understanding of how and where wood is generated throughout the Basin, how wood moves through the system, and how changes outside of the active channel (e.g., forestry practices, wildfire dynamics, terrestrial habitat restoration activities) may affect wood recruitment and supply. There is also a need to improve our understanding of natural and/or historic wood metrics to inform restoration; wood loading information and recommendations commonly used (e.g., those presented in the NMFS Coho Salmon Recovery Plans) suggest targets that are viewed as too low for the region based on local experience, particularly in the Mid- and Lower Klamath (S. Beesley, pers. comm.).

Detailed Recommendations

Recommendation 1 – Measure current large wood concentrations with LiDAR

What – Wood piece density and jam density in terms of: number of wood pieces per kilometer of river length, number of jams per kilometer of river length, and wood jam area (m^2) per kilometer of river length.

How – Measure large wood in river corridors directly with aerial LiDAR interpretation. Manual interpretation of LiDAR point clouds can be used to detect and enumerate large wood pieces and jams across broad watershed areas (Atha and Dietrich 2015; Zischg et al. 2018), with the added benefit of being able to penetrate vegetation canopies to detect wood that would be otherwise obscured in imagery-based assessments (e.g., Atha 2013). For validation to inform confidence in the LiDAR methods, LiDAR wood measurements should be supported with a set of field-based wood measures using standardized methods.

Where – Given the broad spatial coverage provided by aerial LiDAR, this CPI can be assessed throughout the Klamath Basin. Understanding the transport of wood through the system from hillslopes to tributaries to mainstem river segments is valuable to infer watershed processes and predict potential wood supply; wood concentrations should therefore be measured in small and large streams alike. LiDAR wood enumeration is a desktop exercise that is feasible and efficient over broad areas by a trained interpreter (Atha and Dietrich 2015).

When – In the absence of large disturbance events (e.g., extreme floods, mass movements, wildfires), wood concentrations are expected to change slowly in response to channel forming flows with moderate return intervals (i.e., 2-3 years). Repeat LiDAR surveys every five years will capture changes in wood distributions and concentrations with sufficient temporal resolution to link changes in wood dynamics to broader processes or restoration activities. In a given survey year, the LiDAR flight timing should optimally target late summer low flows when wood is unlikely to be submerged and will be most detectable in the point cloud data.

Other considerations – The monitoring for this CPI is largely unaffected by other basin activities or dam removal. The LiDAR data collection can occur irrespective of on-the-ground activities or individual restoration actions. Potential synergies exist with other CPIs that are expected to make use of LiDAR data, including floodplain connectivity, channel complexity, physical habitat quality, and riparian condition. It is also important to consider the safety implications of in-stream wood in relation to other river uses such as recreation and navigation.

Recommendation 2 – Assess potential large wood supply with LiDAR tree height metrics

What – 1) Total potential large wood, defined as the percentage of valley area with standing trees within a particular study segment, anywhere between the study segment and the tops of its associated valley walls (perpendicular to channel direction). This metric captures the availability of all large wood in the valley that exists as standing forest that can potentially enter the stream from broadscale floodplain or hillslope processes such as long-term channel migration or mass wasting. This metric can also inform regeneration and survival of trees over time.

2) Proximal potential large wood, defined as the percentage of area within one channel width from the channel that contains standing trees. Although large wood can be recruited from anywhere in the valley over time, trees closer to the stream channel are more likely to enter the channel over short time scales (McDade et al. 1990). This metric therefore captures trees that are likely to fall directly into the channel due to wind throw, tree mortality, or bank undercutting.

How – Kasprak et al. (2012) present a desktop-based method of identifying potential large wood based on forest canopy heights derived from topographic LIDAR point cloud classification, including total potential large wood and proximal potential large wood. Tree heights are calculated as the difference between LiDAR first returns (top of canopy) and bare earth DEM elevations interpolated between canopy returns.

Where – Potential large wood is generated from anywhere within the Basin, and wood pieces can influence habitat in streams of all sizes. This metric should be calculated for streams throughout the entire Basin using broad extent LiDAR.

When – Changes to vegetation characteristics are gradual in the absence of disturbance events. Potential large wood is expected to change more slowly than current large wood (Recommendation 1); this metric should be assessed at a ten-year timescale.

Other considerations – LiDAR canopy height models and associated metrics can also inform the riparian condition CPI, which will include aspects of riparian vegetation assessment and classification.

Costs

Costs for this CPI are based on topographic LiDAR collection, field validation, and analysis. For specifics of cost estimation, see Appendix G.

Table 5-6. Monitoring costs for large wood recruitment and retention.

Recommendation	1-Year Cost	10-Year Cost
1: Measure current large wood concentrations	1,161,000	3,565,000
2: Assess potential large wood supply	1,149,000	3,539,000

5.3.2 Geomorphic Flushing / Scouring Flows

Why

Rivers regularly require flows sufficient to maintain and shape their channels, to facilitate sediment transport, and to maintain the integrity of aquatic habitats (Kondolf and Wilcock 1996; USFWS and HVT 1999; Bunn and Arthington 2002; NMFS 2010a; Loire et al. 2021). In the Klamath Basin, hydrologic alteration has reduced the occurrence of bed-mobilizing flows and altered their characteristics, affecting bed sediment characteristics and aquatic habitat (NRC 2008). These changes have reduced the quality and quantity of suitable spawning gravels through disrupted gravel supply, increased infilling with fine sediments, and reduced frequency of bed turnover necessary to dislodge fine sediments. Occurrence and pervasiveness of fish diseases in the Klamath Basin are also closely linked with sediment transport processes. Flushing flow events are believed necessary to mobilize the bed and dislodge or smother polychaete worms that are the intermediate hosts for various fish pathogens (Malakauskas and Wilzbach 2012). Flushing flows also decrease the retention of fine sediments associated with the establishment of excessive aquatic vegetation, thereby disrupting microhabitats occupied by polychaete worms, while at the same dispersing the fine organic carbon particulates fed on by the worms. Although flows sufficient to maintain sediment quality are important throughout the Klamath Basin, flushing flows are most relevant in the mainstem Klamath where diseases are most prevalent and sedimentation is an issue. Many tributaries, on the other hand, have flow sufficient to regularly move sediment and are characterized as net transport reaches; flushing flows are therefore less of a focus for these systems. However, future changes in fish disease presence or flow dynamics throughout the Basin may affect where flushing flows are most necessary.

Current Status of Associated Monitoring

Geomorphic flushing flows have been identified as most relevant to sections of mainstem Klamath where dam presence reduces flow magnitudes, reduces substrate turnover, and allows for accumulation of fine detrital material to support high worm densities (NMFS 2010). Detailed assessments of sediment transport and mobility exist on Klamath River (e.g. USBR 2011; Curtis et al. 2021), which have resulted in robust estimates of transport rates and entrainment thresholds that can be related to flows measured at gages. Fluvial bedload transport has also been studied in the Trinity River, including a history of flushing flow studies aimed at removing accumulated fine sediment (e.g. Nelson et al. 1987; Kondolf and Wilcock 1996; Wellmeyer et al. 2005) and direct assessments of bed movement with novel technologies such as hydroacoustics (Barton 2006). Monitoring recommendations for this CPI are targeted at building on existing work and expanding the extent of flow monitoring stations.

Detailed Recommendations

Recommendation 1 – Characterize flushing flows with gage data and transport measurement calibrations

What – Timing, duration, and frequency of flows competent to flush fine sediments and disrupt polychaete worm populations.

How – Use measurements of bedload transport or bed movement (e.g. direct bedload sampling or ADCP moving bed measurements; Curtis et al. 2021) at different flows to estimate entrainment thresholds necessary for incipient bed motion. Existing studies on the mainstem Klamath below Iron Gate Dam have investigated thresholds and bed sediment distributions (Curtis et al. 2021); these approaches should be leveraged to inform assessments of fine sediment flushing and bed turnover to disrupt polychaete worms and applied to broader extents for this CPI. Determined thresholds can be compared to discharge or stage data from existing gages to assess timing, duration, and frequency of competent flows, with the assumption that flows capable of bedload transport are also sufficient to disrupt polychaete worms.

Where – Mainstem Klamath River. Flow manipulations and related restoration actions are most applicable in mainstem Klamath and downstream of existing dams; problems related to polychaete worms are also most strongly concentrated here. Flow gages within different geomorphic units can be used to characterize what flows are necessary to produce competent bed forces for different channel geometries and bed sediment types.

When – Continuous monitoring throughout the year and across years. Although dam removal is a key action that will change flushing flow dynamics and requirements, ongoing monitoring not associated with dam removal will be necessary for longer-term characterization.

Other considerations – Bed sediment characteristics in terms of existing depositional facies are being considered for the substrate size distribution CPI. Although direct measures of transport and competency are not a part of the substrate size distribution CPI, opportunities exist for complementary data collection, analysis, and interpretation.

Costs

Costs for this CPI are based existing flow gages on Mainstem Klamath River and simple calculations with pre-existing information on transport thresholds. 10-year costs increase relative to 1-year costs due to takeover of existing infrastructure following the Definite Plan's completion. For specifics of cost estimation, see Appendix G.

Table 5-7. Monitoring costs for geomorphic flushing / scouring flows.

Recommendation	1-Year Cost	10-Year Cost
1: Characterize flushing flows with gage data	7,000	1,009,000

Related Activities

Sediment and erosion control and monitoring is a key part of the Definite Plan, which prescribes detailed studies of the volumes of sediment stored behind dams, the expected downstream transport and flushing dynamics following dam removal, and thresholds for maintenance of downstream aquatic habitat. The comprehensive data gathering and monitoring associated with the Definite Plan will strongly inform the geomorphic flushing flows CPI; on-going monitoring for the IFRMP after the end of the Definite Plan should leverage existing dataset and protocols.

5.3.3 Floodplain Connectivity / Inundation

Why

Floodplain connectivity is an essential geofluvial habitat function for aquatic organisms in the riverine portions of the Klamath Basin. Floodplains support rearing habitat, inclusive of bioenergetic processes, across a range of flows. Dynamic floodplains are essential to fundamental ecological functions for fishery resources, with clear linkages to riparian ecology and large wood storage and recruitment, and deposition of fine sediments and nutrient-laden particulate matter. Floodplain habitats and their connectivity to the aquatic environment have been lost or degraded within areas of the Klamath Basin as a result of ditching and diking to promote drainage and prevent overbank flows (NMFS and USFWS 2013). Other causes of reduced floodplain connectivity are related to mainstem dams, including reduced frequency and magnitude of channel-forming flows, disruption of sediment transport, and reductions in floodplain forming processes (NRC 2008; USBR 2011). In the Klamath River and its tributaries (e.g., Scott, Sprague, and Shasta rivers), the observed lack of floodplain connectivity is a constraint for fisheries restoration. Loss of floodplain function limits biotic exchanges between the stream channel and the floodplains that can provide additional food and space for aquatic organisms, and leads to a reduction in access to refuge areas from high in-channel velocities (NRC 2008).

Current Status of Associated Monitoring

Floodplain connectivity is not currently monitored on a basin-wide scale. Closely related monitoring activities do exist (e.g. Yurok Fisheries' shallow groundwater wells in Blue Creek that can provide insight into hyporheic exchanges), but groundwater dynamics are driven by a diverse range of processes, only some of which are indicative of functional floodplain/channel hydraulic connectivity in terms of surface flow. More focused metrics that address this interface between channels and floodplains are therefore needed for CPI monitoring going forward. Floodplain connectivity is also addressed indirectly through geomorphic studies of channel changes over time, such as the identification of fossilized bars in the mainstem Klamath below Iron Gate Dam, where river migration has slowed and the geomorphic processes that build active floodplains are heavily restricted (Hetrick et al. 2009). However, to track this CPI throughout the basin over time, more broadly applicable metrics are needed to inform overall floodplain connectivity.

Detailed Recommendations

Recommendation 1 – Map alluvial valleys with floodplains

What – Presence of alluvial valleys with floodplains along stream segments.

How – Use topographic LiDAR elevation datasets to delineate alluvial valleys with current or historical floodplain presence, or the potential for future floodplain development/reactivation. LiDAR data detrended to remove valley slope and produce relative elevation maps can be used to identify relic and current floodplain surfaces (Powers et al. 2019).

Where – Along all streams in the Klamath Basin. It is expected that alluvial valleys are most commonly associated with larger streams (e.g. >3rd order), but the broad, spatially continuous coverage of LiDAR allows for desktop interpretation of all streams to identify potential small floodplain areas.

When – One-time exercise to identify all alluvial valleys as the sample frame for on-going monitoring.

Other considerations – Potential synergies exist with channel complexity and stream condition (physical) CPIs, which may also leverage detrended LiDAR data for metrics extraction.

Recommendation 2 – Monitor timing and duration of overbank flows from gage sites

What – Timing, frequency, and duration of overbank flow periods.

How – Use stage information from any existing gages that are located within the alluvial valleys identified from Recommendation 1 to determine when overbank flows occur and how long they last. Methods based on water level breakpoint analysis (e.g., Navratil et al. 2010; Scott et al. 2019) allow for water level time-series assessments to identify the flow levels at which incipient floodplain activation occurs. Additional stage monitoring sites that employ level-loggers (only water level, not calibrated to discharge) can be a low-cost alternative to full gage sites in alluvial valleys without existing instrumentation. At each gage or level-logger site, a benchmark elevation datum should be surveyed one time to allow comparisons between stream stages and floodplain elevations.

Where – Within delineated alluvial valleys using existing gages, or at supplemental sites installed in alluvial valleys. A sub-set of alluvial valleys should be selected for stage monitoring, preferably using a probabilistic sampling approach, e.g., a stratified random sample based on size or distribution of fishes.

When – Continuous monitoring year-round, to provide estimates of status and trend over time as restoration progresses. Real-time monitoring is not required.

Other considerations – It may be possible to leverage stream flow gages as well as stage gages to inform this CPI.

Recommendation 3 – Map floodplain inundation extent from satellite imagery

What – Wetted area as a proportion of floodplain area for a given flow magnitude.

How – Apply satellite imagery classification methods to identify wetted areas. Multiple satellite platform options could provide suitable data; Pickens et al. (2020) provide a Landsat-derived dataset of inland open surface water extents and dynamics, and Bellido-Leiva et al. (2022) demonstrate how Sentinel-2 imagery can be used to quantify off channel inundated habitat. Surface water extent time series and maps of remotely sensed Normalized Difference Water Index (NDWI) are also available from providers such as ClimateEngine (https://climateengine.com/dataset/surface-water/).

Where – Within alluvial valleys identified from Recommendation 1.

When – Following overbank flood periods identified for Recommendation 2. Once inundation extents have been determined for a set of overbank flows in a baseline year, repeat analysis can occur every five years for change monitoring.

Other considerations – As stream channels change and floodplains are restored, flood-prone areas may change too. Inundation extent should be updated to account for changes to valley morphology and important infrastructure, which can influence where management actions can be implemented.

Costs

Costs for this CPI are based topographic LiDAR collection and analysis, existing and additional gage sites or stage loggers, and analysis of free satellite imagery. For specifics of cost estimation, see Appendix G.

Table 5-8. Monitoring costs for floodplain connectivity / inundation.

Recommendation	1-Year Cost	10-Year Cost
1: Map alluvial valleys	952,000	1,189,000
2: Monitor timing of overbank flows	20,000	141,000
3: Map floodplain inundation extent	26,000	81,000

Related Activities

Monitoring associated with the Definite Plan includes stage measurement at the head of Iron Gate pool and at Walker Road. These sites could be incorporated into floodplain connectivity monitoring to inform overbank flow assessments (Recommendation 2) and maintained following the end of the Definite Plan. The Definite Plan also includes consideration of reactivation of mainstem Klamath floodplain building processes; increased flood peaks and returns to natural gravel supplies are expected to restore fluvial processes that facilitate floodplain connectivity (USBR 2011; Hetrick et al. 2009).

5.3.4 Channel Complexity

Why

Geomorphic channel complexity in the form of spatial heterogeneity is an important part of river ecosystems, with implications for habitat diversity, functional geomorphic processes, and resilience in the face of changing conditions (Murray and Fonstad 2007). Channel complexity can be defined in many ways depending on context and scale of interest, and widely accepted consistent metrics of complexity are generally lacking (Wohl 2016). In the Klamath Basin, a history of watershed modification, including disconnection of river channels from floodplains, disruption of channel forming flows, and interruption of large wood and sediment transport, has resulted in a simplified system with a reduced capacity for dynamic fluvial processes that give rise to high quality in-stream habitat (NRC 2008; USBR 2011; NMFS and USFWS 2013). A common theme in restoration and management actions throughout the Basin is therefore the reintroduction of complexity, with the assumption that spatial physical heterogeneity is related to habitat diversity, and that greater habitat diversity correlates with greater biodiversity and bioproductivity (Bellmore and Baxter 2014; Luck et al. 2010; Stanford et al. 2005). To effectively monitor and manage Basin activities with the intent of increasing complexity, appropriate geomorphic metrics need to be identified to support this CPI.

Current Status of Associated Monitoring

Channel complexity is not currently monitored on a basin-wide scale. Key Klamath mainstem and larger tributary sections have examples of detailed geomorphic assessments that address complexity, including long-term evaluations of channel-floodplain dynamics or detailed studies of process linkages between sediment transport and bedform/barform elevations on the Klamath and Trinity Rivers (Curtis 2015; Gaeuman and Boyce 2018; Curtis et al. 2021). These studies can be useful starting points for complexity assessments and can be drawn on for methods and general context, but widely transferrable metrics that can be used to track adjustments to channel complexity over broad spatial and temporal scales are needed to inform the ecosystem approach taken in the Plan.

Detailed Recommendations

Recommendation 1 – Assess basin-wide planform complexity from imagery

What – Multivariate assessment of complexity metrics including: braid length to main channel length ratio, braid node density, side channel to main channel length ratio, side channel node density, edge length, and wood jam area.

How – Google Earth image interpretation (Beechie et al. 2017; Hall et al. 2018) of stream planform features (i.e., channel shape when viewed from above). This provides a broad first pass at quantifying general complexity and the capacity for streams to be dynamic within their floodplains and is transferrable between different scales of stream.

Where – Planform complexity should be mapped throughout the Klamath basin, including Klamath mainstem and all sub-basins.

When – Channel planform characteristics in the Pacific Northwest adjust over the course of decades in relation to geomorphic processes (Beechie et al. 2006). Comprehensive mapping repeated every ten years should capture adjustments in channel pattern that result in changes in planform complexity.

Other considerations – Planform complexity assessments provide context for other CPIs such as stream habitat (physical) and thermal refugia, which are expected to relate to geomorphic setting. Metrics related to large wood jams and availability should be considered with respect to natural levels of wood loading as well as target levels.

Recommendation 2 – Assess detailed topographic complexity in larger streams

What – Variability of elevations in the channel, relative to a standardized water surface elevation.

How – Measure submerged and sub-aerial elevations within the active channel using high resolution bathymetric LiDAR surveys (Lague and Feldman 2020). Elevation variability within the active channel can be quantified as standard deviation of depths relative to a standardized water surface elevation and relates to many aspects of channel morphology and habitat characteristics (Gaeuman and Boyce 2018). The reference water surface elevation can be determined through hydraulic modelling, simple cross sectional flow analysis, or field measurements of water levels at a target flow. Measuring elevations relative to a standardized water surface elevation also removes the effect of downstream channel slope, revealing the smaller scale variability that is indicative of functional geomorphic processes and reflects a diversity of habitats.

The potential exists for more detailed metrics based on high resolution topography to be developed and employed; measuring and interpreting channel metrics is a topic of study in ongoing projects in the Basin (e.g. USGS work on Mainstem Klamath geomorphology). It is therefore proposed that elevation variability be used as a primary measure of in-stream topographic complexity, with the opportunity for incorporation of other metrics as they are finalized.

Where – Klamath mainstem and sub-basin mainstems.

When – In-channel topographic variability will change on a shorter time scale than planform complexity (Recommendation 1) in response to changing sediment transport or flow conditions, or targeted restoration actions. Repeat surveys every five years should capture this scale of adjustment in the systems of interest.

Other considerations – The stream condition (physical) CPI shares similarities with this CPI and can make use of detailed topo-bathymetric LiDAR datasets to calculate stream condition metrics in a habitat context.

Costs

Costs for this CPI are based on analysis of freely available Google Earth imagery for Recommendation 1 and analysis of bathymetric LiDAR for Recommendation 2. For specifics of cost estimation, see Appendix G.

Table 5-9. Monitoring costs for channel complexity.

Recommendation	1-Year Cost	10-Year Cost
1: Assess basin-wide planform complexity	32,000	72,000
2: Assess topographic complexity in larger streams	3,907,000	12,197,000

Related Activities

The USGS is currently evaluating approaches to assess geomorphic metrics that relate to complexity before and after the proposed dam removal in the mainstem Klamath (C. Anderson pers. comm).

5.3.5 Sediment Distributions

Why

Sediment is a fundamental buildings block of river systems, providing material for construction of riffles, bars, banks, and floodplains. Sediment within a river is supplied from upstream sources (e.g., hillslopes, tributaries) and then transported and deposited downstream. In the Klamath Basin, natural inputs of sediment (particularly coarser fractions) have been depleted, and sediment movement and deposition have been affected historically by multiple geomorphic alterations (NRC 2008). These have included historical mining, dredging, placer mining, floating of logs, building of splash dams to push logs downstream, and blasting rock outcrops in the riverbed to improve log passage (NRC 2008). A primary effect of many of these activities has been the release of fine sediments into the water column, with associated damage to fish habitats, or the reduced supply of suitable sized gravels for fish spawning. The mainstem Klamath dams and water diversions have also had geomorphic effects on the river, trapping sediments and leading to downstream bed coarsening. As a result of such a process, the downstream riverbed can become dominated by larger gravels and cobbles unsuitable for use by spawning fish (Kondolf and Mathews 1991).

To understand the dynamics of sediment transport and storage throughout the Basin and to track changes over time, an ‘inverse method’ (c.f. Church 2006) can be used whereby assessments of contemporary deposits are used to infer geomorphic processes, rather than direct measurements of sediment transport rates. In this case, sediment size distribution can be used as a proxy for sediment transport and deposition processes to inform the CPI. This approach is widely applicable over broad extents from remotely sensed sources and can complement more detailed ongoing measurements of bedload transport and entrainment thresholds. Similarly, the actual distributions and characteristics of bed sediments that reflect the transport processes are what directly influence many aspects of habitat quality and quantity.

Current Status of Associated Monitoring

Studies and plans that include sediment transport monitoring do exist in the Basin, but the need remains for standardized broad-scale approaches. For example, detailed assessments of sediment transport and mobility exist on Klamath River (e.g., USBR 2011; Curtis et al. 2021), which have resulted in robust estimates of transport rates and entrainment thresholds. Fluvial bedload transport has also been studied in the Trinity River, including a history of flushing flow studies aimed at removing accumulated fine sediment (e.g., Nelson et al. 1987; Kondolf and Wilcock 1996; Wellmeyer et al. 2005) and direct assessments of bed movement with novel technologies such as hydroacoustics (Barton 2006). These examples can inform understanding of typical processes of sediment transport throughout the Basin, but are not directly applicable to broad CPI monitoring.

Detailed Recommendations

Recommendation 1 – Map substrate sizes with air photos or bathymetric LiDAR

What – Streambed substrate statistical metrics including D_{16}, D_{50}, D_{84}, and sediment sorting indices.

How – Use high resolution air photos to map sub-aerial sediment sizes on exposed bars (Carbonneau et al. 2004; Dugdale et al. 2010) or submerged sediment sizes in shallow areas (Carbonneau et al. 2005). These methods make use of image classification techniques combined with field calibration datasets to map grain sizes over broad extents. Alternatively, high resolution bathymetric LiDAR surveys can be used to assess sub-meter variations in bed roughness in both submerged and sub-aerial portions of the channel. From these datasets, bed roughness can be computed as the standard deviation of point-cloud elevation within a given sample window (Lague and Feldman 2020) and calibrated to true sediment size values with a set of geolocated field-measured calibration points. Technologies for substrate size mapping are an evolving area of research; other novel emerging methods should also be considered as monitoring continues.

Where – Mainstem Klamath and main sub-basin tributaries where stream sizes are large enough so that sediments are clearly visible in air photos and/or the systems warrant targeted, high resolution bathymetric LiDAR surveys. Within these reaches, a complete map of substrate size can be generated for baseline assessment and change detection.

When – For this application, both air photo collection and bathymetric LiDAR surveys are best targeted at late summer low water levels, when as much of the channel bed is exposed as possible. Exposed sediments are more accurately mapped than submerged sediments from air photos, and issues associated with upper limits on LiDAR water column penetration are minimized under low flow conditions. A dual recommendation of air photo and LiDAR applications also allows flexibility around potential visibility issues that may affect optical air photo reliability throughout the year (e.g. summer algae blooms reducing water clarity, wildfire smoke reducing visibility for photo capture); although air photos are collected efficiently and for lower cost than LiDAR, LiDAR may be necessary if air photo capture is not feasible. Following baseline surveys, repeat monitoring should occur every five years to capture broad-scale sediment dynamics.

Other considerations – High resolution bathymetric LiDAR surveys on the Klamath and large sub-basin tributaries can also be used to inform the channel complexity and stream condition (physical) CPIs, where information on submerged areas in these larger streams will be included in key metrics. The geomorphic flushing flows CPI will also involve assessments of bed sediments and provide insights into transport processes.

Costs

Costs for this CPI are based on collection and analysis of high-resolution air photo or collection and analysis of bathymetric LiDAR. For specifics of cost estimation, see Appendix G.

Table 5-10. Monitoring costs for sediment distributions.

Recommendation	1-Year Cost	10-Year Cost
1: Map substrate sizes (air photos method)	423,000	1,319,000
1: Map substrate sizes (bathymetric LiDAR method)	3,915,000	12,224,000

Related Activities

The Definite Plan includes detailed sediment transport assessments in the hydroelectric reach and immediately downstream of Iron Gate dam to Cottonwood Creek, which will inform understanding of processes on Mainstem Klamath that may also be transferable to other systems in the Basin.

5.4 Habitat

5.4.1 Water Temperature

Why

Water quality is a cross-cutting issue affecting habitat conditions for all focal fish species in the Klamath Basin. Many restoration activities are currently underway or are being considered for the future to improve water quality throughout the Klamath Basin. Water temperature is one aspect of water quality which has been severely altered in the Klamath Basin. The Klamath River was listed on California and Oregon's 303(d) lists of impaired water bodies as a result of high water temperatures and low dissolved oxygen resulting in mandated TMDLs for both.

Increased water temperatures have both direct physiological impacts as well as indirect impacts on Klamath River fish. Indirect impacts include the increased prevalence of disease and cyantoxins in the Lower River resulting from a combination of effects typical of hydroelectric dams (Genzoli et al. 2021), as well as accelerated eutrophication, increased harmful algal blooms, and changes to food web structure. Removal of four mainstem dams and associated reservoirs is expected to improve water temperature below Iron Gate Dam. Tributary restoration in the Upper Klamath Basin is expected to improve water quality including temperature.

Monitoring water temperature is important for compliance with TMDLs, to detect whether the condition of critical fish habitats is maintained or changed over time, as well as to be able to demonstrate basin-wide changes in the thermal regime resulting from the suite of restoration actions implemented throughout the Klamath Basin. Long term information on water temperature, including winter temperature, may be useful in improving our understanding of how climate change impacts may affect the Klamath Basin.

Current Status of Associated Monitoring

Water temperature is the most extensively monitored metric in the Klamath basin with over 100 sites managed by dozens of organizations There are existing water temperature sites in all 13 sub-basins with a roughly equal distribution between Klamath mainstem, sub-basin mainstems, and tributaries. Many of these are continuous gages, however most continuous gages are only downloaded once or twice annually and so cannot inform real-time assessments. There is also a need for better coordination among agencies in terms of how data are collected, reported, and shared. A large fraction of the continuous water temperature data collected in the California portion of the Klamath Basin in recent decades has been compiled and analyzed in several reports available at: https://www.riverbendsci.com/projects/temperature-analyses.

Detailed Recommendations

Recommendation 1 – Maintain/expand the network of continuous sondes with real-time data transmission

What – Water temperature, summarized in a variety of ways e.g., maximum daily maximum temperature (MDMT), mean weekly maximum temperature (MWMT), mean daily average temperature (MDAT), mean weekly average temperature (MWAT), seven-day average of daily maximum (7dAVM) (Pahl, R. 2007).

How – Continuous sondes with real-time data transmission. Reference instrument specifications and quality assurance measures from the Definite Plan (Exhibit O).

Where –

Top priority (1a)

- Adopt the ten mainstem sites identified in the Definite Plan (Section 3.1.1 of Exhibit O) and **maintain after the Definite Plan is completed** (i.e., 4 years or when water quality targets are met). Six of these have real-time data transmission.
- Ensure that a mainstem Klamath site is installed between Seiad Creek and Iron Gate Dam (there is one proposed in the Definite Plan). This reach is currently a data gap despite expectation that it will be influenced by dam removal.
- Adopt the 3 tributary sites identified in the Definite Plan (i.e., Shasta River, Scott River and Salmon River) and **maintain** after the Definite Plan is completed.
- Ensure a sonde is **maintained** at the mouth of each of the remaining sub-basins (Upper Klamath Lake, Williamson, Sprague, Lost, Upper Klamath River, Mid-Klamath River, Lower Klamath River, Trinity, South Fork Trinity). If applicable adopt / integrate existing monitoring efforts from each sub-basin.

Second priority (1b)

- If possible, supplement the network further by placing continuous sondes in areas identified as critical fish habitat (e.g., key spawning and winter rearing areas) to assess the condition of critical fish habitats over time.

When – Continuous data with real-time data transmission provide the best opportunity for assessment of conditions, particularly those associated with unpredictable events such as storms. Spring, summer, fall are generally thought to be most important for evaluating temperature impacts on spawning salmonids. However, it is also important to understand winter temperatures in coho bearing tributaries to evaluate conditions for coho rearing and winter growth. Longer term changes to the thermal regime throughout the year at the basin wide scale are also important to understand the effectiveness of restoration actions in the context of climate change.

Other considerations – There are logistical challenges to continuous sampling during the winter and storm events. USGS has done work to 'harden' sites and equipment but there is potential for damage or theft which should be considered in the budget. This recommendation relates closely to the recommendations for Water Chemistry and Turbidity CPIs.

Recommendation 2 – Standardize data collection and sharing across organizations

Water temperature is measured extensively throughout the Klamath basin by numerous different organizations for different purposes. This reflects the importance of water temperature as a CPI, however it also represents an opportunity for consolidation of efforts. Currently data collection, reporting, and storage is not standardized making it difficult to leverage the available data to its fullest potential.

It would be useful to complete a collaborative study to:

- Agree upon standard Quality Assurance practices and data summaries (e.g., MWAT) to be shared across the basin (e.g., through the KBMP database).
- Identify best practices moving forward so that future data collection is standardized (e.g., methods and equipment).

Compare and contrast objectives and identify potential redundancies or key gaps.

Costs

Costs for this CPI are based on sonde equipment and upkeep costs, and whether sites exist already or need to be installed. For specifics of cost estimation, see Appendix G.

Table 5-11. Monitoring costs for water temperature.

Recommendation	1-Year Cost	10-Year Cost
1a: Continuous sondes: top priority sites	594,000	3,812,000
1b: Continuous sondes: second priority sites	839,000	3,571,000
2: Standardize data practices	Workshop, TBD	Workshop, TBD

Related Activities

Proposed monitoring for this CPI piggybacks on the proposed monitoring within the Definite Plan (Recommendation 1). There are at least 25 agencies, Tribes, community, or academic groups involved in monitoring water temperature for a variety of reasons. This CPI would benefit from improved coordination among organizations (Recommendation 2).

5.4.2 Water Chemistry (DO, pH, conductivity)

Why

Water quality is cross-cutting issue affecting habitat conditions for all focal fish species in the Klamath Basin. Many restoration activities are currently underway or are being considered for the future to improve water quality throughout the Klamath Basin.

Human activities have affected the water quality in the Klamath basin for nearly a century. Annual cycles of flooding, draining, and agricultural activities associated with grazing and irrigated cropland have oxidized peaty soils, caused land subsidence, increased erosion and exported large nutrient loads to Upper Klamath Lake and the downstream river for nearly a century (Carpenter et al. 2009; Snyder and Morace 1997, as cited in NMFS 2013; Walker et al. 2012). Inputs of nutrients from these sources as well as from non peat areas (Williamson and Sprague) where erosion by natural processes (and enhanced in some places by human activities) cause seasonal cyanobacteria blooms that have been linked to degradation of water quality (e.g., low dissolved oxygen, high pH, and toxic levels of un-ionized ammonia) in Upper Klamath Lake and the Klamath River (Walker et al. 2012; NMFS 2013). The Klamath River is currently listed as a Clean Water Act (CWA) impaired waterway (on the "303(d)" list) in both California and Oregon due to water temperature, sedimentation, pH, organic enrichment/low dissolved oxygen, nutrients, ammonia, chlorophyll-a, and algal cyanotoxins.

Monitoring water chemistry is important for compliance with TMDLs, to detect whether the condition of critical fish habitats is maintained or changed over time, as well as to be able to demonstrate basin-wide changes in water chemistry resulting from the suite of restoration actions implemented throughout the Klamath Basin. In addition, diurnal swings in dissolved oxygen be indicative of photosynthetic processes associated with large cyanobacteria blooms, and overall dissolved oxygen depletion can indicate bloom decline and decomposition (Genzoli and Hall 2016). Similarly, water pH is linked to photosynthetic activity, meaning pH can also be used as a potential proxy for nuisance phytoplankton blooms.

Current Status of Associated Monitoring

The majority of sub-basins have at least a few water chemistry monitoring sites. Most sites below IGD are located on the mainstem Klamath River; USGS, Kurok Tribe, and Yurok Tribe also maintain real time sensors in Upper Klamath Lake and selected tributaries, with additional planned monitoring sites downstream of IGD associated with dam removal. Most water chemistry sites are collected 1-12 times per year, except for the Scott River and Shasta River sub-basins which have extensive continuous monitoring networks.

Continuous data and if possible real-time data are preferred to evaluate effects associated with events such as floods more effectively. There is also a need for better coordination among agencies in terms of how data are collected, reported, and shared.

Detailed Recommendations

Recommendation 1 – Expand /maintain the network of continuous sondes with real-time data transmission

What – Dissolved oxygen (DO), pH, and conductivity

How – Continuous sondes with real-time data transmission. Reference instrument specifications and quality assurance measures from the Definite Plan (Exhibit O).

Where –

Top priority (1a)

- Adopt the ten mainstem gages identified in the Definite Plan (Section 3.1.1 of Exhibit O) and **maintain after the Definite Plan is completed**. Six of these gages have real-time data transmission.
- Ensure that a mainstem Klamath site is installed between Seiad Creek and Iron Gate Dam (there is one proposed in the Definite Plan). This reach is currently a data gap despite expectation that it will be influenced by dam removal.

- Adopt the 3 tributary gages identified in the Definite Plan (i.e., Shasta River, Scott River and Salmon River) and **maintain** after the Definite Plan is completed.
- Ensure a gage is **maintained** at the mouth of each of the remaining sub-basins (Upper Klamath Lake, Williamson, Sprague, Lost, Upper Klamath River, Mid-Klamath River, Lower Klamath River, Trinity, South Fork Trinity). If applicable adopt / integrate existing monitoring efforts from each sub-basin.

Second priority (1b)

- If possible, supplement the network further by placing continuous gages in areas identified as critical fish habitat (e.g., key spawning and winter rearing areas) to assess the condition of critical fish habitats over time.

When – Continuous data with real-time data transmission provide the best opportunity for assessment of conditions, particularly those associated with unpredictable events such as storms.

Other considerations – There are logistical challenges to continuous sampling during the winter and storm events. USGS has done work to ‘harden’ gages but there is potential for damage or theft which should be considered in the budget. This recommendation relates closely to the recommendations for Water Temperature and Turbidity CPIs.

Recommendation 2 – Standardize data collection and sharing across organizations

Water chemistry is measured extensively throughout the Klamath basin by numerous different organizations for different purposes. This reflects the importance of water chemistry as a CPI, however it also represents an opportunity for consolidation of efforts. Currently data collection, reporting, and storage is not standardized making it difficult to leverage the available data to its fullest potential.

It would be useful to complete a collaborative study to:

- Agree upon standard Quality Assurance practices and data summaries to be shared across the basin (e.g., through the KBMP database).
- Identify best practices moving forward so that future data collection is standardized (e.g., methods and equipment).

Compare and contrast objectives and identify potential redundancies or key gaps.

Costs

Costs for this CPI are based on sonde equipment and upkeep costs, and whether sites exist already or need to be installed. For specifics of cost estimation, see Appendix G.

Table 5-12. Monitoring costs for water chemistry.

Recommendation	1-Year Cost	10-Year Cost
1a: Continuous sondes: top priority sites	594,000	3,812,000
1b: Continuous sondes: second priority sites	839,000	3,571,000
2: Standardize data practices	Workshop, TBD	Workshop, TBD

Related Activities

Proposed monitoring for this CPI piggybacks on the proposed monitoring within the Definite Plan (Recommendation 1).

5.4.3 Turbidity

Measures of turbidity are a necessary input to estimates of fine sediment loads and concentrations. Refer to Watershed Inputs (Fine Sediment) CPI where the monitoring approach for both turbidity and fine sediment is described.

5.4.4 Thermal refugia

Why

Cold water refugia are patches of water which are relatively cool compared to the average surrounding water temperature. Fish aggregate in thermal refugia to avoid thermal stress enabling them to survive during periods with elevated temperatures (Torgersen et al. 1999; Sutton et al. 2007; Dugdale et al. 2013). Refugia provide respite for returning spawners as well as resident fish and have also been shown to reduce juvenile salmon's exposure to disease (Luciano et al. 2016). Thermal refugia are expected to be increasingly important in the Klamath Basin as stream temperatures increase with climate change across the Pacific Northwest (Beechie et al. 2013).

Thermal refugia may result from groundwater seeps and hyporheic exchanges (the mixing of surface and shallow subsurface water through porous sediment surrounding a river) or cold-water tributaries (Dugdale et al. 2013; Ernst et al. 2015) and may be negatively impacted by water withdrawals, deforestation or agricultural impacts on riparian condition (Dugdale et al. 2013). Thermal refugia, in particular groundwater sourced refugia, are highly variable in space and time (Dugdale et al. 2013). The Upper Klamath Basin is thought to have more groundwater influenced refugia while the Lower Klamath Basin is thought to have more cold-water tributary influenced refugia.

It is important to understand the prevalence, type, size, persistence, and distribution (e.g., how far fish have to move between sites) of thermal refugia in the Klamath Basin and how they change within and across years so as to evaluate and inform restoration efforts. Candidate IFRMP restoration actions that could influence thermal refugia include riparian restoration / protection to increase / maintain canopy cover; groundwater recharge e.g., through installing BDAs or large wood jams to increase hyporheic exchange (Dittbrenner et al. 2022; Stevenson et al. 2022); and reduction of illegal water withdrawals.

Current Status of Associated Monitoring

There is no coordinated basin-wide assessment of thermal refugia in the Klamath basin. Fauch et al. (1999) noted that this type of intermediate scale assessment is a common knowledge gap in watershed restoration. There are a number of groundwater wells which are monitored in the Upper Klamath Basin which may reflect the presence of refugia, however for this CPI it is more important to document where the groundwater expresses itself contributing to refugia than it is to monitor the wells directly. As noted in the section on water temperature there are numerous water temperature gages across the basin and some of those are likely situated in thermal refugia that were identified by local experts, however, these refugia have not been classified or mapped at the basin scale and, there are likely additional refugia on private lands which have not yet been identified. There are a few detailed studies characterizing specific thermal refugia over time (e.g., Martin Creek and Blue Creek) or mapping sections of the mainstem (e.g., the reach between IGD to Seiad Creek was surveyed by the Yurok Tribal Fisheries Program in 1996 (Belchik 1997) providing a useful baseline). Additionally, USGS has conducted detailed studies on the effects of dam removal on flow mixing and water temperature dynamics on Klamath and Trinity Rivers (Perry et al. 2011; Risley et al. 2012; Jones et al. 2016). The priority need for this CPI is to identify thermal refugia at the basin-wide scale. This should then be followed with more detailed monitoring of a subset of refugia to better understand the seasonal variability and utilization of the refugia.

Detailed Recommendations

Recommendation 1 – Identify and map refugia across the basin

What – Identify and map all thermal refugia. Report the number of refugia, the type (i.e., groundwater or tributary influenced), the size, and spatial distribution.

How – Use conventional aerial surveys (small aircraft/helicopter) to collect thermal infrared (TIR) data which can then be post-processed to identify thermal refugia (Dugdale et al. 2013; Ernst et al. 2015; Kuhn et al. 2021). There continue to be advances in machine learning and statistical approaches which may assist with the interpretation of these data (e.g., Fuller et al. 2021). The same approach to interpreting and classifying refugia should be employed across the Klamath basin. Conventional aerial surveys are likely best suited to the broad, basin-wide monitoring associated with this CPI; UAV surveys can provide more detailed supplemental information if needed or can be a lower-cost alternative used to assess representative areas if basin-wide surveys are unfeasible.

Where – Basin-wide assessment including the Klamath mainstem and all sub-basins. There tend to be mainstem refugia at tributary confluences, but there are also known refugia in sub-basin tributaries (e.g., Spencer Creek, North Fork Sprague, Salmon River, Shasta).

When – The TIR survey is intended to provide a broad spatial assessment for a snapshot in time and should be completed during the warmest period of the year (e.g., July). Surveys should be completed across the basin within as small of a window as possible for consistency. Past studies have shown significant between year and within year variability. Basin-wide surveys should be repeated at least every five years to evaluate longer term effects of restoration and climate change and inform associated mitigation efforts. Recommendation 2 addresses the within year variability.

Other considerations – There was some concern about whether the TIR method would underestimate thermal refugia given that it measures the surface water and so would not necessarily detect thermal stratification (e.g., cooler water at the bottom of a pool). However, workgroup experts with experience in this methodology confirmed that it is robust at identifying refugia at a broad spatial scale even though it can’t provide detailed information about temperature stratification. Several studies demonstrate the ability of TIR to identify a variety of different types of refugia (Dugdale et al. 2013; Ernst et al. 2015; Kuhn et al. 2021).

Warm water thermal refugia may also be important for some species in the winter in some locations (e.g., off channel rearing areas). However, this is less of a concern than loss of cold water refugia in the Klamath basin and is not the focus of this assessment.

Recommendation 2 – Detailed monitoring of a subset of thermal refugia

What – Detailed assessment of water temperature in a subset of refugia to assess the seasonal variability in size and persistence.

How – Use continuous temperature sensors (e.g., Hobo sensors) to monitor water temperature in areas of the stream above, below and within the thermal refuge.

Where – Work with local experts to identify critical (i.e., survival bottlenecks) refugia from the master list developed in Recommendation 1. Monitor all critical refugia. Monitor a random sub-set of additional refugia from within the historic range of focal fish species. Consider stratifying this sample by 'type' (groundwater / cold-water tributary) or 'geography' (Upper / Lower basin). Consider additional focus in the Shasta given importance as a cold-water tributary to inform management actions (e.g., protecting groundwater discharge).

When – As noted above, refugia are highly variable within and between years. Collect continuous data within the period of thermal stress (e.g., June-Sept). Monitor critical refugia every year, re-randomize the sample of additional refugia (using the same stratification) every year to obtain better spatial coverage.

Other considerations – There are numerous water temperature sensors available throughout the basin. There should be an effort to coordinate with local researchers to share sites and data.

Recommendation 3 – Assess utilization of thermal refugia

What – Presence or abundance of fish by species and life-stage within refugia.

How – Direct observations of fish (e.g. snorkel surveys, PIT tag arrays, or telemetry).

Where – Use the same sample design as described in Recommendation 2. Observe utilization of all critical refugia as well as a subset of other sites. If budget is constrained, use a subset of the sites from Recommendation 2. Consider adding PIT tag arrays in a few critical sites to facilitate monitoring of fish.

When – Revisit sites monthly throughout the period of thermal stress (e.g. June-Sept).

Other considerations – There may be competition for thermal refugia with hatchery fish depending on the timing of release. Justice et al. (2017b) demonstrate how these data could be used to estimate the refuge capacity for different species and life stages in the Upper Grande Ronde River.

Recommendation 4 – Evaluate the relative proportion of flow and effects on mixing

What – Research / modeling study to evaluate the effects of changes in flow and mixing on cold water refugia. One study has indicated that high flow dam releases in the Klamath River may diminish the size of tributary refugia by increasing mixing (Sutton et al. 2007), although high flow dam releases do not usually occur during periods of maximum thermal stress.

How – Develop 3-D hydraulic models to predict conditions required for pools to stratify. If successful, these modeling efforts could be expanded to model the relative influence of cold-water streams and the extent of the thermal refugia that they create under different flow management scenarios.

Where – There is an initial project underway in the Trinity River (PI, Todd Buxton). If successful, consider applying methodology to critical mainstem refugia to inform flow management decisions.

When – This would be a one-off study.

Other considerations – If successful, this research / modeling activity could be used in combination with the data from Recommendation 2 to inform flow management and restoration.

Costs

Costs for this CPI are based on aerial TIR surveys, installation and upkeep of low-cost temperature sensors, and field visits to monitor fish usage of refugia. For specifics of cost estimation, see Appendix G.

Table 5-13. Monitoring costs for thermal refugia.

Recommendation	1-Year Cost	10-Year Cost
1: Map basin-wide thermal refugia	511,000	1,595,000
2: Monitor subset of thermal refugia	6,000	68,000
3: Assess utilization of thermal refugia	21,000	256,000
4: Evaluate flow / mixing with hydraulic modelling	TBD	TBD

Related Activities

There are several related activities including water temperature and groundwater monitoring. In addition, PIT tags and other fish tracking methods could be used to observe how fish move between refugia to provide additional insight in terms of the relative importance of different refugia and how they are used over time, both within a year and across years. The Klamath River PIT Tag Database provides a valuable tool for coordination and data sharing.

5.4.5 Nutrients (P, N)

Site level estimates of nutrients (e.g., Total P, Total N) are necessary to estimate Nutrient loads. Refer to the Watershed Input (Nutrient load) CPI which describes the proposed monitoring design necessary to inform both CPIs.

5.4.6 Nuisance phytoplankton and associated algal toxins (cyanotoxins)

Why

A legacy of human activities in the Klamath Basin has resulted in increased erosion and loading of nutrients (particularly phosphorus) into the watershed. Inputs of nutrients cause seasonal eutrophication and associated cyanobacteria blooms that have been linked to degradation of water quality (e.g., low dissolved oxygen (hypoxia), high pH, and toxic levels of un-ionized ammonia) in Upper Klamath Lake and the Klamath River (Walker et al. 2012; USDI, USDC, NMFS

2013). Eutrophication has been linked to general impacts to fish health in the upper Klamath Basin (Kann and Smith 1999) and specifically to large die-offs and redistribution of endangered sucker species (Walker et al. 2012). PacifiCorp's large reservoirs in the upper basin act as net nutrient sinks (Asarian et al. 2009) that contribute to large blooms of cyanobacteria that regularly occur during summer months in the downstream reservoirs Copco 1 and Iron Gate (Asarian and Kann 2011). These blooms of cyanobacteria have been documented as the cause of harmful concentrations of toxic cyanotoxins (e.g. microcystin, anatoxin, saixotoxin), both in the reservoirs and in the Klamath River downstream of Iron Gate Dam (USDI, USDC, NMFS 2013; Otten et al. 2015). Although dense Microcystis blooms and associated toxins originate in the lacustrine waters of the Copco and Iron Gate impoundments, cyanobacterial cells and toxins are transported downstream as far as the Klamath River estuary (Otten et. 2015), leading to public health concerns for the entire middle and lower Klamath River (Genzoli and Hall 2016). Bioaccumulation of cyanotoxins can occur in a variety of Klamath River fish species and other aquatic biota (e.g., freshwater mussels) (multiple studies cited in Genzoli et al. 2015). As a result the Klamath River and some of its tributaries are listed as Clean Water Act (CWA) Section 303(d) "impaired" waterways in both California and Oregon with listed impairments including chlorophyll-a and cyanotoxins (NCRWQCB 2010; USDI, USDC, NMFS 2013).

Current Status of Associated Monitoring

Monitoring of phytoplankton (with associated evaluations of chlorophyll-a, toxic cyanobacteria and cyanotoxins) within the Klamath and Trinity River and Upper Klamath Lake is currently undertaken across a wide variety of agencies throughout the Klamath Basin, including the Yurok Tribal Environmental Program in the lower Klamath River mainstem, by the Karuk Tribe in the mid Klamath River mainstem, the Hoopa Valley Tribe in the Trinity River, PacifiCorp within the upper Klamath River hydropower reach, and the Oregon Department of Environmental Quality, the U.S. Bureau of Reclamation, and the Klamath Tribes in the upper Klamath River above the dams and in Upper Klamath Lake. U.S. Bureau of Reclamation also funds chlorophyll-a monitoring efforts undertaken by USGS in the Upper Klamath Lake and in the Like River Dam-Keno Dam reach. Nuisance phytoplankton is not considered a significant issue in the tributary sub-basins at this time and the only monitoring in sub-basins currently is in the Trinity River and at Lake Shastina in the Shasta sub-basin where they have been issues with phytoplankton blooms.

Detailed Recommendations

Recommendation 1 – Maintain/expand the existing monitoring network for evaluating levels of nuisance phytoplankton and associated algal toxins in the Basin

What –Nuisance phytoplankton status may be evaluated through a variety of measures that relate to effects on aquatic systems:

- Chlorophyll-a concentrations
- pH
- Dissolved oxygen (DO) concentrations
- Algal cell counts
- Algal toxin concentrations

Chlorophyll-a, DO concentrations, and pH are considered good, lower cost indicators of the status of algal blooms that can be used as proxies for direct algae measurements (i.e., algal identification and cell counts that represent the most valid indicators of potential risk of eutrophication and/or algal toxicity). Chlorophyll-a concentrations are directly related to algal biomass while large volumes of dying plankton can deplete oxygen levels creating hypoxic conditions. Diurnal swings in DO are indicative of photosynthesis, which in areas with heavy cyano blooms can be a rough proxy for algae bloom size and activity. Low DO is associated with bloom decline and an increase in decomposition. pH can likewise be used as a proxy for photosynthetic activity and therefore bloom size and activity. However particular algal species composition and concentrations will relate to the breadth and timing of toxin production of concern as different algae species will produce different toxins.

How –

1) Indirect – Associated water quality parameters: Continuous sondes with real-time data transmission for measurement of water quality parameters (DO, ph, Chlorophyll-a) (indirect measures of phytoplankton issues). Reference instrument specifications and quality assurance measures from the Definite Plan (Exhibit O). Continuous measures can be supplemented by temporary or seasonal deployments of dedicated probes (e.g. additional Chorophyll-a measurements) to target spring and fall algal blooms.

2) Direct – Phytoplankton and cyanotoxins: Collect surface water grab samples (using ISCO samplers and/or manual grab samples) utilizing standard operating procedure (SOP) methods developed by the Klamath Blue-Green Algae Working Group (2009) followed by lab analysis for algal taxonomic identification and toxin analysis. Quantitative PCR (qPCR) technology can be used to check for algal toxins and is faster and less expensive than direct species composition analysis (Otten 2017). qPCR genetically identifies if algal species are producing toxins or not. This method should be sufficient to support evaluation of IFRMP objectives but would not be sufficient to evaluate against health criteria (e.g., recreational advisory criteria[2]). There is also the potential to employ real-time phycocyanin probes in the Klamath to monitor cyanobacteria species and differentiate them from green algae and diatoms, along with simultaneous chlorophyll-a measurements (Genzoli and Kann 2016).

Where –

1) Indirect (1a) – Associated water quality parameters: Maintain the existing network of continuous water quality monitoring sondes across the Basin (for assessment of chlorophyll-a, DO, pH). Consider also incorporating the ten mainstem sondes identified in the Definite Plan (Section 3.1.1 of Exhibit O) and maintain after the Definite Plan is completed. Six of these sondes have real-time data transmission. Mainstem sites should coincide with the fixed continuous sonde network recommended for Water Temperature, Water Chemistry, and Turbidity CPIs.
2) Direct (1b)- Phytoplankton/cyanotoxins: Water sampling sites for nuisance phytoplankton and algal toxins should continue to include a combination of Klamath River mainstem and Upper Klamath Lake sites post removal of the mainstem dams. Maintain the existing network of water

[2] Other more intensive methods such as ELISA (enzyme-linked immunosorbent assay) or mass spectrometer analysis are required for more rigorous quantitative assessments, refer to the California Regional and State Waters Boards for more information.

sampling sites for seasonal sampling of phytoplankton and cyanotoxins in Upper Klamath Lake. Adopt the same water sampling locations in the mainstem Klamath River as identified by other CPIs (e.g., Nutrient loads and Invasive Species). Sampling frequency and intensity may be adjusted following in the years following dam removal; this decision can be based on assessment of rates of change and post-dam conditions using data from downstream of Keno Dam.

When –

1) Indirect – Associated water quality parameters: Continuous data collection from sondes with real-time data transmission to provide the best opportunity for assessment of changing aquatic habitat conditions.
2) Direct – Phytoplankton/cyanotoxins: Monitoring should be undertaken at water sampling sites at regular intervals throughout the growing season (May to October) for evaluation of seasonal changes in phytoplankton concentrations, species composition, and toxin production.

Other considerations – Analyzing fish tissue for impacts from cyanotoxins will help in understanding how cyanotoxins contribute to stressors impacting fish health. The Klamath Blue-Green Algae Working Group SOP (2009) also discusses methods for collection and processing of fish tissue samples for estimation of cyanotoxins – both qualitative and quantitative (concentration).

Removal of the Klamath mainstem dams will likely shift nuisance algae from phytoplankton in reservoirs to periphyton in the mainstem Klamath rivers. This will shift how monitoring is done (a shift from planktonic to benthic sampling) and expand what algal toxins will need to be monitored. The extent and intensity of this monitoring should reflect the spatial expansion of algae in relation to drinking water sources and human health impacts.

Costs

Costs for this CPI are based on mainstem Klamath River continuous sonde installation and upkeep, mainstem water sampler installation and upkeep, and lab analysis costs. For specifics of cost estimation, see Appendix G.

Table 5-14. Monitoring costs for nuisance phytoplankton.

Recommendation	1-Year Cost	10-Year Cost
1a: Indirect phytoplankton monitoring	35,000	1,431,000
1b: Direct phytoplankton and toxin monitoring	227,000	2,198,000

Related Activities

The Oregon Department of Environmental Quality has developed a harmful algae bloom (HAB) strategy for assessment, prevention, and control of algae blooms in lakes, reservoirs, and rivers of concern in the state (Schaedel 2011). A comparable HAB assessment and support strategy has been developed by the California State Water Resources Control Board (Anderson-Abbs et al. 2016). USGS has also been studying the utility of hyperspectral remote sensing to detect both HAB presence and genera of cyanobacteria in the bloom in Upper Klamath Lake (Slonecker et al. 2020). EPA supports HAB assessments in the Klamath Basin through funding for Tribal monitoring efforts, equipment to characterize HABs, and cyanotoxin analysis. The Klamath Hydroelectric Settlement (KHSA) Interim Measure 15 currently funds monitoring for toxins and cyanobacteria concentration and after license transfer, KRRC will continue this directly above and below the hydropower reach until the end of their required monitoring program.

5.4.7 Stream Habitat Condition

Why

A diversity of high quality, connected habitats is necessary for fish populations to complete their life cycle and maintain a healthy, reproducing status. Habitats for fish in the Klamath Basin have become increasingly degraded and fragmented by human activities, reducing the ability of species to successfully migrate, forage, avoid predators, reproduce, and complete their life cycles (Thorsteinson et al. 2011). Hamilton et al. (2011) concluded that the diversity, productivity, and abundance of many fish populations in the Klamath Basin had been severely impacted due to a variety of habitat-related factors including poor physical habitat quality throughout many tributaries.

Current Status of Associated Monitoring

There have been numerous inventories of physical stream habitat condition undertaken by different groups across, generally as part of effectiveness monitoring for local habitat restoration project, employing standard field-based protocols such as CDFW Level III and IV habitat mapping protocols (Flosi et al. 2010). The USFS also undertakes regular field-based assessments of the habitat condition of streams within their areas of concern. But currently there is no broad-based assessment of the status of physical habitat structure and diversity at the basin-wide scale.

Detailed Recommendations

Recommendation 1 – Assess basin-wide stream habitat diversity from imagery, supplemented in key areas with detailed field-surveys

What – Refer to the remote sensed-approaches (Google Earth imagery [1a] and bathymetric LiDAR [1b]) described in the *What* subsection for the Channel Complexity CPI. These approaches can be used as a coarse estimate of the habitat complexity available within stream reaches to provide the diversity of habitats required to support the needs of focal fish species. Broad basin-wide assessments of habitat condition as derived from remote sensing can be supplemented with more intensive ground-based surveys of physical and aquatic stream attributes (e.g., CDFW level III, IV habitat mapping) where considered necessary for more detailed information in relation to habitat needs of specific fish species (1c).

How – Refer to the *How* descriptions for the Channel Complexity CPI for information on the methods that can be used for interpretation of Google Earth and LiDAR imagery to quantify habitat complexity. Refer also to Hall et al. (2018) for a recent example of how broad-based, remote sensed information can be used effectively for quantifying changes in fish habitat complexity. Refer to Flosi et al. (2010) for field-based survey methods that can be used for detailed fish habitat mapping/rating.

Where – As described for the Channel Complexity CPI planform complexity should be mapped by Google Earth imagery interpretation throughout the Klamath basin while bathymetric LiDAR should target the Klamath River mainstem and all sub-basin mainstems. More intensive field-based surveys can supplement remote sensed interpretations in key areas of concern for particular focal species (i.e., Special Emphasis HUCs).

When – As described for the Channel Complexity CPI comprehensive mapping of planform complexity based on Google Earth imagery should be repeated every ten years while LiDAR overflights should be undertaken every 5 years to capture system adjustments. Detailed field-based surveys could be undertaken on an as needed basis for assessment of habitat changes at local scales in areas of key concern.

Other considerations –

As noted, the Channel Connectivity CPI shares similarities with this CPI and is intended to generate the detailed topo-bathymetric LiDAR datasets necessary to calculate stream condition metrics in a habitat context.

Recommendation 2 – Monitor aquatic invertebrate abundance and species composition

What – Measures of invertebrate abundance and taxonomic composition, as indicators of ecosystem productivity and prey availability for fish. Invertebrates respond rapidly to disturbances and are good indicators of localized conditions and can provide early indications of ecological response to watershed changes such as dam removal (Doyle et al. 2005) or habitat restoration (Davis et al. 2017; Woo et al. 2021).

How – Common invertebrate sampling methods include benthic slack net or kick net sampling for streambed invertebrates and drift net sampling for free drifting invertebrates. Standard operating procedures tailored to California and Oregon should be applied where possible; rapid bioassessment procedures for stream macroinvertebrates are also available from the EPA Office of Wetlands, Oceans, and Watersheds (Barbour et al. 1999).

Where – Mainstem Klamath River and sub-basin tributaries. Sampling sites can be stratified by areas of critical fish habitat (e.g., key spawning and winter rearing areas) to inform prey availability.

When – Resident invertebrate assemblages integrate stress effects over the course of the year, and seasonal cycles of abundance and taxa composition are fairly predictable within the limits of their interannual variability (Barbour et al. 1999). Many sampling and monitoring programs therefore are able to address their management objectives with a single index period. The timing of this period should be based on program objectives, whether seasonal patterns are important relative to other CPIs, and logistics of sampling relative to flow conditions. The specifics of sampling design for this recommendation should be finalized by a group of experts in a workshop setting.

Other considerations – Long-term prey availability data could be incorporated into tools such as bioenergetics models to help identify optimal restoration sites in highly productive habitats. The potential also exists to develop correlative models between site-scale invertebrate prey and other variables like productivity, water temperature, and stream/riparian habitat condition (Woo et al. 2017), which could allow for predictive modelling of invertebrate characteristics throughout the rest of the Basin. There is also potential for eDNA efforts to help inform invertebrate presence/absence.

Costs

Costs for this CPI are based on analysis of freely available Google Earth imagery (1a), collection and analysis of bathymetric LiDAR (1b), field visits to conduct supplemental surveys (1c). Sampling design for aquatic invertebrates (2) remains to be finalized. For specifics of cost estimation, see Appendix G.

Table 5-15. Monitoring costs for stream habitat condition.

Recommendation	1-Year Cost	10-Year Cost
1a: Assess basin-wide planform complexity	32,000	72,000
1b: Assess topographic complexity in larger streams	3,907,000	12,197,000
1c: Supplemental field surveys	5,000	64,000
2: Monitor aquatic invertebrates	Workshop, TBD	Workshop, TBD

Related Activities

The USGS is currently evaluating approaches to assess geomorphic characteristics related to physical habitat and complexity before and after the proposed dam removal in the mainstem Klamath (C. Anderson pers. comm.).

5.4.8 Riparian Condition

Why

Riparian vegetation represents important habitat to both terrestrial and aquatic species. Riparian vegetation also stabilizes stream banks and reduces soil erosion. Degradation or loss of riparian corridors can reduce or eliminate stream shading resulting in increased water temperatures (especially in small tributaries), and can increase delivery of sediment, nutrients, or chemicals to stream channels. Timber harvest and associated activities have occurred over large portions of the Klamath Basin, resulting in significant loss of old-growth and late seral second-growth riparian vegetation along streams in forested areas of the basin (NMFS and USFWS 2013). Large woody debris (LWD) from riparian areas that is deposited in river channels is important for storing sediment, halting debris flows, and decreasing downstream peak flows (Stillwater Sciences 2007). Impacts from reduced LWD supply include poorer spawning habitat quality, loss of pool volume and complexity for adult holding and juvenile rearing, reduced shading, and loss of velocity refugia (NMFS and USFWS 2013). Cumulatively, a legacy of degraded riparian corridors, with resultant increased water temperatures, increased fine sediment delivery, and decreased LWD recruitment have led to widespread impacts to stream habitats used by fish in the Klamath Basin.

Current Status of Associated Monitoring

Riparian condition is assessed for many fish habitat restoration projects across the Basin as part of localized project effectiveness monitoring efforts using standard field-based assessment methods (e.g., CDFW Level III & IV habitat mapping protocols). The Klamath Bird Observatory also undertakes long term bird monitoring for many riparian restoration projects as an indirect measure of the rate at which riparian vegetation complexity is being recovered at restored sites. There is however no program/protocol in place for assessing the changing condition status of riparian habitats broadly across the Klamath Basin.

Detailed Recommendations

Recommendation 1 – Implement remote sensed methods for undertaking broad-scale evaluations of riparian structure and condition

What –

- Dominant riparian vegetation types (which can reflect differences in shade, LWD inputs, water storage)
- Measures of forest canopy height/age classes & intactness
- Riparian buffer extent

How – Topographic LiDAR to capture remote-sensed information on riparian vegetation (1a), with LiDAR-based assessments of riparian attributes initially ground-truthed/validated by field-data collection surveys such as CDFW Level III/IV habitat mapping protocols (1b), supplemented as needed since existing fish habitat survey protocols are often weak on collecting overbank information. Techniques for undertaking LIDAR-based analyses of riparian condition are described in recent papers such as Akay et al. 2012; Laslier et al. 2019; Huylenbroeck et al. 2019; Zurqani et al. 2020; and Roni et al. 2020).

Alternatively, satellite or aerial imagery can be used to calculate the non-dimensional vegetation index (NDVI; Rouse et al. 1974), a widely used metric that is indicative of vegetation condition and robustness (1c). NDVI has the benefits of being easily applied over broad scales and applicable to comparisons between different vegetation types throughout the Basin, and the technique has been successfully used to assess riparian vegetation in the Klamath Basin (e.g., Curtis et al. 2021) and elsewhere (e.g., Gergel et al. 2007; Bertoldi et al. 2011). The metric can be calculated from a variety of remotely sensed products: Curtis et al. (2021) used four-band imagery from the National Agriculture Imagery Program (NAIP); NDVI could also be calculated from Landsat or Sentinel satellite imagery. Additional datasets that could inform this CPI include the 2019 National Land Cover Database (https://www.mrlc.gov/) that includes percent vegetation cover and the gradient nearest neighbor (GNN) forest attribute dataset provided by the Landscape Ecology Modeling, Mapping & Analysis (LEMMA) group (https://lemmadownload.forestry.oregonstate.edu/).

Where – LiDAR or air photo/satellite overflights of streams to be undertaken across the entire Klamath Basin. Potential spatial stratification of LiDAR-derived riparian vegetation data (e.g., stream order, geomorphic condition, etc.,) or NDVI-based categories could be incorporated post-processing.

When – Rate of change for riparian condition will be relatively slow so every 3-5 years would be an appropriate timeframe to target for broad-scale repeat surveys and associated desk-top analyses. Particular watersheds could also be prioritized for repeat surveys after large-scale temporal disturbances (i.e., wildfires or flooding). Alternatively, focused evaluations of riparian condition in key watersheds as needed between broad LiDAR or air photo/satellite repeats could employ use of drone imagery to provide comparable remote-sensed information. Timing of repeat surveys should target the same time of year when riparian foliage is most dense (leaf-on), although acquisition of information during both leaf-on (summer) and leaf-off (winter) periods can help to better classify forest riparian species with LiDAR (Brandtberg 2007; Kim et al. 2009; Laslier et al. 2019).

Other considerations – Not all areas of the upper Klamath Basin had naturally forested riparian zones (e.g., meadow streams, etc.), so any assessment of restored stream riparian condition in such areas must accurately reflect this. Direct measurements of floodplain inundation (see Floodplain Connectivity/Inundation CPI) may be a useful complementary measure to inform surface water/vegetation relationships; NDVI assessments can also inform assessments of vegetation condition for a wide range of vegetation types, not just forests. Measurements of riparian buffer extents should also be considered in the context of their stream and valley type; naturally confined valleys may have narrow riparian buffers that are fully functional despite their width.

Costs

Costs for this CPI are based on topographic LiDAR collection and analysis (1a), field visits to conduct supplemental surveys (1b), and analysis of freely-available imagery for NDVI (1c). For specifics of cost estimation, see Appendix G.

Table 5-16. Monitoring costs for riparian condition.

Recommendation	1-Year Cost	10-Year Cost
1a: Topographic LiDAR assessment of vegetation	1,166,000	3,575,000
1b: Supplemental field surveys	5,000	64,000
1c: Imagery-based NDVI assessment of vegetation	51,000	161,000

Related Activities

Topographic LiDAR for stream riparian type and condition is relevant to a number of other CPIs (e.g., floodplain connectivity, channel complexity, and large wood recruitment and retention) providing opportunities for cost savings across CPIs.

5.5 Biotic Interactions

5.5.1 Disease

Why

Pathogen-induced diseases in the Klamath Basin exacerbated by depleted flows and warmer water caused by dams are a growing concern and can have population level impacts in some years, particularly in regard to Coho and Chinook salmon where disease can represent the leading cause of juvenile mortality and has also been responsible for episodes of major kills of pre-spawning adults. There are six disease pathogens of primary concern to fish in the Klamath Basin, four of which are transmitted fish-to-fish and two which require an intermediate invertebrate host to produce the fish-infectious stages. Understanding the seasonal prevalence and severity of infection of these fish diseases within the Klamath Basin in relation to in-river conditions can inform real-time management decisions such as flow management (i.e., 2017 ROD trigger for lower Klamath River flow augmentation from Trinity River Reservoir releases is based on observed Ich trophont densities per fish gill arch) or fish hatchery releases as well as understanding if the combination of IFRMP restoration actions are reducing the frequency and severity of disease events as intended. General information on the six pathogens of primary concern to salmonid populations in the Klamath Basin is provided in Table 5-17.

Table 5-17: Six pathogens of key concern to Klamath River salmonids: four are transmitted directly fish-to-fish, and the two myxozoan parasites require an invertebrate to produce the fish-infectious stages (source: OSU proposal: Hallett and Alexander 2021).

Pathogen, common name/disease (target tissue)	Type	Present distribution and future concerns
Ceratonova shasta (formerly *Ceratomyxa*) Enteronecrosis (gut, systemic)	Myxozoan parasite	LKB+UKB; clinical disease in LKB. Parasite abundance will increase in the UKB following salmonid re-population
Parvicapsula minibicornis Glomerulonephritis (kidney)	Myxozoan parasite	LKB+UKB; clinical disease in LKB. Parasite abundance will increase in the UKB following salmonid re-population
Ichthyopthierius multifiliis Ich / White spot (gills, skin)	Ciliate parasite	LKB+UKB. Crowding of stressed fish in refugia promotes transmission
Flavobacterium columnarae Columnaris (gills, skin, systemic)	Bacterium	LKB+UKB. Salmonids will incur thermal stress in UKL during summer, and bacteria will thrive under these conditions
Renibacterium salmoninarum Bacterial kidney disease	Bacterium	Asymptomatic carriers in the UKB. Infected resident trout potentially infect in-migrant salmonids
Lernaea sp. Anchor worm (skin)	Copepod parasite	Trout in UKB. Crowding of stressed fish in refugia promotes transmission

Current Status of Associated Monitoring

Ceratonova shasta and Parvicapsula minibicornis

There is currently an established collaborative multi-agency program maintained in the Klamath River for monitoring of *C. Shasta* and *P. minibicornis* prevalence and severity which should be leveraged and built upon as needed to fill any existing monitoring gaps. It is assumed that disease monitoring for *P. Minibicornis* can piggyback/align with existing/future efforts for *C. Shasta* as these species have similar life cycles/effects. Spatial coverage of monitoring for these pathogens is considered adequate in the lower basin below Iron Gate Dam, however there are gaps in the current coverage between the dams in the Klamath River Project Reach (with the river stretch from the Shasta River to Scott River confluences considered of most concern currently) and in major tributaries in the upper Klamath Basin that will require additional sampling sites once the major Klamath dams are removed and salmon are able to migrate farther upriver.

Ichthyopthierius multifiliis (Ich) and Flavobacterium columnarae (Columnaris)

There is currently an established program led by the Yurok Tribe Fisheries Department (YTFD) in the lower Klamath River and in the Trinity River to monitor the prevalence and severity of Ich in adult fall-run Chinook that should be leveraged and built upon. It is assumed that disease monitoring for *columnaris* can piggyback/align with existing/future efforts for *Ich* as these species have similar effects. Impacts of Ich and Columnaris effects on adult fish can often be compounding. Focus of Ich/Columnaris monitoring is on adult salmon as they re-enter the Klamath and Trinity rivers in the late summer/early fall. Methods require direct, lethal sampling of fish hosts and visual quantification of parasite load. This monitoring is intended as an early warning system of Ich disease concerns that could trigger increased water flows from the Trinity River Reservoir to improve conditions in the lower Klamath River. The current "severe" disease-related trigger for an emergency release from the Trinity Reservoir is 5 percent of sampled fish in the lower Klamath River showing 30 Ich trophonts per gill arch. These current used lethal sampling methods can, however, be insensitive to early or light infections of Ich. Researchers at Oregon State University (OSU) have recently developed protocols that allow them to accurately identify and quantify ich parasites from water samples using genetic analysis tools (Howell et al. 2019). The method involves molecular analysis of DNA in water samples (quantitative qPCR assay) for detection of waterborne stages of the Ich parasite. Ich abundance in environmental water samples collected from the lower Klamath River has been shown to relate to observed Ich parasite load on salmon sampled concurrently. YTFD is currently exploring this DNA-based method as an alternative monitoring method for identifying Ich 'hot spots" and possible sources of disease in the lower Basin.

Other pathogen-induced diseases

The current programs for monitoring of *C. Shasta/P. minibicornis* and Ich/Columnaris in the Basin are much more developed than monitoring of disease pathogens affecting other fish species, including endangered suckers. Most of the effective work in this regard would be considered equivalent to fish sentinel studies and no regular waterborne monitoring is undertaken for disease pathogens in the upper Klamath basin currently. Direct evaluation of disease condition in endangered suckers (i.e., Shortnose and Lost River sucker) is logistically difficult (i.e., can be hard to find juveniles) and age-0 chub are often used instead as a surrogate in sentinel studies. At this time it is known that juvenile suckers are host to numerous bacterial and parasitic infections, but it is unclear if any of these substantially contribute to juvenile sucker mortality. Because of low prevalence or lack of pathological response related to infection most of most of the identified parasites are considered likely to be benign to suckers. Three parasites that have been associated with pathology in juvenile suckers, however, include the trematodes *Bolbophorus sp*. And Ichthyocotylurus sp., and the nematode *Contracaecum sp.* (Burdick et al. 2015). The ectoparasitic copepod *Lernaea spp*. Has also been shown to cause severe inflammatory lesions and ulceration at the attachment site in suckers, which can provide portals of entry for opportunistic bacterial pathogens (Burdock et al. 2015).

Detailed Recommendations

Recommendation 1 – Expand existing monitoring network for Ceratonova shasta and Parvicapsula minibornis

What –

- *C. Shasta* spore density (spores/L) in collected water samples (based on quantitative qPCR analysis of filtered DNA)
- Abundance/density of the invertebrate (polychaete) host (*Manayunkia occidentalis)*

- Prevalence of *C. Shasta* infection as determined from existing Klamath salmon outmigrant surveys
- Infection and disease severity (percent morbidity and mean days to morbidity) in sentinel fish as determined through visual observations and molecular assay (PCR).

How –

Protocols for monitoring of C. Shasta in the Klamath River are described in Bartholomew et al. (2016) and at OSU's Monitoring Studies webpage:

https://microbiology.oregonstate.edu/content/monitoring-studies

In summation:

- Collect water samples at all selected monitoring stations. As *C. Shasta* has transmission stages in the water column water sampling enables direct quantification of fish infective stages. Sampling methods generally involve collection of three 1-L water samples from each site which are then filtered @ 5 µm (for *C. Shasta* and other macroparasites) and 6 x 0.5 L filtered @ 0.22 µm (for bacteria).
- Undertake benthic sampling for *C. Shasta* annelid hosts (*Manayunkia occidentalis*) through D-frame bounded substrate scraping at selected sites.
- Place "sentinel" fish highly susceptible to *C. Shasta* (e.g., IGH Fall Chinook, out-of-basin rainbow trout) in cages alongside fish of interest such as in-basin Chinook and coho salmon at index sites along the river for a three-day exposure. Transport sentinel fish to OSU's John L. Fryer Aquatic Animal Health Lab and monitor for infection (~ 60 days).

Where – Expand the current existing program of disease monitoring stations in the Basin as per the recommended design outlined in a recent OSU proposal (Hallett and Alexander 2021, subsequent updates to this proposal provided by S. Hallett pers. comm.). This proposal recommends that nine new index sites be established in the Upper Klamath Basin that are or will be relevant to salmon spawning, rearing, and migration: 6 new sites between the existing dams and 3 new sites in key tributaries to Upper Klamath Lake (i.e., Sprague R., Williamson R., and Wood R.) where it is expected that salmon would re-populate based on historical pre-dam distributions. Refer to Hallett and Alexander (2021) for exact site locations proposed.

When –

- Water samples for spore monitoring should be collected monthly at index sites during the period of key disease concerns (May-October, water temperatures above 16^{o} Celsius), preferably using an automatic 24 hr. sampler to account for within-day variability. Temporal density of water sampling should be adjusted within months (i.e., higher during periods of salmon outmigration, lesser during other times of the year).
- Benthic sampling for annelid hosts should be undertaken at selected sites once each in fall, winter, spring, and summer, and potentially more frequently if flooding or pulse events are scheduled to occur.
- "Sentinel" fish cages should be established at index sites during key periods of disease concern, as indicated by *C. Shasta* spore count monitoring

Other considerations – The IFRMP should support implementation of the currently proposed OSU/ODFW collaborative effort (Hallett and Alexander 2021) to expand sampling of the distribution and abundance of *C. Shasta* and *P. minibicornis* in the Upper Klamath Basin following dam removal (i.e., nine new monitoring locations) and develop a predictive framework that can be used for informing fish disease dynamics. These nine additional sites should be incorporated into the Basin's current long term monitoring program for evaluation beyond the intended 2-year funding period of the proposed OSU/ODFW research project. Changes to funding sources for disease monitoring over time should also be considered; for example, the expiration of PacificCorp-funded disease monitoring downstream of IGD may lead to a funding gap following dam removal.

There is a pressing research need to develop methodologies that could allow effective monitoring of the *C. Shasta* transmission stage from adult salmon (i.e., salmon carcasses) to the intermediate annelid host so as to better inform *C. Shasta* life history modeling and the associated management actions that could help better manage disease in the Basin. This part of the adult fish to annelid worm life cycle (occurring in winter) is currently poorly understood.

Recommendation 2 – Expand existing monitoring network for Ichthyopthierius multifiliis (Ich) and Flavobacterium columnarae (Columnaris)

What –

- Prevalence and intensity of Ich infection (trophonts/gill arch) as determined from examination of sampled adult salmon
- Ich densities (any lifestage) in collected water samples (based on quantitative QPCR analysis of filtered DNA)

How – Continue to support and expand the existing program for Ich and Columnaris monitoring being undertaken by the YTFD and supported by OSU, employing both direct sampling of adult salmon for evaluation of Ich and Columnaris infection rates and broad-based water sampling and associated DNA analyses for monitoring of Ich hotspots/potential areas of disease outbreaks. Protocols for undertaking direct observations of Ich and Columnaris densities and gill lesions in adult salmon in the Klamath River are described in Foot 2003 and McCovey 2010. Methods for molecular analysis of Ich ribosomal DNA in collected water samples are described in Howell et al. (2019).

Where – Continue sampling of adult fall-Chinook for Ich and Columnaris infection at existing YTFD monitoring locations in the lower Klamath River and in the Trinity River above the confluence with the Klamath River. Undertake water sampling for molecular DNA analysis of Ich and Columnaris abundance at selected locations in the lower Klamath River known for past Ich outbreaks.

When – Sampling of adult salmon for monitoring of Ich and Columnaris infection rates should be undertaken continuously from late summer to early fall, coinciding with periods of spawning migration into the Klamath and Trinity Rivers. Monitoring for Ich and Columnaris abundance should be undertaken aet selected sites from May through October with water samples collected on a weekly basis.

Other considerations – Key question is how much pre-spawn mortality is actually caused by Ich and Columnaris (e.g., flow and temperature stress, fish crowding can affect infection rates and mortality from these diseases). There is a need for additional research (e.g., mark-recapture studies) to learn more about the range of factors that might contribute to disease-related adult pre-spawn mortality.

Recommendation 3 – Develop approach for monitoring disease pathogens/parasites affecting endangered suckers

What –

- Prevalence and severity of infection of key parasites of concern in endangered suckers (or surrogate species)
- Percent morbidity / percent mortality from infection by key parasites of concern for endangered suckers

How – Develop network of sentinel sites (mesocosm cages) stocked with juvenile sucker (captive reared progeny) (or age-0 chub surrogates) to monitor rates of pathogen infection and any subsequent pathogen-related morbidity/mortality.

Where – Selected sites within Upper Klamath Lake where it is considered parasite transmission may be most problematic (e.g., near fringing wetlands/marshes).

When – During periods of anticipated highest parasite loads in Upper Klamath Lake, usually July to September.

Other considerations –

A network of sentinel sites maintained for evaluating the extent of any disease issues affecting endangered suckers could also be used for evaluating effects of other factors that could impact suckers in Upper Klamath Lake (i.e., water quality, cyanotoxin toxicity).

Costs

Costs for this CPI are being developed with the OSU/ODFW team.

Related Activities

Monitoring of seasonal stream flows and water temperatures are also critical for understanding the status and potential impacts of disease on Klamath fish populations. It would also be useful to consider whether water sampling required for disease pathogen monitoring could be effectively combined/coordinated with water sampling needed for other CPIs (e.g., water quality, invasives, focal species presence, etc.) to increase overall efficiency of sampling efforts at selected monitoring sites (i.e., same water collected but would require splitting into different sample processing protocols/filter papers etc. in prep for CPI analyses).

5.5.2 Invasive aquatic species

Why

In the last century, the upper Klamath Basin has been invaded by a variety of non-native fish species, most of which were introduced for sport fishing or bait (NRC 2004). Most of these species are not particularly common in the basin, but some are abundant and widespread. The effects of invasives on native fish are poorly understood but spread of non-native species has the potential to threaten native species in both the upper and lower basins through competition and predation (NRC 2004, NMFS and USFWS 2013). Of particular note are populations of non-native brook trout, brown trout, and yellow perch that are now common in many Klamath basin streams. While many invasive fish species are already well established in the Klamath Basin it is important to understand their overlapping distributions with focal native species in sufficient detail to inform restoration efforts needed for protection of key habitats. Other aquatic invasive species known to degrade fish habitats (e.g., non-native molluscs such as New Zealand Mud Snails, Quagga, and Zebra Mussels) are not yet common in the Klamath Basin (although New Zealand Mud Snail has been observed in the Basin downstream of Iron Gate Dam near Bogus Creek). However, there are concerns that these species could be introduced inadvertently through recreational boating activities etc. and it will be important to be able to track any introductions of new, damaging invasives into the Basin and mitigate quickly as possible.

Current Status of Associated Monitoring

There are some existing localized surveys for invasive species, often research focused, and some incidental reporting derived from inadvertent captures of invasives during other Basin fish monitoring efforts. There are, however, no directed, systematic monitoring efforts that could provide information on changing distributions and/or abundance of invasive species across the Klamath Basin.

Detailed Recommendations

Recommendation 1 – Establish eDNA Sampling Network for Monitoring Invasives

What – As living organisms complete their life processes their genetic material, or DNA, is shed exogenously into the surrounding environment. For aquatic and semi-aquatic species environmental DNA (eDNA) can be collected in water samples, filtered to capture eDNA, and effectively assayed to detect the presence of aquatic and semi-aquatic species without direct observation. For some species of concern useable DNA assays will already exist from other programs but for others it may require assay development or additional validation in the Klamath. For purposes of monitoring of invasives in the Klamath an eDNA evaluation of individual species presence/absence at monitored sites would be sufficient as the monitoring metric (with the associated inferred extent of species distribution).

How – Establish a new, coordinated program of eDNA assays and sampling sites across the Klamath Basin for detection of invasive species of major concern (currently or potentially in the future). Key suggested aquatic species to consider for eDNA monitoring include New Zealand Mud Snail, Quagga, Zebra Mussels, Grass Carp, Bull Frog, Brook Trout, Brown Trout, Yellow Perch. Detailed eDNA protocols for the monitoring of aquatic organisms have been developed by a variety of agencies (e.g., Laramie et al. 2015; BCMOE 2017; Jerde et al. 2019; DFO 2020) and can be used to inform a sampling program within the Klamath Basin.

Where – Recommended locations for eDNA sampling is discussed within various protocols. There are suggestions that sampling could be focused on the presumed preferred habitat of particular target species. This sampling approach is considered especially effective for early detection applications (Jerde et al. 2011) but has pitfalls when using the same data to make inferences about broader population trends and may also miss early detection of new invasive species if we misunderstand species habitat preferences. Alternative suggestions are for greater spatial distribution of eDNA samples based on more general habitat stratifications that could be important across all species (e.g., tributaries vs. mainstem, etc.). The total number of eDNA sample sites necessary to detect potentially rare species in aquatic habitats is discussed in a number of papers (Olds et al. 2016; McKelvey et al. 2016; Evans et al. 2017) and will vary depending on the expected species abundance or rarity, and on the total area (lentic) or linear distance (lotic) of the habitat being sampled.

When – Recommended timing of eDNA sampling is discussed within various protocols. Optimal timing can relate to such factors as water temperature (i.e., greater persistence of eDNA in colder water), UV radiation, and alkaline conditions. Suggested timing/frequencies of eDNA sampling could also vary based on individual species behaviors as there are positive relationships between concentrations of eDNA recovered during sampling efforts and the density or activity levels of particular target species over time and/or space. Such timing factors might need to be considered for sampling across each of the target species of concern to improve eDNA detection probabilities. Optimally if sampling could be undertaken on a regular (monthly?) basis at all monitoring sites then potential sources of eDNA detection variability could be adjusted for (as an annual assessment of species presence/absence at a site would be the metric of interest).

Other considerations – It is not expected that Klamath Dam removal would provide any additional concerns around invasive species as most invasive fish species found in the Klamath are already present in the upper Basin (and the expectation is that dam removal should make habitats better for native fish species and less so for non-natives). The focus of monitoring therefore would be less on tracking potential redistribution/expansion of existing competing/predatory invasives and more on providing early detection of any new damaging species that might enter the Klamath Basin in the years ahead.

Water sampling sites for collection of eDNA to track the occurrences/distribution of aquatic invasives could also potentially be piggybacked for increased efficiencies with water sampling being undertaken for monitoring of other CPIs (e.g., water quality, focal species presence/absence). An expanded Basin network of automated water samplers informing multiple CPIs should be considered.

Costs

Costs for this CPI are based on a series of three workshops to bring together local experts and design the sampling network, a reporting cost to document workshop results, and an estimated startup cost for eDNA monitoring implementation. For specifics of cost estimation, see Appendix G.

Table 5-18. Monitoring costs for invasive aquatic species.

Recommendation	1-Year Cost	10-Year Cost
1: Establish eDNA network for invasives	275,000	N/A

Related Activities

A multi-agency coordinated program of monitoring the distribution of aquatic invasives using eDNA protocols could be potentially be supplemented by crowd-sourced citizen science efforts as has been done effectively within the USDA's Aquatic eDNA Atlas Project open-access database: (https://www.fs.fed.us/rm/boise/AWAE/projects/the-aquatic-eDNAtlas-project.html).

5.6 Fish Populations

5.6.1 Focal Species Population Indicators (Presence/Absence, Abundance, Spawning & rearing area extents, Productivity, Spatial Structure,Genetic Diversity, and Life History Diversity

Why

The Klamath Basin is home to 30 native fish species and historically produced an abundance of Steelhead, Chinook salmon, Coho salmon, Green Sturgeon, Eulachon, Coastal Cutthroat Trout, Pacific Lamprey, and Lost River and Shortnose Suckers that contributed to substantial Tribal, commercial and recreational fisheries. There have been significant long-term declines in abundances of Klamath River native anadromous and freshwater resident fish species from the numbers observed in the early 1900s (USDI, USDC, NMFS 2013; Vanderkooi et al. 2011). These declines are considered a result of a suite of cumulative effects acting on Klamath fish populations (e.g., dam construction, hydrologic alteration, overfishing, timber harvest, agricultural development, past mining, and changing ocean conditions). These impacts have resulted in a loss of fish diversity and abundance throughout the Basin (Adams et al. 2011). Among these factors the most significant cause of lost diversity in the Basin is the current impassable upriver migration barrier imposed upon anadromous fish at Iron Gate Dam on the Klamath River mainstem. Recovery of threatened fish populations requires removing or reducing the various stressors facing fish currently in the Basin and ensuring that fish distributions (presence), abundances, spawning/rearing area extents, productivity, spatial structure and genetic and life history diversity are increasing/improving over time.

Current Status of Associated Monitoring

Evaluation of focal fish populations in the Klamath Basin is currently a focus of well-established monitoring programs across a broad range of federal agencies (i.e., NMFS, USFS, USFWS, USGS, USBR), state agencies (i.e., CDFW, ODFW), Tribal organizations (i.e. Yurok Tribal Fisheries Department, Karuk Tribe, Hoopa Valley Tribes), NGOs (i.e. Trout Unlimited), and Community Organizations (i.e. Mid Klamath Watershed Council, Salmon River Restoration Council) that in composite provide broad monitoring coverage of fish population-related CPIs in the Basin. see Chapter 7.2.5 of the Klamath Synthesis Report (ESSA 2017) for detailed descriptions of current fish population monitoring efforts led or funded by each of these organizations in the Klamath Basin. Recent post dam reintroduction plans from CDFW and ODFW also provide comprehensive outlines for tracking fish recolonization and restoration planning and monitoring that the state agencies will conduct (ODFW and the Klamath Tribes, 2021; CDFW 2022). Population information on focal species captured within current Basin monitoring activities includes:

- Spatial and temporal distribution
- Presence of spawning
- Presence of rearing

- Spawner escapement (anadromous species)
- Abundance (non-anadromous species)
- Production
- Survival (in-river)
- Juvenile abundance (anadromous species)
- Harvest (in-river)
- Harvest (ocean)
- Stock composition
- Demographics
- Age structure
- Source populations
- Hatchery-origin versus natural-origin fish

There is currently good spatial and temporal coverage for monitoring of fish populations across the Basin. Identified “gaps” relate primarily to:

1) Ensuring that monitoring infrastructure is in place that can effectively track any changes in status of fish populations subsequent to the removal of the Klamath mainstem dams. Three distinct new Plans are in place however across different agencies for activating new fish population monitoring efforts in different areas of the Basin once the dams are removed: 1) Definite Plan for the Lower Klamath Project (KRRC 2018), 2) Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife (CDFW 2022, draft), and 3) Implementation Plan for the Reintroduction of Anadromous Fish into the Oregon Portion of the Upper Klamath Basin (ODFW and Klamath Tribes 2021). See Appendix H for summaries of specific fish population monitoring efforts within each of these plans that will developed in anticipation of removal of the dams. While many elements of fish population response to dam removal will be evaluated across these plans the most important long-term IFRMP question to address will be whether fish are progressively moving into new areas in response to dam removal and associated upriver habitat restoration efforts that may be implemented and successfully reoccupying their historical habitats. Fish distribution therefore represents a key fish population CPI for the IFRMP to support directly through integration of the current monitoring efforts across agencies, those within the new upcoming Plans, and additional cooperative efforts that could be initiated to expand monitoring coverage.
2) Sharing of collected data on focal fish populations across the varied monitoring entities to allow for full integration of information at the Basin-wide scale.
3) Developing a better understanding of Chinook Salmon fishery management (conducted through the PFMC), specifically age-structured escapement estimates for the Klamath River Basin broken out by sub-basin. Current adult monitoring adequately covers the existing extent of anadromy but will be inadequate to estimate escapement above the existing site of IGD following dam removal.
4) Establishing a life-cycle (adult and juvenile) monitoring site in the lower Klamath River mainstem that would allow for a basin-wide productivity measurement, to inform estimates of juvenile salmon survival and species composition between Weitchpec and the estuary.

Detailed Recommendations

Recommendation 1 – Establish eDNA Sampling Network for Monitoring Distribution of Focal Fish Species

What – Environmental DNA (eDNA) sampling is considered the most simple, cost-effective approach for evaluating fish distribution at the basin scale across focal species. There is no basin-wide eDNA sampling network and this presents a good opportunity for the IFRMP to supplement the existing fish monitoring efforts. As living organisms complete their life processes their genetic material, or DNA, is shed exogenously into the surrounding environment. For aquatic and semi-aquatic species eDNA can be collected in water samples, filtered to extract eDNA, and effectively assayed to detect the presence of fish species without direct observation (Levi et al. 2018; Tillotson et al. 2018; Homel et al. 2020). For some species of concern useable DNA assays are already in place for the Klamath or already exist from other programs but for others it may require assay development or additional validation in the Klamath. eDNA methods can't currently differentiate all Klamath sub-species (fall vs. spring Chinook, steelhead vs. rainbow, Pacific lamprey from other resident lamprey), although it is hoped that this can be resolved over time. In the interim it may that eDNA would be used as an initial flag of species redistribution but would need follow-up field sampling of fish to determine actual sub-species.

How – Establish a coordinated program of eDNA assays and sampling sites across the Klamath Basin to determine if distribution (presence) of focal species is expanding in the upper basin after dam removal, and also in other Klamath sub-basins due to suites of restoration activities that may be implemented over time. Detailed eDNA protocols for the monitoring of aquatic organisms have been developed by a variety of agencies (e.g., Laramie et al. 2015; BCMOE 2017; Jerde et al. 2019; DFO 2020) and can be used to inform a sampling program within the Klamath Basin. Fish distributions as determined through eDNA surveys can be supplemented with information from other ongoing, more intensive fish monitoring activities in the Basin (e.g., spawning surveys, weirs, smolt traps, PIT tag arrays, etc.) as presence/absence is a simple byproduct of such surveys (e.g., abundance data can be reduced to simple presence/absence). It will be beneficial to combine information on presence/absence from multiple surveys (i.e., existing distribution information already assembled, new eDNA surveys, and other new surveys from other methods) within a common data platform that researchers/managers/restoration practitioners can access to share information on potentially changing focal fish distributions. Distribution would provide the first tier of information; once fish presence in a new area is indicated then focus would on determining next level of population information – spawning sites, population structure, genetics, productivity, etc. – with associated development of the requisite monitoring tools to allow such determinations.

Where – Coordinated broad eDNA-based evaluations of focal fish species distributions across the entire Klamath Basin with spatial strata for tracking of potential redistribution over time after dam removals moving progressively from Klamath mainstem sites above the current dams, then to upper basin sub-basin mainstems, then to upper basin sub-basin tributaries. In parallel, fish distributions would be evaluated first in lower basin sub-basin mainstems then moving to smaller tributaries in the sub-basins.

When – Recommended timing of eDNA sampling is discussed within various protocols. Optimal timing can relate to such factors as water temperature (i.e., greater persistence of eDNA in colder water), UV radiation, and alkaline conditions. Suggested timing/frequencies of eDNA sampling could also vary based on individual species behaviors as there are positive relationships between concentrations of eDNA recovered during sampling efforts and the density or activity levels of particular target species over time and/or space. Such timing factors might need to be considered for sampling across each of the focal species of concern to improve eDNA detection probabilities. Optimally if sampling could be undertaken on a regular (monthly?) basis at all monitoring sites then potential sources of eDNA detection variability could be adjusted for (as an annual assessment of species presence/absence at a site would be the metric of interest).

Other considerations – Information on focal fish species presence/absence can be tied to assessments of whether "modeled" suitable habitat or newly restored habitats are being effectively used by target species across the Basin. Presence (or absence) of focal fish species, as assessed through eDNA can indicate problems (i.e., fish not moving upstream as expected – why? Next level of evaluation could focus on potential habitat concerns not alleviated).

There will be challenges to consider in terms of how detection probabilities change with concentration, distance, and time. Recent research from Braden Herman (HSU) and others may be informative.

Water sampling sites for collection of eDNA to track the occurrences/distribution of focal fish species could also potentially be piggybacked for increased efficiencies with water sampling being undertaken for monitoring of other CPIs (e.g., water quality, invasive species presence/absence). An expanded Basin network of automated water samplers informing multiple CPIs should be considered.

Recommendation 2 – Support current initiatives in the Basin focused on integrating and sharing information related to fish population indicators

Efforts exist that focus on facilitating the coordination and implementation of monitoring and research within the Klamath River watershed. Although the current USFWS ServCat service works well for storing, archiving, and management of data, documents, and plans, the need remains for whole-Basin, public-facing, useable interfaces. One organization working in this direction is the Klamath Basin Monitoring Program (KBMP) (https://kbmp.net/), whose monitoring efforts are primarily focused on coordinating water quality information but also on building data systems that can support metadata summaries relating to fish population monitoring in the Basin (e.g., current locations of juvenile and adult monitoring, PIT tag stations, eDNA sampling sites, etc.). These or similar efforts should be supported and expanded as possible to provide greater shared access to Basin monitoring information that can support evaluation of fish population CPIs.

The Klamath Basin PIT Tag Database is an ongoing collaborative effort to compile PIT tagging data collected throughout the Klamath Basin and make this data easily accessible to participating groups. The online database developed by USGS for this effort consists of tagging and reencounter events between 2006 to 2021 as collected by multiple entities including Yurok and Karuk Tribes, Scott River Watershed Council, Mid Klamath Watershed Council, and California Department of Fish and Wildlife. Tagging information exists within this database currently for Coho, Chinook, Steelhead, Redband Trout and Green Sturgeon. A data sharing agreement is now in place for data access permissions for the application. Similarly, in the Upper Basin USGS maintains a database of PIT tag releases and detections of Lost River, Shortnose and Klamath Largescale suckers and Redband trout in the upper Basin by USGS, US Fish and Wildlife Service, Bureau of Reclamation, Klamath Tribes and Oregon Department of Fish and Wildlife. This USGS database is not publicly accessible at the current time, however, and participants must contact USGS database administrators to submit and access data. Further developing and combining these collaborative Basin database efforts at sharing fish population information (especially after removal of the Klamath dams) as well as expanding the associated PIT tagging efforts and PIT detection infrastructure to support them would provide valuable information that could support integrated basin-scale evaluations of multiple CPIs within the IFRMP (e.g., distribution (presence/absence), productivity, life history diversity) and other measures of fish status (e.g., growth rates, juvenile and adult survival, etc.).

Recommendation 3 – Support ongoing fish population monitoring efforts throughout the Basin

As noted above, current fish monitoring efforts are undertaken by a range of organizations (federal, state, tribal, NGOs, community groups), with many well-established programs in place aimed at different species, life stages, and regions. To ensure the continued operation of these programs, it is recommended that funding sources continue to support these programs as the IFRMP progresses and funding opportunities change. Although these programs are currently fully funded, displaying the program costs serves to highlight the substantial ongoing efforts and put a sense of scale to the overall basin-wide level of required funding. These ongoing fish population monitoring efforts will inform measures of fish distribution as part of the broader Focal Species Population Indicators CPI, alongside the other recommendations. Costs for these programs were assessed based on conversations with representatives from each organization.

Recommendation 4 – Fill existing or upcoming gaps on fish life-cycle monitoring

Two additional gaps were identified in the existing monitoring for fish populations: 1) the need for more monitoring data to inform Chinook Salmon fishery management above IGD following dam removal, and 2) the need for a new monitoring site for life-cycle monitoring on the mainstem Klamath River between Weitchpec and the estuary. For Chinook fishery management, current adult monitoring adequately covers the existing extent of anadromy but will be inadequate to estimate escapement above the existing site of IGD. Although the State of California and Oregon reintroduction plans do discuss some potentials for monitoring above IGD post dam removal, it is recommended that experts convene in a workshop to plan explicitly for necessary surveys and associated costs. For an additional new life-cycle monitoring site on the mainstem Klamath River, potential monitoring items include a sonar system (i.e. Didson or other manufacturer) to enumerate adult salmon and sturgeon moving upstream, a fish wheel to monitor species composition, and a series or rotary screw traps that are incorporated into a single trapping site. The specifics of monitoring methods and location and for this gap should also be discussed by local partners in a workshop setting.

Costs

Costs for this CPI are based on a series of workshops for local experts to plan the eDNA network and eDNA network startup costs (same as 5.5.2 Invasive aquatic species), costs to support the PIT Tag Database in a post-dam configuration where monitoring extends through the entire basin, costs for existing fish population monitoring efforts, and workshops to fill existing gaps on life cycle monitoring. For specifics of cost estimation, see Appendix G. On-going fish population monitoring efforts are funded separately from the IFRMP and are not included in monitoring costs total summaries; cost information is provided instead to highlight the importance of continuing these efforts throughout the Basin.

Table 5-19. Monitoring costs for focal species population indicators.

Recommendation	1-Year Cost	10-Year Cost
1: Establish eDNA network for focal fish species	275,000	N/A
2: Support initiatives on fish population information sharing (PIT Tag Database)	8,589,000	51,024,000
3: Support ongoing fish population monitoring efforts	14,094,000	180,426,000
4: Fill existing or upcoming gaps on life-cycle monitoring	Workshop, TBD	Workshop, TBD

Related Activities

A multi-agency coordinated program of monitoring the distribution of focal fish species using eDNA protocols could be potentially be supplemented by crowd-sourced citizen science efforts as has been done effectively for monitoring the distribution of bull trout within the Pacific Northwest within the USDA's Aquatic eDNA Atlas Project open-access database:

(https://www.fs.fed.us/rm/boise/AWAE/projects/the-aquatic-eDNAtlas-project.html).

6 Recommendations for Implementation

This Section

- Outlines recommended future steps for the successful implementation of the IFRMP.
- Many of these recommendations are collective/shared and apply to a range of Federal, State and other entities engaged in restoration in the Klamath Basin.

Because the IFRMP identifies over 140 proposed restoration projects that will take more than two decades to complete, there is an ongoing need for learning and adjustment through time. Doing this successfully will require several near-term actions as well as longer-term actions to create the enabling conditions for success. These enabling conditions include well-defined tools, workflow pathways and resources to support implementation; ongoing collaboration and learning through monitoring and science synthesis; applying ongoing adaptive management learning updates to the Plan to reflect current context; and clear and dedicated governance partnerships to coordinate and maintain momentum over time.

This section describes recommendations for ongoing implementation of the IFRMP that have been drawn from participants across the planning process and are provided here for further consideration. While some of these recommendations are specifically directed at the USFWS, and are clearly identified as such, most are recommendations for consideration by all entities involved in restoration within the basin. Collaborative efforts to carrying out these recommended actions will help to support the ongoing implementation of the IFRMP to deliver the greatest returns on the considerable investments in the IFRMP planning process and ensure the best restoration outcomes for fish, fish habitats, and the ecosystems and communities that rely on them.

The recommendations identified below are mutually supportive of each other and organized in three major categories, namely (I) **essential tools**, (II) **collaborative learning frameworks**, and (III) **ongoing coordination** for IFRMP implementation. Like any plan, the IFRMP is a snapshot of knowledge in time. By carrying out the recommendations listed below and described in more detail in the rest of this section, the over $2M spent on numerous collaborative engagements, tool building and documentation will give the IFRMP the greatest chances of fulfilling its potential.

Key Recommendations for Implementation

I - Sustain Tools & Linkages to Funding Solicitations

I.1 – As appropriate, all organizations funding restoration in the basin should consider issuing solicitation guidance that encourages proposals to link to IFRMP and RAA priorities

I.2 - USFWS should consider supporting long-term maintenance of IFRMP Restoration Prioritization Tool and consider extending the Tool to include a project and data tracking atlas

I.3 – USFWS should consider sponsoring the IFRMP website to consolidate key resources and communications

II- Support Ongoing Collaborative Learning Frameworks

II.1 - Articulate how Adaptive Management will help guide the approach to evidence-based decision-making throughout implementation of the IFRMP

II.2 - Support regular Science Symposia to disseminate learning, measure progress, and decide on updates to future IFRMP Restoration Action Agenda priorities

II.3 - Create a monitoring coordination group and work towards standardizing Basin-wide data collection and assessments

II.4 - Provide ongoing impartial technical facilitation to help address emerging issues

III - Establish Ongoing Coordination for IFRMP Implementation

III.1 – Stakeholders in the basin should discuss the establishment of formal and informal coordination roles, agreements, and activities to for IFRMP implementation to sustain ongoing adaptive management and fish population and habitat recovery

6.1 I - Sustain Tools & Linkages to Funding Solicitations

Translating complex plans into action requires tools that support of a clear workflow for evaluating decision-making priorities as well as supporting tools to consolidate and organize information needed for decision-making, track progress over time, communicate outcomes. As restoration projects are gradually implemented and as restoration priorities and needs in the basin change over time, it is also important to track restoration work that is in progress and learning. Key information tools include both the IFRMP Restoration Prioritization Tool (IRPT) (http://klamath.essa.com/) used for prioritization as well as the Klamath IFRMP Website (https://ifrmp.net/) which provides a platform for public communication about the IFRMP and related funding opportunities and also features a variety of IFRMP resources (e.g., Klamath IFRMP and Synthesis Report, document library, overview videos, and other supporting materials). The IRPT provides the only standardized restoration project scoring and ranking system that can be used by multiple agencies to facilitate basin-wide comparisons among proposed projects and track which projects have been implemented.

Four specific **near-term recommendations** follow below.

> **I.1 - As appropriate, all organizations funding restoration in the basin should consider issuing solicitation guidance that encourages proposals to link to IFRMP and RAA priorities**
> All organizations issuing solicitations for funding functional watershed habitat restoration or monitoring for the benefit of fish populations in the basin should consider requesting that proposal respondents identify corresponding priorities within the IFRMP and/or RAA and these issuing organizations should provide support to facilitate participation in their proposal process.

Solicitation Guidance

The IFRMP represents a participatory, vetted, rigorous filter on the kinds of functional watershed restoration actions most likely to provide the greatest and widest range of possible habitat benefits to multiple native Klamath Basin fish species. Shorter-term priorities by sub-basin are further filtered and identified in the most recent **IFRMP Restoration Action Agenda (RAA)**. The most direct route for integrating these priorities is for calls and solicitations issued by funding agencies that target functional watershed habitat restoration for the benefit of fish populations to consider asking for project proposals to:

- **Identify corresponding restoration and monitoring priorities within the IFRMP and/or RAA** that their restoration proposal responds to.
- **Include key information related to IFRMP prioritization criteria** in their detailed proposals (e.g., action types, stressors addressed, species benefiting, expected scale of benefits, Implementability) that would help update existing projects and add new projects to the IFRMP Restoration Prioritization Tool for future rounds of participatory prioritization.
- **Explain how the project may help to close monitoring gaps and/or reduce key restoration uncertainties** in the Klamath Basin, either through fringe benefits of project effectiveness monitoring (e.g., evaluating effectiveness of novel restoration techniques) or through expanding or establishing dedicated monitoring programs (e.g., adding stream gages or establishing eDNA sampling sites).
- **Explain how project effectiveness monitoring will take place**, ideally including monitoring of some of the core performance indicators identified in the IFRMP, to maximize learning and adaptive management of future restoration efforts.

Including this additional information on proposals will help to identify proposed projects align with IFRMP priorities, as identified by Klamath Basin restoration practitioners and experts, and are thus more likely to provide strategic benefits aimed at meeting multiple restoration objectives.

However, while important, alignment with IFRMP and RAA priorities is not the only criterion for restoration project proposals. Funding decisions made by an impartial proposal evaluation committee familiar with IFRMP and RAA priorities will also need to consider other factors including partner support, the current context of the Klamath Basin and linkages to other emerging plans and initiatives.

Reduce Administrative Barriers for Submitting Proposals

Administrative burden or complexity when submitting proposals often poses a barrier to participation which could lead to fewer overall project proposals and slower progress towards restoration objectives. Measures for reducing these barriers include:

- **Using a pre-proposal stage** where applicants provide a shorter **concept proposal** that is reviewed to ensure it is aligned with the priorities of the solicitation process before being invited to submit a full proposal. This step makes review more efficient and allows funders and applicants to work together make helpful adjustments to ensure that full proposals are in alignment with IFRMP and RAA priorities during the full-proposal stage.
- **Providing administrative support for proposal applicants** where regional representatives can advise applicants on funding opportunities and how to navigate various federal, state, or other funding programs. This ‘Help Desk’ model has been successfully applied in other watershed restoration programs, for example, through the Sacramento-San Joaquin Bay Delta Stewardship Council’s Adaptive Management Liaisons, or Oregon Watershed Enhancement Board (OWEB) grant application assistance representatives.

Maintain and Extend the IFRMP Restoration Prioritization Tool

I.2 - USFWS should consider supporting long-term maintenance of IFRMP Restoration Prioritization Tool and consider extending the Tool to include a project and data tracking atlas
The Klamath IFRMP Restoration Prioritization Tool (IRPT) (http://klamath.essa.com/) is a critical hub for storing core IFRMP data about restoration project concepts and prioritization criteria to support future rounds of prioritization for periodically updating IFRMP RAA priorities. Many IFRMP planning participants identified a restoration tracking atlas as a high-priority extension to the tool to help document and visualize restoration projects that are completed or in progress.

The Klamath IFRMP Restoration Prioritization Tool (IRPT) is one of the most important dynamic products emerging from the IFRMP and should be maintained to provide ongoing services for periodic updates to the IFRMP and RAA. The IRPT is a living web application (http://klamath.essa.com/) and database that provides a critical central hub for storing core IFRMP data about restoration project concepts and prioritization criteria to support future rounds of prioritization for periodically updating IFRMP RAA priorities.

Many participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon identified a **restoration tracking atlas** as a high priority IFRMP implementation need. A restoration tracking atlas in the simplest sense is publicly accessible tools to make it easy to identify what restoration work has already been done and what work is in progress to help identify gaps and reduce unwarranted duplication of efforts. As new funding vehicles increase the number of restoration projects that are implemented, there will be a variety of practical needs to query project types, costs, locations, funding entities, annual reports, and other related details, in addition to tracking cumulative restoration effort over time and space. The most cost-effective solution for implementing this tracking atlas is extension of the existing IRPT's map explorer to include restoration project tracking functions. Alternatively (or in addition) restoration tracking information could also be housed in another agency or not for profit (e.g., KBMP) information system or potentially on the related **Klamath IFRMP Website** (see recommendation I.3 below).

As the initiator of this planning process, it would make the most sense for USFWS to consider taking the lead on maintaining the IRPT tool and any potential extensions to it.

Sustain the Klamath IFRMP Website

I.3 – USFWS should consider sponsoring the IFRMP website to consolidate key resources and communications
We recommend that the Klamath IFRMP Website (https://ifrmp.net/) continue to be available and maintained at the conclusion of Plan development (2023+). Beyond hosting the Klamath IFRMP Plan Document and supporting reference materials, the website supports public access to the Restoration Prioritization Tool, IFRMP document library, and future announcements all of which are living products that need to be periodically updated.

We recommend that the Klamath IFRMP website (https://ifrmp.net/) continue to be available and maintained at the conclusion of Plan development (2023+). The Klamath IFRMP Restoration Prioritization Tool and IFRMP document library are living products and tools intended to be periodically updated and made available through a web portal. Indeed, several participants at the 2022 IFRMP RAA planning workshop in Ashland, Oregon identified a Klamath IFRMP communications website (public portal) as a high priority IFRMP implementation need.

Going forward, this is a straightforward recommendation for consolidating IFRMP products, myriad of funding announcements, scientific news, and announcements (e.g., registration dates for future IFRMP Science symposia). In addition to or instead of the IRPT, restoration tracking atlas could be housed in this Klamath IFRMP website. In practice this would logically involve establishing a scope, protocol, reviewing options, and costs for extensions and ongoing support and hosting of the website.

As the initiator of this planning process, it would make the most sense for USFWS to consider taking the lead on directing an appropriate entity to maintain the IFRMP website.

6.2 II – Support Ongoing Collaborative Learning Frameworks

The IFRMP is the product of substantial stakeholder input and collaboration (Appendix A). Numerous participants noted that the IFRMP's structured collaborative efforts provided participants working across State, Federal, Tribal, NGO and other entities with a valuable and inclusive forum for shared learning and that **formal basin-wide collaboration should continue after the release of the IFRMP Plan Document**. This would help to continue building trust among stakeholders, increase buy-in for restoration priorities and promote more integrative and adaptive approaches to whole-basin recovery in keeping with the recommendations of NRC (2004, 2008).

Four specific **medium-term recommendations** for enabling these benefits follow below.

Strengthen Adaptive Management

II.1 - Articulate how Adaptive Management will help guide the approach to evidence-based decision-making throughout implementation of the IFRMP
We recommend explicitly articulating how Adaptive Management best practices will be applied throughout ongoing implementation and monitoring to support learning, reduce uncertainties, and improve the outcomes of future restoration efforts.

Seventeen years ago, the National Research Council's Committee on Endangered and Threatened Fish in the Klamath Basin (NRC 2004) noted numerous challenges with ecosystem management in the Klamath Basin, and identified the need for using adaptive management as an organizing framework for restoration. Developing a formal Adaptive Management plan was outside the scope of the IFRMP. However, **as the IFRMP planning process moves towards implementation, it will be important to more explicitly integrate adaptive management best practices to help reduce uncertainties and support adjustment of the plan through time.**

In the context of the IFRMP, this might include more deliberately collecting and synthesizing learning about the effectiveness of specific restoration techniques, projects, or suites of projects over time to inform more effective project designs in future years. Importantly, pursuing adaptive management in this way will rely on implementing other recommendations, including a robust science and monitoring program, data consolidation and tracking, and coordination to share knowledge and outcomes (Mount and Moyle 2022).

Although the IFRMP is not itself an Adaptive Management Plan, many adaptive management best practices were successfully employed in the planning process (Marmorek et al. 2006), including clear goals and objectives, understanding the system with conceptual models, identifying alternative actions, identifying monitoring strategies and indicators, participatory development, rigorous peer-review, and clear communication of outcomes. These and other best practices can now be carried forward and built upon over time.

Convene Regular Science Symposia

II.2 - Support regular Science Symposia to disseminate learning, measure progress, and decide on updates to future IFRMP Restoration Action Agenda priorities
As demonstrated through adaptive management programs elsewhere, it will be important during IFRMP implementation to convene regular science / adaptive management symposia to allow for greater engagement and ongoing learning with the participant community and collaboratively restoration and monitoring priorities over time.

Many participants of the 2022 IFRMP RAA planning workshop in Ashland, Oregon encouraged **planning regular Klamath Basin science symposia that include at least one day geared towards updating near-term restoration and monitoring priorities** to inform upcoming funding cycles. As demonstrated through adaptive management programs elsewhere, convening regular science and adaptive management symposia provides a forum for ongoing engagement, sharing, and learning with the participant community and ensures collaborative validation of future restoration and monitoring priorities to maintain transparency in the planning process and help build trust, buy-in, and credibility for future implementation activities.

The 2022 Ashland workshop piloted an effective methodology for collaboratively updating sub-basin RAA's in the IFRMP Restoration Prioritization Tool (IRPT) and, ultimately, the IFRMP. Given other important topics, these symposia would likely be a minimum of 3-day workshop held regularly and potentially include optional additional days for selected field tours and learning or training seminars on selected restoration and monitoring topics, tools, or techniques. In addition to IFRMP RAA updating, participants suggested these symposia could also include one or more of the following components:

- A State of the Klamath Basin update presented using a common reporting tool such as a State of the Klamath Basin Report Card that includes highly summarized information on progress towards IFRMP objectives based on the status of CPIs and the implementation of restoration and monitoring priorities;
- Review of the prior IFRMP RAA and what projects have been funded, initiated, are in progress, or have been completed, and who implemented them;

- Presentations on how Adaptive Management is being implemented to guide restoration and learning;
- Presentations on science and success stories for different types of restoration and monitoring;
- Presentations on funding opportunities, solicitation previews, and science priorities; and
- Optional field tours and training sessions to build capacity for monitoring, restoration, and participation in future funding solicitation processes.

Success of these recurring science symposia would require input from IFRMP stakeholders, purposeful design, and facilitation to make the best use of limited time. The most efficient format would likely use a mixture of facilitated participatory discussions and small-group activities broken out by regional or disciplinary expertise, rather than a presentation-only format.

Major outcomes of the science symposia could include:

1. Updated IFRMP Restoration Action Agenda (RAA) priorities to inform upcoming solicitations;
2. Updates to the IFRMP Restoration Prioritization Tool (IRPT) by updating project concepts that have been partially completed, adding new project concepts, and reviewing basin-wide restoration progress to date; and
3. Discussing and documenting progress towards IFRMP restoration and monitoring goals and priorities to support reporting to broader audiences (e.g., updates to State of the Basin Report Cards).

These outcomes and outputs would be shared more broadly on the IFRMP Website.

Create a Monitoring Coordination Group

II.3 - Create a monitoring coordination group and work towards standardizing Basin-wide data collection and assessments

Commitment to supporting monitoring objectives and needs will be critical to enhance learning that can contribute to better restoration practices and outcomes. The creation of a monitoring coordination group is recommended to coordinate efforts across the many existing and planned monitoring activities conducted by many organizations that will need to be brought together to understand both sub-basin and basin-wide progress towards restoration goals and objectives.

Federal and state agencies and Tribes should consider how to fill remaining monitoring gaps, particularly for new and emerging areas of monitoring and to coordinate with existing efforts. In addition, agencies, working with stakeholders, should consider how best to work towards standardizing Basin-wide data collection and assessment.

With additional support and funding, it will be possible to integrate existing local monitoring efforts within the basin to inform understanding of status and trends, particularly for fish populations which are already well monitored by state and federal agencies and their partners. In other cases, as described in Section 0, new monitoring will be needed. Overall, there is good understanding of where monitoring is comprehensive and where gaps remain, but further efforts are needed to coordinate monitoring and support implementation going forward.

A specific recommendation related to monitoring is to **create a Klamath Basin monitoring coordination group to better standardize basin-wide monitoring data collection and analysis procedures.** Given the wide range of existing and planned monitoring activities conducted by many organizations, an oversight body is needed to coordinate Basin-wide efforts. This basin-wide oversight group will likely be composed of voluntary participants from key agencies and organizations that work with monitoring in the Basin, but experience from other watershed programs has shown that it is most beneficial to have at least one dedicated staff to keep initiatives moving forward. This monitoring oversight group would be distinct from any restoration-focused oversight groups although participation may overlap, and would support on items such as:

- Providing recommendations on how to allocate monitoring investments
- Prioritizing monitoring objectives
- Coordinating data aggregation and reporting
- Developing strategies for the use of monitoring outcomes in adaptive decision-making

The monitoring coordination group would provide guidance on topics such as:

- **Standardizing basin-wide monitoring data collection and analysis procedures**. A common theme in participant feedback through the IFRMP process was the need for standardization of data collection, storage, and processing, and reporting. To promote Basin-wide consistency in this area, it is recommended that actions be taken to:
    - Agree upon standard Quality Assurance practices and data summaries
    - Identify common methods and protocols for CPI monitoring efforts
    - Work towards a common data repository or summary system for basin-wide monitoring data
    - Develop ways to roll-up and synthesize monitoring data for broader communication to other scientists, decision makers, and stakeholders, such as through the advancement of a periodically updated **State of the Klamath Basin Report Card**
    - Explore methods for using standardized effectiveness monitoring data and status and trends monitoring data across the entire basin to support adaptive management adjustments to future, for example, by (1) conducting systematic cross-project comparisons to learn what works best and adaptively inform the design of future restoration projects (Weber et. al 2018), and (2) assessing the broader beneficial cumulative effects of many restoration projects being implemented at the basin scale to inform strategic adaptive management that can help to further promote positive feedback between synergistic efforts and reduce or avoid poor outcomes resulting from counterproductive efforts (Diefenderfer et al. 2021).

- **Identifying and directing resources to filling remaining monitoring gaps.** In some cases, IFRMP planning participants determined that more conversations were needed to fill some remaining monitoring gaps, particularly for new and emerging areas of monitoring and to coordinate with existing efforts. Future efforts in this area could include:
    - Workshops with subject matter experts to flesh out invertebrate and eDNA monitoring
    - Further support for fish species population indicators and incorporation of on-going/existing fish population monitoring efforts
    - Horizon-scanning to track new developments in monitoring best practices and technologies that could be applied to the Klamath Basin

Provide Ongoing Impartial Facilitation

II.4 – Engage in ongoing impartial technical facilitation to help address emerging issues
Given the fundamental importance of inclusive and ongoing collaboration across Klamath Basin stakeholders, it will be essential to provide ongoing impartial technical facilitation to work through challenging issues that may emerge throughout implementation.

With so much at stake, including the effective use of hundreds of millions of restoration dollars, there is always potential for misalignments. For example, hosting science symposia and updating near-term RAA priorities requires both technical understanding of the material and knowledge of effective technical meeting design and facilitation. Another specific example, there are a few restoration projects identified in the IFRMP that are directed at regulatory agencies to uphold existing enforcement obligations related to instream water rights. These are not necessarily restoration “projects” but reflect an example of a specific topic that regulatory agencies and proponents of these actions could come together to understand more fully through facilitated discussion.

6.3 III – Establish Ongoing Coordination for IFRMP Implementation

III.1 – Establish ongoing coordination arrangements and activities to sustain ongoing learning and fish population recovery
Stakeholders in the basin should discuss the establishment of informal and formal coordination roles, agreements, and activities for IFRMP implementation to sustain ongoing adaptive management and fish population and habitat recovery.

Now that the IFRMP is in place, **a final medium to long-term recommendation is to continue coordination of efforts to ensure the ongoing strategic implementation of restoration and monitoring across the entire basin**. This might include forming informal or formal partnerships or working groups to coordinate across entities that might be engaging in similar activities in overlapping regions to help achieve basin-wide goals and objectives. For example, coordination across multiple entities engaged in monitoring activities (as noted in Section 6.2) could help to more effectively fill gaps, reduce duplication of efforts, and pool data to answer broader questions at the whole basin scale. Similarly, coordination across multiple entities engaged in restoration efforts could help to ensure that restoration addresses species stressors across multiple sub-basins and habitats that are important to different parts of their life cycle. In some cases, this coordination can occur through existing forums and processes, and in other cases, new collaborative arrangements will be needed. Coordination can also be critical in pursuing the earlier recommendation of strengthening the adaptive management approach to watershed restoration. Klamath Basin stakeholders should also consider whether coordination should rise to the level of a formal governance structure to guide decision-making during implementation of the IFRMP. A formal governance structure can help to answer questions like:

- *How are decisions made?*
- *Who has a voice in making these decisions?*

- *Who is ultimately accountable?*
- *What form of independent review and advice is required?*
- *What other resources and capacity are needed and in place to support this work?*

While many stakeholders asked about such a governance structure during IFRMP workshops, **addressing governance was beyond the scope of the IFRMP** itself. Many good examples and comparative evaluations of alternative governance structures exist to provide a starting point for the development of such a framework for the Klamath Basin (for example, see: Loftin 2014, Speed et al. 2016, ESSA 2017, Sapkota et al. 2019, Grantham et al. 2019). Smith 2020 offers a general adaptive management program evaluation framework and set of questions for clarifying governance partnership arrangements.

6.4 Conclusion

It is very rare to achieve the degree of sustained collaboration afforded by the IFRMP planning process and to emerge with a Basin-wide package of practical restoration and monitoring priorities. While no Plan is perfect, the IFRMP stands alone in its commitment to integrate and apply available restoration knowledge at the Basin-wide scale. Between 2016 and 2022 the USFWS provided stable funding (including riding out a global pandemic) while many dedicated participants gave hundreds of person hours of their time to create and vet the IFRMP. The IFRMP is a blueprint for fish habitat restoration and monitoring needs in the Klamath Basin and integrates and applies available restoration knowledge at the Basin-wide scale. By following the implementation recommendations identified above the Plan provides a package of credible workflows and tools to sustain ongoing value and relevance over the next twenty (or more) years.

Now is the time for the Basin to come together to make significant progress in restoring the Klamath Basin. This work has delivered the vision of the Klamath Basin IFRMP to provide a unifying framework for planning coordinated recovery of native fish species from the headwaters to the Pacific Ocean while improving flows, water quality, habitat, and ecosystem processes. All are to be commended for their efforts and the legacy of collaboration that was created. The act of maintaining the IFRMP and its products will inspire others to continue to trust more, do more, and learn more together.

Photo: Mouth of the Klamath River | Linda Tanner 2011, used under a CC by 2.0 Licence

7 Literature Cited and Further Reading

Please note that the majority of the documents referenced in this report can be found on the https://ifrmp.net/document-library/.

Adams, P., S. Vanderkooi, and T. Williams. 2011. Chapter 5: Freshwater and marine habitat communities In: Thorsteinson, Lyman, VanderKooi, Scott, and Duffy, Walter, eds., 2011, Proceedings of the Klamath Basin Science Conference, Medford, Oregon, February 1–5, 2010: U.S. Geological Survey Open-File Report 2011-1196.

Adamson, D., and A. Loch. 2014. Possible negative feedbacks from 'gold-plating' irrigation infrastructure. Agricultural Water Management 145: 134–44.

Akay, E.A., M.G. Wing, and J. Sessions. 2012. Estimating structural properties of riparian forests with airborne LIDAR data. International Journal of Remote Sensing 33(22): 7010-7023.

Akins, G. J. 1970. The effects of land use and land management on the wetlands of the Upper Klamath Basin. M.S. Thesis, Western Washington State College, Bellingham. 121 pp.

Alvarez, J.S. and D.M. Ward. 2019. Predation on Wild and Hatchery Salmon by Non-Native Brown Trout (Salmo trutta) in the Trinity River, California. Ecology of Freshwater Fish. Doi: 10.1111/eff.12476.

Anderson-Abbs, B.A., M. Howard, K.M. Taberski, and K.R. Worcester. 2016. California freshwater harmful algal blooms assessment and support strategy. Prepared for the California State Water Resources Control Board. Sacramento, CA.

AquaTerra Consulting. 2011. Shasta River Tailwater Reduction Plan. Report prepared for Shasta Valley Resource Conservation District. 33 pp. Retrieved from: https://svrcd.org/wordpress/shasta-river-tmdl/tailwater/

AquaTerra Consulting. 2013. Shasta River Tailwater Reduction: Demonstration and Implementation Project Final Project Report. Proposition 40/50- Agricultural Water Quality Grant, State Water Resources Control Board. 97 pp. Retrieved from: https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/shasta_river/120521/Tailwater_Final_Report_03_2012.pdf

Armstrong, N. E. and G. H. Ward. 2008. Task 3: Coherence of Nutrient Loads and AFWO Klamath River Grab Sample Water Quality Database, TX. . Technical report prepared for the U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office by Armstrong, Consulting Engineer and Ward University of Texas at Austin, TX. 86 pg.

Asarian, E. and J. Kann. 2013. Synthesis of Continuous Water Quality Data for the Lower and Middle Klamath River, 2001-2011. Prepared by Kier Associates and Aquatic Ecosystem Sciences for the Klamath Basin Tribal Water Quality Work Group. 50p. + appendices.

Asarian, E. J. Kann, and W. Walker, 2009. Multi-year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California. Prepared by Riverbend Sciences, Kier Associates, Aquatic Ecosystem Sciences, and William Walker for the Karuk Tribe Department of Natural Resources, Orleans, CA. 55pp + appendices.

Asarian, J. E., & Robinson, C. 2021. Modeling Seasonal Effects of River Flow on Water Temperatures in an Agriculturally Dominated California River (world) [Preprint]. Earth and Space Science Open Archive; Earth and Space Science Open Archive. https://essopenarchive.org/doi/full/10.1002/essoar.10506606.1

Asarian, J.E. 2016. Stream Temperatures in the South Fork Trinity River Watershed 1989-2015. Prepared by Riverbend Sciences for The Watershed Research and Training Center, Hayfork, CA. 61p. + appendices.

Asarian, J.E., L. Cressey, B. Bennett, J. Grunbaum, L. Cyr, T. Soto, and N. Som. 2019. Salmon River Warming: Climate Change Threatens an Iconic California River. Prepared for the Salmon River Restoration Council by Riverbend Sciences with assistance from the Salmon River Restoration Council, Klamath National Forest, Six Rivers National Forest, and Karuk Tribe Department of Natural Resources. 51 p. + appendices.

Atha, J.B. and Dietrich, J.T., 2016. Detecting fluvial wood in forested watersheds using LiDAR data: a methodological assessment. River Research and Applications, 32(7), pp.1587-1596.

Atha, J.B., 2014. Identification of fluvial wood using Google Earth. River research and applications, 30(7), pp.857-864.

Austin, D., M. Deas, and K. Carlson. 2016. Technical Memorandum: Interim Measure 11, Activity 4 – Conceptual Feasibility Study of Oxygenation Systems at Keno Reservoir, July 18, 2016. Prepared by CH2M and Watercourse Engineering for PacifiCorp, Portland, Oregon. Available from: https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/hydro/klamath-river/khsa-implementation/technical-documents/2016-IM11-Act4-RptF(7-18-16).pdf

Banet, N.V. and Hewitt, D.A., 2019. Monitoring of endangered Klamath Basin suckers translocated from Lake Ewauna to Upper Klamath Lake, Oregon, 2014− 2017 (No. 2019-1085). US Geological Survey.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C. https://www3.epa.gov/region1/npdes/merrimackstation/pdfs/ar/AR-1164.pdf

Barr, B.R., Koopman, M.E., Williams, C.D., Vynne, S., Hamilton, R., Doppelt, B. 2010. Preparing for climate change in the Klamath Basin. 48 pp. National Center for Conservation Science and Policy and the Climate Leadership Initiative. Available from: http://static1.1.sqspcdn.com/static/f/551504/7089933/1296603849477/KlamCFFRep_5-26-10finalLR.pdf?token=hLlatk61cM3TMlIH6Sser0L1Mss%3D

Barry, M., Mattenberger, S., Dunsmoor, L., Peterson, S., and Watson, D., 2010. Projected restoration actions and associated costs under the Klamath Basin Restoration Agreement for the Upper Klamath River Basin above Keno, Oregon. Published July 30, 2010. Retrieved from: https://ifrmp.net/document-library/.

Bartholomew, J., S. Hallett, Holt, R. J. Alexander, S. Atkinson, G. Buckles, R. Craig, A. Javaheri, and M. Babar-Sebens. 2016. Klamath River Fish Health: Disease monitoring and study. Annual Report (FY2015 April 09, 2015 – March 31, 2016.

Barton, J.S., 2006. Passive acoustic monitoring of course bedload in mountain streams. The Pennsylvania State University.

Batchelor C, Reddy VR, Linstead C, Dhar M, Roy S, and R. May. 2014. Do water-saving technologies improve environmental flows? Journal of Hydrology 518: 140–149.

Battin, J., Wiley, M. W., Ruckelshaus, M. H., Palmer, R. N., Korb, E., Bartz, K. K., and Imaki, H. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Sciences, 104(16), 6720–6725. https://doi.org/10.1073/pnas.0701685104

BC Ministry of Environment. 2017. Environmental DNA protocol for freshwater aquatic ecosystems, Version 2.2. Prepared by Hemmera Envirochem Inc. Burnaby, BC.

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: 939-960.

Beechie, T.J., Liermann, M., Pollock, M.M., Baker, S. and Davies, J., 2006. Channel pattern and river-floodplain dynamics in forested mountain river systems. Geomorphology, 78(1-2), pp.124-141.

Beechie, T.J., Nicol, C., Fogel, C.B. and Jorgensen, J., 2019, December. Habitat Restoration May Increase Salmon Resilience to Increasing Extremes in Peak Flow and Stream Temperature. In AGU Fall Meeting Abstracts (Vol. 2019, pp. EP41C-2330).

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

Beechie, T.J., Stefankiv, O., Timpane-Padgham, B.L., Hall, J., Pess, G.R., Rowse, M.L., Liermann, M.C., Fresh, K.L. and Ford, M.D., 2017. Monitoring salmon habitat status and trends in Puget Sound: development of sample designs, monitoring metrics, and sampling protocols for large river, floodplain, delta, and nearshore environments.

Beesley, S. and Fiori, R. 2004. Habitat Assessment and Restoration Planning in the Salt Creek Watershed, Lower Klamath River Sub-Basin, California. 173 pp. Available at: http://www.yuroktribe.org/departments/fisheries/documents/2004RestorationPlanningSaltCreekFINAL_000.pdf.

Beesley, S. and Fiori, R. 2008.Cooperative Restoration of Tribal Trust Fish and Wildlife Habitat in Lower Klamath River Tributaries. Yurok Tribal Fisheries Program, Habitat Assessment and Biological Monitoring Division. Klamath, CA.

Beesley, S. and Fiori, R. 2013. Stream and Floodplain Enhancement of East Fork Hunter Creek, Lower Klamath River: Phase I. Yurok Tribal Fisheries Program, Klamath, California.

Beesley, S. and Fiori, R. 2013b. Stream and Floodplain Enhancement of Hunter Creek, Lower Klamath River: 2010-2013. Yurok Tribal Fisheries Program, Klamath, California.

Beesley, S. and Fiori, R. 2013c. Stream & Floodplain Enhancement of Lower Terwer Creek: 2012. Yurok Tribal Fisheries Program, Klamath, California.

Beesley, S. and Fiori, R. 2016. Enhancement of Salmonid Rearing Habitat in McGarvey Creek - Lower Klamath River. Yurok Tribal Fisheries Program, Klamath, California. http://www.yuroktribe.org/departments/fisheries/documents/McGarvey_USFWS_FinalReport_2016.pdf

Beesley, S. and Fiori, R. 2018. Restoration of Lower Klamath River Fisheries & Riparian Habitats: Hunter Creek & Terwer Creek. Yurok Tribal Fisheries Program, Klamath, California.

Beesley, S. and R. Fiori. 2020. Restoration Feasibility and Planning in Blue Creek, Lower Klamath River (CA). Yurok Tribal Fisheries Department, Klamath CA. Beesley, S. and R. Fiori. 2009. Instream Habitat Enhancement of Tectah Creek, Lower Klamath River: Year 1. Yurok Tribal Fisheries Department, Klamath CA. Beesley, S. and R. Fiori. 2021. Lower Blue Creek Restoration Planning & Basis of Design Report: Fall 2021. Yurok Tribal Fisheries Department, Klamath CA.

Beesley, S., 2017. Lower Klamath Sub-Basin Coordination & Planning - FY 2015 Final Annual Progress Report: 10/01/16 – 09/30/17. Yurok Tribal Fisheries Program, Klamath, CA. http://www.yuroktribe.org/departments/fisheries/documents/LKlamathCoordinationFinalReport_2017.pdf.

Belchik, Michael. 1997. Summer Locations and Salmonid Use of Cool Water Areas in the Klamath River: Iron Gate Dam to Seiad Creek, 1996. Prepared by Yurok Tribal Fisheries Program. Funded by National Biological Service Cooperative Agreement.

Bellido-Leiva, F. J., Lusardi, R. A., & Lund, J. R. (2022). Quantification of Off-Channel Inundated Habitat for Pacific Chinook Salmon (Oncorhynchus tshawytscha) along the Sacramento River, California, Using Remote Sensing Imagery. Remote Sensing, 14(6), 1443. https://doi.org/10.3390/rs14061443

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

Bellmore, J.R., Pess, G.R., Duda, J.J., O'connor, J.E., East, A.E., Foley, M.M., Wilcox, A.C., Major, J.J., Shafroth, P.B., Morley, S.A. and Magirl, C.S., 2019. Conceptualizing ecological responses to dam removal: If you remove it, what's to come?. BioScience, 69(1), pp.26-39.

Berg, L. and T.G. Northcote. 1985. Changes in territorial, gill flaring, and feeding behaviour in juvenile coho salmon (Oncorhynchus kisutch) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42: 1410-1417.

Bienz, C. 2017. Floodplain Connectivity: Connecting Water and Land, Connecting People. JAWRA Journal of the American Water Resources Association 19(2):2.

Biostream Environmental. 2012. Effects of Dwinnell Dam on Shasta River Salmon and Considerations for Priotitizing Recovery Actions.Retrieved from: http://www.karuk.us/images/docs/dnr/Effects%20of%20Dwinnell%20Dam_FINAL%20Lestelle.pdf

Bishop, C. D., Curtis, K. R., and M.K. Kim. 2010. Conserving water in arid regions: Exploring the economic feasibility of alternative crops. Agricultural Systems, 103(8): 535– 542.

Bouwes, N., Bennett, S. and Wheaton, J., 2016. Adapting adaptive management for testing the effectiveness of stream restoration: an intensively monitored watershed example. Fisheries, 41(2), pp.84-91.

Brandtberg, T. 2007. Classifying individual tree species under leaf-off and leaf-on conditions using airborne lidar. ISPRS J. Photogramm. Remote Sens. 61: 325–340.

Buffington, J., C. Jordan, M. Merigliano, J. Peterson, and C. Stalnaker. 2014. Review of the Trinity River Restoration Program following Phase 1, with emphasis on the Program's channel rehabilitation strategy. Prepared by the Trinity River Restoration Program's Science Advisory Board for the Trinity River Restoration Program with assistance from Anchor QEA, LLC, Stillwater Sciences, BioAnalysts, Inc., and Hinrichsen Environmental Services.

Buktenica, M.W., Hering, D.K., Scott, N., Lambert, C., McKee, J., Maletis, E., Pellissier, J., Tinniswood, W. and Banish, N., 2018. A Long-Term Watershed-Scale Partnership to Restore Bull Trout Across Federal, State, Private, and Historic Tribal Land Near Crater Lake National Park, Oregon. Fisheries, 43(4), pp.183-193.

Bunn, S.E. and Arthington, A.H., 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management, 30(4), pp.492-507.

Burdick, S.M. 2012. Distribution and condition of larval and juvenile Lost River and shortnose suckers in the Williamson River Delta restoration project and Upper Klamath Lake, Oregon: 2010 annual data summary: USGS Open-File Report 2012-1027, 38p.

Burdick, S.M., C.O. Ostberg, M.E. Hereford, and M.S. Hoy. 2016, Juvenile sucker Cohort tracking data summary and assessment of monitoring program, 2015: U.S. Geological Survey Open-File Report 2016–1164, 38 pp.

Burdick, S.M., D.G. Elliott, C.O. Ostberg, C.M. Conway, A. Dolan-Caret, M.S. Hoy, K.P. Feltz, and K.R. Echols. 2015. Health and condition of endangered juvenile Lost River and shortnose suckers relative to water quality and fish assemblages in Upper Klamath Lake, Oregon, and Clear Lake Reservoir, California.U.S. Department of the Interior and U.S. Geological Survey. Open-File Report 2015-1217.

CalFish. California Fish Passage Assessment Database: state-wide inventory of known and potential barriers to fish passage. http://www.calfish.org.

California Department of Fish and Wildlife (CDFW) 2014, NOAA-Fisheries, Scott River Water Trust, Siskiyou Resource Conservation District, and U.S. Forest Service – Klamath National Forest. 2015. Cooperative Report of the Scott River Coho Salmon Rescue and Relocation Effort: 2014 Drought Emergency. 60 pp. Available from: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3850544.pdf

California Department of Fish and Wildlife (CDFW). 2004. Recovery Strategy for California Coho salmon. 598 pp. Available from: https://www.wildlife.ca.gov/Conservation/Fishes/Coho-Salmon

California Department of Fish and Wildlife (CDFW). 2016. Best Management Practices for the Sustainable Management of Groundwater: Monitoring Protocols, Standards, and Sites. 27 pp. Available from: https://water.ca.gov/-/media/DWR-

Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-1-Monitoring-Protocols-Standards-and-Sites_ay_19.pdf.

California Department of Fish and Wildlife (CDFW). 2022. Draft Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife. 72pp.

California Natural Resources Agency and the California Department of Fish and Wildlife (CNRA and CDFW). 2021 (Draft). Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife. 56 p.

CalTrout 2017. State of the Salmonids II: Fish in Hot Water (Status, threats and solutions for California salmon, steelhead, and trout. Prepared by Dr. Peter B. Moyle, Patrick J. Samuel, and Dr. Robert A. Lusardi. Retrieved from http://caltrout.org/sos/download-sos-ii/ p. 95.

CalTrout 2017. State of the Salmonids II: Fish in Hot Water (Status, threats and solutions for California salmon, steelhead, and trout. Prepared by Dr. Peter B. Moyle, Patrick J. Samuel, and Dr. Robert A. Lusardi. Retrieved from http://caltrout.org/sos/download-sos-ii/ p. 95.

Camaclang, A.E. (2015). Identifying critical habitat forthreatened species: concepts and challenges. PhD dissertation. p. xvii+188 pp. School of Biological Sciences, University of Queensland Brisbane, Brisbane, QLD,Australia.

Cannon, T. 2011. Removal of Dwinnell Dam and Alternatives Draft Concepts Report. Report prepared for the Karuk Tribe. 42 pp. Retrieved from: http://www.karuk.us/images/docs/press/2012/SHASTA_BYPASS_REPORT_Cannon.pdf

Carbonneau, P.E., Bergeron, N. and Lane, S.N., 2005. Automated grain size measurements from airborne remote sensing for long profile measurements of fluvial grain sizes. Water Resources Research, 41(11).

Carbonneau, P.E., Lane, S.N. and Bergeron, N.E., 2004. Catchment-scale mapping of surface grain size in gravel bed rivers using airborne digital imagery. Water resources research, 40(7).

Carpenter, K.D., D.T. Synder, J.H. Duff, F.J. Triska, K.K. Lee, R.J. Avanzino, and S. Sobieszcyk. 2009. Hydrologic and water-quality conditions during restoration of the Wood River Wetland, upper Klamath River basin, Oregon, 2003-5: U.S. Geological Survey Scientific Investigations Report 2009-5004, 66 p.

Castro, J.M. and Thorne, C.R. 2019. The Stream Evolution Triangle: Integrating Geology, Hydrology, and Biology. March 26, 2019. Available online at: https://onlinelibrary.wiley.com/doi/full/10.1002/rra.3421.

Chaffin, B.C., Craig, R.K. and Gosnell, H. 2015. Resilience, Adaptation, and Transformation in the Klamath River Basin Socio-Ecological System (February 1, 2015). 51 Idaho Law Review 157-193 (2014) (appeared in print 2015) (peer reviewed). Available at SSRN: https://ssrn.com/abstract=2449381

Chakravorty, U., and C. Umetsu. 2003. Basinwide water management: A spatial model. Journal of Environmental Economics and Management 45 (1): 1–23.

Chapman, D.W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society 117: 1-21.

Charnley, S. 2018. Beavers, landowners, and watershed restoration: experimenting with beaver dam analogues in the Scott River basin, California. Res. Pap. PNW-RP-613. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 38 p.

Chesney et al. 2009 -Chesney, W. R., C.C. Adams, W. B. Crombie, H. D. Langendorf, S.A. Stenhouse and K. M. Kirkby. 2009. Shasta River Juvenile Coho Habitat & Migration Study. Report prepared for U. S. Bureau of Reclamation, Klamath Area Office. Funded by U.S. Bureau of Reclamation, National Oceanic and Atmospheric Administration and California Department of Fish and Wildlife. California Department of Fish and Wildlife, Yreka, California.

Church, M., 2006. Bed material transport and the morphology of alluvial river channels. Annu. Rev. Earth Planet. Sci., 34, pp.325-354.

Connelly, and L., Lyons, L., 2007. Upper Sprague Watershed Assessment. Report prepared for the Klamath Basin Ecosystem Foundation. Retrieved from: http://www.klamathpartnership.org/watershed_assessments_upper_sprague.html

Corneil, D., Villeneuve, B., Piffady, J., Chandesris, A., Usseglio-Polatera, P. and Souchon, Y., 2018. Introducing nested spatial scales in multi-stress models: towards better assessment of human impacts on river ecosystems. Hydrobiologia, 806(1), pp.347-361.

Cramer Fish Sciences, Philip Williams & Associates, Ltd., and the Siskiyou Resource Conservation District (SQRCD). 2010. Scott River Spawning Gravel Evaluation and Enhancement Plan. Report prepared for the Pacific States Marine Fisheries Commission and California Department of Fish and Game. 116 pp.

Cressey, Lyra and Karuna Greenburg. 2008. Salmon River Riparian Assessment: 2006-2008. Prepared for the Salmon River Restoration Council in cooperation with the Klamath National Forest.

Curtis, J., 2015. Estimating changes in riparian and channel features along the Trinity River downstream of Lewiston Dam, California, 1980 to 2011. In SEDHYD 2015.

Curtis, J., Poitras, T., Bond, S. and Byrd, K., 2021. Sediment mobility and river corridor assessment for a 140-kilometer segment of the main-stem Klamath River below Iron Gate Dam, California (No. 2020-1141). US Geological Survey.

Dahlke H, Brown A, Orloff S, Putnam D, O'Geen T. 2018. Managed winter flooding of alfalfa recharges groundwater with minimal crop damage. Calif Agr 72(1):65-75.https://doi.org/10.3733/ca.2018a0001

Davis, M.J., Ellings, C.S., Woo, I., Hodgson, S., Larsen, K. and Nakai, G., 2018. Gauging resource exploitation by juvenile Chinook salmon (Oncorhynchus tshawytscha) in restoring estuarine habitat. Restoration Ecology, 26(5), pp.976-986. https://onlinelibrary.wiley.com/doi/abs/10.1111/rec.12643

DeBano, L. F., and Neary, D. G. 1996. Effects of fire on riparian systems. In: Ffolliott, Peter F.; DeBano, Leonard F.; Baker, Malchus B.; Gottfried, Gerald J.; Solis-Garza, Gilberta; Edminster, Carleton B.; Neary, Daniel G.; Allen, Larry S.; Hamre, RH, Tech Coordinators. 1996. Effects of Fire on Madrean Province Ecosystems: A Symposium Proceedings; March 11-15, 1996; Tucson, AZ. Gen. Tech. Rep. RM-GTR-289. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. P. 69-84., 289, 69–84.

Del Tánago, M.G., Gurnell, A.M., Belletti, B. and De Jalón, D.G., 2016. Indicators of river system hydromorphological character and dynamics: understanding current conditions and guiding sustainable river management. Aquatic sciences, 78(1), pp.35-55.

DFO (Fisheries and Oceans Canada). 2020. Advice on the use of targeted environmental DNA (eDNA) analysis for the management of aquatic invasive species and species at risk. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/058.

Dickerson-Lange, S.E., Gersonde, R.F., Hubbart, J.A., Link, T.E., Nolin, A.W., Perry, G.H., Roth, T.R., Wayand, N.E. and Lundquist, J.D., 2017. Snow disappearance timing is dominated by forest effects on snow accumulation in warm winter climates of the Pacific Northwest, United States. Hydrological processes, 31(10), pp.1846-1862.

Diederich, A., J. Swait, and N. Wirsik. 2012. Citizen participation in patient prioritization policy decisions: an empirical and experimental study on patients' characteristics. PLoS One, 7(5), p.e36824

Diefenderfer, H.L., Steyer, G.D., Harwell, M.C., LoSchiavo, A.J., Neckles, H.A., Burdick, D.M., Johnson, G.E., Buenau, K.E., Trujillo, E., Callaway, J.C. and Thom, R.M., 2021. Applying cumulative effects to strategically advance large-scale ecosystem restoration. Frontiers in Ecology and the Environment, 19(2), pp.108-117.

Dittbrenner, B.J., Schilling, J.W., Torgersen, C.E. and Lawler, J.J., 2022. Relocated beaver can increase water storage and decrease stream temperature in headwater streams. Ecosphere, 13(7), p.e4168.

Donnelly, J. Patrick, et al. 2020. Climate and human water use diminish wetland networks supporting continental waterbird migration. Global Change Biology 26: 2042-2059.

Donnelly, J. Patrick, Moore J.N., Casazza M.L., S.P. Coons. 2022 Functional wetland loss drives emerging risks to waterbird migration networks. Frontiers in Ecology and Evolution 10:

Doyle, M.W., Stanley, E.H., Orr, C.H., Selle, A.R., Sethi, S.A. and Harbor, J.M., 2005. Stream ecosystem response to small dam removal: lessons from the Heartland. Geomorphology, 71(1-2), pp.227-244. https://www.sciencedirect.com/science/article/abs/pii/S0169555X05001078

Doyle, M.W., Stanley, E.H., Orr, C.H., Selle, A.R., Sethi, S.A. and Harbor, J.M., 2005. Stream ecosystem response to small dam removal: lessons from the Heartland. Geomorphology, 71(1-2), pp.227-244.

Dugdale, S.J., Carbonneau, P.E. and Campbell, D., 2010. Aerial photosieving of exposed gravel bars for the rapid calibration of airborne grain size maps. Earth Surface Processes and Landforms: The Journal of the British Geomorphological Research Group, 35(6), pp.627-639.

Dugdale, Stephen J., Normand E.Bergeronab André St-Hilairea. 2013. Temporal variability of thermal refuges and water temperature patterns in an Atlantic salmon river. Remote Sensing of Environment Volume 136, September 2013, Pages 358-373

Duit, A., & Galaz, V. (2008). Governance and complexity-emerging issues for governance theory. Governance, 21(3), 311. doi:10.1111/j.1468-0491.2008.00402.x

Elder, D., B. Olson, A. Olson, J. Villeponteaux, and P. Brucker. 2002. Salmon River sub-basin restoration strategy: Steps to recovery and conservation of aquatic resources. Report prepared for the Klamath River Basin Fisheries Restoration Task Force and U.S. Fish and Wildlife Service, Yreka, California. 53 p. Retrieved from: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5110056.pdf

Ernst, A.G., Baldigo, B.P., Calef, F.J., Freehafer, D.A., and Kremens, R.L., 2015, Identifying trout refuges in the Indian and Hudson Rivers in northern New York through airborne thermal infrared remote sensing: U.S. Geological Survey Open-File Report 2015–1078, 17 p., http://dx.doi.org/10.3133/ofr20151078.

ESSA. 2017. Klamath Basin Integrated Fisheries Restoration and Monitoring (IFRM) Synthesis Report. 416 pp + Appendices.

Evans and Associates, Inc. 2005. Upper Williamson River Watershed Assessment. Report prepared for the Klamath Basin Ecosystem Foundation and Upper Williamson River Catchment Group with collaboration from the Upper Klamath Basin Working Group Klamath Watershed Council. 261 pp. Retrieved from: http://www.klamathpartnership.org/watershed_assessments_upper_williamson.html

Evans, N. T., Y. Li, M.A. Renshaw, B.P. Olds, K. Deiner, C.R. Turner, ... and M.E. Pfrender. 2017. Fish community assessment with eDNA metabarcoding: effects of sampling design and bioinformatic filtering. Canadian Journal of Fisheries and Aquatic Sciences, 74(9), 1362-1374.

Evergreen Funding Consultants. 2003. A Primer on Habitat Project Costs. Prepared for the Puget Sound Shared Strategy. Available at: https://www.psp.wa.gov/shared-salmon-strategy/files/PrimeronHabitatProjectCosts_wLetter.pdf . 52 pp.

Fausch, Kurt D., Christian E. Torgersen, Colden V. Baxter, And Hiram W. Li (1999) Landscapes to Riverscapes: Bridging the Gap between Research and Conservation of Stream Fishes. BioScience. Vol. 52 No. 6.

Fennessy, S.M. and Lei, G., 2018. Wetland restoration for climate change resilience. Ramsar Briefing Note, 10. 11 pp. Available from: https://www.ramsar.org/sites/default/files/documents/library/bn10_restoration_climate_change_e.pdf

Fesenmeyer, K. Henrery, R., and Williams, J. 2013. California Freshwater Conservation Success Index: An Assessment of Freshwater Resources in California, with focus on lands managed by the US Bureau of Land Management Version 1.0, December 2013. Trout Unlimited Science program. 45 pp. (Note: Spatial extent of indices encompass entire Klamath Basin in CA and OR; 5-point indicator scale lumped to fit into 3 categories).

Finley, W. L. 1905. State report for Oregon. Pp. 336-342 in Dutcher, W., ed., Annual report of the National Association of Audubon Societies for 1905. Bird-Lore 7:295-344.

Fischenich, J.C., 2006. Functional Objectives for Stream Restoration, EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-52), US Army Engineer Research and Development Center, Vicksburg, Mississippi. http://el.erdc.usace.army.mil/elpubs/pdf/sr52.pdf.

Five Counties Salmonid Conservation Program (Five Counties). 2008. Scott and Salmon River Watersheds Road Erosion Inventory and Assessment Conducted on Siskiyou County roads - Final Report. 56 pp + Appendices. Available from: http://www.5counties.org/dirt.htm

Flosi, G., J. Hopelain, M. Bird, R. Coey, and B. Collins. 2010. California salmonid stream habitat restoration manual, 4th Ed. State of California. The Resources Agency. California Department of Fish and Game. Wildlife and Fisheries Division.

Foglia, L., Neumann, J., Tolley, D., Orloff, S., Snyder, R. and Harter, T., 2018. Modeling guides groundwater management in a basin with river–aquifer interactions. California Agriculture, 72(1), pp.84-95. Available from: http://calag.ucanr.edu/archive/?article=ca.2018a0011

Foott, J. S. 2004. Health monitoring of adult Lost River sucker (Deltistes luxatus) and shortnose sucker (Chasmistes brevirostris) in Upper Klamath Lake, Oregon, April - September 2003. Joint FWS and USGS project. California - Nevada Fish Health Center, U.S. Fish and Wildlife Service, U.S. Department of Interior, Anderson, California.

Foott, J.S. 2003. Health Monitoring of adult Fall-run Chinook Salmon in the lower Klamath River, August – October 2003. U.S. Fish and Wildlife Service. California – Nevada Fish Health Center, Anderson, California.

Foott, J.S. 2018. Comparison of bacterial and parasitic infection between upper Klamath lake and out-migrant (Fish Evaluation Station, FES) 0+ suckers and chubs. National Wild Fish Survey Project 2017, CA-NV Fish Health Center.

Foott, J.S. R. Stone, and A. Wilkens. 2013. Juvenile Lost River Sucker sentinel survival in Upper Klamath Lake mesocosm cages: July 2012 - March 2013. U.S. Fish and Wildlife Service.CA-NV Fish Health Center. Anderson, CA.

Forsgren Associates Inc. 2006. Klamath-Shasta Water Substitution Preliminary Engineering Study (DRAFT). Report prepared for Shasta Valley River Conservation District, Siskiyou County, CA. Project No. 040186. 24 pp.

Fuller, M.R., Ebersole, J.L., Detenbeck, N.E., Labiosa, R., Leinenbach, P. and Torgersen, C.E., 2021. Integrating thermal infrared stream temperature imagery and spatial stream network models to understand natural spatial thermal variability in streams. Journal of Thermal Biology, 100, p.103028.

Gaeuman, D. and Boyce, J., 2018, August. Effects of gravel supply on gravel bar morphology and physical habitat in a reach of the Trinity River, California, USA. In 12th International Symposium on Ecohydraulics.

Gale, D.B. and D.B. Randolph. 2000. Lower Klamath River Sub-basin Watershed Restoration Plan. Yurok Tribal Fisheries Program, Klamath, California.

Gale, D.B. and D.B. Randolph. 2000. Lower Klamath River Sub-basin Watershed Restoration Plan. Yurok Tribal Fisheries Program, Klamath, California. Beesley, S. and Fiori, R. 2012. Lower Terwer Creek Off-Channel Wetland Enhancement. Yurok Tribal Fisheries Program, Klamath, California.

Gale, D.B. and D.B. Randolph. 2000. Lower Klamath River Sub-basin Watershed Restoration Plan. Yurok Tribal Fisheries Program, Klamath, California.

Gannett, M.W., Lite, K.E. Jr., La Marche, J.L., Fisher, B.J., and Polette, D.J., 2010, Ground-water hydrology of the upper Klamath Basin, Oregon and California: U.S. Geological Survey Scientific Investigations Report 2007-5050, 84 p.

Genzoli, L. and J. Kann. 2016. Evaluation of phycocyanin probes as a monitoring tool for toxigenic cyanobacteria in the Klamath River below Iron Gate Dam. Prepared by Aquatic Ecosystem Sciences LLC for the Klamath Tribal Water Quality Consortium. 38 p. + appendices.

Genzoli, L., and Hall, R.O., 2016, Shifts in Klamath River metabolism following a reservoir cyanobacterial bloom. Freshwater Science, v. 35, p. 795–809. https://doi.org/10.1086/687752

Genzoli, L., Bandrowski, D.J., Fricke, S., McCovey, B., Hillemeier, D., Belchik, M., and Soto, T., Eds. 2021. Klamath Dam Removal Science Coordination Workshop Summary Report. Workshop Proceedings, Medford, Oregon, February 12-13, 2020. Yurok Tribe Fisheries Department. 65 p.

Genzoli, L., R.O. Hall, J.E. Asarian, and J. Kann. 2015. Variation and Environmental Association of Ecosystem Metabolism in the Lower Klamath River: 2007-2014. Prepared by the University of Wyoming, Riverbend Sciences, and Aquatic Ecosystem Sciences LLC. for the Klamath Tribal Water Quality Consortium. 44p. + appendices.

Gilvear, D.J., Spray, C.J. and Casas-Mulet, R., 2013. River rehabilitation for the delivery of multiple ecosystem services at the river network scale. Journal of environmental management, 126, pp.30-43.

Goodman, D.H, Harvey, M., Hughes, R., Kimmerer, W., Rose, K., and Ruggerone, G. 2011. Klamath River Expert Panel: Scientific assessment of two dam removal alternatives on Chinook salmon – Addendum to Final Report

Goodman, D.H. and Reid, S.B. 2012. Pacific Lamprey (Entosphenus tridentatus) Assessment and Template for Conservation Measures in California. U.S. Fish and Wildlife Service, Arcata, California. 117 pp.

Goodman, D.H. and Reid, S.B. 2015. Regional Implementation Plan for Measures to Conserve Pacific Lamprey (Entosphenus tridentatus), California – North Central Coast Regional Management Unit. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2015-27, Arcata, California.

Goodman, D.H. and Reid, S.B. 2017. Climbing above the competition: innovative approaches and recommendations for improving Pacific Lamprey passage at fishways. Ecological Engineering, 107, pp.224-232.

Goodman, D.H., J. Alvarez, N.A. Som, A. Martin, and K. De Juilio. 2016. The Effects of Restoration on Salmon Rearing Habitats in the Restoration Reach of the Trinity River at an Index Streamflow, 2009 to 2013. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2016-25. Arcata, California.

Grafton, R. Quentin, et al. 2018. The paradox of irrigation efficiency. Science 361.6404: 748-750.

Grantham, T.E., Matthews, J.H. and Bledsoe, B.P., 2019. Shifting currents: Managing freshwater systems for ecological resilience in a changing climate. Water Security, 8, p.100049.

Green Diamond Resource Company 2006. Green Diamond Resource Company Aquatic Habitat Conservation Plan and Candidate Conservation Agreement with Assurances. 552 pp. Available from: https://www.waterboards.ca.gov/northcoast/board_info/board_meetings/10_2012/pdf/green_diamond/GD_AHCP_Vol1_Final_1006.pdf

Hall, J.E., Greene, C.M., Stefankiv, O., Anderson, J.H., Timpane-Padgham, B., Beechie, T.J. and Pess, G.R., 2018. Large river habitat complexity and productivity of Puget Sound Chinook salmon. Plos one, 13(11), p.e0205127.

Hall, L.S., Krausman, P.R. & Morrison, M.L. (1997). The habitat concept and a plea for standard terminology. Wildlife Soc. Bull.,25, 173-182.

Hallett, S. and J. Alexander. 2021. Distribution and abundance of Upper Klamath Basin salmonid pathogens: developing a predictive framework for informing fish disease dynamics following dam removal. Proposal to ODFW Fish Health Graduate Research Fellowship in Microbiology.

Hamdi, A. Z, C.J. Post , E.A. Mikhailova, M.P. Cope, J.S.Allen, and B.A. Lytle. 2020. Evaluating the integrity of forested riparian bufers over a large area using LiDAR data and Google Earth Engine. Scientific Reports 10:14096.

Hamilton, J. B., G. L. Curtis, S. M. Snedaker, and D. K. White. 2005. Distribution of anadromous fishes in the Upper Klamath River watershed prior to hydropower dams – A synthesis of the historical evidence. Fisheries 30:10-20.

Hamilton, J. et al. 2011. Synthesis of the Effects to Fish Species of Two Management Scenarios for the Secretarial Determination on Removal of the Lower Four Dams on the Klamath River – Final Draft. Prepared by the Biological Subgroup (BSG) for the Secretarial Determination (SD) Regarding Potential Removal of the Lower Four Dams on the Klamath River.

Harling, Will and Bill Tripp. 2014. Western Klamath Restoration Partnership: A Plan for Restoring Fire Adapted Landscapes. Prepared for the Klamath National Forest. Prepared by the Mid-Klamath Watershed Council and Karuk Tribe.

Harman, W., Starr, R., Carter, M., et al. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006.

Harter, Thomas and Ryan Hines. 2008. Scott Valley Community Groundwater Study Plan. Prepared for: North Coast Regional Water Quality Control Board Siskiyou County Resource Conservation District Siskiyou County Board of Supervisors. Available from: http://groundwater.ucdavis.edu/files/136426.pdf

Hassanli, A. M., Ebrahimizadeh, M. A., and S. Beecham. 2009. The effects of irrigation methods with effluent and irrigation scheduling on water use efficiency and corn yields in an arid region. Agricultural Water Management, 96: 93– 99.

Herbold, B., Carlson, S.M., Henery, R., Johnson, R.C., Mantua, N., McClure, M., Moyle, P.B. and Sommer, T., 2018. Managing for salmon resilience in California's variable and changing climate. San Francisco Estuary and Watershed Science, 16(2).

Hereford, M., Wise, T., Gonyaw, A., and Huntington, C. 2018. Draft Implementation Plan for Reintroducing Anadromous Fishes Into The Oregon Portion Of The Upper Klamath Basin – An update. Oran presentation given at the 36th Annual Salmonid Restoration Conference, Fortuna, CA, April 11 – 14, 2018. Available from: https://www.calsalmon.org/sites/default/files/2018_SRF_7_Klamath_0.pdf

Hetrick N.J., T.A. Shaw, P. Zedonis, J.C. Polos, and C.D. Chamberlain. 2009. Compilation of information to inform USFWS principals on the potential effects of the proposed Klamath Basin Restoration Agreement (Draft 11) on fish and fish habitat conditions in the Klamath Basin, with emphasis on fall Chinook salmon. US Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Hewitt, D.A. et al., 2014. Demographics and Run Timing of Adult Lost River (Deltistes luxatus) and Shortnose (Chasmistes brevirostris) Suckers in Upper Klamath Lake, Oregon, 2012, USDI, USGS Open File Report 2014-1186.

Hewitt, D.A., Janney, E.C., Hayes, B.S. and Harris, A.C., 2018. Status and trends of adult Lost River (Deltistes luxatus) and shortnose (Chasmistes brevirostris) sucker populations in Upper Klamath Lake, Oregon, 2017 (No. 2018-1064). US Geological Survey.

Hillemeier, D., Belchik, M., Soto, T., Tucker, S.C., Ledwin, S. 2017. Measures to Reduce Infection of Klamath River Salmonids: A Guidance Document. 133 pp. PCFFA Disease Technical Advisory Team. Available from: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/PCFFA&IGFR/part2/pcffa_154.pdf

Hiner, M.2006. Seasonal water quality in the Klamath River estuary and surrounding sloughs, 2001-2003. Yurok Tribe, Klamath, California 95548.

Homel, K.M, T.W. Franklin, K.J. Carim, K.S. McKelvey, J.C. Dysthe, and M.K. Young. Detecting spawning of threatened chum salmon Oncorhynchus keta over a large spatial extent using eDNA sampling: Opportunities and considerations for monitoring recovery. Environmental DNA. 2020;00:1–12.

Hoopa Valley Tribe. 2014. Hoopa Tribal Forestry. Available from: http://www.hoopaforestry.com/planning.html.

Hoopa Valley Tribe. 2020. Water Quality Control Plan – Hoopa Valley Indian Reservation. 116 pp. Available from: https://www.epa.gov/sites/default/files/2014-12/documents/hoopa-valley-tribe.pdf

Hoopa Valley Tribe. 2020. Water Quality Control Plan – Hoopa Valley Indian Reservation. 116 pp. https://www.epa.gov/sites/default/files/2014-12/documents/hoopa-valley-tribe.pdf

Howell, C.K., S.D. Atkinson, J.L. Bartholomew, and S.L. Hallett. 2019. Development and application of a qPCR assay targeting Ichthyophthirius multifiliis in environmental water samples. Dis Aquat Organ. 134(1): 43-55

Huylenbroeck, L., M. Laslier², S. Dufour, B. Georges, P. Lejeune, and A. Michez. 2019. Using remote sensing to characterized riparian vegetation: A review of available tools and perspectives for managers (Version 1.0). European Cooperation in Science and Technology.

Interior Redband Conservation Team (IRCT). 2016. A Conservation Strategy for Interior Redband (Oncorhynchus mykiss subsp.) in the states of California, Idaho, Montana, Nevada, Oregon, and Washington. 106 pp.

Isaak, D. J., Young, M. K., Nagel, D. E., Horan, D. L., & Groce, M. C. 2015. The cold-water climate shield: delineating refugia for preserving salmonid fishes through the 21st century. Global Change Biology, 21(7), 2540–2553.

James, C. 2014. Post-fire salvage logging, soil erosion, and sediment delivery – Ponderosa Fire, Battle Creek Watershed, Northern California. Sierra Pacific Industries, Redding, California.

Jerde, C. L., A.R. Mahon, W.L. Chadderton, and D.M. Lodge. 2011. “Sight-unseen” detection of rare aquatic

Jerde, C., A. Welsh, C. Wilson, M. Docker, and B. Locke. 2019. Guidance for environmental DNA sampling design and effort. In: Uses and Limitations of Environmental DNA (eDNA) in Fisheries Management. Great Lakes Fishery Commission.

Jumani, S., Deitch, M.J., Valle, D., Machado, S., Lecours, V., Kaplan, D., Krishnaswamy, J. and Howard, J., 2022. A new index to quantify longitudinal river fragmentation: Conservation and management implications. Ecological Indicators, 136, p.108680.

Justice, C., McCullough, D. Seth, W. 2017b. Habitat Characteristics and Fish Use of Cold-water Refuges in the Upper Grande Ronde River Columbia River Inter-Tribal Fish Commission (CRITFC) April 2017.

Justice, C., White, S. M., McCullough, D. A., Graves, D. S., & Blanchard, M. R. 2017a. Can stream and riparian restoration offset climate change impacts to salmon populations? Journal of Environmental Management, 188, 212–227. https://doi.org/https://doi.org/10.1016/j.jenvman.2016.12.005

Kann, J. 2017a. Upper Klamath Lake 2016 Data Summary Report. Technical Memorandum Prepared by Aquatic Ecosystem Sciences LLC for The Klamath Tribes Natural Resources Department, Chiloquin Oregon. 79 pp. May 2015.

Kann, J. 2017b. Upper Klamath Lake tributary loading: 2016 data summary report. Technical Memorandum Prepared by Aquatic Ecosystem Sciences LLC for The Klamath Tribes Natural Resources Department, Chiloquin Oregon. 55 pp. May 2015.

Kann, J. and V.H. Smith. 1999. Estimating the probability of exceeding elevated pH values critical to fish populations in a hypereutrophic lake. Canadian Journal of Fisheries and Aquatic Sciences 56(12): 2262-2270.

Karuk Tribe. 2013. Water Quality Assessment Report: (CWA Section 305(b) Reporting). Karuk Tribe of California Department of Natural Resources

Karuk Tribe. 2015. Karuk Eco-Cultural Resources Management Plan. Available from: https://tribalclimateguide.uoregon.edu/tribal-adaptation-plans/karuk-eco-cultural-resources-management-plan.

Karuk Tribe. 2019. Karuk climate adaptation plan. Karuk Tribe of California. Department of Natural Resources. Available from: http://www.karuk.us/index.php/departments/natural-resources/525-climate-adaptation

Kasprak, A., Magilligan, F.J., Nislow, K.H. and Snyder, N.P., 2012. A Lidar-derived evaluation of watershed-scale large woody debris sources and recruitment mechanisms: Coastal Maine, USA. River Research and Applications, 28(9), pp.1462-1476.

Kim, S., R.J. McGaughey, H.E. Andersen, and G. Schreuder. 2009. Tree species differentiation using intensity data derived from leaf-on and leaf-off airborne laser scanner data. Remote Sens. Environ. 113: 1575–1586.

King, S.L., Laubhan, M.K., and P. Tashjian. 2021. Wetland Conservation: Challenges Related to Water Law and Farm Policy. Wetlands 41: 54.

Klamath Basin Environmental Foundation (KBEF). 2005. Upper Williamson River Watershed Action Plan. Report prepared by the Klamath Watershed Partnership. Retrieved from: http://www.klamathpartnership.org/pdf/brochures/UW_Action_Plan.pdf

Klamath Basin Environmental Foundation (KBEF). 2009. Lower Sprague – Lower Williamson River Watershed Action Plan. Report prepared by the Klamath Watershed Partnership. Retrieved from: http://www.klamathpartnership.org/pdf/brochures/LSLW_Action_Plan.pdf

Klamath Basin Restoration Agreement (KBRA). 2010. Klamath Basin Restoration Agreement for the sustainability of public and trust resources and affected communities. February 18 2010. 371 pp.

Klamath Blue-Green Algae Working Group. 2009. Standard operating procedures: Environmental Sampling of Cyanobacteria for Cell Enumeration, Identification and Toxin Analysis. Developed for the 2009 AIP Interim Measure 12 Water Quality Monitoring Activities, Klamath River.

Klamath River Inter-Tribal Fish and Water Commission (KRITFC). 2016. Middle Klamath Restoration Candidate Actions Plan (Spreadsheet provided by Toz Soto, updated in 2016).

Klamath River Renewal Corporation (KRRC), 2018. Definite Plan for the Lower Klamath Project. Prepared with assistance from AECOM Technical Services, Inc., CDM Smith and River Design Group. pp. 317.

Klamath River Renewal Corporation (KRRC), 2021a [online]. Accessed July 12, 2021. Available at: https://klamathrenewal.org/the-project/

Klamath River Renewal Corporation (KRRC), 2021b [online]. Accessed July 12, 2021. Available at: https://klamathrenewal.org/benefits/Klamath River Renewal Corporation (KRRC). 2021. Definite Plan for the Lower Klamath Project: Exhibit A - Aquatic Resources Management Plan. February 2021. Available online at: https://klamathrenewal.org/wp-content/uploads/2021/02/EX-A-Aquatic-Resources-Mngmnt-Plan-Feb2021.pdf

Klamath River Renewal Corporation (KRRC). 2020. Definite Plan for the Lower Klamath Project. November 2020. Available online at: https://klamathrenewal.org/wp-content/uploads/2021/04/Definite-Decommissioning-Plan.pdf

Klamath River Renewal Corporation (KRRC). 2021c. Definite Plan for the Lower Klamath Project: Exhibit D - Hatcheries Management and Operations Plan. Available online at: https://klamathrenewal.org/wp-content/uploads/2021/02/EX-D-Hatcheries-Mngmnt-and-Operations-Plan-Feb2021.pdf

Klamath River Renewal Corporation (KRRC). 2021d. Definite Plan for the Lower Klamath Project: Exhibit J - Reservoir Area Management Plan. Available online at: https://klamathrenewal.org/wp-content/uploads/2021/02/EX-J-Reservoir-Area-Mngmnt-Plan-Feb2021.pdf

Klamath River Renewal Corporation (KRRC). 2021e. Definite Plan for the Lower Klamath Project: Exhibit K (1 of 2) - Reservoir Drawdown and Diversion Plan. Available online at: https://klamathrenewal.org/wp-content/uploads/2021/02/EX-K-Reservoir-Drawdown-and-Diversion-Plan-Feb2021-Public1-of-2.pdf

Klamath River Renewal Corporation (KRRC). 2021f. Definite Plan for the Lower Klamath Project: Exhibit K (2 of 2) - Reservoir Drawdown and Diversion Plan. Available online at: https://klamathrenewal.org/wp-content/uploads/2021/02/EX-K-Reservoir-Drawdown-and-Diversion-Plan-Feb2021-Public2-of-2.pdf

Klamath River Renewal Corporation (KRRC). 2021g. Definite Plan for the Lower Klamath Project: Exhibit L - Sediment Deposit Remediation Plan. Available online at: https://klamathrenewal.org/wp-content/uploads/2021/02/EX-L-Sediment-Deposit-Remediation-Plan-Feb2021.pdf

Klamath River Renewal Corporation (KRRC). 2021h. Definite Plan for the Lower Klamath Project: Exhibit O – Water Quality Monitoring Management Plan. Available online at: https://klamathrenewal.org/wp-content/uploads/2021/02/EX-O-Water-Quality-Monitoring-and-Mngmnt-Plan-Feb2021.pdf

Klamath Tribal Water Quality Consortium (KTWQC). 2018. Upper Klamath Basin Nonpoint Source Pollution Assessment and Management Program Plan. 78p. Available from: https://klamathwaterquality.com/documents/KlamConsortium_NPS_Plan_20180918_finalweb.pdf

Klamath Watershed Partnership (KWP). 2010. Upper Sprague and Sycan Watershed Action Plan. Report prepared by the Klamath Watershed Partnership. Retrieved from: http://www.klamathpartnership.org/pdf/brochures/USS_Action_Plan.pdf

Knechtle, M. and Chesney, D. 2016. 2015 Scott River Salmon Studies Final Report. Report prepared by the California Department of Fish and Wildlife (CDFW). 29 pp.

Knechtle, M. and Giudice, D. 2021. 2020 Scott River Salmon Studies Final Report. Report prepared by the California Department of Fish and Wildlife (CDFW). 30 pp. Available from: https://static1.squarespace.com/static/62489e807e383e4b1be9bc11/t/62570cb1363b070756cd81eb/1649872049614/CDFW_Scott+River+2020+Salmon+Report_Final.pdf

Kondolf, G.M. and Wilcock, P.R., 1996. The flushing flow problem: defining and evaluating objectives. Water Resources Research, 32(8), pp.2589-2599.

Kuemmerlen, M., Reichert, P., Siber, R. and Schuwirth, N., 2019. Ecological assessment of river networks: from reach to catchment scale. Science of the Total Environment, 650, pp.1613-1627.

Kuhn, J.; Casas-Mulet, R.; Pander, J.; Geist, J. 2021. Assessing Stream Thermal Heterogeneity and Cold-Water Patches from UAV-Based Imagery: A Matter of Classification Methods and Metrics. Remote Sens. 2021, 13, 1379. https://doi.org/10.3390/rs13071379

LaGreca, T. and Fisher, K. 2015. The Klamath Tribes Wetland and Aquatic Resources Program Plan 2015 – 2018. 21 pp. Available from: https://www.epa.gov/sites/production/files/2015-10/documents/tkt_final_warpp.pdf

Lague, D. and Feldmann, B., 2020. Topo-bathymetric airborne LiDAR for fluvial-geomorphology analysis. In Developments in Earth Surface Processes (Vol. 23, pp. 25-54). Elsevier.

Laramie, M.B., D.S. Pilliod, C.S. Goldberg, and K.M. Strickler. 2015, Environmental DNA sampling protocol— Filtering water to capture DNA from aquatic organisms: U.S. Geological Survey Techniques and Methods, Book 2,Chap. A13, 15 p., http://dx.doi.org/10.3133/tm2A13

Larsen, S., Vaughan, I.P. and Ormerod, S.J., 2009. Scale-dependent effects of fine sediments on temperate headwater invertebrates. Freshwater Biology, 54(1), pp.203-219.

Laslier, M., L. Hubert-Moy and S. Dufour. 2019. Mapping riparian vegetation functions Using 3D bispectral LiDAR data. Water 11: 483.

Levi, T., J.E. Joyce, D, Bell, J.R. Russell et al. 2018. Environmental DNA for the enumeration and management of Pacific salmon. ResearchGate, August 2018.

Loch, A., and D. Adamson. 2015. Drought and the rebound effect: A Murray–Darling basin example. Natural Hazards 79 (3): 1429–49.

Loftin, M.K. 2014. Truths and governance for adaptive management. Ecology and Society 19(2):21. http://dx.doi.org/10.5751/ES-06353-190221.

Loire, R., Piégay, H., Malavoi, J.R., Kondolf, G.M. and Bêche, L.A., 2021. From flushing flows to (eco) morphogenic releases: evolving terminology, practice, and integration into river management. Earth-Science Reviews, 213, p.103475.

Lowe, P., R.D. Cooper-Caroselli, L. S. Brophy, and R.N. Fuller. 2018. Coastal resource planning within the Klamath River Estuary Task 3 (spit assessment): Summary report. Prepared by Wolf Water Resources, Portland, OR, USA and Estuary Technical Group, Institute for Applied Ecology, Corvallis, OR, USA, for the Yurok Tribe, Klamath, California, USA.

Luciano V. Chiaramonte, R. Adam Ray, R. Alex Corum, Toz Soto, Sascha L., Hallett & Jerri L. Bartholomew (2016) Klamath River Thermal Refuge Provides Juvenile Salmon Reduced Exposure to the Parasite Ceratonova shasta, Transactions of the American Fisheries Society, 145:4, 810-820, DOI: 10.1080/00028487.2016.1159612: http://dx.doi.org/10.1080/00028487.2016.1159612

Luck, M., Maumenee, N., Whited, D., Lucotch, J., Chilcote, S., Lorang, M., Goodman, D., McDonald, K., Kimball, J. and Stanford, J., 2010. Remote sensing analysis of physical complexity of North Pacific Rim rivers to assist wild salmon conservation. Earth Surface Processes and Landforms, 35(11), pp.1330-1343.

Luoma, S.N., Dahm, C.N., Healey, M., & Moore, J.N., (2015). Challenges facing the Sacramento–San Joaquin Delta:Complex, chaotic, or simply cantankerous? San Francisco Estuary and Watershed Science, 13(3): 7.

Luzier, C.W., Schaller, H.A. Brostrom, J.K., Cook-tabor, C., Goodman, D.H., Nelle, R.D., Ostrand, K., and Streif, B. 2011. Pacific Lamprey (Entosphenus tridentatus) Assessment and Template for Conservation Measures. U.S. Fish and Wildlife Service, Portland, Oregon. 282 pp. Available from: https://www.pacificlamprey.org/wp-content/uploads/2022/02/USFWS-Pacific-Lamprey-Assessment-and-Template-for-Conservation-Measures-2011.pdf

Malakauskas, D.M. and Wilzbach, M.A., 2012. Invertebrate assemblages in the lower Klamath River, with reference to Manayunkia speciosa. California Fish and Game, 98(4), pp.214-235.

Manhard, C. V., N. A. Som, R. W. Perry, J. R. Faukner, and T. Soto. 2018. Estimating freshwater productivity, overwinter survival, and migration patterns of Klamath River Coho Salmon. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2018-33, Arcata, California. Available from: https://www.fws.gov/arcata/fisheries/reports/technical/2018/EstimatingFreshwaterProductivityOverwinterSurvivalandMigrationPatternsofKlamathRiverCohoSalmon.pdf

Markle, D.F., A. Janik, J. T. Peterson , A. Choudhury, D. C. Simon, V.V. Tkach, M.R. Terwilliger, J.L. Sanders, and M.L. Kent. 2020. Odds ratios and hurdle models: a long-term analysis of parasite infection patterns in endangered young-of-the-year suckers from Upper Klamath Lake, Oregon, USA. International Journal for Parasitology 50: 315-330.

Marmorek, D.R., D. Robinson, C. Murray and L. Greig. 2006. Enabling Adaptive Forest Management – Final Report. Prepared for the National Commission on Science for Sustainable Forestry by ESSA Technologies Ltd., Vancouver, B.C. 94 pp.

Martin, B.A., D.A. Hewitt, and C.M. Ellsworth. 2013. Effects of Chiloquin Dam on Spawning Distribution and Larval Emigration of Lost River, Shortnose, and Klamath Largescale suckers in the Williamson and Sprague Rivers, Oregon. USDI/USGS Open-File Report 2013-1039, 28 pp.

McBain Associates. 2015. Assessing the Feasibility of Anadromous Fish Passage Above Lake ShastinaVia Parks Creek and a Constructed Bypass Channel. Report prepared for the Karuk Tribe. 38 pp. Retrieved from: http://www.karuk.us/images/docs/dnr/McBain_Associates_Lake_Shastina_Bypass_Feasibility_report_FINAL.pdf

McCovey, Jr., B.W. 2010. Lower Klamath River adult Chinook Salmon pathology Monitoring, 2009, Final Technical Memorandum, March 2010. Yurok Tribal Fisheries Program. Hoopa, CA.

McDade, M.H., Swanson, F.J., McKee, W.A., Franklin, J.F. and Sickle, J.V., 1990. Source distances for coarse woody debris entering small streams in western Oregon and Washington. Canadian Journal of Forest Research, 20(3), pp.326-330.

McEwan, D. R., Jackson, T. A., Reynolds, F., & Curtis, T. 1996. Steelhead restoration and management plan for California. State of California, Resources Agency, Department of Fish and Game. 246 pp.

McFadin 2019 Instream Flows in Select Trinity River Tributaries and Comparison to Water Use Estimates study. California Water Quality Control Boards. California Environmental Protection Agency. Oral presentation delivered at the 37th Annual Salmonid Restoration Federation Conference, April 24, 2019 (p105 in: https://www.calsalmon.org/sites/default/files/Cannabis%20Session.pdf).

McKelvey, K. S., M.K. Young, W.L. Knotek, K.J. Carim, T.M. Wilcox, T.M. Padgett-Stewart, and M.K. Schwartz. 2016. Sampling large geographic areas for rare species using environmental DNA: a study of bull trout Salvelinus confluentus occupancy in western Montana. Journal of Fish Biology, 88(3), 1215-1222.

McLaughlin, R.L., Smyth, E.R., Castro-Santos, T., Jones, M.L., Koops, M.A., Pratt, T.C. and Vélez-Espino, L.A., 2013. Unintended consequences and trade-offs of fish passage. Fish and Fisheries, 14(4), pp.580-604.Miller, S.A., Gordon, S.N., Eldred, P., Beloin, R.M., Wilcox, S., Raggon, M., Andersen, H., Muldoon, A. 2017. Northwest Forest Plan—the first 20 years (1994–2013): watershed condition status and trends. Gen. Tech. Rep. PNW-GTR-932. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 74 p. Available from: https://www.fs.fed.us/pnw/pubs/pnw_gtr932.pdf

Moody, J.A. and D.A. Martin. 2009. Synthesis of sediment yields after wildland fire in different rainfall regimes in the western United States. International Journal of Wildland Fire 18: 96-115.

Mount, J. and Moyle, P. 2022. Commentary: Klamath Basin Dam Removal Needs a science-driven oversight plan. Public Policy Institute of California. Retrieved December 18, 2022, from https://www.ppic.org/blog/commentary-klamath-basin-dam-removal-needs-a-science-driven-oversight-plan/

Moyle, P.B., Israel, J.A. and Purdy, S.E., 2008. Salmon, steelhead, and trout in California. Center for Watershed Sciences, University of California, Davis. 316 pp. Available from: https://watershed.ucdavis.edu/pdf/SOS-Californias-Native-Fish-Crisis-Final-Report.pdf

Murray et al. 2015**.** Adaptive Management Today: A Practitioner's Perspective. Ch. 10 in Adaptive Management of Natural Resources in Theory and Practice (Allen, Garmestani and Smith (eds), Springer).

Murray, B. and Fonstad, M.A., 2007. Preface: Complexity (and simplicity) in landscapes. Geomorphology, 91(3-4), pp.173-177.

Murray, N. J., Marra, P. P., Fuller, R. A., Clemens, R. S., Dhanjal-Adams, K., Gosbell, K. B., and C.E. Studds. 2018. The large-scale drivers of population declines in a long-distance migratory shorebird. Ecography, 41(6): 867– 876.

Naman, S. 2021. Temperature Synthesis Report, Trinity Management Council, June 16-17, 2021Virtual Meeting. https://www.trrp.net/DataPort/meetingitem.php?id=1006

National Marine Fisheries Service (NMFS). 2015. Klamath River Basin - 2014 Report to Congress. U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service. 37 pp. Accessed online at: http://www.westcoast.fisheries.noaa.gov/klamath/salmon_management.html

National Research Council (NCRWQCB). 2004. Endangered and threatened fishes in the Klamath River Basin: Causes of decline and strategies for recovery. Committee on Endangered and Threatened Fishes in the Klamath River Basin. The National Academies Press, Washington, DC. 425 pp.

National Research Council (NCRWQCB). 2008. Hydrology, ecology, and fishes of the Klamath River Basin The National Academies Press, Washington, DC.. 242 pp. + Appendix

National Research Council (NRC). 2004. Endangered and threatened fishes in the Klamath River Basin: Causes of decline and strategies for recovery. Committee on Endangered and Threatened Fishes in the Klamath River Basin. The National Academies Press, Washington, DC. 425 pp.

National Research Council (NRC). 2008. Hydrology, ecology, and fishes of the Klamath River Basin The National Academies Press, Washington, DC.. 242 pp. + Appendix.

Nelitz, M.A.and Beardmore, B. 2017. Eliciting Judgments, Priorities, and Values Using Structured Survey Methods. In Environmental Modeling with Stakeholders (pp. 65-81). Springer International Publishing, Switzerland.

Nelson, R.W., Dwyer, J.R. and Greenberg, W.E., 1987. Regulated flushing in a gravel-bed river for channel habitat maintenance: a Trinity River fisheries case study. Environmental Management, 11(4), pp.479-493.

NewFields River Basin Services and Kondolf, G. M., 2012, Evaluating stream restoration projects in the Sprague River basin: prepared for Klamath Watershed Partnership in conjunction with the Klamath Tribes, the U.S. Fish and Wildlife Service, the Klamath Basin Rangeland Trust, Sustainable Northwest, and The Nature Conservancy, 222 p. Available from: https://ifrmp.net/file/evaluating-stream-restoration-projects-in-the-sprague-river-basin/

Nichols, A., Lusardi, R., and Willis, Ann. 2017. Little Shasta River Aquatic Habitat Assessment. Report prepared by the UC Davis Center for Watershed Sciences for The Nature Conservancy. 28 pp. Retrieved from: https://watershed.ucdavis.edu/files/biblio/Little%20Shasta%20River%20Aquatic%20Habitat%20Assessment%202016.pdf

NOAA National Marine Fisheries Service (NMFS). 2010. Biological opinion on the operation of the Klamath Project between 2010 and 2018. Prepared for U.S. Bureau of Reclamation by NMFS, Southwest Region

NOAA National Marine Fisheries Service (NMFS). 2013. Klamath River Basin - 2012 Report to Congress. U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service. 3 pp. Accessed online at: http://www.westcoast.fisheries.noaa.gov/klamath/salmon_management.html

NOAA National Marine Fisheries Service (NMFS). 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch). National Marine Fisheries Service. Arcata, CA. 1841 pp.

NOAA National Marine Fisheries Service (NMFS). 2018. (web): Petition Prompts ESA Review of Upper Klamath and Trinity River Chinook Salmon. Retrieved from: https://www.westcoast.fisheries.noaa.gov/stories/2018/23_02232018_.html on January 22, 2019.

NOAA National Marine Fisheries Service and U.S. Fish & Wildlife Service (NMFS and USFWS). 2013. Biological Opinions on the Effects of Proposed Klamath Project Operations from May 31, 2013 through March 31, 2023, on Five Federally Listed Threatened and Endangered Species. NMFS SWR-2012-9372; USFWS 08EKLA00-2013-F-0014.

North Coast Region Water Quality Control Board (NCRWQCB). 2010. Action plan for the Klamath River total maximum daily loads addressing temperature, dissolved oxygen, nutrient, and microcystin impairments in the Klamath River in California and Lost River implementation plan. Santa Rosa, California.

North Coast Regional Water Quality Control Board (NCRWQCB). 2006. Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen TMDLs. 1123. Retrieved from: https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/shasta_river/060707/staff_report.pdf

North Coast Regional Water Quality Control Board (NCRWQCB). 2006b. Action Plan for the Scott River Sediment And Temperature Total Maximum Daily Loads. 14 pp. Available from: https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/scott_river/

North Coast Regional Water Quality Control Board (NCRWQCB). 2011. Scott River Watershed Water Quality Compliance and Trend Monitoring Plan. Available from: https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/scott_river/

North Coast Regional Water Quality Control Board (NCRWQCB). 2018. Water Quality Control Plan for the North Coast Region. Santa Rosa, California. June.

Null, S.E. and Lund, J.R., 2012. Fish habitat optimization to prioritize river restoration decisions. River research and applications, 28(9), pp.1378-1393.

O'Connor, J.E., McDowell, P.F., Lind, Pollyanna, Rasmussen, C.G., and Keith, M.K. 2015. Geomorphology and flood-plain vegetation of the Sprague and lower Sycan Rivers, Klamath Basin, Oregon: U.S. Geological Survey Scientific Investigations Report 2014–5223, 122 p., 1 pl., http://dx.doi.org/10.3133/sir20145223.

O'Keefe, C., Pagliuco, B., Scott, N., Cianciolo, T., Holycross, B. 2022. Klamath Reservoir Reach Restoration Prioritization: A Summary of Habitat Conditions and Restoration Actions in the Mainstem Klamath River and Tributaries Between Iron Gate Dam and Link River Dam. Prepared by NOAA Fisheries, Pacific States Marine Fisheries Commission, and Trout Unlimited. 67 pp.

Olds, B. P., C.L. Jerde, M.A. Renshaw, Y. Li, N.T. Evans, C.R. Turner, C. R., ... and M.E. Pfrender. 2016. Estimating species richness using environmental DNA. Ecology and Evolution, 6(12), 4214-4226.

Oregon Conservation Strategy – Conservation Opportunity Areas. Retrieved from: http://oregonconservationstrategy.org/conservation-opportunity-areas/

Oregon Department of Agriculture (ODA). 2017. Lost River Sub-basin Agricultural Water Quality Management Area Plan. Developed by Lost River Local Agricultural Water Quality Advisory Committee, Oregon Department of Agriculture and the Klamath Soil and Water Conservation District 67 p. Available from: https://www.oregon.gov/ODA/shared/Documents/Publications/NaturalResources/LostRiverAWQMAreaPlan.pdf

Oregon Department of Environmental Quality (ODEQ). 2002. Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP). 204 pp. Retrieved from: https://www.oregon.gov/deq/FilterDocs/UKtmdlwqmp.pdf

Oregon Department of Environmental Quality (ODEQ). 2018. Upper Klamath and Lost River Sub-basins Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP). 449 pp. Retrieved from: https://www.oregon.gov/deq/FilterDocs/klamathlostTMDL2018.pdf

Oregon Department of Fish and Wildlife (ODFW). 2005. Oregon Native Fish Status Report. Volume II. Assessment Methods & Population Results – Upper Klamath Basin Redband Trout. Retrieved from: https://www.dfw.state.or.us/fish/onfsr/docs/volume-2-final.pdf

Oregon Department of Fish and Wildlife (ODFW). 2008. A Plan for The Reintroduction of Anadromous Fish in The Upper Klamath Basin. 56 pp. Available from: https://nrimp.dfw.state.or.us/nrimp/information/docs/fishreports/Klamath%20Reintroduction%20Plan_Final_Commission%20Adopted%202008.pdf

Oregon Department of Fish and Wildlife (ODFW). 2016. Klamath Watershed District Stock Status: Review of native fishes. Klamath Fish District, January, 2016.

Oregon Department of Fish and Wildlife (ODFW). 2018. Oregon Conservation Strategy – Conservation Opportunity Areas. Retrieved from: http://oregonconservationstrategy.org/conservation-opportunity-areas/

Oregon Department of Fish and Wildlife and The Klamath Tribes 2021. Implementation plan for the reintroduction of anadromous fishes into the Oregon portion of the Upper Klamath Basin. Prepared by M.E. Hereford, T.G. Wise, and A. Gonyaw. 135p.

Oregon Department of Fish and Wildlife and The Klamath Tribes. 2021. Implementation plan for the reintroduction of anadromous fishes into the Oregon portion of the Upper Klamath Basin. Prepared by M.E. Hereford, T.G. Wise, and A. Gonyaw. 135 pp.

Oregon Historical Society. 2017. Web Page and Archive. Available at: http://librarycatalog.ohs.org/EOSWebOPAC/OPAC/Index.aspx Accessed: May 5th 2017. – section 1.3

Otten T.G., J.R. Crosswell, S. Mackey, and T.W. Dreher. 2015. Application of molecular tools for microbial source tracking and public health risk assessment of a Microcystis bloom traversing 300km of the Klamath River. Harmful algae 46: 71-81.

Otten, T. 2017. Application of genetic tools for improved cyanobacterial bloom monitoring in the Klamath River system: Implications for public health monitoring. Bend Genetics, LLC.

Pacific Lamprey Technical Workgroup. 2017. Practical guidelines for incorporating adult Pacific lamprey passage at fishways. June 2017. White Paper. 47 pp + Appendix. Available online: https://www.fws.gov/pacificlamprey/mainpage.cfm

Pacific States Marine Fisheries Commission (PSMFC). 2000. Proceedings of the salmon habitat restoration cost workshop. S.T.Alle, C. Thomson, and R.C. Carlson (Eds). Pacific States Marine Fisheries Commission, Portland, OR.

Pacific Watershed Associates (PWA). 1994. Action Plan for Restoration of the South Fork Trinity River Watershed and Its Fisheries (Part Two). U.S. Bureau of Reclamation, Trinity River Task Force.

Pacific Watershed Associates (PWA). 2011. Salmon River Private Roads Sediment Reduction Project, Klamath Watershed Restoration Program, Siskiyou County, California. Prepared for Salmon River Restoration Council and the USDI. 59 pp. Available at: https://srrc.org/publications/programs/roads/Salmon%20River%20Private%20Roads%20Sediment%20Reduction%20Project%20Final%20Report.pdf.

PacifiCorp 2018. Klamath River Hydroelectric Project Interim Measures Implementation Committee: Interim Measure 11 - Development of a Priority List of Projects: Phase 2 Final Report. Prepared by CH2M, Portland, Oregon. Available from:

https://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Hydro/Hydro_Licensing/Klamath_River/2018-2-26-PLP-P2-Final-Rpt-Rev4-12-18.pdf. 48 pp.

Pahl, R. 2007. Water Temperature Characteristics for Selected Northeastern Nevada Streams. Nevada Division of Environmental Protection, Bureau of Water Quality Planning. Available at: https://ndep.nv.gov/uploads/documents/temperature_aug_07.pdf. 50 pp.

Palmer, M., Hondula, K.L., & Koch, B.J., (2014). Ecological restoration of streams and rivers: Shifting strategies and shifting goals. Annual Review of Ecology, Evolution, and Systematics, 45(1): 247-269.

Pander, J. and Geist, J., 2013. Ecological indicators for stream restoration success. Ecological indicators, 30, pp.106-118.

Paradigm Environmental. 2018. Shasta River Watershed Characterization and Model Study Plan. Report prepared for the State Water Resources Control Board. 79 pp. Retrieved from: https://www.waterboards.ca.gov/waterrights/water_issues/programs/instream_flows/cwap_enhancing/docs/shasta_river/shasta_draft_model_plan.pdf

Parks, S. A., and Abatzoglou, J. T. 2020. Warmer and Drier Fire Seasons Contribute to Increases in Area Burned at High Severity in Western US Forests From 1985 to 2017. Geophysical Research Letters, 47(22), e2020GL089858. https://doi.org/https://doi.org/10.1029/2020GL089858

Patterson, W.D. 2009. Klamath River Estuary Wetlands Restoration Prioritization Plan. Yurok Tribe Environmental Program-Water Division, Klamath California.

Paukert, C., Olden, J. D., Lynch, A., et al. 2021. Climate change effects on North American fish and fisheries to inform adaptation strategies. Fisheries, 46(9), 449-464.

Pérez-Blanco, C. Dionisio, Arthur Hrast-Essenfelder, and Chris Perry. 2020. Irrigation technology and water conservation: A review of the theory and evidence. Review of Environmental Economics and Policy.

Pérez-Blanco, C. Dionisio, et al. "Agricultural water saving through technologies: a zombie idea." Environmental Research Letters 16.11: 114032.

Perry, R.W., Risley, J.C., Brewer, S.J., Jones, E.C., and Rondorf, D.W., 2011, Simulating daily water temperatures of the Klamath River under dam removal and climate change scenarios: U.S. Geological Survey Open-File Report 2011-1243, 78 p.

Pfeiffer, L., and C.Y.C. Lin. 2014. Does efficient irrigation technology lead to reduced groundwater extraction? Empirical evidence. Journal of Environmental Economics and Management, 67: 189– 208.

Pickens, A.H., M.C. Hansen, M. Hancher, S.V. Stehman, A. Tyukavina, P. Potapov, B. Marroquin, and Z. Sherani, 2020. Mapping and Sampling to Characterize Global Inland Water Dynamics from 1999 to 2018 with Full Landsat Time-Series. Remote Sensing of Environment 243:111792. doi: 10.1016/j.rse.2020.111792.

Pollock, M. 2016. Using Beaver to Restore Streams. Presentation delivered at the 34th Annual Salmonid Restoration Conference held in Fortuna, CA from April 6-9, 2016. Retrieved from: https://www.calsalmon.org/sites/default/files/2016_SRF_Conference_Beaver_Dam_Analogues_Workshop.pdf

Pool, D. B., Panjabi, A. O., Macias-Duarte, A., and D.M. Solhjem. 2014. Rapid expansion of croplands in Chihuahua, Mexico threatens declining North American grassland bird species. Biological Conservation, 170: 274– 281.

Powers, P.D., Helstab, M. and Niezgoda, S.L., 2019. A process-based approach to restoring depositional river valleys to Stage 0, an anastomosing channel network. River Research and Applications, 35(1), pp.3-13.

Quartz Valley Indian Reservation (QVIR). 2008. Quartz Valley Indian Reservation Water Quality Monitoring and Assessment Report 2007. 59 pp. Available from: https://klamathwaterquality.com/wq_plans.html

Quartz Valley Indian Reservation (QVIR). 2009. Quartz Valley Indian Reservation Water Quality Monitoring and Assessment Report 2008. 65 pp. Available from: https://klamathwaterquality.com/wq_plans.html

Quartz Valley Indian Reservation (QVIR). 2011. Environmental Protection Department Wetland Program Plan. 11 pp. Available from: https://www.epa.gov/sites/production/files/2015-10/documents/quartz_valley_wpp.pdf

Quartz Valley Indian Reservation (QVIR). 2016. Quality Assurance Project Plan Water Quality Sampling and Analysis, 2016 Revision. Available from: https://www.waterboards.ca.gov/water_issues/programs/tmdl/records/region_1/2017/ref4366.pdf

Quiñones, R.M., Johnson, M.L. and Moyle, P.B., 2014. Hatchery practices may result in replacement of wild salmonids: adult trends in the Klamath basin, California. Environmental biology of fishes, 97(3), pp.233-246.

Rabe, A. and Calonje, C. 2009. Lower Sprague-Lower Williamson Watershed Assessment. Report prepared for the Klamath Watershed Partnership. Retrieved from: http://www.klamathpartnership.org/pdf/lslw_watershed_assessment/lslwwa_cover_acronyms_disclaimer.pdf

Rasmussen, J.E. and Childress, E.S., 2018. Population Viability of Endangered Lost River sucker and Shortnose sucker and the Effects of Assisted Rearing. Journal of Fish and Wildlife Management, 9(2), pp.582-592.

Rasmussen, P.P., Gray, J.R., Glysson, G.D. and Ziegler, A.C., 2009. Guidelines and procedures for computing time-series suspended-sediment concentrations and loads from in-stream turbidity-sensor and streamflow data. US geological survey techniques and methods, book, 3, p.52.https://pubs.usgs.gov/tm/tm3c4/

Records, R. M., Arabi, M., Fassnacht, S. R., Duffy, W. G., Ahmadi, M., and Hegewisch, K. C. 2014. Climate change and wetland loss impacts on a western ri'er's water quality. Hydrology and Earth System Sciences, 18(11), 4509-4527.

Regional Water Management Group (Feather River), 2009. Memorandum of Understanding (MOU). June 1, 2009. p. 21.

Regional Water Quality Control Board and U.S. Forest Service (USFS). 2009. Salmon River Memorandum of Understanding between California Regional Water Quality Control Board North Coast Region and U.S. Forest Service Klamath and Six Rivers National Forests Pacific Southwest Region. Available at: https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/salmon_river/062405/Salmon_R_MOU_9-15-09.pdf.

Richter, B. D., Brown, J. D., DiBenedetto, R., Gorsky, A., Keenan, E., Madray, C., and S. Ryu. 2017. Opportunities for saving and reallocating agricultural water to alleviate water scarcity. Water Policy, 19(5): 886– 907.

Roni, P., 2019. Does River Restoration Increase Fish Abundance and Survival or Concentrate Fish? The Effects of Project Scale, Location, and Fish Life History. Fisheries, 44(1), pp.7-19.

Roni, P., Beechie, T., Schmutz, S., and Muhar, S. 2013. Prioritization of Watersheds and Restoration Projects. Chapter 6 in: Roni, P. and Beechie, T., eds. 2013. Stream and Watershed Restoration: A Guide to Restoring Riverine Processes and Habitats, First Edition. John Wiley & Sons, Ltd.

Roni, P., C. Clark, K. Ross, R. Camp, M. Krall, J. Hall, and R. Brown. 2020. Using remote sensing and other techniques to assess and monitor large floodplain and riparian restoration projects. State of Washington Recreation and Conservation Office. Olympia, WA.

Rosenfeld, J.S. & Hatfield, T. (2006). Information needs for assessing critical habitat of freshwater fish. Can. J. Fish.Aquat. Sci.,63, 683-698

Rouse, J.W., Haas, R.H., Schell, J.A. and Deering, D.W., 1974. Monitoring vegetation systems in the Great Plains with ERTS: Proceedings of the Third Earth Resources Technology Satellite-1 Symposium. NASA SP-351, pp.301-317. https://ntrs.nasa.gov/api/citations/19740022614/downloads/19740022614.pdf

Royer, C. F., & Stubblefield, A. P. 2016. Klamath Basin Water Quality Monitoring Plan. Klamath Basin Monitoring Program (KBMP). pp.1–207

Salant, N.L., Schmidt, J.C., Budy, P. and Wilcock, P.R., 2012. Unintended consequences of restoration: Loss of riffles and gravel substrates following weir installation. Journal of Environmental Management, 109, pp.154-163.

Salmon River Restoration Council (SRRC) [online] a. Available from: http://www.srrc.org/programs/firefuels.php?panel=srfsc, accessed Jan 24 24, 2019.

Salmon River Restoration Council (SRRC) [online] b. Water Quality Monitoring Program – Overview. Accessed Sep 17, 2021. Available at: https://srrc.org/programs/monitoring.php.

Salmon River Restoration Council (SRRC). 2020. Salmon River Community Restoration Program Annual Work Plan. 38 pp.

Sapkota, R.P., Stahl, P.D. and Rijal, K., 2018. Restoration governance: An integrated approach towards sustainably restoring degraded ecosystems. Environmental development, 27, pp.83-94.

Sarna-Wojcicki, D., Sowerwine, J., Hillman, L., Hillman, L. and Tripp, B., 2019. Decentring watersheds and decolonising watershed governance: Towards an ecocultural politics of scale in the Klamath Basin. Water Alternatives, 12(1), pp.241-266.

Schaedel, A. 2011. Oregon DEQ Harmful algal bloom (HAB) strategy. Report prepared for Oregon Department of Environmental Quality. Portland, OR.

Scheller, R.M. and Parajuli, R., 2018. Forest management for climate change in New England and the Klamath Ecoregions: Motivations, practices, and barriers. Forests, 9(10), p.626.

Schenk, L.N., Anderson, C.W., Diaz, P., and Stewart, M.A., 2016, Evaluating external nutrient and suspended-sediment loads to Upper Klamath Lake, Oregon, using surrogate regressions with real-time turbidity and acoustic backscatter data: U.S. Geological Survey Scientific Investigations Report 2016-5167, 46 p., https://doi.org/10.3133/sir20165167

Schenk, L.N., Stewart, M.A., and Eldridge, S.L.C., 2018, Nutrient loads in the Lost River and Klamath River Basins, south-central Oregon and northern California, March 2012–March 2015: U.S. Geological Survey Scientific Investigations Report 2018–5075, 55 p., https://doi.org/10.3133/sir20185075.

Scott River Water Trust (SRWT). 2019. Website. https://www.scottwatertrust.org/blank

Scott River Watershed Council (SRWC). 2005. Initial Phase of the Scott River Watershed Council Strategic Action Plan (October 2005 update). Fiscal Administrator: Siskiyou Resource Conservation District, Etna, CA.

Scott River Watershed Council (SRWC). 2006. Limiting Factors Analysis for Coho Salmon and Other Anadromous Fish Scott River Sub-Basin. 81 pp. Available from: https://ifrmp.net/file/limiting-factors-analysis-for-coho-salmon-and-other-anadromous-fish-scott-river-sub-basin/

Scott River Watershed Council (SRWC). 2018. Restoring Priority Coho Habitat in the Scott River Watershed: Modeling and Planning Report. Prepared for the National Fish and Wildlife Foundation, CA. Prepared by Scott River Watershed Council.

Scott River Watershed Council and Siskiyou Resource Conservation District (SRWC and SRCD). 2014. Scott River Watershed Restoration Strategy & Schedule. 64 pp. Available from: https://www.siskiyourcd.com/resources

Scott, C. A., Vicuña, S., Blanco, G. I., Meza, F., and O.C. Varela. 2014. Irrigation efficiency and water-policy implications for river-basin resilience. Hydrology and Earth System Sciences, 18(4): 1339– 1348.

Scott, D.T., Gomez-Velez, J.D., Jones, C.N. and Harvey, J.W., 2019. Floodplain inundation spectrum across the United States. Nature communications, 10(1), pp.1-8.

Shasta River Tailwater Reduction Plan. Report prepared for Shasta Valley Resource Conservation District. 33 pp. Retrieved from: https://svrcd.org/wordpress/shasta-river-tmdl/tailwater/

Shasta Valley Resource Conservation District (SVRCD) and McBain and Trush. 2013. Study Plan to Assess Shasta River Salmon and steelhead Recovery Needs. 146 pp. Retrieved from: https://www.fws.gov/arcata/fisheries/reports/dataSeries/SVRCD%20Shasta%20River%20Final%20Study%20Plan.pdf

Shasta Valley Resource Conservation District (SVRCD), Klamath Basin Monitoring Program (KBMP), and North Coast Regional Water Quality Control Board (NCRWQCB). 2018. Shasta River Watershed Stewardship Report. 184 pp. Available from: https://ifrmp.net/file/shasta-river-watershed-stewardship-report/

Shasta Valley Resource Conservation District (SVRCD). 2011. Shasta Valley Tailwater Reduction Plan. 33 pp. Retrieved from: http://svrcd.org/wordpress/shasta-river-tmdl/tailwater/

Shasta Valley Resource Conservation District (SVRCD). 2018. Shasta River Watershed Stewardship Report (Version 1.2). Prepared by the SVRCD in collaboration with NCRWQCB, and assistance from KBMP. 184 pp.

Silins, U., M. Stone, M. Emelko, and K. Bladon. 2008. Impacts of wildfire and post-fire salvage logging on sediment transfer in the Oldman watershed, Alberta, Canada. Sediment Dynamics in Changing Evironments (Proceedings of a symposium held in Christchurch, New Zealand, December 2008). IAHS Publication 325, 2008.

Siskiyou County Flood Control and Water District Groundwater Sustainability Agency. 2021. Shasta Valley Groundwater Sustainability Plan (Public Draft). 15 pp. Available from: https://www.co.siskiyou.ca.us/sites/default/files/fileattachments/natural_resources/page/28348/shasta_valley_gsp_executive_summary.pdf

Siskiyou Resource Conservation District (SRCD). 2005. Initial Phase of the Scott River Watershed Council Strategic Action Plan. 258 pp. Available from: https://www.siskiyourcd.com/resources

Siskiyou Resource Conservation District (SRCD). 2015. Ranch Water Quality Plan and Monitoring Template for Landowners. 13 pp. Available from: https://www.siskiyourcd.com/resources

Slonecker, T., Simon, N., Graham, J., Allen, D., Bufford, B., Evans, M.A., Carpenter, K., Griffin, D., Hall, N., Jones, D.K., Rebich, R.A., and Manning, M., 2020, Hyperspectral Characterization of Common Cyanobacteria Associated with Harmful Algal Blooms (ver. 2.0, October 2020): U.S. Geological Survey data release, https://doi.org/10.5066/P9SY4PSK.

Smith, C.B. 2020. A Conceptual Model Evaluation Framework for Adaptive Governance and Adaptive Management in Large-Scale Restoration Programs. Doctoral Dissertation. University of Nebraska-Lincoln. Available from: https://digitalcommons.unl.edu/natresdiss/329/

Snyder, D. T., and Morace, J. L. 1997. Nitrogen and phosphorus loading from drained wetlands adjacent to Upper Klamath and Agency lakes, Oregon. In Water-Resources Investigations Report. U.S. Geological Survey, WRIR 97-4059. https://doi.org/10.3133/wri974059

Soto, T. M. Hentz, and W. Harling. 2008. Mid-Klamath Sub-basin Fisheries Resource Recovery Plan, Final Draft. Funded by: US Fish and Wildlife Service, Yreka Office.

species using environmental DNA. Conservation Letters, 4(2), 150-157.

Speed, R., Li, Y., Tickner, D., Huang H., Naiman, R., Cao, J., Lei G., Yu, L., Sayers, P., Zhao, Z. & Yu, W., 2016. River Restoration: A Strategic Approach to Planning and Management. Paris, UNESCO. 204 pp.

Speed, R., Tickner, D., Naiman, R., Gang, L., Sayers, P., Yu, W., Yuanyuan, L., Houjian, H., Jianting, C., Lili, Y. and Zhongnan, Z., 2016. River restoration: a strategic approach to planning and management. UNESCO Publishing. 204 pp. Available from: https://unesdoc.unesco.org/ark:/48223/pf0000245644

Staentzel, C., Beisel, J.N., Gallet, S., Hardion, L., Barillier, A. and Combroux, I., 2018. A multiscale assessment protocol to quantify effects of restoration works on alluvial vegetation communities. Ecological Indicators, 90, pp.643-652.

Stanford, J., W. Duffy, E. Asarian, B. Cluer, P. Detrich, L. Eberle, S. Edmondson, S. Foot, M. Hampton, J. Kann, K. Malone, and P. Moyle. 2011. Conceptual model for restoration of the Klamath River In: Thorsteinson, L., S. VanderKooi, and W. Duffy, eds. 2011. Proceedings of the Klamath Basin Science Conference, Medford, Oregon, February 1-5, 2010: U.S. Geological Survey Open File Report 2011-1196.

Stanford, J.A., Lorang, M.S. and Hauer, F.R., 2005. The shifting habitat mosaic of river ecosystems. Internationale Vereinigung für theoretische und angewandte Limnologie: Verhandlungen, 29(1), pp.123-136.

State of California, Department of Water Resources. 1991. Scott River Flow Augmentation Study. Northern District, Red Bluff, CA. pp.136

Steel, E.A., Hughes, R.M., Fullerton, A.H., Schmutz, S., Young, J.A., Fukushima, M., Muhar, S., Poppe, M., Feist, B.E. and Trautwein, C., 2010. Are we meeting the challenges of landscape-scale riverine research? A review. Living Reviews in Landscape Research. 4: 1. 60 p, 4(1).

Stephenson, W. 1953. The study of behavior; Q-technique and its methodology. Chicago, IL, US: University of Chicago Press.

Stevenson, J.R., Dunham, J.B., Wondzell, S.M. and Taylor, J., 2022. Dammed water quality—Longitudinal stream responses below beaver ponds in the Umpqua River Basin, Oregon. Ecohydrology, 15(4), p.e2430.

Stillwater Sciences, Jones & Trimiew Design, Atkins, Tetra Tech, Riverbend Sciences, Aquatic Ecosystem Sciences, and NSI/Biohabitats. 2013. Water Quality Improvement Techniques for the Upper Klamath Basin: A Technical Workshop and Project Conceptual Designs. Prepared for California State Coastal Conservancy, Oakland, California.

Stillwater Sciences. 2009. Dam Removal and Klamath River Water Quality: A Synthesis of the Current Conceptual Understanding and an Assessment of Data Gaps. Technical report. Prepared for State Coastal Conservancy, 1330 Broadway, 13th Floor, Oakland, CA 94612, 86 pages, February

Stillwater Sciences. 2012. A guide for restoring functionality to mountain meadows of the Sierra Nevada. Prepared by Stillwater Sciences, Berkeley, California for American Rivers, Nevada City, California

Stillwater Sciences. 2014. LiDAR analysis of Salmon River floodplain and mine tailing restoration and enhancement opportunities. Prepared by Stillwater Sciences, Arcata, California for the Salmon River Restoration Council, Sawyers Bar, California.

Stillwater Sciences. 2018. Salmon River Floodplain Habitat Enhancement and Mine Tailing Remediation Project. Phase 1: Technical Analysis of Opportunities and Constraints. Prepared by Stillwater Sciences, Arcata, California for Salmon River Restoration Council, Sawyers Bar, California.

Stinchfield, H.M., Koontz, L., and Sexton, N.R., 2008, Social and economic considerations for coastal and watershed restoration in the Puget Sound, Washington—A Literature Review: U.S. Geological Survey Open-File Report 2009–1079, 78 p.

Stoll, S., Breyer, P., Tonkin, J.D., Früh, D. and Haase, P., 2016. Scale-dependent effects of river habitat quality on benthic invertebrate communities—implications for stream restoration practice. Science of the Total Environment, 553, pp.495-503.

Stone R, J Jacobs, N Som, J Foott, B Phillips, J Ross, D Taylor and T Tyler. 2017. Lost River Sucker Fry Survival in Upper Klamath Lake (July – September 2015). U.S. Fish & Wildlife Service California – Nevada Fish Health Center, Anderson, CA.

Sun, N., M. Wigmosta, T. Zhou, J. Lundquist, S. Dickerson-Lange, and N. Cristea, 2018. Evaluating the Functionality and Streamflow Impacts of Explicitly Modelling Forest-Snow Interactions and Canopy Gaps in a Distributed Hydrologic Model. Hydrological Processes 32:2128–2140. doi: 10.1002/hyp.13150.

Sutton, R. J., M. L. Deas, S. K. Tanaka, T. Soto, and R. A. Corum. 2007. Salmonid observations at a Klamath River thermal refuge under various hydrological and meteorological conditions. River Research and Applications. https://doi.org/10.1002/rra.1026

The Reclamation Act of 1902 (43 U.S.C. 391 et seq.)

The Upper Klamath Basin Watershed Action Plan Team. 2021. The Upper Klamath Basin Watershed Action Plan, March 2021. Prepared by U.S. Fish and Wildlife Service, Trout Unlimited, Klamath Watershed Partnership, The Klamath Tribes, Oregon Department of Environmental Quality, The Nature Conservancy, and the North Coast Regional Water Quality Control Board of California.

Thompson, T.Q., Bellinger, M.R., O'Rourke, S.M., Prince, D.J., Stevenson, A.E., Rodrigues, A.T., Sloat, M.R., Speller, C.F., Yang, D.Y., Butler, V.L. and Banks, M.A., 2019. Anthropogenic habitat alteration leads to rapid loss of adaptive variation and restoration potential in wild salmon populations. Proceedings of the National Academy of Sciences, 116(1), pp.177-186.

Thomson, C. J., and C. Pinkerton. 2008. Habitat restoration cost references for salmon recovery planning. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-425, 75 p.

Thorne, J.H., Boynton, R.M., Flint, L.E. and Flint, A.L., 2015. The magnitude and spatial patterns of historical and future hydrologic change in California's watersheds. Ecosphere, 6(2), pp.1-30.

Thorsteinson, Lyman, VanderKooi, Scott, and Duffy, Walter, eds., 2011, Proceedings of the Klamath Basin Science Conference, Medford, Oregon, February 1–5, 2010: U.S. Geological Survey Open-File Report 2011-1196.

Tillotson, M.D., R.P. Kelly, J.J. Duda, M. Hoy, and J. Kralj. 2018. Concentrations of environmental DNA (eDNA) reflect spawning salmon abundance at fine spatial and temporal scales. Biological Conservation 220: 1-11.

Timpane-Padgham, B. L., Beechie, T., & Klinger, T. 2017. A systematic review of ecological attributes that confer resilience to climate change in environmental restoration. PLOS ONE, 12(3), e0173812. https://doi.org/10.1371/journal.pone.0173812

Torgersen, Christian & Price, David & Li, Hiram & Mcintosh, Bruce. (1999). Multiscale Thermal Refugia and Stream Habitat Associations of Chinook Salmon in Northeastern Oregon. Ecological Applications - ECOL APPL. 9. 301-319. 10.2307/2641187.

Trinity River Restoration Program (TRRP) and ESSA Technologies Ltd. (TRRP and ESSA). 2009. Integrated assessment plan. TRRP, Weaverville, California.

Trinity River Restoration Program (TRRP). (n.d.). Trinity River Restoration Program Restoring the Trinity River. Retrieved 2019, from http://www.trrp.net/

Turnipseed, D.P., and V.B. Sauer. 2010. Discharge measurements at gaging stations: U.S. Geological Survey Techniques and Methods book 3, chap. A8, 87 p. available at http://pubs.usgs.gov/tm/tm3-a8/).

U.S. Bureau of Reclamation (USBR). 2011. Hydrology, hydraulics, and sediment transport studies for the Secretary's determination on Klamath Dam removal and basin restoration. Technical report No. SRH-2011-02.

U.S. Bureau of Reclamation (USBR). 2012. Lewiston Temperature Management Intermediate Technical Memorandum, Lewiston Reservoir, Trinity County, California. Report by U. S. Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA. http://www.trrp.net/library/document/?id=1814

U.S. Bureau of Reclamation (USBR). 2016 Klamath River Basin Study, Summary Report

U.S. Bureau of Reclamation (USBR). 2017 Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River. Available from: https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=22021

U.S. Bureau of Reclamation (USBR). 2018. Environmental Assessment, Increasing Rearing Capacity for Natal and Non-Natal Coho Salmon: McGarvey Beaver Dam Analogue Project, 2018-EA-007, Del Norte County, California, U.S. Bureau of Reclamation Technical Service Center, Denver, Colorado. 35p plus appendices. https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=33982

U.S. Bureau of Reclamation (USBR). 2018. Final Biological Assessment - The Effects of the Proposed Action to Operate the Klamath Project from April 1, 2019 through March 31, 2029 on Federally-Listed Threatened and Endangered Species. 447 pp. Retrieved from: https://www.usbr.gov/mp/kbao/

U.S. Department of Agriculture (USDA) and U.S. Department of the Interior (USDI). 1994. Record of Decision for Amendments to FS and BLM planning documents within the range of the northern spotted own and Standards and Guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. 153 pp. https://www.fs.fed.us/r6/reo/library/downloads/documents/NWFP-S&G-1994.pdf.

U.S. Department of the Interior (USDI). 2000. Record of decision, Trinity River mainstem fishery restoration final environmental impact statement/environmental impact report. Decision by the U.S. Department of Interior, December 2000.

U.S. Department of the Interior (USDI). 2012. Klamath Dam Removal Overview Report for the Secretary of the Interior: An Assessment of Science and Technical Information. Report prepared by the US Department of Interior and the National Marine Fisheries Service of the US Department of Commerce. 377 pp. + Appendices.

U.S. Department of the Interior (USDI). 2016. Sally Jewell (The Secretary of the Interior) 'to' The Honorable Kimberly D. Bose (Secretary, Federal Energy Regulatory Commission). October 17 2016. Secretary of Interior, October 2016 Statement of Support and summary of Secretarial Determination Studies.

U.S. Department of the Interior, U.S. Department of Commerce, National Marine Fisheries Service (USDI, USDC, NMFS). 2013. Klamath Dam removal overview. Report for the Secretary of the Interior: An assessment of the science and technical information. Version 1.1, March 2013.

U.S. Department of the Interior, U.S. Department of Commerce, National Marine Fisheries Service (USDI, USDC, NMFS). 2013. Klamath Dam removal overview. Report for the Secretary of the Interior: An assessment of the science and technical information. Version 1.1, March 2013

U.S. Environmental Protection Agency (EPA). 1998. South Fork Trinity River and Hayfork Creek Sediment Total Maximum Daily Load.

U.S. Fish and Wildlife Service (USFWS). 2012a. Revised recovery plan for the Lost River sucker (Deltistes luxatus) and shortnose sucker (Chasmistes brevirostris). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. 144 pp.

U.S. Fish and Wildlife Service (USFWS). 2013a. Klamath River Fish Habitat Assessment Program: Developing innovative solutions for restoring the Klamath River. USFWS Arcata Fish and Wildlife Office, Fisheries Program.

U.S. Fish and Wildlife Service (USFWS). 2013b. Yreka Fish and Wildlife Office. Status of native anadromous fish species of the Klamath River. Available at: https://www.fws.gov/yreka/HydroStatusAnadromous.html. Accessed March 14 2017.

U.S. Fish and Wildlife Service (USFWS). 2014. FINAL ENVIRONMENTAL ASSESSMENT - Restoring the hydrology of the Williamson River and adjacent wetlands on Klamath Marsh National Wildlife Refuge. U.S. Fish and Wildlife Service, Klamath Marsh National Wildlife Refuge, Chiloquin, OR. 46 pp. Retrieved from: https://www.fws.gov/uploadedFiles/FinalEA26JanKMNWR.pdf

U.S. Fish and Wildlife Service (USFWS). 2015. Klamath Recovery Unit Implementation Plan for Bull Trout (Salvelinus confluentus). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. 144 pp.

U.S. Fish and Wildlife Service (USFWS). 2016. Final Comprehensive Conservation Plan/Environmental Impact Statement (CCP/EIS) for Lower Klamath, Clear Lake, Tule Lake, Upper Klamath and Bear Valley National Wildlife Refuges. Retrieved from: https://www.fws.gov/refuge/Tule_Lake/what_we_do/planning.html

U.S. Fish and Wildlife Service (USFWS). 2017. Lower Klamath, Clear Lake, Tule Lake, Upper Klamath, and Bear Valley National Wildlife Refuges – Record of Decision for the Final Comprehensive Conservation Plan/ Environmental Impact Statement. 81 pp. Retrieved from: https://www.fws.gov/refuge/Tule_Lake/what_we_do/planning.html

U.S. Fish and Wildlife Service (USFWS). 2019a. Biological Opinion on the Effects of Proposed Klamath Project Operations from April 1, 2019, through March 31, 2024, on the Lost River Sucker and the Shortnose Sucker. 222 pp. Available from: https://www.fws.gov/cno/pdf/BiOps/FWS-BiOp-Klamath-Project-Operation-VI508.pdf

U.S. Fish and Wildlife Service (USFWS). 2019b. Pacific Lamprey Entosphenus tridentatus Assessment. 302 pp. Available from: https://www.fws.gov/pacificlamprey/Documents/PacificLamprey_2018Assessment_final_02282019.pdf

U.S. Fish and Wildlife Service and Hoopa Valley Tribe (USFWS and HVT). 1999. Trinity River Flow Evaluation Study (TFES). Final report to the Secretary, U.S. Department of the Interior, Washington, DC. Prepared by U.S. Fish and Wildlife Service and Hoopa Valley Tribe In consultation with U.S. Geological Survey, U.S. Bureau of Reclamation, National Marine Fisheries Service, and California Department of Fish and Game.

U.S. Fish and Wildlife Service. Lower, Clear Lake, Tule Lake, Upper Klamath, and Bear Valley National Wildlife Refuges, Final Comprehensive Conservation Plan and Environmental Assessment. Tule Lake and Sacramento, California: U.S. Fish and Wildlife Service, Pacific Southwest Region.

U.S. Forest Service (USFS). 2000. Rating Watershed Condition: Reconnaissance Level Assessment for the National Forest of the Pacific Southwest Region in California. U.S.D.A. Forest Service, Region 5, San Francisco, CA. 31 p.

U.S. Forest Service (USFS). 2003. Mainstem Trinity Watershed Analysis. Six Rivers National Forest, Lower Trinity District. May.

U.S. Forest Service (USFS). 2008. Middle Hayfork-Salt Creek Watershed Analysis. 118 p.

U.S. Forest Service (USFS). 2010. Klamath National Forest Land and Resource Management Plan. Available from: https://www.fs.usda.gov/main/klamath/landmanagement/planning.

U.S. Forest Service (USFS). 2018. Six Rivers aquatic restoration project: Final environmental assessment. Del Norte, Humboldt, Siskiyou and Trinity Counties, California. (https://www.fs.usda.gov/nfs/11558/www/nepa/96257_FSPLT3_4529205.pdf)

U.S. Forest Service and Bureau of Land Management (USFS and BLM). 2003. Water Quality Restoration Plan Upper Klamath Basin. USDA Forest Service Winema and Fremont National Forests and USDI Bureau of Land Management, Lakeview District, Klamath Falls Resource Area. 63 pp. Available from: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5288818.pdf

U.S.D.A Natural Resource Conservation Service (USDA-NRCS). 2004. Work Plan for Adaptive Management, Klamath River Basin. Prepared by the Natural Resources Conservation Service, Oregon and California. 16 pp.

VanderKooi, S., L. Thorsteinson, and E. Janney. 2011. Chapter 4: Watershed processes In: Thorsteinson, Lyman, VanderKooi, Scott, and Duffy, Walter, eds., 2011, Proceedings of the Klamath Basin Science Conference, Medford, Oregon, February 1–5, 2010: U.S. Geological Survey Open-File Report 2011-1196.

Voight, H., E. Davis, and J. Windsor, 2021. Fisheries Restoration Planning for the Resighini Rancheria: Junior Creek Watershed. Prepared by Thomas Gas & Associates Environmental Consultants for Resighini Rancheria, Klamath CA. 66 p. + appendix.

Walker, J.D., J. Kann, and W.W. Walker. 2015. Spatial and temporal nutrient loading dynamics in the Sprague River Basin, Oregon. Prepared by Aquatic Ecosystem Sciences, J. D. Walker, and W. W. Walker for the Klamath Tribes Natural Resources Department. 73p. + appendices. Available from: https://walkerenvres.com/projects/klamath/2015-sprague-nutrient-dynamics.html

Walker, W.W., J. D. Walker, and J. Kann. 2012. Evaluation of water and nutrient balances for the Upper Klamath Lake Basin in Water Years 1992-2010. Technical Report to the Klamath Tribes Natural Resources Department, Chiloquin, OR.

Ward, F. A., and M. Pulido-Velazquez. 2008. Water conservation in irrigation can increase water use. Proceedings of the National Academy of Sciences of the United States of America, 105(47): 18215– 18220.

Ward, H. H. and Armstrong, N. E.. 2010. Task 6: Assessment of Community Metabolism and Associated Kinetic Parameters in the Klamath River. Technical report prepared for the U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office by Ward and Armstrong, Consulting Engineers. 86 pg.

Watershed Research and Training Center (WRTC). 2016. South Fork Trinity River Supplementary Watershed Assessment 2014-2016. Prepared by The Watershed Research and Training Center, Hayfork, CA for the California Department of Fish and Wildlife Fisheries Restoration Grant Program. 58p. + appendices

Watson, R. 2016. Scott River Water Trust: Improving Stream Flows the Easy Way. Property and Environment Research Center (PERC) Case Study. Available from: https://www.perc.org/wp-content/uploads/2014/01/ScottRiverWaterTrust_PERC_2016.pdf

Weber, C., Åberg, U., Buijse, A. D., Hughes, F. M. R., McKie, B. G., Piégay, H., Roni, P., Vollenweider, S., Haertel-Borer, S., & Sveriges lantbruksuniversitet. (2018). Goals and principles for programmatic river restoration monitoring and evaluation: Collaborative learning across multiple projects. Wiley Interdisciplinary Reviews. Water, 5(1), n/a. https://doi.org/10.1002/wat2.1257

Wegenbrenner, J.W., L.H. MacDonald, R.N. Coats, P.R. Robichaud, and R.E. Brown. 2015. Effects of post-fire salvage logging and a skid trail treatment on ground cover, soils, and sediment production in the interior western United States. Forest Ecology and Management 335: 176-193.

Wellmeyer, J.L., Slattery, M.C. and Phillips, J.D., 2005. Quantifying downstream impacts of impoundment on flow regime and channel planform, lower Trinity River, Texas. Geomorphology, 69(1-4), pp.1-13.

Whittlesey, N. 2003. Improving irrigation efficiency through technology adoption: When will it conserve water? Developments in Water Science 50: 53–62.

Willis, A.D., Nichols, A.L., Jeffres, C.A., Deas, M.L., 2013. Water Resources Management Planning: Conceptual Framework and Case Study of the Shasta Basin. Report prepared for: National Fish and Wildlife Foundation. 65 pp. Retrieved from: https://watershed.ucdavis.edu/files/biblio/Shasta%20Basin%20Planning%20Framework%2010-23-2013.pdf

Wohl, E., 2016. Spatial heterogeneity as a component of river geomorphic complexity. Progress in Physical Geography, 40(4), pp.598-615.

Wohl, E., 2017. Bridging the gaps: An overview of wood across time and space in diverse rivers. Geomorphology, 279, pp.3-26.

Woo, I., Davis, M.J., De La Cruz, S.E.W., Windham-Myers, L., Drexler, J.Z., Byrd, K.B., Stuart-Haëntjens, E.J., Anderson, F.E., Bergamaschi, B.A., Nakai, G., Ellings, C.S. and Hodgson, S. 2021. Carbon Flux, Storage, and Wildlife Co-Benefits in a Restoring Estuary. In Wetland Carbon and Environmental Management (eds K.W. Krauss, Z. Zhu and C.L. Stagg). https://doi.org/10.1002/9781119639305.ch5

Woo, I., Davis, M.J., Ellings, C.S., Nakai, G., Takekawa, J.Y. and De La Cruz, S., 2018. Enhanced invertebrate prey production following estuarine restoration supports foraging for multiple species of juvenile salmonids (Oncorhynchus spp.). Restoration ecology, 26(5), pp.964-975. https://onlinelibrary.wiley.com/doi/abs/10.1111/rec.12658

Wood, T.A., Wherry, S.A. , Carter, J.L., Kuwabara, J.S., Simon, N.S., and Rounds, S.A.. 2013. Technical evaluation of a Total Maximum Daily Load model for Upper Klamath Lake, Oregon. U.S. Geological Survey Open-File Report 2013-1262.

Xu, Y., Si, Y., Wang, Y., Zhang, Y., Prins, H. H. T., Cao, L., & de Boer, W. F. 2019. Loss of functional connectivity in migration networks induces population decline in migratory birds. Ecological Applications, 29(7), e01960.

Yokel, E., S. Witmore, B. Stapleton, C. Gilmore and M.M. Pollock. 2018. Scott River Beaver Dam Analogue Coho Salmon Habitat Restoration Program 2017 Monitoring Report. 57 p. Scott River Watershed Council. Etna, California. https://docs.wixstatic.com/ugd/afbfb7_410476ac741042a883337fa2bf20eb9b.pdf

Yokel, E., Thamer, P., Adams, C., Magranet, L., DeDobbeleer, W., Fiori, R. and Pollock, M.M. 2016. Scott River Beaver Dam Analogue Program 2015 Interim Monitoring Report. Scott River Watershed Council, Etna, California. 87 pp.

Yurok Tribal Fisheries Program and Yurok Tribal Watershed Restoration Program (YTFP and YTWRP). 2000. Lower Klamath River Sub-basin Watershed Restoration Plan. Prepared by Dan B. Gale (YTFP) and D.B. Randolph (YTWRP). 77 p.

Yurok Tribe Environmental Program (YTEP). 2013a. Final 2012 Klamath River Nutrient Summary Report. Prepared by Matthew Hanington and Kathleen Torso. YTEP Water Division, Klamath, CA. 56 pp.

Yurok Tribe Environmental Program (YTEP). 2013b. Final 2013 Klamath River Continuous Water Quality Monitoring Summary Report. Prepared by Matthew Hanington. YTEP Water Division, Klamath, CA.

Yurok Tribe Environmental Program (YTEP). 2013c. Yurok Tribe Environmental Program: Wetlands Program Plan. YTEP Water Division, Klamath, CA. Available at: http://www.yuroktribe.org/departments/ytep/documents/wetlands_plan.pdf.

Yurok Tribe Wildlife Department. 2020. Feral Cattle Management Plan. Yurok Tribe Wildlife Department. Klamath, CA.

Yurok Tribe. 2018. (Press Release): "Yurok Tribe, Partners Begin 'Historic Restoration Project' on South Fork Trinity River Tomorrow". Available at: https://kymkemp.com/2018/09/23/yurok-tribe-partners-begin-historic-restoration-project-on-south-fork-trinity-river-tomorrow/.

Zischg, A.P., Galatioto, N., Deplazes, S., Weingartner, R. and Mazzorana, B., 2018. Modelling spatiotemporal dynamics of large wood recruitment, transport, and deposition at the river reach scale during extreme floods. Water, 10(9), p.1134

Appendix A: Acknowledgements Continued

"By the numbers" breakdown of 134 IFRMP participants during Phase 2 to Phase 4 of Plan development:

Major Groups	# of Participants
USFWS	21
Other Federal Agencies (NOAA, USBR, USGS + other federal agencies)	17
Tribes (Hoopa Valley Tribe, Karuk Tribe, Klamath Tribes, Yurok Tribe)	21
California State Government (including any water quality control boards from California)	18
Oregon State Government (including any water quality control boards from Oregon)	10
Other (NGOs, utilities, consultants, private citizens, etc.)	47
TOTAL	**134**

The tables below provide a breakdown of how people were organized regionally and by subject area to collaboratively develop and review the IFRMP.

Integrated Fisheries Restoration and Monitoring Plan (Phase 3 and/or Phase 4) Federal Coordination Group members:

Federal Coordination Group (FCG)	
Matt Baun	US Fish & Wildlife Service (USFWS)
Chris Wheaton	Pacific States Marine Fisheries Commission (PSMFC)
Robert Clarke	US Fish & Wildlife Service (USFWS)
Terrence Conlon	United States Geological Survey (USGS)
Mike Edwards	US Fish & Wildlife Service (USFWS)
Jenny Ericson	US Fish & Wildlife Service (USFWS)
Ryan Fogerty	US Fish & Wildlife Service (USFWS)
Nick Hetrick	US Fish & Wildlife Service (USFWS)
Bob Pagliuco	NOAA - National Marine Fisheries Service (NMFS)
Josh Rasmussen	Past member of US Fish & Wildlife Service (USFWS)
Jim Simondet	NOAA - National Marine Fisheries Service (NMFS)
Megan Skinner	US Fish & Wildlife Service (USFWS)
Tommy Williams	National Oceanic & Atmospheric Administration (NOAA)
Shari Witmore	National Oceanic & Atmospheric Administration (NOAA)

Integrated Fisheries Restoration and Monitoring Plan (Phase 3 and/or Phase 4) Basin-wide Technical Working Group members:

Basin-wide Technical Working Group (TWG)	
Chauncey Anderson	United States Geological Survey (USGS)
Matt Baun	US Fish & Wildlife Service (USFWS)
Caitlin Bean	California Department of Fish & Wildlife (CDFW)
Michael Belchik	Yurok Tribe
Clayton Creager	North Coast Regional Water Quality Control Board
Mike Edwards	US Fish & Wildlife Service (USFWS)
Ryan Fogerty	US Fish & Wildlife Service (USFWS)

Robert Franklin	Hoopa Valley Tribe
Damon Goodman	US Fish & Wildlife Service (USFWS)
Nick Hetrick	US Fish & Wildlife Service (USFWS)
Mike Hiatt	Oregon Department of Environmental Quality (ODEQ)
Eric Janney	United States Geological Survey (USGS)
Barry McCovey	Yurok Tribe
Bob Pagliuco	NOAA - National Marine Fisheries Service (NMFS)
George Pess	National Oceanic & Atmospheric Administration (NOAA)
Bill Pinnix	US Fish & Wildlife Service (USFWS)
Josh Rasmussen	Past member of US Fish & Wildlife Service (USFWS)
Greg Schrott	US Fish & Wildlife Service (USFWS)
Eli Scott	North Coast Regional Water Quality Control Board
Jim Simondet	NOAA - National Marine Fisheries Service (NMFS)
Wade Sinnen	California Department of Fish & Wildlife (CDFW)
Megan Skinner	US Fish & Wildlife Service (USFWS)
Toz Soto	Karuk Tribe
Stan Swerdloff	Klamath Tribes
Chris Wheaton	Pacific States Marine Fisheries Commission (PSMFC)
Tommy Williams	National Oceanic & Atmospheric Administration (NOAA)
Ted Wise	Oregon Department of Fish and Wildlife (ODFW)

Integrated Fisheries Restoration and Monitoring Plan (Phase 3) Sub-basin Working Group members:

Sub-Basin(s)	Name	Affiliation
Upper Klamath Lake, Williamson & Sprague   	Chauncey Anderson	US Geological Survey
	Greg Austin*	USFWS
	Nolan Banish	USFWS
	Michael Belchik	Yurok Tribe
	Troy Brandt	River Design Group, Inc.
	Mark Buettner*	Klamath Tribes
	Chris Colson	Ducks Unlimited
	Clayton Creager*	CA North Coast Regional Water Quality Control Board
	Kelley Delpit	Sustainable Northwest
	Mike Edwards*	USFWS
	Robert F Franklin	Fishwater Consulting, working for Hoopa Fisheries
	Anthony Falzone	FlowWest
	Jon Grunbaum	Klamath National Forest
	Mike Hiatt*	Oregon Department of Environmental Quality (ODEQ)
	Susan Fricke*	Karuk Tribe
	Will Hatcher	Klamath Tribes
	Mark Hereford*	Oregon Dept of Fish and Wildlife
	Megan Hilgart*	NOAA Restoration Center
	Becky Hyde	Upper Basin Rancher
	Mark Johnson	Klamath Water Users Association
	Jacob Kann*	Aquatic Ecosystem Sciences LLC

Sub-Basin(s)	Name	Affiliation
	Dan Keppen	Family Farm Alliance
	Christie Nichols*	USFWS
	Brad Parrish	Klamath Tribes
	Beth Pietrzak	Oregon Department of Agriculture's Water Quality Program
	Benji Ramirez	Oregon Dept. of Fish and Wildlife
	Josh Rasmussen*	USFWS
	Eric Reiland	Bureau of Reclamation
	Steve Rondeau	Klamath Tribes
	Nell Scott*	Trout Unlimited
	Megan Skinner*	USFWS
	Olivia Stoken*	Oregon Dept. of Fish and Wildlife
	Randy Turner*	Klamath Basin Monitoring Program
	Leigh Ann Vradenburg*	Klamath Watershed Partnership
	Danette Watson	Oregon Water Resources Department
	Ted Wise	Oregon Department of Fish and Wildlife

*Denotes individuals ("refiners") who contributed extra time in spring of 2020 to refining the properties of candidate restoration actions, identifying suspicious ranking results (with rationale), and/or critically reviewing conceptual model stressor – restoration action type relationships, related map layers and other sub-basin input information sources used to support IFRMP prioritization scoring calculations.

Sub-Basin(s)	Name	Affiliation
Lost 	Mark Buettner*	Klamath Tribes
	Chris Colson*	Ducks Unlimited
	Clayton Creager*	CA North Coast Regional Water Quality Control Board
	Anthony Falzone	FlowWest
	Mike Hiatt*	Oregon Department of Environmental Quality (ODEQ)
	Mark Johnson*	Klamath Water Users Association
	Beth Pietrzak	Oregon Department of Agriculture's Water Quality Program
	Josh Rasmussen*	USFWS
	Olivia Stoken*	Oregon Dept. of Fish and Wildlife
	Leigh Ann Vradenburg*	Klamath Watershed Partnership

*Denotes individuals ("refiners") who contributed extra time in spring of 2020 to refining the properties of candidate restoration actions, identifying suspicious ranking results (with rationale), and/or critically reviewing conceptual model stressor – restoration action type relationships, related map layers and other sub-basin input information sources used to support IFRMP prioritization scoring calculations.

Sub-Basin(s)	Name	Affiliation
Mid-Klamath River & Upper Klamath River 	Chauncey Anderson	US Geological Survey
	Michael Bowen	State Coastal Conservancy
	LeRoy Cyr*	Six Rivers National Forest
	Ryan Fogerty*	US Fish & Wildlife Service (USFWS)
	Susan Fricke*	Karuk Tribe
	Damon Goodman*	US Fish & Wildlife Service (USFWS)
	Karuna Greenberg	Salmon River Restoration Council
	Jon Grunbaum*	Klamath National Forest

Sub-Basin(s)	Name	Affiliation
	Mark Hereford*	Oregon Dept of Fish and Wildlife
	Nick Hetrick	UFSWS
	Mark Johnson*	Klamath Water Users Association
	Devon Jorgenson	CA North Coast Regional Water Quality Control Board
	George Kautsky	Hoopa Valley Tribal Fisheries
	Barry McCovey*	Yurok Tribe
	Elizabeth Nielsen	County of Siskiyou
	Bob Pagliuco*	NOAA Restoration Center
	Eric Reiland	Bureau of Reclamation
	Toz Soto*	Karuk Tribe
	Mark Tompkins	FlowWest, LLC
	Charles Wickman*	Mid Klamath Watershed Council
	Ted Wise	Oregon Department of Fish and Wildlife

*Denotes individuals ("refiners") who contributed extra time in spring of 2020 to refining the properties of candidate restoration actions, identifying suspicious ranking results (with rationale), and/or critically reviewing conceptual model stressor – restoration action type relationships, related map layers and other sub-basin input information sources used to support IFRMP prioritization scoring calculations.

Sub-Basin(s)	Name	Affiliation
Shasta 	Jeff Abrams	National Oceanic & Atmospheric Administration (NOAA)
	Michael Belchik*	Yurok Tribe
	Ethan Brown*	Shasta Valley Resource Conservation District
	Amy Campbell	The Nature Conservancy
	Joe Croteau*	CA Dept of Fish and Wildlife
	Ryan Fogerty*	US Fish & Wildlife Service (USFWS)
	Ada Fowler*	California Trout
	Susan Fricke*	Karuk Tribe
	Elizabeth Nielsen	County of Siskiyou
	Eric Reiland	Bureau of Reclamation
	Michael Riney*	Shasta Valley Resource Conservation District
	Crystal Robinson*	Quartz Valley Indian Reservation
	Eli Scott*	North Coast Regional Water Quality Control Board

*Denotes individuals ("refiners") who contributed extra time in spring of 2020 to refining the properties of candidate restoration actions, identifying suspicious ranking results (with rationale), and/or critically reviewing conceptual model stressor – restoration action type relationships, related map layers and other sub-basin input information sources used to support IFRMP prioritization scoring calculations.

Sub-Basin(s)	Name	Affiliation
Scott 	Michael Belchik	Yurok Tribe
	Amy Campbell	The Nature Conservancy
	Joe Croteaux*	CA Dept of Fish and Wildlife
	Robert F Franklin	Fishwater Consulting, working for Hoopa Fisheries
	Ryan Fogerty*	USFWS
	Elizabeth Nielsen	County of Siskiyou

Sub-Basin(s)	Name	Affiliation
	Bob Pagliuco*	NOAA Restoration Center
	Michael Pollock	National Oceanic & Atmospheric Administration (NOAA)
	Crystal Robinson*	Quartz Valley Indian Reservation
	Eli Scott	North Coast Regional Water Quality Control Board
	Toz Soto*	Karuk Tribe
	Betsy Stapleton*	Scott River Watershed Council
	Erich Yokel*	Scott River Watershed Council

*Denotes individuals ("refiners") who contributed extra time in spring of 2020 to refining the properties of candidate restoration actions, identifying suspicious ranking results (with rationale), and/or critically reviewing conceptual model stressor – restoration action type relationships, related map layers and other sub-basin input information sources used to support IFRMP prioritization scoring calculations.

Sub-Basin(s)	Name	Affiliation
Salmon	Joe Croteau	CA Dept of Fish and Wildlife
	LeRoy Cyr	Six Rivers National Forest
	Amy Fingerle	Salmon River Restoration Council
	Karuna Greenberg*	Salmon River Restoration Council
	Dave Hillemeier*	Yurok Tribe
	William Pinnix*	USFWS
	Crystal Robinson*	Quartz Valley Indian Reservation
	Jacob (Jake) Shannon	CA North Coast Regional Water Quality Control Board
	Toz Soto*	Karuk Tribe

*Denotes individuals ("refiners") who contributed extra time in spring of 2020 to refining the properties of candidate restoration actions, identifying suspicious ranking results (with rationale), and/or critically reviewing conceptual model stressor – restoration action type relationships, related map layers and other sub-basin input information sources used to support IFRMP prioritization scoring calculations.

Sub-Basin(s)	Name	Affiliation
Lower Klamath River	Jeff Abrams	NOAA
	Justin Alvarez*	Hoopa Valley Tribal Fisheries
	Chauncey Anderson	US Geological Survey
	Sarah Beesley*	Yurok Tribe
	Michael Bowen	State Coastal Conservancy
	Carley Dunleavy	CA North Coast Regional Water Quality Control Board
	Dan Gale*	US Fish & Wildlife Service
	Barry McCovey*	Yurok Tribe
	Bob Pagliuco*	NOAA Restoration Center
	William Pinnix*	USFWS
	Gregory Schrott*	US Fish & Wildlife Service

*Denotes individuals ("refiners") who contributed extra time in spring of 2020 to refining the properties of candidate restoration actions, identifying suspicious ranking results (with rationale), and/or critically reviewing conceptual model stressor – restoration action type relationships, related map layers and other sub-basin input information sources used to support IFRMP prioritization scoring calculations.

Sub-Basin(s)	Name	Affiliation
Trinity & South Fork Trinity  	Michael Bowen*	State Coastal Conservancy
	Cindy Buxton*	The Watershed Research and Training Center
	LeRoy Cyr*	Six Rivers National Forest
	Kyle De Juilio*	Yurok Tribe
	Mike Dixon*	USBR - Trinity River Restoration Program
	Damon Goodman	UFSWS
	Nick Hetrick	UFSWS
	Andrew Hill*	California Fish and Wildlife
	Paul Petros*	Hoopa Valley Tribal Fisheries
	William Pinnix*	USFWS
	Dean Prat*	CA North Coast Regional Water Quality Control Board
	Wade Sinnen	CDFW

*Denotes individuals ("refiners") who contributed extra time in spring of 2020 to refining the properties of candidate restoration actions, identifying suspicious ranking results (with rationale), and/or critically reviewing conceptual model stressor – restoration action type relationships, related map layers and other sub-basin input information sources used to support IFRMP prioritization scoring calculations.

Regional Restoration Action Costing Working Groups during Phase 4 development of the Integrated Fisheries Restoration and Monitoring Plan:

Klamath Phase 4 – Costing groups	
Costing - R1 - Upper Basin	
Clayton Creager	North Coast Regional Water Quality Control Board
Eric Reiland	Bureau of Reclamation
Mark Buettner	Klamath Tribes
Costing - R2a - Upper-Mid-Klamath River	
Bob Pagliuco	NOAA - National Marine Fisheries Service (NMFS)
Charles Wickman	Mid Klamath Watershed Council
Jon Grunbaum	Klamath National Forest
Mitzi Wickman	Mid Klamath Watershed Council
Toz Soto	Karuk Tribe
Costing - R2b - Mid-Upper Basin	
Ada Fowler	California Trout
Betsy Stapleton	Scott River Watershed Council
Leroy Cyr	Six Rivers National Forest
Toz Soto	Karuk Tribe
Costing - R3 - Lower Basin	
David Gaeuman	Yurok Tribe
Gregory Schrott	US Fish & Wildlife Service
Justin Alvarez	Hoopa Valley Tribal Fisheries
Kyle de Julio	Yurok Tribe
Mark Villers	Blue Ridge Timber Cutting

Note: a larger group of individuals indicated interest in the topic of restoration action costs and were invited, but did not contribute responses to ESSA's formal costing 'homework' exercise. (See Appendix C).

Disciplinary (topic area) Monitoring Working Groups during Phase 4 development of the IFRMP:

Klamath Phase 4 – Monitoring groups	
Monitoring - SA1 - Watershed Inputs & WQ	
Chauncey Anderson	US Geological Survey - Water Science Center
Clayton Creager	North Coast Regional Water Quality Control Board
Crystal Robinson	Quartz Valley Indian Reservation
Eli Scott	North Coast Regional Water Quality Control Board
Grant Johnson	Karuk Tribe
Jacob Kann	Aquatic Ecosystems Sciences
Megan Skinner	US Fish & Wildlife Service (USFWS)
Olivia Stoken	Oregon Dept of Environmental Quality
Randy Turner	Klamath Basin Monitoring Program
Monitoring - SA2 - Fluvial Geomorphology	
Betsy Stapleton	Scott River Watershed Council
Brian Cluer	National Oceanic & Atmospheric Administration
Chauncey Anderson	United States Geological Survey - Water Science Center
Conor Shea	US Fish & Wildlife Service
Dave Gaeuman	Yurok Tribe
Eric Reiland	Bureau of Reclamation
George Pess	National Oceanic & Atmospheric Administration
Karuna Greenberg	Salmon River Restoration Council
Sarah Beasley	Yurok Tribe
Jenny Curtis	USGS
Monitoring - SA3 - Fish Habitat & Connectivity	
Alex Corum	Karuk Tribe
Benji Ramirez	Oregon Dept of Fish and Wildlife
Bill Pinnix	US Fish & Wildlife Service
Erich Yokel	Scott River Watershed Council
Jacob Krause	USGS Klamath Falls Field Station
Karuna Greenberg	Salmon River Restoration Council
Kurt Bainbridge	California Department of Fish & Wildlife
Kyle DeJulio	Yurok Tribe
Leroy Cyr	Six Rivers National Forest
Mark Hereford	Oregon Dept of Fish and Wildlife
Mark Johnson	Klamath Water Users Association
Maureen Purcell	USGS Northwest-Pacific Islands Region
Ryan Fogerty	US Fish & Wildlife Service
Sarah Beasley	Yurok Tribe
Ted Wise	Oregon Department of Fish and Wildlife
Tommy Williams	National Oceanic & Atmospheric Administration
Monitoring - SA4 - Biological Interactions	
Benji Ramirez	Oregon Dept of Fish and Wildlife
Grant Johnson	Yurok Tribe
Justin Alvarez	Hoopa Valley Tribal Fisheries
Kurt Bainbridge	California Department of Fish & Wildlife
Maureen Purcell	USGS Northwest-Pacific Islands Region
Nicholas Som	US Fish & Wildlife Service
Ryan Fogerty	US Fish & Wildlife Service
Sascha Hallett	Oregon State University
Scott Foott	US Fish & Wildlife Service

Refer to Appendix F for listing of individuals who supported the eight (8) formal IFRMP monitoring group webinars convened between June 15th and July 19th 2021.

During the course of the Phase 3 (2019-2020) and Phase 4 (2020-2021) Plan development process, Sub-basin and Disciplinary (topic area) Working Group members were provided with a number of opportunities to provide input (below).

Major activities performed by each Sub-basin Working Group during Phase 3 (2019-2020) and Phase 4 (2020-2021) development of the Integrated Fisheries Restoration and Monitoring Plan:

Format of input	Time period	Topic
Webinar	October 22 2019	Phase 3 kick-off presentation.
Methods Webinar	January 30 2020	Initial overview of prioritization approach.
Survey (to those individuals who expressed interest January 30 2020)	January 31 2020 to February 7 2020	Survey to finalize the list of Proxy Core Performance Indicators (CPIs) used to consistently gage the level of impairment throughout the Klamath basin. Participants received instructions on the Klamath IFRMP website group portal (https://ifrmp.net/).
***Pilot* Webinar** (Scott Sub-basin Working Group)	February 12 2020	Pilot overview of our iterative process for reviewing and updating missing details associated with early (rough) candidate lists of restoration actions and collect feedback on how we can improve the rollout to other Sub-basin Working Groups. This included demonstration of early versions of collector tools. Background information, recommended readings, notes and recordings of webinar documented and shared on website group portal (https://ifrmp.net/).
Results Webinar	February 14 2020	Presentation of outcomes of the CPI survey, with aim of reaching general agreement on the final set of priority proxy CPIs to use to inform the impairment aspect of our prioritization approach.
***Pilot* Q Survey** (Scott Sub-basin Working Group)	February 24 – March 6 2020	Pilot application of Q Survey method for uncovering levels of agreement related to the implementability of classes of restoration actions. Background information, recommended readings, notes and recordings of webinar documented and shared on website group portal (https://ifrmp.net/).
Homework surveys + Webinars (all remaining Sub-basin Working Groups	March 11, 25, 26, 27, April 1, 2, 3 2020	Detailed instructions were supplied with information sought from each sub-basin team. These instructions were accompanied with an information collection tool in Excel. Once individual surveys were compiled, held first major Sub-basin Working Group webinar for reviewing and updating attributes and missing details for each sub-basin's early draft list of restoration actions that the IFRMP will consistently sequence and prioritize (starting from the lists of actions emerging from Phase 2 Draft Plan). Before this webinar, participants were provided with information collector templates, including pointers to information on candidate actions that were

Format of input	Time period	Topic
		missing. Discussions covered a range of topics including characterizing priority areas (HUC12 units) for restoration within the next 5 years, target fish species benefiting, and providing any superior local information that is in hand to inform or override our proxy CPIs, etc.). Background information, collector template files, notes and recordings of these webinars were documented and shared on the appropriate group portal (https://ifrmp.net/).
Q Survey	May 1 – June 12 2020	Sub-basin Working Group Q-Surveys in which participants of each Sub-Basin Working Group were asked to rank a series of statements about restoration needs according to their perceived level of implementability. Background information, recommended readings, notes and recordings of webinar documented and shared on website group portal (https://ifrmp.net/).
1:1 Follow-up Conversations	April – early June 2020	Based on individual input received on earlier steps ESSA Sub-basin Working Group facilitators held multiple phone conversations (supplemented by email exchanges) with sub-basin participants (e.g., to clarify comments, questions they provided).
Sub-basin Results Refinement Meetings & Initial Training in use of Klamath IFRMP Restoration Prioritization Tool	Late June – July 10 2020	KLAMATH IFRMP RESTORATION PRIORITIZATION TOOL Taking input received to date, show latest (at the time) lists of prioritized restoration actions for each sub-basin, further diagnose the accuracy of the interim results. Switch to working directly with the user friendly **Klamath IFRMP Restoration Prioritization Tool** (http://klamath.essa.com/), viewing results, adjusting settings, and exporting results for further review to Excel. Refiners provided another round of input on these questions (all of which were previously posited to the overall Sub-basin Working Groups): • What is your reaction to the default prioritizations from the tool? Are you comfortable with the top 3-5 projects listed? • Please identify and help us document any potential dependencies / sequencing considerations within the list of projects in your sub-basin. • Does it make sense to further adjust weighting factors in the Klamath IFRMP Restoration Prioritization Tool? What should the default weighting factors be? • What is an appropriate default scenario? What would change if the major mainstem dams did/did not come out? Background information, including demonstration video of the IFRMP Prioritization Tool were shared on each website group portal (https://ifrmp.net/).

Format of input	Time period	Topic
Final 1:1 Follow-up Conversations	Late June – July 2020	Based on individual input received on steps in May and June 2020, ESSA Sub-basin Working Group facilitators held select phone conversations (supplemented by email exchanges) with sub-basin participants to further clarify remaining input and advice.
Initiate Phase 4		
Addition of mapping features to Klamath IFRMP Prioritization Tool	October 2020 – January 2021	During the April-June 2020 round of work that included physically situating restoration projects (at the HUC12 scale), we heard numerous comments related to needing an easier way to interact with maps to facilitate participant input on the Plan. Specifically, how a more interactive mapping tool would better facilitate peer review by making it easier to view mapped results and identify spatial errors in HUC12s included in project or species range maps. The U.S. Fish and Wildlife Service believed that interactive mapping would provide value-added support to enable the subsequent review of the numerous restoration projects in the draft plan (this document). As such, ESSA during this period added enhanced mapping features to the Klamath Basin Restoration Prioritization Tool (http://klamath.essa.com) for use as part of the Phase 3 stakeholder/ peer review.
Klamath Phase 4 Kick-off Webinar	May 27, 2021	Basin wide webinar introducing scope, timeline and participation needs for Phase 4 IFRMP development.
Cost validation webinars	1 – Upper Basin (June 14, 2021); 2A - Upper-Mid-Klamath River (June 15, 2021)	(1) Review synthesized results from the costing homework exercise for restoration action costs and discuss any large variations in participant assessments as well as give an opportunity for the ESSA team to address emergent questions on the cost range estimation process; (2) Provide further guidance on gaps in restoration action costs via providing local/sub-regional context that where possible will support ESSA in assigning appropriate “per implementation” cost ranges to Action Types associated with proposed Klamath IFRMP projects.
Monitoring groups meeting 1	Watershed Inputs & Water Quality (June-15, 2021); Fluvial Geomorphology (June 16, 2021); Fish Habitat & Connectivity (June 18, 2021); Biological Interactions (June 21, 2021)	These disciplinary (topic area) workgroup meetings provided an opportunity for (1) subject matter experts to collaboratively evaluate the current state of monitoring of IFRMP core performance indicators (CPI) at the basin-wide scale and (2) identify key gaps and priority opportunities to improve basin-wide monitoring of CPIs.
Cost validation ‘office hour’ sessions	June 28 & 30, 2021; July 9, 15, 16, 23, 2021.	Office hour style sessions to allow participants to ask questions about methods, terminology etc. and align on consistent interpretations. These sessions also helped for further refine the costing methodology, and included some very in-depth high-quality engagement. These sessions also improved exposure of participants to Klamath IFRMP Restoration Action Prioritization Tool and how to use it in the costing process. These sessions improved cost range information available just through the databases of past projects alone.

Format of input	Time period	Topic
Monitoring groups meeting 2	Watershed Inputs & Water Quality (July 7, 2021); Fluvial Geomorphology (July 8, 2021); Fish Habitat & Connectivity (July 12, 2021); Biological Interactions (July 19, 2021)	With support of ESSA monitoring component facilitators, subject matter experts began to develop specific recommendations for basin wide monitoring of CPIs, building on the discussions in Meeting 1.
Monitoring - SA2 - Fluvial Geomorphology follow-up meeting	August 16, 2021	The purpose of this special topic meeting was to refine details/monitoring methods for the 'channel complexity' CPI and to align with the fish habitat group's approaches to evaluating channel condition.
Fish population monitoring costs meeting	April 20, 2022	Meeting to identify existing/on-going monitoring programs related to fish populations, solicit cost estimates for individual fish monitoring program annual budgets, and identify remaining monitoring gaps.
Implementation Workshop for the IFRMP for the Klamath Basin **Ashland, Oregon (in-person/virtual)** Attendance: 78 in-person/ 20 virtual 46 organizations Federal Gov. = 38 State Gov. = 19 Fed. Recognized Tribes = 15 NGOs / Conservation Partners = 26	Sept 27-29, 2022	The objectives of this workshop were to: (1) Finalize current project lists and select a shortlist of actions representing near-term priorities for funding to serve as a 'Klamath Basin Restoration Action Agenda' or RAA for the basin that can be updated in future years. (2) Finalize monitoring recommendations for tracking the state of the basin, (3) Develop and discuss practical recommendations for implementation including those relating to updating restoration priorities over time, selecting and funding specific project proposals, tracking and reporting monitoring and restoration progress over time, and suggestions for ongoing oversight of these activities at the basin-wide scale. This workshop served as a pilot test application for how practitioners in the basin might convene to periodically update the near-term restoration priorities of a 'Klamath Basin Restoration Action Agenda' as prior priorities are addressed and other conditions in the basin continue to evolve.
Groundwater monitoring costs meeting	November 15, 2022	Follow-up Meeting to clarify gaps related to groundwater and snowpack monitoring raised in the Implementation workshop, discuss monitoring approaches, and estimate costs for additional monitoring.

*All supporting materials for these events centralized on the IFRMP website (https://ifrmp.net/) and Sub-basin Working Group portals, complete with comment-response tracking.

Other participants who contributed at workshops, as peer reviewers and/or as Sub-Regional Working Group members during Phase 2 development of the Integrated Fisheries Restoration and Monitoring Plan (*who are not already identified above as participants in Phase 3 or 4):

Other Participants (Phase 2 only)	
John Alexander	Klamath Bird Observatory
Julie Alexander	Oregon State University
Andrew Braugh	California Trout
Bill Chesney	CDFW
Evan Childress	USFWS
Jenny Curtis	US Geological Survey (USGS)
Bobbie DiMonte Miller	US Forest Service (USFS) - Klamath National Forest
Gil Falcone	North Coast Regional Water Quality Control Board
Forest Fortescue	North Coast Regional Water Quality Control Board
Femke Friedberg	National Fish and Wildlife Foundation
Sascha Hallett	Bartholomew Lab at Oregon State University
Will Harling	Mid Klamath Watershed Council (MKWC)
Preston Harris	Scott River Water Trust
Heather Hendrixson	The Nature Conservancy, Oregon
Morgan Knechtle	California State Wildlife Agency
Curtis Knight	California Trout
Cynthia LeDoux-Bloom	Hoopa Valley Tribe
Ken Lindke	Cal Department of Fish and Wildlife
Robert Lusardi	California Trout and UC Davis
Joe Polos	USFWS
Sarah Rockwell	Klamath Bird Observatory
Liam Schenk	US Geological Survey (USGS)
Matthew Sloat	Wild Salmon Center
Ed Stanton	Shasta Valley RCD
Bill Tinniswood	Oregon Department of Fish & Wildlife
Jonathan Warmerdam	North Coast Regional Water Quality Control Board
Scott White	Klamath Water Users Association
Eric Wold	The Nature Conservancy

Appendix B: Restoration Action Dictionary

ACTION CODE	ACTION TYPE CATEGORY (C.0) or ACTION TYPE (C.0.0)	DEFINITION
C.1 	**Fish Screening (general)**	Projects that result in the installation, improvement or maintenance of screening systems that prevent fish from passing into areas that do not support fish survival; for example, into irrigation diversion channels.
C.1.c	**Fish screens installed**	New fish screens installed where no screen had existed previously.
C.1.d	**Fish screens replaced or modified**	Pre-existing fish screens that are replaced, repaired or modified.
C.1.e	**Non-physical barrier devices installed**	Includes non-physical fish-protection devices, such as louvres or sensory deterrents.
C.10.a	**Conservation easement**	A conservation easement is a legal agreement between a conservation body and a landowner that determines permissible and restricted land uses on that property.
C.2 	**Fish passage improvement (general)**	Projects that improve or provide anadromous fish (and potentially other native aquatic organisms) migration up and down stream including fish passage at road crossings (bridges or culverts), barriers (dams or log jams), fishways (ladders, chutes or pools), and weirs (log or rock).
C.2.c-Major	**Major dams removed**	Removal of major dams to allow fish passage and to help restore natural flow regimes.
C.2.c-Minor	**Minor fish passage blockages removed or altered**	Removal or alteration of blockages, impediments or barriers to allow or improve fish passage (other than road crossings reported in C.2.f to C.2.i).
C.2.d	**Fishway chutes or pools Installed**	Placement of an engineered bypass for fish to pass more safely around or over a barrier (other than fish ladder). This includes bedrock chutes, weirs, rock boulder step pools, chutes constructed/roughened in bed rock, and engineered channel structures.
C.2.e	**Fish ladder Installed / improved**	Installation or modification (upgrade/improvement) of a fish ladder.
C.2.f.	**Culvert installed or Improved at road stream crossing**	Installation or improvement/upgrade (including replacement) of a culvert to a standard that provides juvenile and adult fish passage.

ACTION CODE	ACTION TYPE CATEGORY (C.0) or ACTION TYPE (C.0.0)	DEFINITION
C.2.g	**Bridge installed or improved at road stream crossing**	Installation, improvement/upgrade or replacement of a bridge over a stream to provide/improve fish passage under a road. The bridge could be replacing a culvert.
C.2.h	**Rocked ford - road stream crossing**	Placement of a crushed gravel reinforced track through a stream that still allows unimpeded stream flow. This could replace a dysfunctional culvert.
C.2.i	**Road stream crossing removal**	Removal of stream road crossing and the affiliated road structures so that the stream flows unimpeded. This would include removal of culverts and other material in the channel.
C.2.j	**Fish translocation**	Translocation of fish past barriers using trap and haul or other methods.
C.3	**Instream flow project (general)**	Projects that maintain and/or increase the flow of water to provide needed fish habitat conditions. This can include water rights purchases/leases, or irrigation practice improvements (reduced flow into fields) including water conservation projects to reduce stream diversions or extractions.
C.3.d	**Water flow gauges**	Water gauges installed to measure and regulate water use.
C.3.e	**Irrigation practice improvement**	Improvement of irrigation practices (where water is removed from a stream) to protect fish. This includes: installing a headgate with water gauge to control water flow into irrigation canals and ditches; regulating flow on previously unregulated diversions; installing a well or storage holding tanks to eliminate a diversion; or, replacing open canals with pipes to reduce water loss to evaporation and dedicating the saved water to aquatic resources.
C.3.f	**Water leased or purchased**	Water that is leased or purchased, and thus not withdrawn from the stream. This includes the purchase of water rights.
C.3.g	**Manage water withdrawals**	Preventing or reducing water withdrawals from stream (including water rights acquisitions, dedications, transfers).
C.3.h.1	**Manage dam releases (Klamath)**	This action is specific to the Klamath where Klamath flows may be regulated to some extent to provide cooling and improved flows in the mainstem Klamath River
C.3.h.2	**Manage dam releases (Trinity and Lewiston)**	This action is specific to the Klamath where Trinity flows may be regulated to some extent to provide cooling and improved flows in the mainstem Klamath River downstream of the Trinity confluence.

ACTION CODE	ACTION TYPE CATEGORY (C.0) or ACTION TYPE (C.0.0)	DEFINITION
C.3.h.3	**Manage dam releases (Link and Keno)**	This action is specific to the Klamath where Link RIver flows may be regulated to some extent to provide cooling and improved flows in the mainstem Klamath River downstream of the Keno and Link River dams.
C.4	**Instream habitat project (general)**	Projects that increase or improve the physical conditions within the stream environment (below the ordinary high water mark of the stream) to support increased fish population.
C.4.c	**Mechanical channel modification and reconfiguration**	Changes in channel morphology, sinuosity or connectivity to off-channel habitat, wetlands or floodplains. This includes instream pools added/created; removal of instream sediment; meanders added; former channel bed restored; removal or alteration of levees or berms (including setback levees) to connect floodplain; and, creation of off-channel habitat consisting of side channels, backwater areas, alcoves, oxbows, ponds, or side-pools.
C.4.d	**Channel structure placement**	Placement of large woody debris or rocks/boulders (including deflectors, barbs, weirs) to collect and retain gravel for spawning habitat; deepen existing resting/jumping pools; create new pools above and/or below the structure; trap sediment; aerate the water; channel roughening; or, promote deposition of organic debris. This includes floodplain roughening or fencing.
C.4.e	**Streambank stabilization**	Stabilization of the streambank through resloping and/or placement of rocks, logs, or other material on streambank.
C.4.f	**Spawning gravel placement**	Addition of spawning gravel to the stream either in locations where high flows in the near future will entrain and distribute gravel downstream as bars or riffles, or instead placed directly at spawning sites.
C.4.g	**Plant removal/control**	Removal or control of aquatic non-native plants, invasive species or noxious weeds growing in the stream channel and riparian. Removal of aquatic vegetation in wetlands to provide habitat mosaic.
C.4.h	**Beavers & beaver dam analogs**	Introduction or management of beavers to add natural stream complexity (beaver dams, ponds, etc.). Restoration of aquatic habitat to support beaver populations through the usage of deciduous shrub and trees, beaver dam analogs (BDA) or post-assisted woody structures (PAWS).

ACTION CODE	ACTION TYPE CATEGORY (C.0) or ACTION TYPE (C.0.0)	DEFINITION
C.4.i	**Predator/competitor exotic fish species removal**	Control or removal of invasive, non-native/alien fish species fish predators or competitors (e.g., northern pike minnow, non-native fish, invasive animals) from the instream habitat, including construction of barriers to limit the expansion of non-native fish into uninvaded reaches.
C.4.j	**Constrain bottom disturbing activities**	Restriction of activities that could disturb benthic communities or release contaminants stored in river/lake/stream sediments
C.4.k	**Remove contaminated sediments**	Dredging or removal of sediments contaminated with nutrients, metals, oxygen-demanding substances, and persistent toxic organic chemicals
C.5 Riparian Habitat	**Riparian habitat project (general)**	Projects that change areas (above the ordinary high water mark of the stream and within the flood plain of streams) in order to improve the environmental conditions necessary to sustain fish throughout their life cycle. This includes lakeshores of connected lakes.
C.5.c	**Riparian planting**	Riparian planting or native plant establishment.
C.5.d	**Fencing**	Creation of livestock exclusion or other riparian fencing. Open watercourses are assumed to provide open access to cattle.
C.5.e	**Riparian exclusion**	Preventing or removing access to riparian areas by means other than fencing.
C.5.f	**Water gap development**	Installation of a fenced livestock stream crossing or livestock bridge.
C.5.g	**Riparian area conservation grazing management**	Alteration of agricultural land use practices to reduce grazing pressure for conservation (e.g., rotate livestock grazing to minimize impact on riparian areas).
C.5.h	**Riparian plant removal / control**	Removal and/or control (treatment) of non-native species, noxious weeds and other plants or invasive species that adversely affect the riparian zone or water table.
C.5.i	**Riparian Forest Management (RFM)**	Treating or managing trees and undergrowth in riparian area including fuel reduction treatments, prescribed burnings, stand thinning, girdling, stand conversions, and silviculture.
C.5.j	**Debris/structures removal**	Removal of debris (e.g., tires, appliances) or structures (e.g., old cabins) from the riparian area to allow growth of riparian vegetation.
C.5.k	**Remove feral cattle**	Lethal removal feral cattle by hunting or live removal by professional wranglers.

ACTION CODE	ACTION TYPE CATEGORY (C.0) or ACTION TYPE (C.0.0)	DEFINITION
C.6	**Upland habitat and sediment processes (general)**	Landscape level projects implemented above the elevation of the riparian zone (above the floodplain) that are intended to benefit fish habitat (for example, reducing/eliminating sediment flow from upland areas into streams).
C.6.a	**Restore physical process**	Streamflows, mechanical restoration, and sediments combine to restore key physical processes to support a self-maintaining dynamic channel, including bed scour, sediment transport, riparian initiation and establishment, and floodplain development and connectivity, among others.
C.6.b.1	**Manage coarse sediment scour, deposition, and transport**	Develop targets of scour, deposition, and transport by reach necessary to restore physical processes and promote channel complexity across a range of flows. Manage flows and sediment budgets to meet those targets.
C.6.b.2	**Augment coarse sediment**	Add coarse sediment downstream of Iron Gate Dam to mitigate deficit caused by the dam.
C.6.c	**Road drainage system improvements and reconstruction**	Road projects that reduce or eliminate sediment transport into streams. This includes placement of structures or rolling dips to contain/ control run-off from roads, road reconstruction or reinforcement, surface, inboard ditch, culvert and peak-flow drainage improvements, and roadside vegetation. These roads may extend into or are in the riparian zone.
C.6.d	**Road closure / abandonment**	Closure (abandonment), relocation, decommissioning or obliteration of existing roads (including pavement such as parking areas) to diminish sediment transport into stream and/or improve riparian habitat. These roads/pavement may extend into or are in the riparian zone.
C.6.e	**Erosion control structures installed**	Construction/placement of sediment basins, sediment collection ponds, sediment traps, or water bars (other than road projects (see C.6.c) or upland agriculture (see C.6.i)).
C.6.f	**Planting for erosion and sediment control**	Upland projects that control erosion through planting and revegetation or grassed waterways.
C.6.g	**Slope stabilization**	Implementation of slope/hillside stabilization, bioengineering or slope erosion control methods including landslide reparation and non-ag terracing.

ACTION CODE	ACTION TYPE CATEGORY (C.0) or ACTION TYPE (C.0.0)	DEFINITION
C.6.h	**Upland vegetation management including fuel reduction and burning**	Upland vegetation treatment or removal projects for water conservation or sediment control including plant removal (e.g., juniper removal or noxious weeds), selective tree thinning, undergrowth removal, fuel reduction treatments, prescribed burnings, stand conversions, and silviculture.
C.6.i	**Upland agriculture management**	Implementation of best agricultural management practices such as low or no till agriculture, conservation land management; or, upland irrigation water management for water conservation.
C.6.j	**Upland livestock and grazing management**	Upland livestock management action designed to control sediment flow into a stream or riparian area. This includes livestock watering schedules; grazing management plans; upland exclusion and fencing; and, livestock water development (also called off-channel watering or livestock water supply) including installation of upland ditches, wells, and ponds.
C.6.k	**Trail or campground improvement**	Improvements to trails or campgrounds that are designed to control sediment flow into a fish bearing stream. These trails/campgrounds may extend into or are in the riparian zone.
C.6.l	**Upland wetland improvement**	Projects designed to protect, create or improve upland wetlands (wetlands that are not connected to a stream, and are instead charged by groundwater or precipitation).
C.6.m	**Manage fine sediment deposition and transport**	Develop targets for fine sediment deposition and transport by reach to minimize negative impacts to some fisheries (e.g. salmon redds) and maximize other benefits to others (e.g lamprey rearing habitats, riparian establishment).Mobilization of fine sediments is also necessary for fish disease management and prevention purpose.
C.7 Water Quality	**Water quality project (general)**	Projects that improve instream water quality conditions for fish or reduce impacts of instream point/non-point pollution. This includes improved water quality treatment; nutrient enhancement through carcass placement; return flow cooling; removal or prevention of toxins, sewage or refuse; or, the reduction or treatment of sewage outfall and/or stormwater.
C.7.d	**Refuse/debris removal**	Removal of garbage/trash from stream, wetland or other inland body of water used by fish. This would include removal of derelict fishing gear or ghost nets from rivers and lakes.

ACTION CODE	ACTION TYPE CATEGORY (C.0) or ACTION TYPE (C.0.0)	DEFINITION
C.7.e	**Clean up sewage**	Reduction or clean-up of sewage outfall including failed septic systems.
C.7.f	**Clean up past chemical contamination**	Clean-up or prevention of mine or dredge tailings or toxic sediments.
C.7.g	**Reduce herbicide / pesticide use**	Reduce usage of herbicides, pesticides, or other chemical products.
C.7.h	**Carcass or nutrient placement**	Placement of fish carcasses, fish meal bricks, or other fertilizer in or along the stream for nutrient enrichment.
C.7.i	**Livestock manure management**	Relocation or modification of livestock manure holding structures and/or manure piles to reduce or eliminate drainage into streams.
C.7.j	**Stormwater / wastewater modification or treatment**	Modifications to stormwater/wastewater and drainage into stream to improve water quality. Includes bioswales and rain gardens.
C.7.k	**Return flow cooling**	Return flow cooling projects where extracted water that has heated during use is cooled before it is returned to the stream. This can occur in power plants, large industry, and smaller applications which generally consist of replacing old open return ditches with underground PVC pipe (purpose is eliminate to thermal loading by filtering flows underground where they can cool before discharge in streams).
C.7.l	**Reduce fertilizer use**	Reduction of fertilizer applications on agricultural or other lands.
C.7.m	**Rotate crops and wetlands**	Crop rotation program allowing flooding of fields and return to wetland between planting years, providing intermittent habitat and water quality benefits.
C.7.n	**Tailwater return reuse or filtering**	Capturing drainage from fields and using it on fields or directing it to wetlands and/or bioswales for treatment before discharge to subsurface piping leading to streams.
C.7.o	**Stormwater filtering**	Capture and filtering of stormwater through bio-swales or wetlands or both before discharge in streams.
C.7.p	**Algae harvest**	Mechanical harvesting of lake algae
C.7.q	**Dredging of lake or reservoir sediment**	Dredging of lake sediments. Sediment to be disposed of on land (e.g., landfill or as in-fill in landscaping or agriculture projects).
C.7.r	**Targeted aeration for fish refugia**	Oxygen injection via compressed air diffuser or direct oxygen injection by mechanical means in part or all of an enclosed water body (e.g., lake, impoundment, etc.). In the context of the Klamath Basin, this applies to Upper Klamath Lake and Keno Reservoir.

ACTION CODE	ACTION TYPE CATEGORY (C.0) or ACTION TYPE (C.0.0)	DEFINITION
C.7.s	**Phosphorus immobilization using alum**	Alum is a chemical compound containing aluminum and sulfate that when added to water forms a semisolid matrix commonly referred to as a flocculant that inhibits exchange at the water-sediment interface, thus limiting phosphorus return from sediments
C.7.u	**Reduction of impacts related to illegal marijuana grow clean-ups**	Clean-up of illegal marijuana grows that have been cleared by law enforcement and pose risk to aquatic ecosystems. Actions included in this activity would be accomplished by hand or through the utilization of heavy equipment when existing road access permits.
C.8	**Wetland project (general)**	Projects designed to improve connected wetland, meadow or floodplain areas (wetlands that are connected to the stream/riparian area) that are known to support fish production.
C.8.c	**Wetland planting**	Planting of native wetland species in wetland areas.
C.8.d	**Wetland plant removal / control**	Removal and/or control (treatment) of non-native species, noxious weeds and other plants or invasive species that adversely affect the wetland area or water table.
C.8.e	**Wetland improvement / restoration**	Improvement, reconnection, or restoration of existing or historic wetland (other than vegetation planting or removal (C.8.c and C.8.d)).
C.8.f	**Artificial wetland created**	New (artificial) wetland created in an area not formerly a wetland. This is wetland area created where it did not previously exist..
C.9	**Estuarine / nearshore project (general)**	Projects that result in improvement of or increase in the availability of estuarine or nearshore marine habitat (tidally influenced areas) such as tidal channel restoration, tidal floodplain connectivity, tidegate fish passage or diked land conversion.
C.9.c	**Channel modification**	Deepening or widening an existing tidal channel or adding structures to improve fish habitat. This includes creation of new channels that provide or improve intertidal flow to existing estuarine habitat.

ACTION CODE	ACTION TYPE CATEGORY (C.0) or ACTION TYPE (C.0.0)	DEFINITION
C.9.d	**Dike or berm modification / removal**	Removal, breaching, reconfiguration or other action affecting the physical presence of barriers or structures that prevent tidal or riverine access to the estuary. Modification/removal allows for natural flow/flood regime and potential for off-channel habitat usage. This involves lateral structures only, and does not include dams or other perpendicular obstructions to flow.
C.9.e	**Tidegate alteration / removal**	Changes to tidegates that allow water to flow freely when the tide goes out, but prevent water from flowing in the other direction. Changes are generally made to allow fish passage at low and high tide.
C.9.f	**Estuarine culvert modification / removal**	Modification or removal of culvert to improve fish passage between estuarine and off-channel areas.
C.9.g	**Removal of existing fill material**	Removal of fill that isn't associated with a dike (e.g., removal of tideflat fill) or other improvement that reconnects the estuary to the stream or wetland.
C.9.h	**Fill placement**	Placement of fill to raise elevations to allow for proper terrestrial function. Could be to overcome past excavations, to raise portions of a site above tide level for upland vegetation.
C.9.i	**Regrading of slope**	Shaping of terrestrial or aquatic slopes to achieve proper function. Usually done with land based equipment.
C.9.j	**Estuarine plant removal / control**	Removal and/or control (treatment) of non-native species, noxious weeds and other plants or invasive species that adversely affect the estuarine area.
C.9.k	**Shoreline armor removal or modification**	Removal or modification of shoreline armoring structures or bulkheads.
C.9.l	**Beach nourishment**	Physical placement of natural (but not necessarily local) beach substrates to a beach, stretch of shoreline or other location where historic supplies have either been eliminated or are insufficient to overcome existing degradations. This action also includes actions where native materials are allowed to naturally (passive) or through human intervention (active) enter the drift cell.
C.9.m	**Contaminant removal / remediation**	Physical removal (through chemical remediation or biological treatment, if possible) of chemical contamination/hazardous wastes found in the nearshore environment, or prevention of contaminant sources (stormwater modification). Work can benefit fish intertidal, sub-tidal and supra-tidal habitat conditions.

ACTION CODE	ACTION TYPE CATEGORY (C.0) or ACTION TYPE (C.0.0)	DEFINITION
C.9.n	**Debris removal**	Removal of solid waste, derelict and otherwise abandoned items in the nearshore and estuarine areas including bays. Common examples include derelict fishing gear, sunken refuse (vessels, cars), pilings, or other discrete items that adversely affect fish habitat. Does not include removal of fill or contaminated sediments.
C.9.o	**Overwater structure removal / modification**	Modification or removal of overwater structures such as piers, floating decks and docks. Improperly constructed overwater structures can affect light penetration and growth of eelgrass, or provide habitat to predators. Large overwater structures may affect fish behavior. Physical process at play is related to shading and access of solar radiation to Submerged Aquatic Vegetation (SAV).
C.9.p	**Exclusion devices**	Deployment of physical exclusion devices to prevent unwanted disturbance of a restoration feature. Commonly includes fencing to keep public/animals away from delicate or newly planted vegetation, installation of mooring buoys, boardwalks/trails, etc.
C.9.q	**Creation of new estuarine area**	Creation of an estuarine area where one did not exist previously using methods not including tidegates or dikes.
C.9.r	**Estuarine planting**	Estuarine planting or native plant establishment.
C.9.s	**Addition of large woody debris**	Adding large woody debris to help recruit natural sediment and restore natural beaches at the mouths of estuaries.

Appendix C: Methods Used to Estimate Restoration Action Cost Ranges

To establish a estimated estimate of cost ranges associated with projects proposed under the Klamath IFRMP we used a multistep process that included: 1) acquisition and synthesis of existing restoration action cost databases into a single cost database, 2) outreach to experts using a facilitated elicitation exercise and "office-hour" style web meetings, and 3) synthesis of homework responses and cross-validation of cost ranges with available standardized cost documentation. While we were unable to assign cost ranges for all IFRMP restoration actions in all sub-basins, our extensive triangulation of information permitted a reasonable first approximation of cost ranges for 73 (50%) of 146 projects, and the use of proxy cost ranges for 62 (42%) additional projects for **a total of 135 (92%) of 146 projects fully costed**. The remaining projects (7.5%) either had no cost data available or had only partial data (e.g., per unit costs only) with substantial gaps that could not be filled without carrying out a more detailed and targeted assignment.

Appendix D provides expanded cost range results for each project by sub-basin. For each restoration action type and project, Appendix E provides cost range results per implementation as well as expanded cost ranges based on the number of implementations needed to address the project **over the next 2-5 years**.

Below we describe the methods we used to arrive at these expanded cost ranges for each of the three steps described above.

Step 1. Database synthesis

We identified and acquired **22 cost databases** for restoration projects *within* the Klamath basin primarily through internet searches and engagement with participants during previous phases of the IFRMP process. To ensure collected data was in scope and useful for our purposes, only projects that undertook restoration actions matching Action Types in our **IFRMP Action Dictionary** (Appendix B) were included in our synthesized database. Several datasets were integrated, including data received from the following agencies / data sources:

Table C - 1: Data sources used for synthesized cost database.

Data Source	Definition
CalFish	CalFish
CalTrout	California Trout
CoastalConservancy_Direct	Coastal Conservancy
EPA_GRTS	Environmental Protection Agency Grants Reporting and Tracking System
EQIP	US Department of Agriculture Environmental Quality Incentives Program

KDSS-WIT	KDSS Watershed Improvement Tracking
KTAP Database	Klamath Basin Monitoring Program Klamath Tracking and Accounting Program
NFWF_2012_BBNGrantSlate	National Fish and Wildlife Foundation
NFWF_2016GrantSlate	National Fish and Wildlife Foundation
NOAA_PCSRF	NOAA Pacific Coastal Salmon Recovery Fund
NOAA_PNSHP	Pacific Northwest Salmon Habitat Project
NOAA_PNW	NOAA Pacific Northwest
NOAA_RestorationCenter	NOAA Restoration Center
ODFW_Direct	Oregon Department of Fish & Wildlife
OFPBDS	Oregon Fish Passage Barrier Data Standard
ORWI_Direct	Oregon Watershed Enhancement Board Oregon Watershed Restoration Inventory
OWEB_2016GrantSlate	Oregon Watershed Enhancement Board
TroutUnlimited_Direct	Trout Unlimited
TRRP_Direct	Trinity River Restoration Program
UC_Davis_NRPI	UC Davis Natural Resources Project Inventory
USFWS_PFW	US Fish and Wildlife Service - Partners for Fish & Wildlife
USFWS_YrekaOffice	US Fish and Wildlife Service - Yreka

Because each of the datasets had unique formatting and attributes, merging them into one meta-database required different approaches specific to each dataset, but generally involved matching data to our main meta-database using unique identifier codes, cleaning activity names to match those from the IFRMP Action Dictionary, and omitting any data that could not be clearly assigned to a specific action type from this dictionary. For example, two components of a project within the EQIP dataset were coded as “Restoration and Management of Rare or Declining Habitats”, which could be matched to multiple action types in the IFRMP Action Dictionary and so we opted to omit (remove) these two instances from the EQIP data.

For all project costs that had implementation years indicated in the final database, we adjusted the values for inflation to **2020 USD using the Consumer Price Index**[1] (“Cost” column in the database). Data that lacked start or end years could not be inflation-adjusted and so we did not use these data during the subsequent cost analysis to determine cost ranges. However, in Appendix E, as metadata, we do report some cost ranges from standardized cost documentation that have not been inflation adjusted.

When available, we also captured other attributes in addition to costs, like project name and description, start and end years, project status, project size (scale) and units, latitude and longitude, funding agency, grant program, cooperating agencies, sponsors, site names, species of focus, HUC6 and HUC12 codes, and notes. However, many of these attributes were only available from a subset of datasets.

[1] CPI adjustment factors were determined for each “Start_Yr” using the US Inflation Calculator available at https://www.usinflationcalculator.com/

The table below lists all field names contained in our synthesized meta-database along with a short description.

Table C - 2: IFRMP meta- cost database field names and descriptions.

Database Field Name	Description
ID	Database ID
DB_Origin	Original Dataset Source
Fund_Agency	Funding Agency
Grant_Prog	Grant Program
ProjectPK	Project Identifier
WorksitePK	Worksite Identifier
Sponsor_Detailed	Project Sponsor (Specific)
Sponsor	Project Sponsor (General)
Spons_Funding	Funding Supplied by Sponsor
Coop_Agencies	Cooperating Agencies
Proj_Name	Project Name
Proj_Description	Project Description
Site_Name	Site Name
Species_1	Species of Interest 1
Species_2	Species of Interest 2
Species_3	Species of Interest 3
Start_Yr	Project Start Year
End_Yr	Project End Year
Status	Project Status
Cost_Orig	Cost (Not Inflation-Adjusted)
CPI_Adj_Factor	CPI (Inflation) Adjustment Factor (based on "Start Year")
Cost	CPI-Adjusted Cost
HUC6	Hydrologic Unit Code 6
Basin	Basin in which the project is located
HUC8	Hydrologic Unit Code 8
Sub-basin_Old	Original Sub-basin Identifier
Sub-basin	Sub-basin in which the project is located
HUC10a	Hydrologic Unit Code 10a
Watershed	Watershed in which the project is located
Subwatershed	Subwatershed in which the project is located
County	County in which the project is located
ESUS	Evolutionarily Significant Units
State	State in which the project is located
Longitude	Longitude (Decimal Degrees)
Latitude	Latitude (Decimal Degrees)
Locn_Type	Described in what format the location is provided (e.g. polygon)
Proj_Type	Type of Restoration Project (General)
Analysis_Scale	Field of HUC
PrivLand	Whether or not the project took place on private land

Activity_Category	Activity Category under which the Activity (Action) Type occurs
Activity_Type	Restoration Action Type (see IFRMP Action Dictionary for full list)
CountCol	Indicates how many unique sub-projects have been rolled-up (summed) into the corresponding row in the database
HUC12	Hydrologic Unit Code 12
Project_Size	Size of Project
Miles	Miles
Acres	Acres
Square_Miles	Square Miles
River_Miles	River Miles
Acre_or_Feet	Acre or Feet
Acre_or_Number	Acre or Number
Feet	Feet
Sites	Sites
Cubic_Yards	Cubic Yards
cfs	Cubic Feet per Second
GPD	Gallons per Day
Project_Size_Units	Units of Project Size Value
Number_of_Structures	Number of Structures
Notes	Notes

In some cases, data from our source databases were only available in aggregate form for some attributes like project size (i.e., multiple action types were captured in the project size estimate). Where this was the case, we split the data evenly by the number of action types. For example, the ORWI_Direct dataset has a single project with a size of 22 riparian miles that is composed of two sub-projects, one pertaining to fencing and the other pertaining to road drainage system improvement. We split this into 11 miles for each action type to create two separate project records. Some data records lacked information about sub-projects and were therefore not possible to disaggregate in this way. We omitted these projects from our synthesized meta-database. Also, some datasets reported project cost data disaggregated by funding source. Where this was true, we summed the data across all funding sources to get total project costs, which were then incorporated into the main database.

For the special case of NOAA's PCSRF data, main projects were often broken into multiple sub-projects for the same activity type as shown in the image below.

BR	BS	BT	BU	BV	BW	BX
Upland Habitat / Sediment Funding ($)	Acres of upland habitat area treated (Acres)	Miles of road treated in upland area (Miles)	Miles of road treated for drainage system improvements and reconstruction	Average width of road treated for drainage improvements and reconstruction.	Miles of road closed / abandoned (Miles)	Erosion / sediment control installations (#)
C.6.a	C.6.b.1	C.6.b.2	C.6.c.2	C.6.c.3	C.6.d.2	C.6.e.3
28229	2.3	0.35			0.35	
28229	16.8	2.59			2.59	
28229	10.4	1.6			1.6	
28229	5.2	0.8			0.8	
28229	16.1	2.47			2.47	
28229	2.8	0.43			0.43	
28229	1	0.15			0.15	
28229	21.3	3.28			3.28	
28229	2.2	0.34			0.34	
28229	13	2			2	
28229	1.6	0.25			0.25	
28229	9.8	1.5			1.5	
28228	27.5	4.23			4.23	

Figure B - 1: Example of multiple sub-projects within a single main project in NOAA PCSRF database.

When this was the case, we summed the project costs and size units (e.g., miles, acres, structures, etc.) within the same action type (column) and incorporated these into our IFRMP cost meta-database as a single amount for that action type. We still captured the sub-project breakdown for these data in the main database to retain a record of fine-scale project size and cost information, but we only used the aggregated data to generate cost range estimates.

Using the final compiled cost meta-database, we used minimum values and terciles (outliers removed) to develop **high, medium, and low cost ranges** for each action type, which we then used to prepare **Action Type Cost Profiles** to support the next cost refinement step with participants. For example, a low cost range goes from the minimum cost in the dataset for a project of that action type to the cost amount under which 33% of the data reside for that action type. A medium cost range uses that 33% threshold as its lower bound and the cost amount under which 66% of the data reside for that action type as the upper bound. A high cost range follows the same pattern but with an upper bound using the 99% cost threshold.

Step 2. Cost range refinement with participating experts

We held an introductory webinar to introduce the broader group to the cost range refinement task and to clarify volunteers for each of 3 Regions. Region 2 was split into 2a and 2b to reduce group size. The tables below show all invited participants and sub-basins assigned to each group.

COSTING - R1 - Upper Basin (Williamson, Sprague, UKL, Lost)

INVITEE	ORGANIZATION
Clayton Creager*	North Coast Regional Water Quality Control Board
Eric Reiland*	Bureau of Reclamation
Mark Buettner*	Klamath Tribes
Leigh Ann Vradenberg	Klamath Watershed Partnership
Mark Hereford	Oregon Dept of Fish and Wildlife
Mark Johnson	Klamath Water Users Association
Melissa Olson	The Nature Conservancy
Tyler Hammersmith	US Fish & Wildlife Service

*contributed responses to homework exercises and/or participated in ESSA "office hours"; gray shading = invited but did not participate

COSTING - R2a - Upper-Mid-Klamath River (MKR, UKR)

INVITEE	ORGANIZATION
Bob Pagliuco*	NOAA - National Marine Fisheries Service (NMFS)
Charles Wickman*	Mid Klamath Watershed Council
Jon Grunbaum*	Klamath National Forest
Ryan Fogerty	US Fish & Wildlife Service
Leroy Cyr*	Six Rivers National Forest
Mitzi Wickman*	Mid Klamath Watershed Council
Don Flickinger*	NOAA - National Marine Fisheries Service (NMFS)
Grant Johnson*	Karuk Tribe
Toz Soto*	Karuk Tribe
Chad Abel*	Bureau of Reclamation
Eric Reiland	Bureau of Reclamation
Barry McCovey	Yurok Tribe
Tommy Williams	National Oceanic & Atmospheric Administration

*contributed responses to homework exercises and/or participated in ESSA "office hours"*contributed responses to homework exercises and/or participated in ESSA "office hours"; gray shading = invited but did not participate

COSTING - R2b - Mid-Upper Basin (Scott, Salmon, Shasta)

INVITEE	ORGANIZATION
Ada Fowler*	California Trout
Betsy Stapleton*	Scott River Watershed Council
Bob Pagliuco*	NOAA - National Marine Fisheries Service (NMFS)
Ryan Fogerty*	US Fish & Wildlife Service
Justin Alvarez*	Hoopa Valley Tribal Fisheries
Amy Campbell	The Nature Conservancy
Bill Pinnix	US Fish & Wildlife Service
Crystal Robinson	Quartz Valley Indian Reservation
Eli Scott	North Coast Regional Water Quality Control Board
Ethan Brown	Shasta Valley Resource Conservation District
Karuna Greenberg	Salmon River Restoration Council
Matt Parker	Siskiyou County California

Michael Belchik	Yurok Tribe
Rod Dowse	Shasta Valley Resource Conservation District
Toz Soto	Karuk Tribe

*contributed responses to homework exercises and/or participated in ESSA "office hours"; gray shading = invited but did not participate

COSTING - R3 - Lower Basin (LKR, Trinity, South Fork Trinity)

INVITEE	ORGANIZATION
David Gaeuman*	Yurok Tribe
Gregory Schrott*	US Fish & Wildlife Service
Justin Alvarez*	Hoopa Valley Tribal Fisheries
Kyle de Julio*	Yurok Tribe
Mark Villers*	Blue Ridge Timber Cutting
Oliver Rogers*	Bureau of Reclamation
Barry McCovey	Yurok Tribe
Bill Pinnix	US Fish & Wildlife Service
Bob Pagliuco	NOAA - National Marine Fisheries Service (NMFS)
Chad Abel	Bureau of Reclamation
Dan Gale	Arcata USFWS Office PFW Program
Eric Reiland	Bureau of Reclamation
Mike Dixon	Bureau of Reclamation
Nick Hetrick	US Fish & Wildlife Service
Sarah Beesley	Yurok Tribe
Tommy Williams	National Oceanic & Atmospheric Administration
Wade Sinnen	California Department of Fish & Wildlife
DJ Bandrowski	Yurok Tribe

*contributed responses to homework exercises and/or participated in ESSA "office hours"; gray shading = invited but did not participate

We issued the cost range refinement task as a voluntary homework exercise using five main materials: 1) a set of instructions posted at https://kbifrm.psmfc.org, 2) one Excel spreadsheet per sub-basin for responses, 3) a Word document containing Action Type Cost profiles as supporting material, 4) a link to the Klamath IFRMP Restoration Prioritization tool as additional supporting material, and 5) an Excel document containing an Action Type dictionary with descriptions of each Action Type to be costed.

We asked participants to view each project's description in the Klamath IFRMP restoration prioritization tool, and to review the focal HUC12s assigned to that project by participants during previous IFRMP phases. Each proposed IFRMP project is assigned *at least* one Action Type, but many are assigned multiple Action Types. For each project, we asked participants to provide cost ranges in the Excel spreadsheet *per Action Type*, **given the location and context of the project provided in the Klamath IFRMP restoration prioritization tool**. We also asked how many implementations of the Action Type would be needed at that cost range to accomplish the project's goals within the next 2-5 years, how confident participants were in their response (H, M, L), and provided an opportunity for additional comments. Figure C - 2 shows an example homework Excel sheet for the Lost sub-basin, with project numbers listed in the leftmost column.

Project number	Action Types	Action Type Cost Profile Available?	Cost Range of a typical SINGLE implementation of the Action Type in this subbasin (H, M, L) Use Action Type Cost Profiles. Type in a $ range estimate if no Action Type Cost Profile available or if you think data quality is insufficient	Confidence in Cost Range (H, M, L)	Number of implementations needed To bring this Project to completion in 2-5 years considering all parts of the sub-basin highlighted in dark grey in the HUC12 tab of the web tool	Comments General feedback + projects or p
1	Instream flow project (general)	Yes (low data quality)				
	Irrigation practice improvement	Yes				
9	Instream habitat project (general)	Yes (low data quality)				
	Riparian planting	Yes				
	Fencing	Yes				
	Wetland improvement/ restoration	Yes				
3	Water leased or purchased	Yes				
	Manage water withdrawals	No				
8	Fish ladder Installed / improved	Yes				
7	Fish ladder Installed / improved	Yes				
10a	Instream habitat project (general)	Yes (low data quality)				
	Mechanical channel modification and reconfiguration	Yes				
9d	Fencing	Yes				
2	Mechanical channel modification and reconfiguration	Yes				
5	Fish screens installed	Yes				
10b	Instream habitat project (general)	Yes (low data quality)				
	Mechanical channel modification and reconfiguration	Yes				

Figure C - 2: Example homework Excel sheet.

The Action Type Cost profiles leveraged the master cost database to assist participants in refining cost ranges for proposed Klamath IFRMP projects. We asked participants to use high, medium and low cost ranges in the Action Type Cost Profiles as supporting information to identify the most appropriate cost ranges per Action Type for a project (i.e., H,M,L). Figure C-3 shows an example for the Action Type "Artificial Wetland Created".

Artificial Wetland Created

Supporting information:

Cost ranges from existing databases for a single implementation of this Action Type*	**Low** $3.4 – 14.4K	**Medium** $14.4 – 44.7K	**High** $44.7 – 127.8K
Main subbasin(s) these data are from	Shasta, Upper Klamath Lake	Lost, Upper Klamath Lake	Lost, Upper Klamath Lake
Main database(s) these data are from	USFWS_PFW	USFWS_PFW	USFWS_PFW, NOAA_PNW

Figure C - 3: Example supporting information in Action Type Cost Profiles.

In some cases, this supplementary information was insufficient for participants to identify Action Type cost ranges, so, based on participant feedback, we added a worksheet to each Action Type Cost Profile that allowed participants to work through identifying cost drivers, unit measures per implementation, and number of implementations needed to determine a final cost range that could be assigned to the Action Type in the Excel spreadsheet (see Figure C - 4).

Artificial Wetland Created			
Supporting information:			
Cost ranges from existing databases for a single implementation of this Action Type*	**Low** $3.4 – 14.4K	**Medium** $14.4 – 44.7K	**High** $44.7 – 127.8K
Main subbasin(s) these data are from	Shasta, Upper Klamath Lake	Lost, Upper Klamath Lake	Lost, Upper Klamath Lake
Main database(s) these data are from	USFWS_PFW	USFWS_PFW	USFWS_PFW, NOAA_PNW
If, for a specific project, you cannot assign the above cost ranges to this Action Type (e.g., no data or ranges seem off), please fill in the following:			
List key cost drivers, other than the number of units, typically associated with L/M/H implementations of this action type (biggest drivers only - – see Worked Example for guidance):			
Driver 1____?			
etc...			
<insert rows as needed>			
Recommended standard cost unit for this Action Type (e.g., 1 mile, 1 ha, 1 structure):			
*What is the **cost range** per unit?*			
How many units in a typical implementation?			
Your revised cost ranges (range x #units)			
NOW REVISIT THE HOMEWORK EXCEL SHEET. CAN YOU NOW ASSIGN A L, M, H COST RANGE? IF NO, REVISE THE ABOVE AS NEEDED UNTIL YOU CAN, OR PROVIDE COMMENTS BELOW AND/OR IN THE HOMEWORK SHEET. NOTE THAT H, M, L **COST RANGES MAY VARY FROM PROJECT TO PROJECT FOR THE SAME ACTION TYPE**. DON'T FORGET TO FILL IN THE OTHER COLUMNS (CONFIDENCE & NO. IMPLEMENTATIONS NEEDED)			
Key sources (reports, databases, people) and/or comments about this cost profile:			

*List of databases we have used so far (n=18): USFWS PFW; USFWS Yreka; NOAA PCSRF; NOAA PNW; NOAA Restoration Center; NFWF; EPA GRTS; ORWI; ODFW; OWEB; USDA EQIP; CalFish; KDSS-WIT; KTAP; UC Davis NRPI; Coastal Conservancy; TRRP; Trout Unlimited

Figure C - 4: Example full costing worksheet in Action Type Cost Profiles.

We issued the homework exercise to a total of 47 participants on June 7, 2021 but received a low response rate (2-3 responses) along with some feedback during two scheduled webinars about challenges participants were having with the exercise. This feedback led to the expanded Action Type Cost Profile shown above, some "frequently asked questions" responses on the Klamath

IFRMP website blog, and revised homework instructions issued on June 17, 2021. Included in these revisions was the following clarification about what should be included in the cost ranges:

> *the cost range estimates you provide should include **all of** design, permitting, and implementation. Please assume your cost range estimates include all of these components for the current exercise. We ask participants to include project **effectiveness monitoring** *only if* said monitoring is a typical permitting requirement associated with implementing that Action Type. Information about status/trends monitoring is being developed as a separate feature of the plan.*

We also discarded the two remaining regional webinars that were originally planned and replaced these with scheduled "office hours" that participants could sign up for to get personalized feedback on the costing exercise. We scheduled seven office hour sessions of 1.5hrs each between June 28, 2021 and July 26, 2021, which were attended by a total of 15 participants.

As completed homework exercises were received, some participants directed us to other individuals who they felt were better suited to respond. We reached out to all these individuals by email (15 in total), 2 of whom agreed to contribute to the exercise. However, we did not receive responses from these two individuals before the extended task deadline. In total, 17 participants contributed to the costing exercise, 3 from Region1, 7 from Region2a (in a single team response), 2 from Region2b, and 5 from Region3. Many homework responses were partially completed and people struggled to assign a number of implementations for many Action Types, which were required to obtain a final expanded cost range for each project. Different respondents had different areas of expertise and so many only felt qualified to comment on a select number of Action Type cost ranges or for a single sub-basin assigned to their regional group. While the worksheets we incorporated into the Action Type Cost Profiles helped, participants still struggled to think about cost ranges in the context of a given project or sub-basin without first working though cost drivers in detail. Some participants were uncomfortable offering such generalized cost ranges. Stated confidence levels for many cost rages were Low to Medium.

Despite these challenges, several participants were highly engaged with the exercise and it generated additional buy-in about the need to have cost range estimates on hand for potential funders of an integrated, basin-wide plan implementation. The exercise was also a useful way to expose a broader audience to the Klamath IFRMP restoration prioritization tool since they were required to use the tool to inform their responses.

Importantly, the exercise allowed us to improve upon the database cost ranges to identify refined cost ranges *per implementation* for several Action Types associated with several projects, and to generate expanded cost ranges based on the number of implementations proposed by participants.

Step 3. Synthesis of homework results and cross-validation with standardized cost documentation

All cost range results for projects are reported in Appendix D, while Appendix E contains cost result profiles for each Action Type (see Figure C-5).

Addition of large woody debris

Adding large woody debris to help recruit natural sediment and restore natural beaches at the mouths of estuaries.

- One participant indicated a cost of $450.00 per rootwad log in the Trinity sub-basin
- For Lower Klamath River, South Fork Trinity, and Trinity, one participant suggested standard unit costs of $111.8K per km based on the mean costs/km from six projects listed in Cedarholm et al. 1997 as provided in Pollock et al. 2004
- Thomson and Pinkerton (2008) report a standardized cost range of $0.55 – 11.3K per structure (1998 – 2006 USD, not inflation adjusted), while Evergreen (2003) reports an upper bound of $80K.
- The most significant cost driver indicated in Evergreen's (2003) standardized costs is the size of the waterway (stream size). Materials and transportation also drive costs, to a lesser extent. Density of logs needed can influence costs - average wood density is 200-300 pieces per mile or 50-80 pieces per structure. Risk (e.g. proximity of dwellings to waterway) can impact costs, (dwellings more closely positioned to waterways will increase risk (and costs), and minimal risks will occur where there are no dwellings).

Subbasin & Project Number	Cost range with {proximal mid-point} cost for a single implementation *($'000s 2021 USD)*	Suggested number of implementations with {proximal mid-point}	Participant Confidence	Expanded cost range with {proximal mid-point cost} *($'000s 2021 USD)*	Responses	Number of projects in cost databases in this cost range
Lower Klamath River #10	N/A	N/A	N/A	N/A	N/A	N/A
Mid Klamath River #12	N/A	N/A	N/A	N/A	N/A	N/A
Salmon #4	N/A	N/A	N/A	N/A	N/A	N/A
Scott #11	N/A	N/A	N/A	N/A	N/A	N/A
South Fork Trinity #3	$50 – {1,025} – 2,000	2 – {6} – 10	M	$300 – {6,150} – 1,200	1	N/A
South Fork Trinity #9a	$30 – {65} – 100	10 – {15} – 20	M	$450 – {975} – 1,500	1	N/A
Sprague #7b	N/A	10 – {12.5} – 15	M-H	N/A	2	N/A
Trinity #6	$30 – {65} – 100	10 – {15} – 20	M	$450 – {975} – 1,500	1	N/A
Upper Klamath Lake #11	N/A	5	N/A	N/A	1	N/A
Upper Klamath Lake #11b	N/A	5	N/A	N/A	1	N/A
Williamson #8b	N/A	5	N/A	N/A	1	N/A

Figure C - 5: Example cost result profile for the Action Type "Addition of large woody debris".

If data were available from participant responses, the profiles in Appendix D contain a cost range per implementation for each project, a number of implementations (count), and an expanded cost range, which we obtained by multiplying the estimated mid-point number of implementations by the *per implementation* cost range. To obtain estimated mid-point values for number of implementations, we first screened out any responses with Low confidence unless the only responses were at that confidence level. Next, we averaged all participant responses to get the estimated mid-point number of implementations (see Figure C-5).

For estimated mid-point values in the *per implementation* cost ranges, we first pre-rounded all cost range values to the nearest $5K (to avoid false impression of precision), then averaged each participant's response using the sum of that their low and high response divided by 2. We then averaged this result across all participants and rounded again to the nearest $5K. We report these estimated mid-point values in curly brackets {} along with the rounded lowest and highest cost value reported by participants.

Subbasin & Project Number	Cost range with {proximal mid-point} cost for a single implementation *($'000s 2021 USD)*	Suggested number of implementations with {proximal mid-point}	Participant Confidence	Expanded cost range with {proximal mid-point cost} *($'000s 2021 USD)*	Responses	Number of projects in cost databases in this cost range
Sprague #8	$15 – {50} – 130	10 – {17.5} – 25	L-H	$263 – {875} – 2,275	3	0

Figure C - 6: Example excerpt from a cost result profile showcasing additional information provided (e.g., participant confidence, number of responses, number of database records).

The cost result profiles in Appendix E (see Figure C-6) also report confidence ranges, number of participant responses, and the number of records in the master cost database that have cost ranges falling within the *per implementation* cost range for the relevant sub-basin. Metadata are provided as bullet points that reflect useful participant comments about per unit costs and cost drivers, relevant cost information from standardized cost documentation, and any additional relevant points related to database cost information.

Appendix D contains expanded cost results for all projects in each sub-basin (see Figure C-7).

Project #	Action_Type	Low	Mid	High	
	Lost				
Project #1	Instream flow project (general)	$ 10,800	$ 10,800	$ 10,800	
	Irrigation practice improvement	$ 25	$ 350	$ 600	
	TOTAL	$ 10,825	$ 11,150	$ 11,400	
Project #10a	Instream habitat project (general)	$ 20	$ 75	$ 120	
	Mechanical channel modification and reconfiguration	$ 125	$ 330	$ 540	
	TOTAL	$ 145	$ 405	$ 660	
Project #10b	Instream habitat project (general)	$ 40	$ 80	$ 120	
	Mechanical channel modification and reconfiguration	$ 125	$ 330	$ 540	
	TOTAL	$ 165	$ 410	$ 660	
Project #2	Mechanical channel modification and reconfiguration	$ 45	$ 210	$ 540	
	TOTAL	$ 45	$ 210	$ 540	
Project #3	Manage water withdrawals	$ 1,561	$ 3,690	$ 5,813	No data for this subbasin or proximal subbasins. Used average expanded costs from any sub-basin with data (Shasta, South Fork Trinity, Trinity)
	Water leased or purchased	$ 1,625	$ 5,250	$ 8,750	
	TOTAL	$ 3,186	$ 8,940	$ 14,563	
Project #5	Fish screens installed	$ 20	$ 150	$ 370	
	TOTAL	$ 20	$ 150	$ 370	
Project #7	Fish ladder installed / improved	$ 10	$ 30	$ 45	
	TOTAL	$ 10	$ 30	$ 45	
Project #8	Fish ladder installed / improved	$ 10	$ 30	$ 45	
	TOTAL	$ 10	$ 30	$ 45	
Project #9	Fencing	$ 150	$ 420	$ 720	
	Instream habitat project (general)	$ 100	$ 375	$ 600	
	Riparian planting	$ 50	$ 400	$ 950	
	Wetland improvement / restoration	$ 200	$ 2,050	$ 3,600	
	TOTAL	$ 500	$ 3,245	$ 5,870	
Project #9d	Fencing	$ 375	$ 1,050	$ 1,800	
	TOTAL	$ 375	$ 1,050	$ 1,800	
	SUB-BASIN TOTAL	$ 15,281	$ 25,620	$ 35,953	

Figure B - 7: Example expanded cost results for all projects in the Lost sub-basin.

Where cost ranges or number of implementations could not be identified to achieve expanded cost ranges, we relied on proxy cost-ranges from other sub-basins. Our rule for assigning proxy costs was to first use the average expanded cost ranges per Action Type from estimated sub-basins. If no data were available from estimated sub-basins and the sub-basin was downstream of the Klamath dams, then we relied on the average of any sub-basin with data downstream of the dams. If still no data were available or if the sub-basin was upstream of the Klamath dams, we relied on the average expanded cost range from any sub-basin with data.

We cross-validated our cost range results using standardized cost documentation recommended by participants (see Thomson and Pinkerton 2008, and Evergreen 2003) and indicate any differences in the cost result profiles in Appendix E. We also used this documentation to build out the metadata for several cost result profiles, and to fill some of the remaining cost range gaps in Appendix D. Consistent with our approach, the Evergreen (2003) document helpfully provides approximate cost ranges for low, medium, and high-cost projects, for each Action Type available in the documentation (a small subset of our full Action Type list). The Thompson and Pinkerton (2008) document provides a more comprehensive breakdown of actual observed project costs associated with several Action Types. Where many values were reported, we used the average of these values to estimate mid-range project costs, and the lowest and highest values for the outer cost range bounds. If any cost information was provided for specific sub-basins, we reported these values (or the average, max, and min within a single sub-basin and Action Type) in the cost result profiles.

Appendix D: Cost Results for IFRMP Projects by Sub-basin

Keeping data gaps in mind (Table C - 2), including projects we were not able to cost, some of which will likely be significant, **the total cost to carry out ALL 146 proposed projects in the Klamath IFRMP** (Table C - 1) **ranges from $230 million to $814 million, with an estimated midpoint cost of about $484 million (2020 USD).** This does ***not*** include the cost of decommissioning the four (4) PacifiCorp dams: JC Boyle, Copco No. 1 & No. 2 and Iron Gate and implementing the required site remediation and restoration efforts as part of the Klamath Hydroelectric Settlement Agreement Definite Decommissioning Plan - KHSA DDP. **If implemented, the KHSA DDP will result in the largest river restoration effort in the United States at an estimated cost of $450 million (in the event of a cost overrun, California, Oregon, and PacifiCorp will provide up to $45 million in additional funds)**.

A reminder that in our collaborative discussions on restoration project costs we asked participants to scale and constrain their input to what could feasibly be accomplished in a 2-5 year period (including/following permitting) rather than describe a multi-phase multi-year package of actions that practitioners would like to see implemented over ~20 years. We heard and appreciate that for many kinds of restoration projects it can take longer than 5 years to plan, permit and implement. Participants were frequently reminded that where this is the case, those restoration projects would need to be added again to the Klamath IFRMP Restoration Prioritization Tool in future batches of what is implementable/completable in a 2–5-year time frame. This was because resource agencies typically do not issue "20 years" of restoration funding and therefore we adopted 2-5 years as the realistic temporal planning unit. However, the 2–5-year scope restriction does not mean that the restoration work for this project would be finished/over. It is acknowledged that some types of restoration may take ten, twenty or more years of ongoing effort to complete and maintain. However, those projects and needs will become clear during future adaptive implementation of the IFRMP and such projects will be re-entered iteratively as needed into the Klamath IFRMP Prioritization Tool in the future.

With all of this in mind, the restoration projects and the restoration project costs identified in the IFRMP are not a "once and forever" list of all restoration projects needed to "fix" the Klamath Basin. Taking the total estimated midpoint cost to carry out all 146 proposed projects of $484 million (2020 USD), and assuming the average duration of time to complete these projects is 3.25 years, the annual total midpoint cost per year of restoration funding needed is roughly around $149 million dollars (2020 USD). Therefore, by extension, ***if*** **the number of rounds of functional watershed restoration actions required over the entire basin to largely restore ("fix") the Klamath basin is around 5 (or 20 years)[2], the total estimated midpoint cost for all restoration is around $3 billion (2020 USD). The high-end estimate for 5 rounds (or 20 years) of carrying out these actions is nearly $5 billion.**

[2] The total number of rounds of restoration and duration of time required to restore functional watershed processes, flows, water quality, habitat and ecosystem processes.is a major uncertainty. The use of 5 rounds or 20 years is purely for illustration purposes to assist decision-makers interpret IFRMP restoration project cost numbers.

Table C - 1: Detailed cost results for Klamath IFRMP projects, by sub-basin. All units are in $USD 1000s (thousands 2020 USD). Project sub-components highlighted in yellow are not included in costs.

Project #	Action_Type	Low	Mid	High	
	Lost				
Project #1	**Work with agriculture interests and other to improve water use efficiencies throughout the Klamath Project to improve water quality and stream temperatures**				
	Instream flow project (general)	$ 10,800	$ 10,800	$ 10,800	
	Irrigation practice improvement	$ 25	$ 350	$ 600	
	TOTAL	$ 10,825	$ 11,150	$ 11,400	
Project #9	**Improve habitat conditions at the mouth of Willow Creek/Clear Lake to provide spawning habitat for end**				
	Instream habitat project (general)	$ 100	$ 375	$ 600	
	Riparian planting	$ 50	$ 400	$ 950	
	Wetland improvement / restoration	$ 200	$ 2,050	$ 3,600	
	TOTAL	$ 350	$ 2,825	$ 5,150	
Project #3	**Explore acquisition of water rights to increase instream flows in key Lost River tributaries**				
	Manage water withdrawals	$ 82	$ 587	$ 1,083	No data for this subbasin or proximal subbasins. Used average expanded costs from any sub-basin with data (Shasta, South Fork Trinity, Trinity)
	Water leased or purchased	$ 1,625	$ 5,250	$ 8,750	
	TOTAL	$ 1,707	$ 5,837	$ 9,833	
Project #8	**Install passage infrastructure at Harpold and other diversion dams currently restricting access to potentia**				
	Fish ladder installed / improved	$ 10	$ 30	$ 45	
	TOTAL	$ 10	$ 30	$ 45	
Project #7	**Install passage infrastructure at Gerber and Miller Diversion dams to allow access to potential upstream**				
	Fish ladder installed / improved	$ 10	$ 30	$ 45	
	TOTAL	$ 10	$ 30	$ 45	
Project #10a	**Improve condition and extent of spawning habitat for suckers in Tule Lake/Lost River**				
	Instream habitat project (general)	$ 20	$ 75	$ 120	
	Mechanical channel modification and reconfiguration	$ 125	$ 330	$ 540	
	TOTAL	$ 145	$ 405	$ 660	
Project #9d	**Work with agriculture interests and other to install riparian fencing along the mainstem Lost River to reduce grazing impacts**				
	Fencing	$ 375	$ 1,050	$ 1,800	
	TOTAL	$ 375	$ 1,050	$ 1,800	
Project #2	**Reconfigure Willow Creek/Clear Lake forebay to improve access to Willow Creek spawning areas at low**				
	Mechanical channel modification and reconfiguration	$ 45	$ 210	$ 540	
	TOTAL	$ 45	$ 210	$ 540	
Project #5	**Install fish screens at North Canal diversion from Miller Creek to prevent entrainment**				
	Fish screens installed	$ 170	$ 1,275	$ 3,145	
	TOTAL	$ 170	$ 1,275	$ 3,145	
Project #10b	**Reconfigure and reconnect channels in Sheepy Creek to improve habitat conditions for endangered suc**				
	Instream habitat project (general)	$ 40	$ 80	$ 120	
	Mechanical channel modification and reconfiguration	$ 125	$ 330	$ 540	
	TOTAL	$ 165	$ 410	$ 660	
Project #11a	**Work with agriculture interests and other to improve the fish ladder at Keno Dam to provide better upstream passage for migratory fish species**				
	Fish ladder installed / improved	$ 10	$ 30	$ 45	
	TOTAL	$ 10	$ 30	$ 45	
Project #11b	**Improve the fish ladder at Link River Dam to provide better upstream passage for migratory fish species**				
	Fish ladder installed / improved	$ 10	$ 30	$ 45	
	TOTAL	$ 10	$ 30	$ 45	
	SUB-BASIN TOTAL	$ 13,822	$ 23,282	$ 33,368	

Project #	Action_Type	Low	Mid	High	
	Lower Klamath River				
Project #11	**Install BDAs in key tributaries in the Lower Klamath to promote increased base flows and provide impro**				
	Beavers & beaver dam analogs	$ 184	$ 352	$ 520	No data. Used average expanded cost from all proximal sub-basins with data (Scott, Mid Klamath River, Trinity)
	TOTAL	$ 184	$ 352	$ 520	
Project #6	**Increase habitat connectivity and enhance floodplain habitats in key Lower Klamath River streams**				
	Mechanical channel modification and reconfiguration	$ 2,534	$ 5,815	$ 8,607	No data for number of implementations. Used average expanded cost from all proximal sub-basins with data (Scott, Mid Klamath River, Trinity)
	Water quality project (general)	$ 960	$ 1,440	$ 1,880	No data for number of implementations in this sub-basin or proximal sub-basins. Used average expanded cost from all sub-basins with data downstream of Klamath dams (Upper Klamath River)
	TOTAL	$ 3,494.05	$ 7,254.53	$ 10,486.88	
Project #10	**Install LWD to increase floodplain connectivity and provide cover for spawning and rearing fish in key Lo**				
	Addition of large woody debris	$ 450	$ 975	$ 1,500	No data. Used average expanded cost from all proximal sub-basins with data (Trinity)
	TOTAL	$ 450	$ 975	$ 1,500	
Project #7	**Plant riparian vegetation along key Lower Klamath River tributaries to reduce water temperatures**				
	Riparian planting	125	137.5	150	No data for number of implementations in this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Shasta, Upper Klamath River)
	TOTAL	$ 125.00	$ 137.50	$ 150.00	
Project #13	**Remove feral cattle from key Lower Klamath River tributaries where wild herds exist**				
	Remove feral cattle				No data for any subbasin
	TOTAL	$ -	$ -	$ -	
Project #14	**Conduct juvenile fish rescues and relocation in key Lower Klamath River tributaries prone to seasonal dr**				
	Fish translocation				No data for any subbasin
	TOTAL	$ -	$ -	$ -	
Project #12	**Remove non-native estuary plants from key Lower Kamath River estuary and off-estuary tributary habitat**				
	Estuarine plant removal / control				No data for any subbasin
	TOTAL	$ -	$ -	$ -	
Project #3_4	**Upland road decommissioning and drainage system improvements to reduce sediment inputs and promote hydrologic restoration throughout the Lower k**				
	Road closure / abandonment	$ 200	$ 650	$ 1,100	No data for number of implementations. Used average expanded cost from all proximal sub-basins with data (Mid Klamath River, Trinity)
	Road drainage system improvements and reconstruction	$ 714	$ 1,250	$ 1,786	No data for number of implementations. Used average expanded cost from all proximal sub-basins with data (Scott, Trinity)
	TOTAL	$ 914	$ 1,900	$ 2,886	
Project #15	**Seek opportunities to conduct thinning of forest stands and controlled burns to restore historic prairie habitats within key Lowe**				
	Upland vegetation management including fuel reduction and burning	$ 75	$ 200	$ 513	No data. Used average expanded cost from all proximal sub-basins with data (Mid Klamath River, Trinity)
	TOTAL	$ 75	$ 200	$ 513	
	SUB-BASIN TOTAL	$ 5,242	$ 10,819	$ 16,055	

Project #	Action_Type	Low	Mid	High	
	Mid Klamath River				
Project #11	**Reconnect off-channel habitats by removing or reconfiguring stream levees and dikes**				
	Dike or berm modification / removal	$ 644	$ 7,881	$ 24,250	No data for number of implementations in this sub-basin. Used average expanded costs from all proximal sub-basins with data (Trinity)
	Mechanical channel modification and reconfiguration	$ 2,800	$ 3,080	$ 2,800	Expanded cost ranges for **midpoint cost** updated August 10, 2022 to reflect an increased number of implementations due to an 10% increase in the number of HUCs arising from IFRMP document review.
	TOTAL	$ 3,444	$ 10,961	$ 27,050	
Project #9	**Implement projects to provide for fish passage at identified priority fish passage barriers across the Midd**				
	Fish passage improvement (general)	$ 550	$ 4,775	$ 9,000	
	TOTAL	$ 550	$ 4,775	$ 9,000	
Project #6_10	**Remove sediment barriers or construct low flow channels to provide access to existing cold water refugia within the Middle Klamath River sub-basin**				
	Fish passage improvement (general)	$ 150	$ 1,075	$ 2,000	Expanded cost ranges for midpoint cost updated August 10, 2022 to reflect an increased number of implementations due to an 10% increase in the number of HUCs arising from IFRMP document review.
	Instream flow project (general)	$ 4,898	$ 5,834	$ 6,635	No data for this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Shasta, South Fork Trinity, Trinity, Upper Klamath River)
	Minor fish passage blockages removed or altered	$ 750	$ 5,375	$ 10,000	Expanded cost ranges for midpoint cost updated August 10, 2022 to reflect an increased number of implementations due to an 10% increase in the number of HUCs arising from IFRMP document review.
	Water quality project (general)	$ 60	$ 210	$ 470	No data for this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Upper Klamath River)
	TOTAL	$ 5,858	$ 12,494	$ 19,105	
Project #3	**Manage water withdrawals across the Middle Klamath River sub-basin to increase instream flows during**				
	Manage water withdrawals	$ 82	$ 587	$ 1,083	No data for this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Shasta, South Fork Trinity, Trinity)
	TOTAL	$ 82	$ 587	$ 1,083	
Project #8	**Undertake riparian planting to reduce water temperatures and improve fish habitats**				
	Riparian planting	$ 125	$ 138	$ 150	No data for this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Shasta, Upper Klamath River)
	TOTAL	$ 125	$ 138	$ 150	
Project #4a	**Decommission forestry roads to reduce fine sediment inputs to Middle Klamath River streams**				
	Planting for erosion and sediment control	$ 1,170	$ 1,170	$ 1,170	Used standardized cost data from Thomas and Pinkerton (2008) for the Trinity sub-basin.
	Road closure / abandonment	$ 200	$ 650	$ 1,100	
	Slope stabilization				No data to draw from in any subbasin
	TOTAL	$ 1,370	$ 1,820	$ 2,270	
Project #14	**Install BDAs to provide seasonal fish rearing habitats in Middle Klamath River tributaries**				
	Beavers & beaver dam analogs	$ 91	$ 137	$ 183	Expanded cost ranges updated August 10, 2022 to reflect an increased number of implementations due to an 14% increase in the number of HUCs arising from IFRMP document review.
	TOTAL	$ 91	$ 137	$ 183	
Project #12	**Install in-channel structures such as LWD, boulders, etc. to improve condition of fish habitats**				
	Addition of large woody debris	$ 450	$ 975	$ 1,500	No data. Used average expanded costs from all proximal sub-basins with data (Trinity)
	Channel structure placement	$ 2,031	$ 4,062	$ 5,417	Expanded cost ranges updated August 10, 2022 to reflect an increased number of implementations due to an 8.3% increase in the number of HUCs arising from IFRMP document review.
	TOTAL	$ 2,481	$ 5,037	$ 6,917	
Project #5	**Undertake upland vegetation management as needed to restore a fire adapted landscape across the Mid**				
	Upland vegetation management including fuel reduction and burning	$ 100	$ 100	$ 150	
	TOTAL	$ 100	$ 100	$ 150	
Project #16	**Restore upland wetlands and meadows to improve cold water storage and flood attenuation in the Midd**				
	Upland wetland improvement	$ 1,200	$ 1,200	$ 1,200	
	TOTAL	$ 1,200	$ 1,200	$ 1,200	
	SUB-BASIN TOTAL	$ 15,301	$ 37,249	$ 67,108	

Project #	Action_Type	Low	Mid	High	
	Salmon				
Project #7	**Restore upland wetlands and meadows to improve cold water storage and flood attenuation in the Salm**				
	Mechanical channel modification and reconfiguration	$ 3,108	$ 7,038	$ 10,306	No data. Used average expanded costs from all proximal sub-basins with data (Scott, Trinity, Mid Klamath River)
	Riparian area conservation grazing management				No data to draw from in any subbasin
	Riparian Forest Management (RFM)	$ 714	$ 2,500	$ 4,286	No data. Used average expanded costs from all proximal sub-basins with data (Scott)
	Road drainage system improvements and reconstruction	$ 714	$ 1,250	$ 1,786	No data. Used average expanded costs from all proximal sub-basins with data (Scott, Trinity)
	Streambank stabilization				No data to draw from in any subbasin
	Upland wetland improvement	$ 636	$ 671	$ 743	No data. Used average expanded costs from all proximal sub-basins with data (Scott, Mid Klamath River)
	TOTAL	$ 5,172	$ 11,459	$ 17,120	
Project #5	**Protect and enhance existing cold-water refugia through improved maintenance and management of ex**				
	Riparian Forest Management (RFM)	$ 714	$ 2,500	$ 4,286	No data. Used average expanded costs from all proximal sub-basins with data (Scott)
	Water quality project (general)	$ 960	$ 1,440	$ 1,880	No data. No data in proximal subbasins. Average of all sub-basins with data downstream of Klamath dams (Upper Klamath River)
	TOTAL	$ 1,674	$ 3,940	$ 6,166	
Project #2	**Undertake mine tailing remediation in priority reaches of the Salmon River and North and South Forks mainstems and reconnect floodplains**				
	Instream habitat project (general)	$ 5,375	$ 6,469	$ 7,425	No data. Only Trinity has expanded cost data proximal, but likely overestimates for Salmon so averaged all sub-basins downstream of Klamath dams (Shasta, South Fork Trinity, Trinity, Upper Klamath River)
	Mechanical channel modification and reconfiguration	$ 3,108	$ 7,038	$ 10,306	No data. Used average expanded costs from all proximal sub-basins with data (Scott, Trinity, Mid Klamath River)
	TOTAL	$ 8,483	$ 13,506	$ 17,731	
Project #3	**Build and improve connection to off-channel rearing habitats in Salmon Sub-basin tributaries**				
	Mechanical channel modification and reconfiguration	$ 3,108	$ 7,038	$ 10,306	No data. Used average expanded costs from all proximal sub-basins with data (Scott, Trinity, Mid Klamath River)
	TOTAL	$ 3,108	$ 7,038	$ 10,306	
Project #6a_6b	**Undertake riparian planting and management to reduce water temperatures within priority reaches of NF and SF Salmon River**				
	Riparian planting	$ 125	$ 138	$ 150	No data for this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Shasta, Upper Klamath River)
	Riparian Forest Management (RFM)	$ 714	$ 2,500	$ 4,286	No data. Used average expanded costs for all proximal sub-basins with data (Scott)
	TOTAL	$ 125	$ 138	$ 150	
Project #8	**Remove physical barriers blocking fish passage to key thermal refuge areas within the Salmon River Sub**				
	Fish passage improvement (general)	$ 400	$ 1,450	$ 2,500	No data for this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Shasta, South Fork Trinity)
	Minor fish passage blockages removed or altered	$ 388	$ 2,888	$ 5,600	No data. Used average expanded costs from all proximal sub-basins with data (Mid Klamath River, Trinity)
	TOTAL	$ 788	$ 4,338	$ 8,100	
Project #4	**Install LWD, boulders and other in-channel structures to improve fish habitats within the Salmon River a**				
	Addition of large woody debris	$ 450	$ 975	$ 1,500	No data. Used average expanded costs from all proximal sub-basins with data (Trinity)
	Channel structure placement	$ 844	$ 1,771	$ 2,617	No data. Used average expanded costs from all proximal sub-basins with data (Scott, Trinity, Mid Klamath River)
	TOTAL	$ 1,294	$ 2,746	$ 4,117	
Project #1	**Undertake upland vegetation management as needed to restore a fire adapted landscape across the Sal**				
	Upland vegetation management including fuel reduction and burning	$ 50	$ 300	$ 875	No data. Used average expanded costs from all proximal sub-basins with data (Trinity)
	TOTAL	$ 50	$ 300	$ 875	
	SUB-BASIN TOTAL	$ 20,694	$ 43,464	$ 64,564	

Project #	Action_Type	Low	Mid	High	
	Scott				
Project #15	**Calahan dredge tailings remediation**				
	Minor fish passage blockages removed or altered	$ 298	$ 2,065	$ 3,973	No data. Used average expanded costs from all proximal sub-basins with data (Mid-Klamath River, Shasta, Trinity)
	Mechanical channel modification and reconfiguration	$ 6,429	$ 12,143	$ 17,858	No data. Used expanded cost data from project #14
	TOTAL	$ 6,727	$ 14,208	$ 21,831	
Project #14	**Restore upland wetlands and meadows to improve cold water storage and flood attenuation in the Scott**				
	Mechanical channel modification and reconfiguration	$ 6,429	$ 12,143	$ 17,858	Expanded cost ranges updated August 11, 2022 to reflect an increased number of implementations due to an 42% increase in the number of HUCs arising from IFRMP document review.
	Riparian area conservation grazing management				No data to draw from in any subbasin
	Riparian Forest Management (RFM)	$ 714	$ 2,500	$ 4,286	Expanded cost ranges updated August 11, 2022 to reflect an increased number of implementations due to an 42% increase in the number of HUCs arising from IFRMP document review.
	Road drainage system improvements and reconstruction	$ 714	$ 1,250	$ 1,786	Expanded cost ranges updated August 11, 2022 to reflect an increased number of implementations due to an 42% increase in the number of HUCs arising from IFRMP document review.
	Upland wetland improvement	$ 71	$ 143	$ 286	Expanded cost ranges updated August 11, 2022 to reflect an increased number of implementations due to an 42% increase in the number of HUCs arising from IFRMP document review.
	Beavers & beaver dam analogs	$ 369	$ 738	$ 1,108	No data. Used expanded cost data from project #9
	Wetland project (general)				No data to draw from in any subbasin
	Addition of large woody debris	$ 450	$ 975	$ 1,500	No data. Used average expanded costs from all proximal sub-basins with data (Trinity)
	TOTAL	$ 8,748	$ 17,749	$ 26,822	Expanded cost ranges updated August 10, 2022 to reflect changes to action types.
Project #12	**Establish Conservation Easements adjacent to key areas of the Scott River mainstem to allow for levee, d**				
	Conservation easement	$ 4,800	$ 4,800	$ 4,800	Note that the number of HUCs assigned to this project have increased by 133% but we have not adjusted the cost range because the original survey response pertained to the entire Scott subbasin
	TOTAL	$ 4,800	$ 4,800	$ 4,800	
Project #10	**Restore floodplain connectivity and create refuge habitats across Scott River Sub-basin streams as identi**				
	Mechanical channel modification and reconfiguration	$ 6,429	$ 12,143	$ 17,858	No data. Used expanded cost data from project #14
	TOTAL	$ 6,429	$ 12,143	$ 17,858	
Project #11	**Install in-channel structures such as LWD, boulders, etc. to improve condition of fish habitat in priority tri**				
	Addition of large woody debris	$ 450	$ 975	$ 1,500	No data. Used average expanded costs from all proximal sub-basins with data (Trinity)
	Channel structure placement	$ 350	$ 700	$ 933	Expanded cost ranges updated August 11, 2022 to reflect an increased number of implementations due to an 16% increase in the number of HUCs arising from IFRMP document review.
	TOTAL	$ 800	$ 1,675	$ 2,433	
Project #1	**Acquire water rights from willing sellers within priority areas of the Scott River sub-basin to help maintain instream flows for fish**				
	Manage water withdrawals	$ 82	$ 587	$ 1,083	No data for this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Shasta, South Fork Trinity, Trinity)
	Water leased or purchased	$ 150	$ 400	$ 650	No data. Used average expanded costs from all proximal sub-basins with data (Shasta)
	TOTAL	$ 232	$ 987	$ 1,733	
Project #3	**Implement winter flooding of agriculture land in the Scott River Sub-basin as a method of groundwater r**				
	Irrigation practice improvement	$ 25	$ 350	$ 600	No data for this sub-basin, proximal sub-basins, or any subbasins downstream of Klamath dams. Used average expanded costs from any subbasins with data (Lost, Upper Klamath Lake)
	TOTAL	$ 25	$ 350	$ 600	
Project #7	**Improve/decommission priority roads identified in the Five Counties Road Erosion Inventory to reduce fin**				
	Planting for erosion and sediment control	$ 1,170	$ 1,170	$ 1,170	Used standardized cost data from Thomas and Pinkerton (2008) for the Trinity sub-basin.
	Road closure / abandonment	$ 108	$ 340	$ 570	No data. Used average expanded costs from all proximal sub-basins with data (Mid Klamath River, Trinity, Upper Klamath River)
	Road drainage system improvements and reconstruction	$ 714	$ 1,250	$ 1,786	No data for number of implementations. Used expanded cost data from Project #14
	TOTAL	$ 1,992	$ 2,760	$ 3,526	
Project #2	**Ensure compliance with existing water and environmental laws and regulations for ensuring instream f**				
	Manage water withdrawals	$ 82	$ 587	$ 1,083	No data for this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Shasta, South Fork Trinity, Trinity)
	TOTAL	$ 82	$ 587	$ 1,083	
Project #13	**Reduce fuel loads, undertake prescribed burns across the SW Scott River Sub-basin to reduce wildfire ri**				
	Upland vegetation management including fuel reduction and burning	$ 295	$ 465	$ 798	No data. Used average expanded costs from all proximal sub-basins with data (Trinity, Upper Klamath River)
	TOTAL	$ 295	$ 465	$ 798	
Project #9	**Encourage beaver colonization and/or install BDAs to provide seasonal fish rearing habitats in the mains**				
	Beavers & beaver dam analogs	$ 369	$ 738	$ 1,108	Expanded cost ranges updated August 10, 2022 to reflect an decrease number of implementations due to an 7% decrease in the number of HUCs arising from IFRMP document review.
	TOTAL	$ 369	$ 738	$ 1,108	
Project #4	**Improve irrigation system water use efficiencies and associated monitoring within the Scott River Sub-ba**				
	Irrigation practice improvement	$ 25	$ 350	$ 600	No data for this sub-basin, proximal sub-basins, or any subbasins downstream of Klamath dams. Used average expanded costs from any subbasins with data (Lost, Upper Klamath Lake)
	TOTAL	$ 25	$ 350	$ 600	
Project #8	**Remove or reconfigure priority river/stream levees and dikes identified in the SRWC plan to restore chan**				
	Dike or berm modification / removal	$ 644	$ 7,881	$ 24,250	No data. Used average expanded costs from all proximal sub-basins with data (Trinity)
	Mechanical channel modification and reconfiguration	$ 6,429	$ 12,143	$ 17,858	No data. Used average expanded costs from all proximal sub-basins with data (Trinity, Mid Klamath River, Upper Klamath River)
	TOTAL	$ 7,072	$ 20,024	$ 42,108	
Project #5	**Remove physical and hydrologic barriers blocking fish passage to key thermal refuge areas within the S**				
	Fish passage improvement (general)	$ 600	$ 1,800	$ 3,000	No data. Used average expanded costs from all proximal sub-basins with data (Shasta)
	Minor fish passage blockages removed or altered	$ 298	$ 2,065	$ 3,973	No data. Used average expanded costs from all proximal sub-basins with data (Mid Klamath River, Shasta, Trinity)
	TOTAL	$ 898	$ 3,865	$ 6,973	
Project #6b	**Undertake riparian planting to increase shading, help reduce water temperatures and improve fish habit**				
	Riparian planting	$ 125	$ 138	$ 150	No data for number of implementations from this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Shasta, Upper Klamath River)
	TOTAL	$ 125	$ 138	$ 150	
Project #6a	**Improve grazing management of riparian areas to maintain shading, reduce water temperatures and im**				
	Riparian area conservation grazing management				No data to draw from in any subbasin
	TOTAL	$ -	$ -	$ -	
Project #6c	**Install fencing along riparian corridors to reduce grazing damage to riparian habitats within priority stre**				
	Fencing	$ 385	$ 770	$ 963	No data for this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Shasta, Upper Klamath River)
	TOTAL	$ 385	$ 770	$ 963	
	SUB-BASIN TOTAL	$ 39,004	$ 81,609	$ 133,385	

Project #	Action_Type	Low	Mid	High	
	Shasta				
Project #6	**Undertake riparian rehabilitation actions to maintain shading, reduce water temperatures and improve i**				
	Fencing	$ 50	$ 100	$ 125	
	Riparian planting	$ 50	$ 75	$ 100	
	TOTAL	$ 100	$ 175	$ 225	
Project #1	**Work with agriculture interests and other to manage water withdrawals across the Shasta Sub-basin to maintain instream flows and to overcome low**				
	Instream flow project (general)	$ 6,000	$ 6,000	$ 6,000	
	Manage water withdrawals	$ 100	$ 100	$ 100	
	TOTAL	$ 6,100	$ 6,100	$ 6,100	
Project #3	**Increase cold water refuge habitats for fish in the upper Shasta Sub-basin through improved irrigation m**				
	Tailwater return reuse or filtering	$ 120	$ 240	$ 400	No data for this sub-basin, proximal sub-basins, or any subbasins downstream of Klamath dams. Used average expanded costs from any subbasins with data (Upper Klamath Lake)
	Water leased or purchased	$ 150	$ 400	$ 650	
	Manage water withdrawals	$ 100	$ 100	$ 100	
	Irrigation practice improvement	$ 25	$ 350	$ 600	No data for this sub-basin, proximal sub-basins, or any subbasins downstream of Klamath dams. Used average expanded costs from any subbasins with data (Lost, Upper Klamath Lake)
	TOTAL	$ 395	$ 1,090	$ 1,750	
Project #8a	**Restore fish passage above Dwinnell Dam through removal of the dam**				
	Major dams removed	$ 1,500	$ 1,500	$ 1,500	Used data from Thompson and Pinkerton (2008) standardized costs for a single dam decommissioning project.
	TOTAL	$ 1,500	$ 1,500	$ 1,500	
Project #5	**Implement projects to reduce warm tailwater inputs in prioritized implementation areas as guided by the**				
	Tailwater return reuse or filtering	$ 120	$ 240	$ 400	No data for this sub-basin, proximal sub-basins, or any subbasins downstream of Klamath dams. Used average expanded costs from any subbasins with data (Upper Klamath Lake)
	TOTAL	$ 120	$ 240	$ 400	
Project #9	**Undertake habitat restoration projects in streams across the Shasta Sub-basin to restore floodplain conn**				
	Mechanical channel modification and reconfiguration	$ 4,827	$ 8,152	$ 11,086	No data for number of implementations. Used average expanded cost from all proximal sub-basins with data (Scott, Trinity, Mid Klamath River, Upper Klamath River)
	TOTAL	$ 4,827	$ 8,152	$ 11,086	
Project #2	**Relocate, redesign, or eliminate the Parks Creek diversion to improve instream flows for fish**				
	Instream flow project (general)	$ 1,200	$ 1,200	$ 1,200	
	TOTAL	$ 1,200	$ 1,200	$ 1,200	
Project #7	**Implement projects to provide for fish passage at identified priority fish passage barriers across the Shas**				
	Fish passage improvement (general)	$ 600	$ 1,800	$ 3,000	
	Minor fish passage blockages removed or altered	$ 120	$ 420	$ 720	
	TOTAL	$ 720	$ 2,220	$ 3,720	
Project #4	**Adjust discharges from Dwinnell Dam to improve water temperatures and dissolved oxygen concentratio**				
	Instream flow project (general)	$ 1,200	$ 1,200	$ 1,200	
	TOTAL	$ 1,200	$ 1,200	$ 1,200	
Project #10	**Add spawning gravels to priority sediment impoverished river reaches as guided by the Shasta's Spawni**				
	Spawning gravel placement	$ 99	$ 278	$ 528	No data for number of implementations for this sub-basin, and no expanded cost data for proximal sub-basins, or any subbasins downstream of Klamath dams. Used average expanded costs from any subbasins with data (Sprague, Upper Klamath Lake, Williamson)
	TOTAL	$ 99	$ 278	$ 528	
Project #8b	**Restore fish passage above Dwinnell Dam through construction of dam bypass infrastructure**				
	Fish ladder installed / improved	$ 25	$ 35	$ 45	
	TOTAL	$ 25	$ 35	$ 45	
	SUB-BASIN TOTAL	$ 16,286	$ 22,190	$ 27,754	

Project #	Action_Type	Low	Mid	High	
	South Fork Trinity				
Project #3	**Increase groundwater storage in the South Fork Trinity Sub-basin through upland wetland restoration ac**				
	Addition of large woody debris	$ 300	$ 6,150	$ 12,000	
	Beavers & beaver dam analogs	$ 160	$ 320	$ 480	
	Upland wetland improvement	$ 6,000	$ 6,000	$ 6,000	
	TOTAL	$ 6,460	$ 12,470	$ 18,480	
Project #2	**Increase storage capacity and delivery capability of Ewing Reservoir to allow increased seasonal water**				
	Instream flow project (general)	$ 500	$ 1,200	$ 2,000	
	TOTAL	$ 500	$ 1,200	$ 2,000	
Project #6	**Reduce cattle grazing and install fencing in riparian areas to reduce fine sediment inputs into sub- basin**				
	Fencing	$ 188	$ 525	$ 900	
	Riparian area conservation grazing management				No data to draw from in any subbasin
	TOTAL	$ 188	$ 525	$ 900	
Project #9a	**Install LWD, boulders and other in-channel structures to increase habitat complexity in key South Fork T**				
	Addition of large woody debris	$ 450	$ 975	$ 1,500	
	Channel structure placement	$ 270	$ 630	$ 1,350	
	TOTAL	$ 720	$ 1,605	$ 2,850	
Project #7	**Improve planning and oversight of diversions to protect thermal refugia in tributaries of the South Fork T**				
	Instream flow project (general)	$ 6,000	$ 7,050	$ 7,800	
	Manage water withdrawals	$ 120	$ 1,560	$ 3,000	No data. Used expanded cost data from Project #1b
	TOTAL	$ 6,120	$ 8,610	$ 10,800	
Project #5	**Decommission roads and improve road drainage systems to reduce fine sediment delivery to South Fork**				
	Road closure / abandonment	$ 30	$ 60	$ 90	
	Road drainage system improvements and reconstruction	$ 30	$ 120	$ 300	
	TOTAL	$ 60	$ 180	$ 390	
Project #1b	**Work with agricultural irrigators to reduce diversions by developing an incentives and enforcement prog**				
	Manage water withdrawals	$ 120	$ 1,560	$ 3,000	
	TOTAL	$ 120	$ 1,560	$ 3,000	Not included in basin total
Project #12	**Repair the levee in Hyampom Valley by the municipal airport to reduce downstream erosion**				
	Dike or berm modification / removal	$ 50	$ 3,025	$ 10,000	
	TOTAL	$ 50	$ 3,025	$ 10,000	
Project #1a	**Identify diversion flow impacts and cease unauthorized water diversions across the Trinity River sub-bas**				
	Manage water withdrawals	$ 120	$ 1,560	$ 3,000	No data. Used expanded cost data from Project #1b
	TOTAL	$ 120	$ 1,560	$ 3,000	Not included in basin total
Project #9b	**Reconnect channels to increase habitat complexity in key South Fork Trinity tributaries**				
	Mechanical channel modification and reconfiguration	$ 625	$ 1,650	$ 2,700	
	TOTAL	$ 625	$ 1,650	$ 2,700	
Project #4	**Stabilize slopes and revegetate vulnerable areas to reduce fine sediment delivery to South Fork Trinity**				
	Planting for erosion and sediment control	$ 1,170	$ 1,170	$ 1,170	Used standardized cost data from Thomas and Pinkerton (2008) for the Trinity sub-basin.
	Slope stabilization				No data to draw from in any subbasin
	TOTAL	$ 1,170	$ 1,170	$ 1,170	
Project #10	**Implement projects to provide for fish passage at identified priority fish passage barriers across the Sout**				
	Fish passage improvement (general)	$ 200	$ 1,100	$ 2,000	
	Minor fish passage blockages removed or altered	$ 160	$ 560	$ 960	
	TOTAL	$ 360	$ 1,660	$ 2,960	
Project #11	**Identify priority screening needs at diversions within the South Fork Trinity sub-basin**				
	Fish screens installed	$ 125	$ 375	$ 688	
	TOTAL	$ 125	$ 375	$ 688	
	SUB-BASIN TOTAL	$ 16,618	$ 35,590	$ 58,938	

Project #	Action_Type	Low	Mid	High	
	Sprague				
Project #4	**Promote channel migration and improve habitat conditions in the Sprague River mainstem and key trib**				
	Dike or berm modification / removal	$ 644	$ 7,881	$ 24,250	No data for this sub-basin or proximal sub-basins. Used average expanded costs from any subbasins with data (Trinity)
	Road closure / abandonment	$ 200	$ 650	$ 1,100	No data for this sub-basin or proximal sub-basins. Used average expanded costs for of any subbasins with data (Mid Klamath River, Trinity)
	Road drainage system improvements and reconstruction	$ 714	$ 1,250	$ 1,786	No data for number of implementations in this sub-basin and no expanded costs for proximal sub-basins. Used average of any subbasins with data (Scott, Trinity)
	TOTAL	$ 1,558	$ 9,781	$ 27,136	
Project #3	**Work with agriculture interests and other to improve riparian grazing management and undertake riparian actions to improve habitat conditions in t**				
	Fencing	$ 250	$ 700	$ 1,200	
	Riparian area conservation grazing management				No data to draw from in any subbasin
	Riparian planting	$ 50	$ 250	$ 950	
	TOTAL	$ 300	$ 950	$ 2,150	
Project #8	**Construct DSTWs to reduce nutrient loading and improve water quality in key Sprague sub-basin tributar**				
	Artificial wetland created	$ 263	$ 875	$ 2,275	
	Water quality project (general)	$ 1,575	$ 2,713	$ 4,113	
	TOTAL	$ 1,838	$ 3,588	$ 6,388	
Project #5	**Restore cold-water springs that have been ponded or otherwise disconnected in the lower Sprague River**				
	Instream flow project (general)	$ 5,445	$ 5,830	$ 6,220	No data for number of implementations in this sub-basin. Used average expanded costs from all proximal sub-basins with data (Lost, Upper Klamath Lake)
	Water quality project (general)	$ 600	$ 900	$ 1,175	
	TOTAL	$ 6,045	$ 6,730	$ 7,395	
Project #7b_9	**Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater rech**				
	Addition of large woody debris				No data to draw from - did not use SF Trinity and Trinity cost ranges because of potentially large differences in number of implementations required
	Channel structure placement	$ 63	$ 625	$ 1,875	
	Beavers & beaver dam analogs	$ 125	$ 188	$ 250	
	TOTAL	$ 188	$ 813	$ 2,125	
Project #6	**Address fish passage issues (esp. for Redband Trout) at road/stream crossings in key areas of Sprague S**				
	Culvert installed or improved at road stream crossing removal				No data for number of implementations in this sub-basin and no expanded costs for proximal sub-basins.
	Fish passage improvement (general)	$ 467	$ 1,567	$ 2,667	No data for this sub-basin or proximal sub-basins. Used average expanded costs from any subbasins with data (Shasta,Scott,Trinity)
	Minor fish passage blockages removed or altered	$ 25	$ 400	$ 1,200	No data for number of implementations in this sub-basin. Used average expanded costs from all proximal sub-basins with data (Upper Klamath Lake)
	TOTAL	$ 492	$ 1,967	$ 3,867	
Project #11	**Improve riparian grazing practices in USFS allotments and some private rangelands within the Sprague**				
	Riparian area conservation grazing management				No data to draw from in any subbasin
	TOTAL	$ -	$ -	$ -	
Project #10	**Undertake upland forest management and prescribed burns to create forest gaps for improved snowpack**				
	Upland vegetation management including fuel reduction and burning	$ 90	$ 300	$ 525	
	TOTAL	$ 90	$ 300	$ 525	
Project #7a	**Add spawning gravels where needed to improve in-stream habitat conditions in key Sprague Sub-basin**				
	Spawning gravel placement	$ 150	$ 350	$ 550	
	TOTAL	$ 150	$ 350	$ 550	
	SUB-BASIN TOTAL	$ 10,660	$ 24,478	$ 50,135	

Project #	Action_Type	Low	Mid	High	
	Trinity				
Project #1	**Implement managed flows from Trinity and Lewiston dams, gravel augmentation, and reconnect floodpl**				
	Augment coarse sediment	$ 500	$ 750	$ 1,000	
	Dike or berm modification / removal	$ 1,138	$ 14,788	$ 45,500	
	Manage dam releases (Trinity and Lewiston Dams)	$ -	$ -	$ -	
	Mechanical channel modification and reconfiguration	$ 95	$ 5,890	$ 10,260	
	TOTAL	$ 1,733	$ 21,428	$ 56,760	
Project #5	**Reconnect floodplains in the mainstem Trinity River below the North Fork confluence and key tributaries**				
	Dike or berm modification / removal	$ 150	$ 975	$ 3,000	
	Mechanical channel modification and reconfiguration	$ 813	$ 2,145	$ 3,510	
	TOTAL	$ 963	$ 3,120	$ 6,510	
Project #4	**Maintain flows in Weaver Creek by alternatively using Trinity River to provide summer water to the Weav**				
	Manage water withdrawals	$ 25	$ 100	$ 150	
	TOTAL	$ 25	$ 100	$ 150	
Project #8	**Implement projects to provide for fish passage at identified priority fish passage barriers across the Trinity**				
	Fish passage improvement (general)	$ 400	$ 1,450	$ 2,500	No data for number of implementations and no expanded cost data in proximal subbasins. Used average of any subbasins with data (Shasta, South Fork Trinity)
	Minor fish passage blockages removed or altered	$ 25	$ 400	$ 1,200	
	TOTAL	$ 425	$ 1,850	$ 3,700	
Project #6	**Install in-channel structures such as LWD, boulders, etc. to improve fish habitats in priority tributaries**				
	Addition of large woody debris	$ 450	$ 975	$ 1,500	
	Channel structure placement	$ 150	$ 550	$ 1,500	
	TOTAL	$ 600	$ 1,525	$ 3,000	
Project #14	**Increase Trinity recreational harvest of introduced Brown Trout and adjust hatchery release practices to**				
	Hatchery reform and assessment (general)	$ 10,000	$ 15,000	$ 20,000	No data. Used expanded cost data from Project #12
	Predator/competitor exotic fish species removal	$ 5	$ 80	$ 165	
	TOTAL	$ 10,005	$ 15,080	$ 20,165	
Project #7	**Install fish passage infrastructure at Lewiston and Trinity Dams to allow access to upstream habitats**				
	Fish ladder installed / improved	37.5	52.5	67.5	
	TOTAL	37.5	52.5	67.5	
Project #2_11	**Implement projects in Trinity River tributary streams to improve flows to decrease water temperatures and increase dissolved oxygen**				
	Instream flow project (general)	$ 13,000	$ 15,275	$ 16,900	
	TOTAL	$ 13,000	$ 15,275	$ 16,900	
Project #15	**Translocate beaver and install BDAs to impound water and create seasonal fish rearing habitats in Trinit**				
	Beavers & beaver dam analogs	$ 90	$ 180	$ 270	
	TOTAL	$ 90	$ 180	$ 270	
Project #12	**Stocking of spring Chinook and summer steelhead into Trinity streams where currently extirpated and ca**				
	Hatchery reform and assessment (general)	$ 10,000	$ 15,000	$ 20,000	
	TOTAL	$ 10,000	$ 15,000	$ 20,000	
Project #16	**Undertake upland vegetation management as needed to thin forest and reduce fuels across the Trinity Ri**				
	Upland vegetation management including fuel reduction and burning	$ 50	$ 300	$ 875	
	TOTAL	$ 50	$ 300	$ 875	
Project #13	**Stock Trinity and Lewiston lakes to establish landlocked salmon and/or trout runs, using only fish of Trini**				
	Hatchery reform and assessment (general)	$ 10,000	$ 15,000	$ 20,000	No data. Used expanded cost data from Project #12
	TOTAL	$ 10,000	$ 15,000	$ 20,000	
Project #17_18	**Install temperature control device for Trinity Reservoir and evaluate and develop a new conveyance system from Trinity Reservoir to the Carr tunnels to im**				
	Instream flow project (general)				Not costed. Project added after IFRMP review.
	Water flow gauges				New action type added. Not costed. Project added after IFRMP review.
	Manage dam releases (Trinity and Lewiston)				Not costed. Project added after IFRMP review.
	TOTAL	$ -	$ -	$ -	
	SUB-BASIN TOTAL	$ 46,928	$ 88,910	$ 148,398	

Project #	Action_Type	Low	Mid	High	
	Upper Klamath Lake				
Project #14	**Work with agriculture interests and other to separate out and treat tailwater discharge in the northeast section of the Upper Klamath Lake Sub-basin**				
	Artificial wetland created	$ 150	$ 800	$ 1,300	
	Irrigation practice improvement	$ 25	$ 350	$ 600	
	Stormwater filtering				Cost data per implementation available, but no data about number of implementations to draw from in any subbasin
	Tailwater return reuse or filtering	$ 120	$ 240	$ 400	
	TOTAL	$ 295	$ 1,390	$ 2,300	
Project #7	**Work with agriculture interests and other to improve summertime flows by encouraging irrigation water use efficiencies and voluntary transfer of wat**				
	Manage water withdrawals	$ 81	$ 587	$ 1,083	No data for this sub-basin or proximal sub-basins. Used average expanded costs from all sub-basins with data downstream of Klamath dams (Shasta, South Fork Trinity, Trinity)
	Water leased or purchased	$ 1,788	$ 5,775	$ 9,625	
	TOTAL	$ 1,869	$ 6,362	$ 10,708	
Project #1	**Work with agriculture interests and other to improve riparian grazing management and undertake riparian actions to improve habitat conditions in**				
	Fencing	$ 313	$ 875	$ 1,500	
	Riparian area conservation grazing management				No data to draw from in any subbasin
	Riparian planting	$ 125	$ 563	$ 1,188	
	TOTAL	$ 438	$ 1,438	$ 2,688	
Project #3	**Restore fringe wetlands in priority areas identified in the UKBWAP to improve water quality and provide**				
	Dike or berm modification / removal	$ 644	$ 7,881	$ 24,250	No data for this sub-basin, proximal sub-basins, or any sub-basins downstream of Klamath dams. Used average expanded cost from any subbasins with data (Trinity)
	Wetland improvement / restoration	$ 50	$ 525	$ 900	Expanded cost ranges updated August 11, 2022 to reflect an decreased number of implementations due to an 16% decrease in the number of HUCs arising from IFRMP document review.
	TOTAL	$ 694	$ 8,406	$ 25,150	
Project #8b_11	**Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater rech**				
	Addition of large woody debris	$ 400	$ 2,700	$ 5,000	No data for this sub-basin or proximal sub-basins. Used average expanded costs from any subbasins with data (Trinity, South Fork Trinity)
	Channel structure placement	$ 75	$ 150	$ 200	
	Spawning gravel placement	$ 150	$ 350	$ 550	
	Beavers & beaver dam analogs	$ 28	$ 83	$ 138	
	TOTAL	$ 653	$ 3,283	$ 5,888	
Project #11a	**Supplement spawning gravels in key sub-basin tributaries to benefit trout and returning anadromous sal**				
	Spawning gravel placement	$ 150	$ 350	$ 550	
	TOTAL	$ 150	$ 350	$ 550	
Project #6	**Reconnect key springs in the sub-basin and restore surrounding habitat to provide fish refuges during per**				
	Instream flow project (general)	$ 90	$ 860	$ 1,640	
	Water quality project (general)	$ 60	$ 210	$ 470	
	TOTAL	$ 150	$ 1,070	$ 2,110	
Project #9	**Screen priority diversions around Upper Klamath Lake and other key areas in the sub-basin using physi**				
	Fish screens installed	$ 315	$ 2,835	$ 5,828	Expanded cost ranges updated August 11, 2022 to reflect an decreased number of implementations due to an 40% decrease in the number of HUCs arising from IFRMP document review.
	TOTAL	$ 315	$ 2,835	$ 5,828	
Project #4	**Establish DSTWs across the sub-basin to reduce nutrient loading to Upper Klamath and Agency lakes or**				
	Artificial wetland created	$ 660	$ 3,080	$ 5,720	Expanded cost ranges updated August 11, 2022 to reflect an decreased number of implementations due to an 20% decrease in the number of HUCs arising from IFRMP document review.
	TOTAL	$ 660	$ 3,080	$ 5,720	
Project #16	**Manage livestock in upland areas of the sub-basin to improve vegetation structure, control erosion and re**				
	Upland livestock and grazing management	$ 775	$ 4,650	$ 9,300	
	TOTAL	$ 775	$ 4,650	$ 9,300	
Project #8a	**Reconstruct channelized portions of key sub-basin tributaries to improve fish habitat, increase water resid**				
	Mechanical channel modification and reconfiguration	$ 625	$ 9,450	$ 25,000	
	TOTAL	$ 625	$ 9,450	$ 25,000	
Project #13	**Remove priority fish passage barriers at small dams and culverts across key sub-basin tributaries**				
	Culvert installed or improved at road stream crossing				Cost data per implementation available, but no data about number of implementations to draw from in any subbasin
	Minor fish passage blockages removed or altered	$ 25	$ 400	$ 1,200	
	TOTAL	$ 25	$ 400	$ 1,200	
Project #10a	**Supplement shoreline spawning gravels for lake-spawning suckers in Upper Klamath Lake**				
	Spawning gravel placement	$ 25	$ 200	$ 550	
	TOTAL	$ 25	$ 200	$ 550	
Project #2	**Work with agriculture interests and other to improve irrigation practices to reduce sediment and phosphorus loading to key streams in the Upper Kla**				
	Irrigation practice improvement	$ 94	$ 437	$ 750	Expanded cost ranges updated August 11, 2022 to reflect an decreased number of implementations due to an 16% decrease in the number of HUCs arising from IFRMP document review.
	TOTAL	$ 94	$ 437	$ 750	
Project #10b	**Ensure access for suckers to Upper Klamath Lake shoreline spawning areas by managing lake levels**				
	Manage Dam Releases (Link and Keno)				No data to draw from in any subbasin
	TOTAL	$ -	$ -	$ -	
	SUB-BASIN TOTAL	$ 6,767	$ 43,350	$ 97,741	

Project #	Action_Type	Low	Mid	High	
	Upper Klamath River				
Project #2	**Adaptively manage releases from mainstem dams to restore natural hydrologic regime**				
	Manage Dam Releases (Klamath Dams)				No data to draw from in any subbasin
	TOTAL	$ -	$ -	$ -	
Project #10	**Reconnect floodplains and off-channel habitats by removal of levees and other barriers within the Upper Klamath River sub-basin**				
	Dike or berm modification / removal	$ 644	$ 7,881	$ 24,250	No data for this sub-basin, proximal sub-basins, or any sub-basins downstream of Klamath dams. Used average expanded cost from any subbasins with data (Trinity)
	Mechanical channel modification and reconfiguration	$ 14,000	$ 17,500	$ 21,000	Expanded cost ranges updated August 11, 2022 to reflect an increase number of implementations due to an 100% increase in the number of HUCs arising from IFRMP document review.
	TOTAL	$ 14,644	$ 25,381	$ 45,250	
Project #12	**Construct new fishways for passage above major Klamath River mainstem dams**				
	Fishway chutes or pools Installed				No data to draw from in any subbasin
	TOTAL	$ -	$ -	$ -	
Project #19	**Identify and implement projects to protect existing or potential cold-water refugia for fish**				
	Water quality project (general)	$ 960	$ 1,440	$ 1,880	
	TOTAL	$ 960	$ 1,440	$ 1,880	
Project #3	**Improve irrigation practices to increase instream flows in Upper Klamath River tributaries**				
	Instream flow project (general)	$ 2,000	$ 3,400	$ 4,800	
	Irrigation practice improvement	$ 59	$ 394	$ 675	No data. Used average expanded costs from all proximal sub-basins with data (Upper Klamath Lake)
	TOTAL	$ 2,059	$ 3,794	$ 5,475	
Project #16	**Replace existing culverts with bridges at priority road crossings in Upper Klamath River tributaries to improve access to**				
	Bridge installed or improved at road stream crossing	$ 1,050	$ 7,525	$ 14,000	
	TOTAL	$ 1,050	$ 7,525	$ 14,000	
Project #5c	**Undertake riparian planting to reduce erosion into the Upper Klamath River mainstem and key tributaries**				
	Riparian planting	$ 200	$ 200	$ 200	
	TOTAL	$ 200	$ 200	$ 200	
Project #9	**Supplement the mainstem UKR with coarse sediment below Iron Gate Dam**				
	Augment coarse sediment	$ 500	$ 750	$ 1,000	No data for this sub-basin, proximal sub-basins, or any sub-basins downstream of Klamath dams. Used average expanded cost from any subbasins with data (Trinity)
	TOTAL	$ 500	$ 750	$ 1,000	
Project #7	**Reduce fuels and re-introduce low intensity fires to re-establish natural fire regimes across the Upper Klamath River**				
	Upland vegetation management including fuel reduction and burning	$ 540	$ 630	$ 720	Expanded cost ranges updated August 11, 2022 to reflect an increase number of implementations due to an 20% increase in the number of HUCs arising from IFRMP document review.
	TOTAL	$ 540	$ 630	$ 720	
Project #5b	**Work with agriculture interests and other to install fencing along riparian corridors to reduce erosion into the UKR mainstem and key tributaries**				
	Fencing	$ 720	$ 1,440	$ 1,800	
	TOTAL	$ 720	$ 1,440	$ 1,800	
Project #5a	**Improve riparian grazing management to reduce erosion into the UKR mainstem and key tributaries**				
	Riparian area conservation grazing management				No data to draw from in any subbasin
	TOTAL	$ -	$ -	$ -	
Project #17	**Restore upland wetlands and meadows to improve cold water storage and flood attenuation in the Upper**				
	Upland wetland improvement	$ 3,600	$ 3,600	$ 3,600	
	TOTAL	$ 3,600	$ 3,600	$ 3,600	
Project #6	**Implement upland road decommissioning in key areas of the Upper Klamath River sub-basin with high fine sediment**				
	Road closure / abandonment	$ 15	$ 30	$ 40	
	TOTAL	$ 15	$ 30	$ 40	
Project #18	**Install BDAs in key Upper Klamath River tributaries to provide improved seasonal fish rearing habitats**				
	Beavers & beaver dam analogs	$ 170	$ 255	$ 340	
	TOTAL	$ 170	$ 255	$ 340	
Project #4	**Implement projects to reduce warm tailwater inputs to tributaries in the Upper Klamath River**				
	Tailwater return reuse or filtering	$ 120	$ 240	$ 400	No data. Used average expanded costs from all proximal sub-basins with data (Upper Klamath Lake)
	TOTAL	$ 120	$ 240	$ 400	
Project #14	**Install fish screens at diversions of priority concern within the Upper Klamath River sub-basin**				
	Fish screens installed	$ 770	$ 1,680	$ 2,590	
	TOTAL	$ 770	$ 1,680	$ 2,590	
Project #13	**Remove/repair road/stream crossings to restore fish passage to upstream habitats within Upper Klamath**				
	Culvert installed or improved at road stream crossing				Cost data per implementation available, but no data about number of implementations to draw from in any subbasin
	Remove/repair road/stream crossings to restore fish passage to upstream habitats within Upper Klamath				Cost data per implementation available, but no data about number of implementations to draw from in any subbasin
	TOTAL	$ -	$ -	$ -	
Project #20	**Address restoration needs of PacifiCorp Parcel A lands**				
	Instream habitat project (general)	$ 53	$ 177	$ 280	No data for this sub-basin, proximal sub-basins, or any sub-basins downstream of Klamath dams. Used average expanded cost from any subbasins with data (Lost)
	Riparian habitat project (general)	$ 200	$ 200	$ 200	New action type added. Not costed. Used "riparian planting" from UKR as proxy cost range.
	TOTAL	$ 253	$ 377	$ 480	
	SUB-BASIN TOTAL	$ 25,601	$ 47,342	$ 77,775	

Project #	Action_Type	Low		Mid		High	
	Williamson						
Project #4_7	**Work with agriculture interests and other to improve grazing practices and fence and/or plant vegetation to improve riparian and instream conditions within the Williamson River and key tributar**						
	Fencing	$	250	$	700	$	1,200
	Riparian area conservation grazing management							No data to draw from in any subbasin
	Riparian planting	$	100	$	450	$	950
	Upland livestock and grazing management	$	775	$	4,650	$	9,300	No data for number of implementations in this sub-basin. Used average expanded costs from all proximal sub-basins with data (Upper Klamath Lake)
	TOTAL	$	1,125	$	5,800	$	11,450
Project #5	**Reconnect channels to restore fish access to existing cold-water springs in Williamson River mainstem reaches and key sub-b**						
	Instream flow project (general)	$	5,445	$	5,830	$	6,220	No data for number of implementations in this sub-basin. Used average expanded costs from all proximal sub-basins with data (Upper Klamath Lake, Lost)
	Water quality project (general)	$	745	$	1,274	$	1,919	No data for number of implementations in this sub-basin. Used average expanded costs from all proximal sub-basins with data (Upper Klamath Lake, Sprague, Lost)
	TOTAL	$	6,190	$	7,104	$	8,139
Project #10	**Improve hydrological and habitat connectivity both within the Williamson River delta and between the Williamson River mains**						
	Mechanical channel modification and reconfiguration	$	625	$	1,650	$	2,700
	TOTAL	$	625	$	1,650	$	2,700
Project #3_8b	**Implement low-tech process-based restoration measures in key tributaries to create fish habitat and increase water residence times and groundwater recharge**						
	Addition of large woody debris	$	400	$	2,700	$	5,000	No data for this sub-basin or proximal sub-basins. Used average expanded costs from any subbasins with data (Trinity, South Fork Trinity)
	Channel structure placement	$	75	$	300	$	750
	Beavers & beaver dam analogs	$	75	$	113	$	150
	Upland wetland improvement	$	2,718	$	2,736	$	2,771	No data for this sub-basin or proximal sub-basins. Used average expanded costs from any subbasins with data (Upper Klamath River, South Fork Trinity, Scott, Mid Klamath River)
	TOTAL	$	3,268	$	5,848	$	8,671
Project #6	**Improve connection of Williamson River to the Klamath Marsh NWR and convert existing drains and levees into**						
	Dike or berm modification / removal	$	644	$	7,881	$	24,250	No data for this sub-basin, proximal sub-basins, or any subbasins downstream of Klamath dams. Used average expanded costs from any subbasins with data (Trinity)
	Mechanical channel modification and reconfiguration	$	375	$	990	$	1,620
	TOTAL	$	375	$	990	$	1,620
Project #9	**Thin lodgepole pine forest encroaching into the upper Williamson River to prevent loss of upland meadows**						
	Upland vegetation management including fuel reduction and burning	$	50	$	375	$	875
	TOTAL	$	50	$	375	$	875
Project #11	**Undertake multiple linked road-related restoration and re-construction projects to enable improved fish pass**						
	Bridge installed or improved at road stream crossing	$	1,350	$	2,370	$	3,390
	Culvert installed or improved at road stream crossing							Cost data per implementation available, but no data about number of implementations to draw from in any subbasin
	Road closure / abandonment	$	108	$	340	$	570	No data for number of implementations in this sub-basin and no expanded cost data in proximal subbasins. Used average expanded costs from any subbasins with data (Mid Klamath River, Upper Klamath River, Trinity)
	Road drainage system improvements and reconstruction	$	372	$	685	$	1,043	No data for number of implementations in this sub-basin and no expanded cost data in proximal subbasins. Used average expanded costs from any subbasins with data (Scott, Trinity, South Fork Trinity)
	Road stream crossing removal							Cost data per implementation available, but no data about number of implementations to draw from in any subbasin
	Rocked ford - road stream crossing							Cost data per implementation available, but no data about number of implementations to draw from in any subbasin
	TOTAL	$	1,830	$	3,395	$	5,003
Project #8a	**Add spawning gravels to reaches of the upper Williamson River to improve habitat conditions for Redband Trout**						
	Spawning gravel placement	$	20	$	140	$	440
	TOTAL	$	20	$	140	$	440
Project #2	**Undertake upland forest management and prescribed burns to create forest gaps for improved snowpack accu**						
	Upland vegetation management including fuel reduction and burning	$	90	$	300	$	525
	TOTAL	$	90	$	300	$	525
	SUB-BASIN TOTAL	$	13,573	$	25,602	$	39,423

Table C - 2: Consolidated summary of un-costed Klamath IFRMP projects that we were unable to obtain cost information for (grouped by sub-basin).

Action Type	Occurences - Project # (and Subbasin)
Estuarine plant removal / control	Project #12 (Lower Klamath River)
Remove feral cattle	Project #13 (Lower Klamath River)
Fish translocation	Project #14 (Lower Klamath River)
Planting for erosion and sediment control	Project #4a (Mid Klamath River)**
Slope stabilization	Project #4a (Mid Klamath River)
Riparian area conservation grazing management	Project #7 (Salmon)
Streambank stabilization	Project #7 (Salmon)
Riparian area conservation grazing management	Project #14 (Scott)
Streambank stabilization	Project #14 (Scott)
Riparian area conservation grazing management	Project #6a (Scott)
Planting for erosion and sediment control	Project #7 (Scott)**
Major dams removed	Project #8a (Shasta)**
Planting for erosion and sediment control	Project #4 (South Fork Trinity)**
Riparian area conservation grazing management	Project #6 (South Fork Trinity)
Riparian area conservation grazing management	Project #11 (Sprague)
Riparian area conservation grazing management	Project #3 (Sprague)
Culvert installed or improved at road stream crossi	Project #6 (Sprague)
Planting for erosion and sediment control	Project #10 (Trinity)**
Slope stabilization	Project #10 (Trinity)
Riparian area conservation grazing management	Project #1 (Upper Klamath Lake)
Manage Dam Releases (Link and Keno)	Project #10b (Upper Klamath Lake)
Culvert installed or improved at road stream crossi	Project #13 (Upper Klamath Lake)
Stormwater filtering	Project #14 (Upper Klamath Lake)
Fishway chutes or pools Installed	Project #12 (Upper Klamath River)
Culvert installed or improved at road stream crossi	Project #13 (Upper Klamath River)
Road stream crossing removal	Project #13 (Upper Klamath River)
Manage Dam Releases (Klamath Dams)	Project #2 (Upper Klamath River)
Riparian area conservation grazing management	Project #5a (Upper Klamath River)
Culvert installed or improved at road stream crossi	Project #11 (Williamson)
Road stream crossing removal	Project #11 (Williamson)
Rocked ford - road stream crossing	Project #11 (Williamson)
Riparian area conservation grazing management	Project #7 (Williamson)
Manage dam releases (Trinity and Lewiston Dams	Project #1 (Trinity)
Restore reservoir footprint to former conditions in t	Project #15 (Upper Klamath River)

** = project partially costed, see Table C - 1.

Appendix E: Cost Result Profiles for Klamath Projects by Action Type

Addition of large woody debris

Adding large woody debris to help recruit natural sediment and restore natural beaches at the mouths of estuaries.

- One participant indicated a cost of $450.00 per rootwad log in the Trinity sub-basin
- For Lower Klamath River, South Fork Trinity, and Trinity, one participant suggested standard unit costs of $111.8K per km based on the mean costs/km from six projects listed in Cedarholm et al. 1997 as provided in Pollock et al. 2004
- Thomson and Pinkerton (2008) report a standardized cost range of $0.55 – 11.3K per structure (1998 – 2006 USD, not inflation adjusted), while Evergreen (2003) reports an upper bound of $80K.
- The most significant cost driver indicated in Evergreen's (2003) standardized costs is the size of the waterway (stream size). Materials and transportation also drive costs, to a lesser extent. Density of logs needed can influence costs - average wood density is 200-300 pieces per mile or 50-80 pieces per structure. Risk (e.g. proximity of dwellings to waterway) can impact costs, (dwellings more closely positioned to waterways will increase risk (and costs), and minimal risks will occur where there are no dwellings).

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Lower Klamath River #10	N/A	N/A	N/A	N/A	N/A	N/A
Mid-Klamath River #12	N/A	N/A	N/A	N/A	N/A	N/A
Salmon #4	N/A	N/A	N/A	N/A	N/A	N/A
Scott #11	N/A	N/A	N/A	N/A	N/A	N/A
South Fork Trinity #3	$50 – {1,025} – 2,000	2 – {6} – 10	M	$300 – {6,150} – 1,200	1	N/A
South Fork Trinity #9a	$30 – {65} – 100	10 – {15} – 20	M	$450 – {975} – 1,500	1	N/A
Sprague #7b	N/A	10 – {12.5} – 15	M-H	N/A	2	N/A
Trinity #6	$30 – {65} – 100	10 – {15} – 20	M	$450 – {975} – 1,500	1	N/A
Upper Klamath Lake #11	N/A	5	N/A	N/A	1	N/A
Upper Klamath Lake #11b	N/A	5	N/A	N/A	1	N/A
Williamson #8b	N/A	5	N/A	N/A	1	N/A

Artificial wetland created

New (artificial) wetland created in an area not formerly a wetland. This is wetland area created where it did not previously exist.

- The cost database indicates 38 past projects ranging from $3 - $127K per implementation (outliers removed).
- For Upper Klamath Lake, one participant noted that Trout Unlimited or The Nature Conservancy should be able to provide an estimate of the number of acres of restored wetland needed to supplement pumpoff filtration.

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Sprague #8	$15 – {50} – 130	10 – {17.5} – 25	L-H	$263 – {875} – 2,275	3	0
Upper Klamath Lake #14	$15 – {80} – 130	10	M-H	$150 – {800} – 1,300	3	11

Upper Klamath Lake #4	$15 – {70} – 130	10 – {55} - 100	M-H	$825 – {3,850} – 7,150	3	11

	Augment coarse sediment
	Add coarse sediment downstream of Iron Gate Dam to mitigate deficit caused by the dam. • Cost drivers indicated by participants included: gravel source (onsite, nearby, hauling); gravel processing (cleaning/sorting or no cleaning/sorting); end-state of gravel addition or source gravel pile (no targeted end surface, final surface surveyed to ensure specs are as designed); injection method (bulldozer or front end loader, excavator, conveyor belt), hauling requirements (e.g., process onsite or haul) • One participant indicated a multiplier of 3x from low to mid cost and 5x from low to high cost in the Trinity sub-basin • The Trinity RoD calls for an average of 10,300 cubic yards annually

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Trinity #1	$100 – {150} – 200	5	L-H	$500 – {750} – 1,000	2	N/A
Trinity #9	$10 – {55} – 100	2 – {6} – 10	M	$60 – {330} – 600	1	N/A
Upper Klamath River #9	N/A	N/A	N/A	N/A	N/A	N/A

	Beavers & beaver dam analogs
	Introduction or management of beavers to add natural stream complexity (beaver dams, ponds, etc.). Restoration of aquatic habitat to support beaver populations through the usage of deciduous shrub and trees, beaver dam analogs (BDA) or post-assisted woody structures (PAWS). • The cost database indicates 13 past projects ranging from $3.6 - $19.8K per implementation (outliers removed). • Cost drivers indicated by participants included: posts (hand-held hydraulic, manual post pounder, heavy machine mounted hydraulic post pounder); # of transport material (e.g. 2, 4, or 10), accessibility (drive vs. hike to site), substrate (soft/sand, gravel, cobble/boulder), channel width (narrow, wide, mainstem vs. tributary), efficiencies of scale (e.g., cheaper to do many structures at once rather than one standalone), length • One participant indicated a cost of $10/post in the Trinity sub-basin • One participant group suggested a standard cost unit measure of 10 BDAs per project • For Lower Klamath River, South Fork Trinity, and Trinity, one participant suggested a standard unit cost of $1000.00 – 5,000.00 per structure. See Davee et al. 2019 (USFS research paper PNW-RP-612)

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Lower Klamath River #11	N/A	N/A	N/A	N/A	N/A	0
Mid-Klamath River #14	$10 – {15} – 20	8	M	80 – {120} - 160	Group (7)	0
Scott #9	$10 – {20} – 30	40	H	400 – {800} – 1200	1	4
South Fork Trinity #3	$10 – {20} – 30	12 – {16} – 20	L	$160 – {800} – 1,200	1	0
Sprague #9	$10 – {15} – 20	10 – {12.5} – 15	M-H	125 – {187.5} – 250	3	0
Trinity #15	$10 – {20} – 30	9	L-H	90 – {180} – 270	2	0
Upper Klamath Lake #8b	$5 – {15} - 25	5 – {5.5} – 6	M	27.5 – {82.5} – 137.5	3	0
Upper Klamath River #18	$10 – {15} – 20	17	M	170 – {255} – 340	Group (7)	0
Williamson #3	$10 – {15} – 20	5 – {7.5} – 10	M-H	75 – {112.5} – 150	3	0

	Bridge installed or improved at road stream crossing
	Installation, improvement/upgrade or replacement of a bridge over a stream to provide/improve fish passage under a road. The bridge could be replacing a culvert. • The cost database indicates 21 past projects ranging from $16.2 - $1,130K per implementation (outliers removed). In Upper Klamath Lake, 4 past projects were in the $16.2 – 135.4 range. • Cost drivers indicated by participants included: road type (small/private or forest service road, state highway, country road, instream barrier) • For the Upper Klamath River sub-basin, participants indicated the following locations: Deer Cr, Indian Cr (JC Boyle area), Middle, Seiad (Canyon), Cade, McKinney, Portuguese, Lumgrey/Empire, Scotch, Camp, Fall through KRRC (1 million each) • Thomson and Pinkerton (2008) report a standardized cost range of $23 – 746K per bridge (1998 – 2007 USD, various projects, not inflation adjusted), with most costs falling in the $100 – 500K per bridge range. • A cost driver suggested in Thomson and Pinkerton's (2008) report is whether or not the bridge is prefabricated – prefabricated bridges tend to have costs at the lower end of the cost range. • Evergreen (2003) suggests that waterway size and road type/size will drive costs (larger waterways and larger roads will cost more).

Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** ($'000s *2020* USD)	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** ($'000s *2020* USD)	**Responses**	**Number of projects in cost databases in this cost range**
Upper Klamath River #16	$150 – {1,075} – 2,000	7	M	$1,050 – {7,525} – 14,000	Group (7)	0
Williamson #11	$450 – {790} – 1,130	3	L-H	$1,350 – {2.370} – 3,390	3	0

	Channel structure placement
	Placement of large woody debris or rocks/boulders (including deflectors, barbs, weirs) to collect and retain gravel for spawning habitat; deepen existing resting/jumping pools; create new pools above and/or below the structure; trap sediment; aerate the water; channel roughening; or, promote deposition of organic debris. This includes floodplain roughening or fencing. • The cost database indicates 219 past projects ranging from $0.5 - $148.7K per implementation (outliers removed). • Cost drivers indicated by participants included: "chop and drop" vs. importing material, unanchored vs. anchored/ballasted or ELJ • One participant group suggested a unit cost measure of 1 structure per project • Thomson and Pinkerton (2008) report a standardized cost range of $0.55 – 11.3K per structure (1998 – 2006 USD, not inflation adjusted) • The most significant cost driver indicated in Evergreen's (2003) standardized costs (for large woody debris) is the size of the waterway (stream size). Materials and transportation also drive costs, to a lesser extent. Density of logs needed can influence costs - average wood density is 200-300 pieces per mile or 50-80 pieces per structure. Risk (e.g. proximity of dwellings to waterway) can impact costs, (dwellings more closely positioned to waterways will increase risk (and costs), and minimal risks will occur where there are no dwellings).

Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** ($'000s *2020* USD)	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** ($'000s *2020* USD)	**Responses**	**Number of projects in cost databases in this cost range**
Mid-Klamath River #12	$15 – {30} – 40	125	M	$1,875 – {3,750} – 5,000	Group (7)	15
Salmon #4	N/A	N/A	N/A	N/A	N/A	N/A
Scott #11	$15 – {30} – 40	20	M	$300 – {600} – 800	1	0
South Fork Trinity #9a	$30 – {70} – 150	6 – {9} – 12	M	$270 – {630} – 1,350	2	0
Sprague #7b	$5 – {50} – 150	10 – {12.5} - 15	M-H	$50 – {625} – 1,875	2	11

Trinity #6	$15 – {55} – 150	5 – {10} – 20	M-H	$150 – {550} – 1,500	3	0
Upper Klamath Lake #11	$15 – {30} – 40	5	M-H	$75 – {150} – 200	2	14
Williamson #8b	$15 – {60} – 150	5	M-H	$75 – {300} – 750	2	0

Conservation easement

A conservation easement is a legal agreement between a conservation body and a landowner that determines permissible and restricted land uses on that property.

- Cost drivers indicated by participants included: type of land (e.g., hillside/low value, undeveloped valley bottom, timberland or developed agricultural land); whether water rights are included as part of easement, whether riparian areas are included, whether the streams are fish bearing
- Evergreen (2003) reports a standardized cost range between $0.7 – 4.8K per acre for conservation easement on undeveloped land, and a range of $5K – 1.2M for developed land. Thomson and Pinkerton (2008) report a lower standardized cost bound of $0.042K.
- Drivers of costs reported in Evergreen (2003) pertain mostly to the development status of the land; Land that is permitted to be residentially and commercially developed (high developmental potential) will cost more than land that is not permitted to be as developed (low developmental potential). Sites nearer to urban areas will have higher values, so costs will be higher. Proximity to sensitive areas (wetlands, floodplains, steep slopes, etc.) will be cheaper than areas with minimal sensitive areas, because sensitive areas will have low developmental potential, thus costs will be lower.

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation ($'000s *2020* USD)	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} ($'000s *2020* USD)	Responses	Number of projects in cost databases in this cost range
Scott #12	$60	80	M	$4,800	1	N/A

Culvert installed or improved at road stream crossing

Installation or improvement/upgrade (including replacement) of a culvert to a standard that provides juvenile and adult fish passage.

- The cost database indicates 62 past projects ranging from $2 - $1,335K per implementation (outliers removed).
- Compared to the participant responses, 12 past projects for Sprague fall in the cost range of $8 – 215K, suggesting a potential underestimate by participants of costs in that sub-basin
- Compared to the participant responses, 7 past projects for Sprague fall in the cost range of $6 – 403K, suggesting a potential underestimate by participants of costs in that sub-basin
- Thomson & Pinkerton (2008) report a standardized cost range of $27.5 – 295K per culvert (1998 – 2007, various projects, not inflation adjusted)
- According to Evergreen (2003), drivers of costs include the type/size of road (forest road, minor 2 lane, major 2 lane, highway of 4 or more lanes; larger roads require larger culverts), and the size of waterway (larger rivers require larger culverts).

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Sprague #6	$5 – {30} – 50	N/A	H	N/A	1	12
Upper Klamath Lake #13	$5 – {30} – 50	N/A	H	N/A	1	7
Upper Klamath River #13	N/A	N/A	N/A	N/A	N/A	N/A
Williamson #11	$5 – {30} – 50	N/A	H	N/A	1	N/A

	Dike or berm modification / removal					
	Removal, breaching, reconfiguration or other action affecting the physical presence of barriers or structures that prevent tidal or riverine access to the estuary. Modification/removal allows for natural flow/flood regime and potential for off-channel habitat usage. This involves lateral structures only and does not include dams or other perpendicular obstructions to flow. • Cost drivers indicated by participants included: berm volume (low, medium, high); haul distance (onsite, across a channel, off site); ease of access for machine (open no obstacles/off-road, clear haul road, challenging to navigate or use of Road Safe haul trucks); whether materials are left on site or hauled off site • One participant group response indicated a cost of \$20.00/cubic yard if left on site and \$40.00/cubic yard if hauled off site in the Mid/Upper Klamath River sub-basins					
Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *(\$'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *(\$'000s 2020 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Scott #8	N/A	N/A	N/A	N/A	N/A	N/A
South Fork Trinity #12	\$50 – {3,025} – 10,000	1	L	\$50 – {3,025} – 10,000	2	N/A
Sprague #4	N/A	N/A	N/A	N/A	N/A	N/A
Trinity #1	\$50 – {650} – 2,000	1 – {22.75} - 44	L	\$1,138 – {14,788} – 45,500	2	N/A
Trinity #5	\$50 – {325} – 1,000	3	L	\$150 – {435} - 720	2	N/A
Upper Klamath Lake #3	N/A	N/A	N/A	N/A	N/A	N/A
Upper Klamath River #10	N/A	N/A	N/A	N/A	N/A	N/A
Williamson #6	N/A	N/A	N/A	N/A	N/A	N/A

	Estuarine plant removal / control					
	Removal and/or control (treatment) of non-native species, noxious weeds and other plants or invasive species that adversely affect the estuarine area. • Successful eradication of reed canary grass would likely require 5-10 years of work/site, although significant reductions can be achieved in 2-3 years. Costs would depend on methods used, which should be dictated by site conditions. • Evergreen (2003) reports a standardized cost range of \$20K – 3M per acre (not inflation adjusted) for "estuary restoration" projects • Evergreen (2003) notes drivers of costs for "estuary restoration" include the extent of earthmoving (quantity of materials and distance to disposal sites), and site land use type (undeveloped vs sites with utilities, roads, buildings). • Thomson and Pinkerton (2008) report a standardized cost range of \$5 – 12K per acre (2004 USD, not inflation adjusted) for "invasive/noxious weed control"					
Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *(\$'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *(\$'000s 2020 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Lower Klamath River #12	N/A	N/A	N/A	N/A	N/A	N/A

	Fencing

	Creation of livestock exclusion or other riparian fencing. Open watercourses are assumed to provide open access to cattle. • The cost database indicates 233 past projects ranging from \$0.3 - \$121.1K per implementation (outliers removed). • One participant indicated a unit cost of \$1.50 per linear foot for South Fork Trinity (July 2021) • Another participant indicated a unit cost of \$9/foot for Scott (July 2021) • Cost drivers indicated by participants included: type of fence; site conditions • The standardized cost range reported in Evergreen (2003) is \$0.001 – 0.012K per lineal foot. Thomson and Pinkerton (2008) report an upper standardized cost bound of \$0.02K per lineal foot. • Costs are primarily driven by the type of material used to construct the fence (barbed wire with few posts will be cheap, whereas wooden, split rail fences with gates and many posts will be the most costly), according to Evergreen (2003).

Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *(\$'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *(\$'000s 2020 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Lost #9	\$25 – {70} – 120	2 – {6} – 10	M	\$150 – {420} - 720	2	0
Lost #9d	\$25 – {70} – 120	10 – {15} – 20	M-H	\$375 – {1,050} – 1,800	2	0
Scott #6c	N/A	N/A	N/A	N/A	N/A	20
Shasta #6	\$10 – {20} – 25	5	M	\$50 – {100} - 125	1	12
South Fork Trinity #6	\$25 – {70} – 120	5 – {7.5} – 10	L	\$187.5 – {525} - 900	1	0
Sprague #3	\$25 – {70} – 120	10	M-H	\$250 – {700} – 1,200	2	15
Upper Klamath Lake #1	\$25 – {70} – 120	5 – {12.5} – 20	M	\$313 – {875} – 1.500	2	13
Upper Klamath River #5b	\$10 – {20} – 25	72	M	\$720 – {1,440} – 1,800	Group (7)	15
Williamson #7	\$25 – {70} – 120	10	L-H	250 – {700} – 1,200	2	0

	Fish ladder Installed / improved
	Installation or modification (upgrade/improvement) of a fish ladder. • The cost database indicates 8 past projects ranging from \$6 - \$44.1K per implementation (outliers removed). • Thomson and Pinkerton (2008) suggest a standardized cost for fish ladders of \$500K/ladder (small waterway) and \$900K/ladder (large waterway). • For the Lost sub-basin, one participant expressed concerns about the condition of Harpold, which could complicate the addition of fish passage infrastructure, thereby affecting the cost. • For Upper Klamath Lake, one participant noted, "I believe fish ladder improvements at Link River Dam would cost several (~5) million." • Thomson and Pinkerton (2008) report a standardized cost range of \$300K – 2.3M per ladder (1997 – 2004 USD, various projects, not inflation adjusted). They note that most of the projects they reviewed fall within the \$500 – 900K per ladder range. • Thomson and Pinkerton (2008) note the cost of ladders installed on smaller waterways will be lower than those installed in larger waterways (e.g., tributaries vs. large stream/rivers)

Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *(\$'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *(\$'000s 2020 USD)*	**Responses**	**Number of projects in cost databases**

						in this cost range
Lost #7	$10 – {30} – 45	1	L-M	$10 – {30} – 45	2	0
Lost #8	$10 – {30} – 45	1	L-M	$10 – {30} – 45	2	0
Lost #11	$10 – {30} – 45	1	L-H	$10 – {30} – 45	2	1
Shasta #8b	$25 – {35} – 45	1	H	$25 – {35} – 45	1	0
Trinity #7	$25 – {35} – 45	1 – {1.5} – 2	L-M	$38 – {53} – 68	3	1

Fish passage improvement (general)

Projects that improve or provide anadromous fish (and potentially other native aquatic organisms) migration up and down stream including fish passage at road crossings (bridges or culverts), barriers (dams or log jams), fishways (ladders, chutes or pools), and weirs (log or rock).

- Cost drivers indicated by participants included: road type (small/private or forest service road, state highway, county road, instream barrier)
- Thomson and Pinkerton (2008) report a standardized cost range of $5 – 65K (with some notable exceptions in the $460 – 485K range) per culvert, for culvert improvement projects. Cost ranges for replacement of culverts with bridges ("Bridge installed or improved at road stream crossing"), and culvert replacement ("Culvert installed or improved at road stream crossing") are provided in their respective summary tables.

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Mid-Klamath River #10	N/A	N/A	N/A	N/A	N/A	N/A
Mid-Klamath River #6	$150 – {1075} – 2,000	1	M	$150 – {1075} – 2,000	N/A	N/A
Mid-Klamath River #9	$183 – {1,592} - 3,000	3	M	$550 – {4,775} – 9,000	N/A	N/A
Salmon #8	N/A	N/A	N/A	N/A	N/A	N/A
Scott #5	N/A	N/A	N/A	N/A	N/A	N/A
Shasta #7	$200 – {600} – 1,000	3	L	$600 – {1,800} – 3,000	1	N/A
South Fork Trinity #10	$50 – {275} – 500	4	L	$200 – {1,100} – 2,000	1	N/A
Sprague #6	N/A	N/A	N/A	N/A	N/A	N/A
Trinity #8	$40 – {140} – 240	N/A	L	N/A	1	N/A

Fish screens installed

New fish screens installed where no screen had existed previously.

- The cost database indicates 90 past projects ranging from $1.2 - $184.1K per implementation (outliers removed).
- For Upper Klamath River, participants indicated the following locations: at least 3 in Shovel, 2 in Klamath mainstem, 1 in Hayden Cr, 1 in Edge Cr, 1 in Jenny, 1 in Beaver Cr (above Iron Gate), Horse/Middle, Seiad/Panther
- Thomson and Pinkerton (2008) report a standardized cost range of $1.2K – 9.4M per screen (1995 – 2007 USD, various projects, not inflation adjusted).

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range

Lost #5	$10 – {75} – 185	17	M-H	$170 – {1,275} – 3,145	2	0
South Fork Trinity #11	$10 – {30} – 55	5 – {12.5} – 20	L	$125 – {375} – 687.5	1	0
Upper Klamath Lake #9	$10 – {90} – 185	5 – {52.5} – 100	L-H	$525 – {4,725} – 9,712.5	3	0
Upper Klamath River #14	$55 – {120} – 185	14	M	$770 – {1,680} – 2,590	Group (7)	0

	Fish translocation					
	Translocation of fish past barriers using trap and haul or other methods.					
Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *($'000s 2021 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *($'000s 2021 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Lower Klamath River #14	N/A	N/A	N/A	N/A	N/A	N/A

	Hatchery reform and assessment (general)					
	Hatchery reform projects that assess or evaluate hatchery production levels and strategies for maximizing harvest levels while minimizing ESA and wild salmonid impacts, and/or minimizing hatchery/wild interactions.					
Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *($'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *($'000s 2020 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Trinity #12	$10,000 – {15,000} – 20,000	1	L	$10,000 – {15,000} – 20,000	1	N/A
Trinity #13	N/A	5	M	N/A	1	N/A
Trinity #14	N/A	5	M	N/A	1	N/A

	Instream flow project (general)					
	Projects that maintain and/or increase the flow of water to provide needed fish habitat conditions. This can include water rights purchases/leases, or irrigation practice improvements (reduced flow into fields) including water conservation projects to reduce stream diversions or extractions. • The cost database indicates 2 past projects, one in Sprague for $821.6K and another in Shasta for $1,200K • The Farmers Conservation Alliance is working on strategic planning with Tulelake Irrigation District and Klamath Irrigation District that will provide improved cost estimates for flow improvement measures in the Lost sub-basin. • For the Lost sub-basin, one participant noted that "installing new nozzles is cheap" • For the Upper Klamath River sub-basin, participants indicated the following locations: Shovel, Hayden, Edge, at least 2 on mainstem Klamath River, Seiad/Panther, Horse/Middle					
Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation**	**Suggested number of implementations**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}**	**Responses**	**Number of projects in cost databases**

	($'000s 2020 USD)	with {estimated mid-point}		($'000s 2020 USD)		in this cost range
Lost #1	$1,200	9	L-H	$10,800	2	0
Mid-Klamath River #6	N/A	N/A	N/A	N/A	N/A	0
Shasta #1	$1,200	5	M	$6,000	1	1
Shasta #11		1	H		1	1
Shasta #2	$1,200	1	H	$1,200	1	1
Shasta #4	$1,200	1	H	$1,200	1	1
South Fork Trinity #2	$500 – {1,200} – 2,000	1	L	$500 – {1,200} – 2,000	2	0
South Fork Trinity #7	$1,000 – {1,175} – 1,300	6	L-M	$6,000 – {7,050} – 7,800	2	0
South Fork Trinity #8	$1,000 – {1,175} – 1,300	6	L-M	$6,000 – {7,050} – 7,800	2	0
Sprague #5	$820 – {1,010} – 1,200	N/A	M-H	N/A	2	1
Trinity #11	$1,000 – {1,175} – 1,300	13	L	$13,000 – {15,275} – 16,900	2	0
Trinity #17						
Trinity #18						
Upper Klamath Lake #6	$45 – {430} – 820	2	L-M	$90 – {860} – 1,640	2	0
Upper Klamath River #3	$500 – {850} – 1,200	4	M	$2,000 – {3,400} – 4,800	Group (7)	0
Williamson #5	$820	N/A	M	N/A	1	0

Instream habitat project (general)

Projects that increase or improve the physical conditions within the stream environment (below the ordinary high water mark of the stream) to support increased fish population.

- The cost database indicates 30 past projects ranging from $22.4K – 120K per implementation (outliers removed).
- For the Lost sub-basin, one participant noted that characterization of dredged sediment is needed before estimating cost (e.g., clean so easy disposal, or contaminated requiring landfill).

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation ($'000s 2020 USD)	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} ($'000s 2020 USD)	Responses	Number of projects in cost databases in this cost range
Lost #10a	$20 – {75} – 120	1	L	$20 – {75} – 120	2	0
Lost #10b	$40 – {80} – 120	1	M	$40 – {80} – 120	1	0
Lost #9	$20 – {75} – 120	5	M-H	$100 – {375} – 600	2	0
Salmon #2	N/A	N/A	N/A	N/A	N/A	0

Irrigation practice improvement

Improvement of irrigation practices (where water is removed from a stream) to protect fish. This includes: installing a headgate with water gage to control water flow into irrigation canals and ditches; regulating flow on previously unregulated diversions; installing a well or storage holding tanks to eliminate a diversion; or, replacing open canals with pipes to reduce water loss to evaporation and dedicating the saved water to aquatic resources.

- The cost database indicates 59 past projects ranging from $2.3K – 119.2K per implementation (outliers removed).
- Thomson and Pinkerton (2008) report a standardized cost range of $0.8 – 2.5K per acre (2004 – 2007 USD, various projects, not inflation adjusted).

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Lost #1	$5 – {70} – 120	5	L-M	$25 – {350} - 600	3	20
Scott #3	N/A	N/A	N/A	N/A	N/A	N/A
Scott #4	N/A	N/A	N/A	N/A	N/A	N/A
Upper Klamath Lake #14	$5 – {70} – 120	5	L-H	$25 – {350} - 600	3	0
Upper Klamath Lake #2	$15 – {70} – 120	5 – {7.5} – 10	M-H	$112.5 – {525} - 900	3	0
Upper Klamath River #3	N/A	N/A	N/A	N/A	N/A	0

Major dams removed

Removal of major dams to allow fish passage and to help restore natural flow regimes.

- Thomson and Pinkerton (2008) report one example project of dam decommissioning. The cost was $1.5M per decommissioning (1999 USD).

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Shasta #8a	N/A	1	N/A	N/A	1	N/A

Manage dam releases

Regulate flows to some extent to provide cooling and improved flows in the mainstem Klamath River.

- Cost drivers indicated by participants included: NEPA/ESA Section 7
- For the Trinity sub-basin, one participant noted: "Measuring the costs of altering the operation of these dams would be a complex exercise and could be done in a number of ways. BoR would likely be the best agency to address this."

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Upper Klamath River #2 (Klamath Dams)	N/A	N/A	N/A	N/A	N/A	N/A
Upper Klamath Lake #10b (Link and Keno)	N/A	N/A	N/A	N/A	N/A	N/A
Trinity #1 (Trinity and Lewiston Dams)	$0 – {250,000} – 500,000	1 – {3} – 5	L	$0 – {750,000} – 1,500,000	2	N/A

Manage water withdrawals

Preventing or reducing water withdrawals from stream (including water rights acquisitions, dedications, transfers).

- Cost drivers indicated by participants included: site conditions; specific issues/concerns

Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *($'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *($'000s 2020 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Lost #3	N/A	N/A	N/A	N/A	N/A	N/A
Mid-Klamath River #3	N/A	N/A	N/A	N/A	N/A	N/A
Scott #1	N/A	N/A	N/A	N/A	N/A	N/A
Scott #2	N/A	N/A	N/A	N/A	N/A	N/A
Shasta #1	$20	5	L	$100	1	N/A
South Fork Trinity #1a	N/A	7		N/A	N/A	N/A
South Fork Trinity #1b	$20 – {260} – 500	6	L	$120 – {1,560} – 3,000	1	N/A
South Fork Trinity #7	N/A	6	L-M	N/A	2	N/A
Trinity #2	$300 – {650} – 1,000	20	L	$6,000 – {13,000} – 20,000	1	N/A
Trinity #4	$5 – {20} – 30	5	L	$25 – {100} – 150	2	N/A
Upper Klamath Lake #7	N/A	N/A	N/A	N/A	N/A	N/A

	Mechanical channel modification and reconfiguration					
	Changes in channel morphology, sinuosity or connectivity to off-channel habitat, wetlands or floodplains. This includes instream pools added/created; removal of instream sediment; meanders added; former channel bed restored; removal or alteration of levees or berms (including setback levees) to connect floodplain; and, creation of off-channel habitat consisting of side channels, backwater areas, alcoves, oxbows, ponds, or side-pools. • The cost database indicates 139 past projects ranging from $1.1K – 541.2K per implementation (outliers removed). • Compared to participant responses, 8 past projects for Upper Klamath Lake are at a lower cost range per implementation ($1.1 – 45.2K) in cost database • Compared to participant responses, 8 past projects for Upper Klamath River are at a lower cost range per implementation ($45.2 – 123.8K) in cost database • Cost drivers indicated by participants included: design, permitting, mobilization, temporary access (clearing and grubbing), dewatering and/or turbidity management, wood procurement/transportation/placement, boulders not onsite, placement and anchoring of boulders, floodplain grading (using heavy equipment), riparian plants, seeding/mulch/planting, administrative overhead, personnel, stream width (e.g., mainstem or tributary), proximity to human infrastructure • One group response indicated a cost of $150/ton of boulders placed and anchored, $1/sqft for riparian plants • One group response indicated that 1 bale of straw can be used for 800 sqft, and 20lbs of native grass seed will cover 1 acre • One participant recommended a standard cost unit of 0.25 river miles • Evergreen (2003) reports a standardized cost range of $20 – 300K per acre for channel reconnection. • Cost drivers reported in Evergreen (2003) include level of permitting required (costs tend to be higher when land to be adjoined has a road or structure on it, or if it is along an important salmon-bearing river), and materials needed (type and amount).					
Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *($'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *($'000s 2020 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Lost #10a	$125 – {330} – 540	1	L-M	$125 – {330} – 540	2	0
Lost #10b	$125 – {330} – 540	1	M	$125 – {330} – 540	1	0
Lost #2	$45 – {210} – 540	1	L-M	$45 – {210} – 540	2	0
Lower Klamath River #6	$125 – {330} – 540	N/A	M	N/A	1	0

Mid-Klamath River #11	$560	5	H	$2800	Group (7)	0
Salmon #2	N/A	N/A	N/A	N/A	N/A	0
Salmon #3	N/A	N/A	N/A	N/A	N/A	0
Salmon #7	N/A	N/A	N/A	N/A	N/A	0
Scott #10	$5 – {20} – 45	N/A	M	N/A	1	10
Scott #14	$45 – {85} – 125	100	M	$4,500 – {8,500} – 12,500	1	0
Scott #8	N/A	N/A	N/A	N/A	N/A	0
Shasta #9	$125 – {330} – 540	N/A	L	N/A	1	0
South Fork Trinity #9b	$125 – {330} – 540	5	L-H	$625 – {1,650} – 2,700	2	0
Trinity #1	$5 – {312} – 540	5 – {19} – 47	H	$25 – {5,890} – 10,260	3	17
Trinity #5	$125 – {330} – 540	5 – {6.5} – 8	L-H	$812.5 – {2,145} – 3,510	2	17
Upper Klamath Lake #8a	$125 – {1,890} – 5,000	5	L-M	$625 – {9,450} – 25,000	3	0
Upper Klamath River #10	$500 – {625} – 750	14	M	$7,000 – {8,750} – 10,500	Group (7)	0
Williamson #10	$125 – {330} – 540	5	L-M	$625 – {1,650} – 2,700	3	0
Williamson #6	$125 – {330} – 540	3	M	$375 – {990} – 1,620	2	0

Minor fish passage blockages removed or altered

Removal or alteration of blockages, impediments or barriers to allow or improve fish passage (other than road crossings).

- The cost database indicates 179 past projects ranging from $1.1K – 238K per implementation (outliers removed).
- Compared to participant responses, 20 past projects for Sprague are at a higher cost range per implementation ($39.7 – 238K) in cost database
- Compared to participant responses, 34 past projects for Mid-Klamath River are at a lower cost range per implementation ($1.1 – 5.2K) in cost database
- The cost database indicates 14 past projects in Scott in the $1.1 – 5.2K range
- Cost drivers indicated by participants included: road type (small/private or forest service road, instream barrier, county road, state highway)
- Participants indicated agreement this action type should be removed from Mid-Klamath River Project #9
- Thomson and Pinkerton (2008) report a standardized cost range of $65K – 1.4M per barrier (structure).

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Mid-Klamath River #10	N/A	N/A	N/A	N/A	N/A	N/A
Mid-Klamath River #6	$150 – {1,075} – 2,000	5	M	$750 – {5,375} – 10,000	Group (7)	0
Salmon #8	N/A	N/A	N/A	N/A	N/A	0
Scott #5	N/A	N/A	N/A	N/A	N/A	0
Shasta #7	$40 – {140} – 240	3	L	$120 – {420} - 720	1	16
South Fork Trinity #10	$40 – {140} – 240	4	L	$160 – {560} - 960	1	20
Sprague #6	$5 – {10} – 40	N/A	M-H	N/A	2	0
Trinity #8	$5 – {80} – 240	5	M	$25 – {400} – 1,200	2	10
Upper Klamath Lake #13	$5 – {80} – 240	5	M-H	$25 – {400} – 1,200	2	0

	Planting for erosion and sediment control
	Upland projects that control erosion through planting and revegetation or grassed waterways. • Cost drivers indicated by participants included: seed and mulch (generic grass seed, weed free vs. any available straw, native grass seed); application method (by hand, seeder and straw blower, tacifier), woody plantings (none, some, lots), woody plant source (small/large container, cuttings) • One participant indicated a cost of $5-8/bale of straw and $40-75/lb of grass seed in the Trinity sub-basin • One participant suggested a standard unit cost of $500/acre for South Fork Trinity and Trinity • Thomson and Pinkerton report a single standardized cost (only one example project) of $2K per acre (2002 USD).

Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *($'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *($'000s 2020 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Mid-Klamath River #4a	N/A	N/A	N/A	N/A	N/A	N/A
Scott #7	N/A	N/A	N/A	N/A	N/A	N/A
South Fork Trinity #4	N/A	N/A	N/A	N/A	N/A	N/A

	Predator/competitor non-native fish species removal
	Control or removal of invasive, non-native/alien fish species fish predators or competitors (e.g., northern pike minnow, non-native fish, invasive animals) from the instream habitat, including construction of barriers to limit the expansion of non-native fish into uninvaded reaches. • The cost database indicates 2 past projects in Upper Klamath Lake ranging from $167.4 – 192.2K. • Thomson and Pinkerton report a standardized cost of $0.01 – 12K per acre.

Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *($'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *($'000s 2020 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Trinity #14	$5 – {80} – 165	1	L-H	$5 – {80} – 165	2	0

	Remove feral cattle
	Lethal removal feral cattle by hunting or live removal by professional wranglers.

Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *($'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *($'000s 2020 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Lower Klamath River #13	N/A	N/A	N/A	N/A	N/A	N/A

	Riparian area conservation grazing management
	Alteration of agricultural land use practices to reduce grazing pressure for conservation (e.g., rotate livestock grazing to minimize impact on riparian areas).

	• Cost drivers indicated by participants included: NEPA/ESA Section 7 • For Upper Klamath River Project #5a, the participant group felt this action type is covered by Fencing in Project #5b • For Scott, on participant noted: "This is difficult to cost because it is an action over time, rather than implmentaion. Perhaps including a management plan in the easement category. Also, NCRWQCB has riparian shade as a TMDL waiver requirement, so much of this should be covered under regulatory compliance and not paid for with restoration dollars."

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Salmon #7	N/A	N/A	N/A	N/A	N/A	N/A
Scott #14	N/A	N/A	N/A	N/A	N/A	N/A
Scott #6a	N/A	N/A	N/A	N/A	N/A	N/A
South Fork Trinity #6	N/A	N/A	N/A	N/A	N/A	N/A
Sprague #11	$5 – {10} – 20	N/A	M	N/A	1	N/A
Sprague #3	N/A	N/A	N/A	N/A	N/A	N/A
Upper Klamath Lake #1	N/A	20	M	N/A	1	N/A
Upper Klamath River #5a	N/A	N/A	N/A	N/A	N/A	N/A
Williamson #7	N/A	N/A	N/A	N/A	N/A	N/A

	Riparian Forest Management (RFM)
	Alteration of agricultural land use practices to reduce grazing pressure for conservation (e.g., rotate livestock grazing to minimize impact on riparian areas). • The cost database indicates 19 past projects in Upper Klamath River ranging from $11.3 – 152.3K per implementation (outliers removed), and 2 past projects in Shasta and Trinity ranging from $152.3 – 180K per implementation • One participant recommended a standard cost unit of 10 acres

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Lower Klamath River #5	N/A	N/A	N/A	N/A	N/A	N/A
Salmon #5	N/A	N/A	N/A	N/A	N/A	N/A
Salmon #6a	N/A	N/A	N/A	N/A	N/A	N/A
Salmon #7	N/A	N/A	N/A	N/A	N/A	N/A
Scott #14	$10 – {35} – 60	50	M	$500 – {1,750} – 3,000	1	0

	Riparian planting
	Riparian planting or native plant establishment. • The cost database indicates 214 past projects ranging from $0.1K – 93.3K per implementation (outliers removed). • Cost drivers indicated by participants included: type of planting material, seedlings and plants, mulching/irrigation, planting (e.g., by hand), fencing placement/removal, density of planting, depth to groundwater • One group of participants suggested a unit cost measure of 1 acre per project • Thomson and Pinkerton (2008) report a standardized cost range of $1 – 95K per acre. • Evergreen (2003) reports a standardized cost range of $5 – 135K per acre. Their cost range includes construction, design, permitting, 2-year basic monitoring, routine maintenance, and project management.

	• Drivers for standardized costs reported in Evergreen (2003) include the level of site preparation (e.g. amount of clearing required), and material/site accessibility (e.g. slope, distance from roads).

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Lost #9	$5 – {40} – 95	10	M-H	$50 – {400} - 950	3	11
Lower Klamath River #7	$20 – {60} – 95	N/A	M	N/A	1	16
Mid-Klamath River #8	N/A	40	M	N/A	Group (7)	0
Salmon #6b	N/A	N/A	N/A	N/A	N/A	0
Scott #6b	$10 – {15} – 20	N/A	H	N/A	1	34
Shasta #6	$10 – {15} – 20	5	M	$50 – {75} – 100	1	17
Sprague #3	$5 – {25} – 95	10	M-H	$50 – {250} - 950	3	19
Upper Klamath Lake #1	$10 – {45} – 95	5 – {12.5} – 20	M-H	$125 – {562.5} – 1,187.5	3	13
Upper Klamath River #5c	$5	40	M	$200	Group (7)	0
Williamson #7	$10 – {45} – 95	10	M-H	$100 – {450} - 950	3	0

	Road closure / abandonment
	Closure (abandonment), relocation, decommissioning or obliteration of existing roads (including pavement such as parking areas) to diminish sediment transport into stream and/or improve riparian habitat. These roads/pavements may extend into or are in the riparian zone. • The cost database indicates 120 past projects ranging from $1.8K – 380.1K per implementation (outliers removed) • Compared to participant responses, 8 past projects for Upper Klamath River are at a lower cost range per implementation ($1.1 – 16.6K) in cost database • Compared to participant responses, 22 past projects for Sprague are at a lower cost range per implementation ($16.6 – 42.4K) in cost database • One participant group recommended a standard cost unit of 0.5 miles per implementation • Thomson and Pinkerton (2008) report a standardized cost range of $3.6 – 111.2K per mile of decommissioned road.

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Lower Klamath River #4	$40 – {210} – 380	N/A	M	N/A	1	18
Mid-Klamath River #4a	$20 – {65} – 110	10	M	$200 – {650} – 1,100	Group (7)	0
Scott #7	N/A	N/A	N/A	N/A	N/A	0
South Fork Trinity #5	$5 – {10} – 15	6	L-H	$30 – {60} - 90	2	0
Sprague #4	$40 – {210} – 380	N/A	L-H	N/A	2	0
Trinity #10	$5 – {10} – 15	15	L-H	$75 – {225} - 600	3	8
Upper Klamath River #6	$15 – {30} – 40	1	M	$15 – {30} – 40	Group (7)	0
Williamson #11	$40 – {210} – 380	N/A	M	N/A	1	0

	Road drainage system improvements and reconstruction
	Road projects that reduce or eliminate sediment transport into streams. This includes placement of structures or rolling dips to contain/ control run-off from roads, road reconstruction or reinforcement, surface, inboard ditch, culvert and peak-flow drainage improvements, and roadside vegetation. These roads may extend into or are in the riparian zone.

- The cost database indicates 68 projects ranging from $0.7 – 142.5K per implementation (outliers removed)
- Compared to participant responses, 10 past projects for Sprague are at a higher cost range per implementation ($19.6 – 51.9K) in cost database
- Compared to participant responses, 4 past projects for South Fork Trinity and 4 past projects from Scott are at a higher cost range per implementation ($51.9 – 142.5K) in cost database
- Cost drivers indicated by participants included: number of crossing/culverts needing improvement; accessibility (e.g., private gated road vs. public access road); level of reconstruction required; site conditions
- See Watershed Action Plan for project locations in Sprague
- Thomson and Pinkerton (2008) report a standardized cost range of $0.015 – 0.096K per foot for ditch lining projects (2001 – 2007 USD, various projects, not inflation adjusted). They also report a standardized cost of $0.016K per foot for pipe installment.

Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *($'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *($'000s 2020 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Lower Klamath River #3	$50 – {95} - 140	N/A	M	N/A	1	0
Salmon #7	N/A	N/A	N/A	N/A	N/A	N/A
Scott #14	$20 – {35} – 50	25	M	$500 – {875} – 1,250	1	0
Scott #7	N/A	N/A	N/A	N/A	N/A	N/A
South Fork Trinity #5	$5 – {20} – 50	6	L-H	$30 – {120} – 300	2	0
Sprague #4	$50 – {95} – 140	N/A	L-H	N/A	3	0
Williamson #11	$50 – {95} – 140	N/A	M	N/A	1	0

Road stream crossing removal

Removal of stream road crossing and the affiliated road structures so that the stream flows unimpeded. This would include removal of culverts and other material in the channel.

- The cost database indicates 11 projects ranging from $16 – 775.7K per implementation (outliers removed), 7 projects occurred in the Lower Klamath River, the other 3 are unspecified. 5 of the 7 Lower Klamath River Projects fall between $106.1 – 775.7K.

Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation** *($'000s 2020 USD)*	**Suggested number of implementations with {estimated mid-point}**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}** *($'000s 2020 USD)*	**Responses**	**Number of projects in cost databases in this cost range**
Upper Klamath River #13	N/A	N/A	N/A	N/A	N/A	N/A
Williamson #11	$105 – {380} – 775	N/A	M	N/A	2	0

Rocked ford – road stream crossing

Placement of a crushed gravel reinforced track through a stream that still allows unimpeded stream flow. This could replace a dysfunctional culvert.

Sub-basin & Project Number	**Cost range with {estimated mid-point} cost for a single implementation**	**Suggested number of implementations**	**Participant Confidence**	**Expanded cost range with {estimated mid-point cost}**	**Responses**	**Number of projects in cost databases**

	($'000s 2020 USD)	with {estimated mid-point}		($'000s 2020 USD)		in this cost range
Williamson #11	$5 – {15} – 25	N/A	H	N/A	1	

	Slope stabilization
	Implementation of slope/hillside stabilization, bioengineering or slope erosion control methods including landslide reparation and non-ag terracing. • The cost database indicates 2 projects, one costing $17.8K and the other costing $173.9K. Both projects occurred in the Lower Klamath River. • Thomson and Pinkerton (2008) report a standardized cost range of $1 – 3.5K/acre/site (2004 USD, based on 4 sub-projects, not inflation adjusted)

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Mid-Klamath River #4a	N/A	N/A	N/A	N/A	N/A	N/A
South Fork Trinity #4	$50 – {100} – 145	N/A	L	N/A	1	0

	Spawning gravel placement
	Addition of spawning gravel to the stream either in locations where high flows in the near future will entrain and distribute gravel downstream as bars or riffles, or instead placed directly at spawning sites. • The cost database indicates 34 projects ranging from $0.6 - 109K per implementation (outliers removed). • Thomson and Pinkerton (2008) report a standardized cost range of $0.01 – 0.072K per cubic yard.

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Shasta #10	$15 – {20} – 30	N/A	M	N/A	1	0
Sprague #7a	$30 – {70} – 110	5	M	$150 – {350} – 550	1	0
Upper Klamath Lake #10a	$5 – {40} – 110	5	M	$25 – {200} – 550	2	11
Upper Klamath Lake #11	$30 – {70} – 110	5	M	$150 – {350} – 550	1	11
Upper Klamath Lake #11a	$30 – {70} – 110	5	M	$150 – {350} – 550	1	11
Williamson #8a	$5 – {35} – 110	3 – {4} – 5	M-H	$20 – {140} – 440	3	0

	Stormwater filtering
	Capture and filtering of stormwater through bio-swales or wetlands or both before discharge in streams.

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Upper Klamath Lake #14	$15 – {30} – 50	N/A	H	N/A	1	N/A

	Streambank stabilization
	Stabilization of the streambank through re-sloping and/or placement of rocks, logs, or other material on streambank. • The cost database indicates 29 projects ranging from $1.1 - $119.7K per implementation (outliers removed). In the Scott sub-basin, 7 projects occurred between $15.5 – 36.4K, and 15 projects occurred between $36.4 – 119.7. • Thomson and Pinkerton (2008) report a standardized cost range of $0.01 – 1.1K per lineal foot (1995 – 2005 USD, various projects, not inflation adjusted). • Evergreen (2003) suggests several drivers of costs, with size of waterway (more powerful rivers require more stable materials to anchor the streambank) and excavation of streambanks (remove existing materials, relocate levees, create streambank profile that can accommodate plants/materials) being the most significant drivers. Similarly, slope severity will impact costs associated with excavation. Materials used, site characteristics, and design options and permitting also drive costs. • Thomson and Pinkerton (2008) suggest area of implementation as a cost driver (e.g., urban areas will have high costs associated with them compared to rural ones).

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Salmon #7	N/A	N/A	N/A	N/A	N/A	N/A
Scott #14	N/A	N/A	N/A	N/A	N/A	N/A

	Tailwater return reuse or filtering
	Capturing drainage from fields and using it on fields or directing it to wetlands and/or bioswales for treatment before discharge to subsurface piping leading to streams. • One participant noted that several projects are underway through FWS Partners for Fish and Wildlife in Upper Klamath Lake that could be used to validate cost ranges • For Upper Klamath Lake, one participant noted that there are several locations that practice "winter field pumpoff". Oregon Department of Agriculture has identified the operators who use this practice. The Klamath Tribes and ODEQ are monitoring the effluent. Interim Measure 11 is funding a winter pumpoff filtration feasibility project. The project is entering Phase 2. Phase 3 will provide data that will allow estimating cost by site. This practice also produces a fertilizer soil amendment that can be sold as fertilizer, thus offsetting the project costs. • For the Shasta sub-basin, one participant noted: "Some of these projects would be simple and cheap, for example TNC put a water level monitor on a tailwater pond, this allowed the rancher to re-use tailwater when it was available and turn off his river pump. In the SHA in the upper Shasta, they are doing source switch projects, switching water MWCD water for spring water. These projects are expensive. 1M ++" • Thomson and Pinkerton (2008) report a standardized cost range of $0.020 – 0.4K per acre (2006 – 2007 USD) • Thomson and Pinkerton (2008) note that standardized cost per acre declines as acreage increases

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Shasta #3	N/A	5	L	N/A	1	N/A
Shasta #5	N/A	5	L	N/A	1	N/A
Upper Klamath Lake #14	$15 – {30} – 50	8	H	$120 – {240} - 400	2	N/A
Upper Klamath River #4	N/A	N/A	N/A	N/A	N/A	N/A

	Upland livestock and grazing management
	Upland livestock management action designed to control sediment flow into a stream or riparian area. This includes livestock watering schedules; grazing management plans; upland exclusion and fencing; and, livestock water development (also called off-channel watering or livestock water supply) including installation of upland ditches, wells, and ponds. • The cost database indicates 29 projects ranging from $0.7 - $60K per implementation (outliers removed). In the Williamson sub-basin, 2 projects occurred between $9.8 – 24.3K, and 5 projects occurred between $24.3 – 60K per implementation. • For Upper Klamath Lake, the Comprehensive Agreement may include an estimate of total acres. • Cost drivers indicated by participants included: NEPA/ESA Section 7 for federal lands

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Upper Klamath Lake #16	$5 – {30} – 60	10 – {155} – 300	L-M	$775 – {4,650} – 9,300	3	N/A
Williamson #4	$10 – {40} – 60	N/A	M-H	N/A	2	N/A

	Upland vegetation management including fuel reduction and burning
	Upland vegetation treatment or removal projects for water conservation or sediment control including plant removal (e.g., juniper removal or noxious weeds), selective tree thinning, undergrowth removal, fuel reduction treatments, prescribed burnings, stand conversions, and silviculture. • The cost database indicates 253 projects ranging from $0.1 – 175.3K per implementation (outliers removed) • In the Scott sub-basin, 22 past projects ranged from $30.5 – 175.3K per implementation • Compared to participant responses, 78 past projects for Upper Klamath River are at a lower cost range per implementation in the cost database (19 @ $0.1 – 10.9K; 21 @ $10.0 – 30.5K; 38 @ $30.5 – 175.3K) • Cost drivers indicated by participants included: density of fuels, slope, terrain, site productivity, distance from road, thinning and piling method (by hand, heavy equipment), piles and burning method (by hand, by machine), mastication, understory burning (initial entry), understory burning (maintenance), whether fire control lines are needed, amount of handline/dozer line construction needed, distance to plumb for hose lays and porta tanks, number of water tenders, number of on-site and contingency resources needed for implementation, post burn patrols or mop-up needed, type of heavy equipment needed, mobilization, biomass utilization, type of treatment (prescribed burn, mechanical mastication, hand removal and pile burning) • One participant recommended a standard cost unit of 5 acres, another participant group recommended 1000 acres (Mid-Klamath River) • For the Williamson sub-basin, the Klamth Tribes Resource Management Plan may contain useful information to help validate cost ranges. • Horse Creek should be added as a focal HUC12 for Upper Klamath River Project #7

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Lower Klamath River #15	N/A	N/A	N/A	N/A	N/A	N/A
Mid-Klamath River #5	$10 – {12.5} – 15	10	H	$100 – {125} – 150	Group (7)	0
Salmon #1	N/A	N/A	N/A	N/A	N/A	N/A
Scott #13	N/A	N/A	N/A	N/A	N/A	N/A
Sprague #10	$30 – {100} – 175	3	L-H	$90 – {300} - 525	2	0
Trinity #16	$10 – {60} – 175	5	L-M	$50 – {300} – 875	2	0
Upper Klamath River #7	$150 – {175} – 200	3	H	$450 – {525} - 600	Group (7)	0

Williamson #2	$30 – {100} – 175	3	L-H	$90 – {300} - 525	3	0
Williamson #9	$10 – {75} – 175	5	M-H	$50 – {375} - 875	3	0

Upland wetland improvement

Projects designed to protect, create or improve upland wetlands (wetlands that are not connected to a stream, and are instead charged by groundwater or precipitation).

- Cost drivers indicated by participants included: amount of conifer removal needed, opportunities for manual shovel work (e.g., BDAs and/or pond and plug), permitting (number of endangered species).
- One participant group suggested a standard cost unit measure of 30 acres per project (Mid and Upper Klamath River)
- Thomson and Pinkerton (2008) report a standardized cost range of $1 – 375K per acre for "wetland restoration" (1995 – 2007 USD, various projects, not inflation adjusted)

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Mid-Klamath River #16	$400	3	L	$1,200	Group (7)	N/A
Salmon #7	N/A	N/A	N/A	N/A	N/A	N/A
Scott #14	$5 – {10} – 20	10	M	$50 – {100} – 200	1	N/A
South Fork Trinity #3	$2,000	1 – {3} – 5	M	$6,000	1	N/A
Upper Klamath River #17	$900	4	L	$3,600	Group (7)	N/A
Williamson #3	N/A	5	H	N/A	1	N/A

Water leased or purchased

Water that is leased or purchased, and thus not withdrawn from the stream. This includes the purchase of water rights.

- The cost database indicates 19 projects ranging from $1.8 – 347.6K per implementation (outliers removed).
- In the Scott sub-basin, one past project in the cost database was in the cost range $66.3 – 347.6K
- Cost drivers indicated by participants included: the number of water rights that need to be leased/purchased, whether the leasing is for one or multiple years,
- The Farmers Conservation Alliance is working on strategic planning with Tulelake Irrigation District and Klamath Irrigation District that will help determine if there is a purchase market and the price per acre foot.
- Thomson and Pinkerton (2008) report a standardized cost range of $0.043 – 0.246K per acre foot per year (2001 – 2004 USD)

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Lost #3	$65 – {210} – 350	25	L	$1,625 – {5,250} – 8.750	2	0
Scott #1	N/A	N/A	N/A	N/A	N/A	N/A
Shasta #3	$15 – {40} – 65	10	H	$150 – {400} - 650	1	0
Upper Klamath Lake #7	$65 – {210} – 350	5 – {27.5} – 50	M-H	$1,787.5 – {5,775} – 9,625	3	1

Water quality project (general)

Projects that improve instream water quality conditions for fish or reduce impacts of instream point/non-point pollution. This includes improved water quality treatment; nutrient enhancement through carcass placement; return flow cooling; removal or prevention of toxins, sewage or refuse; or, the reduction or treatment of sewage outfall and/or stormwater.

- The cost database indicates 7 projects ranging from $14.6 – 236K per implementation (outliers removed)
- In the Salmon sub-basin, the cost database indicates 1 past project that cost between $14.6 – 91.3K
- In the Williamson sub-basin, spring dependent waterway means water quality treatments can be expensive.

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Lower Klamath River #6	$90 – {105} – 120	N/A	L	N/A	1	0
Mid-Klamath River #6	N/A	N/A	N/A	N/A	N/A	N/A
Salmon #5	N/A	N/A	N/A	N/A	N/A	N/A
Sprague #5	$120 – {180} – 235	5	L-H	$600 – {900} – 1,175	3	0
Sprague #8	$90 – {155} – 235	10 – {17.5} – 25	L-H	$1,575 – {2712.5} – 4,112.5	3	0
Upper Klamath Lake #6	$30 – {105} – 235	2	L	$60 – {210} – 470	2	0
Upper Klamath River #19	$120 – {180} – 235	8	M	$960 – {1,440} – 1,880	Group (7)	0
Williamson #5	$90 – {105} – 120	N/A	L	N/A	1	0

Wetland improvement / restoration

Improvement, reconnection, or restoration of existing or historic wetland (other than vegetation planting or removal).

- The cost database indicates 133 past projects ranging from $1.4 - $360.4K per implementation (outliers removed).
- Cost drivers indicated by participants included: "Low Tech BP" vs. "plug and pond"
- For Upper Klamath Lake, a USFWS/BoR report for Agency Lake/Barnes Ranch should provide a good cost estimate to validate cost range.
- Thomson and Pinkerton (2008) report a standardized cost range of $1 – 375K per acre for "wetland restoration" (1995 – 2007 USD, various projects, not inflation adjusted)

Sub-basin & Project Number	Cost range with {estimated mid-point} cost for a single implementation *($'000s 2020 USD)*	Suggested number of implementations with {estimated mid-point}	Participant Confidence	Expanded cost range with {estimated mid-point cost} *($'000s 2020 USD)*	Responses	Number of projects in cost databases in this cost range
Lost #9	$20 – {205} - 360	10	M	$200 – {2,050} – 3,600	2	12
Upper Klamath Lake #3	$20 – {210} - 360	3	M	$60 – {630} – 1,080	3	25

Appendix F: Monitoring Workgroups

Eight formal IFRMP monitoring group webinars in total were convened between June 15th and July 19th 2021 (2 webinars for each of four monitoring theme workgroups: 1) Watershed Inputs/Water Quality, 2) Fluvial Geomorphic Processes, 3) Habitat/Fish Populations, and 4) Biological Interactions. Webinar participants are listed in the tables below. Grey cells indicate participant **absences** at one of the scheduled meetings.

Table E – 1: SA1 - Watershed Inputs & WQ

NAME	ORGANIZATION	Webinar 1 June 15	Webinar 2 July 7
Chauncey Anderson	**US Geological Survey - Water Science Center**		
Clayton Creager	North Coast Regional Water Quality Control Board		
Crystal Robinson	Quartz Valley Indian Reservation		
Eli Scott	North Coast Regional Water Quality Control Board		
Grant Johnson	Karuk Tribe		
Jacob Kann	Aquatic Ecosystems Sciences		
Megan Skinner	US Fish & Wildlife Service (USFWS)		
Olivia Stoken	Oregon Dept of Environmental Quality		
Randy Turner	Klamath Basin Monitoring Program		

Table E - 2: SA2 - Fluvial Geomorphology

NAME	ORGANIZATION	Webinar 1 June 16	Webinar 2 July 8
Betsy Stapleton	Scott River Watershed Council		
Brian Cluer	National Oceanic & Atmospheric Administration		
Chauncey Anderson	United States Geological Survey - Water Science Center		
Conor Shea	US Fish & Wildlife Service		
Dave Gaeuman	Yurok Tribe		
Eric Reiland	Bureau of Reclamation		
George Pess	National Oceanic & Atmospheric Administration		
Karuna Greenberg	Salmon River Restoration Council		
Sarah Beasley	Yurok Tribe		
Jenny Curtis	USGS – attended August 16th follow-up call		

On August 16th 2021 an additional Klamath Fluvial Geomorphology follow-up conference call was convened with participants to further refine details and monitoring methods for the 'channel complexity' CPI and to help align with the Fish Habitat group's approaches to evaluating channel condition.

Table E - 3: SA3 - Fish Habitat & Connectivity

NAME	ORGANIZATION	Webinar 1 June 18	Webinar 2 July 12
Alex Corum	Karuk Tribe		
Benji Ramirez	Oregon Dept of Fish and Wildlife		
Bill Pinnix	US Fish & Wildlife Service		
Erich Yokel	Scott River Watershed Council		
Jacob Krause	USGS Klamath Falls Field Station		
Karuna Greenberg	Salmon River Restoration Council		
Kurt Bainbridge	California Department of Fish & Wildlife		

Kyle DeJulio	Yurok Tribe		
Leroy Cyr	Six Rivers National Forest		
Mark Hereford	Oregon Dept of Fish and Wildlife		
Mark Johnson	Klamath Water Users Association		
Maureen Purcell	USGS Northwest-Pacific Islands Region		
Ryan Fogerty	US Fish & Wildlife Service		
Sarah Beasley	Yurok Tribe		
Ted Wise	Oregon Department of Fish and Wildlife		
Tommy Williams	National Oceanic & Atmospheric Administration		

Table E - 4: Monitoring SA4 – Biological Interactions

NAME	ORGANIZATION	Webinar 1 June 21	Webinar 2 – July 19
Benji Ramirez	Oregon Dept of Fish and Wildlife		
Grant Johnson	Yurok Tribe		
Justin Alvarez	Hoopa Valley Tribal Fisheries		
Kurt Bainbridge	California Department of Fish & Wildlife		
Maureen Purcell	USGS Northwest-Pacific Islands Region		
Nicholas Som	US Fish & Wildlife Service		
Ryan Fogerty	US Fish & Wildlife Service		
Sascha Hallett	Oregon State University		
Scott Foott	US Fish & Wildlife Service		

Appendix G: Monitoring Costs

To determine cost estimates for the recommended monitoring activities described in Section 0, we gathered information from a variety of sources. Our goal was to capture the broad overall costs for each CPI in terms of factors such as general number of sites, equipment required, operation and maintenance, purchases of additional existing data, new bespoke data collection efforts (e.g. LiDAR, targeted air photos), field visits for manual surveys, desktop analyses, lab analyses, costs to continue existing monitoring programs, and planned workshops when details for a certain CPI remain to be determined by a group of experts. In most cases where monitoring actions take place at individual sites, the specifics of monitoring site locations and unique logistics are not yet finalized; we therefore used a single best estimate of cost for all sites to provide a range-of-magnitude cost that can be refined as sites locations are refined. The costs provided in Section 0 are therefore subject to change in the future but provide valuable information about relative costs for each CPI, facilitating initial prioritization of monitoring efforts and highlighting monitoring activities that inform multiple CPIs and therefore provide high value on investment.

Cost information was assembled from individual requests to practitioners and experts from organizations in the Klamath region, communication with commercial providers, literature searches for monitoring activity costs from similar applications, and assumptions about general fieldwork costs. Once we had costs for each monitoring activity (e.g., start up and annual cost for one new flow gage site installation), we created costing calculators to apply individual costs to the recommended sampling design (e.g., Figure 5-1) and multiply by the relevant number of sites or spatial extent. These calculators included options for initialization of new sites, maintenance of existing sites, and different sampling and analysis frequencies. Where a new desktop analysis method was recommended (e.g., LiDAR assessment of potential large woody debris), costs were estimated from literature review when possible and supplemented with professional judgement. Costing calculators were set up to project costs into the future at 5-year increments (1, 5, 10, 15, 20-year costs) to demonstrate the effects of sample/analysis frequencies over time, capture the effects of inflation, and account for the fact that some costs will change based on changes in funding to programs in the future. For example, water quality monitoring sites are covered in the Definite Plan (Section 3.1.1 of Exhibit O) but are not guaranteed to be supported following the Plan's end; costs for monitoring activities such as automatic water samplers or continuous sondes therefore increase to fully take over these efforts in the years after the Definite Plan's completion.

Because individual monitoring activities can inform multiple CPIs, we first presented the costs for each CPI individually, not accounting for synergies/overlapping coverage between CPIs. These costs reflect what it would take to fund each CPI in isolation. We then examined the effects of overlapping coverage for monitoring activities in terms of a 'gestalt prioritization' where we ranked individual CPI/recommendations with our own judgement on a scale from 1 (most important) to 5 (least important) and summarized total costs for the monitoring activities to cover each tier of priority (see details of priorities in **Error! Reference source not found.**). In Section 0, costs are presented for each individual CPI/recommendation as the isolated cost (not accounting for overlap) in the body text for each CPI; summaries of priority tier totals are presented for overall context in the Section 0 summary section (5.1.2).

This appendix presents a summary of CPI/recommendation costs, sources for cost information, and the costing calculators used for each monitoring activity.

Table H - 1. Data sources and references for individual monitoring activity costs.

Ref ID	Cost	Cost Description	Reference
A. Flow gages			
A1	$30,000 /unit	Purchase cost of equipment and supplies, labor for site installs and database setup, and working on permits as needed	Marc Stewart, USGS, mastewar@usgs.gov
A2	$23,900 /unit/year	Annual O&M - operation, calibration, and ongoing maintenance	Marc Stewart, USGS, mastewar@usgs.gov
B. Water samplers			
B1	$4,500 /unit (low) $6,000 /unit (med) $8,000 /unit (high)	Purchase & installation - Full costs for 1 new flow gage	Grant Johnson, Karuk Tribe, gjohnson@karuk.us
B2	$2,000 /unit/year (low) $5,000 /unit/year (med) $8,000 /unit/year (high)	Annual O&M - Full costs for 1 flow gage	Grant Johnson, Karuk Tribe, gjohnson@karuk.us
B3	$1,000 /day	Site visit for data collection, assume a truck and a crew (2 people)	James Lee, jclee@usbr.gov
B4	$30 /sample	Lab Analyses (Nutrient Loads - P)	Pacificorps, communication by Randy Turner
B5	$44 /sample	Lab Analyses (Nutrient Loads - N)	Pacificorps, communication by Randy Turner
B6	$152 /sample	Lab Analyses (algal cell counts)	EMSL Analytical Inc. 2022 Commercial Price List. July 9, 2022.
B7	$137 /sample	Lab Analyses (Microcystin)	EMSL Analytical Inc. 2022 Commercial Price List. July 9, 2022.
B8	$181 /sample	Lab Analyses (Invertebrates)	EMSL Analytical Inc. 2022 Commercial Price List. July 9, 2022.
B9	$175-350 /sample	Lab Analyses (Invertebrates)	Aquatic Biology Associates. https://www.aquaticbio.com/services/price-guidelines/
C. Sondes			
C1	$30,000 /unit (low) $40,000 /unit (med) $50,000 /unit (high)	Purchase & installation - Full costs for 1 new sonde	Grant Johnson, Karuk Tribe, gjohnson@karuk.us
C2	$10,000 /unit/year (low) $12,000 /unit/year (med) $15,000 /unit/year (high)	Annual O&M - Full costs for 1 sonde	Grant Johnson, Karuk Tribe, gjohnson@karuk.us
C3	$1,000 /day	Site visit for data collection, assume a truck and a crew (2 people)	James Lee, jclee@usbr.gov
C4	$48 /sample	Lab Analyses (sediments) (lab cost for Total Suspended Solids)	EMSL Analytical Inc. 2022 Commercial Price List. July 9, 2022.
C5	$56 /sample	Lab Analyses (DO)	EMSL Analytical Inc. 2022 Commercial Price List. July 9, 2022.
C6	$14.40 /sample	Lab Analyses (pH)	EMSL Analytical Inc. 2022 Commercial Price List. July 9, 2022.
C7	$28.95 /sample	Lab Analyses (conductivity)	EMSL Analytical Inc. 2022 Commercial Price List. July 9, 2022.
C8	$14/sample	Lab Analyses (chlorophyll-a)	Pacificorps, communication by Randy Turner
C9	$21/sample	Lab Analyses (turbidity)	Pacificorps, communication by Randy Turner
D. LiDAR			
D1	$500,000 /40 miles	Red lidar & boat-based bathymetry - Includes survey costs for 40 miles of stream	James Lee, jclee@usbr.gov
D2	$6,944 /2.5 miles	Red lidar - Includes survey and data processing costs for 2.5 miles of stream. Adjusted for 2022 USD	Roni et al. 2020.
D3	$12,936 /2.5 miles	Bathymetry - Includes survey and field costs for 2.5 miles of stream. Adjusted for 2022 USD	Roni et al. 2020.
D4	$39,200 /8 miles	Green LiDAR - Survey and data processing for 8 miles of stream. Adjusted for 2022 USD.	Roni et al. 2020.
D5	$4,032 /8 miles	Green LiDAR - Field data	Roni et al. 2020.
D6	$428 /miles	Broad extent LiDAR - Survey and data processing costs per unit area. Adjusted for 2022 USD.	NRCP Attachment A - Proposal Submission_final
D7	$150 /mile on top of TIR survey	On top of TIR survey	Taylor Davis, Taylor.Davis@terraremote.com
D8	$774,000 /1,210 sqmi	Entire basin broad extent LiDAR. Classified LAS files and Reporting, No Integration with other datasets	Cort Pryor, Cpryor@yuroktribe.nsn.us
D9	$760,000 /76 miles	Bathymetric survey (depth soundings). Trinity sub-basin.	Cort Pryor, Cpryor@yuroktribe.nsn.us
D10	$2,570,000 /257 miles	Bathymetric survey (depth soundings). Entire mainstem.	Cort Pryor, Cpryor@yuroktribe.nsn.us
D11	$7,260,000 /726 miles	Bathymetric survey (depth soundings). All tributaries to the mainstem.	Cort Pryor, Cpryor@yuroktribe.nsn.us
D12	$340,480 /76 miles	Bathhymetric survey (green lidar). Trinity sub-basin.	Cort Pryor, Cpryor@yuroktribe.nsn.us
D13	$822,400 /257 miles	Bathhymetric survey (green lidar). Entire mainstem.	Cort Pryor, Cpryor@yuroktribe.nsn.us
D14	$2,323,200 /726 miles	Bathhymetric survey (green lidar). All tributaries to the mainstem.	Cort Pryor, Cpryor@yuroktribe.nsn.us
E. Air photos			
E1	$31,000 /40 miles, 0.5 miles on either side of river	Air photos survey cost	James Lee, jclee@usbr.gov
E2	$50 /mile on top of TIR survey	5 cm RGB imagery on top of TIR survey	Taylor Davis, Taylor.Davis@terraremote.com
E3	$72,960 / 76 miles, 0.5 mi on either side of channel	Trinity sub-basin. 4-band imagery	Cort Pryor, Cpryor@yuroktribe.nsn.us
E4	$82,240 /257 miles, 0.5 mi on either side of channel	Entire mainstem. 4-band imagery	Cort Pryor, Cpryor@yuroktribe.nsn.us
E5	$232,320 /726 miles, 0.5 mi on either side of channel	All tributaries to the mainstem. 4-band imagery	Cort Pryor, Cpryor@yuroktribe.nsn.us
F. TIR			
F1	$360-$400 /mile	30 cm TIR imagery mosaics over a 200 m wide corridor	Taylor Davis, Taylor.Davis@terraremote.com
G. Field Work			
G1	$1000 - 2 ppl and a truck, 1 day	Rough assumption for 2 ppl and a truck for 1 day. Rough estimate based on Hoopa Valley Tribe rates	James Lee, jclee@usbr.gov
H. PIT Tag Program			
H1	$380,000	Start-up costs (Post dam removal configuration)	Betsy Stapleton, betsy@scottriver.org
H2	$2,230,000	Annual and recurring costs (Post dam removal configuration)	Betsy Stapleton, betsy@scottriver.org
I. Telemetry for PIT Tag Program			
I1	$3,400,000	Start-up costs (Post dam removal configuration)	Betsy Stapleton, betsy@scottriver.org
I2	$2,370,000	Annual and recurring costs (Post dam removal configuration)	Betsy Stapleton, betsy@scottriver.org
J. Groundwater Monitoring			
J1	$5,000	Groundwater sensor installation	Groundwater working group
J2	$500	Annual maintenance	Groundwater working group

Table H - 2. Individual costs for each CPI/recommendation, including gestalt priority for each recommendation. Costs are shown as separate for each recommendation, not accounting for monitoring activity overlaps.

CPI	Rec. #	Task	Cost: 1 year	Cost: 10 year	Priority
5.2.1 Seasonal Instream Flow	1a	Expand existing network of real-time streamflow gaging stations (top priority sites)	$ 685,110.00	$ 5,326,431.79	1
	1b	Second priority sites	$ 847,162.50	$ 5,395,556.35	5
	2	Track groundwater levels at monitoring wells	$ 84,562.50	$ 192,012.68	4
5.2.2 Nutrient Loads	1a	Establish network of automated water samplers (top priority sites)	$ 298,582.50	$ 3,091,404.17	1
	1b	Second priority sites	$ 305,193.75	$ 2,774,583.25	5
5.2.3 Fine Sediment Loads and Turbidity	1a	Expand/maintain network of continuous real-time sondes	$ 594,295.00	$ 3,812,091.77	1
	1b	Second priority sites	$ 839,475.00	$ 3,571,435.88	5
	2	Standardize data collection and sharing	TBD	TBD	3
5.3.1 Large Wood Recruitment and Retention	1	Measure large wood concentrations with LiDAR	$ 1,161,467.68	$ 3,565,716.46	3
	2	Assess potential large wood supply with LiDAR	$ 1,149,959.80	$ 3,539,280.15	4
5.3.2 Geomorphic Flushing / Scouring Flows	1	Characterize flushing flows with gage data and transport measurement calibrations	$ 7,380.00	$ 1,009,986.71	2
5.3.3 Floodplain Connectivity / Inundation	1	Map alluvial valleys with floodplains	$ 952,081.50	$ 1,189,019.33	4
	2	Monitor timing and duration of overbank flows from gage sites	$ 19,587.75	$ 140,937.31	4
	3	Map floodplain inundation extent from satellite imagery	$ 25,830.00	$ 80,645.33	5
5.3.4 Channel Complexity	1	Assess basin-wide planform complexity from imagery	$ 31,570.00	$ 71,684.73	2
	2	Assess detailed topographic complexity in larger streams	$ 3,906,726.00	$ 12,197,413.59	4
5.3.5 Sediment Distributions	1 (1)	Map substrate sizes: bathymetric LiDAR option	$ 3,915,336.00	$ 12,224,295.36	2
	1 (2)	Map substrate sizes: air photo option	$ 422,529.60	$ 1,319,203.93	5
5.4.1 Water Temperature	1a	Expand/maintain network of continuous real-time sondes (top priority sites)	$ 594,295.00	$ 3,812,091.77	1
	1b	Second priority sites	$ 839,475.00	$ 3,571,435.88	5
	2	Standardize data collection and sharing	TBD	TBD	3
5.4.2 Water Chemistry	1a	Expand/maintain network of continuous real-time sondes (top priority sites)	$ 594,295.00	$ 3,812,091.77	1
	1b	Second priority sites	$ 839,475.00	$ 3,571,435.88	5
	2	Standardize data collection and sharing	TBD	TBD	3
5.4.3 Turbidity	1a	Expand/maintain network of continuous real-time sondes	$ 594,295.00	$ 3,812,091.77	1
	1b	Second priority sites	$ 839,475.00	$ 3,571,435.88	5
	2	Standardize data collection and sharing	TBD	TBD	3
5.4.4 Thermal Refugia	1	Identify and map refugia across the basin	$ 510,942.00	$ 1,595,241.36	2
	2	Detailed monitoring of a subset of thermal refugia	$ 6,315.03	$ 68,497.32	4
	3	Assess utilization of thermal refugia	$ 20,500.00	$ 256,016.91	5
	4	Evaluate the relative proportion of flow and effects on mixing	TBD	TBD	5
5.4.5 Nutrients	1a	Establish network of automated water samplers	$ 298,582.50	$ 3,091,404.17	1
	1b	Second priority sites	$ 305,193.75	$ 2,774,583.25	5
5.4.6 Nuisance phytoplankton / algal toxins	1a	Indirect measures: Maintain/expand existing monitoring network for nuisance phytoplankton/algal toxins	$ 34,645.00	$ 1,431,134.52	2
	1b	Direct measures of phytoplankton/cyanotoxins	$ 227,070.30	$ 2,198,314.79	5
5.4.7 Stream Habitat Condition	1a	Same as channel complexity (Rec #1: planform complexity from remote sensing)	$ 31,570.00	$ 71,684.73	2
	1b	Same as channel complexity (Rec #2: topographic complexity in larger streams)	$ 3,906,726.00	$ 12,197,413.59	4
	1b	Supplemental field surveys (CDFW methods)	$ 5,125.00	$ 64,004.23	5
	2	Monitor aquatic invertebrates	TBD	TBD	3
5.4.8 Riparian Condition	1a	Topographic LiDAR assessment of vegetation	$ 1,165,744.80	$ 3,575,122.52	5
	1b	Supplemental field surveys (CDFW methods)	$ 5,125.00	$ 64,004.23	5
	1c	Imagery-based NDVI assessment of vegetation	$ 51,660.00	$ 161,290.65	2
5.5.1 Disease	1	Expand existing monitoring network for *Ceratonova shasta* and *Parvicapsula minibornis*	TBD	TBD	2
	2	Expand existing monitoring network for Ich and Columnaris	TBD	TBD	2
	3	Develop approach for monitoring disease pathogens/parasites affecting endangered suckers	TBD	TBD	3
5.5.2 Invasive aquatic species	1	Establish eDNA sampling network for monitoring invasives	$ 281,875.00	$ 281,875.00	3
5.6.1 Focal Species Population Indicators	1	Establish eDNA sampling network for monitoring distribution of focal fish species	$ 281,875.00	$ 281,875.00	Costed separately
	2	Support initiatives in the Basin focused on fish population	$ 8,589,500.00	$ 51,024,500.00	Costed separately
	3	Support ongoing fish population monitoring efforts	$ 14,447,277.63	$ 180,426,700.42	Costed separately
	4	Fill existing or upcoming gaps on life-cycle monitoring	TBD	TBD	Costed separately

Asumptions

#	Item	
2.5%	Projected Annual Inflation	
12	# new samplers	
6	# existing samplers	
6	Annual sampling frequency	
25	Sampler replacement frequency (yrs)	
0	P	1 = yes, 0 = no
0	N	1 = yes, 0 = no
1	Algal cell counts	1 = yes, 0 = no
1	Microcystin	1 = yes, 0 = no
0	Disease	1 = yes, 0 = no

Table 1: Costing Details

Start Up				
Item	**Unit**	**Cost (unit)**	**Cost (total)**	**Ref ID**
Purchase & installation	site	$ 6,000.00	$ 72,000.00	B1
Annual				
Item	**Unit**	**Cost (unit)**	**Cost (total)**	**Ref ID**
Annual O&M (ex)	site	$ 5,000.00	$ 30,000.00	B2
Annual O&M	site	$ 5,000.00	$ 60,000.00	B2
Water sampler replacement	site	$ 240.00	$ 4,320.00	B2
Site visit/data collection	2 sites/day	$ 1,000.00	$ 54,000.00	G1
Lab Analyses (Nutrient Loads - P)	sample	$ 30.00	$ -	B4
Lab Analyses (Nutrient Loads - N)	sample	$ 44.00	$ -	B5
Lab Analyses (algal cell counts)	sample	$ 152.00	$ 16,416.00	B6
Lab Analyses (Microcystin)	sample	$ 137.00	$ 14,796.00	B7
Lab Analyses (Disease)	sample	$ 50.00	$ -	B8

Table 2: Site Costs

Duration	Total	Total (Present Value)
1 Year	$ 190,320.00	$ 195,078.00
5 Year	$ 663,600.00	$ 750,802.49
10 Year	$ 1,405,200.00	$ 1,798,774.80
15 Year	$ 2,146,800.00	$ 3,109,206.50
20 Year	$ 2,888,400.00	$ 4,732,979.73

Table 3: Lab Costs

Duration	Total	Total (Present Value)
1 Year	$ 31,212.00	$ 31,992.30
5 Year	$ 156,060.00	$ 176,567.57
10 Year	$ 312,120.00	$ 399,539.99
15 Year	$ 468,180.00	$ 678,064.24
20 Year	$ 624,240.00	$ 1,022,889.93

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$ 221,532.00	$ 227,070.30
5 Year	$ 819,660.00	$ 927,370.06
10 Year	$ 1,717,320.00	$ 2,198,314.79
15 Year	$ 2,614,980.00	$ 3,787,270.74
20 Year	$ 3,512,640.00	$ 5,755,869.65

CPI	Recommendation	# new sampler	# existing sampler	Sampl freq	Repl freq	P	N	Algal	Microcyst	Disease
5.2.2 Nutrient Loads	1a	12	6	15	25	1	1	0	0	0
	1b	15	0	15	25	1	1	0	0	0
5.4.5 Nutrients	1a	12	6	15	25	1	1	0	0	0
	1b	15	0	15	25	1	1	0	0	0
5.4.6 Nuisance phytoplankton and associated algal toxins	1b	12	6	6	25	0	0	1	1	0

Figure H - 1. Costing calculator for water samplers.

Asumptions

#	Item
2.5%	Projected Annual Inflation
15	# new
0	# existing
1	Annual sampling frequency
25	Sampler replacement frequency (yrs)

Table 1: Costing Details

Start Up				
Item	**Unit**	**Cost (unit)**	**Cost (total)**	**Ref ID**
Purchase & installation	site	$ 600.00	$ 9,000.00	C1
Annual				
Item	**Unit**	**Cost (unit)**	**Cost (total)**	**Ref ID**
Annual O&M (ex)	site	$ 150.00	$ -	C2
Annual O&M (new)	site	$ 150.00	$ 2,250.00	C2
Stage logger replacement	site	$ 24.00	$ 360.00	C1
Site visit/data collection	2 sites/day	$ 1,000.00	$ 7,500.00	G1

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$ 19,110.00	$ 19,587.75
5 Year	$ 59,550.00	$ 67,375.36
10 Year	$ 110,100.00	$ 140,937.31
15 Year	$ 160,650.00	$ 232,669.10
20 Year	$ 211,200.00	$ 346,075.79

CPI	Recommendation	# new	# existing	Smpl Freq	Repl freq
5.3.3 Floodplain Connectivity / Inundation	2	15	0	1	25

Figure H - 2. Costing calculator for stage loggers.

Asumptions

#	Item
2.5%	Projected Annual Inflation
12	# new gages
6	# existing gages
25	Sampler replacement frequency (yrs)

Table 1: Costing Details

Start Up				
Item	**Unit**	**Cost (unit)**	**Cost (total)**	**Ref ID**
Purchase & installation	site	$ 30,000.00	$ 360,000.00	A1
Annual				
Item	**Unit**	**Cost (unit)**	**Cost (total)**	**Ref ID**
Annual O&M (new)	site	$ 23,900.00	$ 286,800.00	A2
Annual O&M (ex)	site	$ 23,900.00	$ 143,400.00	A2
Flow gage replacement	site	$ 1,200.00	$ 21,600.00	A1

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$ 668,400.00	$ 685,110.00
5 Year	$ 1,902,000.00	$ 2,151,938.42
10 Year	$ 4,161,000.00	$ 5,326,431.79
15 Year	$ 6,420,000.00	$ 9,298,074.23
20 Year	$ 8,679,000.00	$ 14,221,552.09

CPI	Recommendation	# new gages	# existing gages	Repl freq
5.2.1 Seasonal Instream Flow	1a	12	6	25
	1b	15	0	25
5.3.2 Geomorphic Flushing / Scouring Flows	1	0	6	25

Figure H - 3. Costing calculator for flow gages.

Asumptions

#	Item
2.5%	Projected Annual Inflation
10	# new sonde
13	# existing sonde
2	Annual sampling frequency
25	Sampler replacement frequency (yrs)

Table 1: Costing Details

Start Up				
Item	**Unit**	**Cost (unit)**	**Cost (total)**	**Ref ID**
Purchase & installation	site	$ 40,000.00	$ 400,000.00	C1
Annual				
Item	**Unit**	**Cost (unit)**	**Cost (total)**	**Ref ID**
Annual O&M (ex)	site	$ 12,000.00	$ 156,000.00	C2
Annual O&M (new)	site	$ 12,000.00	$ 120,000.00	C2
Sonde replacement	site	$ 1,600.00	$ 36,800.00	C1
Site visit/data collection	2 sites/day	$ 1,000.00	$ 23,000.00	G1

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$ 579,800.00	$ 594,295.00
5 Year	$ 1,299,000.00	$ 1,469,699.27
10 Year	$ 2,978,000.00	$ 3,812,091.77
15 Year	$ 4,657,000.00	$ 6,744,724.56
20 Year	$ 6,336,000.00	$ 10,382,273.77

CPI	Recommendation	# new sonde	# existing sonde	Smpl Freq	Repl freq
5.2.3 Fine Sediment Loads and Turbidity	1a	10	13	2	25
	1b	15	0	2	25
5.4.1 Water Temperature	1a	10	13	2	25
	1b	15	0	2	25
5.4.2 Water Chemistry (DO, pH, conductivity)	1a	10	13	2	25
	1b	15	0	2	25
5.4.3 Turbidity	1a	10	13	2	25
	1b	15	0	2	25
5.4.6 Nuisance phytoplankton and associated algal toxins	1a	0	13	2	25

Figure H - 4. Costing calculator for sondes.

Asumptions

#	Item
2.5%	Projected Annual Inflation
986	Miles of stream to survey
5	Survey frequency (years)
5	Analysis frequency (years)
200	Estimated effort (hours)

Table 3: Costing details

Startup				
Item	**Unit**	**Cost (/unit)**	**Cost (total)**	**Ref ID**
Survey and data processing	miles	$ 3,200.00	$ 3,155,200.00	D13/D14
Analysis	hr	$ 140.00	$ 28,000.00	-
Annual				
Item	**Unit**	**Cost (/unit)**	**Cost (total)**	**Ref ID**
Survey and data processing	mile	$ 640.00	$ 631,040.00	D13/D14
Analysis	hr	$ 28.00	$ 5,600.00	-

Table 4: Costing totals based on Cort Pryor estimate

Duration	Total	Total (Present Value)
1 Year	$ 3,819,840.00	$ 3,915,336.00
5 Year	$ 6,366,400.00	$ 7,202,997.25
10 Year	$ 9,549,600.00	$ 12,224,295.36
15 Year	$ 12,732,800.00	$ 18,440,890.89
20 Year	$ 15,916,000.00	$ 26,080,219.26

CPI	Recommendation	Estimate ref	Miles	Surv freq	Anlsys Freq	Effort
5.3.4 Channel Complexity	2 (2)	Cort Pryor	986	5	5	150
5.3.5 Sediment Transport	1 (1)	Cort Pryor	986	5	5	200
5.3.7 Stream Habitat Condition	1b	Cort Pryor	986	5	5	200

Figure H - 5. Costing calculator for bathymetric LiDAR.

Asumptions

#	Item	
2.5%	Projected Annual Inflation	
1424	Survey area (square miles)	
5	Survey frequency (years)	0 = no recurring survey
5	Analysis frequency (years)	0 = no recurring analyses
237	Estimated effort (hours)	
5	Field days for initial survey	
0	Field days for recurring surveys	

Table 1: Costing Details

Startup				
Item	**Unit**	**Cost (/unit)**	**Cost (total)**	**Ref ID**
Survey & data processing	sqmi	$ 640.00	$ 911,360.00	D8
Analysis	hr	$ 140.00	$ 33,180.00	-
Field surveys	days	$ 1,000.00	$ 5,000.00	G1
Annual				
Item	**Unit**	**Cost (/unit)**	**Cost (total)**	**Ref ID**
Survey & data processing	sqmi	$ 128.00	$ 182,272.00	D8
Analysis	hr	$ 28.00	$ 1,327.20	-
Field surveys	days	$ -	$ -	G1

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$ 1,133,139.20	$ 1,161,467.68
5 Year	$ 1,867,536.00	$ 2,112,945.57
10 Year	$ 2,785,532.00	$ 3,565,716.46
15 Year	$ 3,703,528.00	$ 5,363,812.81
20 Year	$ 4,621,524.00	$ 7,572,905.21

CPI	Recommendation	Survey area	Surv freq	Anlsys freq	Effort	Field (initial)	Field (recurring)
5.3.1 Large Wood Recruitment and Retention	1	1424	5	5	237	5	0
	2	1424	5	10	200	0	0
5.3.3 Floodplain Connectivity / Inundation	1	1424	0	0	125	0	0
5.4.8 Riparian Condition	1a	1424	5	5	300	0	0

Figure H - 6. Costing calculator for topographic LiDAR.

Asumptions

#	Item	
2.5%	Projected Annual Inflation	
5	Analysis frequency (years)	0 = no recurring analyses
300	Estimated effort (hours)	

Table 1: Costing Details

Startup				
Item	**Unit**	**Cost (/unit)**	**Cost (total)**	**Ref ID**
Analysis	hr	$ 140.00	$ 42,000.00	-
Annual				
Item	**Unit**	**Cost (/unit)**	**Cost (total)**	**Ref ID**
Analysis	hr	$ 140.00	$ 8,400.00	-

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$ 50,400.00	$ 51,660.00
5 Year	$ 84,000.00	$ 95,038.29
10 Year	$ 126,000.00	$ 161,290.65
15 Year	$ 168,000.00	$ 243,314.09
20 Year	$ 210,000.00	$ 344,109.45

CPI	Recommendation	Anlsys freq	Effort
5.3.3 Floodplain Connectivity / Inundation	3	5	150
5.3.4 Channel Complexity	1	10	200
5.4.7 Stream Habitat Condition	1a	10	200
5.4.8 Riparian Condition	1c	5	300

Figure H - 7. Costing calculator for satellite imagery.

Asumptions

#	Item
2.5%	Projected Annual Inflation
15	# sites
1	Annual sampling frequency

Table 1: Costing Details

Annual				
Item	**Unit**	**Cost (unit)**	**Cost (total)**	**Ref ID**
Site visit/fish survey	3 sites/day	$ 1,000.00	$ 5,000.00	G1

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$ 5,000.00	$ 5,125.00
5 Year	$ 25,000.00	$ 28,285.21
10 Year	$ 50,000.00	$ 64,004.23
15 Year	$ 75,000.00	$ 108,622.36
20 Year	$ 100,000.00	$ 163,861.64

CPI	Recommendation	# sites	Smpl Freq
5.4.4 Thermal Refugia	3	15	4
5.4.7 Stream Habitat Condition	1c	15	1
5.4.8 Riparian condition	1c	15	1

Figure H - 8. Costing calculator for field visits.

Asumptions

#	Item
2.5%	Projected Annual Inflation
15	# new
0	# existing
1	Annual sampling frequency
3	# loggers per site
25	Sampler replacement frequency (yrs)

Table 1: Costing Details

Start Up				
Item	**Unit**	**Cost (unit)**	**Cost (total)**	**Ref ID**
Purchase & installation	site	$ 60.00	$ 900.00	C1
Annual				
Item	**Unit**	**Cost (unit)**	**Cost (total)**	**Ref ID**
Annual O&M (new)	site	$ 15.00	$ 225.00	C2
Temperature logger replacement	site	$ 2.40	$ 36.00	C1
Site visit/data collection	3 sites/day	$ 1,000.00	$ 5,000.00	G1

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$ 6,161.00	$ 6,315.03
5 Year	$ 27,205.00	$ 30,779.96
10 Year	$ 53,510.00	$ 68,497.32
15 Year	$ 79,815.00	$ 115,595.92
20 Year	$ 106,120.00	$ 173,889.98

CPI	Recommendation	# new	# existing	Smpl Freq	Repl freq
5.3.3 Floodplain Connectivity / Inundation	2	15	0	1	25
5.4.4 Thermal Refugia	2	15	0	1	25

Figure H - 9. Costing calculator for temperature loggers.

Asumptions

#	Item	
2.5%	Projected Annual Inflation	
986	Miles of stream to survey	
5	Survey frequency (years)	0 = no recurring survey
5	Analysis frequency (years)	0 = no recurring analyses
150	Estimated effort (hours)	

Table 1: Costing Details

Startup				
Item	**Unit**	**Cost (/unit)**	**Cost (total)**	**Ref ID**
Survey & data processing	mile	$ 400.00	$ 394,400.00	F1
Analysis	hr	$ 140.00	$ 21,000.00	-
Annual				
Item	**Unit**	**Cost (/unit)**	**Cost (total)**	**Ref ID**
Survey & data processing	mile	$ 80.00	$ 78,880.00	F1
Analysis	hr	$ 28.00	$ 4,200.00	-

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$ 498,480.00	$ 510,942.00
5 Year	$ 830,800.00	$ 939,973.94
10 Year	$ 1,246,200.00	$ 1,595,241.36
15 Year	$ 1,661,600.00	$ 2,406,492.23
20 Year	$ 2,077,000.00	$ 3,403,406.35

CPI	Recommendation	Miles	Surv freq	Anlsys freq	Effort
5.4.4 Thermal Refugia	1	986	5	5	150

Figure H - 10. Costing calculator for thermal infrared imagery.

Asumptions

#	Item	
2.5%	Projected Annual Inflation	
986	Miles of stream to survey	
5	Survey frequency (years)	0 = no recurring survey
5	Analysis frequency (years)	0 = no recurring analyses
200	Estimated effort (hours)	

Table 1: Costing Details

Startup				
Item	**Unit**	**Cost (/unit)**	**Cost (total)**	**Ref ID**
Survey & data processing	mile	$ 320.00	$ 315,520.00	E4/E5
Analysis	hr	$ 140.00	$ 28,000.00	-
Annual				
Item	**Unit**	**Cost (/unit)**	**Cost (total)**	**Ref ID**
Survey & data processing	mile	$ 64.00	$ 63,104.00	E4/E5
Analysis	hr	$ 28.00	$ 5,600.00	-

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$ 412,224.00	$ 422,529.60
5 Year	$ 687,040.00	$ 777,322.70
10 Year	$ 1,030,560.00	$ 1,319,203.93
15 Year	$ 1,374,080.00	$ 1,990,077.54
20 Year	$ 1,717,600.00	$ 2,814,487.60

CPI	Recommendation	Miles	Surv freq	Anlsys Freq	Effort
5.3.5 Sediment Transport	1 (1)	986	5	5	200

Figure H - 11. Costing calculator for air photos.

Asumptions

2.5%	Projected Annual Inflation

Table 1: Costing Details

Start Up		
Item	**Cost**	**Ref ID**
PIT tag start up costs	$380,000	H1
Telemetry start up costs	$3,400,000.00	I1
Annual		
Item	**Cost**	**Ref ID**
PIT tag annual and recurring costs	$2,230,000	H2
Telemetry annual and reccuring costs	$2,370,000.00	I2

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$8,380,000	$ 8,589,500.00
5 Year	$26,780,000	$ 27,449,500.00
10 Year	$49,780,000	$ 51,024,500.00
15 Year	$72,780,000	$ 74,599,500.00
20 Year	$95,780,000	$ 98,174,500.00

Figure H - 12. Costing calculator for PIT Tag Database program.

Asumptions

2.5%	Projected Annual Inflation

Table 1: eDNA startup costs

Component	Cost
Series of three expert workshops	75,000
Report of workshop findings	50,000
Startup costs for eDNA network	150,000

Table 2: Costing Totals

Duration	Total	Total (Present Value)
1 Year	$275,000	$ 281,875.00

Figure H - 13. Costing calculator for eDNA workshop and startup.

Asumptions

2.5%	Projected Annual Inflation

Table 1: Program budgets

Organization	Annual Cost
Klamath Tribes	$62,117
USFWS: Happy Camp/Oak Knoll Ranger Districts	$31,425
USFWS: Six Rivers National Forest	$149,000
CDFW	$2,375,000
USFWS	$577,000
Yurok Tribe	$565,000
Resighini Rancheria	$24,620
Karuk Tribe	$250,000
ODFW	$35,000
Hoopa Valley Tribes	$1,206,000
USGS Klamath Falls Field Station	$1,300,000
Salmon River Restoration Council	$100,000
USBR	$7,419,743

Table 2: Costing totals

Duration	Total	Total (Present Value)
1 year	$14,094,905	$14,447,278
5 Year	$70,474,525	$79,735,456
10 Year	$140,949,050	$180,426,700
15 Year	$211,423,575	$306,204,376
20 Year	$281,898,100	$461,922,861

Figure H - 14. Costing calculator for ongoing/existing fish population monitoring programs.

Priority	Cost: 1 year	Cost: 10 year	CPI	Rec. #	Task
1	$1,577,987.50	$12,229,927.74	5.2.1 Seasonal Instream Flow	1a	Expand existing network of real-time streamflow gaging stations (top priority sites)
			5.2.2 Nutrient Loads	1a	Establish network of automated water samplers (top priority sites)
			5.2.3 Fine Sediment Loads and Turbidity	1a	Expand/maintain network of continuous real-time sondes (top priority sites)
			5.4.1 Water Temperature	1a	Expand/maintain network of continuous real-time sondes (top priority sites)
			5.4.2 Water Chemistry	1a	Expand/maintain network of continuous real-time sondes (top priority sites)
			5.4.3 Turbidity	1a	Expand/maintain network of continuous real-time sondes (top priority sites)
			5.4.5 Nutrients	1a	Establish network of automated water samplers (top priority sites)
2	$4,583,103.00	$16,565,318.07	5.3.2 Geomorphic Flushing / Scouring Flows	1	Characterize flushing flows with gage data and transport measurement calibrations
			5.3.4 Channel Complexity	1	Assess basin-wide planform complexity from imagery
			5.3.5 Sediment Distributions	1 (1)	Map substrate sizes: bathymetric LiDAR option
			5.4.4 Thermal Refugia	1	Identify and map refugia across the basin
			5.4.6 Nuisance phytoplankton / algal toxins	1a	Indirect measures: Maintain/expand existing monitoring network for nuisance phytoplankton/algal toxins
			5.4.7 Stream Habitat Condition	1a	Same as channel complexity (Rec #1: planform complexity from remote sensing)
			5.4.8 Riparian Condition	1c	Imagery-based NDVI assessment of vegetation
			5.5.1 Disease	1	Expand existing monitoring network for Ceratonova shasta and Parvicapsula minibornis
			5.5.1 Disease	2	Expand existing monitoring network for Ich and Columnaris
			5.5.1 Disease	3	Develop approach for monitoring disease pathogens/parasites affecting endangered suckers
3	$1,443,342.68	$ 3,847,591.46	5.2.3 Fine Sediment Loads and Turbidity	2	Standardize data collection and sharing
			5.4.1 Water Temperature	2	Standardize data collection and sharing
			5.4.2 Water Chemistry	2	Standardize data collection and sharing
			5.4.3 Turbidity	2	Standardize data collection and sharing
			5.4.7 Stream Habitat Condition	2	Monitor aquatic invertebrates
			5.5.1 Disease	3	Develop approach for monitoring disease pathogens/parasites affecting endangered suckers
			5.5.2 Invasive aquatic species	1	Establish eDNA sampling network for monitoring invasives
			5.3.1 Large Wood Recruitment and Retention	1	Measure large wood concentrations with LiDAR
4	$4,969,272.78	$13,787,880.23	5.2.1 Seasonal Instream Flow	2	Track groundwater levels at monitoring wells
			5.3.1 Large Wood Recruitment and Retention	2	Assess potential large wood supply with LiDAR
			5.3.3 Floodplain Connectivity / Inundation	1	Map alluvial valleys with floodplains
			5.3.3 Floodplain Connectivity / Inundation	2	Monitor timing and duration of overbank flows from gage sites
			5.3.4 Channel Complexity	2	Assess detailed topographic complexity in larger streams
			5.4.4 Thermal Refugia	2	Detailed monitoring of a subset of thermal refugia
			5.4.7 Stream Habitat Condition	1b	Same as channel complexity (Rec #2: topographic complexity in larger streams)
5	$5,613,141.90	$25,193,907.15	5.2.1 Seasonal Instream Flow	1b	Second priority sites
			5.2.2 Nutrient Loads	1b	Second priority sites
			5.3.3 Floodplain Connectivity / Inundation	3	Map floodplain inundation extent from satellite imagery
			5.4.1 Water Temperature	1b	Second priority sites
			5.4.3 Turbidity	1b	Second priority sites
			5.4.4 Thermal Refugia	3	Assess utilization of thermal refugia
			5.4.4 Thermal Refugia	4	Evaluate the relative proportion of flow and effects on mixing
			5.4.5 Nutrients	1b	Second priority sites
			5.4.6 Nuisance phytoplankton / algal toxins	1b	Direct measures of phytoplankton/cyanotoxins
			5.4.7 Stream Habitat Condition	1b	Supplemental field surveys (CDFW methods)
			5.4.8 Riparian Condition	1a	Topographic LiDAR assessment of vegetation
			5.4.8 Riparian Condition	1b	Supplemental field surveys (CDFW methods)

Table H - 3. Summary of total costs for each tier of gestalt priority CPI/recommendations (accounting for site co-location and synergies between monitoring activities that inform multiple CPIs).

Appendix H: Related Plan Summaries

F1 Upper Klamath Basin Watershed Action Plan (UKBWAP)

Objectives **- The Upper Klamath Basin Watershed Action Plan (UKBWAP)** overseen by The Klamath Tribes and collaborating Klamath Basin restoration entities provides science-based guidance regarding types of restoration projects necessary to address specific impairments to riverine and riparian process and function, and develops monitoring regimes tied to quantifiable restoration objectives at multiple scales within the Upper Klamath Lake, Williamson, and Sprague sub-basins (UKBWAPT 2021). The UKBWAP is intended to follow a process of adaptive management to refine condition assessments, recommended restoration actions, and monitoring approaches as new information becomes available.

Restoration actions and targeted species **-** The UKBWAP seeks to generally improve wetland, riverine, riparian, and floodplain process and function to achieve water quality goals and improve habitat conditions for threatened/sensitive fish species currently resident in the upper basin (i.e., Lost River and Shortnose Sucker, Redband Trout, and Bull Trout) while also providing useable habitat to returning anadromous Chinook, Coho, Steelhead, and Pacific Lamprey after the pending removal of four Klamath River dams.

Scale of evaluations **-** A key element of the UKBWAP is reach-scale watershed condition assessments that are used to prioritize reaches (based on degree of impairment) for subsequent implementation of specific volunftary restoration activities. Reach prioritization criteria and summaries are presented on a publicly available web-based Interactive Reach Prioritization Tool (IRPT). Specifically, the IRPT defines 3-mile reaches on major streams and 3-mile shoreline segments along Upper Klamath Lake (UKL) and scores each for restoration actions in the Upper Klamath Basin based on multiple habitat condition metrics (high scores indicate a greater degree of current impairment and an associated higher priority for restoration). In total, the IRPT presents the scored habitat condition of 268 stream reaches and 41 Upper Klamath Lake shoreline segments in the Upper Klamath Basin.

Indicators **-** Condition metrics evaluated within the IRPT include:

- Channelization (applied to stream reaches)
- Channel incision (applied to stream reaches)
- Levees and berms (applied to stream reaches)
- Wetlands (applied to UKL shoreline segments)
- Riparian and floodplain vegetation (applied to stream reaches)
- Irrigation practices (applied to both stream reaches and UKL shoreline segments)
- Springs (applied to stream reaches)
- Fish passage (applied to stream reaches)
- Roads (applied to stream reaches)

- Fish entrainment (applied to stream reaches)
- Large woody debris (applied to both stream reaches and UKL shoreline segments)
- Spawning substrate (applied to both stream reaches and UKL shoreline segments)

Monitoring Focus **-** The Monitoring Framework (UKBWAPT 2021) that has been proposed for the UKBWAP is intended to inform both project-scale and watershed-scale monitoring regimes. The watershed-scale monitoring element of the UKBWAP Monitoring Framework will rely on ongoing Klamath Tribes and USFS aquatics programs in the Upper Klamath Basin and this information should link in well with the needs of the IFRMP and its focus on understanding, advancing and integrating watershed monitoring efforts/data to allow broad Klamath basin-scale tracking of the state of selected CPIs.

IFRMP alignment ***-*** Many of the elements of the UKBWAP parallel the structure of the IFRMP. For example, assessed habitat condition metrics evaluated within the UKBWAP's IRPT are generally consistent with many of the Core Performance Indicators (CPIs) intended for evaluation and monitoring within the IFRMP, the key difference between the two programs being the spatial scale of habitat condition evaluations. The IFRMP is focused on evaluating/scoring differences in (average) habitat condition at a broad sub-watershed (HUC12) scale whereas the UKBWAP evaluates/score habitat condition at a much finer scale resolution (i.e., 3-mile delineated stream reaches and lake segments).

Targeted fish species within the UKBWAP are all represented within the IFRMP's ten focal fish species of concern, which are designated as targets for associated functional watershed restoration actions to be coordinated by the IFRMP. The purpose of the UKBWAP and IFRMP therefore overlap considerably and alignment of these programs will be of benefit for ensuring that the most effective actions (what and where) are undertaken for achieving maximum benefit for upper basin fish populations.

The IFRMP's web-based interactive Klamath IFRMP Restoration Prioritization Tool captures a broader range of considerations within its algorithms for scoring/ranking watersheds for restoration prioritization (habitat considerations as in the IRPT but also incorporating additional measures of watershed comparison including focal fish species distributions (presence/absence) and the extent of potential disruption to fluvial geomorphic processes and watershed inputs. Aligning information/tools across the two programs shows promise for useful integration in the Upper Klamath Basin, as the IFRMP can provide an initial coarse-scale approach for identifying priority sub-watersheds for potential restoration efforts and the UKBWAP could then provide the finer-scaled approach for then identifying particular sites to subsequently target within the prioritized sub-watersheds. Although the UKBWAP provides valuable guidance for restoration, it does not cover all action types or regions of the Upper Klamath Basin (notably excluding the Lost sub-basin), and should be considered along with other plans, initiatives, and data-sets with complementary objectives.

Summary of Unique Plan Elements

- UKBWAP evaluates habitat condition in the upper basin at a finer spatial scale than does the IFRMP (i.e., reach vs. sub-watershed)
- UKBWAP has a greater focus on local project effectiveness monitoring than does the IFRMP (which focuses primarily on broad-scale status and trend monitoring)
- Development and implementation of a web-based Interactive Reach Prioritization Tool (IRPT) for quantifying habitat condition of upper Klamath Basin stream reaches and Klamath Lake shoreline segments
- It should be noted that this plan does not cover the Lost Sub-Basin

References

Interactive Reach Prioritization Tool (IRPT): https://trout.maps.arcgis.com/apps/webappviewer/index.html?id=92a7112de1cb44bb9231cee57268c446

F2 Implementation Plan for the Reintroduction of Anadromous Fish into the Oregon Portion of the Upper Klamath Basin

Objectives **- The Implementation Plan for the Reintroduction of Anadromous Fish into the Oregon Portion of the Upper Klamath Basin** (ODFW and Klamath Tribes 2021) recommends efforts to be undertaken within the Oregon portion of the Upper Klamath Basin to reintroduce anadromous fish to suitable, historically-occupied areas above the site of Iron Gate Dam (i.e., Upper Klamath River, Williamson River, Sprague River, and Upper Klamath Lake sub-basins). Recommended efforts within this plan (including both passive and active reintroduction) are intended to take place within a science-based, adaptive framework.

Restoration actions and targeted species **-** This plan does not itself focus on habitat restoration actions but is instead intended to guide the reintroduction of Chinook Salmon, Coho Salmon, Steelhead Trout, and Pacific Lamprey into the Oregon portion of the Klamath Basin, with the goal of establishing self-sustaining, naturally produced populations of these species following the removal of the four Klamath Hydroelectric dams. Efforts within the Reintroduction Implementation Plan are intended to be incorporated with other actions that are helping to restore key aquatic environments across the Klamath Basin.

Scale of evaluations **-** Occurrences, abundance, and condition of anadromous fish in newly accessible habitat will be evaluated within this plan at the scale of the upper Klamath River mainstem reaches and upper Klamath basin stream/tributary reaches.

Indicators **-** Indicators to be monitored within the Reintroduction Implementation Plan are focused on assessing fish population response and include:

- Presence/absence

- Distribution (spatial structure)
- Abundance (number of spawners)
- Productivity (recruitment)
- Life history diversity
- Genetic diversity/population structure
- Disease pathogen prevalence/intensity
- Fish health

Monitoring Focus **-** This plan includes a recommended strategy for monitoring re-establishment of anadromous fish following the removal of the four Klamath Hydroelectric dams. The strategy for monitoring will be focused on fundamental questions. Immediately following the availability of passage, monitoring will focus on determining if anadromous fish are migrating into habitat immediately above the dams. As fish populations become more widely established, monitoring will be more specific and focused toward management objectives, such as determining adult escapement, juvenile productivity, and spatial distribution within each sub-basin.

IFRMP alignment - Targeted fish species for monitoring within this plan (i.e., Chinook Salmon, Coho Salmon, Steelhead, and Pacific Lamprey) are all represented within the IFRMP's ten focal fish species of concern, which are designated as targets for associated functional watershed restoration actions to be coordinated by the IFRMP. Elements of this plan and the IFRMP therefore align and shared information from these programs will help ensure that effective actions (what and where) are being undertaken within the IFRMP to help achieve desired responses from newly re-introduced upper basin fish populations.

Summary of Unique Plan Elements

- The Reintroduction Implementation Plan focuses principally on determining whether anadromous fish populations are returning to the upper Klamath Basin after removal of the major Klamath River dams and the strategies for their reintroduction (passive or active) have been successful.

F3 Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife

Objectives - **The Klamath River Anadromous Fishery Reintroduction and Restoration Monitoring Plan for the California Natural Resources Agency and the California Department of Fish and Wildlife** (CNRA and CDFW. 2021 (draft)) provides a framework for the reintroduction and monitoring of anadromous fish in the upper Klamath Basin of California once fish passage is restored through removal of the four mainstem hydroelectric dams. This Plan relies on an adaptive management strategy with volitional migration as the preferred method for reintroduction, while also including general guidance for active reintroduction, if necessary and appropriate, to repopulate newly available habitat. The Plan is intended to be compatible with current monitoring programs for anadromous fish downstream of Iron Gate Dam and consistent with reintroduction and monitoring programs currently under development by the ODFW and the Klamath Tribes for the Oregon portion of the Klamath River watershed.

Restoration actions and targeted species **-** This plan does not itself focus on habitat restoration actions but is instead intended to guide the reintroduction of native anadromous species that were historically known to occur in the Klamath River upstream of Iron Gate Dam. These include spring and fall-run Chinook Salmon, Coho Salmon, Steelhead Trout, and Pacific Lamprey. Efforts within the Reintroduction Implementation Plan are intended to be incorporated with other actions that are helping to restore key aquatic environments across the Klamath Basin.

Scale of evaluations **-** Evaluation of occurrences, abundance, and condition of anadromous fish within this plan will be restricted to California and include the Klamath River and associated tributaries from the Iron Gate Dam upstream to the Stateline (referred to as the monitoring reach). The monitoring reach encompasses approximately 31.2 kilometers of the mainstem Klamath River and approximately 26.3 kilometers of tributary habitats.

Indicators **-** Indicators to be monitored across the different phases of this plan are focused on assessing fish population response and include:

- Occupancy (spatial and temporal)
- Distribution
- Abundance
- Age structure
- Productivity
- Hatchery component (pHOS)
- Pre-spawning mortality
- Out-migrant timing
- Seasonal habitat use by juveniles
- Genetic diversity
- Life-history diversity
- Fish health
- Pathogen prevalence

Monitoring Focus **-** Monitoring within this plan is intended to measure and track the rate of change in the number of fish per species per year and progress toward viable self-sustaining populations of anadromous fish in the monitoring reach following removal of the dams. The proposed approach is to monitor volitional reintroduction for three to four generations (12 to 15 years) depending on species. Monitoring will follow a four-phased approach: **Phase I** – Reintroduction, **Phase II** – Establishment, **Phase III** – Productivity and Abundance, and **Phase IV** – Spatial Structure and Diversity, with the monitoring phases designed to coincide with the temporal and spatial aspects of volitional reintroduction and associated habitat restoration actions.

IFRMP alignment **-** Targeted fish species for monitoring within this plan (i.e., Chinook Salmon, Coho Salmon, Steelhead, and Pacific Lamprey) are all represented within the IFRMP's ten focal fish species of concern, which are designated as targets for associated functional watershed restoration actions to be coordinated by the IFRMP. Elements of this plan and the IFRMP therefore align and shared information from these programs will help ensure that effective actions (what and where) are being undertaken within the IFRMP to help achieve desired responses from newly re-introduced upper basin fish populations.

Summary of Unique Plan Elements

- The Reintroduction Implementation Plan focuses principally on determining whether anadromous fish populations are returning to the California areas of the upper Klamath River sub-basin after removal of the major Klamath River dams and the strategies for their reintroduction and re-establishment in the upper Klamath River (natural through volitional migration or active through transplantation) have been successful.

F4 Klamath Hydroelectric Settlement Agreement (KHSA) Definite Decommissioning Plan (Definite Plan)

Objectives **– the amended Klamath Hydroelectric Settlement Agreement (KHSA) Definite Decommissioning Plan (DDP)** overseen by the Klamath River Renewal Corporation (KRRC)[1] has petitioned the Federal Energy Regulatory Commission (FERC) to take ownership and **decommission and remove four (4) PacifiCorp dams** (built between 1903 and 1962): **JC Boyle, Copco No. 1 & No. 2 and Iron Gate** to restore fish passage and formerly inundated lands and implement required mitigation measures in compliance with all federal, state and local regulations (KRRC 2021a [online]). If implemented, the KHSA will result in the largest river restoration effort in the United States. Amongst other objectives, dam decommissioning will improve the **habitat and health of fisheries** by allowing salmon, steelhead, and lamprey access to over 400 stream-miles of historic habitat upstream of the dams. Restoring the river will eliminate the reservoirs associated with algae blooms and **improve water quality** that will benefit the region's wildlife, recreation, economy, and health. Klamath dams trap nutrient rich waters in shallow reservoirs contributing to massive blooms of toxic blue-green algae that pose a threat to wildlife and human health. These algae blooms also trap heat and deplete oxygen, further degrading water quality and habitat for native fish species. Decommissioning will also prevent

[1] The KRRC is a private, independent non-profit organization formed by signatories of the amended Klamath Hydroelectric Settlement Agreement (KHSA) including the States of California and Oregon, local governments, Tribal nations, dam owner PacifiCorp, irrigators, and several conservation and fishing groups (KRRC 2021 website, viewed 12 July 2021, <https://klamathrenewal.org/our-story/>).

stagnant reservoirs from increasing water temperatures in the summer and help alleviate the poor habitat **conditions that contribute to fish diseases** below these existing dams (KRRC 2021b [online]).

Restoration actions and targeted species **-** The amended KHSA DDP seeks to restore anadromous fish populations by re-establishing volitional passage to historic cold-water habitat, habitat that is needed more than ever in the face of accelerating global heating and climate breakdown. This passage restoration is achieved by **removing four (4) PacifiCorp dams — JC Boyle, Copco No. 1 & No. 2 and Iron Gate**. In addition to achieving a free-flowing condition, the KHSA DDP also includes **short-term site remediation and restoration efforts** to avoid prolonged adverse impacts related to **elevated suspended and larger grain sediment** loads (e.g., fish passage barrier removal, gravel augmentation or other actions including installation of large woody material, in-channel habitat enhancement (e.g., boulder clusters), revegetation efforts, riparian planting for shade coverage, off-channel habitat enhancement, wetland enhancement, bank stability interventions, and cattle exclusion fencing) to improve spawning and rearing habitat (see KRRC 2021 - Exhibit J).

During reservoir drawdown, and if access allows, the KRRC will grade reservoir surfaces to **promote sediment evacuation** by water flowing the tributaries and mainstem river using machinery such as small excavators. Culturally sensitive areas will be designated by the KRRC prior to drawdown to ensure that these areas are not entered with machinery. *Adequate flows in the tributaries and the mainstem river are critical for active sediment evacuation activities*. Active measures to increase discharge in the river will be infeasible. Potential **assisted sediment evacuation methods** rely on flowing water in either the river or a tributary to transport sediment away from the site. The KRRC will use sediment jetting with an air-boat-mounted water jet to maximize stored sediment erosion at the Copco No. 1 and Iron Gate Reservoirs (KRRC 2021 - Exhibit J). This approach is not anticipated at the J.C. Boyle Reservoir. The intent of **construction interventions at the priority tributary sites is to advance the stream evolutionary clock** to achieve favorable site conditions following initial establishment without having to wait for natural processes to stabilize the sites over a longer period of time (KRRC 2021 - Exhibit J).

As part of dam decommissioning, **CDFW will relocate all aquaculture production** (adult holding, spawning, egg incubation, fish production) **from the Iron Gate Fish Hatchery (IGFH) to an upgraded Fall Creek Fish Hatchery (FCFH) facility** (KRRC 2021 - Exhibit D). This will effectively remove all potential Iron Gate water use and effluent concerns. Some historic functional facilities remain at FCFH but substantial infrastructure improvements are required to achieve Hatcheries Management and Operation Plan fish production goals. The KRRC will modify the FCFH site to upgrade existing facilities and construct new facilities for Coho and fall-run Chinook salmon production. FCFH will be in operation prior to the drawdown of Iron Gate Reservoir. Post-removal dam conditions will allow anadromous fish to ascend Fall Creek and be trapped for future brood purposes. The NMFS and CDFW have determined the priorities for fish production at FCFH under the Hatcheries Management and Operation Plan. The disposition of any remaining facilities at the IGFH will be the discretion of CDFW and CDFW will operate the FCFH. Current rearing production program scenarios plan for a total of 75,000 Coho salmon and approximately 3.25 million Chinook salmon at various release dates. NMFS and CDFW support discontinuation of steelhead production (KRRC 2021 - Exhibit D). Hatchery production at FCFH is expected to occur until license surrender is effective, or for 8 years following Iron Gate Dam removal (KRRC 2021 - Exhibit D).

The KHSA Definite Plan contains *sixteen (16) topic area Management Plans* that describe the specific methods that the KRRC will use to remove the 4 dams then restore lands currently occupied by dams and other facilities and reservoirs. Anadromous fish are expected to be amongst the primary beneficiaries of dam removal: Pacific Lamprey, Steelhead, Coho salmon, Fall-run Chinook salmon, and Spring-run Chinook salmon with modest anticipated habitat benefits for four (4) resident species: Shortnose suckers, Lost river suckers, Redband trout and Rainbow trout. Decommissioning the dams removes migration barriers to formerly available habitat (including access to upstream thermal refugia), improves fluvial geomorphic processes (sediment transport, instream flows) and as noted above improves nutrient cycling and water temperatures while reducing the risk of toxic algae blooms (i.e. improves water quality) while reducing incidence of disease in the Klamath River for juvenile and adult salmon.

The Management Plans with the most relevance to native fish species are: Exhibit A – Aquatic Resources Management Plan, Exhibit C – Erosion and Sediment control Plan, Exhibit D – Hatchery Management and Operations Plan, Exhibit J – Reservoir Area Management Plan, Exhibit K – Reservoir Drawdown and Diversion Plan, Exhibit L – Sediment Deposit Remediation Plan and Exhibit O – Water Quality Monitoring Management Plan. Within these Management Plan Exhibits, for example, the Aquatic Resources Management Plan, there are often a series of further *sub-plans*:

- Appendix A: Spawning Habitat Availability Report and Plan
- Appendix B: California AR-6 Adaptive Management Plan-Suckers
- Appendix C: Fish Presence Monitoring Plan
- Appendix D: Tributary-Mainstem Connectivity Plan
- Appendix E: Juvenile Salmonid and Pacific Lamprey Rescue and Relocation Plan
- Appendix F: Oregon AR-6 Adaptive Management Plan-Suckers

The summary description here *attempts* to fairly amalgamate the essence of thousands of pages of Management Plans and sub-plans into a high-level summary.

Scale of evaluations **–** The **KSHA DDP** geographic area encompasses the dam removal Proposed Action area (Figure F - 1) and may or may not expand beyond the FERC boundary associated with the Lower Klamath Project. The focus is on the mainstem Klamath River and key tributaries in within study area. Detailed map books are available within the technical appendices of the KSHA DDP, e.g., Exhibit A that define a large number of specific monitoring sites.

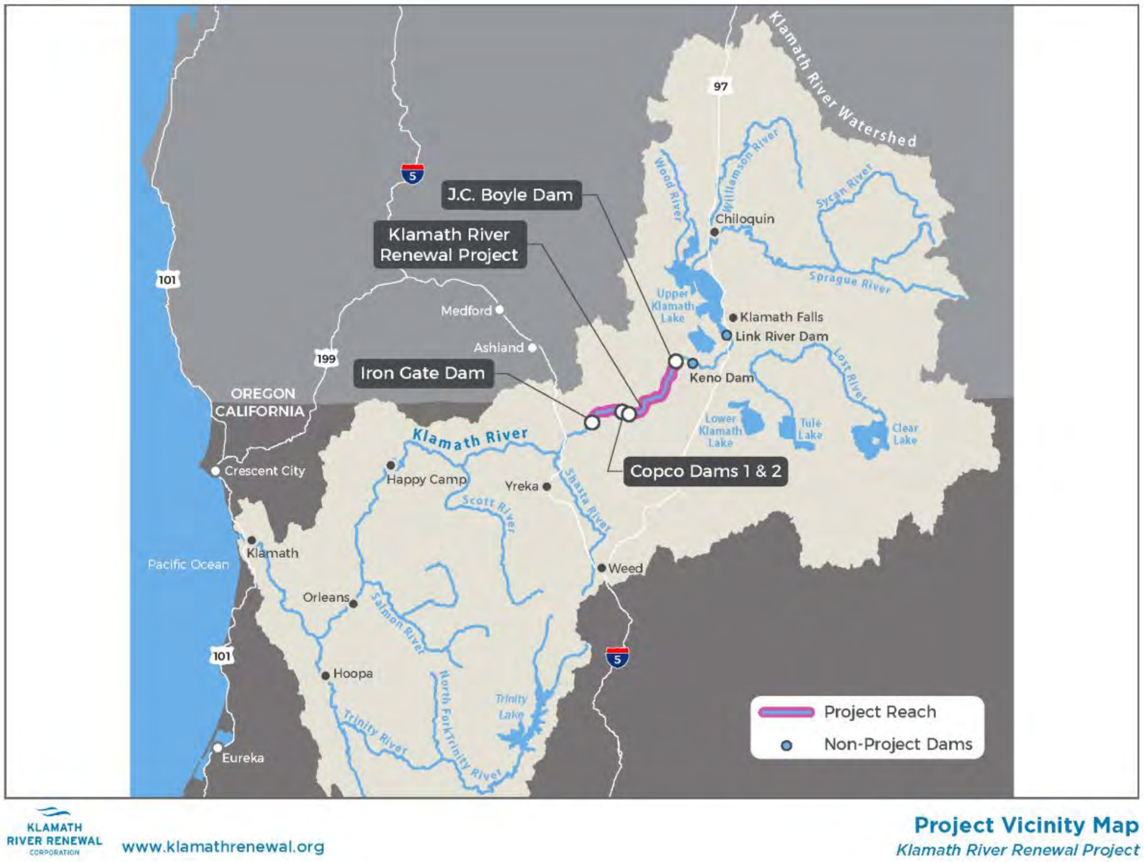


Figure F - 1: Map of the Klamath Basin showing location of the Klamath River Renewal Corporation's Klamath River Dam Decommissioning project area boundaries. Not shown at this scale are specific focal tributaries. Source: https://klamathrenewal.org/the-project/.

Indicators *(not exhaustive)* – Diagnostic and target (offset/mitigation and effectiveness) monitoring metrics identified within the amended KHSA DDP include:

- Measurement of **tributary and mainstem discharge (river flow), water temperature, turbidity, conductance, pH, dissolved oxygen** (concentration and percent saturation)
    - E.g., Measurement of **water temperature** at thirteen (13) tributary confluences (Seiad Creek (RM 131.9); Grider Creek (RM 132.1); Walker Creek (RM 135.2); O'Neil Creek (RM 139.1); Tom Martin Creek (RM 144.6); Scott River (RM 145.1); Horse Creek (RM 149.5); Beaver Creek (RM 163.3); Humbug Creek (RM 173.9); Shasta River (RM 179.3); Cottonwood Creek (RM 185.1); Dry Creek (RM 190.9); Bogus Creek (RM 192.6)). The 7-day average of the daily maximum temperature has associated early warning and action trigger/threshold values (17°C and 19°C).
- **Grab samples of nitrogen** (ammonia, nitrate, nitrite, total nitrogen), **phosphorus** (orthophosphate, organic phosphorus, total phosphorus), **carbon** (dissolved organic carbon, particulate carbon), **chlorophyll-a.** A number of additional water quality parameters are identified in Table 4 of Appendix A in KRRC 2021 - Exhibit O (e.g.,

sediment grab samples include wide range of metals and contaminant parameters, e.g., arsenic).

- Water temperature and turbidity measurements will be accompanied with **visual observations of fish densities, fish behavior, visible disease and injury** in the tributary and the thermal mixing zone where mainstem and tributary waters mix. This information will be used to inform capture and relocation efforts.
    - Each monitored tributary has a list of primary and secondary fish relocation sites (Table 3-1, KRRC 2021 - Exhibit A).
- **Suspended sediment (water turbidity proxy) and bedload movement measurements** (mainstem Klamath River downstream from Iron Gate Dam, RM 193.1). Turbidity levels are associated with water quality triggers (using USGS stations at the Klamath River Below Iron Gate Dam CA gage (No. 11516530) and USGS Klamath River Near Seiad Valley CA gage (No. 11520500)).
- **Identification of potential fish barrier formation** along the mainstem Klamath River and at identified fish-bearing tributary confluences within the Tributary Mainstem Connectivity fish passage monitoring area (KRRC 2021 - Exhibit A, Tributary-Mainstem Connectivity Plan), i.e.,
    - Assessment of potential **access to mainstem spawning habitat** (mainstem Klamath River from Iron Gate Dam RM 193.1 to Keno Dam, RM 239.2, including use of unmanned aerial vehicles (UAV))
    - Assessment of potential **access to tributary spawning habitat** in target tributaries upstream of Iron Gate Dam including identification of passage barriers to potentially remove (Fall Creek, Jenny Creek, Shovel Creek, Spencer Creek, Camp Creek, Scotch Creek, Dutch Creek, Deer Creek, and Beaver Creek, including use of unmanned aerial vehicles (UAV))
    - **Fixed photo point monitoring** at each of the **in-scope tributary confluences** to assess **potential sediment accretion**. Photo point monitoring will also be accompanied by low-elevation geolocated oblique aerial video (UAV) to assess **potential barriers at confluence sites** (e.g., headcut migration impeding migration)
- Measurement of **spawning habitat patch area delineation including visual substrate particle classification** (air photo patch delineation and substrate composition using unmanned aerial vehicles (UAV))
    - If, based on UAV and other surveys, one or more of the spawning habitat Target Metrics have not been met, the KRRC will, in consultation with the Aquatics Technical Working Group, determine if gravel augmentation or other actions to improve spawning and rearing habitat are appropriate
- **Fish passage (and presence) monitoring** (Coho salmon, Spring-run Chinook salmon, Fall-run Chinook salmon and Pacific lamprey) **along the 8-mile reach of the mainstem Klamath River** from the downstream side of the Iron Gate Dam footprint (RM 193.1) to Cottonwood Creek (RM 185.1), at the confluence locations of the five fish-bearing streams within the Reach (Bogus Creek, Dry Creek, Little Bogus Creek, Willow Creek, and Cottonwood Creek), and at the Shovel Creek confluence with the Klamath River above the Copco No. 1 Reservoir. Similarly, anadromous **fish presence** monitoring in mainstem

and **key tributaries** (Jenny Creek, Fall Creek, Shovel Creek, and Spencer Creek, Camp Creek and Scotch Creek complex)

- Adult **redd and carcass surveys in key tributaries** (using shoreline visual, inflatable catarafts and snorkeling methods) during Target Species spawning periods.
- In selected tributaries, **underwater video surveillance of returning adult salmonids, spawning ground utilization and carcass surveys, and juvenile outmigration monitoring**. CDFW plans to monitor several tributaries in the Upper Klamath Basin in California for anadromous fish presence, including Shovel Creek (K. Bainbridge, pers. comm., 2020 as cited in KRRC 2021 - Exhibit A).

Monitoring Focus **–** The amended KHSA DDP monitoring focus is intended to inform **Target Metric achievement** utilising the performance indicators listed above and documented in numerous sub-plans. For example, see Table 6-6 in KRRC 2021 - Exhibit J for monitoring success criteria. The KRRC will begin monitoring these indicators for the target species in October of the first year after the year in which drawdown of the reservoirs commenced. Depending on the indicators, monitoring will occur for approximately five years between **2023-2028 or 2025-2029** (see KRRC 2021 - Exhibit A and Table 6-5 in KRRC 2021 - Exhibit J). For example, monitoring in a given tributary will cease if monitoring surveys document the presence of anadromous fish in that tributary during a given year. The KRRC has adopted the **Stream Evolution Triangle** (SET) developed by Castro and Thorne (Castro and Thorne, 2019) as the conceptual model for communicating riverine geomorphology for the Project (see Figure 6-2 in KRRC 2021 - Exhibit J). The SET will be used by the KRRC to communicate the geomorphic state of restoration sites based on stream evolution by indicating site condition relative to dominant process which include hydrology, geology, and biology (KRRC 2021 - Exhibit J). Geomorphic site condition will then be tracked over time during subsequent phases noting trends during monitoring activities to plot stream evolution trajectories over time. If the trend at a site is diverging from desirable outcomes, then the KRRC will consider adaptive measures.

Documented **anadromous fish presence in a tributary** will indicate that anadromous fish have access to the mainstem Klamath River *below* that tributary, and that portion of the mainstem will therefore no longer be monitored (KRRC 2021 - Exhibit A). During drawdown various water quality and visual fish behavior (health) monitoring efforts will take place to inform the **need for capture** (e.g., backpack electrofishing, fyke netting , seining) **and relocation** of target species and life stages. Other forms of monitoring may cease following consultation with the Aquatics Technical Working Group. The KRRC may, in coordination with the California Department of Fish and Wildlife (CDFW), also use rotary screw traps. Upon capture, the KRRC will transfer juvenile salmonids to insulated coolers (i.e., holding coolers), filled with water from the tributary and equipped with battery operated aerators (KRRC 2021 - Exhibit A).

If the KRRC determines that there is a potential fish passage barrier, a field-based fish **passage barrier evaluation** will be undertaken in consultation with the Aquatic Technical and Restoration Technical Working Groups. Under the KSHA DDP, significant discontinuities in water surface elevations may trigger additional adaptive management assessments, such as long profile surveys to evaluate need for physical barrier removal and other interventions. The **KRRC will remedy tributary obstructions that limit fish passage** through appropriate manual or mechanical means necessary to address obstructions.

In regard to tracking the **elevation evolution of the mainstem Klamath River and tributary confluences** pre-drawdown topographic data from 2018 baseline bathymetry is stored and publicly available at www.opentopography.org. Project baseline data can be downloaded at https://opentopography.org/news/klamath-river-renewal-project-data-access-throughopentopography and https://doi.org/10.5069/G9DN436N. The KRRC will also establish fixed photo point monitoring locations pre-drawdown at each of the tributary confluences within the Tributary Mainstem Connectivity Plan fish passage monitoring area to establish that confluence sites are not blocked by sediment and that the sediment present does not obscure fish passage.

The KRRC will assess reported **sediment deposits below Iron Gate Dam to the mouth of the Klamath Estuary** within 60 days of property owner notification to determine if the deposits are consistent with physical sediment properties associated with reservoir sediments (KRRC 2021 - Exhibit L). If testing is performed, the KRRC will test soil samples in the vicinity of the deposited sediments (e.g., from the adjacent riverbank and/or floodplain) for arsenic to determine the local background arsenic concentrations. If the measured **arsenic** concentrations in the deposited sediments are less than or equal to measured local background soil concentrations for arsenic, the KRRC will not take any additional actions. If a reported sediment deposit requires further actions, the KRRC will submit a **sediment deposit remediation plan** to the State Water Resources Control Board (SWRCB), the property owner and FERC. This may include removal of a quantity of the soil.

The KRRC will use ODEQ Oregon Administrative Rule Chapter 340 Division 41 **water quality objectives** when comparing water quality data from upstream and downstream of Project activities (pre-drawdown, post-drawdown) as well as comparing to data collected as part of IM 15 (KRRC 2021 - Exhibit O). For analytes where there is no ODEQ numeric value, the KRRC will compare water quality results with the numeric values of the Water Quality Control Plan objectives for the North Coast Region (North Coast Basin Plan; North Coast Regional Water Quality Control Board (NCRWQCB) 2018 and see Table 3.1 in KRRC 2021 - Exhibit O). Site layout for continuous water quality monitoring and grab sample monitoring is provided in KRRC 2021 - Exhibit O, Appendix A.

CDFW is expected to monitor anadromous fish returns at the Fall Creek Hatchery following dam removal.

The Oregon Department of Fish and Wildlife (ODFW) plans to implement an anadromous salmonid monitoring program for the Upper Klamath River following dam removal (ODFW, 2020, as cited in KRRC 2021 - Exhibit A). This program will likely involve a combination of electrofishing surveys, and spawning ground and carcass surveys. On the lower reach of Spencer Creek, these ODFW monitoring plans include an out-migrating juvenile fish trap, a video weir, and passive integrated transponder (PIT) tag arrays. ODFW will also monitor the Oregon portion of the Hydroelectric Reach. Approximately 13 miles of the mainstem Klamath River from Keno Dam to the state line will be monitored for anadromous salmonid spawning and carcasses. The survey reaches include the Keno Reach, which extends 6.8 miles from Keno Dam to just downstream of Spencer Creek, and the Frain Ranch Reach, which extends 6 miles from the Spring Island Boat

Ramp to Caldera Rapid. In addition, ODFW monitoring includes the operation of a rotary screw trap on the Klamath River downstream of the Spencer Creek confluence and/or on the lower end of the Frain Ranch Reach. Continued coordination with ODFW on the implementation of their monitoring program will aid in the documentation of the location and species of anadromous fish that are observed in Oregon's portion of the Klamath River during the Fish Presence Monitoring Plan 's monitoring period.

Within the current KRRC DPP purview, much of the monitoring efforts are time limited with commitments ending approximately 2-5 years following the reservoir drawdown. It is not immediately clear how unexpected events, such as sustained droughts would affect these time frames.

IFRMP alignment **–** The KHSA DDP has many objectives in common with the IFRMP, including a strong focus on fish population restoration (essentially the same focal species though the IFRMP has a proportionately higher focus on resident, non-anadromous species). For example, one central performance indicator of the KHSA DDP is enabling range expansion of anadromous fish which is central to the IFRMP's Core Objective 1.5 of maintaining or increasing the spatial distributions of focal fish (Section 2.2). Likewise, there are many other parallels with CPIs for habitat, water quality, watershed inputs and fluvial geomorphic processes. One key difference between the two programs is the spatial scale of habitat condition evaluations and the duration over which the two plans are intended to remain active. The KHSA DDP program duration is roughly 2022 – 2029, while the IFRMP is an implementation framework for a multi-decadal adaptive restoration plan. Further, the IFRMP is focused on evaluating/scoring differences in (average) habitat condition at a broad sub-watershed (HUC12) scale whereas the KHSA DDP evaluates effectiveness of specific restoration and mitigation actions at a much finer scale resolution (i.e., specific point locations, specific river mile delineated stream reaches and lake segments).

The KHSA DDP is focused on considerations associated with removal of dams, sediment evolution, related water quality measures and effectiveness of fish passage. The web-based interactive Klamath IFRMP Restoration Prioritization Tool captures a broader range of watershed process and habitat considerations within its algorithms for scoring/ranking watersheds for all classes of habitat restoration prioritization throughout the entire Klamath basin. And indeed, the KHSA DDP is itself one of the highest ranking restoration actions within the IFRMP (Table 4-17).

Summary of Unique Plan Elements

- If implemented, the KHSA DDP will result in the largest river restoration effort in the United States. Subject to remaining FERC authorizations, the DDP has secured $450 million from the State of California, Oregon and PacifiCorp (plus an additional $45 million in the event of a cost overrun). At the time of writing, the IFRMP is not attached to any firm funding commitments, though the IFRMP for the first time in over a decade provides an estimate of the cost of functional watershed restoration throughout the entirety of the basin Appendix D.

- The KHSA DDP, like most of the other plans summarized in Section 0, evaluates habitat (and fish population) condition in the dam removal area and downstream at a finer spatial scale (i.e., specific focal reaches, specific monitoring sites) than the basin-wide IFRMP which relies upon proxy and other standardized CPIs at the sub-watershed HUC12 scale at which CPI data can be consistently generated.
- Similarly, the KHSA DDP is necessarily focused on mitigating short term dam removal impacts associated with large sediment loads, various metrics and triggers for instituting remedial adaptive management measures (e.g., removal of sediment barriers to fish passage, fish relocation) and on local sub-project effectiveness monitoring and monitoring needed to comply with all federal, state and local regulations. The IFRMP focuses on broad-scale status and trend monitoring for purposes of assessing sub-watershed habitat condition used to prioritize/score the need for additional restoration over multiple decades.
- The KHSA DDP contemplates a concentrated period of action and monitoring running from ~2022 to 2029 while the IFRMP is a long term multi-decadal plan for coordinating ongoing habitat restoration and adaptive management throughout the basin.
- Dam decommissioning under the KHSA DDP includes relocating all aquaculture production (adult holding, spawning, egg incubation, fish production) from the Iron Gate Fish Hatchery (IGFH) to an upgraded Fall Creek Fish Hatchery (FCFH) facility. Fisheries actions including hatchery management are outside the scope of the IFRMP which is focused on watershed process and habitat restoration and related CPIs.
- The KRRC has adopted the Stream Evolution Triangle (SET) developed by Castro and Thorne (Castro and Thorne, 2019) as the conceptual model for communicating riverine geomorphology for the Project (see Figure 6-2 in Exhibit J). The KHSA DDP necessarily involves a greater focus on fluvial geomorphic performance indicators than the IFRMP.

F5 Mid-Klamath River Recovery Plan

Objectives **- The Mid Klamath Sub-basin Fisheries Recovery Plan (MKSFRP)**, overseen by The US Fish and Wildlife Service (Yreka Office), aims to identify and recommend actions that will improve conditions for the sub-basin's anadromous fish, both through restoration of aquatic and terrestrial environments and protection of unimpaired environments. The plan outlines both passive and active restoration actions that address the most important physical and biological processes for healthy anadromous fish runs. It is designed to target the eight sub-watersheds within the Mid Klamath sub-basin: The Volcanic Outer Region, Checkerboard, Red Butte, Grider Elk, Siskiyou, Western Marble Mountain, Orleans, and Red Cap. It considers cumulative watershed impacts, upland management, wilderness protection opportunities, physical and biological monitoring, public engagement, and identification of planning needs and information gaps. Further, it summarizes key issues, priorities, opportunities, and current or proposed restoration actions within each of the sub-watersheds.

Restoration actions and targeted species **-** Active (e.g., field work) and passive (e.g., policies to protect existing environments) restoration actions seek to improve the overall condition of upland/upslope, riparian, streambank, and instream environments to facilitate protection and recovery of anadromous fish. This includes on-the-ground work such as removal of barriers to fish passage, dam removal, fish screen installation, road decommissioning or closure, grazing management, revegetation of riparian areas, and monitoring efforts such as macroinvertebrate sampling, observation of the influence of hatchery fish on wild salmon, and disease studies. Anadromous fish species of particular concern within the plan are Chinook salmon, Coho salmon, Steelhead, Green Sturgeon, and Pacific Lamprey.

Scale of evaluations **-** Evaluations for the MKSFRP are undertaken at the sub-watershed scale, with the eight sub-watersheds identified within the Mid-Klamath sub-basin delineated based on landscape contiguity, biogeography, and the specific management circumstances distinct to each.

Priority Restoration Actions **-** Priority restoration actions within the MKSFRP include:

- Stream flow
- Water temperature
- Water quality (pH, conductivity, do, turbidity)
- Fish barriers
- Fish disease
- Fish health
- Fish harvest
- Chinook spawning escapement
- Steelhead holding counts
- Outmigrants
- Thermal refugia

Monitoring Focus **-** Monitoring is carried out by many different agencies, Tribes, and community organizations. Broadly, monitoring includes fish population monitoring, stream flow monitoring, water quality monitoring, physical habitat monitoring, and monitoring of restoration sites. The MKSFRP seeks to utilize short and long term monitoring in order to guide and prioritize the implementation of recovery actions, and to measure the success of implemented efforts. Long term monitoring endeavours include effectiveness monitoring, stream flow and water quality monitoring, fish population and run size monitoring, and fish habitat monitoring. Short term monitoring includes stream flow and water quality monitoring, fish disease and health monitoring, harvest monitoring, and monitoring of threatened or endangered fish populations.

IFRMP alignment ***-*** The MKSFRP aligns well with the IFRMP in many way. The vast majority of restoration actions outlined in the recovery plan match the actions listed in the IFRMP. The MKSFRP outlines restoration actions and monitoring endeavours that take place at the same scale (i.e., the sub-watershed scale) as the IFRMP. The priority anadromous fish species within the MKSFRP overlap with the key species of interest for the Mid-Upper Klamath basin within the IFRMP. While the restoration plan contains many of the same elements of the IFRMP, it lacks clear and measurable objectives and a robust evaluation framework to determine the effectiveness of restoration actions. Overall, there is strong alignment of restoration and monitoring endeavours between the MKSFRP and the IFRMP, which could foster greater knowledge generation.

Summary of Unique Plan Elements

- The MKSFRP specifies restoration actions for on-the-ground restoration, management, public and community outreach, and monitoring.
- It highlights the importance of cooperation among several stakeholder groups in order to achieve restoration goals

F6 Shasta Watershed Stewardship Plan

Objectives - **Shasta River Watershed Stewardship Report (SRWSR)** overseen by The Shasta Valley Resource Conservation District (SVRCD) and in collaboration with the North Coast Regional Water Quality Control Board (NCRWQCB), is a non-regulatory report that outlines key actions to improve water quality and habitats for sensitive species. It provides a watershed-scale, adaptive management-focused, stewardship framework to support its goals. It also highlights current monitoring endeavours and observed water quality trends throughout the sub-basin. It is intended that the report will be continuously updated, based on information gleaned from the many stakeholders involved in undertaking the actions outlined within, and as a result of its adaptive management approach.

Restoration actions and targeted species - The SRWSR seeks to improve water quality and species habitat through six main stewardship actions, namely riparian fencing, riparian planting, tailwater management, removal of fish barriers, stream flow augmentation, and spring restoration/reconnection. Anadromous fish of greatest concern presented in the report are Steelhead, Coho salmon, and Chinook salmon.

Scale of evaluations - Evaluations are undertaken at the reach scale.The SRWSR outlines priority monitoring areas at very specific river reach locations, and at a fine geographic scale (between 0.03 – 47.53 river miles) in order to quantitatively evaluate the effectiveness of the suite of various implemented stewardship/restoration actions.

Indicators - Condition metrics evaluated within the SRWSR include:

- Water temperature
- Dissolved oxygen concentrations
- pH
- Nutrient concentrations

Monitoring Focus **-** The SRWSR includes the Shasta River Watershed Water Quality Monitoring Plan. The main intent of monitoring is to support beneficial uses and develop long-term water quality management plans. Within the plan, four types of monitoring are highlighted: a) **implementation monitoring**, b) **effectiveness monitoring**, c) **validation monitoring**, and d) **compliance monitoring**. The SRWSR employs sstrategic monitoring locations throughout the sub-basin to better assess general progress towards water quality improvement and overall stewardship program effectiveness. The SRWSR monitoring program is not designed to address individual water quality compliance issues or individual project effectiveness.

Monitoring is primarily focused on two of the Shasta River's most impaired conditions - water temperature and dissolved oxygen concentrations, however pH and nutrient concentrations are also monitored. The plan highlights the importance of expanding current monitoring practices to include benthic algal biomass monitoring, meteorological monitoring, stream flow monitoring, shade and riparian vegetation monitoring, instream physical habitat monitoring, and fish studies. Specific rationales are provided for each of the 15 monitoring locations (nine in the Shasta River, six across the major tributaries), including ease of access, level of impairment, its status as an already-existing monitoring location, prior existence of water flow gauges, and how representative the location is of upstream or downstream reaches. Because the overarching program (Klamath Basin Monitoring Program (KBMP)) under which the SRWSR exists is made up of several partner organizations, agencies, and Tribes collaborating together, monitoring data can be collected from over 165 monitoring locations throughout the Shasta River sub-basin. From these many monitoring locations, a comprehensive water quality dataset can be developed in order to assess watershed conditions.

IFRMP alignment - Many components of the SRWSR align well with the IFRMP. The actions listed within the report mostly match with the IFRMP's restoration action dictionary, excluding "spring restoration". Both the SRWSR and the IFRMP emphasize the critical nature of continued monitoring and adaptive management. The report's adaptive management framework utilizes a six-step approach that differs only marginally from the IFRMP's; monitoring is considered to be a discrete step in the IFRMP, while it is more implicit within the "Measure and Evaluate Progress" step of the SRWSR. Further, both examine restoration at the sub-watershed scale (although SRWSR monitoring is at the reach scale).

Summary of Unique Plan Elements

- Building partnerships in order to foster collaboration is highly emphasized throughout the SRWSR, since the report exists as a result of successful collaborations between the many stakeholders undertaking restoration and monitoring in the Shasta River sub-basin. It is also a main focus of Step 1 in the report's adaptive management framework.
- Priority monitoring locations are at specific river reaches that are considered most impaired, in order to track and quantitatively evaluate the effectiveness of restoration activities at natural river breakpoints.

F7 Scott River Strategic Action Plan

Objectives **- The Scott River Watershed Strategic Action Plan (SAP)** is intended to improve the effectiveness of natural resource management and enhancement by both assessing watershed condition and by providing a basis for setting priorities for future restoration and management actions in the Scott River sub-basin.

Restoration actions and targeted species **-** Major restoration concerns within the watershed addressed by the SAP focus on improving water quality and habitat conditions for threatened Coho, Chinook, and Steelhead (anadromous salmonids). Restoration opportunities considered under the SAP include bank stabilization, fish passage and screening of diversions, riparian fencing and replanting, alternative stock water systems, tailwater return systems, and road reconditioning.

Scale of evaluations **-** The SAP assesses fish population status and habitat conditions at a variety of spatial scales: 1) whole sub-basin, 2) sub-watersheds (defined as collections of springs within the same geographic area), 3) Scott River mainstem reaches and 4) tributary streams.

Indicators **-** Parameters considered for evaluations within the SAP include:

- Water temperature
- In-stream habitat condition
- Riparian condition
- Channel conditions
- Thermal refugia
- Stream flow
- Suspended and deposited sediment
- Macroinvertebrates
- Spawner abundance
- Smolt outmigrants
- Juvenile habitat utilization

Monitoring Focus **-** Monitoring within the SAP is intended to contribute to long-term trend monitoring while also providing input into Scott River sub-basin watershed restoration and land management planning by providing data to assess the effectiveness of implemented restoration projects.

IFRMP alignment ***-*** Many of the elements of the SAP parallel the structure of the IFRMP. For example, assessed biological values and habitat condition metrics evaluated within the SAP are generally consistent with many of the Core Performance Indicators (CPIs) intended for evaluation and monitoring within the IFRMP, the key difference between the two programs being the spatial scale of habitat condition evaluations. The IFRMP is focused on evaluating/scoring differences in (average) habitat condition at a broad sub-watershed (HUC12) scale whereas the SAP evaluates habitat condition at finer scale resolutions (i.e., Scott River mainstem reaches, tributary streams). Restoration actions considered within the SAP mirror those identified within the IFRMP as potential actions for the Scott River sub-basin.

Identified fish species of primary concern within the SAP are represented within the IFRMP's ten focal fish species of concern, which are designated as targets for associated functional watershed restoration actions to be coordinated by the IFRMP. The purpose of the SAP and IFRMP therefore overlap considerably and alignment of these programs will be of benefit for ensuring that the most effective actions (what and where) are undertaken for achieving maximum benefit for upper basin fish populations.

Summary of Unique Plan Elements

- SAP evaluates biological value and habitat condition in the Scott River Basin at a broader range of spatial scales than does the IFRMP (i.e., mainstem reaches, tributary streams vs. sub-watershed)

F8 Salmon River Restoration Plan

Objectives - **The Salmon River Restoration Strategy (SRRS)** was developed by the Salmon River Restoration Council (SRRC) and the Klamath National Forest to collaboratively restore and protect aquatic habitats used by native fish communities in high-priority drainages of the Salmon River watershed. The Salmon River contains some of the most pristine waters in the Lower Klamath (SRRC [online] a). As such, the strategy is heavily protection and prevention-focused, with preventative actions primarily targeting the reduction of upslope hazards that might impact existing high quality aquatic habitats. The SRRS has five overarching goals: 1) assess current watershed conditions and needs, 2) determine the extent of restoration needed to meet target conditions, 3) target high-priority geographic areas to derive the greatest benefit, 4) focus on highest priority restoration needs, and 5) promote education and collaboration. The plan is intended to meet anadromous fish recovery goals through the use of multi-year restoration objectives and priority watershed conditions.

The SRRS provides an objective-oriented restoration action plan, as well as a monitoring plan. The action plan in broken into short-term (three-year) and long-term (ten-year) objectives. Short term objectives include a road sediment source inventory and risk assessment, development of a fuels reduction plan, implementation of high-priority road projects, development of a long-term effectiveness monitoring plan, implement fuel reduction projects, and undertake implementation and effectiveness monitoring. Long-term objectives include review and revision of the strategy and its monitoring plans, completion of road and fuel-related actions in high-priority areas, and assessing whether target conditions have been achieved in all watersheds.

Restoration actions and targeted species - The SRRS initially targets watersheds exhibiting the highest quality aquatic conditions and values. Within these priority watersheds, active restoration is directed to addressing the greatest risks to their physical and biological integrity. Restoration is focused on ensuring habitat conditions support the many fish communities present throughout the Salmon River. These communities include anadromous fish such as spring and fall Chinook salmon, summer and winter steelhead, Coho salmon, Pacific lamprey, and green sturgeon, as well as non-anadromous species such as Klamath speckled dace, Klamath small scale sucker, and marbled sculpins.

Scale of evaluations **-** The SRRS assesses restoration of priority areas within the Salmon River sub-basin at the drainage scale. The sub-basin consists of 63 drainages, averaging approximately 7,500 acres.

Indicators **-** Condition metrics evaluated within the SRRS include:

- Sedimentation from upslope areas (mass wasting, surface erosion, surface water runoff)
- Fire fuel availability
- Channel stability
- Water quality
- Habitat connectivity
- Fish community integrity

Monitoring Focus **-** The SSRS is focused mainly on monitoring stream temperatures and stream flow. Monitoring follows the Klamath Land Resource Management Plan framework, with specific restoration actions guided by the prioritization methods of the SRRS. Implementation and effectiveness monitoring are the two main forms of monitoring taken in the SRRS, with effectiveness monitoring is intended to evaluate whether the restoration actions are meeting the target objectives. Monitoring is driven by three key questions: 1) are environmental and administrative land management standards being met, 2) have planned target conditions been met, and 3) how effective has the SRRS been in reducing habitat degradation and recovery of anadromous fish?

IFRMP alignment ***-*** Both the SRRS and the IFRMP employ prioritization frameworks for identifying target watersheds for restoration actions that integrate information on fish values, habitat condition, and habitat risks (e.g., upslope risks etc.).

Summary of Unique Plan Elements

- The SRRS uses data collected from monitoring stations to prioritise restoration projects in particular drainages through cumulative effects modeling. The modeling considers the level of impairment of the aquatic environment, and the risks associated with fire fuels and upslope impacts (e.g., sediment deposition from roads).

F9 Lower Klamath River Restoration Plan

Objectives **- The Lower Klamath Sub-Basin Restoration Plan (LKRP)** seeks to restore aquatic habitat conditions within Lower Klamath River tributaries to a level that supports viable, self-sustaining populations of native salmonids (YTFP and YTWRP 2000). These goals will be accomplished through treatment of road networks and upslope sediment sources, improvement of instream and riparian habitats, and through interaction with public and private landowners to implement improved long-term land management practices in the sub-basin.

Restoration actions and targeted species **-** The LKRP encompasses upslope watershed restoration actions that relate to the remediation of water diversions and erosional problems that have the potential to deliver sediment to streams (e.g., road and skid trail decommissioning, road upgrades, slope stabilization). The LKRP considers that success of in-stream restoration efforts will be largely dependent upon addressing upslope conditions and sediment sources. Additional instream restoration activities that may also be implemented include migration barrier treatment (impassable culverts, logjams), riparian revegetation, streambank stabilization, and in-channel habitat restoration. The LKRP focuses on restoring habitat conditions for anadromous salmonids using Lower Klamath sub-basin tributaries (i.e., Chinook, Coho, Steelhead, and Coastal Cutthroat Trout).

Scale of evaluations **-** The LKRP assesses habitat condition at the scale of tributary streams (i.e., 30 anadromous fish-bearing tributaries with the Lower Klamath sub-basin). Tributaries are ranked for potential restoration actions using a watershed restoration prioritization matrix that scores streams based on six criteria: 1) Anadromous salmonid diversity, 2) Relative biological importance (e.g. source areas, thermal refugia, off-channel habitat), 3) Channel & riparian condition, 4) Habitat connectivity, 5) Road density, and 6) Stream crossing density. Watersheds in the best biological and physical condition, and that likely have the largest number of erosion sites in need of treatment, are ranked highest. Tributaries that are less biologically diverse and significant, had poorer habitat conditions, and/or had fewer potential upslope treatment sites correspondingly rank lower for restoration activities.

Indicators **-** Habitat condition metrics evaluated within the LKRP include:

- Water quality (water temperature, dissolved oxygen, turbidity)
- Stream discharge
- Stream channel condition
- Riparian condition

Monitoring Focus **-** Monitoring within the LKRP is intended to provide input into Lower Klamath Basin watershed restoration and land management planning by providing long-term baseline data to assess the effectiveness of implemented restoration projects and to monitor any physical and/or biological changes resulting from anthropogenic activities.

IFRMP alignment ***-*** Many of the elements of the LKRP parallel the structure of the IFRMP. For example, assessed biological values and habitat condition metrics evaluated within the LKRP are generally consistent with many of the Core Performance Indicators (CPIs) intended for evaluation and monitoring within the IFRMP, the key difference between the two programs being the spatial scale of habitat condition evaluations. The IFRMP is focused on evaluating/scoring differences in (average) habitat condition at a broad sub-watershed (HUC12) scale whereas the LKRP evaluates/scores habitat condition at a finer scale resolution (i.e., tributary streams). Restoration actions considered within the LKRP mirror those identified within the IFRMP as potential actions for the Lower Klamath River sub-basin.

Three of the four targeted fish species within the LKRP are represented within the IFRMP's ten focal fish species of concern, which are designated as targets for associated functional watershed restoration actions to be coordinated by the IFRMP. The exception is targeting of Coastal Cutthroat Trout within the LKRP, which is not a focal species within the IFRMP. The purpose of the LKRP and IFRMP therefore overlap considerably and alignment of these programs will be of benefit for ensuring that the most effective actions (what and where) are undertaken for achieving maximum benefit for upper basin fish populations.

Summary of Unique Plan Elements

- LKRP evaluates biological value and habitat condition in the lower Klamath Basin at a finer spatial scale than does the IFRMP (i.e., tributary streams vs. sub-watershed)

F10 Trinity River Restoration Plan (TRRP)

NOTE: The TRRP is currently in the process of developing a Program Document and Science Plan. This is a multi-year and multi-partner effort to refine the Program approach building on lessons learned over the previous 20 years of implementation. This summary reflects the author's current understanding of the Program and how it relates to the IFRMP but will need to be updated once the TRRP Refinements process is complete.

Objectives **- The Trinity River Restoration Program (TRRP):**
"The purpose of this Program is to mitigate impacts of the Trinity River Division of the Central Valley Project on anadromous fish populations in the Trinity River by successfully implementing the 2000 Trinity River Record of Decision and achieving Congressionally mandated restoration goals. The long-term goals of the Program are to: 1) restore the form and function of the Trinity River; 2) restore and sustain natural production of anadromous fish populations in the Trinity River to pre-dam levels; and 3) to facilitate full participation by dependent Tribal, commercial, and sport fisheries through enhanced harvest opportunities." – extract from the draft TRRP Program Document, in progress.

Restoration actions and targeted species **-** The TRRP Record of Decision described six components of restoration: (1) flow management out of Lewiston Dam; (2) sediment management, including gravel augmentation to offset losses behind the dams; (3) channel rehabilitation in the mainstem Trinity above the North Fork, through direct manipulation; (4) watershed rehabilitation, to reduce fine sediment inputs and improve connectivity; (5) infrastructure improvements, including bridge retrofits and moving houses in the floodplain; and (6) adaptive management, to monitor the effects of the restoration actions and guide future restoration. Restoration actions are intended to restore fluvial-geomorphic processes, increase habitat for juveniles and adults, increase juvenile salmon production, and ultimately create harvest opportunities for the following species: fall-run Chinook salmon, spring-run Chinook salmon, coho salmon, steelhead, Pacific lamprey, and green sturgeon.

Scale of evaluations **-** TRRP objectives for harvest include the entire Trinity basin, including the South Fork. However, the 40-mile reach between Lewiston Dam and the North Fork are the primary focus for restoration efforts, including flow management, sediment management, and channel rehabilitation. Watershed restoration efforts were initially focused on reduction of fine sediment but have evolved to consider additional opportunities. The TRRP will look to the IFRMP for guidance on the best opportunities to improve fish habitat in the Trinity and South Fork Trinity watersheds.

Indicators **-** There has been extensive monitoring and research activity through the TRRP. Current priorities are being developed through the Refinements process. Synthesis reports have been completed or are underway for the following subjects:

- Tributary delta
- Fish habitat
- Juvenile Chinook Production
- Cohort reconstruction
- Adult salmon spawning
- Bed mobility and scour
- Cottonwood seed dispersal
- Riparian encroachment
- Sediment storage
- Channel complexity
- Fine sediment
- Water temperature
- Large wood management
- Flow synthesis

Monitoring Focus **-** Monitoring efforts are currently under review through the Refinements process. Monitoring to date includes a combination of effectiveness monitoring (e.g., habitat changes at channel rehabilitation sites) and status and trends monitoring to evaluate progress towards goals (e.g., smolt production and spawner abundance).

IFRMP alignment ***-*** The TRRP has focused restoration and monitoring primarily on the mainstem Trinity River between Lewiston dam and the North Fork. Many indicators overlap (e.g., water temperature, sediment transport, large wood, channel complexity, and physical habitat). There is strong alignment between the TRRP and the IFRMP in both directions (a) the TRRP addresses many of the CPIs of interest to the IFRMP in the mainstem Trinity and (b) the IFRMP provides guidance on watershed restoration opportunities in the Trinity and South Fork Trinity as well as monitoring the impacts of poor water quality and disease in the Lower Klamath River which negatively affect the survival of smolts leaving the Trinity basin.

Summary of Unique Plan Elements

- The South Fork Trinity River is California's largest unregulated watershed. The Trinity River hosts two impassible dams, the Lewiston and Trinity Dam. The Trinity River sub-basin is also host to the Trinity River Hatchery near Lewiston dam.
- The TRRP is the result of a Record of Decision by the Department of Interior in 2000.
- TRRP has a greater focus on local project effectiveness monitoring than does the IFRMP (which focuses primarily on broad-scale status and trend monitoring)
- The TRRP is managed by the Trinity Management Council, which includes representatives from: Bureau of Reclamation, U.S. Fish and Wildlife Service, Hoopa Valley Tribe, Yurok Tribe, California Natural Resources Agency, National Marine Fisheries Service, U.S. Forest Service, and Trinity County.

F11 Klamath Reservoir Reach Restoration Prioritization Plan

Objectives – In lieu of the removal of four major Klamath River dams, the **Klamath Reservoir Reach Restoration Prioritization Plan** aims to summarize habitat conditions, identify key limiting stresses and threats, identify restoration actions, identify diversions that need screening/flow restoration, and prioritize those restoration actions in watershed areas between Iron Gate Dam and Link River Dam (the 'Reservoir Reach'). The resulting Plan serves as a road map to restoration for funders, scientists, regulators, restoration practitioners, and other involved parties particularly interested in cold-water refugia, water diversions, and baseline habitat conditions.

Restoration actions and targeted species - This effort resulted in the identification and prioritization of 82 habitat restoration projects, 91 potential diversion screening projects, and 38 potential flow restoration projects. It is anticipated that coho salmon, Chinook salmon, *O. mykiss* (steelhead, rainbow, and redband trout), and lamprey will disperse throughout these tributaries after the dam removal, and threatened Southern Oregon/Northern California Coast (SONCC) coho salmon will come to occupy Spencer Creek within the Reservoir Reach. Though the Plan focuses primarily on salmonids, the actions described will likely also benefit suckers and lamprey.

Scale of evaluations - NOAA assessed habitat conditions, identified limiting factors, and identified restoration actions throughout 63 miles of mainstem habitat and 39.4 miles of tributary habitat from Iron Gate dam to Link River Dam ('Reservoir Reach').

Indicators - The 211 projects identified in this plan address stressors that have degraded habitat conditions for native fish, considering numerous indicators including:

- Fish entrainment
- Flow
- Temperature
- Channel modification
- Fish habitat
- Large woody debris and riparian conditions

Monitoring Focus - There is no monitoring elements described in this plan because they are described in detail in the IFRMP, the California Department of Fish and Wildlife Klamath Monitoring Framework and the Oregon Department of Fish and Wildlife/Klamath Tribes Reintroduction Plan.

IFRMP Alignment - The idea for this Plan was born out of NOAA's early participation in the IFRMP process when it was realized that data and knowledge surrounding habitat and restoration priorities between Iron Gate Dam and Link River Dam were lacking. Restoration projects identified in this Plan align with the following Action Type Categories of the IFRMP: improving instream flow, instream habitat, fish passage and screening, upland habitat and sediment, and restoring riparian habitat.

Summary of Unique Plan Elements

- Neither robust habitat inventory, restoration project identification, nor prioritization effort have been a focus before, due to this section of the Klamath mainstem and tributary habitats being primarily underwater and most of the ESA-listed fish concentrated above and below this reach. This plan identified site-specific restoration actions and assessed habitat conditions in the reservoir reach (O'Keefe et al. 2022).
