Klamath Basin Integrated Fisheries Restoration and Monitoring Plan (IFRMP) Phase 2 (Task 1.2)

Draft Plan

October 15, 2019

Prepared for the Pacific States Marine Fisheries Commission

ESSA

Prepared for:
Pacific States Marine Fisheries Commission

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October 15, 2019

(Previous draft June 12, 2019)

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Sub-regional Working Group members have provided helpful individual input, reviewing and in some instances co-authoring IFRMP sub-products with ESSA. We gratefully acknowledge all contributors for their time and expertise.

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Suggested Citation: ESSA. 2019. Klamath Basin Integrated Fisheries Restoration and Monitoring Plan (IFRMP): Phase 2 Draft. 167 pp.

More information available at: http://kbifrm.psmfc.org/

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Acknowledgements

To be completed in Phase 3.

Executive Summary

To be completed in Phase 3.

1 Introduction

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 also historically one if its most significant producers of salmon and other native fish (Hamilton et al. 2005; NRC 2008; Thorsteinson et al. 2011; NMFS 2015). The Basin has long been the backdrop for a tale of heavy watershed modification (Chaffin et al. 2015) with a variety of interested participants collaboratively seeking a path towards the restoration and lasting resilience of dynamic watershed processes and habitats capable of supporting vibrant fisheries and other ecosystem services (ESSA 2017). The headwaters of the river originate in a low-gradient, arid region featuring extensive farm and ranch lands, wetlands, lakes, and meandering tributaries fed by annual snowmelt and springs. Downstream of Upper Klamath Lake, the Lower Klamath Basin's physical and hydrographic features deviate naturally due to geology and a series of mainstem dams. Although the Lower Basin still supports some agriculture and extensive 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 fishes, and particularly anadromous fishes, as nursery and rearing habitat (Vanderkooi et al. 2011).

While land use is now dominated by forestry and agriculture/rangeland, other key economic drivers include fisheries, hydropower production, 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 hunted and fished in the Klamath Basin since time immemorial. The Basin is home to six federally-recognized tribes: The Klamath Tribes, 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.

1.2 Current Conditions & Limiting Factors

A wide range of historical and ongoing human activities across the Klamath Basin, including agriculture, ranching, logging, legacy mining impacts and operation of several major dams across the river's mainstem have contributed to reduced flows, habitat loss, and increases in nutrient and sediment inputs (NRC 2008; Stanford et al. 2011; USDI et al. 2012; USDI, USDC, NMFS 2013; ESSA 2017). Some of these impacts represent **key stressors**, those stressors which are most strongly constraining the productivity, abundance, distribution and diversity of fish species considered in this plan. A more detailed exploration of key stressors in each sub-region and sub-basin along with potential restoration strategies can be found in Section 3 of this Initial Draft Plan and are also summarized in ESSA (2017).

Figure 1.1. Map of the Klamath River Basin showing major dams, sub-basin, and sub-regional boundaries used throughout this plan. 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.

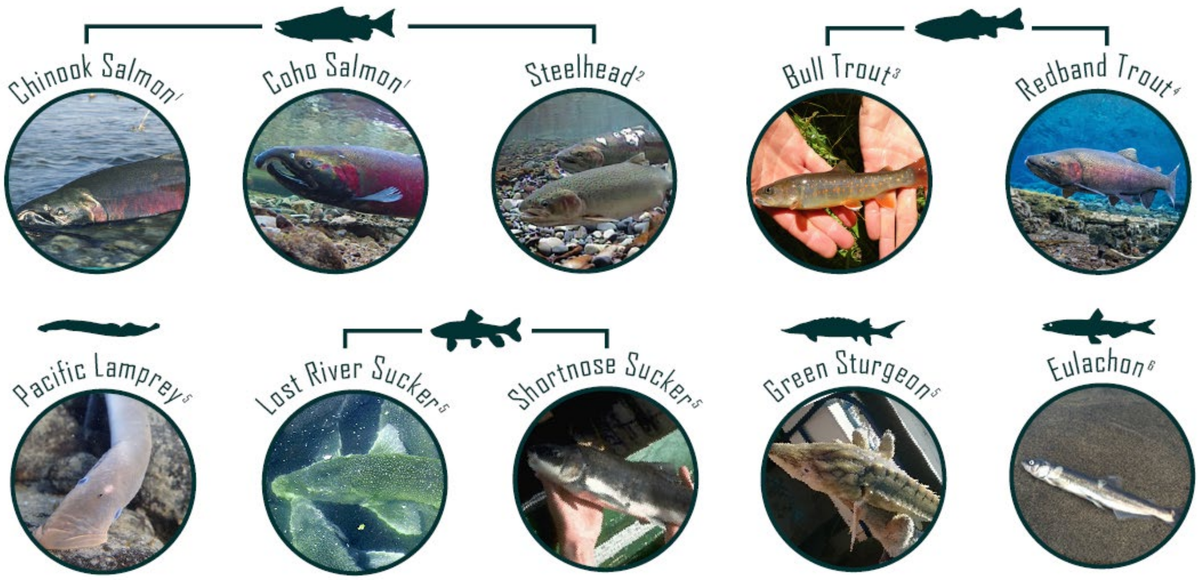


Figure 1.2. IFRMP focal fish species. Photos credited to (1) BLM, (2) Oregon State University, (3) ODFW, (4) Jason Ching, (5) USFWS, (5) Sam Beebe, all images public domain or licensed under CC by 2.0.

These key stressors have significantly impaired underlying watershed functional processes, eroded water quality, and contributed to dramatic declines in the populations of many native fishes (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 medi*rostris), Bull Trout (*Salvelinus confluentus*), Redband Trout (*O. mykiss newberrii*), and the endangered shortnose sucker (*Deltistes luxatus*) and Lost River sucker (*Chasmistes brevirostris*) (Hamilton et al. 2005; NRC 2008; Stanford et al. 2011; USDI et al. 2012; USDI, USDC, NMFS 2013; ESSA 2017).

These losses 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 and economic importance while also sustaining other natural goods and services, for example, supplying water and hydroelectric power for farmers, ranchers, local communities (Chaffin et al. 2015). Numerous local, tribal, state, and federal organizations have responded by spearheading a diverse range of restoration efforts, most recently including a plan to remove four major dams pending a decision by the Federal Energy Regulatory Commission (FERC). Many other regional and watershed restoration and fisheries recovery plans exist or are in development (ESSA 2017).

> "[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."
>
> ~ pg. 343, NRC (2004)

While past efforts have been invaluable, expert reviews have called for a more transparent, science-driven, 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). This need for basin-wide integration and coordination has become increasingly urgent. Endangered Lost River and shortnose 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, either via dam removal or through enhanced fish passage above the hydroelectric project. In addition, there are a suite of additional water quality, water quantity, fish screening, and habitat restoration actions that are needed across the basin (UDSI 2016; ESSA 2017).

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

The **vision** of the Klamath Basin IFRMP is to provide a unifying framework for planning the 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 (or Plan) will serve as a blueprint that describes the highest priority flow, water quality, and ecosystem process ("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 will provide an answer to the basic question: **given all we know; which habitat restoration actions will provide the broadest possible benefits to native Klamath Basin fish species– throughout the Basin and within each sub-basin watershed**. The IFRMP will also help inform the wise allocation of funds for restoration and monitoring work in the Klamath Basin. Funding to do broad scale restoration and monitoring work is limited so it is imperative to ensure that funds are used as strategically as possible to maximize the value of restoration efforts in the Basin.

Prioritization of candidate restoration activities was out of scope for phase 2 of the work (this report) but will be one of the goals in the next phase which is expected to begin in late July 2019 and carry into 2020. Ultimately, a fully funded IFRMP planning process (2020-2021) will include recommendations on **how to sequence and prioritize** potential restoration actions for restoring fish populations and fish habitat, how to design monitoring and evaluation activities to assess the effectiveness of restoration actions, and how to adjust restoration actions based on what is learned through adaptive management. However, it should be noted that projects identified through this planning process process are not binding on federal agencies and do not commit federal funding, or future federal funding, to specific restoration projects.

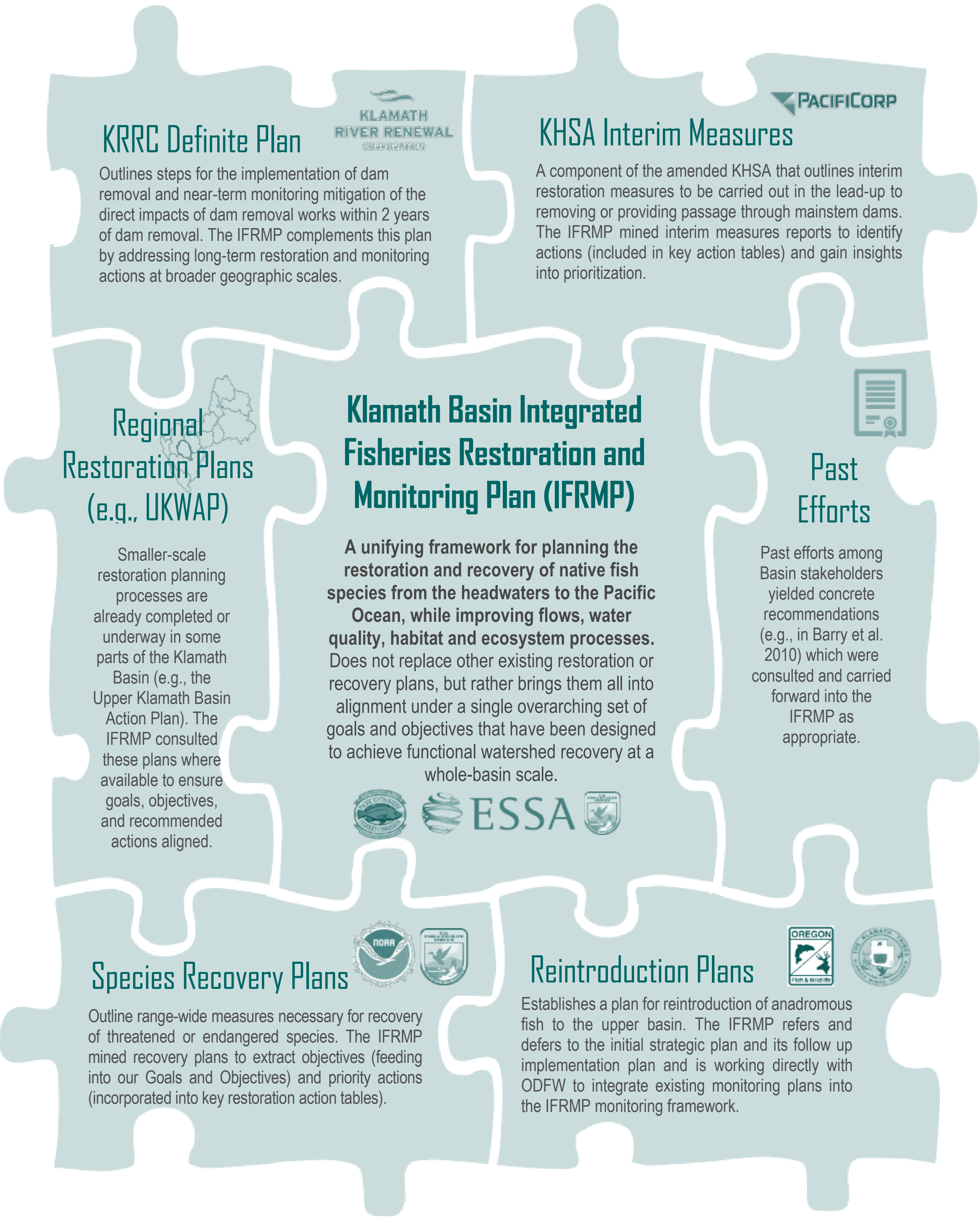
The U.S. Fish and Wildlife Service (USFWS) engaged the Pacific States Marine Fisheries Commission (PSMFC) and ESSA to develop this Draft Integrated Fisheries Restoration and Monitoring Plan (IFRMP or Plan) as a way to more fully inform the conversation about *what it takes to restore Klamath Basin fisheries*? The Service directed PSMFC and ESSA to help find answers to this question by engaging experts and interested stakeholders in a planning process that uses a set of guiding principles consistent with the recommendations of the National Research Council (2004, 2008). These **guiding principles** specify that any integrated restoration plan for the Klamath Basin should seek to:

1. Use a big-picture, integrative, whole-basin approach to restoring ecological processes and fish populations and monitoring.
2. Use the best available science, leveraging (rather than re-inventing) past efforts at synthesis.

3. Use an inclusive, transparent process involving representatives of all interested participants, with peer review.
4. Use an Adaptive Management (AM) framework and best practices to promote learning and adjustment of the Plan through time.
5. Provide strong scientific evidence to guide future decision-making on fish population and ecological processes restoration & monitoring priorities.

The IFRMP is organized around the major sub-basin watersheds of the Basin. For each sub-basin, the IFRMP identifies specific stressors or limiting factors that have a negative impacts on the native fish of the Klamath Basin. The IFRMP seeks to identify actions that could be taken to help alleviate these stressors, and in future phases will provide information on priority monitoring activities. Monitoring is important because it helps restoration practitioners understand whether projects that have been implemented are making a difference.

The intent of the IFRMP is not to replace other existing planning efforts, but to address key gaps and strategically bring existing plans and planning efforts together using an adaptive management framework (see Figures 1.3 and 1.4).



KRRC Definite Plan

Outlines steps for the implementation of dam removal and near-term monitoring mitigation of the direct impacts of dam removal works within 2 years of dam removal. The IFRMP complements this plan by addressing long-term restoration and monitoring actions at broader geographic scales.

KHSA Interim Measures

A component of the amended KHSA that outlines interim restoration measures to be carried out in the lead-up to removing or providing passage through mainstem dams. The IFRMP mined interim measures reports to identify actions (included in key action tables) and gain insights into prioritization.

Regional Restoration Plans (e.g., UKWAP)

Smaller-scale restoration planning processes are already completed or underway in some parts of the Klamath Basin (e.g., the Upper Klamath Basin Action Plan). The IFRMP consulted these plans where available to ensure goals, objectives, and recommended actions aligned.

Klamath Basin Integrated Fisheries Restoration and Monitoring Plan (IFRMP)

A unifying framework for planning the restoration and recovery of native fish species from the headwaters to the Pacific Ocean, while improving flows, water quality, habitat and ecosystem processes. Does not replace other existing restoration or recovery plans, but rather brings them all into alignment under a single overarching set of goals and objectives that have been designed to achieve functional watershed recovery at a whole-basin scale.

Past Efforts

Past efforts among Basin stakeholders yielded concrete recommendations (e.g., in Barry et al. 2010) which were consulted and carried forward into the IFRMP as appropriate.

Species Recovery Plans

Outline range-wide measures necessary for recovery of threatened or endangered species. The IFRMP mined recovery plans to extract objectives (feeding into our Goals and Objectives) and priority actions (incorporated into key restoration action tables).

Reintroduction Plans

Establishes a plan for reintroduction of anadromous fish to the upper basin. The IFRMP refers and defers to the initial strategic plan and its follow up implementation plan and is working directly with ODFW to integrate existing monitoring plans into the IFRMP monitoring framework.

Figure 1.3. A schematic of the interrelationships between the IFRMP and other parallel restoration initiatives.

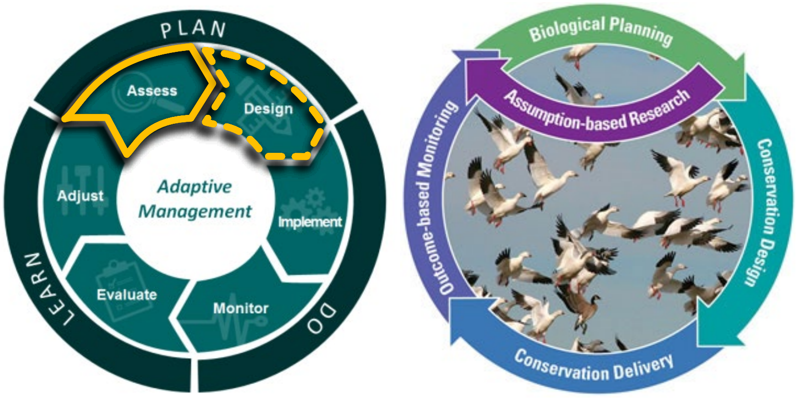


Figure 1.4. Representations of Adaptive Management cycles used by ESSA and USFWS. Orange highlight reflects current IFRMP focus and progress.

IMPORTANT CAVEAT: This is a planning document that can help inform and guide restoration practitioners and agency resource managers alike. However, nothing in this Draft IFRMP constitutes an official federal agency position or obligation for current or future action. Implementation of any restoration activity requires cooperation and support of private landowners, states, Tribes, local governments and other organizations that call the Klamath Basin home.

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

The state of the science in river restoration ecology increasingly calls for more holistic approaches to restoration at the basin scale. Contemporary approaches ***seek to address multiple root causes of ecosystem degradation*** by emphasizing restoration of landscape-scale ecological processes and functions ***rather than the traditional focus on the resulting symptoms*** for individual sites and species (Beechie et al. 2010, Whipple et al. in revision). In practice, process-based restoration urges thinking 'outside the channel' and incorporating more watershed-scale actions that address the hydrogeomorphic and biogeochemical processes which drive channel conditions and, ultimately, habitat suitability (Palmer et al. 2014). This approach recognizes the inherent hierarchical nature of watershed processes, whereby improvements in underlying hydrogeomorphic and biogeochemical processes are expected to yield cascading benefits across more localized channel, habitat, and population processes (Roni and Beechie 2013, Harman et al. 2012). Carefully considering such dependencies during restoration planning helps to ensure the maximum potential benefits of restoration actions are realized. Emphasis on addressing root causes yields intuitive principles for sequencing types of restoration actions, both across and within watershed functional tiers (Figure 2.1) (Roni and Beechie 2013).

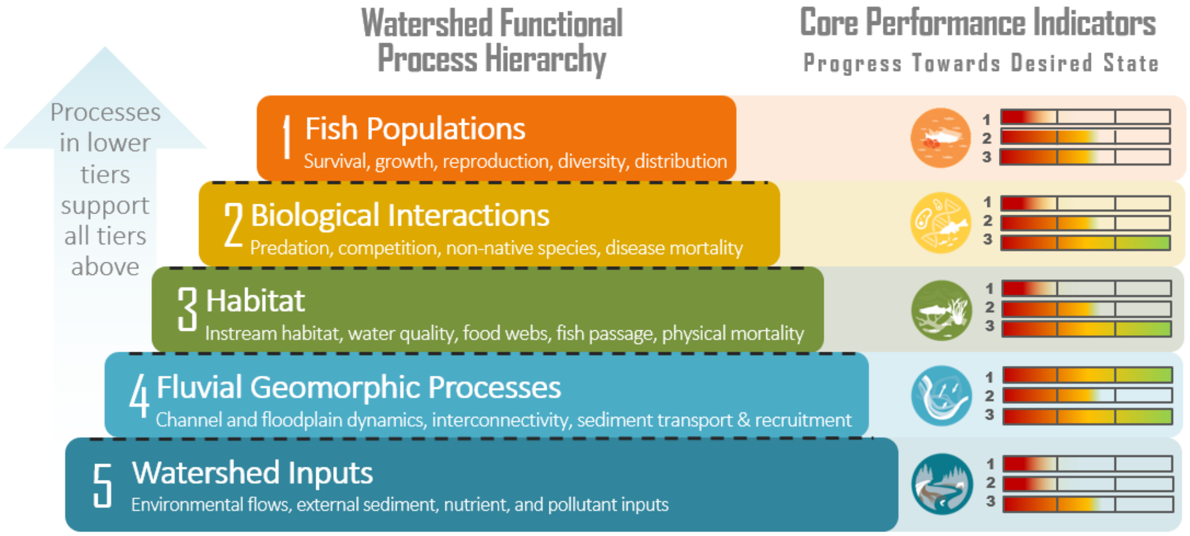


Figure 2.1. Schematic illustrating the concept of bottom-up restoration by tier of watershed processes, where practitioners should focus first on addressing the underlying causes at the base of the hierarchy before carrying out restoration in other tiers that rely on this foundation (after Roni and Beechie 2013, Harman et al. 2012). Progress towards objectives in each tier is measured as the status of selected Core performance Indicators relative to science-driven suitability thresholds (vertical lines, see Section 2.3 for more information).

Perhaps most importantly, process-based restoration encourages consideration of a diverse portfolio of complementary restoration actions that can provide greater cumulative power to achieve restoration goals (Beechie et al. 2010).

This holistic approach requires evaluating suites of candidate restoration actions for complementary benefits and overall potential to contribute to ecosystem-scale recovery (Beechie et al. 2010, Luoma et al. 2015). Section 3 describes a multiple lines of evidence approach to coarse-scale evaluation of cumulative benefit across tiers of watershed processes and types of restoration actions that are considered in this plan. The coarse evaluation provides a starting point for broader conversations among restoration practitioners that will need to consider many other factors including current species conservation needs, socio-economic constraints, and other special circumstances. These factors are considered further in the prioritization framework described in Section 4, which provides a workflow for considering the merit of individual restoration projects within the broader process-based restoration framework.

To determine how well actions are working to restore ecological function, any watershed restoration plan must also have defined goals and objectives as well as 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 represent specific and measurable tasks that must be completed to attain the related goal (Beechie et al. 2008, 2013). The goals and objectives of the IFRMP have been collated from existing plans 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 (Table 2.1). This approach follows best practices for functional restoration planning outlined by the EPA (Harman et al. 2012). Under this scheme, 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.

It is important to understand that natural systems often recover slowly, and that there will be a time lag between the successful restoration of underlying watershed processes and the benefits of these actions at higher levels of organization. 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, this may extend to several decades after the supporting watershed processes are sufficiently restored. For this reason, it would be preferable to track overall progress towards the desired state of the system ***within each watershed tier*** rather than measure success against a small subset of discrete indicators and benchmarks at higher biological tiers.

2.3 Core Performance Indicators

Core Performance Indicators and Thresholds

Objectives and their associated monitoring question(s) are associated with performance indicators that are directly monitored to track and communicate progress from baseline conditions towards the desired state of the process or system in question.

Table 2.1: Klamath IFRMP Goals and Objectives Hierarchy

Whole-Basin Nested Goals	Nested Core Objectives
Fish Populations 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 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 is 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 exotic 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

Although a wide range of candidate 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, those 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 of these CPIs is expected to leverage or proceed alongside other types of monitoring already occurring in the basin. While some monitoring may be limited in space and time to track project implementation and effectiveness, other monitoring will continue across all tiers for ongoing tracking of status and trends and to confirm the recovery achieved is maintained over time. As described in Section 4, we envision Plan implementers will establish and maintain a living Integrated Tracking Inventory & Scoring Tool for tracking CPI status and generating associated scores for iterative prioritization of restoration actions. As with vital signs in medicine, worrisome signals in monitoring of CPIs may indicate the need for further diagnostic investigation through additional monitoring or special studies.

For each indicator, suitability thresholds or benchmarks must be identified to contextualize broad changes in status and the degree of progress towards particular goals and objectives. For example, there may be thresholds for poor, fair, or high habitat suitability for a given species within a given time period and contingent on extenuating events (e.g., high flows, etc.). These thresholds can be used to inform the **phasing** of classes of restoration actions (described further below). For example, where a performance indicator in a given area reaches a favourable status, managers may choose to shift focus onto a different class of restoration action addressing a stressor that is still in poor or fair status.

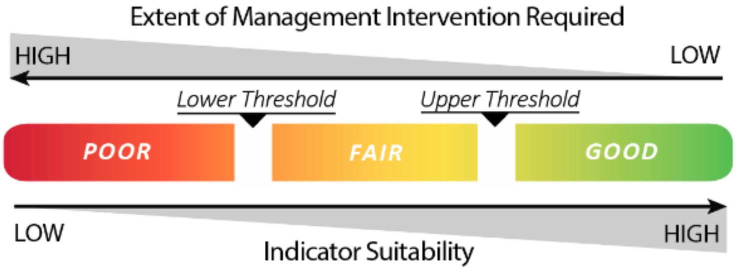


Figure 2.2. Schematic illustrating suitability thresholds and their relationship to management interventions.

Core Performance Indicators Across Spatial Scales

The large size of the Klamath River Basin and its many nested sub-basins, tributaries, and sites warrants special attention to the way the proposed restoration and monitoring framework can be implemented across spatial scales.

Restoration programs in other river systems have approached this issue by designating indicators specific to one or more spatial scales (Steel et al. 2010, del Tánago et al. 2016, Corneil et al. 2018, Kuemmerlen et al. 2019). To reflect this reality, we have organized our CPI framework to more explicitly address four spatial scales – ***site or reach, tributary or lake, sub-basin (including portions of the mainstem), and whole basin***. We then parsed CPIs identified through the planning process to date into their most relevant spatial scale(s) and identified corresponding indicators at other spatial scales to provide CPIs for each major tier of watershed process at each major spatial scale considered in this plan, from sites to watersheds to whole river basins. CPIs can be rolled up to higher scales, so that lower-scale CPIs often inform higher-scale CPIs. However, CPIs measured at broader landscape scales cannot always be rolled down to the site scale. For CPIs that can be used at multiple spatial scales, separate scale-dependent thresholds may be needed.

Providing this range of spatial resolutions will make this Plan more useful for a broader range of restoration practitioners who work at different spatial scales and will also help to facilitate collaboration across scales. Monitoring indicators at a range of special scales can also help to reveal scale-dependent interactions between local and regional habitat quality that may influence restoration outcomes and guide the future distribution of restoration efforts (Pander and Geist 2013). For stream invertebrates, for example, community structure responds differently to changes in fine sediment inputs at different spatial scales (Larsen et al. 2009), while local-scale restoration efforts have been shown to yield the greatest benefits in areas of intermediate regional-scale habitat quality (Stoll et al. 2016). Similar scale-dependent responses to restoration have also been documented for riparian vegetation (Staentzel et al. 2018). Moreover, monitoring at multiple spatial scales could also help to disentangle the benefits of many small restoration projects or of larger versus smaller restoration projects across the landscape (Roni 2019).

Core Performance Indicators of This Plan

Table 2.2 presents the initial draft CPIs proposed for this Plan. These CPIs have been drawn from existing regional restoration plans, the scientific literature, and local practitioners. CPIs are shown alongside each overarching watershed process goal. ***CPIs will be refined further in Phase 3 of work.***

2.4 Restoration and Monitoring Phasing & Sequencing

Beyond tracking and reporting, CPIs and their thresholds can also be used for planning restoration priorities over time. By looking at the status of CPIs relative to thresholds, practitioners can determine when one aspect of watershed function has recovered sufficiently to shift more, but not necessarily all, effort and resources towards the next aspect in need of improvement. For example, if issues with watershed inputs and fluvial geomorphic processes have been sufficiently addressed, 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 on tailwater management to one of restoring wetlands within the Watershed Inputs tier) and moving from emphasis on one functional tier to another as **phasing** (e.g., shifting from a focus on improving water quality in the Watershed Inputs tier to a focus on improving instream flows in the Fluvial Geomorphic Processes tier).

Because this plan identified CPIs for use at multiple spatial scales, phasing and sequencing according to these guidelines can also be considered at a range of spatial scales. Thus, an organization working at the reach scale could use this framework and local-scale CPIs to guide and report on their restoration of a particular tributary, while larger organizations like state and federal agencies could use this framework and landscape-scale CPIs to guide restoration strategy at the sub-basin or basin scale. Although these organizations may be working separately at different scales, using the same framework and CPIs will greatly facilitate data-sharing and reporting across scales and collaborators.

Because of the large scale of the Klamath River Basin and the diversity of restoration needs in its sub-basins, the decision to move from one phase of restoration to the next at any scale ought to be determined through group deliberation based on multiple lines of evidence, rather than strict decision criteria or rules. Beyond CPI status, these discussions may consider action effectiveness, cost-efficiency, feasibility, and special circumstances. How these factors might influence sequencing and phasing is discussed further in Section 4 on prioritization. The associated monitoring framework will also adapt over time. For example, distribution monitoring (e.g., presence/absence) will precede monitoring for abundance or genetic diversity. Effectiveness monitoring will depend on the restoration action sequencing and phasing. The monitoring framework will identify dependencies among activities as well as spatial and temporal sequencing and phasing.

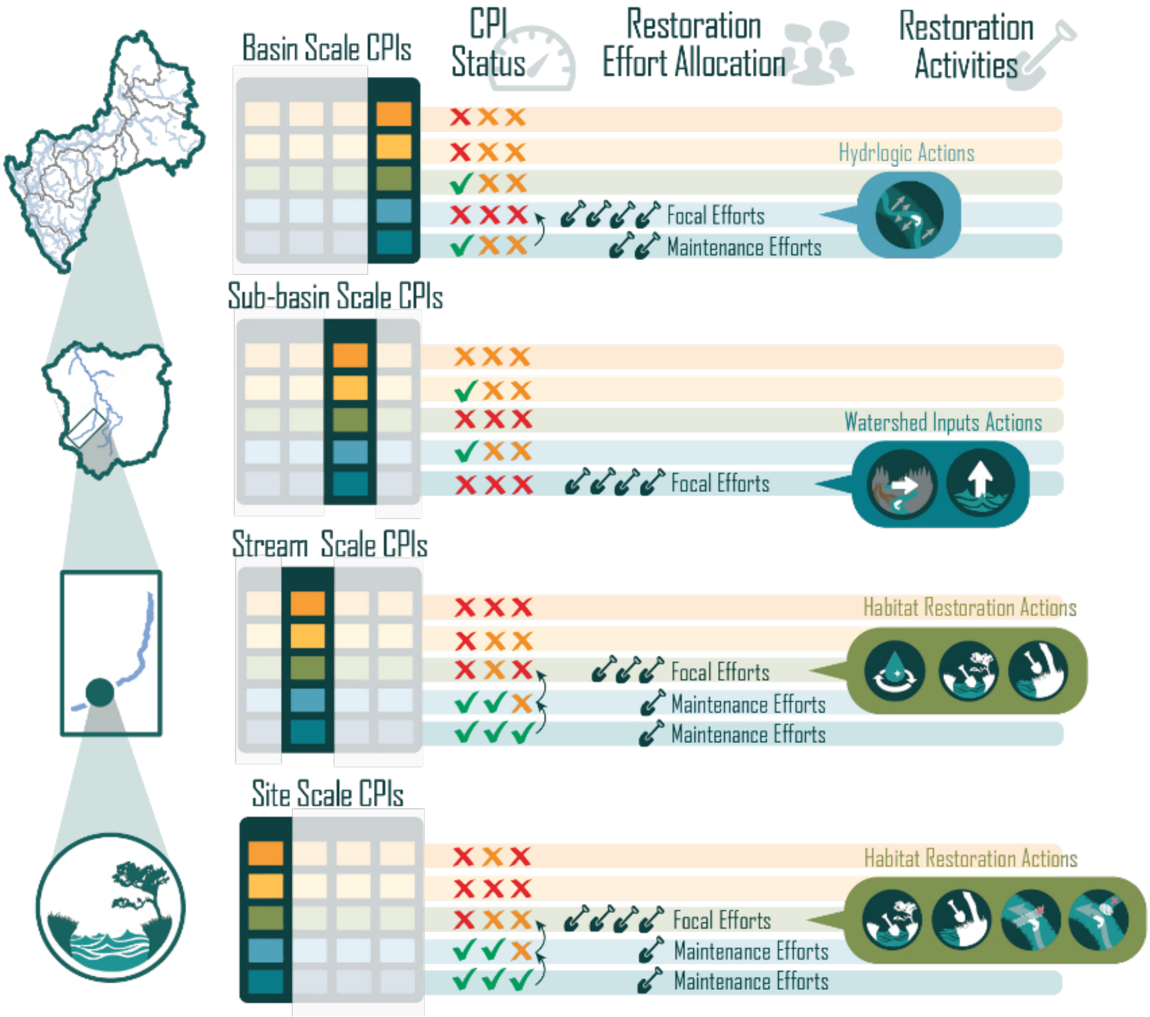


Figure 2.3: Application of the restoration framework across spatial scales, where the status of CPIs within each scale and watershed functional tier inform restoration practitioners' discussions about where to focus restoration effort (i.e., at the first tier with CPIs in poor status) and which restoration activities should take place at the focal tier. The prioritization framework described in Section 4 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.

Table 2.2: IFRMP Core Performance Indicators across goals and spatial scales, with relevant objectives for each indicator listed in [square brackets]. The mainstem is captured at the sub-basin scale for those sub-basins it runs through. Indicators highlighted in yellow are new and added during expansion to these new spatial scales primarily by rolling up existing lower-level indicators. These new initial draft CPIs at higher spatial scales are to be reviewed with SRWGs in Phase 3.

Goal	Site / Reach	Tributary / Lake	Sub-basin*	Whole Basin
Fish Populations *(by species)* 1. Achieve naturally self-sustaining native fish populations.	• Presence / absence [1.3, 1.5] • Presence of spawning [1.2, 1.3] • Abundance [1.3] • Growth • Survival	• Juveniles per adult [1.1] • Abundance [1.3]	• % of historical habitat occupied [1.5] • Age structure and demographics [1.2] • Genetic diversity [1.4]: Integrity, Redundancy, Life History Diversity • Estimated population size [1.3]	• # sub-basins achieving their population targets (for occupancy, abundance, extinction risk, etc.) for species that have sub-basin specific targets [1.3, 1.5] • Total # of fish populations [1.3, 1.5]
Biological Interactions (BI) 3. Reduce biotic interactions that could have negative effects on native fish pops.	• Non-native species presence, abundance [3.2] • Host polychaete *M. speciosa* and *C.shasta* densities	• Prevalence of infection [3.1] • Prevalence of mortality [3.1]	• Total stream miles with high prevalence of infection, mortality [3.1] • Total stream miles with high levels of impact by non-native species [3.2]	• # sub-basins with concerning levels of disease. • # sub-basins with concerning levels of non-native species.
Habitat (H) 4. Improve freshwater habitat access and suitability for fish and the quality and quantity of habitat used by all freshwater life stages	• Core Water Quality Metrics in suitable ranges (*by species*) [4.2] Temperature , Dissolved Oxygen, pH, Total Phosphorous, Total Nitrogen, Nuisance Phytoplankton (density, chlorophyll-a, cyanotoxins)	• Stream Condition Index [4.3] (via SWAMP monitoring program) • Habitat Suitability Rating [4.5] By species based on: Water depth and velocity, pool frequency (depth and area), D_{50} (median particle size), % fines, salinity (estuary), lake level (suckers)	• % historical habitat accessible [4.1] • % of moderate/ high intrinsic Potential (IP) habitat occupied [4.1] • Estimated number of fishes entrained (*by species*) [4.4] • Cumulative size and number of thermal / WQ refugia habitat [4.2, 4.5]	• # sub-basins with desirable habitat suitability (*by species*) [5.1, 5.2, 5.3]
Fluvial Geomorphic Processes (FG) 5. Create and maintain spatially connected and diverse channel and floodplain morphologies	• Bed mobility at selected reaches [5.1] • Large wood recruitment [5.3]	• Geomorphic flushing flows (extent and duration) [5.1] • Area of connected floodplain • Index of channel complexity • % of riparian area disturbed	• Area and duration of inundation at identified key flow thresholds [5.2] *(including floodplain, wetlands, off-channel habitat)* • Total area recently logged	• # sub-basins with desirable morphology [5.1, 5.2, 5.3] • Total stream miles with desirable morphology [5.1, 5.2, 5.3]
Watershed Inputs (WI) 6. Improve water quality, quantity, and ecological flow regimes	• Ratio fine to coarse particulate organic matter (FPOM: CPOM) [6.2]	• # diversions / area OR # cfs dedicated to stream (temporary v. permanent) [6.1] • Monthly flows as % of modelled historical natural flows [6.1] • Annual loads sand or larger grain sizes (magnitude and variability) [5.2] • Annual fine sediment loads	• Implementation rate of agricultural, ranching, and logging best management practices [6.3] • Total stream miles with desirable flow and sediment conditions [6.1, 6.2, 6.3] • Road density	• # Sub-basins with desirable mean flow and sediment conditions [6.1, 6.2, 6.3] • Total stream miles with desirable flow and sediment conditions [6.1, 6.2, 6.3]

3 Initial Draft Candidate Restoration & Monitoring Actions

IMPORTANT CAVEAT:
The sub-basin profiles and the initial lists of candidate restoration and monitoring actions contained in this section represent an early draft. The information is based on previous workshop discussions and cited literature. The candidate restoration actions that are identified herein will be further refined and prioritized in the next phase of work. Further, the addition of approximate cost information for the identified candidate restoration actions will be completed in a later phase.

Nothing in this draft IFRMP constitutes an official federal agency position or obligation for current or future action. Furthermore, nothing in this Draft IFRMP shall be interpreted as or constitute a commitment or requirement that any Federal Agency Party obligate or pay funds. Any action by any Federal Agency Party in implementing the IFRMP is subject to appropriations by Congress.

This Section

- Identifies the types of key candidate restoration actions which address the most objectives, focal fish species, and key stressors for each sub-basin in a given sub-region and provides examples of such actions identified by existing regional plans, studies, and practitioners as having a high benefit.

Making progress towards basin-scale restoration goals requires first identifying the limiting factors or 'key stressors' associated with each objective in each sub-basin and then identifying the restoration actions best able to address them. In this section, we consider multiple lines of evidence on river restoration actions to evaluate their relative potential to address these key stressors and contribute to ecosystem-scale recovery (Beechie et al. 2010, Luoma et al. 2015).

Key stressors on focal fish species or habitats and the actions proposed to alleviate them were initially identified at a sub-regional scale through literature review. This information was then tailored to reflect the most important key stressors in individual sub-basins through consultations and surveys of regional experts as well as additional literature review of sub-basin specific restoration plans and studies.

This exercise serves as a first coarse-scale filter to narrow down the types of restoration actions that should be further considered in detailed restoration planning, and helps to inform finer-scale prioritization of individual restoration projects (see Section 4) to ensure they are contributing towards achieving basin-wide restoration objectives across all focal fish species.

Header Image: Klamath river basin sub-basins. Google Earth.

It is important to keep in mind that the summaries of key sub-basin stressors and actions presented in this section represent an initial overview that will require further supplementation and validation through ongoing collaboration with regional experts.

3.1 Overarching Basin-Wide Restoration Actions

When considering candidate restoration actions across all sub-basins presented in this section, a subset of actions is consistently identified by non-federal stakeholders as having the greatest potential to provide the widest-reaching benefits at a whole-basin scale. Those actions are listed here in approximate order of importance, beginning with those addressing watershed inputs, followed by fluvial geomorphic conditions, and finally fish habitat.

- Improve water quality in each of the Keno Impoundment, Lake Ewauna, and Upper Klamath Lake in the Upper Klamath sub-region so that they do not pose physiological barriers to suckers and unassisted fish passage during critical migratory periods (i.e., strive to meet water quality standards for in-migrating adults and for out-migrating juveniles during their corresponding migratory periods) (Goodman et al. 2011). This would have cascading benefits on water quality in downstream reaches. In practice, this could be accomplished through measures including:
  - Temporary oxygenation and/or seasonal algae harvest during critical migratory periods, if the cost-effectiveness of these methods can be improved (Austin et al. 2016, short-term measure)
  - Reducing nutrient inputs (e.g., via erosion reduction and tailwater return recapture and treatment projects) as well as reclaiming and restoring wetlands and riparian corridors to increase opportunities for nutrient deposition throughout the watersheds (long-term measure).
- Remove the Iron Gate, Copco 1 & 2, and J.C. Boyle dams in the Mid-Upper Klamath sub-region to restore fish passage and historical hydrogeomorphic processes, improve flow regimes, and reduce incidence of disease immediately below dam sites. Fish passage into the Upper Klamath Basin via dam removal is currently proposed by the Klamath River Renewal Corporation and contingent on decision by FERC or via enhanced fish passage.
- Increase instream flows throughout the Klamath Basin via measures addressing both water supply and water demand, e.g.:
  - Improve upland forest conditions using fire and forest management to maximize winter accumulation of snowpack and subsequent release as cool-water runoff to improve base flows (supply-side measure);
  - Decommissioning of abandoned roads, restoration of high-elevation wet meadows, reintroduction of beavers or construction of beaver dam analogues, channel reconfiguration and re-connection of springs, all of which contributes to slowing flows, increasing groundwater recharge, and promoting gradual release of cold-water flows throughout the summer, which can help increase resiliency to future climactic extremes (supply-side measure);

  - Work with private landowners through irrigation conveyance efficiency initiatives, water rights transfers and purchases, or conservation easements to increase flows dedicated to streams and increase the number of streams with active watermasters to ensure these measures are implemented (demand-size measure).

Create and reconnect floodplains, springs, and off-channel habitat to channels to improve habitat connectivity, contribute to groundwater recharge and improved baseflows, and provide access to additional slow-water habitat and cold-water refugia from future climactic extremes, particularly in the Mid-Upper and Lower Klamath Sub-regions.

Improve both upstream and downstream fish passage at remaining Link River and Keno dams in the Upper Klamath sub-region to restore access to the upper basin for all migratory species and maximize potential range expansion permitted by restoring passage through former dam sites. It may also be desirable to improve fish passage at anthropogenic barriers in other parts of the basin, while maintaining or restoring natural barriers which contribute to the habitat partitioning that is important for the persistence of some species (e.g., spring-run Chinook Salmon, Thompson et al. 2019).

Building on the benefits provided by the above actions, carry out habitat restoration projects focused on expanding the area of suitable spawning and rearing habitat for focal fish species throughout the Klamath Basin.

3.2 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 aquifers 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 important **stressors** in this sub-region (Table 3.1). In a system already sensitive to evaporation, drainage of large wetland areas, straightening and diking of natural waterways, and the establishment of irrigation diversions over the last several decades have contributed to disconnection of stream channels from their floodplains, reduced flow inundation events, increased fish passage or entrainment hazards, and loss of fish habitat. At the same time, some livestock grazing practices have contributed to increased erosion of nutrient-rich sediments as well as the loss of riparian vegetation that 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 eutrophication owing to high background loadings of phosphorus from volcanic sediments. Within the lake itself, the resulting hypereutrophic conditions contribute to toxic algal blooms resulting in elevated pH and low dissolved oxygen conditions that are detrimental to fish health and may prevent successful migration, spawning, and rearing in affected waterways (Adams et al. 2011, Stanford et al. 2011).

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, by Natascia Tamburello © 2017.

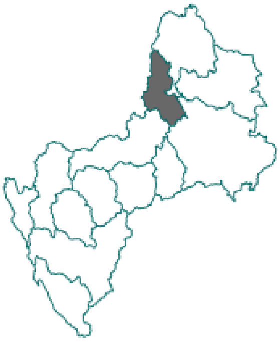
Table 3.1: Synthesis of hypothesized stressors (X) and key stressors (yellow highlighted) affecting focal fish species/functional groups across the Upper Klamath Basin sub-region (as identified through IFRMP Synthesis Report and technical group conceptual modeling exercises).

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::::::

IMPORTANT CAVEAT: The sub-basin profiles and the initial lists of candidate restoration and monitoring actions contained in this section represent an early draft. The information is based on previous workshop discussions and cited literature. The candidate restoration actions that are identified herein will be further refined and prioritized in the next phase of work.

3.2.1 Upper Klamath Lake Sub-basin



This 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, and Upper Klamath National Wildlife Refuge.

A. Key Species

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

B. Key Stressors

Table 3.2: 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].	●	○	○	○	○
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].	○	●	●	●	○
Instream Flow *(T)*	WI, FG	Stream flow restoration priorities include waterways immediately surrounding UKL and Agency Lake[2], particularly tributaries north of UKL which may experience 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 and Fourmile Creek[1,3]. Furthermore, substantial numbers of suckers are entrained into the East Side and West Side hydroelectric canals at Link River 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].	●	●	○	●	●

Key Stressors	Tier	Stressor Summary for the Upper Klamath Lake Sub-basin	Species				
			SU	RT	BT	*CS*	*PL*
Anthropogenic barriers *(T)*	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 limited by fish passage barriers include Link River, Threemile Creek, Fourmile Creek, and Annie Creek, among others[5]. In Upper Klamath Lake, relates to the effect of lake levels on maintaining 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

C. Key Restoration & Monitoring Actions:

Table 3.3: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups across the Upper Klamath Lake sub-basin in rough order of importance, with more important actions that address underlying watershed processes listed first.

KS	No.	Identified Restoration Actions to Reduce Stressors
Water Quality - Hypereutrophication (related to dissolved oxygen, pH) *(L)*	1	**Action:** 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). Closely related to Action 5 (riparian planting and fencing) and usually implemented together. **Monitoring:** Key CPIs are all water quality metrics, including DO, pH, and phosphorous. Improvements to water quality in the Wood River can be monitored by a dedicated USGS sampling site at the outflow of the Wood River into UKL, where water quality data on DO, pH, and other water quality parameters is periodically collected.
	2	**Action:** 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). **Monitoring:** Number and percent change in kms and acres converted from flood and furrow irrigation into drip, sprinkler, or gated pipe irrigation across Upper Klamath Lake sub-basin with a focus on fields with the greatest return flows and/or highest nutrient/sediment/thermal loading; individual farm return flow gages; agency stream gages for monitoring of discharge and seasonal grab samples for phosphorus and sediment loads.
	3	**Action:** 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). **Monitoring:** Monitoring of key water quality parameters in UKL (e.g., P, TSS, etc.); monitoring of sucker habitat conditions as well as sucker occupancy and abundance in restored wetlands.

KS	No.	Identified Restoration Actions to Reduce Stressors
	4	**Action:** 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). **Monitoring:** Monitoring of nutrient and sediment loads in inflow and outflow of individual DSTWs to understand efficacy; stream gages for flow and outlet pipe monitoring of nutrient and sediment loads downstream of DSTW clusters (including in UKL and Link River) both within and outside of the tailwater season to understand annual variation in loading; inventory of numbers/ha of DSTWs across Upper Klamath Lake sub-basin.
	5	**Action:** Manage and restore riparian corridors to re-establish canopy, shade, and instream habitat through planting and fencing 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 through cooperative agreements, conservation easements or land acquisition for wetland and stream habitat as needed. Closely related to Action 1 (grazing management) and usually implemented together. **Monitoring:** Agency stream gages for monitoring of phosphorus and sediment loads in tributaries flowing into Upper Klamath Lake; ODFW assessments of fish habitat condition in tributary streams; relevant Forest Service and Bureau of Land Management Aquatic and Riparian Effectiveness Monitoring Program (AREMP) stream habitat condition monitoring in the Upper Klamath Lake sub-basin (see Miller et al. 2017).
	6	**Action:** 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). **Monitoring:** Agency stream gages and USGS/OWRD groundwater monitoring wells at Wood River and Pelican Bay for monitoring of water quality; sucker PIT-tagging/tracking to evaluate seasonal use of and abundance within restored spring-fed stream refugia.
Instream Flow (*T*)	7	**Action:** Implement improvements in summertime stream flows through increased water use efficiency, transfer of water rights to instream uses, and other voluntary actions, particularly in the Wood River (Annie Creek and Crooked Creek), and Fourmile Lake reaches (IRCT 2016). **Monitoring:** Improvements to overall flows in this sub-basin can be monitored at the sub-basin scale via the dedicated USGS stream flow gage at the outflow of the Wood River into UKL. However, the current water monitoring program for this sub-basin is considered to be lacking the level of resolution necessary to detect water quality and quantity improvements from small-scaled restoration actions (e.g., water rights purchases and irrigation conveyance efficiency work) and greater capacity will be needed to adequately monitor effects form these actions.
	8	**Action:** Strategic restoration to stage 0 through hydrologic reconnection, re-meandering, and beaver management 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). **Monitoring:** Monitor groundwater recharge and changes in hydraulic residence time via USGS/OWRD groundwater wells where available across restored streams (e.g. Annie Creek, Fourmile Creek, Seven Mile Creek); ODFW assessments of fish habitat condition in restored streams.

K S	No.	Identified Restoration Actions to Reduce Stressors
Fish Entrainment (*T*)	9	**Action:** 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 entrainment of suckers and possibly Redband Trout into the East Side and West Side hydroelectric canals at Link River Dam should also be further explored (USFWS 2012). **Monitoring:** In the Upper Basin, diversion screening is monitored by the ODFW's Fish Screening Program which includes periodic inventories to prioritize unscreened diversions (last done in 2013) and field inspections of installed screens to determine need for maintenance or replacement. As the number of screens to be inspected increases while staffing and budgets are already fully committed, capacity for frequent inspections will continue to be an ongoing challenge without additional funding.
Habitat Complexity (*T*)	10	**Action:** Improve habitat quantity and quality of shoreline springs in Upper Klamath Lake for lake-spawning suckers through reasonable gravel substrate improvement and expansion and ensure access during periods of poor water quality (July to September) by managing lake levels to ensure spring connectivity (USFWS 2012). Additional habitat improvements for suckers via wetland restoration already captured above. **Monitoring:** Sucker PIT-tagging/tracking to evaluate sucker spawning use of improved lake shorelines; assessments of condition of sucker habitat (including water quality) in improved lake shoreline areas. Associated research should be undertaken to better evaluate the impact of UKL fluctuations as they relate to sucker spawning and rearing.
	11	**Action:** Improve spawning and rearing habitat in tributaries through addition of large wood and spawning gravels in 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). **Monitoring:** ODFW/NOAA Fisheries assessments of habitat condition for salmonids in Wood River and tributaries. Additional studies may be needed to inventory spawning areas and substrate suitability in order to plan implementation of this action.
Anthropogenic Barriers (*T*)	12	**Action:** Improve the efficacy of the Link River Dam fish ladder to improve upstream and downstream passage for migrating fish, including all migratory life stages of suckers, Pacific Lamprey, and salmonids (Goodman et al. 2015, USFWS 2012). **Monitoring:** USBR/PacifiCorp monitoring of fish passage at the Link River dam fish ladder.
	13	**Action:** 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. **Monitoring:** ODFW/ODOT fish passage barrier inventories for assessing fish passage issues in Upper Klamath Lake sub-basin, fish species affected, and extent and quality of fish habitat accessible at each site if passage issues are mitigated.

D. 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 inhabiting this sub-basin, ***Shortnose Sucker and Lost River Sucker*** are of the greatest immediate conservation concern, with captive rearing programs being carried out to counter ongoing 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 historically occupied this sub-basin and are expected to recolonize 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 including maintaining or enhancing wetland habitats through reconnection of lakeside wetlands, restoring natural connections and hydrology to the Williamson River Delta, and restoring riparian habitat to increase habitat complexity (ODFW 2016).

The following table summarizes selected major restoration activities in this sub-basin and the species which these activities have benefited. Despite the completion of these restoration actions, it should be noted that not all restored habitats have yet regained full ecological function, and that some of these activities have occurred at smaller scales that have yielded local benefits but are not yet sufficient to detect improvements in water quality conditions at the sub-basin scale.

Table 3.4: 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 improving spawning conditions for suckers at lakeside springs and in tributaries (through addition of gravels). These actions have also benefited other species using these habitats.	●	○	○	○	○
Water management (including improved irrigation conveyance efficiency, tailwater capture & treatment) and grazing management 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 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 implemented through a variety of partnerships between The Klamath Tribes, the USGS, the USFWS, the ODFW, Oregon State University (OSU), Trout Unlimited (TU), and private landowners.

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

Since 1995, the USGS has also implemented a long-term capture-recapture program to assess the status and dynamics of Lost River and Shortnose suckers. This program is ongoing and feeds into what is likely 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 (Hewitt et al. 2014, 2018; Banet and Hewitt 2019). Beginning in 2005, individuals that had been previously PIT-tagged are also re-encountered on remote underwater antennas deployed throughout sucker spawning areas. Captures and remote encounters are used to describe the sucker spawning migrations in that year and are incorporated into capture-recapture analyses of population dynamics. 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 this institution continues to contribute to our understanding of fish in this sub-basin through research by Dr. Jonny Armstrong on the movement ecology of adfluvial Redband Trout and their use of cold-water springs.

The USFW 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 USBR has undertaken monitoring of juvenile and adult suckers in Upper Klamath Lake and Lake Ewauna for nearly two decades. 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 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). The majority 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.

Trout Unlimited (TU) undertakes monitoring in the Upper Klamath Lake sub-basin to help guide future restoration actions. TU collects information on stream temperatures and flows, water quality metrics, 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 3.1 provides a high-level, general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken across agencies in the Upper Klamath Lake sub-basin. Location-specific agency metadata (where available[1]) on monitoring projects has been incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. Further investigation will be required to confirm the utility of the current available data to help answer key monitoring questions for the sub-basin (i.e., species relevance, spatial and temporal extent, data quality) and isolate any existing monitoring gaps. In general, there exist 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 is generally tracked as part of funder reporting requirements (although this data is not always readily available). However, monitoring effectiveness for improving conditions at broader basin scales is difficult given that most monitoring programs in the region are geared towards long-term monitoring of status and trends at larger spatial scales and do not provide sufficient resolution for assessing the effects of individual projects.

As indicated by KBMP’s 2015 basin inventory of monitoring stations, a high concentration of groundwater and water quality monitoring sites occurs within the Upper Klamath Lake sub-basin, particularly where water withdrawals for irrigation and impacts from agriculture are common. However, occasional equipment failures and spatial gaps between monitoring stations suggest room for improvement, particularly to help achieve the spatial resolution of monitoring necessary to better 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.

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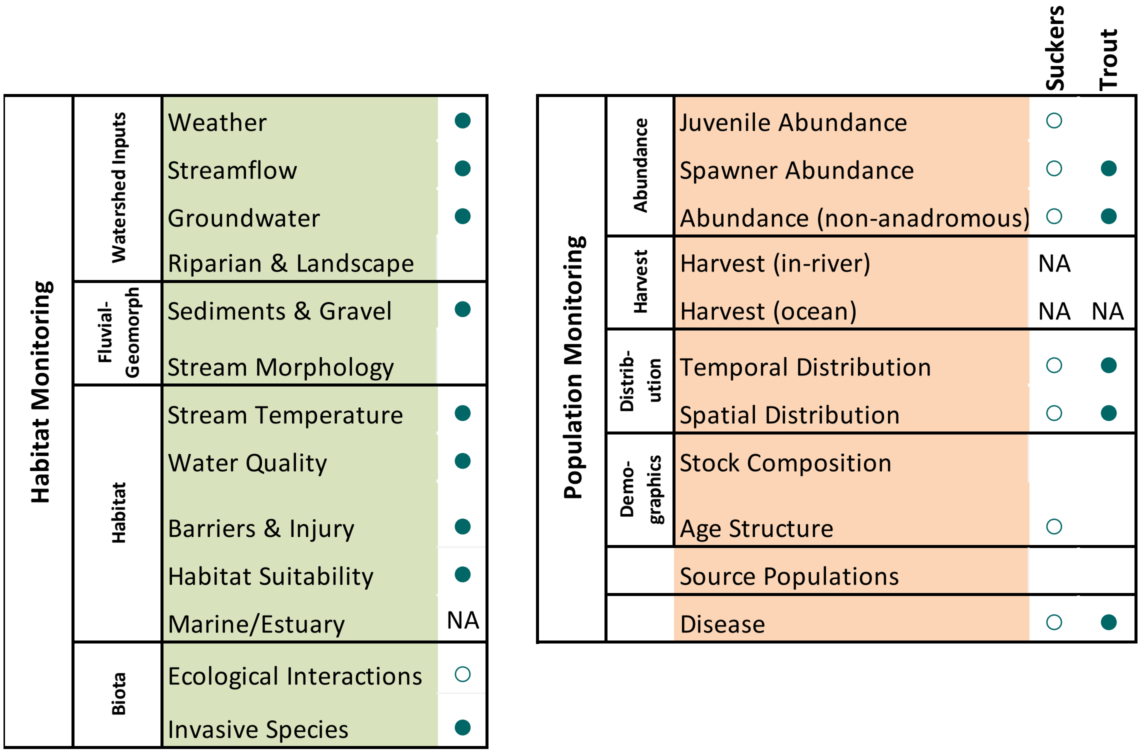
[1] Note that only some available information on past monitoring activities across sub-basins provides specific location information within spatially referenced databases that would allow for reliable transfer to the project’s Integrated Tracking Inventory.

Upper Klamath Lake Sub-basin Interim Monitoring Summary



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

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

●	Ongoing monitoring
○	Past monitoring, unknown if ongoing
NA	Monitoring not relevant to this sub-basin

Figure 3.1. 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 Management Plans

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017 Ch 2.4, Appendix K):

- 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 Fishes into the Oregon portion of the Upper Klamath Basin (in progress) 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.
- 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)
- 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

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 Upper Klamath Basin Watershed Action Plan (UKB WAP) 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).

2. The Reintroduction Implementation Plan of Anadromous Fishes 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 fishes recolonizing this area following restoration of fish passage, and are likely to provide overlapping benefits to resident fish.

Upper Klamath Lake Sub-basin

Sub-Basin Summary

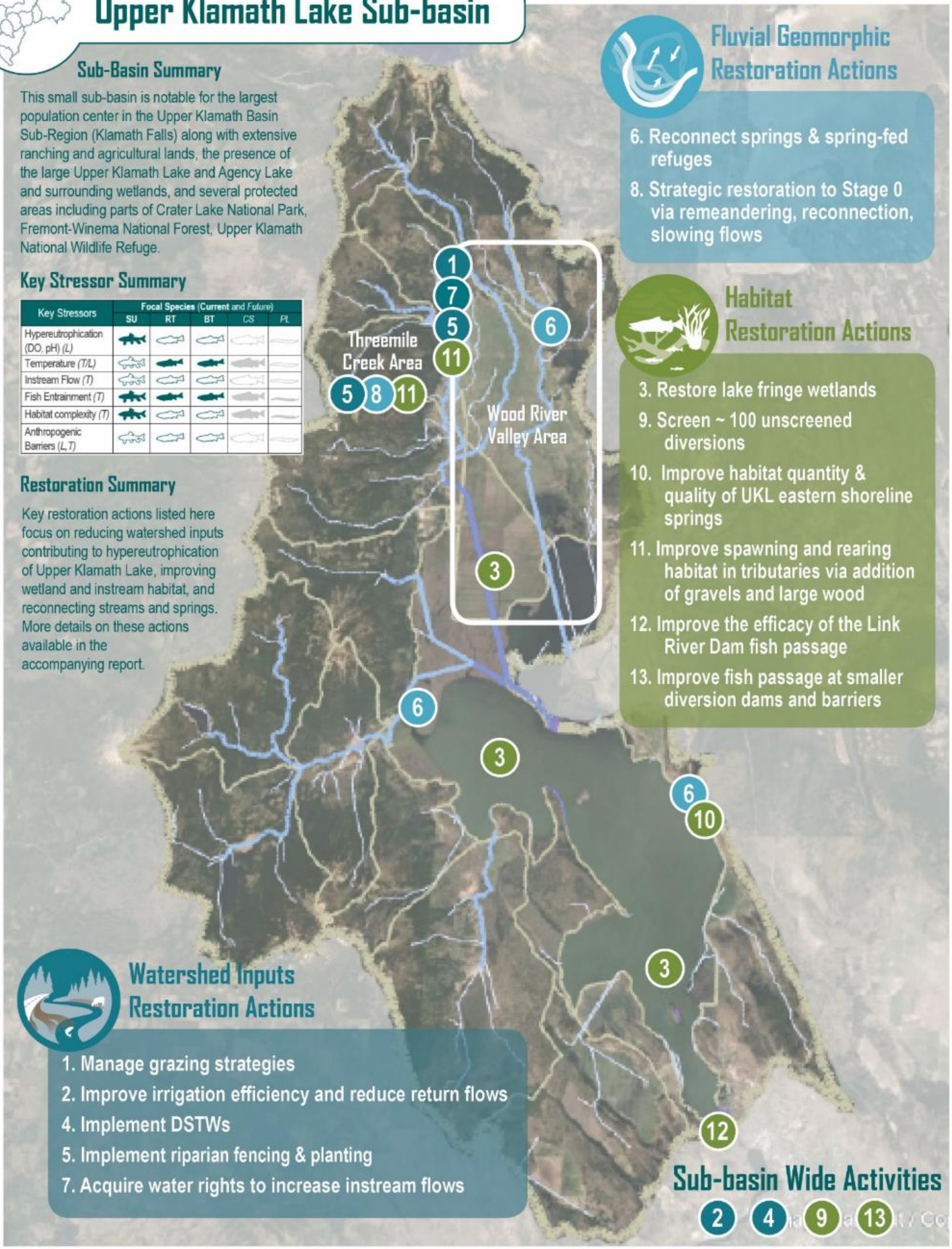
This small sub-basin is notable for the largest population center in the Upper Klamath Basin Sub-Region (Klamath Falls) along with extensive ranching and agricultural lands, the presence of the large Upper Klamath Lake and Agency Lake and surrounding wetlands, and several protected areas including parts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

Key Stressor Summary

Key Stressors	Focal Species (Current and *Future*)				
	SU	RT	BT	*CS*	*PL*
Hypereutrophication (DO, pH) *(L)*	●	○	○	○	○
Temperature *(T/L)*	○	●	●	●	○
Instream Flow *(T)*	○	○	○	○	○
Fish Entrainment *(T)*	●	●	●	●	●
Habitat complexity *(T)*	●	○	○	●	●
Anthropogenic Barriers *(L, T)*	○	○	○	○	○

Restoration Summary

Key restoration actions listed here focus on reducing watershed inputs contributing to hypereutrophication of Upper Klamath Lake, improving wetland and instream habitat, and reconnecting streams and springs. More details on these actions available in the accompanying report.



Fluvial Geomorphic Restoration Actions

6. Reconnect springs & spring-fed refuges
8. Strategic restoration to Stage 0 via remeandering, reconnection, slowing flows

Habitat Restoration Actions

3. Restore lake fringe wetlands
9. Screen ~ 100 unscreened diversions
10. Improve habitat quantity & quality of UKL eastern shoreline springs
11. Improve spawning and rearing habitat in tributaries via addition of gravels and large wood
12. Improve the efficacy of the Link River Dam fish passage
13. Improve fish passage at smaller diversion dams and barriers

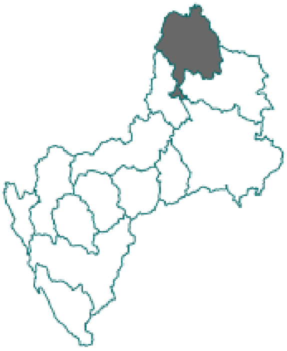
Watershed Inputs Restoration Actions

1. Manage grazing strategies
2. Improve irrigation efficiency and reduce return flows
4. Implement DSTWs
5. Implement riparian fencing & planting
7. Acquire water rights to increase instream flows

Sub-basin Wide Activities

2 4 9 13

3.2.2 Williamson Sub-Basin



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.

A. Key Species

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

B. Key Stressors

Table 3.5: 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].	●	○	○	○
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 fishes 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.	○	●	●	○

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

C. Key Restoration Actions

IMPORTANT CAVEAT: Restoration actions identified below do not constitute an official federal agency position or obligation for current or future action, or funding.

Table 3.6: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups across the Williamson sub-basin in rough order of importance, with more important actions addressing underlying watershed processes listed first.

KS	No.	Identified Restoration Actions to Reduce Stressors
Instream Flow	1	**Action:** Implement improvements in summertime stream flows through increased water use efficiency, transfer of water rights to instream uses, and other voluntary actions to help meet instream flows in the portion of the Williamson River downstream of Klamath Marsh (Evan & Associates 2005). **Monitoring:** Improvements to overall flows in this sub-basin can be monitored at the sub-basin scale via two dedicated USGS stream flow gages : (1) within and surrounding the Upper Klamath Marsh NWR and (2) on the Lower Williamson River flowing into UKL. More localized monitoring to determine the benefits of individual water rights purchases would need to be made through other means.
	2	**Action:** 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. **Monitoring:** OWRD gage on Williamson River for monitoring of seasonal stream flow; relevant AREMP riparian condition ratings within the Williamson sub-basin.
	3	**Action:** Strategic restoration to stage 0 through beaver management 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). Related to Action #7 in this section **Monitoring:** Improvements to the water table in the Upper Williamson River region from restoration of slowing flows could be monitored with USGS groundwater gages near Jack Creek and near the mainstem Williamson River above the Klamath Marsh NWR.
Fine Sediment	4	**Action:** USDA Forest Service to 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). **Monitoring:** Agency gage in Upper Williamson River for monitoring of sediment loads (not currently in place); USGS/ODFW assessments of condition of fish habitat in the upper Williamson River;
Hydrology	5	**Action:** 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)[1,2]. **Monitoring:** Water table levels in the upper part of the Williamson River sub-basin can be monitored though USGS groundwater wells located near Jack Creek, Sheep Creek, and the mainstem Williamson River above the

KS	No.	Identified Restoration Actions to Reduce Stressors
		Klamath Marsh NWR, and in the lower part of the sub-basin through USGS and OWRD groundwater wells near Larkin Creek; new agency surface water gages required for monitoring of flow and water temperature in key creeks with critical species habitat; USGS/ODFW/ NOAA Fisheries assessments of fish habitat condition in key streams.
	6	**Action:** 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). **Monitoring:** Monitoring for this work is anticipated to include ground and surface water hydrology and native fish and wildlife surveys, including surveys of recolonization by ESA-listed Oregon Spotted Frog by the USGS.
Habitat Complexity (mesohabitats)	7	**Action:** 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), 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 may be carried out alongside grazing management strategies and off-channel watering projects to protect investment in riparian restoration. Beyond providing habitat, these actions should also help to reduce sediment inputs and improve water quality. **Monitoring:** USGS/ODFW assessments of condition of fish habitat in restored streams; new agency surface water gages as required for monitoring of flow, WQ and sediment loads in restored streams
	8	**Action:** Add large wood and spawning gravels to the Upper Williamson River on USDA Forest Service land and private lands to improve habitat conditions and complexity primarily for Redband Trout (Barry 2010, IRCT 2016). **Monitoring:** ODFW/ NOAA Fisheries assessments of fish habitat condition for salmonids in Upper Williamson.
	9	**Action:** 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. **Monitoring:** Assessments of landscape conditions in the Williamson sub-basin by the Nature Conservancy.
Access to Habitats	10	**Action:** 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). **Monitoring:** ODFW/ NOAA Fisheries assessments of fish habitat condition in reconnected Williamson River tributaries; (e.g. Hog Creek, Yoss Creek, Jackson Creek); new agency stream gages as needed for monitoring of flow, temperature, WQ in reconnected tributaries.

(1) CDFW BIOS Map of USFWS Species Critical Habitats, (2) National Park Service UKL Bull Trout Range Map

D. 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, with distributions focused on rearing areas in the Williamson River Delta recently returned to wetlands as well as spawning areas in the lower reaches of the Williamson River up to its confluence with the Sprague River (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 once had a much larger historical 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 recolonize this sub-basin following restoration of fish passage from 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 including maintaining or enhancing connectivity, flow and hydrological function, riparian habitat, and wetland habitat (ODFW 2016). The following table summarizes select major restoration activities in this sub-basin to date and those species which they have benefited.

Table 3.7: 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 implemented through 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 include assessing the 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 to directly benefit sucker populations. An associated long-term sucker population monitoring program was established in 2006 to assess changes in the distribution, condition, abundance, and habitat use of endangered larval suckers. Following intentional levee breaches, TNC began monitoring water quality and vegetation across the re-inundated portion of the Williamson River Delta Preserve, with vegetation monitoring that involved cataloguing changes in wetland diversity over time. TNC has monitored the effectiveness of these re-vegetation efforts in the delta annually since 2010. Trout Unlimited, The Klamath Tribes, the USFWS, and ODFW conduct a large number of restoration projects in the upper Klamath Basin directed toward Indigenous fishes, including Lost river Sucker, Shortnose Sucker, Redband Trout and Bull Trout. Associated monitoring focuses on assessing occupancy/distribution and abundance as well as 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.

Major Data Gaps:

Figure 3.2 provides a high-level, general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken across agencies in the Williamson sub-basin. Location-specific agency metadata (where available2) on monitoring projects has been incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. Further investigation will be required to confirm the utility of the current data available to help answer key monitoring questions for the sub-basin (i.e., species relevance, spatial and temporal extent, data quality) and to isolate any existing monitoring gaps. While population monitoring of key focal species in the Williamson sub-basin appears well supported, as is habitat monitoring in the lower delta of the Williamson River, KBMP's 2015 inventory of habitat-related monitoring across the Klamath Basin indicates that the Williamson sub-basin has only a limited number of stations currently in place for long term monitoring of weather, surface water flow, 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.

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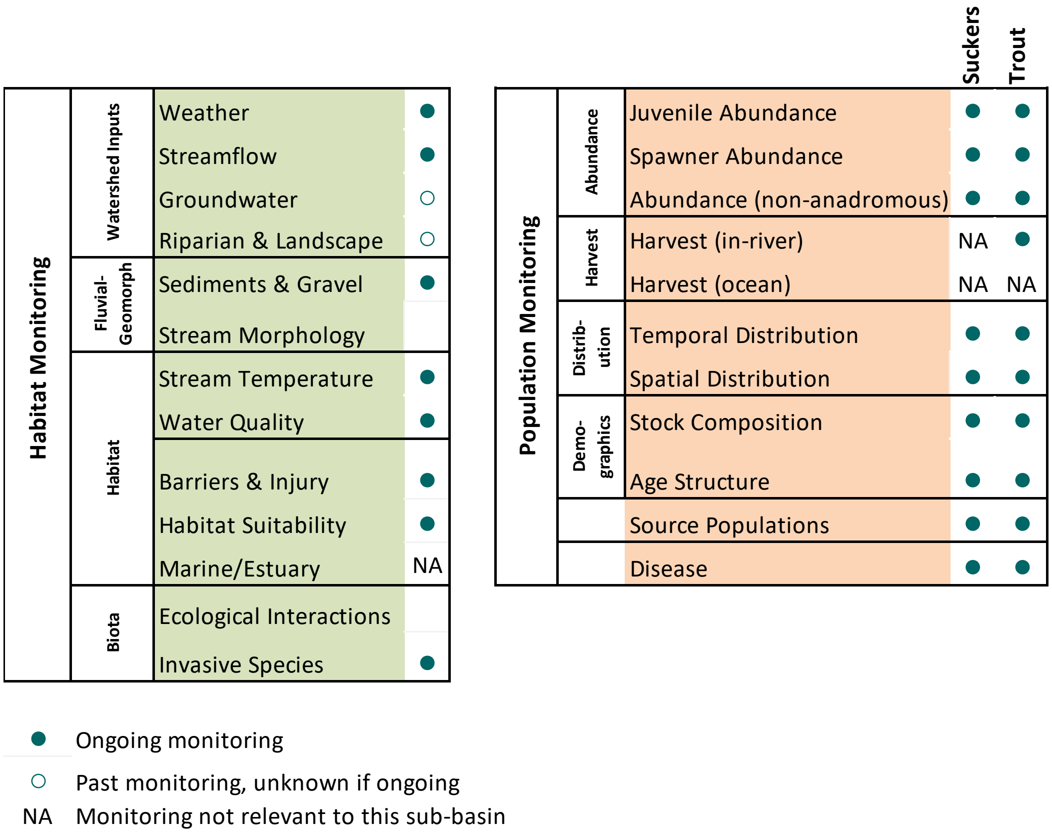
[2] Note that only some available information on past monitoring activities across sub-basins provides specific location information (i.e. beyond indicating that it occurs somewhere within a sub-basin) and can be found in existing spatially-referenced databases that would allow for reliable transfer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



Williamson Sub-basin Interim Monitoring Summary

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

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

●	Ongoing monitoring
○	Past monitoring, unknown if ongoing
NA	Monitoring not relevant to this sub-basin

Figure 3.2. 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 Management Plans

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017 Ch 2.4, Appendix K):

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- 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 Fishes into the Oregon portion of the Upper Klamath Basin (in progress) 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)
- 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

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 Upper Klamath Basin Watershed Action Plan (UKB WAP) 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).
2. The Reintroduction Implementation Plan of Anadromous Fishes 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 fishes recolonizing this area following restoration of fish passage and will likely provide overlapping benefits to resident fishes.
3. 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.

Williamson River 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 O2, 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.

Key Stressor Summary

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

Restoration Summary

Key restoration actions listed here focus on restoring instream flow, upland vegetation management to improve water storage and reduce encroachment in meadows, grazing management and riparian restoration to reduce sediment inputs, and reconnection and restoration of tributary spawning and rearing habitats. More details on these actions are available in the accompanying report.

Watershed Inputs Restoration Actions

1. Improve irrigation efficiency & acquire water rights to increase instream flow
2. Thin upland vegetation to improve snowpack accumulation and storage for slow release
4. Manage grazing strategies to reduce bank erosion & sediment inputs

Sub-basin Wide Activities

2 4 7 9

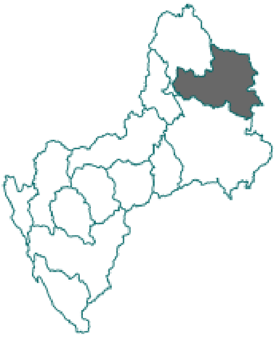
Fluvial Geomorphic Restoration Actions

3. Strategic restoration to Stage 0 via remeandering, reconnection, slowing flows using beavers or beaver dam analogues
5. Reconnect springs & spring-fed refuges
6. Restoration of Williamson River hydrology within Klamath Marsh NWR
10. Reconnect tributaries with historical focal fish habitat to mainstem Williamson River

Habitat Restoration Actions

7. Riparian fencing & planting
8. Improve spawning and rearing habitat in tributaries via addition of gravel and large wood
9. Thinning of trees, especially lodgepole pines, to prevent encroachment on wet meadows

3.2.3 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 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. 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 O_2, high pH, and high nutrient loading, which can in turn influence downstream water quality in Upper Klamath Lake. The primary human activities in this basin are agriculture (primarily to produce hay for cattle), ranching, and timber management (Newfields & Kondolf 2012).

A. Key Species

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

B. Key Stressors

Table 3.8: 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, as well as downstream of where it meets the state border, and along 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 Klamath Lake (Walker et al. 2015). Though not as prevalent as in other parts of the basin, areas around the Lower Sprague River (near Kamkaun Spring), the Sycan River, the Sycan Marsh, and the North Fork Sprague are 303d listed for sediment[3].This stressor is related in part to a lack of floodplain	●	○			

Key Stressors	Tier	Stressor Summary for the Sprague Sub-basin	Species				
			SU	RT	BT	CS	*PL*
		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 fishes 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.	●	●		●	○
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).		●		●	○
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).	○	●	●	●	○

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

C. Key Restoration Actions

IMPORTANT CAVEAT: Restoration actions identified below do not constitute an official federal agency position or obligation for current or future action, or funding.

Table 3.9: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups across the Sprague sub-basin in rough order of importance, with more important actions addressing underlying watershed processes listed first.

KS	No.	Identified Restoration Actions to Reduce Stressors
Instream Flows / Groundwater Interactions	1	**Action:** Consider acquisition of instream water rights to improve instream flows and groundwater recharge throughout the mainstem Sprague River and its tributaries, particularly in the North Fork Sprague River for Redband Trout as well as the South Fork Sprague River and its tributaries and the Sycan River and Marsh (an area of groundwater recharge) for Bull Trout (Gannett et al. 2010, USFWS 2015, IRCT 2016). **Monitoring:** Improvements to overall flows in this sub-basin can be monitored at the sub-basin scale via two dedicated USGS stream flow gages : (1) on the Lower Sprague River near Chiloquin, OR, and (2) at the at the confluence with the Sycan river. More localized monitoring to determine the benefits of individual water rights purchases would need to be made through other means.

KS	No.	Identified Restoration Actions to Reduce Stressors
	2	**Action:** Improve instream flows through increased water use efficiency, particularly through installation of piping to replace unlined irrigation diversions on the upper end of the Middle Sprague and in the North Ditch of the North Fork Sprague River (PacifiCorp 2018). **Monitoring:** Improvements to overall flows in this sub-basin can be monitored at the sub-basin scale via two dedicated USGS stream flow gages : (1) on the Lower Sprague River near Chiloquin, OR, and (2) at the at the confluence with the Sycan river. More localized monitoring to determine the benefits of individual water rights purchases would need to be made through other means.
Fine Sediment Inputs	3	**Action:** 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). In addition to reducing sediment inputs, this action will help to reduce stream temperatures in narrower reaches and is related to Action #5. **Monitoring:** Inventory of miles of stream with functional riparian fencing and riparian management agreements in the sub-basin; agency stream gages for monitoring of temperature and sediment inputs in the Sprague mainstem and sub-basin tributaries.
	4	**Action:** 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). In some cases, re-meandering may require whole-channel reconstruction which has been proposed for the South Fork Sprague mainstem and several upstream tributaries. This action is also expected to increase habitat complexity and is related to Action #6. **Monitoring:** Remote sensed analysis of stream sinuosity and total extent of floodplain present in the Sprague River mainstem and sub-basin tributaries; ODFW/USGS assessments of fish habitat condition in restored streams.
Temperature	5	**Action:** 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, including, Long Creek, Fivemile Creek, Meryl Creek, Deming Creek, Brownsworth Creek (Gannett et al. 2010, IRCT 2016). **Monitoring:** USGS groundwater monitoring wells existing near Whitehorse Spring and Kamkaun Spring and USGS/ORWD groundwater monitoring wells along the Sprague River mainstem and forks and in Sycan River; agency surface flow gages in the Sprague mainstem and tributaries.
Anthropogenic Barriers	6	**Action:** 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) **Monitoring:** ODFW/ NOAA Fisheries assessments of fish habitat condition in restored streams and fish occupancy, abundance, and usage of that habitat.
Habitat Complexity (mesohabitats)	7	**Action:** Improve in-stream habitat by adding large wood and spawning gravels and supporting pool development to improve habitat conditions and complexity for Bull Trout, Redband Trout, and future recolonizing salmonids, with particular focus on the North Fork Sprague, South Fork Sprague, and Sycan Rivers (IRCT 2016). **Monitoring:** ODFW/ NOAA Fisheries assessments of fish habitat condition in restored streams and fish occupancy, abundance, and usage of that habitat.

D. 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, with distributions focused on spawning areas in the Lower Sprague River from its confluence with the Williamson River upstream to midway 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 recolonize this sub-basin following restoration of fish passage from 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 enhancing in-channel watershed function, flow, hydrology, and connectivity, as well as restoring riparian habitats and upland forest habitats (ODFW 2016). Table 3.10 summarizes select major restoration activities in this sub-basin to date and those species which they have benefited.

Table 3.10: 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

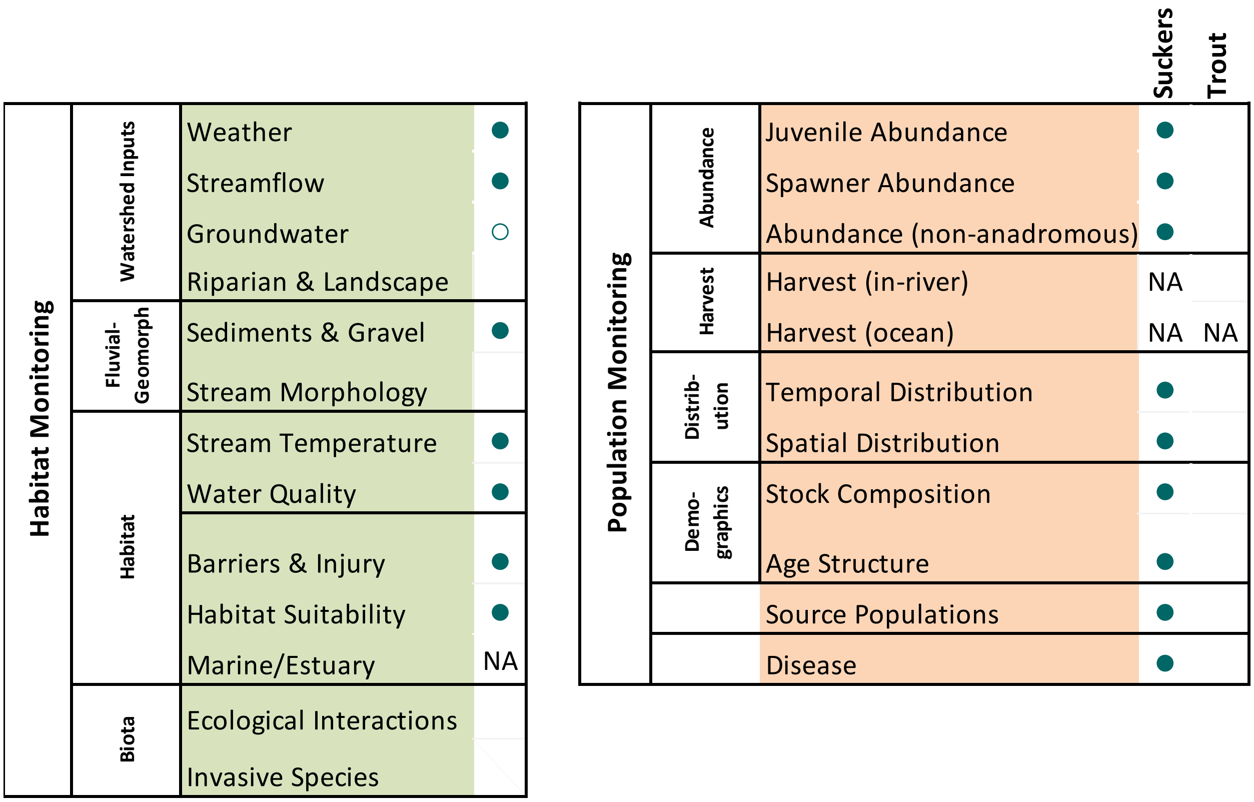
Past and Ongoing Monitoring:

Water quality data on nutrient and sediment loads has been collected at sites in the Sprague River to Upper Klamath Lake has been collected 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 to provide the foundation for a 10-year basin-wide beaver restoration effort. 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 localized effectiveness of individual restoration projects is generally tracked as part of funder reporting requirements (although this data is not always readily available). However, monitoring effectiveness for improving conditions at broader basin scales is difficult given that most monitoring programs in the region are geared towards long-term monitoring of status and trends at larger spatial scales and do not provide sufficient resolution for assessing the effects of individual projects.

Major Data Gaps:

Figure 3.3 provides a high-level, general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken across agencies in the Sprague 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. Further investigation will be required to confirm the utility of the current data available to help answer key monitoring questions for the Sprague sub-basin (i.e., species relevance, spatial and temporal extent, data quality) and isolate any existing monitoring gaps. A high number of USGS/OWRD groundwater monitoring sites occur throughout the lower part of the sub-basin, while KBMP’s 2015 monitoring inventory indicated high numbers of agency gages for monitoring of surface water flow, water quality and water temperature although these are concentrated in certain areas and not widely present across the sub-basin. The KMBP 2015 inventory of monitoring in the Sprague sub-basin indicated good coverage of monitoring stations for a range of habitat information (i.e., water quality, surface flow, groundwater, water temperature, weather) but that most of these stations were concentrated in the Oregon section of the sub-basin; fewer monitoring sites were present within California.

Sprague Sub-basin Interim Monitoring Summary



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

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

●	Ongoing monitoring
○	Past monitoring, unknown if ongoing
NA	Monitoring not relevant to this sub-basin

Figure 3.3. 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 Management Plans

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017 Ch 2.4, Appendix K):

- 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 Fishes into the Oregon portion of the

Upper Klamath Basin (in progress) 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)
- Water Quality Restoration Plan for the Upper Klamath Basin (USFS and BLM 2003)
- Winema and Deschutes National Forest Land and Resource Management Plans

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 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).
2. The Reintroduction Implementation Plan of Anadromous Fishes 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 fishes recolonizing this area following restoration of fish passage and are likely to provide overlapping benefits to resident fishes.

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 placs, 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 O2, 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

Key restoration actions listed here focus on restoring instream flow, restoring natural hydrology through levee breaching and remeandering as well as riparian fencing and restoration to reduce sediment inputs, reconnection of springs to provide access to cold-water refuges, and instream habitat improvements to increase spawning and rearing habitat.More details on these actions are available in the accompanying report.

Key Stressor Summary

Key Stressors	Focal Species (Current and *Future*)				
	SU	RT	BT	*CS*	*PL*
Instream Flow	●	●	●	◍	○
Fine Sediment Delivery	●				
Groundwater Interactions	●	●	●	◍	○
Water Temperature	●	●	●	◍	○
Anthropogenic Barriers		●		◍	○
Habitat Complexity (mesohabitats)	○	●	●	◍	○

Watershed Inputs Restoration Actions

1. Acquire water rights to increase instream flows
2. Improve irrigation efficiency to increase instream flow
3. Riparian fencing, planting, and riparian grazing agreements

Sub-basin Wide Activities

① ② ③ ⑥

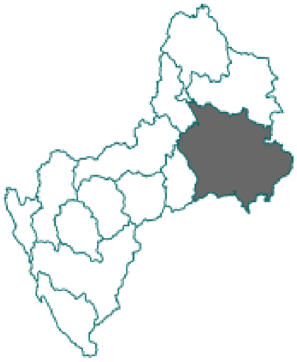
Fluvial Geomorphic Restoration Actions

4. Remove or set back levees, reconstruct channels to restore floodplains that trap sediment
5. Reconnect springs & spring-fed refuges

Habitat Restoration Actions

6. Improve habitat connectivity at road and stream crossings acting as barriers to fish passage
7. Improve spawning and rearing habitat in tributaries via addition of gravel and large wood

3.2.4 Lost River Sub-basin



The Lost River sub-basin is notable for large areas of private agricultural and grazing lands, many of which benefit from irrigation through the Bureau of Reclamation's Klamath Project. This 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, and flow is controlled by the Clear Lake and Gerber Reservoirs. To support these 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 entrainment as well as seasonally high stream temperatures, high pH, low dissolved O_2, 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).

A. Key Species

- **Current**: Shortnose Sucker, Lost River Sucker, Redband Trout
- **Historical**: 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.

B. Key Stressors

Table 3.11: 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.,	●	●	●	○

Key Stressors	Tier	Stressor Summary for the Lost Sub-basin	Species			
			SU	RT	*CS*	*PL*
		<40 cfs in Willow Creek) and can contribute to greater exposure to bird predation both in the lake and creek (USBOR 2018).				
Water Quality Hypereutrophication (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 fishes (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 fishes. In general, water quality is not considered to be limiting for fishes 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 fishes. 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 (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 as well as Clear Lake suckers spawning in Willow Creek (USFWS 2012).	●	○	○	○

Spatial stressor hotspots identified from, (1) CDFW BIOS Map of 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

C. Key Restoration Actions

IMPORTANT CAVEAT: Restoration actions identified below do not constitute an official federal agency position or obligation for current or future action, or funding.

Table 3.12: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups across the Lost River sub-basin in rough order of importance, with more important actions addressing underlying watershed processes listed first.

KS	No.	Identified Restoration Actions to Reduce Stressors
Instream Flow	1	**Action:** Pursue priority improvements to water conservation and irrigation conveyance efficiency projects throughout the Klamath Project and Lost River Irrigation District, Horsefly, and Langell Valley Irrigation Districts, the Klamath Irrigation District, and the Tule Lake Irrigation District and Lake Ewauna and Keno Impoundment area. In particular, implement measures recommended by the upcoming Natural Resources Conservation Service (NRCS) National Water Quality Initiative (NWQI) study in the upper Lost River watershed for the Langell Valley-Lost River region west of Gerber Reservoir (PacifiCorp 2018). This work would also yield improvements for ***water quality*** and ***temperature***. While these actions may benefit remnant populations of Redband Trout in the Lost River, maximal benefits to focal fish species would be contingent on restoration of fish passage past Gerber and Miller Diversion dams (see Action # 7) which would allow Redband Trout and suckers to regain access to this part of the Lost River. **Monitoring:** Monitor via networks of existing USGS stream flow gages and groundwater wells, as well as through local water meters at project sites as necessary.
	2	**Action:** 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. **Monitoring:** Effectiveness for facilitating spawning migration can be assessed through existing USGS sucker monitoring programs in Clear Lake and potentially through additional tagging and tracking studies to assess fish passage through new structures compared to past tracking studies (USBOR 2018, USGS 2018).
	3	**Action:** Determine the status of Redband Trout in Upper Lost River and Miller Creek below the Gerber Reservoir to clarify whether or not the population has been extirpated. If populations still exist, explore options for acquisition of water rights to increase instream flows and reduce fall and winter dewatering events in Miller Creek which historically supported populations of Redband Trout (ODFW 2005, IRCT 2016). **Monitoring:** Fish detection could be more effectively carried out using an eDNA approach similar to a current rangewide monitoring effort for Bull Trout by the U.S. Forest Service. Improvements to flows in Miller Creek could be monitored through reactivation of an inactive USGS flow gage site on Langell Valley Road near Miller Creek, or through changes in groundwater levels detectable at the adjacent and still active USGS monitoring well.
Water Quality - Hypereutrophication (related to DO, pH, and temperature)	4	**Action:** Improve fringing wetland around the margins of Lake Ewauna and the Keno Impoundment, potentially through the construction of treatment wetland sites, primarily to help improve water quality but also to provide rearing habitat for any juvenile suckers from Upper Klamath Lake entrained through the Link River Dam (PacifiCorp 2018, USBOR 2018). Additional treatment wetland sites have also been proposed in parts of the Klamath Project. **Monitoring:** Monitoring of nutrient and sediment loads in inflow and outflow of individual DSTWs to understand efficacy; stream gages for flow and outlet pipe monitoring of nutrient and sediment loads downstream of DSTW clusters (including in the Keno Impoundment) both within and outside of the tailwater season to understand annual variation in loading; inventory of numbers/ha of DSTWs across this sub-basin.

KS	No.	Identified Restoration Actions to Reduce Stressors
Fish Entrainment	5	**Action:** Carry out assessment of entrainment risk and screening prioritization study on the many unassessed or unknown status diversions (per the California Fish Passage Assessment Database) in the Lost River Basin to determine screening needs (USBOR 2018), particularly those connected to Designated Critical Habitats for suckers and core conservation populations of Redband Trout, and screen off priority diversions. **Monitoring:** It is presumed that development of the plan would involve a short-term monitoring program to determine entrainment risks and screening needs across a subset of unassessed diversions, and effectiveness monitoring following screening would be carried out by the USFWS, ODFW, and/or CDFW as part of their Fish Screening Programs.
Anthropogenic Barriers	6	**Action:** Improve fish passage at Keno Dam for all anadromous fish including salmonids and Pacific Lamprey that may recolonize the upper basin after downstream passage is restored (KBRA 2010, USFWS 2012). **Monitoring:** Passage can be monitored through observations at the fish ladder (or alternative passage infrastructure) as well as through tagging (visual, PIT, or telemetry) studies of fish moving both upstream and downstream through the dam.
	7	**Action:** 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. **Monitoring:** Action effectiveness can be assessed through existing intermittent USFWS and Reclamation sucker monitoring in Gerber Reservoir and potentially through additional tagging and tracking studies to assess fish passage through new structures compared to past tracking studies (USBOR 2018).
	8	**Action:** Contingent on improvements to limiting factors 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. **Monitoring:** Effectiveness for improving fish passage can be assessed through population monitoring above and below dams as well as dedicated tracking studies similar to those carried out at Link River Dam following installation of its fish ladder.
Habitat Complexity (mesohabitats)	9	**Action:** Improve in-stream, wetland, and riparian habitat in around the mouth of Willow Creek where it meets Clear Lake and throughout its upstream reaches to provide habitat for spawning suckers in Clear Lake (USFWS 2012). **Monitoring:** Effectiveness for facilitating spawning migration can be assessed through existing USGS sucker monitoring programs in Clear Lake and potentially through additional tagging and tracking studies to assess fish passage through new structures compared to past tracking studies (USBOR 2018, USGS 2018)
	10	**Action:** 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. **Monitoring:** Effectiveness for facilitating spawning migration can be assessed through additional tagging and tracking studies to assess fish passage through new structures compared to past tracking studies (USBOR 2018, USGS 2018)

D. 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 fragmented 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 been extirpated and the current status of the species in this sub-basin is presently 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, which would not have been continuously connected to the mainstem.

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 enhancing connectivity, flow and hydrological function, riparian habitat, and floodplain wetland habitat (ODFW 2016). The following table summarizes select major restoration activities in this sub-basin to date and those species which they have benefited.

Table 3.13: 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 annual 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). The majority of these efforts are focused on population monitoring for a variety of listed and unlisted species, although in the past ODFW also monitored temperatures within Redband Trout habitat. A high concentration of surface water quality and water temperature monitoring sites and USGS/OWRD/CDWR groundwater monitoring stations occurs 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.

Major Data Gaps:

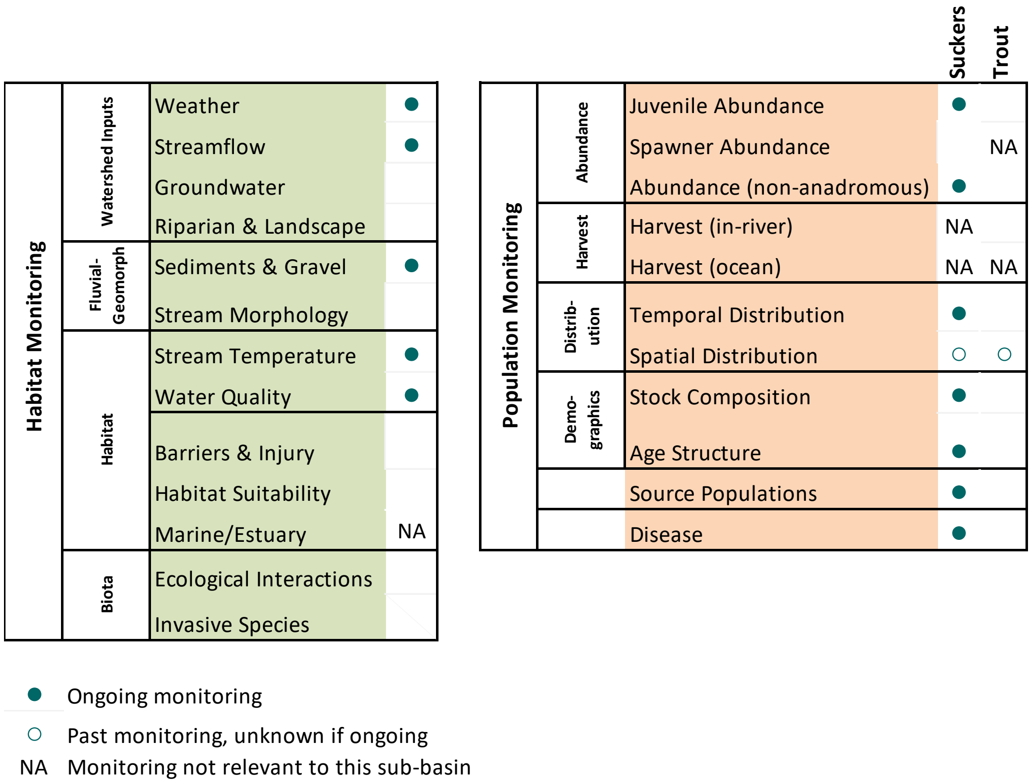
Figure 3.4 provides a high-level, general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken across agencies in the Lost River sub-basin. Location-specific agency metadata (where available) on monitoring projects has been incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. Further investigation will be required to confirm the utility of the current data available to help answer key monitoring questions for the Lost River sub-basin (i.e., species relevance, spatial and temporal extent, data quality) and isolate any existing monitoring gaps. A high number of USGS/OWRD groundwater monitoring sites occur throughout the lower part of the sub-basin, while KBMP's 2015 monitoring inventory indicated high numbers of agency gages for monitoring of surface water flow, 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 indicated that only a limited number of agency stations are currently in place for long term monitoring of weather, and these are found only in the upper basin.

Recent and Forthcoming Management Plans

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017 Ch 2.4, Appendix K):

- 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

Lost Sub-basin Interim Monitoring Summary



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

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

●	Ongoing monitoring
○	Past monitoring, unknown if ongoing
NA	Monitoring not relevant to this sub-basin

Figure 3.4. 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.

- 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/Environmental Impact Statement (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)

At the time of writing, there were no other ***forthcoming plans and initiatives*** specific to this sub-basin under development, recently completed, or soon to proceed to implementation.

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 these agricultural activities, 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 O2, high pH, high nutrient loading, and channelization and diversions contributing to fish entrainment. The Lost River subbasin also includes the Clear Lake, Tule Lake, and Lower Klamath National Wildlife Refuges and part of the Fremont, Klamath, Modoc and Winema National Forests.

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)	●	○	○	○

Restoration Summary

Key restoration actions listed here focus on restoring instream flow and water quality in sucker critical habitats and key spawning streams, assessing entrainment risk and screening priority diversions, improving fish passage through anthropogenic or hydrologic barriers, and expanding wetland rearing habitat around Clear Lake, Tule Lake, and adjacent sparning streams.

Watershed Inputs Restoration Actions

1. Improve irrigation efficiency to increase instream flow and lake levels
3. Acquire water rights to increase instream flows in the Miller Creek area
4. Improve fringing wetland around the margins of the Keno Reservoir and Lake Ewauna to improve water quality

Sub-basin Wide Activities

1 5

Fluvial Geomorphic Restoration Actions

2. Reconfigure Willow Creek forebay of Clear Lake to improve upstream passage in low water years

Habitat Restoration Actions

5. Assess and screen priority diversions
6. Improve fish passage at Keno Dam for all species
7. Improve fish passage at other area dams limiting access to spawning habitat around Gerber Reservoir
8. Improve fish passage at other area dams limiting access to spawning habitat above Tule Lake and
9. Improve in-stream, wetland, and riparian habitat in around the mouth of Willow Creek
10. Improve habitat conditions in Tule Lake and adjacent tributary of the Lost River

3.3 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 four reservoirs behind hydropower dams that also currently block the upstream passage of anadromous fishes. Limited flushing flows, long durations of low flows, and warm water temperatures in the Klamath mainstem are all considered factors contributing to the often-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 3.14: 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.

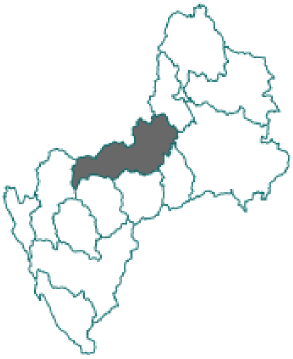
Mid/Upper Klamath River (MUK) sub-region							
Stressor Tier	Stressor	Focal Fish Species					
		PL	CH	CO	ST	RT	GS
Watershed Inputs (WI)	9.3.1 Klamath River flow regime	X	X	X	X	X	X
	9.2.2 Instream flow (tributaries)	X	X	X	X	X	
	7.2.1 Increased fine sediment input/delivery	X	X	X	X		X
	7.1.1 Decreased 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
	8.5 pH	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
	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::::::

3.3.1 Upper Klamath River Sub-basin



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. The upper portion of the sub-basin includes four impassable mainstem dams (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 is the current limit of distribution for anadromous fishes. Water resources are overallocated throughout the mainstem Klamath River and major tributaries (NMFS 2014). Irrigation and the operation of hydroelectric dams in this sub-basin have also altered the natural hydrologic regime, act as a barrier to sediment movement, negatively affect downstream water quality, and exacerbate impacts of disease. For the purpose of this report 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 confluence with Portuguese Creek. High road densities particularly 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 within the Klamath National Forest. Long term fire suppression has allowed fuel loads to build, leading to an increase in catastrophic fires particularly in the upper portion of the watershed. There are substantial restoration opportunities in this sub-basin.

A. 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)

B. Key Stressors

Table 3.15: 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 above IGD, preventing access to 63.6 km of mainstem habitat between IGD and Keno Dam, numerous tributaries with suitable habitat for anadromous fishes within this sub-basin (e.g., California: Slide, Scotch, Camp, Jenny, and Shovel; and Oregon: Spencer Creek) as well as a number of tributaries above this sub-basin (e.g., Oregon: Williamson River, Wood River, and Sprague River). In addition, according		●	●	●	●

Key Stressors	Tier	Stressor Summary for the Upper Klamath River Sub-basin	Species				
			RT	CH	CO	ST	PL
		to the California Fish Passage Assessment (accessed April 11, 2019) there are about 45 total barriers to fish passage 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 lower mainstem Klamath River and estuary as a result of managed water releases from the operation of the Klamath Irrigation Project. In particular, the timing of peak and base flows shifted after construction and the magnitude of spring and summer flows decreased. In addition, the mainstem is impacted by agricultural water diversions upstream of IGD and within the Scott and Shasta watersheds.	●	●	●	●	●
Instream Flow (tributaries[3])	WI	Tributaries with summer rearing potential are impacted by agriculture and historical timber harvest. There are numerous water diversions within this sub-basin[4]. Low flow conditions may also result in seasonal barriers to fishes. 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 during low flow conditions (NMFS 2014).		○	●	○	●
Water Quality	H	The timing and Water temperatures below IGD[5] 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 and increased overlap with *C. shasta*. A combination of low flows, elevated temperatures, and nutrients from upstream reservoirs tends to result in impaired water quality (e.g., low DO and increased pH) through the 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 in particular reduces habitat quality for Coho Salmon.		○	○	○	○

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

[4] 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

[5] The predicted impacts of dam removal on water temperatures are greatest immediately downstream of IGD and attenuate downstream (Perry et al. 2011).

Key Stressors	Tier	Stressor Summary for the Upper Klamath River Sub-basin	Species				
			RT	CH	CO	ST	PL
Channelization and Lack of Complexity (Below IGD)	FG	Tributary and mainstem habitat complexity is limited by a lack of coarse sediment 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 the 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.

C. Key Restoration & Monitoring Actions:

Table 3.16: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups across the Upper Klamath River sub-basin in rough order of importance, with more important actions addressing underlying watershed processes listed first.

KS	No.	Identified Restoration Actions to Reduce Stressors
Klamath Flow Regime, Water Quality, and Disease	1	**Action:** Contingent upon FERC deliberations, removal of Klamath mainstem dams: Iron Gate, Copco 1 and 2, and JC Boyle to restore natural hydrologic regime and consequently improve water quality. **Monitoring**: A network of mainstem gages within the Upper Klamath River is currently used to monitor flows, water quality, and disease below IGD. These gages are maintained by a variety of organizations including: The Karuk Tribe, USFWS, USFS, USGS, Pacificorp, and Oregon State University (refer to list of gages in 'current monitoring and data gaps'. There is also some direct *C. Shasta*-related monitoring in this reach including: sentinel fish studies, eDNA water sampling, measuring the percent of fish infected, and the percent of polychaetes infected. Complete a gap analysis to evaluate whether there is sufficient information at appropriate spatial scales to inform key management decisions. For example, there is a 60-mile gap in dissolved oxygen (DO) monitoring between IGD and Seiad Cr, and yet past studies indicate that this reach is one of the lowest in DO and greatest in pH of any currently accessible by anadromous fish (Asarian et al. 2013). Initiate long-term flow study to understand the ecosystem needs of the mainstem Klamath at various points after dam removal. After dam removal, the channel of the river will readjust to its new sediment regime above, below, and within the hydroelectric project reach, and older studies (e.g. Hardy Phase 2) may not be applicable any longer.
	2	**Action:** Adaptively manage releases from Klamath mainstem dams (while they remain in place, as per 2019 BiOp, USFWS 2019a). **Monitoring**: Same as for Action 1.
Instream flow and Fine Sediment	3	**Action:** Improve irrigation conveyance efficiency and water conservation practices to increase instream flows in tributaries. Focus first on streams where Coho would immediately benefit (e.g., Seiad Valley, Beaver, Hornbrook, Cottonwood, Bogus, Grider, Little Grider, Willow, Horse, Little Horse, Walker, Elliott, 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).

KS	No.	Identified Restoration Actions to Reduce Stressors
		Monitoring: Tributary flows can be monitored at numerous surface water flow gages currently maintained in different streams (e.g., Seiad, Horse, and Beaver) throughout the Upper Klamath River sub-basin by the Karuk Tribe, the USFS and others. This network of flow gages could be supplemented as needed for more complete coverage or for targeted streams (e.g., Cottonwood).
	4	**Action:** Work to implement or expand tailwater reduction programs to reduce warm inputs to tributaries. **Monitoring:** The Karuk Tribe and the USFS currently maintain an extensive network of water temperature loggers throughout tributaries in the Upper Klamath sub-basin. Where gaps occur, install water temperature loggers at bottom of tributaries where tailwater practices are changed.
	5	**Action:** 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. **Monitoring:** Sediment inputs and transport processes in the Upper Klamath River are monitored through existing sediment gages maintained by the Karuk Tribe and USGS in the mainstem Klamath River (see above). More gages are planned prior to dam removal, including major tributaries.
	6	**Action**: 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. **Monitoring:** Sediment inputs and transport processes in the Upper Klamath River can be monitored currently through existing sediment gages maintained by the Karuk Tribe and USFS in the mainstem Klamath River below IGD at Seiad Cr. Additional gages should be considered at the mouth of tributaries where substantial restoration occurs. The Klamath and Six Rivers National Forests and the Karuk Tribe have also cooperatively completed Road Sediment Source (RSS) inventories across the Mid-Klamath sub-basin (which, as they have defined, extends to Iron Gate Dam), which can be used for determining sediment risk-issues (Soto et al. 2008).
	7	**Action:** 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. **Monitoring:** Monitoring the frequency, size and intensity of fires is the key metric for evaluating the effectiveness of these actions.
Coarse Sediment Inputs	1	**Action:** Contingent upon possible FERC decision, removal of upstream Klamath mainstem dams (refer to Action 1 to restore fluvial geomorphic processes including supply of coarse sediment for spawning. **Monitoring:** There is an existing collaborative project between the Yurok Tribe, Army Corps of Engineers, USGS and private foundation funding. In 2018, this collaboration collected bathymetric sonar and LiDAR data for the entire river and select tributaries within the hydroelectric reach. If this action occurs, post-removal LIDAR and bathymetric data are expected. In addition, the Definite Plan includes nominal monitoring to ensure tributary confluences are not blocked through the deposition of sediment immediately following dam removal. For example, USGS has begun measuring sediment at several key mainstem locations (refer to gage locations above) and more gages are expected to be added over the next two years. The geographic focus of this assessment is between J.C. Boyle and Cottonwood Creek, which is predicted to be the point of geomorphic equilibrium downstream of Iron Gate Dam (Hetrick et al. 2009).

KS	No.	Identified Restoration Actions to Reduce Stressors
	8	**Action:** Supplement mainstem with coarse sediment below IGD while dams remain in place (Action #1). **Monitoring:** Given that the action relates to sediment supply only and not transport (because gravel is being applied directly at key spots), monitoring should focus on whether supplemented spawning gravel is used by salmonids and whether the amount is sufficient.
Channelization	9	**Action:** 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.). **Monitoring:** Revisit sites periodically to evaluate whether they: (1) remain connected after significant flow events; (2) provide suitable refugia during low water or overwintering conditions; and (3) whether they are utilized by juvenile salmonids.
Anthropogenic barriers	1	**Action:** Contingent upon possible FERC decision, removal of upstream Klamath mainstem dams (refer to Action #1 to allow access to upstream habitat). **Monitoring:** This action will require a long-term and extensive monitoring plan. There are several relevant documents which will be critical to informing the effectiveness monitoring for this action including: the KRRC's Definite Plan, the State of California's 401 permit, and the Implementation Plan for the reintroduction of anadromous fishes above IGD (ODFW and The Klamath Tribes, Draft 2018).
	10	**Action:** Provide fish passage (i.e., construct and operate fishways) at each of the four Klamath mainstem dams. This action would only be completed if Action #1 is not implemented. **Monitoring:** This action would use the same monitoring plan as described in Action #1.
	11	**Action:** 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[6]. This action should be completed in addition to Action #1 or Action #2. **Monitoring**: Revisit restoration sites for several years post project to verify physical objectives are met. Use e-DNA or occupancy monitoring and modeling for spawners or juveniles to determine if the habitat is used.
Fish Entrainment	12	**Action:** 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). **Monitoring:** Development of the screening program would involve a short-term monitoring program to determine entrainment risks and screening needs across a subset of unassessed diversions, and effectiveness monitoring following screening would be carried out by the USFWS, Karuk, or CDFW as part of their Fish Screening Programs.
Multiple	35	**Action:** Contingent on Action #1. Restore the former reservoir footprint for fisheries purposes. Some activities have begun (e.g., seed bank gathering of native plants for replanting) in anticipation of this. **Monitoring:** Monitoring for this action will depend on the specific actions and objectives developed as part of the plan. Assessments are expected to include: riparian vegetation, habitat and water quality, and ultimately fish usage and abundance.

Sources for restoration actions: NMFS 2014; USFWS 2019a; Sub-regional working group survey responses.

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[6] Consult with the California Fish Passage Forum to leverage their experience and strategies in prioritizing sites.

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

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

The federally listed Southern Oregon/Northern California Coast Evolutionarily Significant Unit of ***Coho Salmon*** have been the driving force behind restoration actions in this sub-basin, as in other parts of the mid and lower Klamath basin (NMFS 2014). 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 fishes were extirpated above IGD and spring-run Chinook Salmon are extirpated 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*** are anticipated to benefit from many of the restoration actions proposed for Coho Salmon recovery. Beyond the Endangered Species Act, the United States has trust responsibilities to the Tribes of the Klamath Basin, which include thinking about all species. This program presents an opportunity to take a broader ecosystem-based approach to restoration which would benefit other fishes and species in addition to Coho.

Table 3.17: 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 Gages

USGS measures flow, turbidity, and temperature at a number of mainstem and tributary sites. More sites are anticipated to be added over the next two years. The Karuk Tribe employs continuous water quality monitors at many of the same locations[7]:

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 EPA, which led to the decree in March 1997 for Total Maximum Daily Loads (TMDLs) to be developed in 17 California watersheds including the Klamath Basin. TMDLs for temperature, dissolved oxygen, nutrients, and microcystin impairments were adopted 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. Several mainstem sites 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

CDFW has been collecting population data for Coho, Chinook, and steelhead since 1978. Coho spawner surveys exist for most years since 1979. Sporadic 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). Fall spawner surveys have been completed by a variety of organizations including Karuk Tribe, Yurok Tribe, Mid Klamath Watershed Council, CDFW, and the USFS. Run-size estimates are primarily based on redd or carcass counts although there is an adult fish video weir in Bogus Creek. 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

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[7] 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.

infection. Oregon State University (OSU) also completes extensive disease monitoring including spore monitoring, sentinel exposure studies, and polychaete abundance surveys.

Effectiveness Monitoring

A review of restoration projects found limited evidence of project effectiveness monitoring in this sub-basin (ESSA 2017). Reintroduction[8] of native anadromous fishes 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 implementation plan (ODFW and The Klamath Tribes, Draft 2018) which will be critical in informing the effectiveness monitoring for this action. The Yurok Tribe is also preparing to complete a biological census of the Klamath River including macroinvertebrates and fish species for locations above and below the dams, through to the mouth of the river.

If the dam removal does occur as per the Definite Plan released by the Klamath River Renewal Corporation (KRRC 2018) there will also be a need to evaluate the physical outcomes of the action. The focus of the Definite Plan (KRRC 2018) is on how to actually decommission the dams. There is a small monitoring component to this plan, however it is focused only on the 2 years immediately post dam-removal in the 18-mile reach between Iron Gate Dam and Cottonwood Creek where the bulk of geomorphic change is expected (Hetrick et al. 2009). Specifically, the Definite Plan specifies monitoring several tributary/mainstem confluences to ensure that connectivity isn’t affected by sediment deposits immediately following 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 The collaborative monitoring effort described in Table 3.16 between the Yurok Tribe, ACOE, and USGS will provide key baseline information.

Major Data Gaps:

Figure 3.9 provides a high-level, general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken across agencies in the Upper Klamath River 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. Further investigation will be required to confirm the utility of the current data available to help answer key monitoring questions for the Upper Klamath River sub-basin (i.e., species relevance, spatial and temporal extent, data quality) and isolate any existing monitoring gaps. The most obvious population data gap is with respect to Pacific Lamprey and Redband Trout in the Upper Klamath River sub-basin. There are relatively strong data on salmonid populations as well as for water temperature and flow, which is of particular concern below IGD. Moving forward rigorous effectiveness monitoring will be important to inform future restoration strategies, particularly responses to dam removal if it occurs. The reintroduction of anadromous fishes will require a significant monitoring effort to guide the implementation and evaluation of effectiveness. There is

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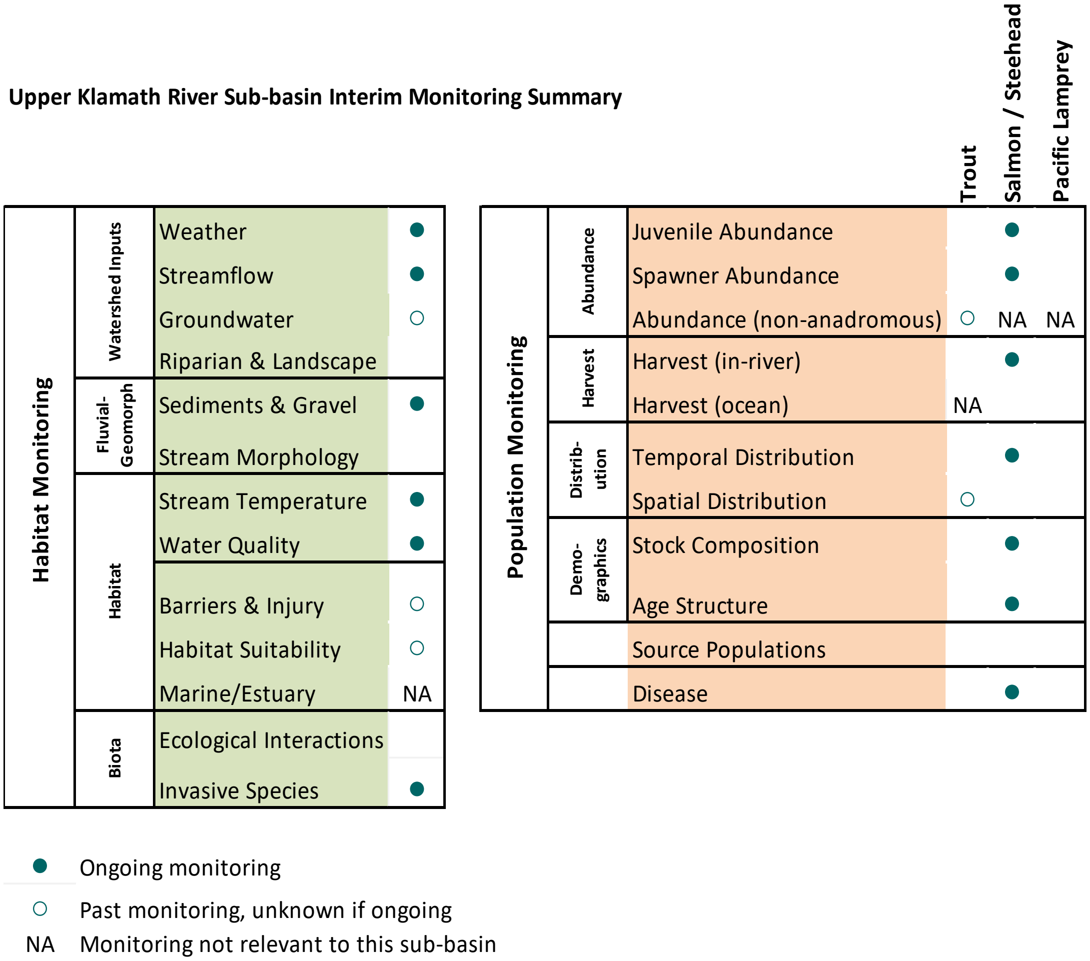
[8] Under a dam removal scenario, only spring-run Chinook will be reintroduced immediately. Other species/runs will be left to recolonize on their own at first.

no current plan for monitoring physical changes downstream of IGD beyond the limited scope described in the Definite Plan.



Upper Klamath River Sub-basin Interim Monitoring Summary

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

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

● Ongoing monitoring
○ Past monitoring, unknown if ongoing
NA Monitoring not relevant to this sub-basin

Figure 3.5. 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 Management Plans

Existing plans and initiatives important for watershed management in this sub-basin include:

Whole Basin

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

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)

At the time of writing, and beyond the Reintroduction Implementation Plan already stated above, there were no other ***forthcoming plans and initiatives*** specific to this sub-basin under development, recently completed, or soon to proceed to implementation.

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. The upper portion of the sub-basin includes four impassable mainstem dams (IGD-1962, Copco 1-1918, Copco 2-1925, and JC Boyle-1958). IGD is the lowest of the dams and is the current limit of distribution for anadromous fishes. The dams in this sub-basin have also altered the natural hydrologic regime, act as a barrier to sediment movement, negatively affect downstream water quality, and exacerbate impacts of disease. Water diversions exceed the available water. While there are legacy effects of timber harvest in the lower portion of the sub-basin, the bulk of this forest is now within the Klamath National Forest. 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

A number of Coho habitat enhancement and fish passage improvement projects have been completed or are underway in tributaries to the Klamath mainstem. The Klamath National Forest is working on a plan to analyze and improve road conditions. The 2019 BiOp specifies implementation of flushing flows to mimic the natural hydrograph with the intent of minimizing the prevalence of disease.

Watershed Inputs Restoration Actions

1. Remove 4 mainstem dams* for multiple benefits, including improved water quality
2. Adaptively manage releases from Klamath mainstem dams (while they remain in place, as per 2019 BiOp)
3. Improve irrigation practices to increase tributary flows
4. Implement tailwater reduction program to reduce warm-water inputs to streams
5. Improve grazing practices and carry out riparian restoration to reduce fine sediment inputs
6. Decommission roads to reduce fine sediment inputs, particularly in areas of immediate benefit to coho

Fluvial Geomorphic Restoration Actions

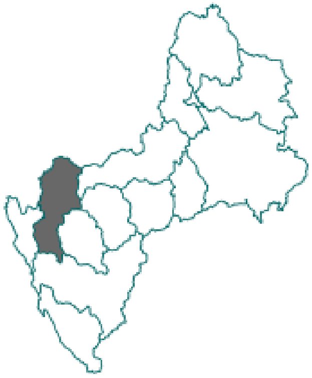
1. Remove mainstem dams* for multiple benefits, including restored sediment processes
7. Re-establish natural fire regime through fuel reduction and managed wildfire
8. Supplement mainstem with coarse sediment below IGD until mainstem dams removed
9. Remove barriers from alluvial deposits or legacy mining, reconnect floodplain and increase off-channel habitat

Habitat Restoration Actions

1. Remove 4 mainstem dams* for multiple benefits, including restored fish passage
10. OR Provide fish passage at each of the four mainstem dams (if Action 1 not implemented)
11. Restore fish passage in tributaries, espcially at barriers along Klamath River Highway (Hwy. 96)
12. Prioritize and screen diversions
13. Contingent on Action 1, restore the former reservoir footprint to improve function as fish habitat.

*Note: The final decision on dam removal is contingent on pending Federal Energy Regulatory Commission (FERC) deliberations

3.3.2 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 SONCC Coho Salmon 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 and forestry activities in the sub-basin as well as from 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 need for the sub-basin. Altered hydrological function due to upriver dams and high nutrient loads from upstream agriculture and associated algal blooms have also impacted water quality in the Klamath mainstem throughout this reach and created conditions for fish disease proliferation. TMDLs have been established within this sub-basin for high nutrient load; low dissolved O_2; microcystin; high stream temperatures, and organic matter.

A. Key Species

- **<u>Current</u>**: Chinook Salmon (fall-run and spring-run), Coho Salmon, steelhead, Pacific Lamprey, Green Sturgeon

B. Key Stressors

Table 3.18: 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 in the Mid Klamath River as a result of managed water releases from major dams in the upper Klamath River. 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	●	●	●	●	●
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.	○	●	●	●	●

Key Stressors	Tier	Stressor Summary for the Mid Klamath River Sub-basin	Species				
			GS	CH	CO	ST	PL
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 particular is considered inadequate in many Mid Klamath 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.

C. Key Restoration & Monitoring Actions:

IMPORTANT CAVEAT: Restoration actions identified below do not constitute an official federal agency position or obligation for current or future action, or funding.

Table 3.19: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups across the Mid Klamath River sub-basin in rough order of importance, with more important actions addressing underlying watershed processes listed first.

KS	No.	Identified Restoration Actions to Reduce Stressors
Klamath River flow regime	1	**Action:** Contingent upon possible FERC decision, removal of upstream Klamath mainstem dams to improve lower Klamath River fish habitat (McEwan et al. 1996, NMFS 2014, Caltrout State of Salmonids Report 2017). **Monitoring:** Flows in the Lower Klamath River mainstem can be monitored from an extensive network of surface water flow gages maintained at different locations in the mainstem reach of the sub-basin by the Karuk Tribe, USGS, and USFS.
	2	**Action:** Adaptively manage releases from Klamath mainstem dams while they remain in place to restore natural flow regimes and to improve Klamath River fish habitat conditions (McEwan et al. 1996, NMFS 2014, Caltrout State of Salmonids Report 2017, USFWS 2019a). **Monitoring:** Flows in the mid Klamath River mainstem can be monitored from an extensive existing network of surface water flow gages maintained at different locations in the mainstem reach of the sub-basin by the Karuk Tribe, USGS, and USFS.
Instream flow (tributaries)	3	**Action:** 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). Through its relationship to fish passage, this action is also related to Action #8. **Monitoring:** Tributary flows can be monitored at numerous surface water flow gages currently maintained at different streams throughout the Mid Klamath River sub-basin by the Karuk Tribe and the USFS. This network of flow gages could be supplemented as needed for more complete coverage or for targeted streams.
Increased fine sediment input	4	**Action:** Reduce inputs of fine sediment through road decommissioning where necessary, timber harvest management, slope stabilization, and fuels reduction in high severity fire risk areas on private and public lands (NMFS 2014). **Monitoring:** Sediment inputs and transport processes in the Mid Klamath River can be monitored currently through existing sediment gages maintained by the Karuk Tribe and USFS in the Klamath River mainstem near Happy Camp and by the Karuk Tribe at Orleans. The USFS has recently undertaken multi-year stream sediment monitoring in select tributary streams in the sub-basin (i.e., Elk Creek and Fort Goff Creek). The Klamath and Six Rivers National Forests and the Karuk Tribe have also cooperatively completed Road Sediment Source (RSS) inventories across the Mid-Klamath River sub-basin, which can be used for determining sediment risk-issues (Soto et al. 2008).
	5	**Action:** Upland vegetation management to re-establish 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. The plan identifies three key components: Restoring and maintaining resilient landscapes, creating fire-adapted communities, and responding to wildfires. WKRP efforts currently extensively address the first two components

KS	No.	Identified Restoration Actions to Reduce Stressors
		and are working with Federal managing agencies to begin to address the third component This document refers to actions associated with the first component, although recognizes that all of the components are important. **Monitoring:** Monitoring the frequency, size and intensity of fires is the key metric for evaluating the effectiveness of these actions. Fires over 40 acres have been mapped since 1911, current data resolution is 1:24,000 and is based on remote sensed data. The WKRP describes treatment-specific implementation, effectiveness, and validation requirements.
Water Temperature, Dissolved Oxygen (DO)	6	**Action:** Identify and implement projects to protect existing or potential cold-water refugia for fish (NMFS 2014). **Monitoring:** The Karuk Tribe and the USFS currently maintain an extensive network of water temperature loggers throughout tributaries in the Mid Klamath River sub-basin as well as on the mainstem river (as does the USFWS and Oregon State University) which could be supplemented as needed for broader monitoring coverage. Karuk Department of Natural Resources staff also conduct summer monitoring of thermal refugia across the Mid Klamath River sub-basin where in addition to monitoring water temperature, staff complete periodic surveys that note use of refuge areas by juvenile and adult salmonids.
	7	**Action:** Work to identify and implement projects to reduce warm tailwater inputs from irrigation into streams (NMFS 2014). **Monitoring:** The Karuk Tribe and the USFS currently maintain an extensive network of water temperature loggers throughout tributaries in the Mid Klamath River sub-basin.
	8	**Action:** Implement riparian fencing and planting to restore forest and instream vegetation for shading with benefits for reducing water temperatures and improving instream habitat (NMFS 2014). **Monitoring:** The Karuk Tribe and the USFS currently maintain an extensive network of water temperature loggers throughout tributaries in the Mid Klamath River sub-basin.
Anthropogenic Barriers	9	**Action:** Assess barriers and prioritize for removal leveraging the existing California Fish Passage Assessment Database, remove barriers based on evaluation (NMFS 2014). **Monitoring:** Monitoring of fish passage issues is currently undertaken in mid-Klamath River sub-basin tributaries by the USFWS, with support from the Karuk Tribe and other partners.
	10	**Action:** Remove sediment barriers formed by alluvial deposits or construct low flow channels and reduce gradient to provide fish passage over deposits (NMFS 2014). **Monitoring:** Monitoring of fish passage issues is currently undertaken in the Mid Klamath River sub-basin tributaries by the USFWS, with support from the Karuk Tribe and other partners.
Instream Structural Complexity	11	**Action:** Reconnect channels to existing off-channel ponds, wetlands, and side channels. Remove, set back, or reconfigure levees and dikes (NMFS 2014). **Monitoring:** Karuk Department of Natural Resources staff currently conduct summer monitoring of key thermal refugia across the Mid Klamath River sub-basin where in addition to monitoring water temperature, staff complete periodic surveys that note use of habitats by juvenile and adult salmonids.
	12	**Action:** Implement habitat restoration projects including LWD, boulders, and other instream structures (NMFS 2014). **Monitoring:** Karuk Department of Natural Resources staff currently conduct summer monitoring of key thermal refugia across the Mid Klamath River sub-basin where in addition to monitoring water temperature, staff complete periodic surveys that note use of habitats by juvenile and adult salmonids.

KS	No.	Identified Restoration Actions to Reduce Stressors
Pathogens	13	**Action:** Estimate the infection and mortality rate of juvenile Coho from pathogens such as *Ichthyophthirius multifiliis*, *Ceratonova shasta* and *Parvicapsula minibicornis* (NMFS 2014). Through its relationship to mainstem flows and water quality, this action is related to Actions #1 and #2. **Monitoring:** The Karuk Tribe conducts Mid Klamath River fish disease monitoring at sites on the river near Orleans, as does Oregon State University's Aquatic Animal Health Laboratory.

Sources for restoration actions: NMFS 2014; USFWS 2019a,b; Mid-Klamath sub-basin Fisheries Resource Recovery Plan (2008); Sub-regional working group survey responses.

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

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

Coho Salmon are of the greatest immediate conservation concern in this sub-basin as they 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.

The federally listed Southern Oregon/Northern California Coast Evolutionarily Significant Unit of ***Coho Salmon*** is the driving force behind many restoration actions in the Mid Klamath (NMFS 2014). The Mid-Klamath Watershed Council (MKWC) is a lead group in planning, coordinating, and implementing restoration projects in this section of the Klamath River 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 works in collaboration with the Karuk Tribe 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). The Karuk Tribe's Water Pollution Control Program also focuses on evaluating 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 decommission roads, stabilize road-stream crossings and re-establish natural hillslope drainage patterns.

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

Table 3.20: 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, 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 middle 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.	●	○	○	○	

*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.

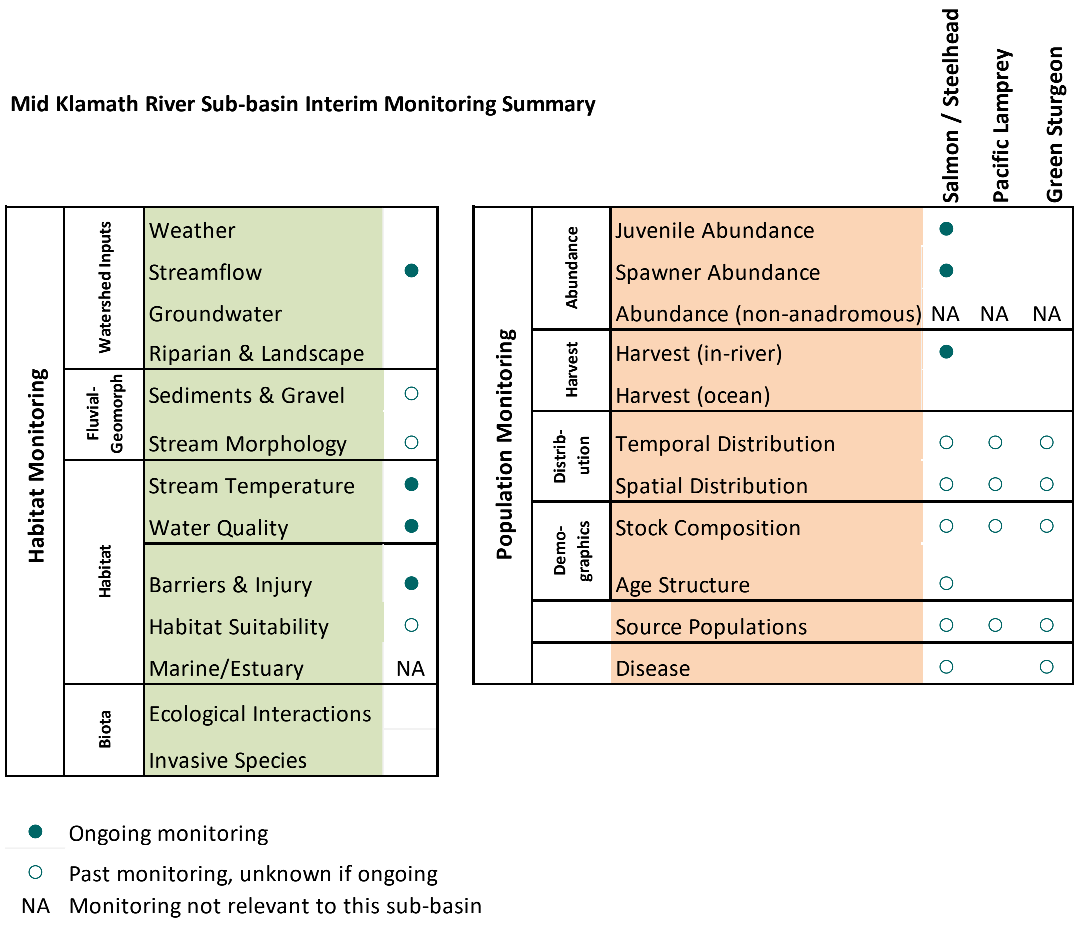
The U.S. Forest Service conducts ongoing monitoring of water quality (sediment and temperature) in USFS designated reference streams and managed streams across the Klamath National Forest (KNF), as well as base flow conditions in Mid Klamath tributaries (more information at this link). USFS designated reference streams show very little, if any, sign of human management and serve as a baseline for comparison with managed stream conditions. In addition to water quality monitoring, the Forest Service opportunistically conducts habitat reach surveys, which include multiple physical parameters. The Klamath National Forest has 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 USFWS and partners conduct fish passage barrier surveys in mid-Klamath River tributaries and water quality monitoring along the Klamath mainstem (Ward and Armstrong 2010; Armstrong and Ward 2008).

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) (Karuk Tribe 2013). The Karuk Tribe also samples nutrients, phytoplankton and algal toxins, which assists in fish disease monitoring conducted by Oregon State University as well as baseline public health monitoring. Real-time and archived continuous water quality data are available online at: http://waterquality.karuk.us. The Karuk Tribe is also involved in monitoring of flows, fish passage barriers, thermal refugia use, and fish health. In collaboration with USGS, 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, outmigrating 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 fishes.

Major Data Gaps:

Figure 3.9 provides a high-level, general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken across agencies in the Mid Klamath River 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. Further investigation will be required to confirm the utility of the current data available to help answer key monitoring questions for the Mid Klamath River sub-basin (i.e., species relevance, spatial and temporal extent, data quality) and isolate any existing monitoring gaps. There is relatively strong data on the key fish species using this sub-basin particularly for Coho and other salmonid populations, as well as 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 and fire management and other fine sediment reduction practices.



Mid Klamath River Sub-basin Interim Monitoring Summary

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

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

● Ongoing monitoring
○ Past monitoring, unknown if ongoing
NA Monitoring not relevant to this sub-basin

Figure 3.6. 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 Management Plans

Existing plans and initiatives important for watershed management in the Mid Klamath River sub-basin include (ESSA 2017 Ch 2.4, Appendix K):

- Northwest Forest Plan – Aquatic Conservation Strategy (USFS 1994)
- Klamath National Forest Land and Resource Management Plan (USFS 2010)
- Six Rivers National Forest Aquatic Restoration Project (USFS 2018)
- Mid Klamath sub-basin Fisheries Resource Recovery Plan (Soto et al. 2008)
- Middle Klamath Restoration Candidate Actions Plan (KRITFWC 2016, unpubl.)
- Eco-cultural Resources Management Plan (draft) (Karuk Tribe 2015)
- Karuk Department of Natural Resources Strategic Plan for Organizational Development (Karuk DNR 2015)
- Western Klamath Restoration Partnership – Plan for Restoring Fire Adapted Landscapes (Klamath National Forest 2014)
- Karuk Tribal Water Quality Plan (2014)
- North Coast Region Water Quality Control Plan (2011)
- Final Recovery Plan for the SONCC ESU of Coho Salmon (NMFS 2014)
- Yurok Tribe Comprehensive Cultural Riverscape Restoration Plan (draft)
- Karuk Climate Adaptation Plan (KTDNR 2019)
- 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.). Intent is to develop a website that will provide sediment and other data including in real-time.

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.

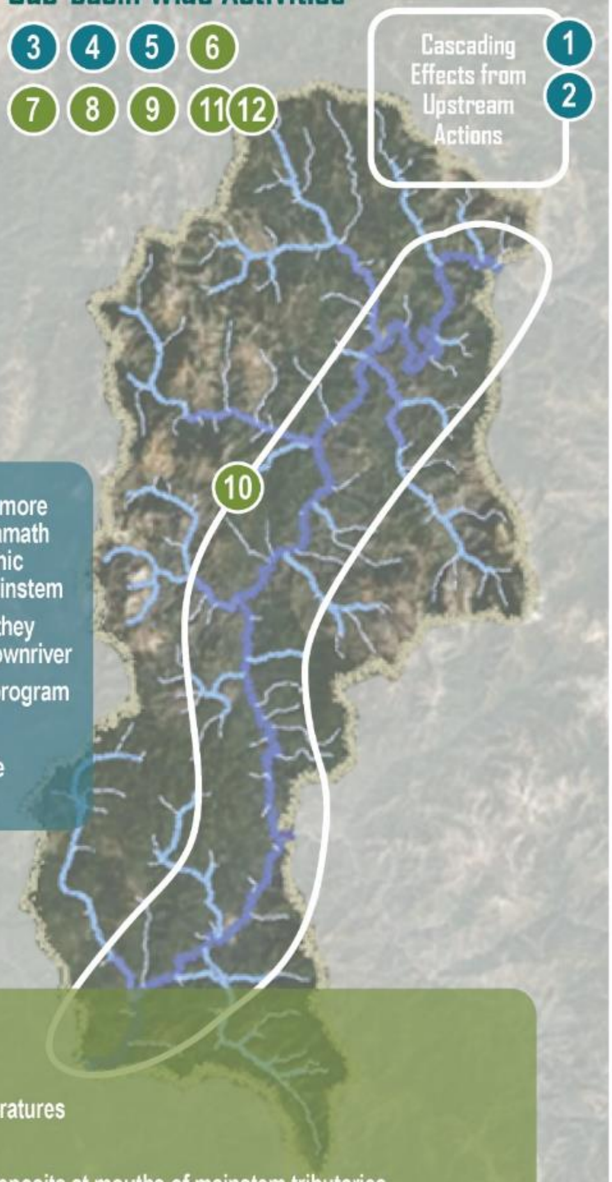
Restoration Summary

Removal of upstream Klamath River mainstem dams or else adaptively managing releases from Klamath mainstem dams (while they remain in place) would help to restore natural flow regimes and improve conditions for fish in the Mid Klamath Sub-basin. Other key restoration actions include removing stream diversions to improve tributary flows, reducing inputs of fine sediment through watershed restoration and fuels reduction in high severity fire risk areas. There is also a focus on protecting existing or potential cold water refugia for fish, improving stream riparian areas, removing fish passage barriers, reconnecting stream channels to floodplains, and providing LWD and other physical habitat improvements to streams to increase rearing capacity.

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	●	●	○		

Sub-basin Wide Activities



Watershed Inputs Restoration Actions

1. Remove four dams* in the upstream Klamath River to restore a more natural flow regime in the middle mainstem river. See Upper Klamath River actions. Dam removal would also benefit fluvial geomorphic processes and habitat conditions for fish in the middle river mainstem
2. Adaptively manage flow of upstream Klamath River dams (while they remain in place) to improve conditions for fish and fish habitat downriver
3. Remove unauthorized flow diversions and develop incentives program
4. Reduce fine sediment inputs through road decommissioning
5. Reduce fine sediment inputs through upland vegetation and fire management.

Habitat Restoration Actions

6. Protect and enhance tributary stream cold water refugia
7. Reduce warm tailwater inputs
8. Implement riparian planting and fencing to improve water temperatures
9. Remove anthropogenic barriers to fish passage
10. Remove sediment barriers to fish passage caused by alluvial deposits at mouths of mainstem tributaries

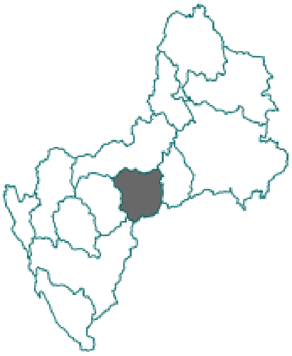
11 + 12. Increase habitat complexity of tributaries through channel reconfiguraion and addition of instream structures

*Note: The final decision on dam removal is contingent on pending Federal Energy Regulatory Commission (FERC) deliberations

IMPORTANT CAVEAT: The sub-basin profiles and the initial lists of candidate restoration and monitoring actions contained in this section represent an early draft. The information is based on previous workshop discussions and cited literature. The candidate restoration actions that are identified herein will be further refined and prioritized in the next phase of work.

3.3.3 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 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 also encompasses parts of the Klamath and Shasta-Trinity National Forests.



A. Key Species

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

B. Key Stressors

Table 3.21: 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 surface flows (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 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	●	●	●	●

Key Stressors	Tier	Stressor Summary for the Shasta Sub-basin	Species			
			CH	CO	ST	PL
		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 fishes (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)	FG H	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

C. Key Restoration & Monitoring Actions:

IMPORTANT CAVEAT: Restoration actions identified below do not constitute an official federal agency position or obligation for current or future action, or funding.

Table 3.22: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups across the Shasta sub-basin in rough order of importance, with more important actions addressing underlying watershed processes listed first.

KS	No.	Identified Restoration Actions to Reduce Stressors
Instream Flow	1	**Action:** 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.

KS	No.	Identified Restoration Actions to Reduce Stressors
		Monitoring: Monitoring the effectiveness of this action is proposed as attaining at least a 55 cfs target summer base flow, or baseflow sufficient for recovery of all affected life stages of Coho Salmon, at USGS water gage 11517000 on the Shasta River (NMFS 2014).
	2	**Action:** 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). **Monitoring:** There are no flow gages currently in the vicinity of Parks Creek Diversion.
Water Temperature, Dissolved Oxygen (DO)	3	**Action:** 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, and securing water rights to dedicate cold water to instream flows. Priority areas of focus for this work include Big Springs Lake Dam, Parks Creek, Kettle Springs, Bridge Field Springs Complex, Little Shasta River, and the upper Shasta River (NMFS 2014). **Monitoring:** There are over 170 current and historic temperature-monitoring locations along the Shasta River and upper Shasta River (operated by several organizations including the CDFW, the SVRCD, TNC, the Karuk Tribe, the Yurok Tribal Fisheries Program, and the US Forest Service (USFS).
	4	**Action:** Investigate feasibility of changing drawdown location on Dwinnell Dam or otherwise controlling discharges to maximize cold water and dissolved oxygen (NCRWQCB 2006, NMFS 2014). **Monitoring:** There are over 170 current and historic water temperature-monitoring locations along the Shasta River and upper Shasta River (operated by several organizations including the CDFW, the SVRCD, TNC, the Karuk Tribe, the Yurok Tribal Fisheries Program, and the US Forest Service (USFS). Dissolved oxygen is currently measured at 8, regularly spaced monitoring stations along the Shasta River downstream of the Dwinnell Dam and into upper Shasta River (stations 105SRU1DO, 105SRP1DO, 105SRN1DO, 105SRV1DO, 105SRT1DO, 105SRS1DO ,105SRM1DO, and 105SRA1DO, all operated by the SVRCD). As funding allows, the SVRCD and AquaTerra monitor dissolved oxygen and water temperature at 33 stations along the Shasta River, and at selected springs and tributaries (SVRCD et al. 2018).
	5	**Action:** 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). **Monitoring:** There are over 170 current and historic water temperature-monitoring locations along the Shasta River and upper Shasta River (operated by several organizations including the CDFW, the SVRCD, TNC, the Karuk Tribe, the Yurok Tribal Fisheries Program, and the US Forest Service (USFS). Existing stations could be used to measure the effectiveness of warm tailwater reduction efforts. In order to address the high water temperatures and low dissolved oxygen caused in part through the influence of warm tailwater inputs, the SVRCD and AquaTerra Consulting undertook monitoring along the Shasta River, and selected springs and tributaries in 2017 under grant agreement 13-501-251-2 (SVRCD 2018b). Monitoring

KS	No.	Identified Restoration Actions to Reduce Stressors
		occurred at 33 locations, including 15 at the Dwinnell Dam outlet to Parks Creek, 1 at Parks Creek, 1 along the reach between Parks Creek and Big Spring Creek, 4 between Big Springs Creek to Willow Creek, 3 between Willow Creek and Little Shasta River, 5 between Little Shasta River and Yreka Creek, 1 at Yreka Creek, and 3 between Yreka Creek and the mouth of the Shasta River (SVRCD 2018b).
	6	**Action:** 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. **Monitoring:** At least 7 temperature-monitoring stations are currently in operation immediately downstream of the Grenada Irrigation District Diversion. Water temperature is also measured at Station 105SRPCO at the downstream end of the Parks Creek overflow channel, and at Station 105SRP1DO (which also measures DO) located in Parks Creek near the confluence with the Shasta. Immediately downstream of the Dwinnell Dam, there are numerous temperature-monitoring stations along the mainstem Shasta River. Over 170 current and historic temperature-monitoring locations exist along the Shasta River with some sites going back to 1997. The SVRCD intends to develop a multi-agency monitoring program based on the framework outlined in the Watershed Stewardship Report (2018) that will track Shasta water quality and provide information on Coho abundance, productivity, diversity, and spatial extent (SVRCD et al. 2018).
Anthropogenic Barriers	7	**Action:** 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). **Monitoring:** The SVRCD intends to regularly update its Watershed Stewardship Action Plan with information derived from the tracking of its implemented actions, of which removing barriers to fish passage and maintaining fish access to spawning habitat and cold-water refugia are identified actions. Monitoring to track these actions will be outlined in the multi-agency monitoring program the SVRCD plans to develop (SVRCD 2018). There are monitoring stations operated by CDWR, SVRCD, TNC, and the USGS that are in close proximity of known fish passage barriers, screens, and diversions (e.g., Station 105SRN1DO near the Novy-Rice Diversion).
	8	**Action:** 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). **Monitoring:** The SVRCD intends to regularly update its Watershed Stewardship Action Plan with information derived from the tracking of its implemented actions, of which removing barriers to fish passage and maintaining fish access to spawning habitat and cold-water refugia are identified actions. Monitoring to track these actions will

KS	No.	Identified Restoration Actions to Reduce Stressors
		be outlined in the multi-agency monitoring program the SVRCD plans to develop (SVRCD 2018). There are monitoring stations operated by CDWR, SVRCD, TNC, and the USGS that are in close proximity of known fish passage barriers, screens, and diversions (e.g., Station 105SRN1DO near the Novy-Rice Diversion).
Channelization & Habitat complexity (mesohabitats)	9	**Action:** 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. **Monitoring:** The SVRCD intends to develop a multi-agency monitoring program based on the framework outlined in the Watershed Stewardship Report (2018) that will track implemented Watershed Stewardship Actions including riparian planting, spring restoration, and riparian fencing.
	10	**Action:** 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). **Monitoring:** A monitoring station at the mouth of the Shasta River that monitors sediment is operated by the Karuk Tribe. Several sediment monitoring stations exist just downstream of the Dwinnell Dam, and along Parks Creek which could be used to monitor spawning gravel. CDFW monitors Coho spawning activity in the Shasta and since 2008 has been monitoring Coho movements and juvenile emergence/survival outmigration (Chesney 2016).

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

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

The state and federally listed Southern Oregon/Northern California Coast Evolutionarily Significant Unit of ***Coho Salmon*** are the driving force behind restoration actions in the Shasta sub-basin, as in other parts of the mid and lower Klamath basin (NMFS 2014). Fall-run ***Chinook Salmon***, 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, none of the populations of these three species occurring in the Klamath Basin are ESA-listed, although steelhead are a species of Special Concern. Spring-run Chinook Salmon also once ran up the Shasta River, but their current distribution ends just past the settlement of Happy Camp in the Mid-Klamath sub-basin.

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

Table 3.23: 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 fishes (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, operated by the USGS and the California Department of Water Resources (DWR), along the Shasta River since 1957 (SWRCB 2018). Streamflow monitoring has also been undertaken 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 extensively monitored along the Shasta River at over 100 monitoring stations operated by many organizations including the CDFW, the 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 which outlines monitoring needed to measure the effectiveness of established 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 under a different grant agreement number 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 and provide support for beneficial uses. The waiver requires landowners to implement BMPs that minimize, control, and prevent the discharge of tailwater into the Shasta River and allow for the natural establishment of native riparian vegetation. The waiver also prohibits the discharge of 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 that will be delineated in the multi-agency monitoring program that will be developed (SVRCD et al. 2018).

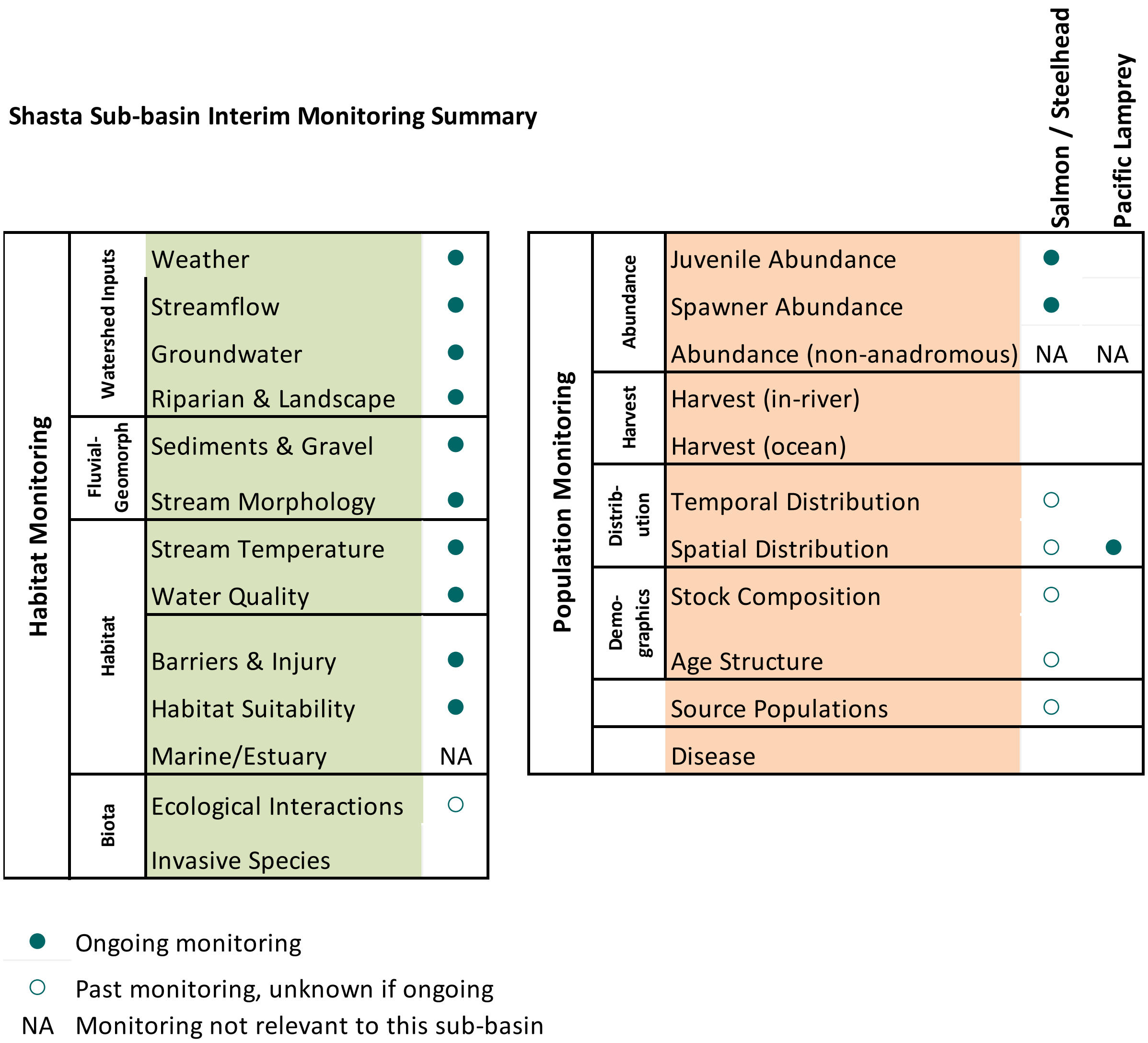
CDFW's Klamath River Project (KRP) conducts population monitoring in the Shasta sub-basin (and other areas of the Klamath Basin). The KRP collects information on population abundance, hatchery composition, run timing, spawning distribution, fork length frequency, age composition, and sex ratios for salmonids (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. The video facility consists of a video camera, counting flume and an Alaska style weir.

CDFW's Yreka Fisheries Program has operated rotary screw traps since 2000 in the Shasta River for the purpose of generating population estimates for outmigrating juvenile salmon (Stenhouse et al. 2016a,b). Using rotary screw traps, all age classes of outmigrating 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 in the river (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 led by the USFWS have included initiatives to assess lamprey passage/entrainment issues at the Grenada water diversion dam as well as to develop a general monitoring plan for outmigrating macrophthalmia 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.

Major Data Gaps:

Figure 3.7 provides a high-level, 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 has been incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. Further investigation will be required to confirm the utility of the current data available to help answer key monitoring questions for the Shasta River sub-basin (i.e., species relevance, spatial and temporal extent, data quality) and isolate any existing monitoring gaps. 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 at locations that would benefit effectiveness evaluations for implemented restoration actions (e.g., temperature monitoring at the lower reach of Parks Creek).



Shasta Sub-basin Interim Monitoring Summary

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

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

● Ongoing monitoring
○ Past monitoring, unknown if ongoing
NA Monitoring not relevant to this sub-basin

Figure 3.7. 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 Management Plans

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017 Ch 2.4, Appendix K):

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)

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)

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) signed into legislation in September 2014, the Shasta sub-basin is required to develop a Groundwater Sustainability Plan (GSP) by January 31, 2022, that will assess the current and projected future conditions of four basins (Shasta, Scott, Butte, and Tulelake), and will establish management and monitoring activities and long-term goals (Siskiyou County 2019). The initial notification for development of this plan has been issued and development is ongoing.

It is worth noting that many of the landowners in the Shasta are attempting to create a Safe Harbor program and already have fairly advanced ideas about what restoration projects they would willingly conduct on their lands in exchange for ESA take protections under NMFS' policy of Safe Harbour Agreements for Private Landowners which provides assistance and incentives for landowners to help salmon and steelhead. These discussions are currently in progress (communication from Yurok Tribe).

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.

Key Stressor Summary

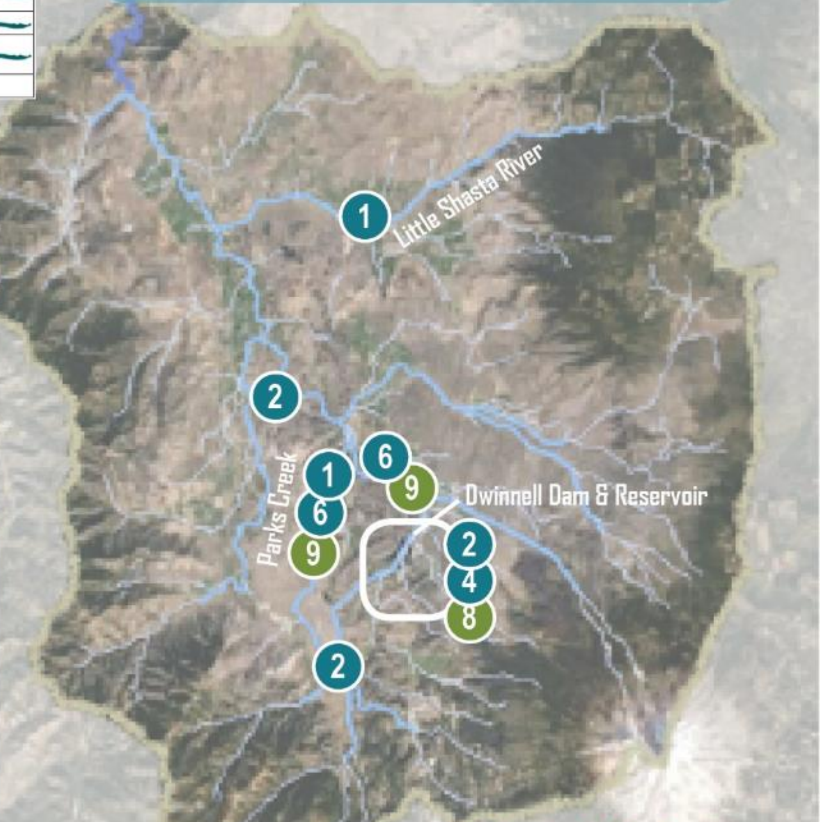
Key Stressors	Focal Species (Current)				
	GS	CH	CO	ST	PL
Klamath River Flow Regime	●	●	●	●	●
Instream Flow (tributaries)	○	●	●	●	●
Fine Sediment Delivery		●	●	●	○
Water Temperature and Quality (DO, pH)	●	●	●	●	●
Anthropogenic Barriers		●	●	●	●
Instream Structural Complexity (mesohabitats)		●	●	●	●
Mesohabitats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

Restoration Summary

Key restoration actions listed here focus on restoring instream flow and cold stream temperatures in the middle and downstream reaches of the basin that are most altered by irrigation and agriculture, on restoring fish passage past major barriers blocking access to suitable habitat in headwater streams, and restoring riparian and off-channel habitats to benefit spawning and rearing salmonids and particularly Coho.

Fluvial Geomorphic Restoration Actions

9. Restore off-channel areas to help reconnect floodplains and create habitat (also relevant to habitat)



Watershed Inputs Restoration Actions

1. Improve instream flows through flow assessment, securing unused water rights, and establishing a water trust to improve spawning and rearing habitat and address low-water barriers
2. Assess and improve diversion points at Parks Creek cross-channel diversions to improve flows and their timing
3. Increase cold water in the Upper Shasta Basin by assessing / securing water rights to dedicate cold water to instream flows
4. Modify drawdown location or other aspects of Dwinnell Dam discharges to maximize cold water and dissolved oxygen in outflows
5. Implement tailwater reuse and reduction projects to reduce warm return flows
6. Implement riparian fencing and planting projects to restore riparian and instream shade and habitat

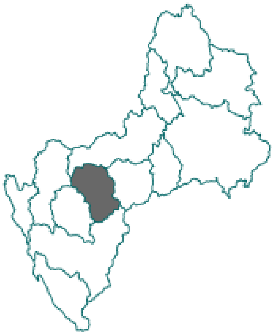
Sub-basin Wide Activities

① ③ ⑤ ⑥ ⑦ ⑨

Habitat Restoration Actions

7. Prioritize and address fish passage barriers throughout the subbasin, including low-water barriers
8. Improve fish passage at Dwinnell Dam to restore access to upstream salmonid spawning habitat
10. Enhance spawning gravels through supplementation in key reaches, including in Parks Creek and areas downstream of Dwinnell Dam

3.3.4 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, especially in low water years (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. Both of 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 River basin (Yokel et al. 2016).

A. Key Species

- **Current:** Chinook Salmon (fall-run only, spring-run extirpated), Coho Salmon, steelhead (winter-run throughout, spring/summer run in mainstem only), and Pacific Lamprey

B. Key Stressors

Table 3.24: 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 the loss of beaver dams, has contributed to low summer flows and disconnection or complete dewatering of some spawning and rearing habitats important 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	●	●	●	●

Key Stressors	Tier	Stressor Summary for the Scott Sub-basin	Species			
			CH	CO	ST	PL
		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 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).	●	●	●	●
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. In these areas, sediment may prevent spawning and smother any salmonid eggs that are deposited (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[9] 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).	●	●	●	●
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 and upper Kidder Creek (Figure 25 in Cramer et al. 2010).	●	●	●	○

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

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[9] Groundwater removal may also contribute to this stress as, the ground water table retreat combined 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.

C. Key Restoration & Monitoring Actions:

Table 3.25: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups across the Scott sub-basin in rough order of importance, with more important actions addressing underlying watershed processes listed first.

KS	No.	Identified Restoration Actions to Reduce Stressors
Instream Flows	1	**Action:** Acquire water rights 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). 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. **Monitoring:** Monitoring of instream flows occurs at multiple scales from the individual diversion to the sub-basin. (1) The effectiveness of individual water transfers can be monitored in the short term via an existing monitoring program operated by the Siskiyou Resource Conservation District on behalf of the Scott River Water Trust, however monitoring should ultimately be completed by an independent agent and funded in perpetuity via associated tax assessments. (2) Each diversion should have a 1600 agreement that ensures adequate bypass flows as mandated. (3) Each major tributary should also have flow gages, these may include the existing flow monitoring sites operated by the Quartz Valley Indian Reservations (viewable via the KBMP Monitoring Locations web portal). Complementary monitoring for temperature benefits of increased flows is likely to occur via these same gages and is required by the Scott River's TMDL Action Plan to evaluate progress towards established temperature TMDLs (NCRWQCB 2006), and a monitoring plan has been created for this purpose (NCRWQCB 2011). This monitoring plan provides a framework for water quality related monitoring which could be employed more broadly to ensure consistency among data collected by different entities. (4) Consider implementing a groundwater monitoring network (e.g., as recommended by Harter and Hines, 2008). (5) Improvements to overall flows in this sub-basin can be monitored at the sub-basin scale via the existing dedicated USGS stream flow gage (#11519500) along the lower mainstem Scott River near Fort Jones. (5) Development of a comprehensive instream flow study to help evaluate the adequacy of flow improvement efforts. This study should take into account both surface and ground water and the relationship between them to ensure adequate flows remain in the Scott River and its tributaries.
	2	**Action:** Enforcement of existing water and environmental laws. 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. **Monitoring:** As described for Action 1, monitoring should be conducted through an independent agent with long-term funding provided via associated tax assessments.
	3	**Action:** Winter flooding of agricultural land in the Scott Valley with the purpose of groundwater recharge. 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

KS	No.	Identified Restoration Actions to Reduce Stressors
		the groundwater table (Dahlke et al. 2018). This management action utilizes the naturally occurring runoff to recharge the groundwater table during non-critical periods. **Monitoring:** Groundwater could be directly measured where this action is implemented. The same gages as described in Action 1 for tributary and sub-basin level monitoring would provide additional feedback. The frequency of low flow or dewatering events is another potential performance indicator for this action.
	4	**Action:** 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, making revenue-neutral changes to water pricing to promote conservative water use, and monitoring allocations through a watermaster program (NMFS 2014). **Monitoring:** Improvements to on-farm water use can be assessed via on-farm water meters through the watermaster program and via an existing monitoring program operated by the Siskiyou Resource Conservation District on behalf of the Scott River Water Trust, while overall flows in this sub-basin can be monitored using the same flow gages describes above.
Temperature	5	**Action:** 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 from Boulder Creek to Tompkins Creek, Canyon Creek, and Kelsey Creek) (Table 36-5 in NMFS 2014). **Monitoring:** Juvenile passage and usage of thermal refugia could be assessed via a PIT tagging program jointly operated by SRCD and SRWC (Yokel et al. 2016).
	6	**Action:** Grazing 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 River Water Shed Council's new plan: Restoring Priority Coho Habitat in the Scott River Watershed: Modeling and Planning Report (SRWC 2018). **Monitoring:** Monitoring for temperature benefits of riparian restoration is likely to occur via existing monitoring networks as required by the Scott River's TMDL Action Plan to evaluate progress towards established temperature TMDLs (NCRWQCB 2006), and a monitoring plan has been created for this purpose (NCRWQCB 2011).
Sediment Inputs	7	**Action:** 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 upper reaches where the most significant sources of sediment production are found (e.g., Moffett Creek upstream of the Highway 3 bridge). This sediment propagates downstream and has 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).

KS	No.	Identified Restoration Actions to Reduce Stressors
		Monitoring: Monitoring of both sediment and temperature, including project implementation and upslope effectiveness monitoring, is required by the Scott River's TMDL Action Plan to evaluate progress towards established TMDL thresholds for these parameters (NCRWQCB 2006), and a monitoring plan has been created for this purpose leveraging existing monitoring sites for turbidity and other parameters operated by the USFS, the Quartz Valley Indian Reservation, and other organizations (NCRWQCB 2011)(sites viewable via the KBMP Monitoring Locations web portal).
Impaired Channel and Floodplain Hydrology	8	**Action:** Remove, setback, or reconfigure levees and dikes to restore channel form and 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 as well as 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. **Monitoring:** These types of actions would likely involve project effectiveness monitoring, and may also leverage existing USGS stream flow and groundwater monitoring gages to assess the effects of a reconnected floodplain on underlying hydrologic function.
Habitat Complexity (mesohabitats)	9	**Action:** 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. **Monitoring:** Adult passage and spawning upstream of beaver dams or BDAs can be assessed via a video counting system on the mainstem operated by the CDFW and annual spawning surveys performed by the Siskiyou Resource Conservation District (SRCD). Juvenile usage and passage of these structures can be assessed via a PIT tagging program jointly operated by the CDFW, SRCD, and SRWC (Yokel et al. 2018). Finally, the influence of these structures on flow can be assessed using gages described previously.
	10	**Action:** Enhance refugia habitats and construct off channel-ponds, alcoves, backwater habitat, floodplain reconnection, and stream oxbows as per SRWC 2018 plan. **Monitoring:** Monitoring can be carried out using the ongoing adult and juvenile monitoring programs operated by the CDFW, SRCD, and SRWC and specified in the beaver dam row of this table (Yokel et al. 2018).
	11	**Action:** Placement of instream structures including large woody debris and boulders to provide cover for rearing salmonids at streams identified as priorities for this purpose (NMFS 2014). **Monitoring:** Monitoring can be carried out using the ongoing adult and juvenile monitoring programs operated by the CDFW, SRCD, and SRWC and specified in the beaver dam row of this table (Yokel et al. 2018).

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 survey responses.

D. 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 declined significantly from historical levels in the Scott sub-basin (QVIR 2016).

The state and federally listed Southern Oregon/Northern California Coast Evolutionarily Significant Unit of ***Coho Salmon*** are the driving force behind restoration actions in the Scott sub-basin, as in other parts of the mid and lower Klamath basin (NMFS 2014). 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 River 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 and contributes an average of 9% of the remaining total salmon escapement in the Klamath Basin (Knechtle and Chesney 2016). While ***Pacific Lamprey*** have thus far maintained a distribution and abundance similar to historical levels in this sub-basin, they are now considered to be in rapid decline (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, and have more recently transitioned into more diverse efforts to restore floodplain structure and function with a focus on beaver restoration, channel reconstruction and levee setbacks, and restoring instream flows (Table 3.26).

Table 3.26: 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 operates a comprehensive salmonid monitoring program in the Scott sub-basin including adult spawning migration counts, spawning ground surveys, and rotary screw trap sampling outmigrating 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 correspond with the operational window of the weir. Given this, 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 outmigration 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 for this species led by the USFWS have included initiatives to carry out distribution surveys on mainstems and principal tributaries in the Scott River as well as to develop a monitoring plan for outmigrating macrophthalmia with screw trap programs and to carry out telemetry studies to assess habitat use and migration behaviour 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 one http://cdec.water.ca.gov/cgi-progs/plotReal2?staid=sfjreal time monitoring datasonde on the mainstem Scott River, deployed at the site of an existing USGS flow gage near Shackleford Creek, which records temperature, specific conductivity, dissolved oxygen, pH and turbidity. 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).

There has also been a significant investment in restoration and associated effectiveness monitoring through implementation of the action plan for the Scott River TMDLs[10], the Scott River Watershed Restoration Strategy, and the Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (SONCC). 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.

Major Data Gaps:

Figure 3.8 provides a high-level, general overview of available metadata on past/current fish habitat and focal fish population monitoring undertaken 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. Further investigation will be required to confirm the utility of the current data available to help answer key monitoring questions for the Scott sub-basin (i.e., species relevance, spatial and temporal extent, data quality) and isolate any existing monitoring gaps. There is relatively strong data on salmonid populations, with the exception of steelhead, as well as for sediment, water temperature, and flow, which is of particular importance for evaluating landscape level restoration actions in the Scott sub-basin. In addition, new monitoring and assessment data on Pacific Lamprey is helping to fill important historical data gaps for this species and is ongoing. Moving forward, rigorous effectiveness monitoring will be important to inform future restoration strategies, particularly responses to instream flow and floodplain restoration measures.

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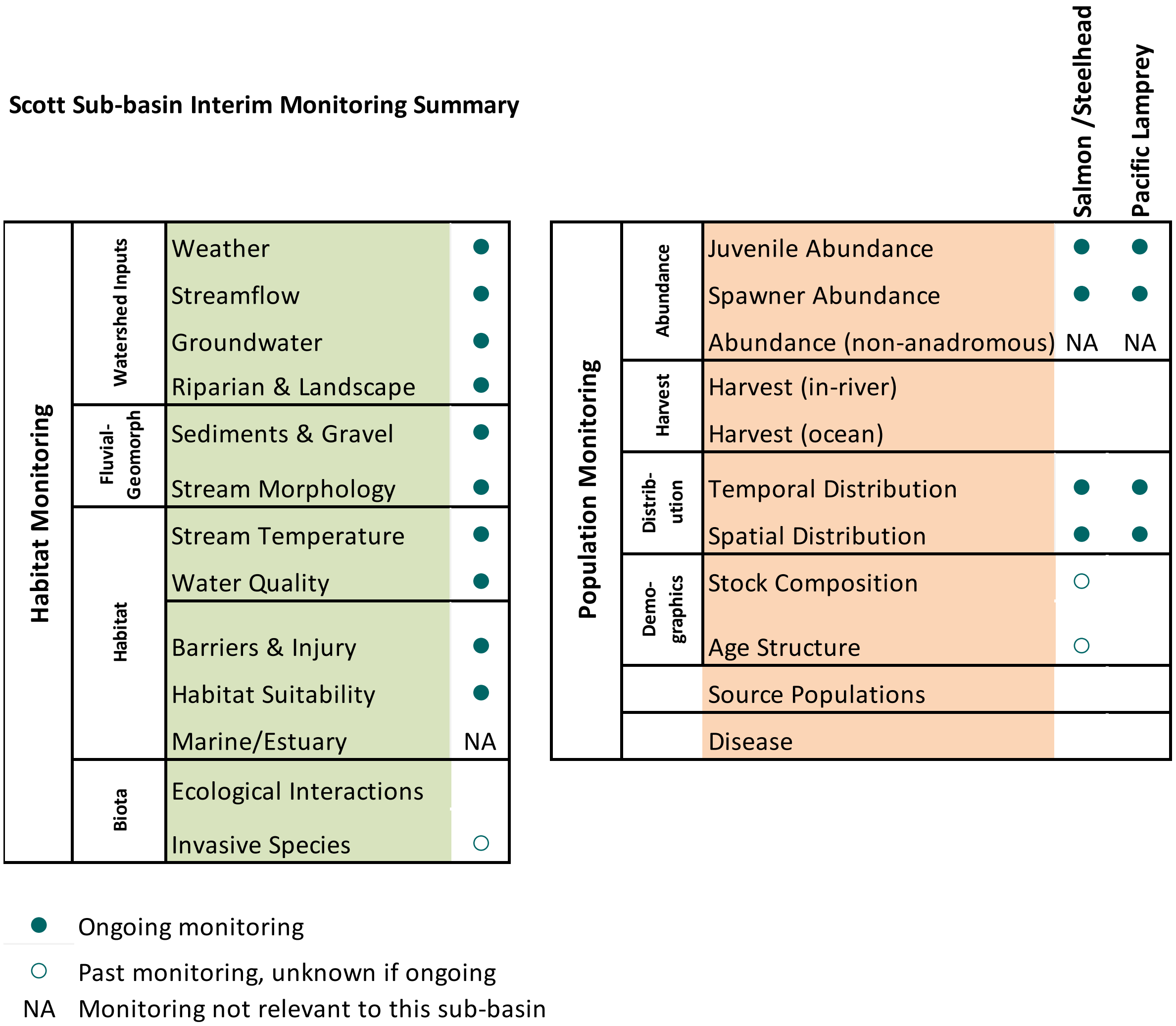
[10] The Conditional Waiver of Waste Discharge Requirements is particularly relevant as it drives most of the on-the-ground TMDL compliance on ranches and requires site-specific effectiveness monitoring from those properties where Grazing and Riparian Management Plans are required to guide the implementation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



Scott Sub-basin Interim Monitoring Summary

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

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

●	Ongoing monitoring
○	Past monitoring, unknown if ongoing
NA	Monitoring not relevant to this sub-basin

Figure 3.8. 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 Management Plans

Existing plans and initiatives important for watershed management in this sub-basin include:

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)

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)

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.

- Scott River Watershed Council and Siskiyou Resource Conservation District

  Per California's Sustainable Groundwater Management Act (SGMA) signed into legislation in September 2014, the Scott sub-basin is required to develop a Groundwater Sustainability Plan (GSP) by January 31, 2022, that will assess the current and projected future conditions of the basins, and will establish management and monitoring activities and long-term goals (Siskiyou County 2019). The initial notification for development of this plan has been issued and development is ongoing.

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.

Watershed Inputs Restoration Actions

1. Acquire water rights to increase instream flow in key reaches
2. Expansion of oversight by watermasters
3. Winter flooding of agricultural land to promote groundwater recharge.
4. Improve irrigation efficiency
5. Reduce physical barriers preventing fish access to thermal refugia
6. Manage grazing strategies, fence, and plant riparian areas to improve stream shading and reduce water temperatures
7. Pursue road upgrades and decommissioning at high-priority sites of roadside erosion to reduce excess sediment inputs

Sub-basin Wide Activities

⑨ ⑩ ⑪

Habitat Restoration Actions

9. Increase abundance of beavers and /or beaver dam analogues
10. Construct off channel-ponds, alcoves, backwater habitat, and oxbows
11. Placement of instream structures including large woody debris and boulders to provide cover for rearing salmonids

Fluvial Geomorphic Restoration Actions

8. Assess and remove, setback, or reconfigure levees and dikes to restore channel form and floodplain connectivity

IMPORTANT CAVEAT: The sub-basin profiles and the initial lists of candidate restoration and monitoring actions contained in this section represent an early draft. The information is based on previous workshop discussions and cited literature. The candidate restoration actions that are identified herein will be further refined and prioritized in the next phase of work.

3.3.5 Salmon Sub-basin

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. 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 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 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. Key Species

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

B. Key Stressors

Table 3.27: 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.

C. Key Restoration & Monitoring Actions:

Table 3.28: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups across the Salmon sub-basin in rough order of importance, with more important actions addressing underlying watershed processes listed first.

KS	No.	Identified Restoration Actions to Reduce Stressors
Restore Natural Fire Regime	1	**<u>Action:</u>** Upland vegetation management to re-establish 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. **<u>Monitoring:</u>** Monitoring the frequency, size and intensity of fires is the key metric for evaluating the effectiveness of these actions. Fires over 40 acres have been mapped since 1911, current data resolution is 1:24,000 and is based on remote sensed data. The WKRP describes treatment specific implementation, effectiveness, and validation requirements.

KS	No.	Identified Restoration Actions to Reduce Stressors
Channelization & Habitat Complexity (mesohabitats)	2	**Action:** Floodplain enhancement and mine tailing remediation. Address historical mining impacts in riparian areas. Activities may include removing or setting back tailings piles, providing soil where 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). This action is related to riparian restoration (Action #6) and increasing channel complexity (Action #3). **Monitoring:** This is a multi-phase project with plans to incorporate rigorous project level effectiveness monitoring.
	3	**Action:** Increase channel complexity. Construct 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 Action #2. Because these projects may also involve instream structure placement and riparian restoration, this action is also related to Action #4 and Action #6. **Monitoring:** SRRC habitat enhancement projects include a minimum of two-years of post-project effectiveness monitoring. The SRRC, USFS, and USFWS are working to secure funding for longer term effectiveness monitoring.
	4	**Action:** 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. 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. **Monitoring:** SRRC habitat enhancement projects include two-years of post-project effectiveness monitoring.
Water Temperature	5	**Action:** 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. **Monitoring:** Extensive water temperature and flow data are collected particularly for cold-water tributaries. These monitoring data are a requirement of the TMDL and provide critical feedback to landscape level actions including ongoing protection of riparian areas as well as related actions: Action #1 and Action #6.

KS	No.	Identified Restoration Actions to Reduce Stressors
	6	**Action:** Riparian habitat restoration. The TMDL requires that the Salmon River "be managed for increasing vegetation cover and increasing vegetation height within the riparian zones". Riparian vegetation provides shade, thus 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 temperature, but also for instream habitat and is related to Action 4. 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. **Monitoring:** Extensive water temperature and flow data are collected. These monitoring data are a requirement of the TMDL and provide critical feedback to landscape level actions (Action #1 and Action #6). In addition, project level implementation and effectiveness monitoring will be implemented by the SRRC to evaluate the site level effectiveness of riparian habitat restoration.

Sources for restoration actions: NMFS 2014; Salmon River sub-basin Restoration Strategy (Elder et al.); Salmon River TMDL Implementation Plan; Salmon River Restoration Council; Sub-regional working group survey responses; Western Klamath Restoration Partnership.

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

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

The federally listed Southern Oregon/Northern California Coast Evolutionarily Significant Unit of ***Coho Salmon*** are the driving force behind restoration actions in the Salmon sub-basin, as in other parts of the mid and lower Klamath basin (NMFS 2014). 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 while the review process unfolds. The Salmon River hosts the last remaining viable wild population of spring-run Chinook in the Klamath basin. Fall- and spring-run ***Chinook Salmon***, sspring/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 [ds1204]). 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 3.4). 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 3.29: 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.	●	●	●	○	
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 fishes 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

Adult population counts of spring Chinook and summer steelhead have occurred annually since 1995 in an effort coordinated by the SRRC and USFS, with cooperation from and participation by local tribes, NOAA Fisheries, CDFW, MKWC, and community volunteers. The fact that juveniles originating from other sub-basins may rear in the lower reaches of the Salmon presents a potential complication in interpreting presence or abundance of juveniles. The SRRC, in coordination with the Klamath National Forest and the Karuk Tribe, has 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 implementation of the Salmon River sub-basin Restoration Strategy and the Klamath National Forest Land and Resource Management Plan, which were both named in the Salmon TMDL implementation plan. Each of these plans includes a section on monitoring and the 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.

Major Data Gaps:

Figure 3.9 provides a high-level, 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 has been incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. Further investigation will be required to confirm the utility of the current data available to help answer key monitoring questions for the Salmon sub-basin (i.e., species relevance, spatial and temporal extent, data quality) and isolate any existing monitoring gaps. The most obvious population data gap is with respect to Pacific Lamprey and 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 salmonid populations as well as for 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.

Recent and Forthcoming Management Plans

Existing plans and initiatives important for watershed management in this sub-basin include:

Whole Basin

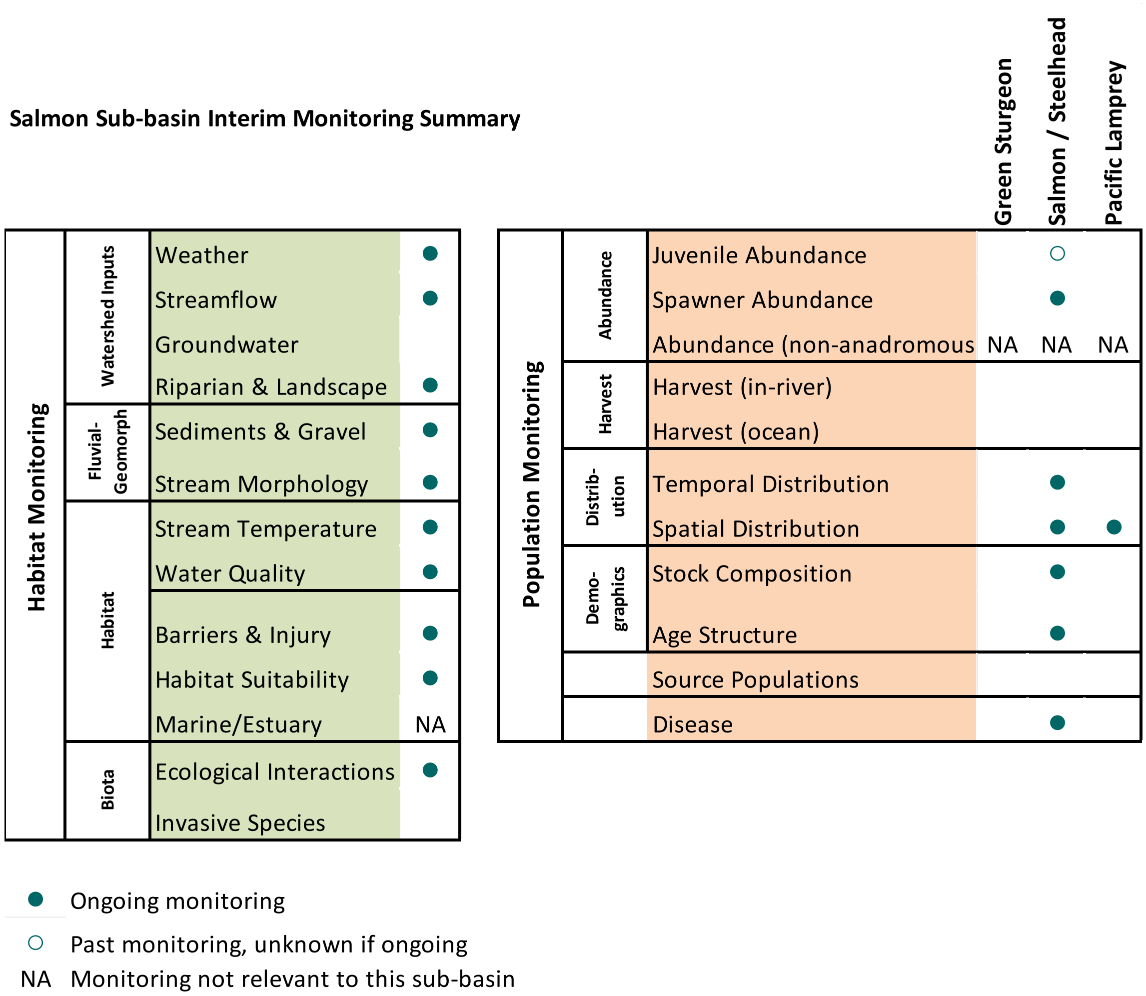
- Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (SONCC) (National Marine Fisheries Service, Arcata, CA, 2014)
- Recovery Strategy for California Coho Salmon (CDFW 2004)

Regional 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)

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 Sub-basin Interim Monitoring Summary

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

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

● Ongoing monitoring

○ Past monitoring, unknown if ongoing

NA Monitoring not relevant to this sub-basin

Figure 3.9. 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.

- 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 River's 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.

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

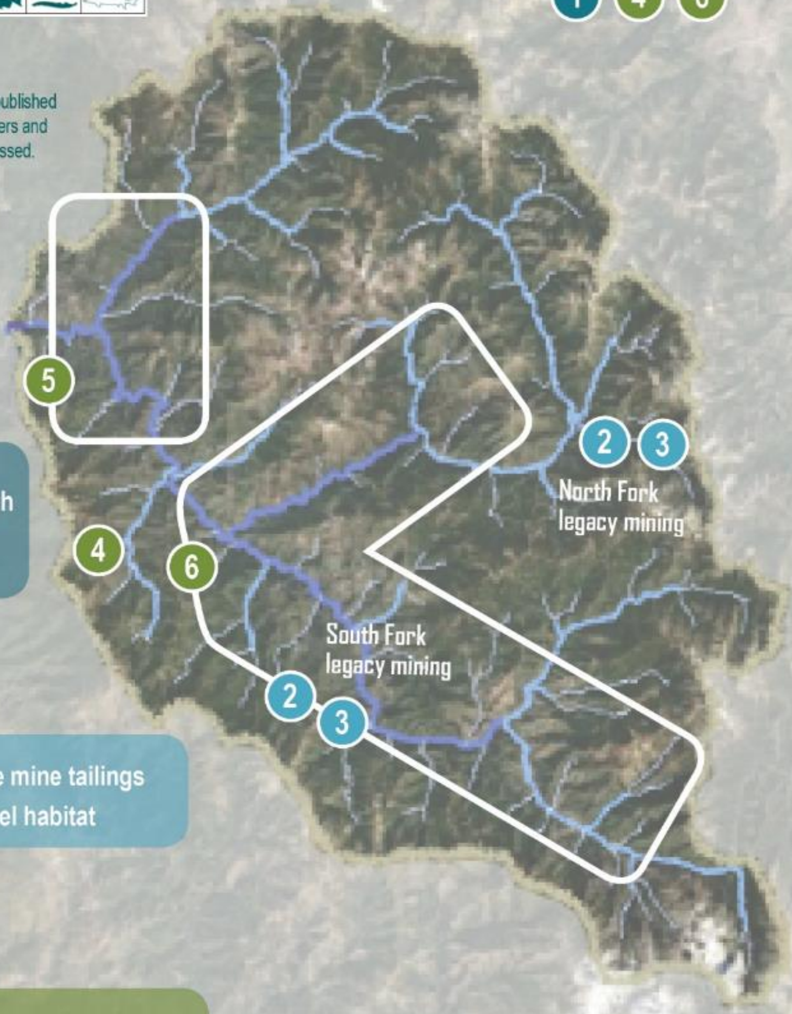
Key Stressors	Focal Species				
	CO	CH	ST	PL	GS
Channelization	●	●	●	●	
Fine Sediment Retention	○	○	○	●	○
Water Temperature	●	●	●	●	●
Instream Structural Complexity	●	●	●	●	○

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. A variety of restoration efforts have occurred to re-establish a natural fire regime, however this remains a priority. More recent restoration efforts focus on instream or riparian habitat enhancement.

Sub-basin Wide Activities

① ④ ⑥



Watershed Inputs Restoration Actions

1. Restore natural fire regime through fuel reduction, prescribed burns, and managed wildfire

Fluvial Geomorphic Restoration Actions

2. Enhance floodplain and remediate mine tailings
3. Reconnect or construct off-channel habitat

Habitat Restoration Actions

4. Increase instream complexity
5. Protect and enhance existing cold water refugia
6. Restore riparian areas to reduce water temperature

3.4 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 fishes in the sub-region (Vanderkooi et al. 2011) but can be prone to excessive fine sediment loading due to erosive soils and the heavy logging activity and associated high road densities in the area (Stanford et al. 2011). 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 fishes (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 in turn reduce the size of the estuary's saltwater wedge, decrease overall salinity, and subsequently increase water temperatures in the estuary to levels detrimental to outmigrating 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, courtesy of the BLM.

Table 3.30: 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					
	6.2.3 Fine sediment retention			X	X	X	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
	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::::::

3.4.1 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 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.

A. Key Species

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

B. Key Stressors:

Table 3.31: 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 major dams in both the upper 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).			●	●	●	○
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 fishes (Vanderkooi et al. 2011).	●	●	●	●	●	●

Stressors identified from: NMFS 2014; Yurok Tribal Environmental Program, Sub-regional working group survey responses.

C. Key Restoration & Monitoring Actions:

IMPORTANT CAVEAT: Restoration actions identified below do not constitute an official federal agency position or obligation for current or future action, or funding.

Table 3.32: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups within the Lower Klamath River sub-basin (including the Klamath Estuary) in rough order of importance, with more important actions addressing underlying watershed processes listed first.

KS	No.	Identified Restoration Actions to Reduce Stressors
Klamath River Flow Regime	1	**Action:** Remove upstream Klamath mainstem dams (would be undertaken in MUK sub-region) to improve lower Klamath River fish habitat (McEwan et al. 1996, NMFS 2014, Caltrout State of Salmonids Report 2017). **Monitoring:** Lower basin river surface elevation can be monitored by a tidal gage maintained by the Yurok Tribal Environmental Program in the Klamath River Estuary.
	2	**Action:** Adaptively manage releases from Klamath mainstem dams (while they remain in place) (action to be undertaken in MUK sub-region) to restore natural flow regimes. Also manage in combination with releases from Lewiston Dam (as part of the Trinity River Restoration Program), to improve lower Klamath River fish habitat conditions (McEwan et al. 1996, NMFS 2014, Caltrout State of Salmonids Report 2017). **Monitoring:** Lower basin mainstem flows can be monitored by a USGS stream flow gage currently maintained in the lower Klamath River upstream of Resighni Rancheria and surface water elevations by a tidal gage maintained by the Yurok Tribal Environmental Program in the Klamath River Estuary.
Instream flows (tributaries)	3	Action: 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 thru cut banks to help recharge the mountain aquifers and help boost base flow (Yurok Tribe communication). Additionally implement base flow restoration techniques such as full outslope/recontour of decommissioned roads and installing beaver dam analogues (BDA) to help promote increased base flows and thus increased cold water inputs; **Monitoring:** Lower basin flows can be monitored by a number of flow/water temperature gages maintained by the Yurok Tribal Environmental Program in key lower river tributaries.
Sediment Inputs	4	**Action:** Prioritize and implement upland road decommissioning in Lower Klamath River tributaries to reduce sediment delivery impacts (from both fine and coarse grained materials) (especially for Waukell, Ah Pah, Surpur, Blue, McGarvey, Hoppaw, Mynot, Hunter, Terwer, and Tarup creeks) (McEwan et al. 1996; Fesenmeyer et al. 2013; as noted by participants at IFRMP Workshop 2018). Additionally prioritize and implement wood loading activities (i.e. install constructed/engineered log jams and whole tree materials) in Lower Klamath River tributaries to help meter, sort, and slow the delivery of channel stored coarse and fine sediment resulting from legacy and existing land use (e.g. timber harvest). **Monitoring:** Agency gages for monitoring of sediment inputs and transport processes in key Lower Klamath River sub-basin tributaries to supplement the existing sediment gages currently maintained in sections of the lower Klamath River and key streams (i.e., McGarvey, Tewer, and Blue Creeks and within the Klamath Estuary) maintained by the Yurok Tribal Environmental Program and by the Resighni Rancheria.
Water Temperature	5	**Action**: Restrict forest harvest in remaining undisturbed areas to maintain water temperatures and protect important salmonid spawning tributaries (McEwan et al. 1996). **Monitoring:** Lower basin water temperatures can be monitored by a USGS stream flow/temperature gage currently maintained in the lower Klamath River upstream of Resighni Rancheria and by a number of water temperature gages maintained by the Yurok Tribal Environmental Program in key lower river tributaries and in the Klamath River Estuary, the Green Diamond Resource Company also has multiple water temperature gages in the lower river below

KS	No.	Identified Restoration Actions to Reduce Stressors
		the confluence with Hunter Creek (although access to this data is restricted); and GIS-based assessments of extent of past/ongoing forest harvest across the Lower Klamath River sub-basin.
	6	**Action**: Mechanical restoration / reconnection of thermal refugia in lower Klamath streams 303d listed for temperature (Fesenmeyer et al. 2013) (as noted by participants at IFRMP Workshop 2018) **Monitoring:** The Yurok Tribal Environmental Program currently maintains water temperature gages in a number of key lower river tributaries which could be supplemented as needed for broader monitoring coverage. Yurok Fisheries staff also conduct summer monitoring of thermal refugia across the Lower Klamath River sub-basin where in addition to monitoring water temperature, staff complete periodic surveys that note use of refuge areas by juvenile and adult salmonids.
	7	**Action:** Remove feral cattle and 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). **Monitoring:** The Yurok Tribal Environmental Program currently maintains water temperature gages in a number of key lower river tributaries which could be supplemented as needed for broader monitoring coverage. Yurok Fisheries staff also conduct summer monitoring of thermal refugia across the Lower Klamath River sub-basin where, in addition to monitoring water temperature, staff complete periodic surveys that note use of refuge areas by juvenile and adult salmonids.
Contaminated Sediment	8	**Action:** Restrict dredging or other bottom disturbing activities on the lower Klamath river mainstem and disposal of any dredged materials, especially during fish spawning periods. **Monitoring**: Requires agency compliance monitoring of any restrictions on lower river activities that could disturb mainstem river bottom substrates; Monitoring of contaminants (e.g., metals, pesticides, herbicides) in the lower river and estuary to supplement Yurok Tribal Environmental Program's current network of gages.
Habitat Conditions	9	**Action:** Restore floodplain connectivity and create off channel habitats in the lower Klamath River, Terwer, Klamath Glen, Salt, High Prairie, Hunter, Mynot, Hoppaw, Waukell, Blue, and Ah Pah Creeks (SONCC Recovery Plan, NMFS 2014; Beesley 2017, Yurok Tribe communication) **Monitoring:** Yurok Tribe's Lower Klamath Division of Fisheries (YTFP-LKD) fish habitat assessments in restored off channel areas in the estuary and key lower basin tributaries.
	10	**Action:** Install complex wood jams in mainstems, side channels, and off channel ponds in Klamath River and all anadromous lower river tributaries (especially Waukell, Ah Pah, Surpur, Blue, McGarvey, Hoppaw, Mynot, Hunter, Terwer, and Tarup Creeks) (SONCC Recovery Plan, NMFS 2014; Beesley and Fiori, 2016). **Monitoring:** Yurok Tribe's Lower Klamath Division of Fisheries (YTFP-LKD) fish habitat assessments in restored lower basin tributaries.
	11	**Action:** 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) **Monitoring:** Yurok Tribe's Lower Klamath Division of Fisheries (YTFP-LKD) fish habitat assessments where BDA's have been installed in lower gradient lower basin tributary streams.
	12	**Action:** Remove non-native estuary vegetation such as Reed Canary Grass from Salt, Panther, and Waukell Creeks and plant riparian trees (i.e.in Salt, Panther, Hunter, Tewer, and Blue Creeks) (Yurok Tribe communication). **Monitoring:** Yurok Tribe's Lower Klamath Division of Fisheries (YTFP-LKD) fish habitat assessments for areas of the estuary where non-native species have been removed and within lower river tributaries where riparian vegetation has been planted.

D. 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 fishes as nursery and rearing habitat.

The federally listed Southern Oregon/Northern California Coast Evolutionarily Significant Unit of ***Coho Salmon*** are the driving force behind many restoration actions in the lower Klamath (NMFS 2014). The Yurok Tribal Fisheries Program (YTFP) has a major focus on restoring mainstem, estuary, and associated off-estuary 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 and implement meaningful and 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 3.33: 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, Terwer, and McGarvey Creeks (Beesley and Fiori 2018, Beesley and Fiori 2012, 2013a,b,c; Gale 2009, Gale 2008, Yurok Tribal Fisheries Program 2010).	●	●	●	○		
The Yurok Tribe has recently implemented riparian habitat restoration along Terwer, 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 Tribe's Lower Klamath Division of Fisheries (YTFP-LKD) (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 River Basin, which includes both habitat and population monitoring. Since the late 1990s, the Yurok Tribe's Lower Klamath Division of Fisheries (YTFP-LKD) has conducted comprehensive watershed and physical habitat assessments to guide watershed restoration and species recovery efforts in the Lower Klamath River. 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, YTFP-LKD 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. In addition to monitoring water temperature, staff 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 gages in several lower Klamath tributaries.

Major Data Gaps:

Figure 3.10 provides a high-level, 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[11]) on monitoring projects has been incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. Further investigation will be required to confirm the utility of the current data available to help answer key monitoring questions for the Lower Klamath River sub-basin, including the Klamath Estuary (i.e., species relevance, spatial and temporal extent, data quality), and isolate any existing monitoring gaps. 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.

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[11] 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 Interim Monitoring Summary

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

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

●	Ongoing monitoring
○	Past monitoring, unknown if ongoing
NA	Monitoring not relevant to this sub-basin

Figure 3.10. 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 Management Plans

Existing plans and initiatives important for watershed management in this sub-basin include (ESSA 2017 Ch 2.4, Appendix K):

- 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)
- 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. Klamath, CA, Beesley, S. and R. Fiori. 2008)
- Restoration Planning in Lower Blue Creek, Lower Klamath River: Phase I (Yurok Tribal Fisheries Program. Klamath, CA, Beesley, S. and R. Fiori. 2008b)
- 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)

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. 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).

Lower Klamath River Sub-basin

Sub-Basin Summary

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 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.

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	●	●	●	●	●	●

Restoration Summary

Major focus in the sub-basin has been on process-based restoration projects that maintain, enhance, or create lower mainstem, estuary, and associated off-estuary habitats. Such projects include road decommissioning and erosion control, upslope and riparian restoration, instream and floodplain fish habitat restoration and enhancement, and barrier modification.

Sub-basin Wide Activities

③ ④ ⑤ ⑥

Watershed Inputs Restoration Actions

1. Remove Klamath River mainstem dams*
2. Manage Klamath River dam releases in coordination with TRRP releases from Lewiston Dam on the Trinity River
3. Implement base flow restoration techniques (e.g., cutbank removal, road recontouring, BDAs) to improve instream flows
4. Implement upland road decommissioning in areas with high fine sediment input, transport, and storage

Fluvial Geomorphic Restoration Actions

6. Mechanically restore and reconnect thermal refugia in lower Klamath streams 303d listed for temperature
9. Restore floodplain connectivity and create off channel habitats in the Klamath River Estuary and lower river tributaries

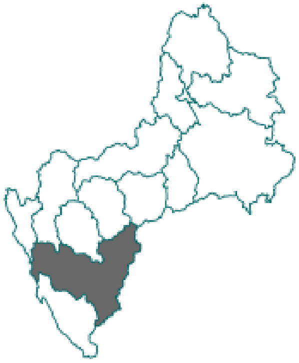
Habitat Restoration Actions

5. Restrict forest harvest to maintain water temperatures
7. Remove feral cattle and plant riparian vegetation to protect riparian habitats that provide cooling shade.
8. Restrict dredging/bottom disturbing activities on the lower Klamath River
10. Install complex wood jams in Klamath mainstem and tributary side channels and off channel ponds
11. Install BDAs in lower gradient streams
12. Remove non-native estuary vegetation and plant native riparian trees

*Note: The final decision on dam removal is contingent on pending Federal Energy Regulatory Commission (FERC) deliberations

IMPORTANT CAVEAT: The sub-basin profiles and the initial lists of candidate restoration and monitoring actions contained in this section represent an early draft. The information is based on previous workshop discussions and cited literature. The candidate restoration actions that are identified herein will be further refined and prioritized in the next phase of work.

3.4.2 Trinity Sub-basin



The Trinity 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 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 a period of 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 mobilize sediment also resulted in significant changes to habitat including channelization and a loss of floodplain and off-channel habitat (USFWS and HVT 1999). In addition to the dams, there were 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). The Shasta-Trinity National Forest 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 portion of the sub-basin and recreational activities such as rafting and fishing are prevalent in the upper portion of the sub-basin (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 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. Use of the reservoir in this manner depends on maintaining a sufficient volume of water and may be threatened if there are too many dry years in a row.

A. *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

B. Key Stressors

Table 3.34: 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 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	●	●	●	●	●

Key Stressors	Tier	Stressor Summary for the Trinity Sub-basin	Species				
			GS	CH	CO	ST	PL
		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 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.

C. Key Restoration & Monitoring Actions:

IMPORTANT CAVEAT: Restoration actions identified below do not constitute an official federal agency position or obligation for current or future action, or funding.

Table 3.35: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups across the Trinity sub-basin in rough order of importance, with more important actions addressing underlying watershed processes listed first.

KS	No.	Identified Restoration Actions to Reduce Stressors
TR Mainstem Flows	1	**Action:** Implement adaptive management of the Trinity River flows from the Trinity and Lewiston Dams within 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. 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. **Monitoring:** Flow in the mainstem Trinity River below the dams can be monitored from numerous USGS flow gages located on the mainstem river from Lewiston down river to Hoopa. There is also an active USGS flow gage on the Trinity River above the dams near Coffee Creek.
Instream Flows	2	**Action:** Improve flow timing or volume by identifying and ceasing unauthorized water diversions. **Monitoring**: Tributary stream flows within the Trinity sub-basin can be monitored from active USGS flow gages located on Rush Creek, Grass Valley Creek, Indian Creek, and North Fork Trinity. There are also currently inactive flow gages throughout sub-basin tributaries providing a wealth of historical baseline information dating back as far as 1911 in some cases.
	3	**Action:** Improve flow timing or volume by improving regulatory mechanisms, improving water management techniques and developing/implementing plans to reduce effects of marijuana cultivation. **Monitoring:** Tributary stream flows within the Trinity sub-basin can be monitored from active USGS flow gages located on Rush Creek, Grass Valley Creek, Indian Creek, and North Fork Trinity. There are also currently inactive flow gages throughout sub-basin tributaries providing a wealth of historical baseline information dating back as far as 1911 in some cases.
	4	**Action:** Provide funding for the Weaverville Community Services District to use the Trinity River for their summer water supply instead of East/West Weaver Creek (TTRP, Weaverville Community Services District, 5 Counties Salmonid Conservation Program). **Monitoring:** Establish a gauge on Weaver Creek for seasonal flow monitoring.
Channelization and Complexity	5	**Action:** Undertake actions to reconnect the channel to the floodplain by removing levees and constructing off-channel habitats, backwater habitat, and old stream oxbow in the Trinity River mainstem and in key tributary streams. The TRRP takes the lead on this within in the upper 40 miles of river below Lewiston Dam, undertaking a total of 47 planned channel rehabilitation projects in this area as mandated by the ROD. **Monitoring**: Effectiveness monitoring of channel rehabilitation sites along the river is undertaken by TRRP partner agencies.
	6	**Action:** Increase instream complexity through addition of LWD, boulders, or other instream structures to the mainstem and key tributary streams.

KS	No.	Identified Restoration Actions to Reduce Stressors
		Monitoring: Effectiveness monitoring of stream rehabilitation projects undertaken in the sub-basin would be undertaken by various agencies in the sub-basin.
Anthropogenic Barriers	7	**Action:** Provide for fish passage at Lewiston and Trinity Dams. **Monitoring:** Evaluations of fish passage success at the Trinity and Lewiston dams (if provided for) would be expected to be undertaken by staff with the USBR as the manager of the facilities. Monitoring of distribution and condition of passed fish would be undertaken by various agencies in the sub-basin.
	8	**Action:** 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.) **Monitoring:** Monitoring of fish passage improvements in tributaries could be undertaken by contractors for Trinity County, USFS staff with the Shasta-Trinity National Forest, or other TRRP partner agencies.
Coarse Sediment Supply	9	**Action**: Increase availability of spawning gravels to the river through direct gravel augmentation. The TRRP adds gravel to the river at several locations in the Trinity River above the confluence of Weaver Creek. Below Weaver Creek, it is thought that tributaries provide sufficient gravel to river processes. The overall TRRP restoration strategy is to restore a balance between coarse sediment supply and coarse sediment transport using high flows and mechanical gravel introduction. **Monitoring:** The TRRP monitors both coarse and fine sediment transport at four Trinity mainstem sampling locations, constituting one of the most comprehensive datasets of its kind in existence.
Fine Sediment	10	**Action:** Reduce delivery of fine sediment to streams through road deactivation and sediment abatement through watershed restoration actions. **Monitoring:** The TRRP monitors both coarse and fine sediment transport at four Trinity mainstem sampling locations, which could be supplemented through a broader network of sediment sampling on key streams.
Water Temperature	11	**Action:** Reduce water temperatures and increase dissolved oxygen in tributary streams by taking actions to increase stream flow. **Monitoring:** Numerous water temperature loggers are maintained in the Trinity River and in tributary streams across the sub-basin by various TRRP partner agencies (i.e., USFWS, USFS, Hoopa Valley Tribe, USBOR).

Sources for restoration actions: NMFS 2014; Trinity River Restoration Program website (http://www.trrp.net/); Sub-regional working group survey responses.

D. 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 driving force behind 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 below the depensation threshold. ***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 Trinity River, particularly within the 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 3.36: 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 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	○	●	●	●	○

Key Restoration Activities in the Upper Klamath Sub-basin to Date	Species Benefiting				
	GS	CO	CH	ST	PL
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 and carcass tag-recovery, and juvenile salmonid and non-salmonid trap monitoring in the Trinity River. The USFWS also funds project effectiveness monitoring which has included assessment of the effects 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, adult fall-Chinook harvest). The TRRP's Physical Work Group monitors sediment transport processes in the Trinity River during the spring flow release at four mainstem sampling locations. Bed scour and bed mobility monitoring is also conducted by the group 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).

Major Data Gaps:

Figure 3.11 provides a high-level, 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 has been 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 placed 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.

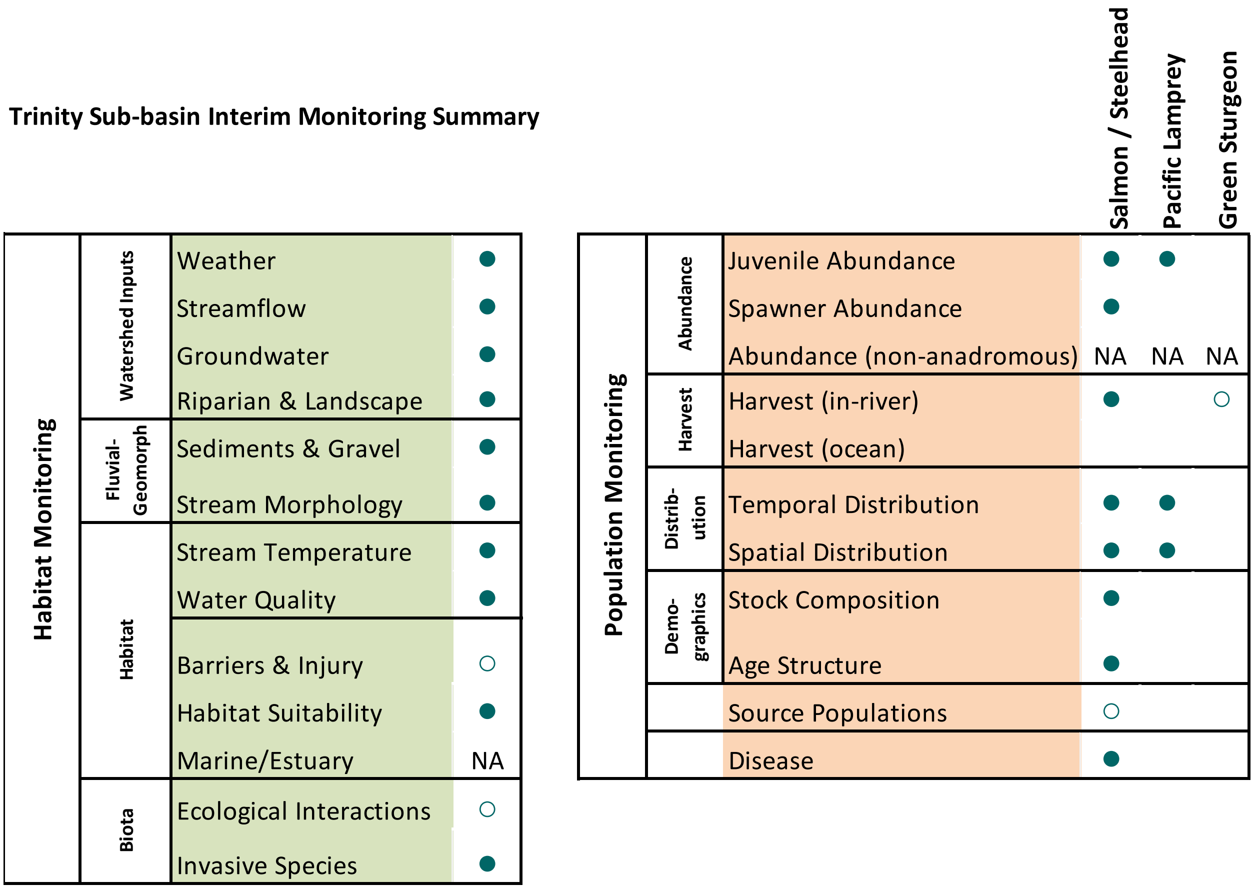
A great deal of data is available for salmonids in the Trinity sub-basin, although there are gaps in information on ecological interactions and hatchery impacts There is a deficiency of information related specifically to Green Sturgeon and Pacific Lamprey populations in the sub-basin.

Recent and Forthcoming Management Plans

Existing plans and initiatives important for watershed management in this sub-basin include:

- 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).

Trinity Sub-basin Interim Monitoring Summary



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

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

● Ongoing monitoring

○ Past monitoring, unknown if ongoing

NA Monitoring not relevant to this sub-basin

Figure 3.11. 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.

- Klamath Basin Water Quality Monitoring Plan (KBMP 2016)
- Water Quality Control Plan Hoopa Valley Indian Reservation (Hoopa Valley Tribe 2008)
- 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/

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.

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		○	○	○	

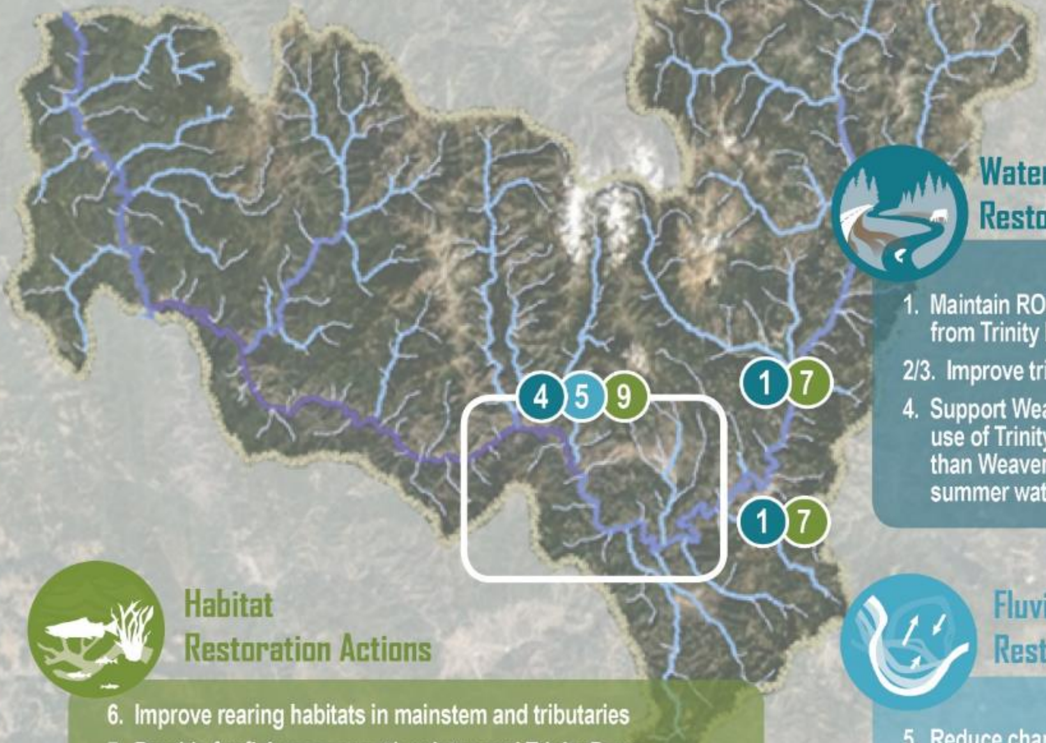
Restoration Summary

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. Other major actions include major watershed restorations to reduce fine sediment inputs to the mainstem river and tributaries.

Sub-basin Wide Activities

2 3 10

6 8 11



Watershed Inputs Restoration Actions

1. Maintain ROD-mandated flows from Trinity River dams

2/3. Improve tributary flows

4. Support Weaverville CSD for use of Trinity River rather than Weaver Creek for their summer water supply.

Habitat Restoration Actions

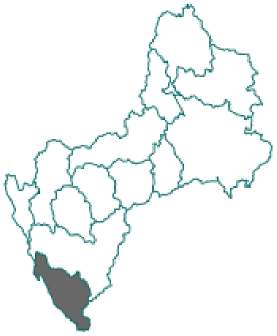
6. Improve rearing habitats in mainstem and tributaries
7. Provide for fish passage at Lewiston and Trinity Dams
8. Remove fish barriers in tributary streams
9. Increase salmon spawning habitat in the mainstem
11. Reduce water temperatures by improving insream flow (via # 2/3)

Fluvial Geomorphic Restoration Actions

5. Reduce channel confinement and reconnect floodplains in the mainstem

10. Reduce fine sediment inputs

3.4.3 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 so that nearly 70 percent of the South Fork Trinity is under federal protection. 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.

A. Key Species

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

B. Key Stressors:

Table 3.37: 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 summer low flows lead to elevated water temperatures and a constriction of summer rearing habitat (NMFS 2014)		●	●	●	●

Key Stressors	Tier	Stressor Summary for the South Fork Trinity Sub-basin	Species				
			GS	CH	CO	ST	PL
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 derisions, 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 a 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 throughout the sub-basin and could potentially block a significant amount of 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 pose a very high threat to juvenile Coho (NMFS 2014).	●	●	●	●	●

Stressors identified from: NMFS 2014; WRTC 2016; Sub-regional working group survey responses.

C. Key Restoration & Monitoring Actions:

Table 3.38: Identified restoration actions to reduce key stressors affecting focal fish species/functional groups within the South Fork Trinity sub-basin in rough order of importance, with more important actions addressing underlying watershed processes listed first.

Ks	No.	Identified Restoration Actions to Reduce Stressors
Instream Flows	1	**Action:** 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). Through its relationship to fish passage and water quality, this action is also related to Actions #7 and #9. **Monitoring:** Surface flow in the lower South Fork Trinity River can be monitored at gages currently maintained by the USGS and the Watershed Research and Training Center (WRTC) on the river below Hyampom. This network of flow gages could be supplemented as needed for more complete coverage or for targeted streams. The WRTC also has flow gages on multiple tributary streams in the upper part of the sub-basin (i.e., Smoky Creek, Salt Creek, Hayfork Creek, Big Creek, Tule Creek)
	2	**Action:** 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). **Monitoring:** The WRTC has recently established multiple flow gages on Hayfork Creek itself as well as on several nearby tributaries (i.e., Smoky Creek, Salt Creek, Big Creek, Tule Creek).
	3	**Action:** 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). **Monitoring:** Surface flow in the lower South Fork Trinity River can be monitored at gages currently maintained by the USGS and the Watershed Research and Training Center (WRTC) on the river below Hyampom. This network of flow gages could be supplemented as needed for more complete coverage or for targeted streams. The WRTC also has flow gages on multiple tributary streams in the upper part of the sub-basin (i.e., Smoky Creek, Salt Creek, Hayfork Creek, Big Creek, Tule Creek).
Fine Sediment Inputs	4	**Action:** Reduce delivery of sediment to streams by assessing and reducing mass wasting hazards by stabilizing slopes and revegetating vulnerable areas. **Monitoring:** While there has been a history of sediment monitoring in sub-basin by the USFS, there does not appear to be any gages in place currently. Development of a network of gages in the mainstem and key tributaries would be valuable for tracking effectiveness of sediment reduction actions.
	5	**Action:** 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. **Monitoring:** While there has been a history of sediment monitoring in the sub-basin by the USFS, there does not appear to be any gages in place currently. Development of a network of gages in the mainstem and key tributaries would be valuable for tracking effectiveness of sediment reduction actions.

Ks	No.	Identified Restoration Actions to Reduce Stressors
	6	**Action:** Reduce delivery of fine sediment to streams by improving grazing practices and fencing livestock out of riparian areas. **Monitoring:** While there has been a history of sediment monitoring in the sub-basin by the USFS, there does not appear to be any gages in place currently. Development of a network of gages in the mainstem and key tributaries would be valuable for tracking effectiveness of sediment reduction actions.
Water Temperature/Dissolved Oxygen	7	**Action:** 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. **Monitoring:** Water temperatures in the sub-basin can be monitored through temperature loggers currently maintained in key tributary streams throughout the sub-basin by the USFS (Grouse Creek, Salt Creek, Carr Creek) and the WRTC (Salt Creek, Hayfork Creek, East Fork Hayfork Creek, Tule Creek, Carr Creek).
	8	**Action:** Develop and implement plans to reduce water temperatures and increase dissolved oxygen by increasing flows in sub-basin tributary streams. **Monitoring:** Water temperatures in the sub-basin can be monitored through temperature loggers maintained at different points in the South Fork Trinity mainstem by the USFS and in key tributary streams throughout the sub-basin by the USFS (Grouse Creek, Salt Creek, Carr Creek) and the WRTC (Salt Creek, Hayfork Creek, East Fork Hayfork Creek, Tule Creek, Carr Creek).
Instream Structural Complexity	9	**Action:** Increase habitat complexity in key tributary streams by adding LWD, boulders, and/or other instream structures and constructing such features as off-channel habitats, alcoves, backwater habitats, and old stream oxbows. **Monitoring:** Habitat response to restoration actions could be monitored using standard fish habitat monitoring protocols by USFS with the Shasta–Trinity National Forest and/or Yurok Tribe technical staff.
Anthropogenic Barriers	10	**Action:** 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. **Monitoring:** Monitoring of fish passage improvements in the South Fork Trinity could be undertaken by contractors for Trinity County or by USFS staff with the Shasta–Trinity National Forest.
Fish Entrainment (juveniles)	11	**Action:** 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. **Monitoring:** Monitoring of the benefits of diversion screening in the South Fork Trinity could be undertaken by contractors for Trinity County or by USFS staff with the Shasta–Trinity National Forest.

D. 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 driving force behind 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 notable long-term declines in the Basin. The South Fork Trinity sub-basin which once supported large runs of Coho and both spring and fall Chinook is considered to hold vast potential for restoration and wild salmonid recovery. Spring Chinook in particular is of additional conservation concern as the South Fork Trinity once had runs of over 10,000 a year. Counts of spring Chinook have been less than 50 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 decommissioning, 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 to work 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 3.39: 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 discharge records dating back to 1965. This represents the only continuous discharge data for the river. Historically, the USGS gaged 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.

Major Data Gaps:

Figure 3.12 provides a high-level, 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[12]) on monitoring projects has been incorporated into an Integrated Tracking Inventory Excel spreadsheet internal to the project. Further investigation will be required to confirm the utility of the current data available to 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 gages in the sub-basin for monitoring of sediment inputs/transport processes.

Recent and Forthcoming Management Plans

Existing plans and initiatives important for watershed management in the South Fork Trinity sub-basin include:

- 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 - Klamath Watershed Management Area (CA NC RWQCB 2011)

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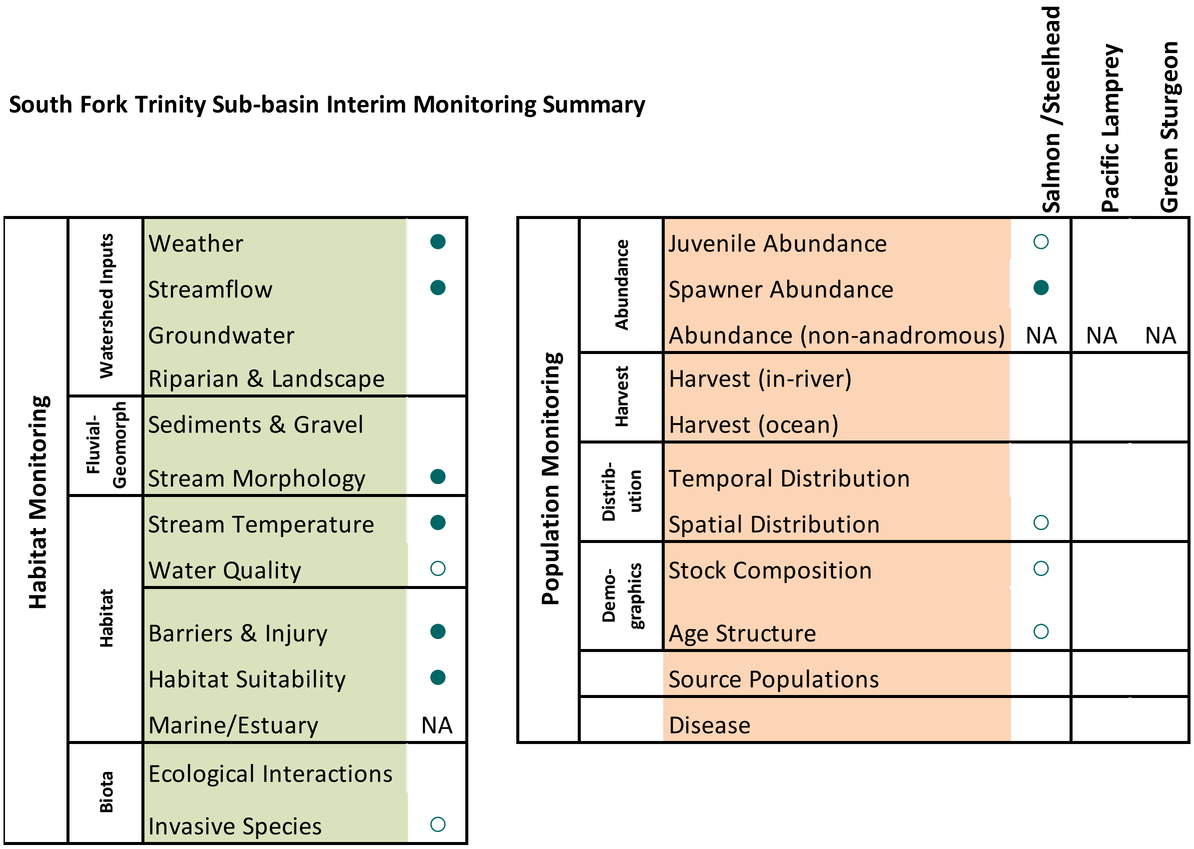
[12] Note that only some available information on past monitoring activities across sub-basins provides specific location information (i.e. beyond indicating that it occurs somewhere within a sub-basin) and can be found in existing spatially-referenced databases that would allow for reliable transfer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

- Recovery Strategy for California Coho Salmon (CDFW 2004)
- Trinity County Resource Conservation District programs (Watershed Management, Native Habitat Restoration, Forest Health, Agriculture) http://www.tcrcd.net/

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.



South Fork Trinity Sub-basin Interim Monitoring Summary

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

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

● Ongoing monitoring

○ Past monitoring, unknown if ongoing

NA Monitoring not relevant to this sub-basin

Figure 3.12. 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.

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

A major focus in the sub-basin has been on reducing stream diversions and increasing storage capacity/delivery capability for Ewing Reservoir. Other key actions include road decommissioning and other watershed restoration to reduce fine sediment inputs, protecting and enhancing thermal refugia in tributary streams, removing barriers to passage, and increasing habitat complexity by addition of LWD and other instream structures.

Watershed Inputs Restoration Actions

1. Improve flow timing and volume during critical low flow periods
2. Increase storage capacity/delivery for Ewing Reservoir in the Hayfork Valley
3. Slow flows to improve water storage and groundwater recharge on valley floors at higher elevations
4. Reduce fine sediment delivery through slope stabilization and vegetation management
5. Reduce fine sediment delivery by reducing road-stream conections and decomissioning roads where appropriate
6. Reduce fine sediment inputs by improving grazing practices and fencing streams

Sub-basin Wide Activities

1 3 4 5 6

7 8 9 10 11

Habitat Restoration Actions

7. Identify and protect existing and potential thermal refugia in tributaries
8. Implement plans to improve water temperatures and dissolved oxygen concentrationsprimarily by increasing instream flows in tributaries
9. Increase habitat complexity in the mainstem and tributary streams by adding LWD and other instream structures
10. Assess and remove fish passage barriers
11. Assess and provide fish screening at priority diversions

4 Methodology for Iterative Restoration Action Prioritization & Sequencing

IMPORTANT CAVEAT: This section contains a draft version of the prioritization approach and has not yet been piloted tested with local experts, practitioners and managers. The draft material outlined in this document will be further tested and refined in Phase 3 between late 2019 and 2020.

4.1 Overview

When developing a restoration plan encompassing an entire river basin, an organizing framework is necessary to prioritize the sequence[13] of restoration activities that will most effectively contribute to recovery of overall ecosystem function and target species (Beechie et al. 2008). Effective prioritization frameworks provide a **systematic, repeatable, and transparent rationale** for making restoration decisions given limited funding, capacity, and time (Beechie et al. 2008, Roni et al. 2013). Prioritization in this sense refers to the process of scoring or ranking potential restoration actions to determine the most beneficial sequencing to inform funding and implementation decisions, and to begin to logically group the top-tier of priority restoration actions into a coherent set of restoration packages (or portfolios).

The prioritization scores resulting from these efforts are not intended to be perfect definitive decisions but a logical starting point to help structure unbiased identification of restoration actions and to support management and stakeholder discussions. Moreover, restoration priorities are not static and must be iteratively revisited as pressures in different locations shift, natural disturbances unfold in different portions of the stream network and monitoring generates new information on the effectiveness of restoration actions, and available funding changes (Roni et al. 2013).

Structured prioritization frameworks help to clarify the decision-making process for funding agencies, proposal reviewers, project proponents, and other stakeholders that will be affected by these decisions, and facilitates iterative 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 alternatively by habitat type, but prioritization at smaller scales needs to be consistent with a basin-wide restoration strategy. Initiatives at a regional scale may take a multi-level approach involving prioritization across watersheds within a basin-wide strategy, followed by prioritization of projects within watersheds (Beechie et al. 2008, Roni et al. 2013). It is also common for overall restoration strategies to take into account or yield to urgent considerations such as actions to mitigate losses of critically endangered species or adjust to recent severe disturbances like wildfires. Iterative application of the prioritization approach described in this section provide opportunities to alter weighting schemes amongst criteria.

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[13] Prioritization is linked with the concept of sequencing. Restoration needs will change through time with the state of the system and through what is learned during monitoring and experimentation on the effectiveness of restoration actions (all indexed by CPI status) and, the priorities in future years will differ from priorities in prior years. Iterative application of the structured prioritization framework described in this section will generate a defined sequence of restoration actions through time.

Designing and implementing restoration measures is not only a scientific exercise but requires creativity and political-social endorsement. Prioritization systems inform a rational, neutral dialogue amongst rating committee members, managers and interested participants, but they are not a precise "computer formula" which replaces human decision-making. It is therefore very important that all rating/scoring steps are documented so that funding partners, those reviewing restoration projects, and those proposing the projects can easily understand the process and the process can be consistently repeated periodically.

4.2 Tiered Multi-Criteria Scoring Approach

After careful consideration of alternatives, we recommend that the Plan develop and use a **multi-criteria scoring approach**. The proposed tiered scoring approach we describe below is consistent with IFRMP SRWG member advice, and once tested and refined in Phase 3 of IFRMP development will provide managers with needed transparency and flexibility when comparing portfolios of restoration projects **at different scales**. The resultant prioritization scores should be viewed as **an initial method to encourage informed and consistent discussions** of the benefits, opportunities and risks of different strategies to improve fish habitat and stream function rather than a rigid list defining exactly what restoration must occur.

The 2-tiered approach to scoring IFRMP restoration projects is illustrated in Figure 4.1. Under this simple scoring model, those restoration projects deemed to have sufficient **breadth of potential benefits** through Tier 1 evaluation (if desired) may be advanced to Tier 2 cost and social consideration scoring. The end product from the prioritization method defined in this section is a "Master Rating Table" (a rank ordered list) for the appropriate spatial domain of interest (sub-basin, sub-region, entire basin). This Master Rating Table can be generated with or without reference/use of Tier 2 criteria.

The 2-tiered multi-criteria scoring approach described in this section will be tested, refined and applied during Phase 3 of IFRMP development in 2019-2020. This will uncover further refinements for how to improve the prioritization approach iteratively in future. Also note, the intention behind this prioritization method is that it be *iteratively applied every few years* as state of the system and social landscape changes over time. The priorities identified during IFRMP work in 2020 will not be accurate in 2024+.

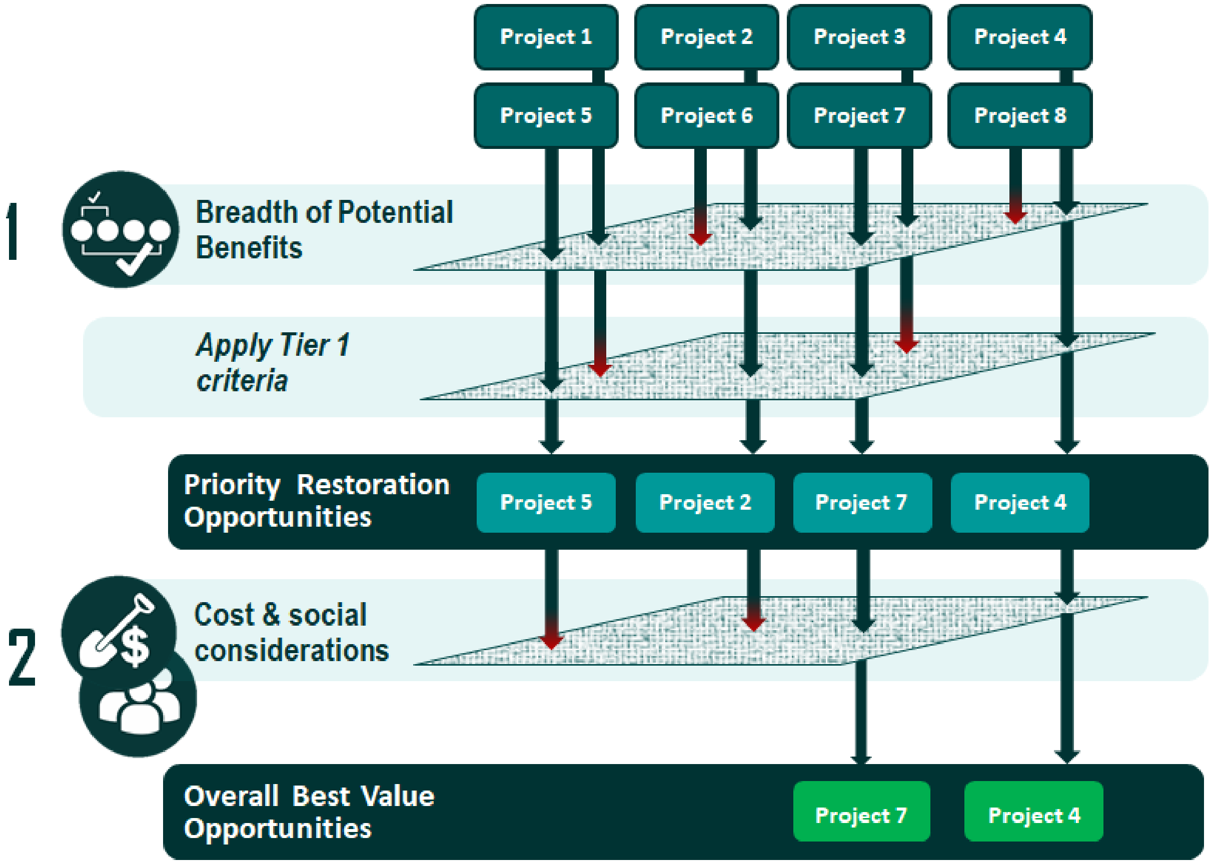

Figure 4.1. Conceptual representation of the 2-tiered approach to scoring and ranking IFRMP restoration projects. In practice projects are not "filtered out" but receive lower scores and drop to the bottom of ranked lists owing to low scores on one or more criteria. The highest ranked actions therefore would be the best value opportunities at that time.

Tier 1 criteria address the breadth of potential benefits for recovery, and involve combining and weighting **four criteria**:

1. No. of key stressors addressed by the proposed restoration project;
2. No. of objectives targeted by the proposed restoration project;
3. Multi-species benefit score associated with the proposed restoration project; and
4. Spatial scale of potential benefits & coincidence of restoration with critically designated / priority habitat.

These criteria are summarized in the Section 4.3 below.

Tier 2 involves identifying *scores* for **two criteria** (5) the level of collaborative buy-in & stewardship commitment and reporting but not "scoring" (6) the overall restoration comparison cost. Hence, cost is *not* used to influence the overall scores produced by the multi-criteria method (i.e., cheaper projects are not inherently favoured over expensive projects, and vice versa).

Instead, cost becomes a primary piece of "metadata" to list beside the scores for each proposed restoration action.
These two criteria are summarized in the Section 4.4 below.

It is important to understand that a low prioritization score for a project does *not* necessarily mean a project should *never* be implemented. For example, some projects may have greater benefit if implemented later in the restoration sequence after other tasks have already been completed, while in other instances *some* lower ranking projects may be implemented anyway because they are either easy to implement, less expensive or take advantage of ephemeral funding / cost-sharing opportunities. Landowner interest, professional judgment, opportunities created by scheduled maintenance or construction, and restoration emphasis in a particular watershed by multiple agencies or stakeholders must also be factored into final decisions.

4.3 Breadth of Potential Benefits for Recovery (Tier 1)

As described below, the breadth of potential benefits for recovery would be determined by scoring each proposed restoration action according to: (i) the number of key stressors addressed (ii) the number of objectives[14] it primarily addresses, (iii) scoring the number of Plan focal species that would most benefit and (iv) scoring the scale of potential benefits and coincidence of the restoration project location(s) with critically designated habitat.

4.3.1 Criterion 1.1: Weighted No. of Key Stressors Addressed

In watersheds, stream functions are interrelated and build on each other in a specific order, a **functional biophysical hierarchy** (Harman et al. 2012). Within this hierarchical framework, higher-level functions are supported by lower level functions, like a pyramid (Figure **4.2**). In the context of watershed restoration, these biophysical functions and processes should generally be addressed in the order shown (Harman et al. 2012). The overall concept exemplifies how the underlying physiochemical functions are important to support and fully realize the higher order biological functions (Beechie et al. 2010). The breadth of potential benefits is greater for restoration actions targeting key stressors at the lower pyramid tiers.

While this may seem obvious to some, Fischenich (2006) notes that efforts to restore streams are often ineffective because they fail to address the underlying processes that create and maintain the habitat and biological functions. Many aquatic restoration methodologies address biological indicators without adequately addressing the underlying processes and controls provided by watershed inputs, geomorphology, hydraulics and hydrology (Beechie et al. 2010, Somerville 2010 as cited in Harman et al. 2012).

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[14] Note: if the Technical Rating Committee or sub-basin teams believed that there was a strong degree of overlap between stressors and objectives, then either objectives could be excluded from the score, or the combined score for stressors and objectives divided by 2.

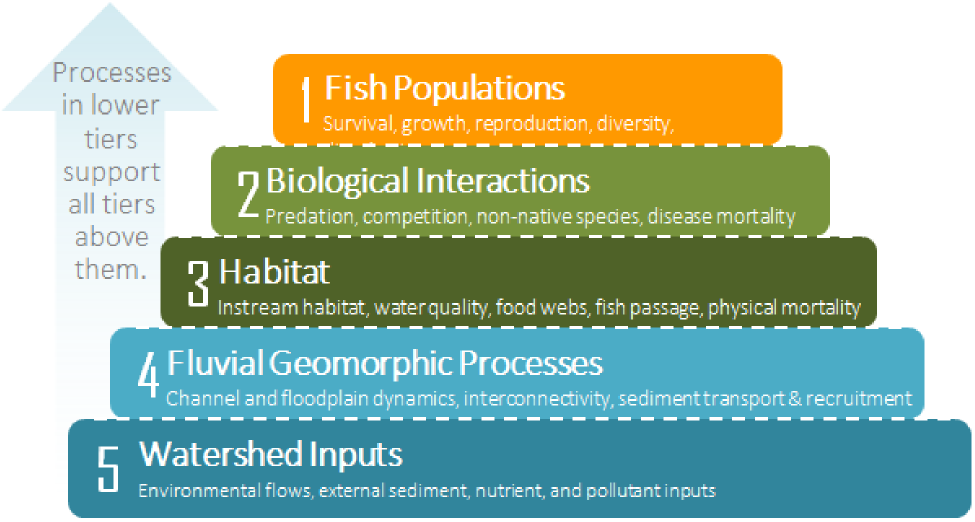

Figure 4.2. Representation of functional biophysical hierarchy illustrating the linkages between watershed inputs, fluvial geomorphic processes and attributes, habitat conditions, and the responses of aquatic biota (Harman et al. 2012). Cause-effect linkages cascade from the bottom of the figure to the top, with stressors acting either indirectly or directly on the yellow box at the top representing aquatic biota. Within this hierarchical framework, higher-level functions are supported by lower level functions, like a pyramid.

For each restoration project, the **Integrated Tracking Inventory and Scoring Tool** (described in section 4.6) assigns the restoration project to a restoration type (based on the Pacific Coastal Salmon Recovery Fund (PCSRF) Data Dictionary) and locates the number of key stressors addressed[15]. These stressors are further assigned to the primary biophysical tier in the hierarchy[16] (Figure 4.2). Informed by the current conditions of CPIs within these tiers in the location of interest, a Technical Rating Committee (or sub-basin and sub-regional teams) then assign a weight to the five biophysical tiers. This culminates in a score for the Weighted No. of Key Stressors Addressed (criterion 1.1) for each restoration project. As outlined later in section 4.6.1, this (and other) weighting decisions could be derived from results of participant choice surveys.

Later, as restoration and monitoring occurs and values for CPIs mapped to different biophysical tiers begin to improve, the weightings applied to the need for stressor reduction within the different tiers will likewise change. For example, if after several years of watershed input restoration in a particular sub-basin those conditions in that sub-basin indeed improve, the weighting factor for the future need for watershed input restoration may be reduced by the Technical Rating Committee (or sub-basin and sub-regional teams).

4.3.2 Criterion 1.2: Weighted No. of Objectives Targeted

For each restoration project, the **Integrated Tracking Inventory and Scoring Tool** locates the number of objectives targeted by the restoration project. The Technical Rating Committee (or sub-

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[15] Based on IFRMP conceptual model development work completed early in Phase 2.

[16] Where a project fits into more than one tier, scale and other considerations will need to be made to assign the project to a **primary** biophysical tier.

basin and sub-regional teams) then assign a weight to the importance of this criterion relative to criterion 1.1 and arrive at a weighted score for this criterion. Given the potential overlap between stressors addressed and objectives, we suggest taking the average value of criterion 1.1 and 1.2 and using this value when computing the total score. As outlined later in Section 4.6.1, this (and other) weighting decisions could be derived from results of participant choice surveys.

4.3.3 Criterion 1.3: Multi-species Benefit Score

Depending on the nature of the restoration project and the sub-basin it occurs in, the focal species principally benefitting will also vary. The **Integrated Tracking Inventory and Scoring Tool** will also be used to determine how the key stressors that each restoration project is believed to address relates to the different Plan focal species. These stressor x species counts are then subdivided into tercile ranges of high (3), medium (2), low (1) and null (0) to standardize species benefit scores. Optionally, depending on the location, the Technical Rating Committee (or sub-basin and sub-regional teams) may wish to assign a weight to the importance of different focal species. Hence, through the weighting preferences applied, the multi-criteria scoring approach is flexible to be tailored to emphasize multi-species benefits or to differentially value restoration actions that benefit one or a few Plan focal species.

The individual species scores are then summed, culminating in a Weighted Multi-species Benefit Score (criterion 1.3). As outlined later in Section 4.6.1, this (and other) weighting decisions could be derived from results of participant choice surveys.

4.3.4 Criterion 1.4: Spatial Scale of Potential Benefits & Coincidence of Restoration with Priority Habitat

The final Tier 1 criterion determines the expected spatial scale of benefit of each restoration action. Each restoration project is assigned a default score as follows:

1. **Site scale** restoration projects receive a score of 1
2. **Stream/tributary/lake scale** restoration projects receive a score of 2
3. Restoration projects anticipated to provide benefits **throughout a sub-basin** receive a score of 3
4. Restoration projects that provide benefits throughout the **entire basin** receive a score of 4.

Optionally, the Technical Rating Committee (or sub-basin and sub-regional teams) may wish to assign a weight to the importance of the scale of potential benefit. As outlined later in Section 4.6.1, this (and other) weighting decisions could be derived from results of discrete choice experiments.

The designation of critical habitat is a feature of endangered species protection laws in the United States and in several other countries. Definitions of priority or critical habitat differ, but generally are defined as habitat that is necessary for the survival or recovery of a target species (often threatened or endangered) that is identified as the species' required subset of habitat, resources and conditions needed to ensure the species persistence over the long term (Hall et al. 1997; Rosenfeld & Hatfield 2006; Camaclang et al. 2015). This criterion envisions identifying a set of areas vital to both listed and non-listed species (whether based on critical habitat designations or less formal designations).

In this manner, the Klamath Integrated Tracking Inventory and Scoring Tool can also take into consideration whether proposed restoration projects are targeting restoration of valuable current or historical habitats. This is accomplished by applying multipliers to the default (weighted) score for spatial scale of potential benefit based on the designation of the habitat where the restoration project occurs (Table 4.1). This culminates in a score for the Spatial Scale of Potential Benefits & Coincidence of Restoration with Priority Habitat (criterion 1.4).

Table 4.1. Proposed multipliers (modifiers) for criterion 1.4 – coincidence of restoration locations with priority habitat.

Category	Score
Considering the *primary* focal species targeted by the project and/or the *primary* (most limiting) stressors faced by this species in this location…	
Restoration project occurs within federally designated critical habitat	**2**
Restoration project occurs in historical (or current) habitat that is not designated	**1**
Restoration project does not occur in historical habitat (or habitat currently used by focal species)	**0**
Unknown (or not applicable)	**1**$^{\delta}$

$^{\delta}$ In practice, knowledge of the subsets of habitat needed to ensure species persistence over the long term is not always available.

4.4 Cost and Social Considerations (Tier 2)

Finite economic resources mean that restoration actions should be prioritized at least in part by consideration of economic costs alongside their overall scientific merit and benefits (Roni et al. 2013). Scoring the Tier 2 criteria defined in this section will only be required for the priority actions emerging from Tier 1 scoring.

4.4.1 Criterion 2.1 - Level of Collaborative Buy-in & Stewardship Commitment

Restoration projects can be ground to a halt due to opposition if decision-makers fail to recognize the importance of social considerations (Stinchfield et al. 2008). Identification of practical restoration opportunities frequently involves working with landowners, farmers, ranchers, duck club owners, anglers, and other stakeholders to adjust expectations on projects. Stakeholder participation is one important part of restoration planning because it increases the chances of buy-in, opportunity identification and long-term success.

The partnerships and community support for a restoration project is an important consideration for both project sponsors and funders. This includes working with the landowner and residents that may be affected and addressing their concerns. In particular, a key social consideration is landowner interest in a given restoration project when that project legally or administratively requires their support. Hence, projects with direct evidence of established collaboration between stakeholders and agencies with a high probability of long-term stewardship support may be given preference over single-party projects or projects that are built without a plan to support their longer-range maintenance.

We propose that the Technical Rating Committee (or sub-basin and sub-regional teams) ask restoration proponents to provide a score for the Level of Collaborative Buy-in & Stewardship Commitment (criterion 2.1); (Table 4.2).

Table 4.2. Proposed scoring scale for criterion 2.1 – level of landowner cooperation and stewardship commitment for the proposed restoration project.

Category	Score
Very low to negligible social resistance, high land access & 'implementability' owing to very high level of support/endorsement from private landowners, property abutters, or local, state or federal agencies that regulate essential dams / infrastructure. Stewardship commitment and collaboration for the project very likely to persist for many years.	5
Low social resistance, promising land access & 'implementability' owing to the high level of support/endorsement from private landowners, property abutters, or local, state or federal agencies that regulate essential dams / infrastructure. Stewardship commitment and collaboration for the project likely to persist for many years.	3
Moderate social resistance and constraints on land access owing to moderately low support/endorsement from private landowners, property abutters, or local, state or federal agencies that regulate essential dams / infrastructure. Stewardship commitment and collaboration for the project likely to persist for several years.	1
Very high social resistance, very low access to land/infrastructure owing to very low support/endorsement from private landowners, property abutters, or local, state or federal agencies that regulate essential dams / infrastructure. Stewardship commitment and collaboration for the project may persist during implementation and possibly 1 or 2 subsequent years.	0.5
Unknown/not provided (i.e., default score when information not available)	1
Not required/not relevant for the restoration project type	5

4.4.2 Criterion 2.2 - Overall Restoration Comparison Cost

Projecting costs of restoration projects that will occur in the future should be adjusted for inflation (e.g., using appropriate Price Indices / Federal Office of Management and Budget guidelines to account for the effects of inflation). The object is to remove cost changes that are attributable to future price movements, arriving at a real, or inflation-adjusted indicator in the year in which the future costs are projected to occur.

Restoration costs would be determined through two methods:

- Independently for high priority restoration packages determined as part of the Plan development process (Phase 3 and resources permitting, Phase 4). This will lead to a "snapshot" cost range for priority restoration packages.
- Iteratively, individual project costs would be submitted by restoration proponents. These would be used to update cost accounting lists. Asking proponents to provide this information is also prudent because costs for similar types of restoration projects can differ widely.

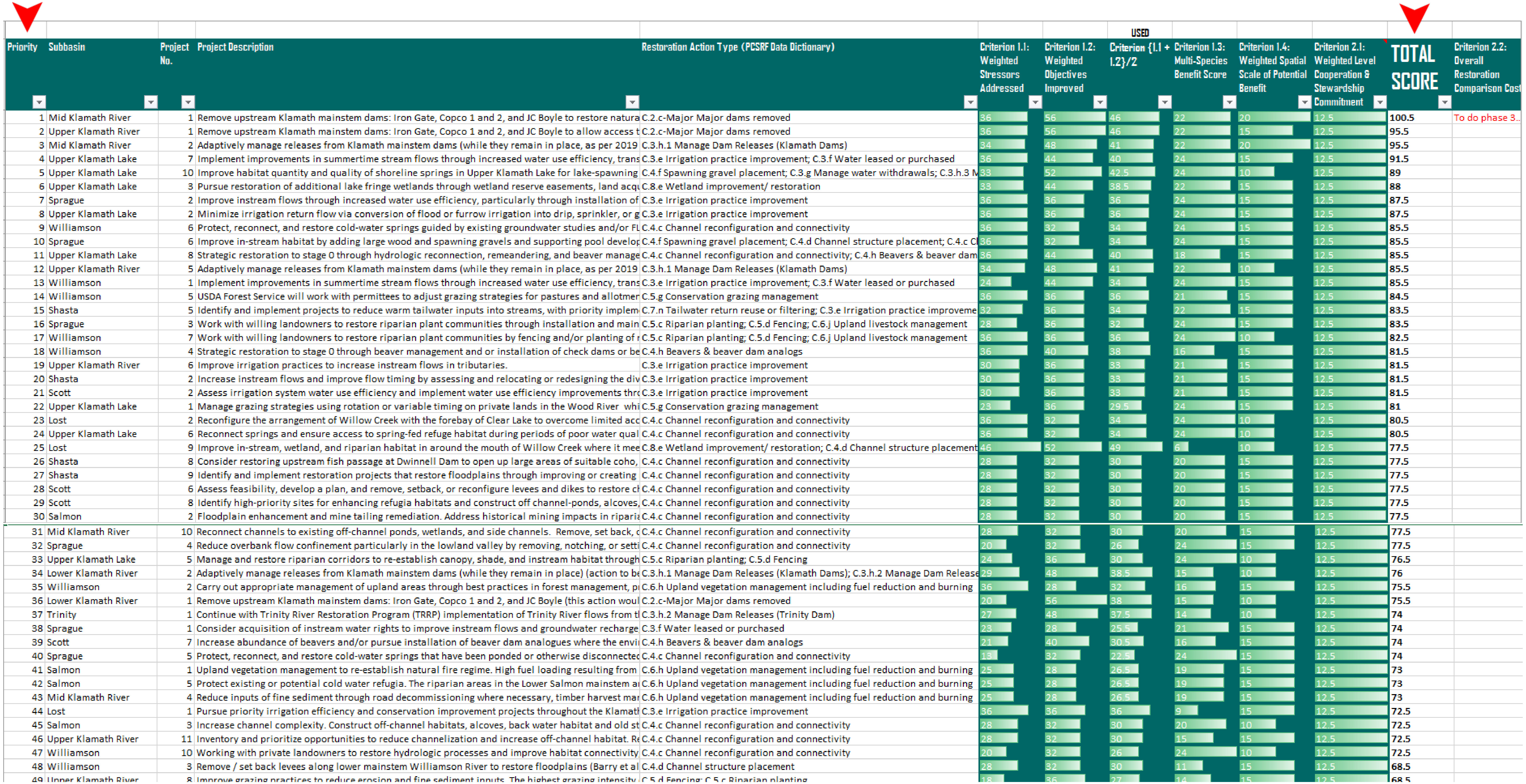
Costs of different restoration projects should include the cost of design, direct labor, materials, equipment, facilities, services, contingency costs (that address foreseeable risks) and the cost of necessary support staff. This includes all costs for staff performing *environmental compliance, permitting, contract management*, related administration, construction, etc. to carry out the initial construction/implementation of the restoration work. Note that the restoration comparison costs should seek to remove costs that ought to be supported via funding resources available to their project through existing statutory authorities and common appropriations. Combined, these costs are referred to as the **initial planning and implementation costs**.

The other cost component that should be sought *from restoration proponents* is an estimate of the **expected ongoing annual operation & maintenance costs** necessary to ensure that the restoration action continues to deliver its expected benefits. This would include monitoring costs for tracking status of CPIs. Pre-existing established monitoring programs that could be leveraged would not be included in costing for this purpose. This requires some thought with regards to the project's expected lifespan and over what period the restoration project requires an investment in operations or physical maintenance following initial implementation. For restoration actions that are considered permanent, a maximum value may need to be applied to enable cost comparisons (e.g., a period of 20 or 30 years).

Once the estimated costs for the major components of the restoration projects are summed, any **matching or "in-kind" cost sharing funds** provided by the project proponent and partners should be identified and subtracted, after applying any appropriate time-based discount or inflation adjustments. This will provide a final real-adjusted base-year or present value comparison cost.

If helpful, the overall restoration comparison cost can also be converted into an **annualized value** by dividing the total cost by the expected lifespan of the project.

This cost information could then be used as a secondary filter on the Tier 1 Master Rating Tables (i.e., secondary sorting component applied to products like Figure 4.3 in the previous section).



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Priority	Subbasin	Project No.	Project Description	Restoration Action Type (PCSRF Data Dictionary)	Criterion 1.1: Weighted Stressors Addressed	Criterion 1.2: Weighted Objectives Improved	Criterion {1.1 + 1.2}/2	Criterion 1.3: Multi-Species Benefit Score	Criterion 1.4: Weighted Spatial Scale of Potential Benefit	Criterion 2.1: Weighted Level Cooperation & Stewardship Commitment	TOTAL SCORE	Criterion 2.2: Overall Restoration Comparison Cost
1	Mid Klamath River	1	Remove upstream Klamath mainstem dams: Iron Gate, Copco 1 and 2, and JC Boyle to restore natura	C.2.c-Major Major dams removed	36	56	46	22	20	12.5	100.5	To do phase 3..
2	Upper Klamath River	1	Remove upstream Klamath mainstem dams: Iron Gate, Copco 1 and 2, and JC Boyle to allow access t	C.2.c-Major Major dams removed	36	56	46	22	15	12.5	95.5	
3	Mid Klamath River	2	Adaptively manage releases from Klamath mainstem dams (while they remain in place, as per 2019	C.3.h.1 Manage Dam Releases (Klamath Dams)	34	48	41	22	20	12.5	95.5	
4	Upper Klamath Lake	7	Implement improvements in summertime stream flows through increased water use efficiency, trans	C.3.e Irrigation practice improvement; C.3.f Water leased or purchased	36	44	40	24	15	12.5	91.5	
5	Upper Klamath Lake	10	Improve habitat quantity and quality of shoreline springs in Upper Klamath Lake for lake-spawning	C.4.f Spawning gravel placement; C.3.g Manage water withdrawals; C.3.h.3 M	33	52	42.5	24	10	12.5	89	
6	Upper Klamath Lake	3	Pursue restoration of additional lake fringe wetlands through wetland reserve easements, land acq	C.8.e Wetland improvement/ restoration	33	44	38.5	22	15	12.5	88	
7	Sprague	2	Improve instream flows through increased water use efficiency, particularly through installation of	C.3.e Irrigation practice improvement	36	36	36	24	15	12.5	87.5	
8	Upper Klamath Lake	2	Minimize irrigation return flow via conversion of flood or furrow irrigation into drip, sprinkler, or g	C.3.e Irrigation practice improvement	36	36	36	24	15	12.5	87.5	
9	Williamson	6	Protect, reconnect, and restore cold-water springs guided by existing groundwater studies and/or FL	C.4.c Channel reconfiguration and connectivity	36	32	34	24	15	12.5	85.5	
10	Sprague	6	Improve in-stream habitat by adding large wood and spawning gravels and supporting pool develo	C.4.f Spawning gravel placement; C.4.d Channel structure placement; C.4.c Cl	36	32	34	24	15	12.5	85.5	
11	Upper Klamath Lake	8	Strategic restoration to stage 0 through hydrologic reconnection, remeandering, and beaver manage	C.4.c Channel reconfiguration and connectivity; C.4.h Beavers & beaver dam	36	44	40	18	15	12.5	85.5	
12	Upper Klamath River	5	Adaptively manage releases from Klamath mainstem dams (while they remain in place, as per 2019	C.3.h.1 Manage Dam Releases (Klamath Dams)	34	48	41	22	10	12.5	85.5	
13	Williamson	1	Implement improvements in summertime stream flows through increased water use efficiency, trans	C.3.e Irrigation practice improvement; C.3.f Water leased or purchased	24	44	34	24	15	12.5	85.5	
14	Williamson	5	USDA Forest Service will work with permittees to adjust grazing strategies for pastures and allotme	C.5.g Conservation grazing management	36	36	36	21	15	12.5	84.5	
15	Shasta	5	Identify and implement projects to reduce warm tailwater inputs into streams, with priority implem	C.7.n Tailwater return reuse or filtering; C.3.e Irrigation practice improveme	32	36	34	22	15	12.5	83.5	
16	Sprague	3	Work with willing landowners to restore riparian plant communities through installation and main	C.5.c Riparian planting; C.5.d Fencing; C.6.j Upland livestock management	28	36	32	24	15	12.5	83.5	
17	Williamson	7	Work with willing landowners to restore riparian plant communities by fencing and/or planting of	C.5.c Riparian planting; C.5.d Fencing; C.6.j Upland livestock management	36	36	36	24	10	12.5	82.5	
18	Williamson	4	Strategic restoration to stage 0 through beaver management and or installation of check dams or be	C.4.h Beavers & beaver dam analogs	36	40	38	16	15	12.5	81.5	
19	Upper Klamath River	6	Improve irrigation practices to increase instream flows in tributaries.	C.3.e Irrigation practice improvement	30	36	33	21	15	12.5	81.5	
20	Shasta	2	Increase instream flows and improve flow timing by assessing and relocating or redesigning the div	C.3.e Irrigation practice improvement	30	36	33	21	15	12.5	81.5	
21	Scott	2	Assess irrigation system water use efficiency and implement water use efficiency improvements thr	C.3.e Irrigation practice improvement	30	36	33	21	15	12.5	81.5	
22	Upper Klamath Lake	1	Manage grazing strategies using rotation or variable timing on private lands in the Wood River whi	C.5.g Conservation grazing management	23	36	29.5	24	15	12.5	81	
23	Lost	2	Reconfigure the arrangement of Willow Creek with the forebay of Clear Lake to overcome limited acc	C.4.c Channel reconfiguration and connectivity	36	32	34	24	10	12.5	80.5	
24	Upper Klamath Lake	6	Reconnect springs and ensure access to spring-fed refuge habitat during periods of poor water qual	C.4.c Channel reconfiguration and connectivity	36	32	34	24	10	12.5	80.5	
25	Lost	9	Improve in-stream, wetland, and riparian habitat in around the mouth of Willow Creek where it mee	C.8.e Wetland improvement/ restoration; C.4.d Channel structure placement	46	52	49	6	10	12.5	77.5	
26	Shasta	8	Consider restoring upstream fish passage at Dwinnell Dam to open up large areas of suitable coho,	C.4.c Channel reconfiguration and connectivity	28	32	30	20	15	12.5	77.5	
27	Shasta	9	Identify and implement restoration projects that restore floodplains through improving or creating	C.4.c Channel reconfiguration and connectivity	28	32	30	20	15	12.5	77.5	
28	Scott	6	Assess feasibility, develop a plan, and remove, setback, or reconfigure levees and dikes to restore c	C.4.c Channel reconfiguration and connectivity	28	32	30	20	15	12.5	77.5	
29	Scott	8	Identify high-priority sites for enhancing refugia habitats and construct off channel-ponds, alcoves,	C.4.c Channel reconfiguration and connectivity	28	32	30	20	15	12.5	77.5	
30	Salmon	2	Floodplain enhancement and mine tailing remediation. Address historical mining impacts in riparia	C.4.c Channel reconfiguration and connectivity	28	32	30	20	15	12.5	77.5	
31	Mid Klamath River	10	Reconnect channels to existing off-channel ponds, wetlands, and side channels. Remove, set back,	C.4.c Channel reconfiguration and connectivity	28	32	30	20	15	12.5	77.5	
32	Sprague	4	Reduce overbank flow confinement particularly in the lowland valley by removing, notching, or setti	C.4.c Channel reconfiguration and connectivity	20	32	26	24	15	12.5	77.5	
33	Upper Klamath Lake	5	Manage and restore riparian corridors to re-establish canopy, shade, and instream habitat through	C.5.c Riparian planting; C.5.d Fencing	24	36	30	24	10	12.5	76.5	
34	Lower Klamath River	2	Adaptively manage releases from Klamath mainstem dams (while they remain in place) (action to b	C.3.h.1 Manage Dam Releases (Klamath Dams); C.3.h.2 Manage Dam Release	29	48	38.5	15	10	12.5	76	
35	Williamson	2	Carry out appropriate management of upland areas through best practices in forest management, p	C.6.h Upland vegetation management including fuel reduction and burning	36	28	32	16	15	12.5	75.5	
36	Lower Klamath River	1	Remove upstream Klamath mainstem dams: Iron Gate, Copco 1 and 2, and JC Boyle (this action woul	C.2.c-Major Major dams removed	20	56	38	15	10	12.5	75.5	
37	Trinity	1	Continue with Trinity River Restoration Program (TRRP) implementation of Trinity River flows from t	C.3.h.2 Manage Dam Releases (Trinity Dam)	27	48	37.5	14	10	12.5	74	
38	Sprague	1	Consider acquisition of instream water rights to improve instream flows and groundwater recharge	C.3.f Water leased or purchased	23	28	25.5	21	15	12.5	74	
39	Scott	7	Increase abundance of beavers and/or pursue installation of beaver dam analogues where the envi	C.4.h Beavers & beaver dam analogs	21	40	30.5	16	15	12.5	74	
40	Sprague	5	Protect, reconnect, and restore cold-water springs that have been ponded or otherwise disconnecte	C.4.c Channel reconfiguration and connectivity	13	32	22.5	24	15	12.5	74	
41	Salmon	1	Upland vegetation management to re-establish natural fire regime. High fuel loading resulting from	C.6.h Upland vegetation management including fuel reduction and burning	25	28	26.5	19	15	12.5	73	
42	Salmon	5	Protect existing or potential cold water refugia. The riparian areas in the Lower Salmon mainstem a	C.6.h Upland vegetation management including fuel reduction and burning	25	28	26.5	19	15	12.5	73	
43	Mid Klamath River	4	Reduce inputs of fine sediment through road decommissioning where necessary, timber harvest ma	C.6.h Upland vegetation management including fuel reduction and burning	25	28	26.5	19	15	12.5	73	
44	Lost	1	Pursue priority irrigation efficiency and conservation improvement projects throughout the Klamat	C.3.e Irrigation practice improvement	36	36	36	9	15	12.5	72.5	
45	Salmon	3	Increase channel complexity. Construct off-channel habitats, alcoves, back water habitat and old st	C.4.c Channel reconfiguration and connectivity	28	32	30	20	10	12.5	72.5	
46	Upper Klamath River	11	Inventory and prioritize opportunities to reduce channelization and increase off-channel habitat. Re	C.4.c Channel reconfiguration and connectivity	28	32	30	15	15	12.5	72.5	
47	Williamson	10	Working with private landowners to restore hydrologic processes and improve habitat connectivity	C.4.c Channel reconfiguration and connectivity	20	32	26	24	10	12.5	72.5	
48	Williamson	3	Remove / set back levees along lower mainstem Williamson River to restore floodplains (Barry et al	C.4.d Channel structure placement	28	32	30	11	15	12.5	68.5	
49	Upper Klamath River	8	Improve grazing practices to reduce erosion and fine sediment inputs. The highest grazing intensity	C.5.d Fencing; C.5.c Riparian planting	18	36	27	14	15	12.5	68.5	

Figure 4.3. *Unverified* illustration of Klamath Plan Integrated Tracking Inventory & Scoring Tool assisted multi-criteria scoring. Six (6) criterion scores are added together to produce a total score. As noted in text, various criteria can be weighted to reflect importance placed on stressor reduction within various biophysical tiers, objectives, focal species, and locations. Note: this is an illustration only and does NOT provide actual scores. Some scores include arbitrarily assigned values for demonstration purposes. In this example, criterion 2.1 has not been scored, and default value is used for all restoration projects listed.

4.5 General Metadata & Other Considerations

We recommend that the scoring tables/lists associated with this prioritization framework should also track a variety of fundamental metadata attributes, including:

- Name of the project
- Proponent and partner name(s)
- Location of project (e.g., map coordinates; centroid)
- Statement of goals, objectives and synopsis outlining the merit and rationale for the project[1]
- Whether the project is new or an application to extend/continue an existing/ongoing project
- Whether the proposed restoration project is a pilot study
- Name of the restoration technique
- Key species anticipated to benefit
- Description of risk and challenges that need to be overcome (e.g., landowner support)
- Foundational references and information sources that support the summary statements provided for the proposed restoration project

This metadata would be provided by restoration proponents/practitioners.

4.6 Klamath IFRMP Integrated Tracking Inventory & Scoring Tool

As part of developing the Plan an **Integrated Tracking Inventory and Scoring Tool** has been developed (Figure 4.4). This is a simple database system used to link restoration projects to restoration types (based on the Pacific Coastal Salmon Recovery Fund (PCSRF) Data Dictionary) and leverages our prior Plan development efforts on conceptual models along with input received from participant surveys and workshop activities to define interrelationships amongst stressors, objectives, CPIs and focal species benefitting. Using the Tool, it is possible to tally the number of stressors, objectives, and focal species each type of proposed restoration action will benefit and produce an initial ranking of anticipated overall benefits.

Within the Tool, additional criteria can be added to the initial list of broad benefit actions, including the anticipated **spatial scale of benefits** as well as "Tier 2" considerations such as level of **collaborative buy-in and overall costs** (described below). Importantly, the Tool has been developed to allow Technical Rating Committee members (or sub-basin and sub-regional teams) to adjust weights applied to different criteria, e.g., for restoration actions **targeting key stressors at specific biophysical tiers** (Figure 2.1).

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[1] Note: The Integrated Tracking Inventory tool developed to streamline completing elements of this prioritization scheme would include default mappings to classify the restoration action proposed, and the types of stressors, objectives and species it would primarily support. When submitting funding proposals, restoration proponents/practitioners could be asked to provide their stated beliefs about objectives and the rationale for the proposed project.

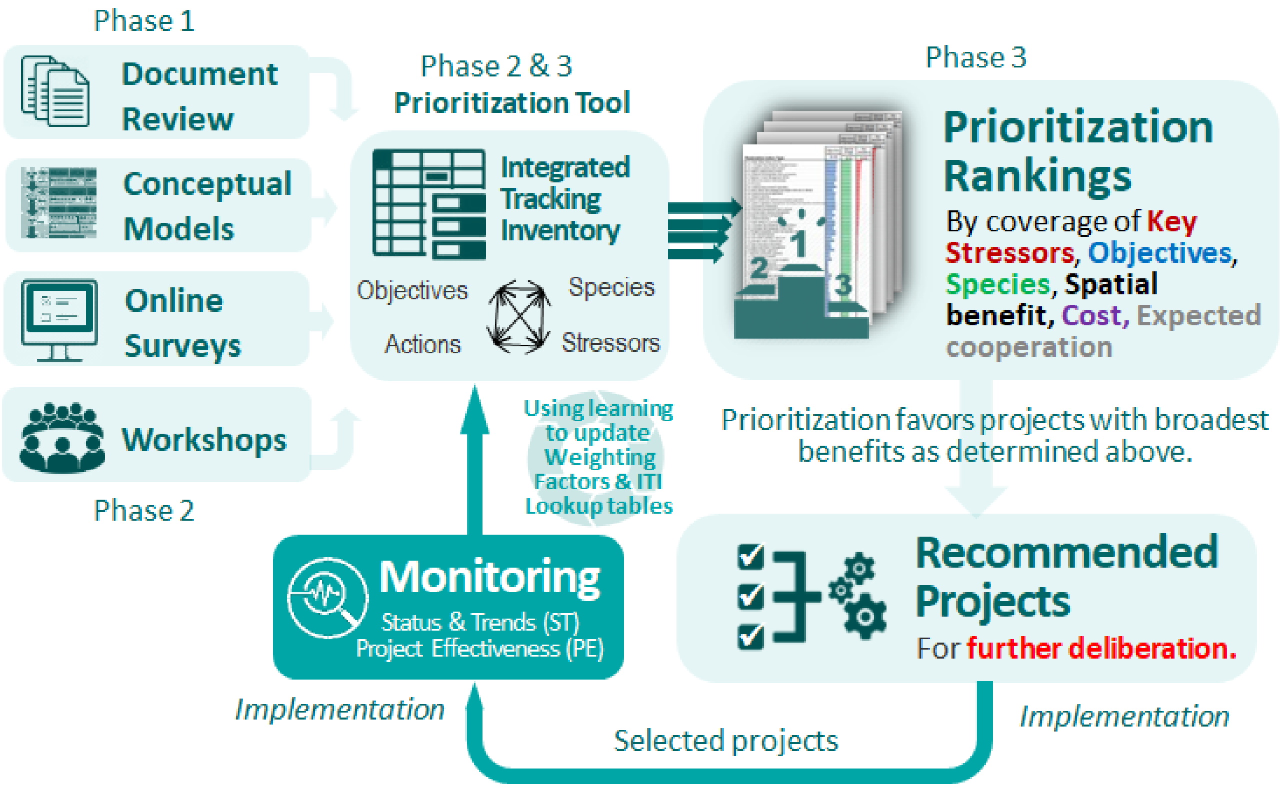


Figure 4.4. Klamath Basin Integrated Tracking Inventory & Scoring Tool and role in supporting iterative prioritization of restoration actions.

For example, by placing higher weights on actions that alleviate stressors operating at the watershed input and fluvial geomorphology levels, with weights for habitat in the middle, and the smallest weights on biological interactions and fisheries actions. In practice during implementation, **these weights would be informed by status of CPIs linked to the various biophysical tiers** (again, see Figure 2.1). These and other weighting factors chosen involve application of expert judgment and need to be agreed upon by **the Technical Rating Committee (or sub-basin and sub-regional teams).** In practice, this would include pilot testing and sensitivity analysis.

The resulting set of recommended restoration projects emerging from each iterative application of the Tool will provide a starting point for more focused expert deliberation by authorities responsible for selecting the best investments in restoration whether at sub-basin or sub-regional or basin-wide scales. However, while this Plan is intended to identify restoration priorities and guide coordination of restoration efforts across the entire Klamath River Basin, at this time no specific funds have been secured or allocated to support Plan implementation. As federal funding becomes available, the intention is that this Plan and the “living” prioritization approach described within would be iteratively applied to guide future funding decisions. However, projects identified in the IFRMP process are not binding on federal agencies and do not commit federal funding, or future federal funding, to specific restoration projects.

Lastly, the relationships defined in the Integrated Tracking Inventory & Scoring Tool would also need to be periodically updated based on the results of ongoing effectiveness monitoring and insights gained on key focal species stressors through adaptive learning.

4.6.1 Weighting Criteria & Conducting Iterative Prioritization

Responsibility for developing scoring systems included in the Integrated Tracking Inventory and Scoring Tool and developing appropriate weighting scenarios can be accomplished by working initially with focused experts (e.g., a **Technical Rating Committee**) and then subsequently eliciting weighting preferences from multiple interested participants (e.g., **sub-basin and sub-regional teams** of experts, proponents and managers). Typically, the Technical Rating Committee focuses on refining base scoring systems for the chosen criteria (e.g., ensuring restoration actions are properly linked to type/class of restoration project, and on linkages with stressors they reduce) while broader stakeholder groups are engaged to identify weighting preferences (e.g., whether in a given area actions for specific focal species will be weighted more highly than those for another). The most successful Technical Rating Committees typically include no more than 5–10 individuals with expertise in aquatic ecology, fluvial geomorphology, hydrology, and habitat restoration design and engineering (Roni et al. 2013). To preserve the integrity of the Committee, these individuals should not be directly or indirectly involved in carrying out the proposed restoration work.

A “broad participation” approach in establishing weighting preferences (or scenarios) builds on work done by the Technical Rating Committee but is more likely to generate support across a larger range of affected groups because it engages these groups directly in the prioritization process. Using this broader representative sample of individuals also helps ameliorate impacts of bias / conflicts when the people providing rating information are the same people proposing to do some of the restoration work and monitoring. ESSA’s experience has shown that supplementing Technical Rating Committee decisions with information supplied by a broader set of interested participants can be useful for developing weighting and scoring schemes with wide support.

An effective way of engaging these larger groups to incorporate broad participation includes use of survey-based methods. Web-based survey methods can be designed and deployed in facilitated meetings to develop weighting preferences that are representative of a broad audience (Nelitz and Beardmore 2017, Diederich et al. 2012). Many of these methods rely on quantitative techniques to analyze qualitative information such as individual preferences for topics such as weighting criteria (Stephenson 1953), which can also be statistically stratified into demographic groups. Survey methods that permit this sort of stratification (e.g., discrete choice experiments, Q-methodology) are useful for prioritization because they not only show how different participants rank various actions or decision criteria, but also they can isolate areas of general agreement.

For large regional settings like the Klamath basin, a multi-level approach will most likely be necessary (Roni et al. 2013), where first restoration projects within sub-basins are ranked and sequenced, then these priority sub-basin projects are compared within their broader functional sub-regions to determine the appropriate sequencing at the regional and basin-wide levels. **A critical step in Phase 3 of IFRMP development will be assembling sub-basin teams to refine base scoring systems, including the potential development and application of participant choice survey methods to inform weighting preferences/scenarios.**

4.7 Future Considerations

In the future, other considerations for restoration action prioritization and sequencing may be added to the approach described above. This could include tracking how many actions within an overarching class are *already* underway in a sub-basin or sub-region as well as the achievability/feasibility and time required for success. If the master Integrated Tracking Inventory were maintained, it would provide a practical means of determining whether restoration proponents are bringing forward proposals that are largely “in hand” in a given area or whether their proposal adds value to the existing portfolio of restoration activities. This may affect the opinion of Technical Rating Committees or sub-basin and sub-regional teams on how to iteratively prioritize future restoration projects.

During completion of the Plan as well as in future phases the Technical Rating Committee will be key to maintaining the **Integrated Tracking Inventory & Scoring Tool** (described above) and for generating associated restoration scores. These lists of IFRMP restoration priorities from the scoring method described above *will be “snapshots” in time.* These snapshots require iterative maintenance, review and updating every 2-3 years by the Technical Rating Committee, building on knowledge gained (including status of CPIs), adjusting to changing environmental conditions, and reflecting new innovations from restoration practitioners.

From an adaptive management perspective this kind of tracking would also support and link with effectiveness monitoring and learning to determine whether certain classes of restoration were or were not effective. Achieving learning objectives, especially in regard to resolving key uncertainties, could be a useful additional criterion to consider in choosing one project over another.

In practice, when applying for funding, **restoration proponents** could also be asked to submit certain kinds of key information on costing and other attributes of a restoration proposal that can be used to support some of the (Tier 2) criteria in the scoring system recommended here. This could also include requests to provide general input pertaining to factors such as the level of collaborative buy-in and stewardship commitment. In other words, *the total burden for sourcing information needed to complete scoring does not rest solely with a Technical Rating Committee (or sub-basin and sub-regional teams).*

Lastly, in the future, a Technical Rating Committee or sub-basin and sub-regional teams may also be called upon to participate during major proposal solicitations to support evaluators review short-listed applications.

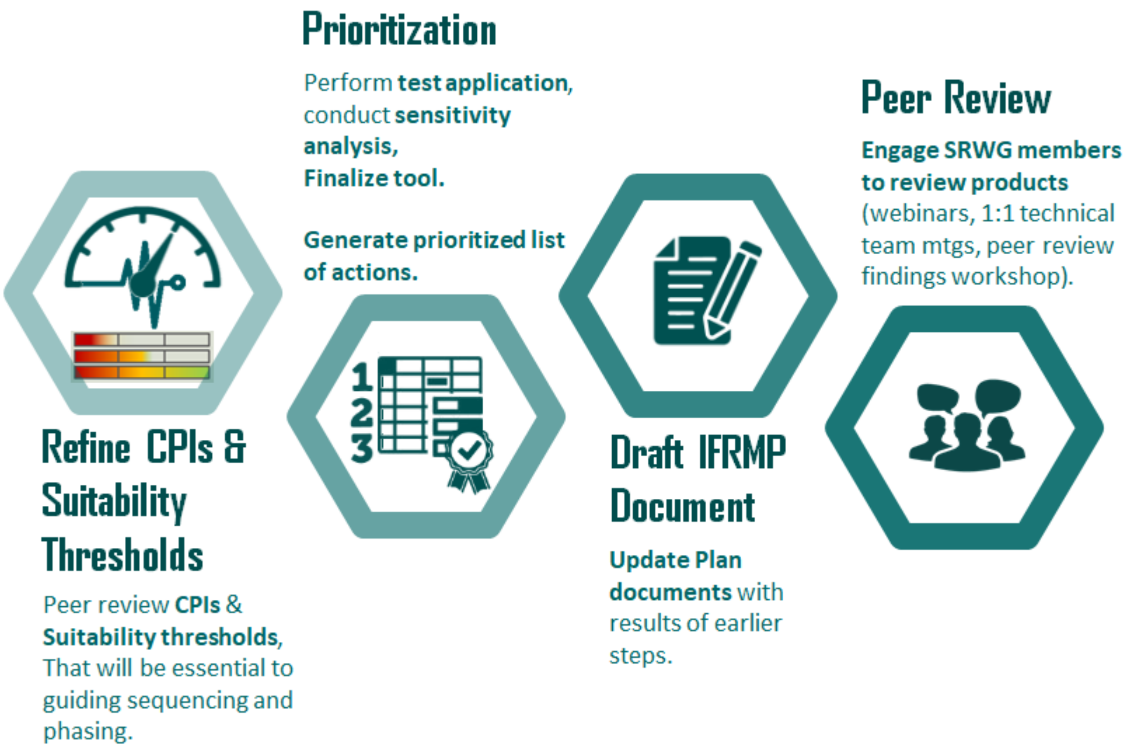
5 Recommended Future Steps

This Initial Draft Integrated Fishery Restoration and Monitoring Plan represents the 2nd of up to 4 proposed phases in the planning process. With additional funding for Phase 4 of Plan development through 2021, the Plan is expected to provide a blueprint that describes the highest priority habitat restoration and monitoring actions that can help managers learn about the most effective ways to reverse the declines of native Klamath Basin fisheries.

5.1 Overview of IFRMP Phase 3 (2019-2020)

Phase 3 of the Integrated Fisheries Restoration and Monitoring Plan development is currently anticipated to run from July 2019 to June 2020. Subject to available funding and direction from the FCG and PSMFC, the focus of Phase 3 may include:

- Peer reviewing and refining the CPIs proposed (Table 2.2) in Phase 3, with particular emphasis on confirming CPIs for the higher spatial scales as well as determining appropriate Suitability Thresholds to enable Plan implementers to iteratively sequence and phase priority restoration actions (see Sections 2.3, 2.4, 3.1).
- Testing, refining and finalizing the Integrated Tracking Inventory and Prioritization Scoring Tool and using it to provide a list of prioritized restoration actions for subsequent peer review (for each sub-basin and for the basin as a whole).
    - Assemble a trial Technical Rating Committee or sub-basin and sub-regional teams. Review and update data relationship mappings in the Integrated Tracking Inventory.
    - Perform group sensitivity analyses on weighting systems.
    - Where *readily* available, provide ballpark restoration action estimates. Time permitting, confirm best resources and identify approaches for estimating costs.
- Continuing to engage interested participants in the development and peer review of the Initial Draft Plan, and working with technical teams and SRWG member, the FCG and PSMFC to refine products.
- Design and convene 1-day peer review findings workshop near the conclusion of Phase 3.



Refine CPIs & Suitability Thresholds

Peer review **CPIs** & **Suitability thresholds,** That will be essential to guiding sequencing and phasing.

Prioritization

Perform **test application,** conduct **sensitivity analysis,** **Finalize tool.**

Generate prioritized list of actions.

Draft IFRMP Document

Update Plan documents with results of earlier steps.

Peer Review

Engage SRWG members to review products (webinars, 1:1 technical team mtgs, peer review findings workshop).

Figure 5.1: Anticipated major activities comprising Phase 3 (2019-2020) Plan development. The specific work performed is subject to available funding and direction from the FCG and PSMFC.

5.2 Overview of IFRMP Phase 4 (2020-2021)

Phase 4 of the Integrated Fisheries Restoration and Monitoring Plan development depends on securing additional funding. If secured, and subject to direction from the FCG and PSMFC the focus of Phase 4 may include:

- Identification of key monitoring gaps and provision of key status and trend monitoring templates/designs needed to support tracking of CPIs that support sequencing and phasing.
- Provision of priority effectiveness monitoring plan templates/designs for key restoration actions that are not already addressed by individual agency monitoring plans.
- Provision of more detailed cost estimates for restoration action priorities and associated monitoring.
- Alignment of Final Plan content with the Reintroduction Implementation Plan of Anadromous Fishes (salmon, steelhead, lamprey) into the Upper Klamath Basin that is being developed by the Klamath Tribes and Oregon Department of Fish and Wildlife and Klamath River Removal Corporation dam removal process decisions by FERC, etc. to ensure consistency with any final decisions regarding restoration that have been made with other parallel processes.
- Provision of an adaptive management/SHC strategy & learning process including AM "readiness" products, including mock bi-annual adaptive management reporting template, potentially including specific powerful experimental designs to test challenging hypotheses about restoration effectiveness.
- Provision of an *automated* version of the Integrated Tracking Inventory and Prioritization Scoring Tool to streamline and support ongoing evaluation of information on the implementation of the Plan.

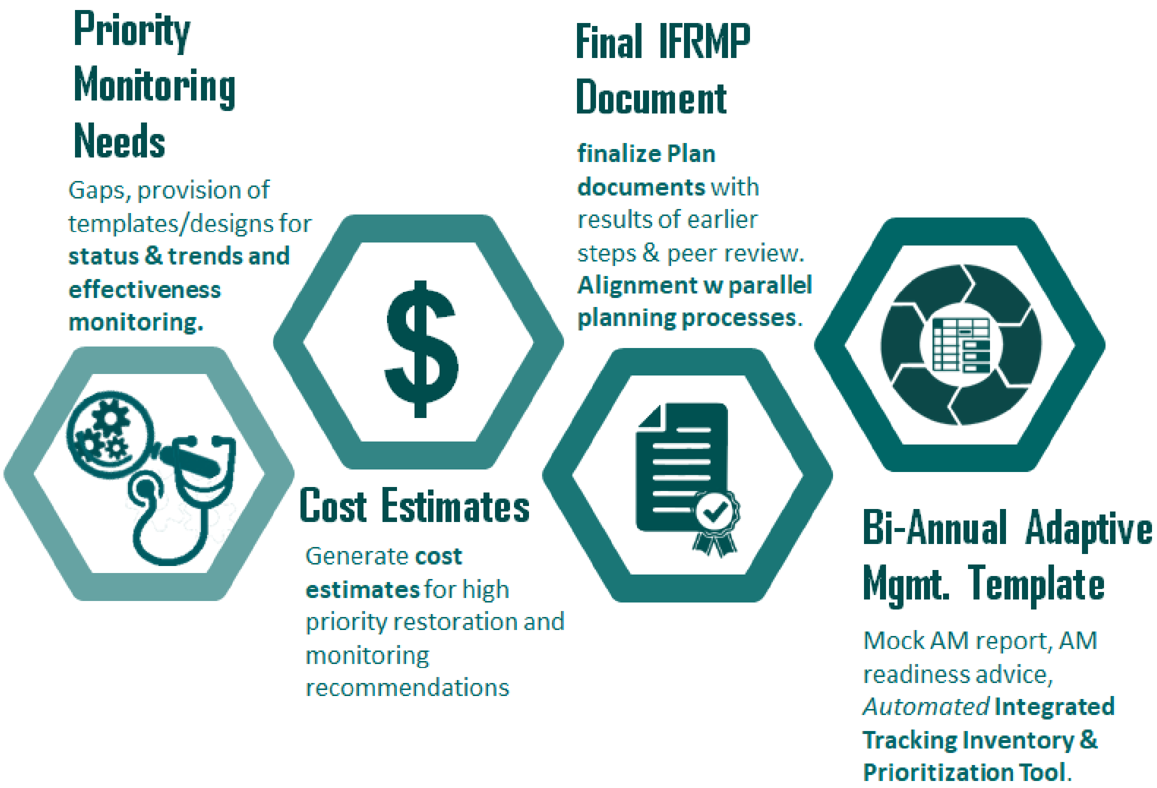


Figure 5.2: Phase 4 of the Integrated Fisheries Restoration and Monitoring Plan development depends on securing additional funding. If secured, this diagram identifies the anticipated major activities comprising Phase 4 (2020-2021) Plan development. The work performed is subject to available funding and direction from the FCG and PSMFC.

These Phase 4 items here would be components of the Plan that would be delayed or excluded if additional funding is not secured in 2020.

5.3 Recommendations for Plan Implementation

As the IFRMP planning process moves towards implementation, it will be important to continue to integrate adaptive management best practices. Over fifteen years ago, the National Research Council's Committee on Endangered and Threatened Fishes in the Klamath River Basin (NRC 2004, 2008) encouraged the broad community of organizations and interested participants pursuing Klamath River restoration to organize assessments around the **best practices of adaptive management**, and to use adaptive management to rigorously assess the river's response to restoration actions and ultimately the response of fish populations that depend on the river. The Committee stated that the adaptive management approach "*is both ecologically and socially responsible, given that ultimately all agencies and other stakeholders have limited resources with which to operate*", and that 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*".

5.3.1 Robust Governance Powers Technical Underpinnings of Adaptive Management

Unfortunately, Adaptive Management (AM) has become a plastic phrase used to describe any situation when decision-makers apply flexibility in their decision making. **Truly successful AM programs balance learning and doing** (Figure 5.3); (Murray et al. 2015; Greig et al. 2013; and see case studies provided in ESSA 2017). Institutional factors enable and support execution of decisions (**doing**) while technical factors strengthen resource manager's ability to **learn** about the effectiveness of actions. Moreover, processes to generate technical information are separated from processes to explore preferences and make decisions. Different enabling factors support progress along both technical and institutional dimensions, but insufficient focus on key factors within *both* dimensions needed to enable AM normally leads to failure (Marmorek et al. 2015). Ideally AM should strive for a robust system to serve both the functions of doing and learning, and there are many benefits of robust systems since they can help build trust, generate knowledge, collaborative learning, decision making, and help resolve conflicts.

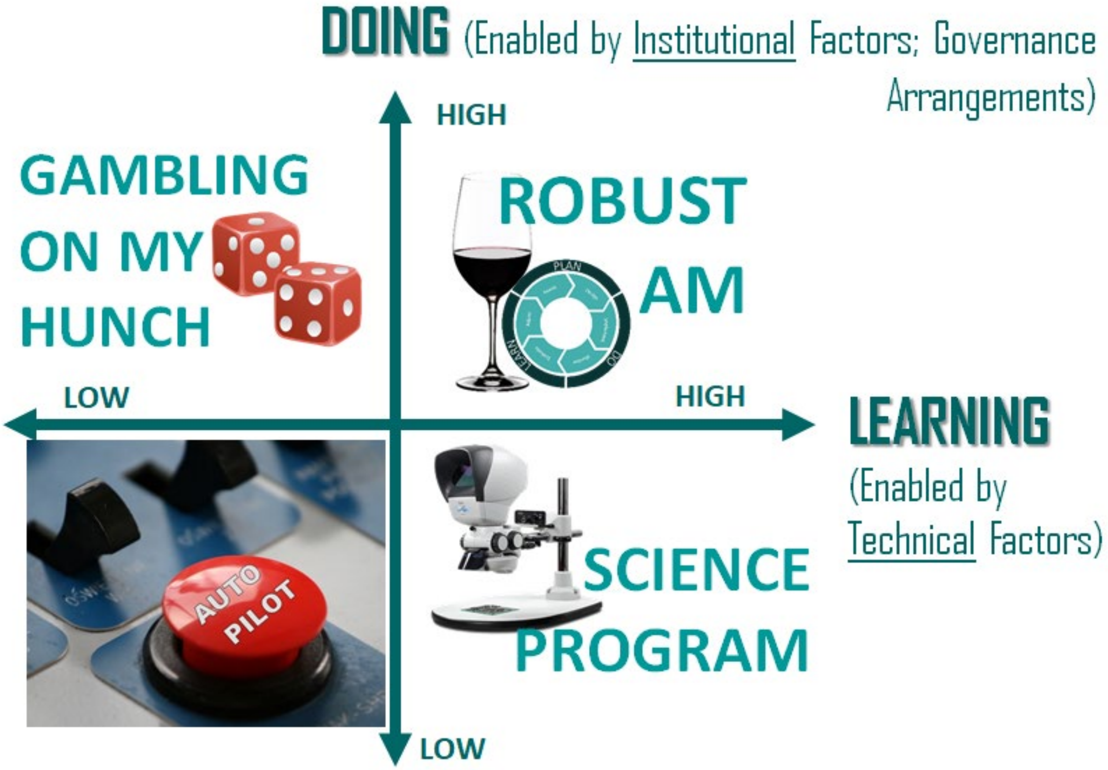


Figure 5.3: Robust Adaptive Management programs strive to balance learning and doing. Adapted from Duit and Galaz 2008.

In terms of **institutional factors** that enable successful AM, practitioners widely agree that successful implementation requires clearly distinguishing technical roles and responsibilities from management roles and responsibilities. Table 5.1 summarizes how technical and management roles would differ in each of the six adaptive management steps.

Table 5.1. Differences between management and technical responsibilities, for each of the six steps of adaptive management (adapted from Murray et al. 2011).

Step in AM Cycle	**Management Role (includes Decision Makers and Interested Participants)**	**Technical Role**
	Responsibilities are numbered in approximate sequence within each step, although frequent iteration will occur within and amongst steps.	
Overall	• **Clear Executive direction and authority (leadership)** • **Effective governance arrangements** • **Strong communication with agencies and stakeholders** • **Trust**	• **Rigorous Adaptive Management science (identification of critical uncertainties, hypotheses to test, thorough experimental designs, strong contrasts, replication, targeted monitoring & evaluation)** • **Science boiled down for decision-makers (strong & frequent science communication); typically, a coordinating group to facilitate synthesis of science across diverse entities**
1. Assess	1.2 Raise issues and concerns. 1.3 Develop fundamental objectives (what is desired, not how to get there). 1.4 Explain to technical scientists why each fundamental objective matters (i.e., keep scientists focused on what matters to the decision makers). 1.5 Ask questions about efficacy of different management approaches and cause-effect relationships.	1.1 Summarize existing knowledge about the ecosystem, and its history. 1.6 Develop performance measures/indicators associated with each fundamental objective, so that managers can use these to evaluate options. 1.7 Develop formal sets of alternative hypotheses that would inform critical uncertainties and are tied to fundamental Program objectives. 1.8 Filter these hypotheses down by summarizing what is known, what is not known, and what is unknowable. Focus in on critical uncertainties affecting resource management decisions. 1.9 Explain to decision makers and interested participants results of the filtering process (i.e., keep decision makers realistic about known / unknown).
2. Design	2.1 Develop broad strategies and alternatives to achieve the fundamental objectives and resolve critical uncertainties concurrently. 2.4 Evaluate the alternative sets of management actions under consideration, and trade-offs among objectives (including learning as an objective). 2.6 Assess what level of investment is acceptable in monitoring and evaluation (depends on both funding and the risks of incorrect decisions based on faulty inferences). 2.7 Assess what management responses would be depending upon the outcome of the AM experiment. 2.9 Provide input on politically acceptable experimental designs and approve the design of the AM experiment.	2.2 Convert broad strategies and alternatives into hypotheses to be tested based on Step 1. Translate into specific sets of management actions that can be conducted in an AM experiment. 2.3 Simulate alternatives in a suite of models to evaluate expected outcomes of proposed alternatives, help design the AM experiment, and assess rates of learning. 2.5 Use models to assess the likely level of certainty in conclusions with different levels of investment in monitoring and evaluation, and with different designs of the AM experiment. 2.8 Through dialogue with managers and interested parties, converge to a design for the AM experiment which best meets both policy considerations and statistically reliability.

Step in AM Cycle	Management Role (includes Decision Makers and Interested Participants)	Technical Role
	Responsibilities are numbered in approximate sequence within each step, although frequent iteration will occur within and amongst steps.	
3. Implement	3.1 Ensure that the implementation planned is followed. 3.4 Review and approve annual implementation plans.	3.2 Work through all of the technical details of implementation consistent with the Plan and annual decisions. 3.3 Suggest annual revisions to implementation plan (if required) to managers and revise as required.
4. Monitor	4.1 Ensure that the monitoring planned is followed. 4.6 Review and approve annual monitoring plans.	4.2 Carry out field monitoring consistent with the Plan and annual decisions. 4.3 Enter data into databases. 4.4 Conduct research necessary to support monitoring methods, including analyses of costs and benefits. 4.5 Present proposed annual monitoring plan (if required) to managers and revise as required.
5. Evaluate	5.4 Provide feedback to technical group on presentations of interim results from evaluations, and presentations from peer reviews. 5.5 Request additional evaluations to help in decision making.	5.1 Perform analyses and evaluations as described in the Plan and annual data analysis plans. 5.2 Compare monitoring results against Program objectives, hypotheses, model predictions. 5.3 Synthesize evaluations for managers and interested parties; provide summaries and presentations at annual symposia. 5.6 Respond to peer reviews and requests from managers for additional evaluations.
6. Adjust	6.2 Decide if adjustments to actions are warranted based on information from technical scientists, and other factors affecting decisions.	6.1 Clarify implications of evaluations for possible adjustments to actions and hypotheses, including risks and benefits of alternative decisions.

The best scientific plans only come to fruition with strong participatory, transparent systems of governance that make it clear how all interested participants, co-managers, implementing agencies, and restoration practitioners will be engaged. Ad hoc governance arrangements simply cannot power the coordinated technical underpinnings of AM. **In short, without transparent decision-making processes, it will not be possible to implement the scientific and technical advice developed for the Plan.**

5.3.2 Follow Adaptive Management Best Practices

There are widely varying uses of the term adaptive management, many of which fall far short of what is described in Box 5.1 and stray outside of what we refer to as ‘rigorous’ adaptive management. Table 5.2 summarizes what adaptive management entails when being practiced in a rigorous manner that aims to maximize the value of information for decision-making, and which of these steps have so far been initiated in development of the Plan.

Table 5.2. Summary of technical best practices for adaptive management (from Marmorek et al. 2006). [DQO] refers to practices which overlap with the Data Quality Objectives process (EPA 2006). "⚙" represents best practice steps largely completed during Phases 1 and 2 of the planning process to develop the Plan.

	Best Practices within each Step
Step 1. **Assess and define the problem**	1. **Clearly stated management goals and quantitative objectives** (i.e., restoration and recovery goals and objectives for Klamath) ⚙ 2. State the problem based on **overall conceptual model** [DQO] ⚙ 3. **ID the decisions that you want to make annually, episodically** [DQO] [*Initiated in phase 2, in progress*] 4. **Build conceptual models** (of system, of limiting factors, of restoration actions) ⚙ 5. **Articulate unknowns, ID key uncertainties** ⚙ (e.g., how restoration actions should affect focal species indicators, hypotheses to be tested) 6. **ID alternative restoration actions** (including existing restoration plans for Klamath) ⚙ [*Initiated in phase 2, in progress*] 7. **ID focal species and measurable indicators** ⚙ 8. **ID spatial / temporal bounds** (representative study locations) ⚙ 9. ID the boundaries of the study [DQO] ⚙ 10. **State up front how what is learned will be used** [*Initiated in phase 2, in progress*] 11. **Involve interested participants, scientists and managers** ⚙
Step 2. **Design**	1. Active AM - **have documented AM designs for implementing actions in a systematic way** (contrasting treatments, replications, controls where feasible at smaller scales) 2. **Obtain statistical advice and generate a statistical design** for implementation of restoration actions to provide information of sufficient statistical power and reliability for future decisions [DQO] 3. Consider range of possible outcomes (prediction, use of models), and **have draft If/Then decision criteria or triggers for steps to follow under alternative states of nature and/or outcomes of restoration actions** ⚙ [*Initiated in phase 2, in progress*] 4. **Monitoring plan** (existing monitoring plans) [*Initiated in phase 2, in progress*] 5. Develop "if-then" decision rules; triggers for what to monitor [DQO] [*Initiated in phase 2, in progress*] 6. Specify tolerable limits on decision errors [DQO] 7. **Develop a Data Management Plan** (existing data management plans; tools) ⚙ [*Integrated Tracking Inventory and Prioritization Scoring Tool -- initiated in phase 2, in progress*] 8. **Formal AM plan** (for all steps, not just monitoring) 9. Plan to revise full plan on a 5-yr timeframe (otherwise will become irrelevant) **10.** **Peer review of design** ⚙ [*Initiated in phase 2, in progress*] 11. Draw up multi-year plans and obtain multi-year budget commitments **12.** **Involve interested participants, scientists and managers** ⚙ [*Initiated in phase 2, in progress*]
Step 3. **Implementation**	1. **Perform contrasting restoration actions** as designed (contrasts over space, or over time; won't be possible for some large-scale actions like dam removal) 2. **Document any unavoidable changes** from what was designed **3.** **Monitor the implementation**
Step 4. **Monitoring**	**1.** **Baseline ("before") monitoring** **2.** **Implement monitoring plan as designed** **3.** **Undertake status and trends monitoring** 4. Concurrently undertake **physical and biological effectiveness monitoring** (incl. short-term pilot programs) 5. **Implement the Data Management Plan** as it was designed

Best Practices within each Step	
Step 5. **Evaluation of results**	1. **Compare monitoring results against restoration objectives** [moving towards or away from goals?] 2. **Compare monitoring results against assumptions, uncertainties, hypotheses, models** [e.g., model predictions; existing analytical methods] 3. **Receive further statistical or analysis advice** – review adequacy of monitoring 4. Ensure data analysis keeps up with data generation from monitoring activities
Step 6. **Adjustment / revision of hypotheses, monitoring and management**	1. **Document meaningful learning** and how it has / will be used to change priority restoration and monitoring actions 2. **Communicate learning to decision makers**, all other participants, and the broader community 3. Deliver at annual or bi-annual science symposiums (what has been learned, including surprises) 4. Conduct parallel public outreach effort to communicate simplified science, lessons and obtain impressions of public/interested participants 5. **Update decision criteria / triggers** that will be used to evaluate whether restoration actions are working / need adjusting in future ***6. Return to Step 1 and adjust the list of critical uncertainties, hypotheses, models, and monitoring approaches based on what has been learned; continue the next iteration of the cycle***

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Please note: The majority of the documents referenced in this report can be found on the IFRMP Web Library.

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Appendix A: IFRMP Phase 2 Comment Response Summary

The public review period for Phase 2 of the IFRMP document received 661 comments from 23 commenters representing 15 organizations. Comments received are organized by comment class in Figure 1A. Roughly 85% of comments received were classified as ‘easy fixes’ including observations not requiring a response, correcting errors in spelling and grammar, requests for revisions to language to improve clarity and, the largest category, simple factual corrections (e.g., adding a stream to a list, updating a citation, adding a simple factual detail, etc.). The vast majority of these comments fell within the Sub-Basin Profiles and have been addressed to the best of our ability within time and budget constraints in the current revised version of the Phase 2 IFRMP document. Given the volume of these comments, their straightforward nature, the fact that they have been addressed, we are not providing line by line responses for comments of class 4 or lower in this Appendix. We greatly appreciate the time taken by the 23 commenters to help us improve the Plan document.

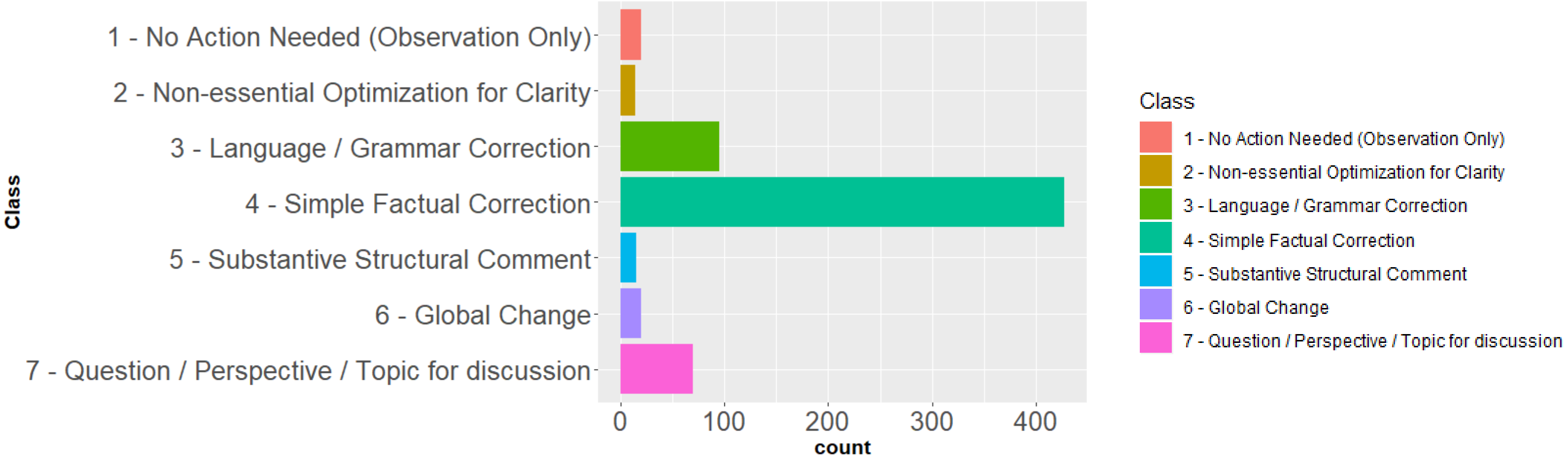

Figure 1A: Quantitative summary of IFRMP Phase 2 comments received by class.

The remaining 15% of comments (class 5 or higher) included requests for changes in either Plan structure, global changes in language to be applied across the document, and more overarching questions or perspectives on approach that required consultation with the Federal Coordination Group overseeing this work. Many of these comments fell into similar themes, and often referred to activities (e.g., refining core performance indicators, testing the prioritization framework) that are already planned in the upcoming Phase 3 of work. For transparency, we provide overarching responses to these comment themes in Table 1A.

Table 1A: Overarching responses to major substantive comments received on the draft Phase 2 IFRMP document.

Overarching Theme / Comment	Response
Suggestions to add recommendations for various baseline scientific inventories and studies to the list of restoration actions.	This Plan focuses on types of restoration actions that could be implemented for direct benefits to focal fish species. Identifying additional scientific studies and monitoring that might be required in order to implement these actions is outside the scope of the current 2019-2020 phase of Plan development. With additional funding for Phase 4 of Plan development, monitoring priorities would be a key additional component added to the IFRMP.
Comments received from multiple reviewers suggesting modifications or additions to the proposed core performance indicators (CPIs) listed in Table 2.2.	Refining the CPIs proposed in Table 2.2 is a major component of Phase 3 of work on the IFRMP. As such, we will not be addressing comments related to CPIs at this time. Instead, we will be compiling comments within this category in a separate document that will act as a starting point for further refining CPIs in the early stages of work on Phase 3 of the IFRMP. We will be discussing our approach to this work in a webinar introducing Phase 3 of work. Briefly, we anticipate convening a few meetings with small working groups of subject-matter experts for each tier of watershed function to discuss this initial set of comments received during this review cycle and refine CPIs with additional input from these groups. Participation in these discussions will be voluntary and expected to entail a relatively small time commitment.
Comments on the lack of detailed or relative cost estimates for key restoration and monitoring actions listed.	Although inclusion of cost estimates was considered and provided in an earlier version of this Plan, it was determined during Federal review that existing cost estimates for restoration actions were too outdated and efforts should focus on identifying the priority restoration actions in in the major sub-basins before efforts are undertaken to identify costs. With additional funding for a potential Phase 4, the Services agree that cost-estimates would be a helpful addition to the overall Plan. For now, costs estimates are beyond the scope of Phases 2 and 3.
Question on whether (i) the IFRMP prioritization approach would need to be applied prior to funding decisions **and** (ii) how the Plan will guide future funding decisions.	Restoration projects identified through the IFRMP serve only as neutral state-of-science guidance to federal agencies and other parties interested in Klamath Basin fisheries restoration. Projects identified in the IFRMP process are not binding on federal agencies and do not commit federal funding, or future federal funding, to specific restoration projects. The intent of the IFRMP is to help inform federal agencies (and others interested parties) on how to effectively coordinate basin-scale efforts to restore fish habitat and related watershed processes in the Klamath Basin. Further, the IFRMP, and those parties involved in its development, do not constitute a decision-making body. 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.
Comments on reconciliation of this Plan with the Upper Klamath Basin Watershed Action Plan (UKBWAP) and the Implementation Plan for the	Alignment of IFRMP with other plans in the Basin -- UKBAP, the Implementation Plan for the Reintroduction of Anadromous Fishes, tribal fisheries plans, FERC dam removal plans (if available) will occur in Phase 4, if funding is available. It is our understanding that the UKBAP and the reintroduction plan are still in development and have not yet been shared with the IFRMP project team. If these plans are provided to the IFRMP project team, we will consider

Overarching Theme / Comment	Response
Reintroduction of Anadromous Fishes into the Oregon portion of the Upper Klamath Basin (an appendix to ODFW Klamath Basin fisheries management Plan).	that information as we develop the next draft, but significant major alignment will occur in a Phase 4 (2020-2021), if funded.
Overall, this document will receive mixed reviews within the agricultural community. … [T]he Plan cannot depict agriculture as undesirable or the enemy or use careless terminology[1]. Also, irrigators have well-founded concerns that past mis-representations of benefits for farmers that will result from restoration have not borne out[2]. In the uppermost basin, the areas tributary to Upper Klamath Lake, irrigators are experiencing hardship due to water right calls and over-regulation due to the ESA. They are not receiving necessary signals that their interest is important, and justifiably have a reluctance to prioritize other interests when they are in this position. The Plan should explain that this needs to change.	We adjusted some of the descriptions based on this comment (e.g., to ensure comments related to landowners, water diversions and agriculture and their effects on Plan focal species are where appropriate placed in the context of *cumulative* stresses). The agriculture communities in the Klamath Basin are a valued partner in conservation and restoration. The main focus of the IFRMP is how best to go about improving fisheries habitat and watershed processes throughout the Klamath Basin. The IFRMP is intended to provide neutral state-of-science guidance that will help inform federal agencies on how to best use public funds to advance the restoration of Klamath Basin fisheries. As we enter Phase 3 (2019-2020), we are reliant on all stakeholders to help improve this Plan. One of the bedrock principles required when working with diverse groups of participants is to ensure to sequester and characterize sources of potential conflict and dispute by differentiating problems arising because of (i) different perceptions or **values**, (ii) reliance on different sources of **evidence** and understanding and (iii) reconciling and **balancing trade-offs**. As a science focused Plan, the IFRMP will continue to use a transparent and collaborative process designed to tease apart differences around values, evidence and trade-offs. Promoting better understanding and respect for both values differences and a respect for evidence contributes to clearer communication and building bridges rather than trying to manoeuvre people into thinking a certain way owing to vested interest.
Request to consider the use of occupancy (a probability modelled from	The sub-regions working groups discussed this question at length at the core performance indicator workshop session in Phase 2 of the planning process. Everyone agreed that occupancy modelling would with the requisite input data be

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[1] *Anonymous*: For example, discussion of "extensive" diversions for the Klamath Project on (page 20, line 12) is not necessary. On page 20, lines 15-21, it is suggested that agricultural production contributes most of the nutrient load to UKL via tributaries. Much of the phosphorus load is naturally occurring in the sediments due to the volcanic legacy of the area and usually enters the system with the initial flushing event in the spring. [H]istorically, the evaporation on Lower Klamath Lake alone was about two-thirds of the average Project diversions. That does not include evapotranspiration from the former Tule Lake. In other words, the loss of water to the system on Project land is almost certainly less today than it was before development. Klamath Project irrigators are extremely efficient with their annual allocation and much collaboration between the districts ensures the water is utilized to the fullest extent possible. In addition, the great value of farm and ranch land for terrestrial wildlife, and of water delivery systems for aquatic and riparian life, should be recognized and promoted.

[2] Anonymous: Examples include removal of Chiloquin Dam, restoration of the Williamson River Delta, and retirements of tens of thousands of acres of agricultural land generally.

Overarching Theme / Comment	Response
habitat suitability information) instead of presence/absence (direct field observation) as a core performance indicator for fish populations.	the preferred approach and could leverage existing quantitative spatial models for intrinsic habitat potential (focus on hydrogeomorphic and flow suitability) and of realized habitat potential (focus on biotic habitat suitability) that have been or are currently being developed by NOAA and the USFWS. However, participants in these discussions also agreed that using occupancy as an indicator would require a great deal of work by NOAA and the USFWS to parameterize these models for focal species within the Klamath Basin (given that all the data required will still need to be collected and collated) and is likely an unrealistic objective to complete within the relatively brief window for work on Phase 3 of this Plan. Much of the landscape is very remote and lacks basic habitat evaluation. For the time being, we propose keeping a presence-absence indicator that could be “upgraded” to include occupancy modelling at a future date when more data and modelling capacity is available from agency partners in this work.