Potential Responses of Coho Salmon and Steelhead Downstream of Iron Gate Dam to No-Action and Dam-Removal Alternatives for the Klamath Basin

Prepared for
U.S. Bureau of Reclamation
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Table of Contents

1 INTRODUCTION..1

1.1 Background and Approach 1
1.1.1 Restoration actions 2
1.1.2 Trinity River considerations.. 3
1.1.3 Water quality 3
1.1.4 Comparison of alternatives... 4

2 COHO SALMON..4

2.1 Legal Status... 4
2.2 Life History.. 4
2.3 Distribution 6
2.4 Population Trends 7
2.5 Coho Salmon Conceptual Model 7
2.5.1 Mainstem Klamath River downstream of Iron Gate Dam.................................... 7
2.5.2 Tributary streams downstream of Iron Gate Dam.. 9
2.6 Population Response to Alternatives 10
2.6.1 Current Conditions 12
2.6.2 Dams-Out Alternative 15

3 SUMMER STEELHEAD 18

3.1 Legal Status... 18
3.2 Life History.. 18
3.3 Distribution 20
3.4 Population Trends 22
3.5 Summer Steelhead Conceptual Model.. 22
3.5.1 Mainstem Klamath River downstream of Iron Gate Dam.................................. 22
3.5.2 Tributary streams downstream of Iron Gate Dam.. 23
3.6 Population Response to Alternative Actions 23

4 WINTER STEELHEAD 24

4.1 Legal Status... 24
4.2 Life History.. 24
4.3 Distribution 26
4.4 Population Trends 27
4.5 Winter Steelhead Conceptual Model 27
4.5.1 Mainstem Klamath River downstream of Iron Gate Dam.................................. 27
4.5.2 Tributary streams downstream of Iron Gate Dam.. 28
4.6 Population Response to Alternative Actions 28

List of Tables

Table 1. Life-history timing of coho salmon in the Klamath downstream of Iron Gate ...... **Error! Bookmark not defined.**
Table 2. Magnitude of restoration actions under each alternative. 11
Table 3. Life-history timing of summer steelhead in the Klamath downstream of Iron Gate..... 19
Table 4. Life-history timing of winter steelhead in the Klamath downstream of Iron Gate 24

Appendix: Table of proposed restoration actions and anticipated benefits to salmonids.

1 INTRODUCTION

1.1 Background and Approach

The Klamath River is located in southern Oregon and northern California, traversing approximately 409 km (254 mi) from Upper Klamath Lake to the Pacific Ocean. Four dams on the mainstem Klamath River—J. C. Boyle, Copco I and II, and Iron Gate—are being considered for removal in 2020 under concurrent agreements recently entered into by the settlement parties, which include various federal, state, and local agencies and stakeholders. The Klamath Hydropower Settlement Agreement stipulates that a determination must be made by the U.S. Secretary of the Department of the Interior regarding whether or not dam removal will enhance salmonid fisheries in the basin and is in the public interest. Under an affirmative determination, facilities removal would proceed under the applicable regulations of the National Environmental Policy Act and California Environmental Quality Act. Under a negative determination, dam removal would not proceed. The Klamath Basin Restoration Agreement (KBRA) of 2010 outlines a framework for conducting basin-wide habitat restoration activities to (1) maintain and enhance natural production of and harvest opportunities for fish, (2) establish reliable water and power supplies for agriculture and other identified land uses, and (3) contribute to the public welfare. Full implementation of the KBRA would fund numerous aquatic and terrestrial restoration efforts throughout the Klamath River Basin through the year 2020.

The intent of this report is to summarize the anticipated effects of fulfilling the terms of both the Klamath Hydropower Settlement Agreement as well as the Klamath Basin Restoration Agreement (i.e., dam removal paired with KBRA actions) on two species of anadromous salmonids: coho salmon (*Oncorhynchus kisutch*) and steelhead (*O. mykiss*), as compared with a "no action" alternative. This report will be made available to selected panels of fisheries experts to aid in the Secretarial Determination process. The analysis only addresses potential fish population responses within the Klamath mainstem and tributaries downstream of Iron Gate Dam.

A summary of the Secretarial Determination process for evaluating potential effects of removing the four lowermost dams on the Klamath River, as well as a synthesis of available biological information for the Klamath River basin, can be found in the *Biological Synthesis for the Secretarial Determination on Potential Removal of the Lower Four Dams on the Klamath River* (Hamilton et al. 2010). Hamilton et al. describe the two project alternatives in more detail, as well as existing watershed conditions and the projected effects of the alternatives on biota. The project alternatives evaluated with respect to coho salmon and steelhead in the Klamath River downstream of Iron Gate Dam can be described as:

No Action: Current management conditions, which includes ongoing programs under existing laws and authorities that contribute to the continued existence of threatened and endangered species, salmonid populations, and Tribal Trust species, and those actions that are reasonably foreseeable in the next 50 years. This alternative would be realized if a negative Secretarial Determination is made. The No Action Alternative and is hereafter referred to as the "Current Conditions Alternative."

Proposed Action: Removal of the four lowermost Klamath River dams and implementing the full range of KBRA measures, and those actions that are reasonably foreseeable in the next 50 years. This alternative, the "Dams-Out Alternative," would be realized if an affirmative Secretarial Determination is made.

The analysis was based on projected conditions of the watershed and salmonid habitats 50 years following the initiation of each alternative, after which time we would expect to more clearly distinguish their effects. We describe key factors likely to be limiting to coho salmon and steelhead populations downstream of Iron Gate Dam, and envisage how individual components of each alternative (e.g., floodplain restoration) might alter salmonid habitats and population dynamics (see Appendix: *Table of Proposed Restoration Actions and Anticipated Benefits to Salmonids*). Following the analysis of each alternative's various components, the effects of each alternative 'as a whole' on each species was evaluated in terms of Viable Salmonid Population (VSP) parameters (abundance, population growth rate, population spatial structure, and diversity). The results are necessarily qualitative in nature, due to reliance on assumptions made at each step in the process.

Hamilton et al. (2010) describe expected water quality and flow conditions under the project alternatives, with the analysis of effects focusing on instream flows and water temperatures. The portions of our analysis dependent on these habitat components rest upon on the results of analyses currently underway by the Water Quality Subgroup of the Secretarial Determination process. The following sections discuss key considerations for the analysis.

1.1.1 Restoration actions

This report summarizes anticipated benefits of restoration actions under both alternatives. The Current Conditions Alternative includes only those restoration actions that are ongoing or reasonably foreseeable in the Klamath River downstream of Iron Gate Dam under existing programs for the protection of listed salmonids and other special-status species. The Dams-Out Alternative comprises changes in the watershed resulting from dam removal (as described in Hamilton et al. 2010), along with restoration actions described in the KBRA. There are no *specific* restoration actions that are certain to occur in either alternative; therefore, we addressed restoration actions most likely to be carried out under each alternative based on the following process:

- An initial list of potential restoration actions was developed based on actions recommended in the National Marine Fisheries Service's Southern Oregon and Northern California coho salmon recovery plan. The recovery plan list of actions was developed collaboratively with stakeholders that included federal and state agencies, watershed groups, resource conservation districts, and Tribes.
- These actions were then prioritized in terms of perceived importance by the National Marine Fisheries Service (NMFS), the Yurok Tribe, the Karuk Tribe, U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), and California Department of Fish and Game (CDFG).
- Costs were allocated to determine what actions will likely be completed with available funds.
    - *Current Conditions Alternative*: Projections for Current Conditions are based on averaging the ten years (2000 to 2009) of federal and state funding (NMFS 2010a) with consideration for likelihood of continued levels of funding (J. Simondet, Fisheries Biologist, NOAA, pers. comm., July 2010). Funding sources considered included NMFS, CDFG, Coastal Conservancy, USFWS, Klamath National Forest, Bureau of Reclamation, and the National Resources Conservation Service. On average, around $12.6 million has been spent on restoration actions in the Klamath River basin per year

since 2000; therefore, it is assumed that in the eight-year period during which the KBRA is implemented, all federal and state funds will result in an additional $100.9 million for restoration actions.

  - *Dams-Out Alternative*: Funding for the Dams-Out Alternative is based on assuming all funds available under Current Conditions will be available under this alternative as well, and in addition, KBRA will provide roughly $141.6 million for restoration (aquatic and upland) through the year 2020. The KBRA describes specific funding amounts for separate portions of the watershed (e.g., lower Klamath River). The total amount of funding under KBRA is assumed to be $242.5 million.

- To determine which actions were included in each alternative, we assumed that under the Current Conditions Alternative, $108 million will be spent on the highest priority actions (as determined by NMFS and CDFG staff). Under the Dams-Out Alternative, we assumed that all available funds combined would be spent on implementing the highest priority actions.
- The Current Conditions Alternative also includes actions already receiving funding by PacifiCorp or other entities.

1.1.2 Trinity River considerations

The Trinity River is the largest tributary to the Klamath River; however, its confluence with the Klamath River is 20 miles upstream of the confluence, and nearly 275 miles downstream of Iron Gate Dam. The Trinity River Restoration Program provides around $10 million annually with the goal of restoring populations of naturally spawning salmon and steelhead to pre-Trinity Dam numbers. Overall, the alternatives evaluated in this report are not anticipated to significantly affect anadromous salmonid stocks in the Trinity River, with the exception of potential benefits for Trinity River coho salmon stocks migrating downstream in the mainstem Klamath River as described in Section 2.6.2.1.

1.1.3 Water quality

The entire Klamath River and its tributaries are currently listed as impaired under section 303(d) of the Clean Water Act for temperature, dissolved oxygen, and nutrients (NCRWQCB 2006, EPA 2006). The lower Klamath River is also listed as impaired for sediment from the Trinity River confluence to the estuary mouth (NCRWQCB 2006, EPA 2006). Klamath River from Copco 1 Reservoir to Iron Gate Dam is listed as impaired for toxicity due to the presence of microcystin, a toxin produced by blue-green algae *Microcystis aeruginosa* present in the Project reservoirs (EPA 2008).

Water quality analyses currently underway by the Water Quality Subteam for the Secretarial Determination process have identified expected trends for water temperature, dissolved oxygen, and nutrients (total nitrogen and total phosphorus) for the No Action and Dams-Out alternatives. These analyses incorporate the anticipated effects of implementing mainstem Klamath River TMDLs under development in California (NCRWQCB 2010) and Oregon (ODEQ 2010) during the analysis period (2012–2062). Preliminary results indicate general improvements in water temperature, dissolved oxygen, and nutrients in the mainstem river with differences diminishing with distance from the dam removal site; little difference between the alternatives is expected in the lower river (i.e., Turwar) (Stillwater Sciences, *in prep*.).

In addition, instream flow studies are currently being conducted in the Shasta River and are expected to result in new flow prescriptions. A groundwater modeling study is being conducted in the Scott River that will also likely result in changes to instream flows. We are not certain what instream flow prescriptions will result from these studies and what flows to expect under the Current Conditions Alternative. State Code 5937 directs the state to evaluate and implement recommended minimum flows regardless of which alternative is pursued. For this analysis we assumed that the 5937 process would result in instream flow increases in key tributaries such as the Shasta and Scott rivers sufficient to provide habitat conditions suitable for fish migration, spawning, and rearing.

1.1.4 Comparison of alternatives

Our assessment was based on comparing the two alternatives assuming they are implemented during the specified KBRA implementation period (2012 to 2020). We assume that some actions would result in immediate effects (e.g., access to habitat afforded by dam removal), while other actions may take years or decades to become effective (e.g., riparian vegetation enhancement). For the purposes of making a more meaningful comparison between the alternatives, each was viewed from the perspective of 50 years in the future (2060), after which time the ultimate effects of the actions, and their potential benefits to salmonids will likely be more apparent

Forty-one actions were identified as likely to receive funding from KBRA or CDFG under the alternatives. The Appendix, *Table of proposed restoration actions and anticipated benefits to salmonids*, describes the restoration actions and their anticipated benefits for salmonids.

2 COHO SALMON

2.1 Legal Status

The Southern Oregon/Northern California coho salmon ESU is listed as federally threatened. This ESU includes all naturally spawning populations between Punta Gorda, California and Cape Blanco, Oregon, which encompasses the Trinity and Klamath river basins (NMFS 1997). Critical habitat includes all stream habitat between the Elk River in Oregon and the Mattole River in California, excluding tribal lands on the Klamath and Trinity rivers (NMFS 1999).

2.2 Life History

Adult coho salmon enter the Klamath River between September and mid-December, with peak upstream migration occurring between late-October and mid-November (Table 1) and spawning generally occurring within a few weeks of arrival at spawning grounds. Based on data from Maurer (2002), most adult coho salmon enter Scott Creek in late November, with most spawning occurring in early December.

Table 1. Life-history timing of coho salmon in the Klamath River basin downstream of Iron Gate Dam (peak activity is indicated in black).

Life stage (citations)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult migration[9]												
Spawning[9, 11]												
Incubation												
Emergence[1, 2, 3]												
Rearing[4]												
Juvenile redistribution[5]												
Juvenile outmigration[6, 7, 8, 9, 10]												

[1] CDFG (2000, unpubl. data, as cited in NRC 2004); [2] CDFG (2001, unpubl. data, as cited in NRC 2004); [3] CDFG (2002, unpubl. data, as cited in NRC 2004); [4] Sandercock (1991); [5] T. Soto, Fisheries Biologist, Yurok Tribe, pers. comm., 2008; [6] Scheiff et al. (2001); [7] Chesney and Yokel (2003); [8] T. Shaw (USFWS, unpubl. data, 2002, as cited in NRC (2004); [9] NRC (2004); [10] Wallace (2004); [11] Maurer (2002)

Coho salmon fry begin to emerge from redds in late February. Peak emergence occurs in March and April, although fry may be observed until early July. Coho salmon typically rear in streams for one year, and outmigrate in the spring following that in which they hatched. In the Shasta River, downstream migration of fry and juvenile fish peaks in early April and mid-May, respectively, indicating that they may rear in the mainstem after exiting the Shasta River. Fry and juveniles in the Trinity River also move downstream in the spring to enter the mainstem Klamath River (Scheiff et al. 2001). In the Scott River, fry and juvenile outmigration appears to occur later in the spring and in summer (Chesney and Yokel 2003), and less time is probably spent in the mainstem prior to outmigration to the Pacific Ocean. Few juvenile coho are observed in pools at the mouths of tributaries in the mainstem by early fall (T. Shaw, USFWS, unpubl. data, 2002, as cited in NRC 2004).

Age 1+ coho salmon migrate from tributaries into the mainstem Klamath River from February through mid-June with a peak in April and May, which often coincides with the descending limb of the spring hydrograph (USFWS, unpub. data, 1998, as cited in NRC 2004; Chesney and Yokel 2003; Scheiff et al. 2001; NRC 2004). Age 1+ fish appear to outmigrate from the Shasta River sooner than those rearing in the Scott or Trinity rivers (Chesney and Yokel 2003). Once in the mainstem, smolts appear to move downstream rather quickly; Wallace (2004) reported that numbers of coho salmon smolts in the Klamath River estuary peaked in May, the same month as peak outmigration from the tributaries. Wallace (2004) also observed a significant decrease in estuary presence by June and July, suggesting that smolts spend only a brief period in the estuary prior to entering the ocean.

Redistribution of age-0 juveniles from tributaries to the mainstem occurs in the fall (October through November), when many juveniles depart from tributaries in the mid-Klamath, including the Shasta, Scott, and Salmon rivers, as well as from smaller tributaries such as Independence, China, Dylan, Thompson, and Stanshaw creeks. These downstream movements typically take place during the first rainfall and freshet of the season (T. Soto, Fisheries Biologist, Yurok Tribe, unpubl. data, 2008). In fall 2007, juvenile coho salmon PIT-tagged during these downstream movements were detected migrating upstream into tributaries (including some that were dry during summer), off-channel ponds, and other winter refuge habitat in the lower Klamath River near or within the estuary, including Waukell, Panther, Hunter, and McGarvey creeks (M. Hiner, Yurok Tribe fisheries biologist, unpubl. data, 2008). These movements from the mainstem Klamath River into tributaries appear to occur in October and November, with some movement occurring in December.

2.3 Distribution

Iron Gate Dam (RM 190) blocks the upstream migration of coho salmon to historically available habitat in the upper watershed. Before the construction of the dams, coho salmon were apparently common and widely distributed throughout the watershed, probably in both mainstem and tributary reaches up to and including Spencer Creek at RM 228 (Figure 1) (NAS 2004, as cited in NMFS 2007).

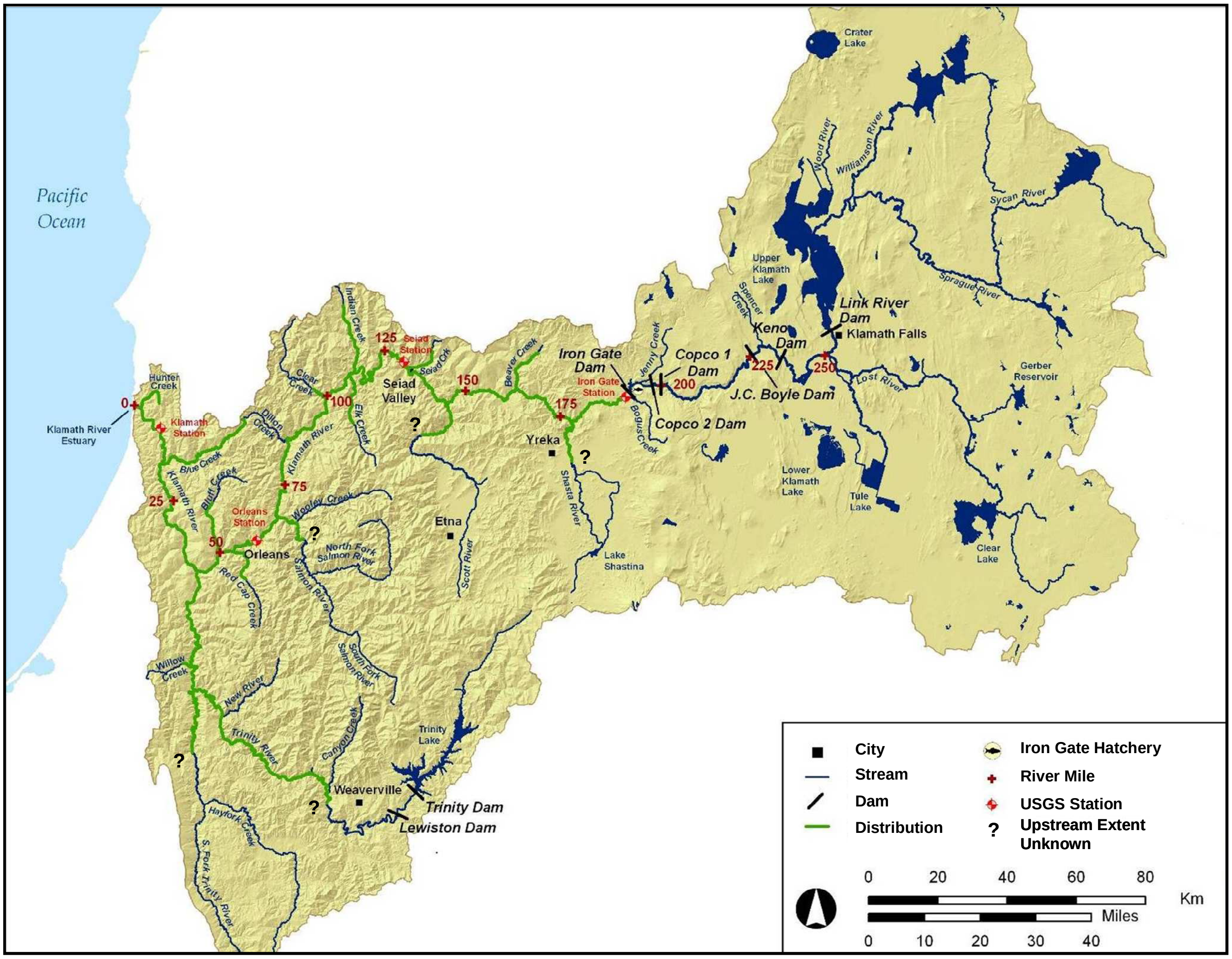

Figure 1. Coho salmon distribution in the Klamath River basin. Coho are also distributed in numerous other small tributaries downstream of Iron Gate Dam.

Coho salmon are known to prefer relatively low-gradient tributary habitats for spawning and rearing and the same is true in the Klamath River (NRC 2004); however, the mainstem Klamath River also contains habitat suitable for all freshwater life stages. For example, juvenile coho salmon utilize thermal refugia habitat in the mainstem Klamath River through periods of temperature stress. These refugia are generally located at the confluence of tributaries with the mainstem and in locations of hyporheic flow and groundwater infiltration.

Important coho salmon spawning tributaries in the lower Klamath Basin include:

- the Shasta, Scott, Salmon, and Trinity rivers;
- six small tributaries entering the Klamath River between Iron Gate Dam and Seiad Valley;
- thirteen small tributaries between Seiad Valley and Orleans; and
- twenty-seven small tributaries between Orleans and the mouth of the Klamath River.

2.4 Population Trends

Coho salmon in the Klamath River watershed are in decline. Less than 70% of streams historically inhabited by coho salmon in the Klamath Basin still contain small populations. Two of the Shasta Rivers coho salmon year-classes are considered "functionally extinct," meaning that coho salmon only return to spawn one out of every three years. In some streams, such as the Trinity River, wild coho salmon stocks are estimated to be as little as 4% of their former abundance (NRC 2004).

The vast majority of coho salmon that spawn in the Klamath River Basin are believed to be of hatchery origin. Indirect estimates indicate that 90% of adult coho salmon in the Klamath River system return directly to hatcheries or spawning grounds in the immediate vicinity of hatcheries (Brown et al. 1994). Most natural spawning appears to occur in tributaries of the Klamath River below Weitchpec (Wallace 2004). The largest spawning escapement appears to be in the Trinity River, where escapements from 1997 to 2002 ranged from an estimated 239 to 51,826 fish (KRIS 2004a). However, over 90% of spawners in the Trinity River are estimated to be of hatchery origin (U.S. Fish and Wildlife Service and Hoopa Valley Tribe 1999). The Shasta River typically had fewer than 400 spawners in the period from 1930 to 2002, with ≤30 fish returning from 1985 to 2000 (KRIS 2004b). Redd surveys on the Scott River identified 212 redds in the 2001/2002 spawning season (FERC 2006). Escapement data for the mainstem Klamath River and other tributaries does not appear to be available.

2.5 Coho Salmon Population Considerations

2.5.1 Mainstem Klamath River downstream of Iron Gate Dam

While the majority of coho salmon spawn and rear in tributaries, the mainstem Klamath River serves an important function to the viability of coho salmon. Some adults spawn in the mainstem, and a component of the life history strategies of juvenile coho salmon includes rearing in the mainstem. As conditions in key tributaries have degraded in recent history, the role of the mainstem Klamath River in the viability of coho salmon has heightened.

Water quality in the mainstem Klamath River below Iron Gate Dam is characterized by seasonal alterations to water temperature, dissolved oxygen, and nutrients, as well occasional blooms of *Microcystis aeruginosa*. Temperature modeling scenarios indicate that the upstream reservoirs generally release cool water from mid-January to April, variably cool or warm water from April through early August, and warm water from August through November. Just downstream of Iron Gate Dam, this translates to a temperature reduction of 1–2.5°C (1.8–4.5°F) during spring and a temperature increase of 2–10°C (3.6–18°F) during summer and fall (PacifiCorp 2005). During much of the summer and early fall, dissolved oxygen concentrations throughout the middle and lower Klamath River fall below the Basin Plan minimum criterion of 8 mg/L, particularly during the night. Rare occurrences of daily dissolved oxygen minimums of 5.5 mg/L have been reported in the middle and lower Klamath River (USFWS 2008, FERC 2007, Karuk Tribe 2002, 2003). In September 2007, a particularly intense *Microcystis aeruginosa* bloom extended from Iron Gate Dam to the mouth of the Klamath River (Kann and Asarian 2007, Kann and Corum 2007). The effect of water quality alterations is that conditions (especially water temperature and DO) are critically stressful for coho salmon for much of the summer (June through September) (NMFS 2010b).

2.5.1.1 Adult upstream migration in fall

Factors affecting survival of adult coho salmon in the mainstem Klamath River may include:

(1) warm water temperatures resulting from reduced flows, combined with poor water quality, can stress adult fish, delay migration, reduce availability of coldwater refugia, and promote disease infection and transmission, and (2) passage obstructions at tributary confluences caused by insufficient tributary flows.

2.5.1.2 Juvenile rearing and outmigration in mainstem

There is little direct observation data available on juvenile rearing within the mainstem Klamath River (Hardy et al. 2006, NMFS 2010b). However, downstream migrant trapping in various locations has provided good information on distribution and life history timing of juveniles and downstream migrating smolts. Trapping studies by Stutzer et al. (2006) suggest that age 1+ coho salmon were not continuously migrating downstream while in the mainstem; instead, these fish were holding and rearing for indeterminate periods of time while moving downstream. In general, it appears that a combination of density-dependant and density-independent factors affect coho salmon juveniles rearing and migrating in the mainstem. Density-dependant factors include competition for food and cold-water habitat with hatchery Chinook and coho salmon that are released in the millions (NMFS 2010b), while density-independent factors may include predation, disease, and high water temperatures. Important factors affecting survival of rearing and migrating age 0+ and age 1+ juvenile coho salmon in the mainstem Klamath River include:

- competition with hatchery Chinook and coho salmon for food and cold-water habitat,
- reduced flows that cause elevated water temperatures when combined with poor water quality, can reduce availability of suitable rearing habitat and coldwater refugia in the mainstem, and
- warm water temperatures resulting from reduced flows, combined with poor water quality, can reduce the availability of suitable rearing habitat, and
- high water temperatures may promote higher incidence of disease or parasitism, which may increase vulnerability to predation by juvenile Chinook salmon and steelhead (NRC 2004).

In a radio-tagging study, coho salmon smolts outmigrating from the Klamath River near Iron Gate Dam suffered mortality rates between 35 and 70% (Beeman et al. 2007, 2008). While these survival rates represent only a few years of data, they suggest that (1) occupying the mainstem near a disease infection zone located near the mouth of the Shasta River may result in high rates of mortality, and (2) higher spring discharge appears to improve survival (Beeman et al. 2007, 2008).

Under historical, unregulated conditions, an annual spring pulse flow occurred in the Klamath River and in its tributaries (NRC 2004). Under current conditions a spring pulse still occurs, but is altered by water management. The magnitude of the spring flow is believed to have resulted in higher survival of coho salmon juvenile outmigrants and smolts relative to current conditions through several mechanisms, including (1) reduced rates of infection in juvenile salmon by *Ceratomyxa shasta* and *Parvicapsula minibicornis*, (2) a reduced period of residency spent in the mainstem prior to smolting, and (3) greater habitat availability in the mid-Klamath River (Hardy et al. 2006), especially in the reach between Shasta River and Scott River where survival is particularly poor (Beeman et al. 2007, 2008).

2.5.2 Tributary streams downstream of Iron Gate Dam

Coho salmon in the Klamath River Basin primarily spawn and rear in tributary streams and juvenile coho salmon commonly rear for up to 18 months in fresh water, making freshwater habitat conditions particularly important. Factors affecting survival in tributaries include (1) reductions in the quality and quantity of water due to diversions and pumping, (2) habitat degradation due to myriad land uses and urbanization, and (3) obstacles to migration reducing habitat available for spawning and rearing (e.g., impassable culverts, dams) (NMFS 2010b).

Adults enter tributaries in late fall to spawn, and are subjected to both density-dependant and density-independent factors, including:

- elevated fine sediment input from logging, roads, and burned hillslopes reducing spawning success,
- destruction of redds by livestock,
- formation of migration barriers at the mouths of tributaries and within tributaries associated with reduced flows and sediment accumulation, and
- migration barriers associated with road crossings and culverts.

Fry emerge in spring, and juveniles rear for up to a year prior to outmigrating from tributaries to the mainstem Klamath River. During this time juveniles are subjected to both density-dependant and density-independent factors, including:

- elevated sediment input may simplify stream habitat and reduce availability of suitable summer and winter rearing habitat,
- elevated sediment input may reduce food production,
- surface diversions and groundwater pumping may elevate stream temperatures, reducing summer rearing habitat, and strand fish,
- tailwater returns from agriculture may elevate stream temperatures,
- loss of riparian vegetation by logging and grazing may reduce rearing habitat quantity and quality by reducing LWD input, breaking down stream banks, and increasing water temperatures,
- grazing by livestock within riparian areas may simplify stream habitat, reduce floodplain function, compact soils, spread invasive plant species, and reduce riparian cover,
- road crossings and culverts may impede or prevent seasonal movements of juvenile salmonids within and between tributaries,
- sediment accumulation at the mouths of tributaries may impede or prevent movements of juvenile fish when seeking suitable winter habitat and increase stranding risk, and

- unscreened diversion structures may entrain fry and juvenile coho salmon.

Chesney et al. (2007, as cited in Ericksen et al. 2007) observed that increased springtime (typically April) diversion of water and agricultural operations appeared to increase water temperature and decrease available habitat in the Shasta River, apparently leading to a pulse in outmigration of fry and juveniles into the mainstem Klamath River.

During a 2008 PIT-tag study of juvenile coho salmon in the Shasta River, Chesney et al. (2009) found juvenile coho only in areas where temperatures were moderated by cold springs; the remainder of potential rearing habitat was too warm (> 20°C). Rearing habitat suitability appeared to be heavily influenced by land use practices such as releasing warm water from upstream reservoirs, diverting cool spring water, and warm agricultural return water. Chesney et al. (2009) documented the following stressors on the coho salmon population in the Shasta River:

- destruction of redds by cattle,
- low-flow barriers preventing juvenile access to suitable rearing habitat,
- extreme water temperatures caused by springtime water diversions and warm agricultural return flow (March 1 through June 30),
- reduced coldwater refugia during the summer due to springtime water diversions and warm agricultural return flow (March 1 through September 30),
- warming of coldwater refugia due to release of warm water from Lake Shastina (May 1 through September 15), and
- reduced survival of outmigrating smolts due to low flows and increased water temperatures due to diversions and agricultural return flows (March 15 through May 31).

2.6 Population Response to Alternatives

Restoration actions are reasonably foreseeable under both alternatives. Table 2 summarizes the magnitude of restoration actions anticipated under each alternative. In this comparison, it is assumed that the Dams-Out Alternative includes all actions that will occur under Current Conditions, in addition to actions anticipated to occur as part of the KBRA.

Table 2. Magnitude of anticipated restoration actions under each alternative.

Restoration Action	Current Conditions	Dams-Out
Mainstem Klamath River		
Floodplain rehabilitation (miles of channel)	0.8	2
Large woody debris (miles of channel)	10	63
Cattle exclusion (miles of river)	122	146
Conservation easements/land purchase (acres)	0	1,176
Gravel augmentation downstream of Iron Gate Dam	yes	until dams removed
Klamath River Tributaries		
Floodplain rehabilitation (miles of channel)	6.21	13.27
Large woody debris (miles of channel)	38	198
Fish passage (number of locations)	66	73
Cattle exclusion (miles of river)	41	153
Riparian planting (acres)	0	346
Mechanical thinning to promote conifers (acres)	200	7,945
Fire treatment (acres)	45,000	116,050
Conservation easements/land purchase (acres)	10,000	21,800
Road decommissioning (miles of road)	470	1,330
Treating sediment sources (projects)	100	240
Instream flow studies	Yes	yes
Obtaining minimum flows	Possible	Likely

All of the actions occurring under the Current Conditions Alternative will also occur under the Dams-Out Alternative, and thus the benefits described above in Section 2.6.1 also apply to the Dams-Out Alternative. Aside from the benefits in water quality and flow regimes of removing the lower four dams on the Klamath River, with implementation of the KBRA there are key distinguishing differences between alternatives. The primary difference is the allocation of funds. Under Current Conditions there is a combined state and federal allocation of funds of approximately $100.9 million dollars of funding to be allocated during the analysis period (2012 to 2020), compared with a potential of more than $242.5 million from KBRA and state and federal funding under the Dams-Out Alternative.

As a result the dramatically higher funding opportunities under Dams-Out Alternative, the magnitude of the actions is proportionally higher under the Dams-Out Alternative, and thus the rate and potential of influence of the actions differs. For example, whereas the Current Conditions Alternative provides for LWD treatment within around 48 miles of channel, the Dams-Alternative provides for over 260 miles of channel. Therefore benefits of LWD treatment, such as increased winter habitat carrying capacity, is likely to occur sooner and have a greater amount of benefiit under the Dams-Out Alternative. In addition, some of the benefits anticipated under the Current Conditions Alternative, such as decreased water temperature and increased instream flows in tributaries, have much higher certainty of occurring under the Dams-Out

Alternative since there are a wider variety of projects and options made available with the increased allocation of funds.

2.6.1 Current Conditions

Restoration actions reasonably foreseeable under the Current Conditions Alternative are detailed in the Appendix table and summarized in Table 2. No quantitative population model has been constructed to estimate abundance increases for coho salmon under the Current Conditions Alternative. However, based on the life history needs of coho salmon, restorative actions are expected to improve the fitness and survival of coho salmon in the locations where actions occur, as described below.

2.6.1.1 Mainstem

As described in Hamilton et al. (2010), under the Current Conditions Alternative, instream flows resulting from Iron Gate Dam operation and maintenance would continue to increase minimum water temperatures in July and August by reducing the effects of nocturnal cooling. Key restoration actions that are reasonably foreseeable under the Current Conditions Alternative that will likely reduce water temperatures, include increased placement of LWD in confluence pools to increase coldwater refuge habitat and exclusion of livestock from the riparian zone. Other actions, such as gravel augmentation downstream of Iron Gate Dam, are also likely to occur in the mainstem Klamath River. Combined, these actions are likely to benefit coho salmon populations in terms of the VSP parameters as follows:

Abundance

- Gravel augmentation will likely reduce incidence of fish disease by enhancing the scour capabilities of flow thereby disturbing the preferred habitat of the polychaete worm that hosts *Ceratomyxa shasta*, a myxozoan parasite that limits survival of juvenile salmon. Gravel augmentation may also benefit mainstem spawning habitat. The efficacy of gravel augmentation to combat disease is dependent on the future flow schedule. Under the Current Conditions Alternative, regulated flows out of Iron Gate Dam will impede the success of gravel augmentation actions.
- Excluding livestock from floodplain habitat, reconnecting and rehabilitating floodplains, increasing tributary flows, and increasing the amount of LWD structure in confluence pools are expected to increase survival of juvenile fish. Actions in the lower mainstem may also increase survival for outmigrating smolts originating from the Trinity River. However, since proposed mainstem LWD projects are targeted at increasing cover for summertime coldwater refugia, increases in low-velocity winter habitat may be minor.
- LWD projects at confluence pools and livestock exclusion from riparian zones will likely reduce water temperatures in some locations and increase habitat complexity in pools acting as coldwater refugia, increasing summer rearing carrying capacity and survival, and leading to increased end-of-summer juvenile abundance. Downstream-migrating smolts may also benefit from increased cover in coldwater refugia, possibly increasing smolt survival.

Productivity

Excluding livestock from riparian areas and increasing LWD cover under the Current Conditions Alternative are anticipated to increase growth rates of juvenile coho salmon by mediating high water temperatures, particularly during summer and fall.

Spatial structure

No significant increases in the distribution of coho salmon spawning or rearing habitat are anticipated under the Current Conditions Alternative.

Biological and genetic diversity

Improvements in water temperature and quality in the mainstem under the Current Conditions Alternative will likely result in greater success of the mainstem rearing life history strategy, thereby improving biological diversity.

2.6.1.2 Tributaries

Key restoration actions reasonably foreseeable in tributaries to the Klamath River under Current Conditions Alternative include LWD projects to improve summer and winter rearing habitat, fish passage improvement projects, cattle exclusion from the riparian zone, and road decommissioning.

Perhaps one of the more notable actions occurring under the Current Conditions Alternative is increased instream flow regulation. State code 5937 and TMDL implementation described in Section 1.1.3 may result in increased instream flows and reduced water temperatures in key coho salmon rearing locations in mid-Klamath tributaries, such as the Shasta and Scott rivers. These actions will likely improve tributary rearing habitat conditions and increase summer survival, leading to increased smolt abundance. Moreover, improving tributary rearing habitat will likely expand distribution of coho salmon within the Klamath River Basin if fish can successfully spawn and rear in a greater number of locations. Increased flows will likely also increase juvenile growth rates, improving winter survival, outmigration survival in the mainstem, and subsequent ocean survival. Increased instream flows may also increase length of juvenile residency in tributaries, and support a life-history pattern of fish remaining in tributaries until they outmigrate as smolts, rather than entering the mainstem as fry, when they are most vulnerable to predation. The above described actions are likely to benefit coho salmon populations under the Current Conditions Alternative in terms of the VSP parameters as follows:

Abundance

- Modifying barriers at tributary outlets, culvert improvements, and increased instream flows will likely improve fish passage conditions for upstream migrating adults, which will likely increase the abundance of spawners and eggs deposited.
- Treatment of fine sediment sources, treatment of fire-prone areas, conservation easement, land purchases, road decommissioning, and cattle exclusion will likely reduce fine sediment delivery to streams, improving spawning habitat resulting in higher egg-to-emergent survival and increased fry abundance. Reduced fine sediment also anticipated to increase summer rearing habitat capacity, and increase number of overwintering juveniles in tributaries.
- Conservation easements, land purchases, mechanical thinning, road decommissioning, fire treatment, and increased instream flows potentially reduced temperature- and disease-

related mortality, increasing survival of upstream-migrating adult salmon, which will likely increase abundance of spawners and eggs deposited. These same actions are likely to result in decreases summer water temperatures, increasing survival during, and resulting in increased number of overwintering juveniles in tributaries.

- Increased instream flows, LWD treatments, and cattle exclusion will likely decreased fine sediment delivery will likely increase summer rearing habitat complexity and availability, anticipated to result in increasing summer habitat carrying capacity, which will likely increases number of overwintering juveniles in tributaries.
- Conservation easements, land purchases, mechanical thinning, road decommissioning, fire treatment, and increased instream flows potentially reduced temperature- and disease-related mortality, thus increasing summer habitat carrying capacity and survival, which will likely increases number of overwintering juveniles in tributaries.
- Floodplain rehabilitation, land purchases, conservation easements, cattle exclusion from flood plain habitat and LWD projects will likely increase coho salmon juvenile winter rearing carrying capacity and survival, which would be anticipated to result in increased coho salmon juvenile end-of-summer and smolt abundance in tributaries.

Productivity

- Conservation easements, land purchases, mechanical thinning, road decommissioning, fire treatment, and increased instream flows are anticipated to increase food availability and decrease water temperature, resulting in increased growth rates and the size of outmigrating juveniles and smolts under the Current Conditions Alternative. Larger smolts entering the mainstem are likely to have higher migration survival rates, and larger smolts entering the ocean are likely to have improved marine survival.
- Access to a wider range of spawning and rearing habitat conditions may allow fish to better adapt to seasonal or cyclical changes in climate, or ongoing changes to climate and surrounding habitats, resulting in greater productivity and resilience; e.g., juveniles would have greater access to suitable summer or winter habitat that may be suitable in any given year.

Spatial structure

- Modifying barriers at tributary outlets, culvert improvement projects, and increased instream flows are anticipated to improve upstream passage, providing increased access to habitat and a greater spatial distribution of spawning.
- Improved water quality, increased instream flows, and habitat restoration actions are anticipated to increase the amount and spatial distribution of summer and winter rearing.
- Increased distribution will likely reduce the risk of subpopulation extinction from catastrophic stochastic events such as wildfire, flooding, and debris flows by improving the ability of coho salmon to recolonize depopulated tributaries once conditions are favorable.

Biological and genetic diversity

- Improved spawning habitat quality and expanded distribution are anticipated to increase genetic diversity via higher egg-to-emergence survival, decreasing the risk of founder effects.
- Higher juvenile summer rearing carrying capacity is expected to support a tributary rearing strategy.

2.6.2 Dams-Out Alternative

Restoration actions reasonably foreseeable under the Dams-Out Alternative are detailed in the Appendix and summarized in Table 2. No quantitative population model has been constructed to estimate abundance increases for coho salmon under the Dams-Out Alternative. However, based on the life history needs of coho salmon, restorative actions are expected to improve the fitness and survival of coho salmon in the locations where actions occur, as described below.

2.6.2.1 Mainstem

As described in Hamilton et al. (2010), the removal of four mainstem dams is expected to eliminate an existing thermal lag (approximately 2 weeks) and the river would become warmer earlier in the spring and early summer, and cooler earlier in the late summer and fall consistent with ambient meteorology (Hamilton et al 2010). The river would experience higher maximum water temperatures, lower minimum water temperatures, and increased variability inherent in local unregulated river systems. These effects would be most prevalent immediately downstream of Iron Gate Dam with decreasing effects downstream to the Scott River. As described below, these changes are anticipated to increase the survival and abundance of coho salmon adult upstream migrants, summer rearing juveniles, and downstream migrating smolts.

Dam removal is also expected to decrease the duration of severely stressful conditions for juvenile coho salmon in the mainstem upstream of Seiad Valley. Improving water quality in the reach upstream of Seiad Valley is expected to benefit rearing conditions for juvenile coho salmon produced from key mid-Klamath tributaries, including the Shasta and Scott rivers. These improvements are expected reduce the prevalence of conditions considered stressful to rearing coho salmon and improve conditions for life history strategies relying on the mainstem for rearing.

In addition to dam removal, key restoration actions reasonably foreseeable in the mainstem Klamath River under the Dams-Out Alternative include floodplain rehabilitation, cattle exclusion and conservation easements to increase over-wintering habitat, and LWD projects at confluence pools to increase coldwater refuge habitat. These actions are focused on alleviating factors limiting coho salmon production in the Klamath River, including improving migration conditions for adult spawners and outmigrating smolts by reducing the incidence of disease and increasing cold water refuge habitat, increased summer habitat carrying capacity by increasing refuge rearing habitat, increased winter habitat carrying capacity by increasing high flow refuge habitat, and improved conditions in the estuary. These actions are likely to benefit populations in terms of VSP parameters as follows:

Abundance

- Uninterrupted sediment transport and more natural flow regime and decreased nutrients from upstream sources are expected to reduce the incidence of disease by enhancing the scour capabilities of flow, thereby disturbing the habitat of the polychaete worm that hosts *Ceratomyxa shasta*, a myxozoan parasite that limits survival of juvenile salmon. Gravel augmentation may also increase mainstem spawning habitat. Therefore, reducing polychaete habitat will likely increase abundance of smolts by increasing outmigration survival.

- Conservation easements, floodplain rehabilitation, LWD treatments, and livestock exclusion from floodplain habitat will likely increase coho salmon winter rearing carrying capacity and survival, which would be anticipated to result in increased numbers of coho salmon smolts.
- Conservation easements, floodplain rehabilitation, LWD treatments, and livestock exclusion from estuary habitat will likely increase coho salmon juvenile survival which would be anticipated to result in increase smolt abundance.
- Actions to restore the natural flow regime, increased instream flows in tributaries, conservation easements, LWD enhancement at confluence pools, and livestock exclusion from riparian zones will likely reduce summer water temperatures in some locations and increase rearing habitat complexity in coldwater pools increasing coho salmon summer rearing carrying capacity and survival leading to increased end-of-summer juvenile abundance. Outmigrants may also experience higher survival rates from these habitat improvements and those implemented in the lower mainstem.

Productivity

- Improved conditions in confluence pools due to livestock exclusion, floodplain rehabilitation, conservation easements, and LWD projects are anticipated to support increased growth rates of juvenile coho salmon, particularly during summer and fall.
- Conservation easements, floodplain rehabilitation, LWD treatments, and livestock exclusion from estuary habitat will likely increase coho salmon juvenile residency time and growth in the estuary, which would be anticipated to result in production of larger smolts with increased marine survival.

Spatial structure

Extensive conservation easements, floodplain rehabilitation, LWD treatments, and livestock exclusion from floodplain habitat will likely increase winter rearing distribution.

Biological and genetic diversity

Reduced water temperature and improved water quality in the mainstem will likely result in greater success of a mainstem rearing life-history strategy.

2.6.2.2 Tributaries

Key restoration actions reasonably foreseeable in tributaries to the Klamath River the Dams-Out Alternative include LWD treatments, floodplain rehabilitation, fish passage projects, cattle exclusion, riparian planting, mechanical thinning to promote conifers, fire treatment to prevent catastrophic fire, land purchases and conservation easements, road decommissioning, treatment of sediment sources, and increased instream flows. These actions are focused on alleviating the factors limiting coho salmon production in tributaries, including improved migration opportunities for adult spawners and juveniles, improved fry-to-emergent survival by treating sources of fine sediment, increased summer habitat carrying capacity by decreasing water temperatures and increasing rearing habitat, and increased winter habitat carrying capacity by increasing high flow refuge habitat. Considering all actions comprehensively, these actions are likely to benefit VSP parameters, including:

Abundance

- Modifying barriers at tributary outlets, culvert improvements, and increased instream flows will likely improve fish passage conditions for upstream migrating adults, which will likely increase abundance of spawners and eggs deposited.
- Treatment of fine sediment sources, treatment of fire-prone areas, conservation easement, land purchases, road decommissioning, and cattle exclusion will likely reduce fine sediment delivery to streams, improving spawning habitat resulting in higher egg-to-emergent survival and increased fry abundance. Reduced fine sediment also anticipated to increase summer rearing habitat capacity, and increase number of overwintering juveniles in tributaries.
- Conservation easements, land purchases, riparian planting, mechanical thinning, road decommissioning, fire treatment, and increased instream flows potentially reduced temperature- and disease-related mortality, increasing survival of upstream-migrating adult salmon, which will likely increase abundance of spawners and eggs deposited. These same actions are likely to result in decreases summer water temperatures, increasing survival during, and resulting in increased number of overwintering juveniles in tributaries.
- Increased instream flows, LWD treatments, and cattle exclusion will likely decreased fine sediment delivery will likely increase summer rearing habitat complexity and availability, anticipated to result in increasing summer habitat carrying capacity, which will likely increases number of overwintering juveniles in tributaries.
- Conservation easements, land purchases, riparian planting, mechanical thinning, road decommissioning, fire treatment, and increased instream flows potentially reduced temperature- and disease-related mortality, thus increasing summer habitat carrying capacity and survival, which will likely increases number of overwintering juveniles in tributaries.
- Floodplain rehabilitation, land purchases, conservation easements, cattle exclusion from flood plain habitat and LWD projects will likely increase coho salmon juvenile winter rearing carrying capacity and survival, which would be anticipated to result in increased coho salmon juvenile end-of-summer and smolt abundance from tributaries.

Productivity

- Conservation easements, land purchases, riparian planting, mechanical thinning, road decommissioning, fire treatment, and increased instream flows are anticipated to increase food availability and decrease water temperature, resulting in increased growth rates and the size of outmigrating juveniles and smolts. Larger smolts entering the mainstem are likely to have higher migration survival rates, and larger smolts entering the ocean are likely to have improved marine survival.
- Access to a wider range of spawning and rearing habitat conditions may allow fish to better adapt to seasonal or cyclical changes in climate, or ongoing changes to climate and surrounding habitats, resulting in greater productivity and resilience; e.g., juveniles would have greater access to suitable summer or winter habitat that may be suitable in any given year.

Spatial structure

- Modifying barriers at tributary outlets, culvert improvement projects, and increased instream flows are anticipated to improve upstream passage, providing for an increase in access and spatial distribution of spawning.

- Improved water quality, increased instream flows, and habitat restoration actions are anticipated to increase the amount and spatial distribution of summer and winter rearing.
- Increased distribution will likely reduce the risk of subpopulation extinction from catastrophic stochastic events such as wildfire, flooding, and debris flows by improving the ability of coho salmon to recolonize depopulated tributaries once conditions are favorable.

Biological and genetic diversity

- Improved spawning habitat quality and distribution anticipated to improve genetic diversity from higher emergent success, decreasing the risk of founder effects.
- Higher juvenile summer rearing carrying capacity anticipated to support tributary rearing life history.

3 SUMMER STEELHEAD

Some sources refer to this run as a "summer" run (e.g., Moyle 2002, NRC 2004, USFWS 1998, Papa et al. 2007), while others refer to it as a "spring" run (Hopelain 1998). In this document, it is referred to as a "summer" run.

3.1 Legal Status

Klamath Basin summer steelhead and winter steelhead populations both belong to the Klamath Mountain Province (KMP) Evolutionary Significant Unit. In a 2001 status review, NMFS determined that KMP steelhead did not warrant ESA listing (NMFS 2001a), despite acknowledging that their numbers are declining and they are in danger of extinction (Busby et al. 1994). In addition to genetic differences (Papa et al. 2007), summer steelhead differ from the other runs by run timing, sexual maturity upon freshwater entry, incidence of repeat spawning, and incidence of the half-pounder life-history (described below). Within the Klamath River Basin summer steelhead population there are considerable behavioral (Hopelain 1998) and genetic (Papa et al. 2007) differences from the other runs.

3.2 Life History

Summer steelhead enter the Klamath River earlier than either the fall or winter-runs, and unlike the other runs, enter sexually immature (Barnhart 1994, Moyle 2002). Although data are limited, it is believed that summer steelhead adults enter the mainstem Klamath River from March to June (Table 3) (Hopelain 1998), and migrate to cooler tributaries (Barnhart 1994, Moyle 2002). Summer steelhead adults appear to migrate rapidly once entering freshwater and appear to hold in tributaries longer than other runs. This contention is supported indirectly by observed run timing on the New River in 1994 (tributary to the Trinity River). Summer steelhead entry into the New River ranged from late March to mid-July, with a peak in late June (USFWS 1996, as cited in USFWS 1998). They have also been observed during snorkel surveys in several Klamath River tributaries during July through September (Dean 1995, USFWS 1998). There is a greater incidence of repeat spawning for summer steelhead, 40–64% as compared with 18–48% for fall run, and 31% for winter-run (Hopelain 1998).

Table 3. Life-history timing of summer steelhead in the Klamath River Basin downstream of Iron Gate Dam. Peak life history periods are shown in black.

Life stage (citations)	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult migration in mainstem[4]					▒	▒	▒	▒	▒	▒	▒	▒												
Adult holding in tributaries[1, 5, 8, 9]													▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	
Spawning[1, 10]	▒	▒	▒	▒																			▒	▒
Incubation	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒											▒	▒
Emergence[1]						▒	▒	▒	▒	▒	▒	▒												
Rearing[2, 3]	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Juvenile outmigration[3, 4, 5]							■	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	
Half-pounder residence[4, 6, 7]	▒	▒	▒	▒	▒	▒										▒	▒	▒	▒	▒	▒	▒	▒	▒
Run-backs[5]						▒	▒	■	▒	▒														

[1] PacifiCorp 2004; [2] NRC 2004; [3] PacifiCorp 2004; [4] Hopelain 1998; [5] Wallace 2004; [5] USFWS 1998; [6] CDFG 1988, as cited in USFWS 1998; [7] NRC 2004; [8] USFWS 1996, as cited in USFWS 1998; [9] Dean 1995; [10] Klamath River Stock Identification Committee (KRSIC) 1993, as cited in USFWS 1998

All steelhead runs share the "half-pounder" life-history pattern, in which an immature fish emigrates to the ocean in the spring, returns to the river in the fall, spends the winter in the river, then emigrates to the ocean again the following spring (Busby et al. 1994, Moyle 2002). Half-pounders enter freshwater from approximately mid-August to mid-October, with peak entry occurring during the last week in August to mid-September (CDFG 1988, as cited in USFWS 1998). Half-pounders typically utilize the mainstem Klamath River, although they also use larger tributaries such as the Trinity River during the fall (Dean 1994, 1995). Half-pounders that overwintered in freshwater during the previous winter typically outmigrate in March. The incidence of half-pounders appears to vary greatly, depending on the population of summer steelhead in the basin (Hopelain 1998). Most data on observations of half-pounders is not run-specific, to our knowledge. The half-pounder life history does not appear to be as prominent for the summer run when compared with the fall run. Hopelain (1998) found that only 32% of summer steelhead adults (17 adults in all) in the North Fork Trinity River exhibited a half-pounder life history, in comparison with 94% for upper Klamath River fall steelhead (406 adults); however, 100% of all summer steelhead adults in Clear Creek (11 adults) exhibited a half-pounder life history.

Spawning probably occurs slightly earlier for summer steelhead than for the other runs, with timing thought to be from December through February (Table 3) (KRSIC 1993, as cited in USFWS 1998). Adult steelhead downstream migrants (run-backs) are thought to migrate to the ocean from mid-March to late May, based on steelhead emigration in New River, tributary to the Trinity River (USFWS 1998).

Age-0, 1, and 2 juveniles all rear to some extent in the mainstem during fall. Run-type has not been identified for juveniles observed in the mainstem Klamath River to our knowledge. It is assumed that summer-run fish have a similar life-history pattern to observed steelhead juveniles, presumably of different run types. In tributaries to the Klamath River above Seiad Creek, it appears that large numbers of age-0 and 1 juveniles leave tributaries and enter the mainstem in spring and summer, and that these fish are likely rearing in the mainstem before leaving as age-2 outmigrants (CDFG 1990a, 1990b, as cited in USFWS 1998). Upstream of the Trinity River confluence, around 13% of rearing juveniles (run is unknown) are age-0, 47% are age-1, 37% age-2, and 3% are age-3 (Scheiff et al. 2001). Similar proportions occur in Trinity River. Age-0 steelhead were also observed rearing in the upper mainstem Klamath River from mid-May through mid-October (CDFG 1990a, 1990b, both as cited in USFWS 1998). Rearing also takes place in tributaries to the Klamath River, as well as the estuary during fall. Based on rotary screw trapping[1] in the Trinity River through October or November, age-0, 1, and 2 juvenile outmigrants were all captured as late as early December (Scheiff et al. 2001). Assuming that these fish reached the Klamath River mainstem shortly thereafter, mainstem Klamath River rearing occurred throughout the entire fall period (and for the entire year for age-0 outmigrants). Juveniles are also captured in the estuary as late as September and October, when sampling ends (Wallace 2004). Juveniles were also captured at the Big Bar rotary trap on the mainstem Klamath River from mid-September to mid-December (USFWS 1998).

Summer steelhead juveniles share a similar life-history pattern to fall and winter steelhead, with over 90% smolting at age-2 (Hopelain 1998). Smolts appear to outmigrate throughout the entire fall period, with smolts captured in the estuary during the entire sampling period (typically from May to September, although sometimes as late as October) (Wallace 2004), and from mid-September to mid-December at the rotary screw trap at Big Bar (USFWS 1998). It appears, however, that peak smolt outmigration occurs earlier than fall (i.e., in April, May, or June), based on estuary captures (Wallace 2004).

3.3 Distribution

Summer steelhead are distributed throughout the Klamath River downstream of Iron Gate Dam, and in its tributaries (Figure 2). Spawning is primarily in tributaries, and based on direct observation is believed to include the following streams: Bluff Creek, Red Cap Creek, Dillon Creek, Clear Creek, Indian Creek, Elk Creek, Wooley Creek, Salmon River, South Fork Trinity River, North Fork Trinity River, New River, and Canyon Creek (Roelofs 1983). Based on analysis of available escapement data from 1978 through 1997, on average around 53% of the population spawn in tributaries to the Klamath River upstream of the confluence with the Trinity River. It is believed that summer steelhead adults are fairly rare above Seiad Creek, due to high water temperatures (Kent Bulfinch, California In-River Sport Fishing Community Representative, pers. comm., 1996, as cited in NRC 2004). Half-pounders appear to travel upstream along with fall-run Chinook salmon during their fall spawning migration (USFWS 1998).

[1] Rotary screw traps capture downstream migrating fish by sampling a portion of the water column.

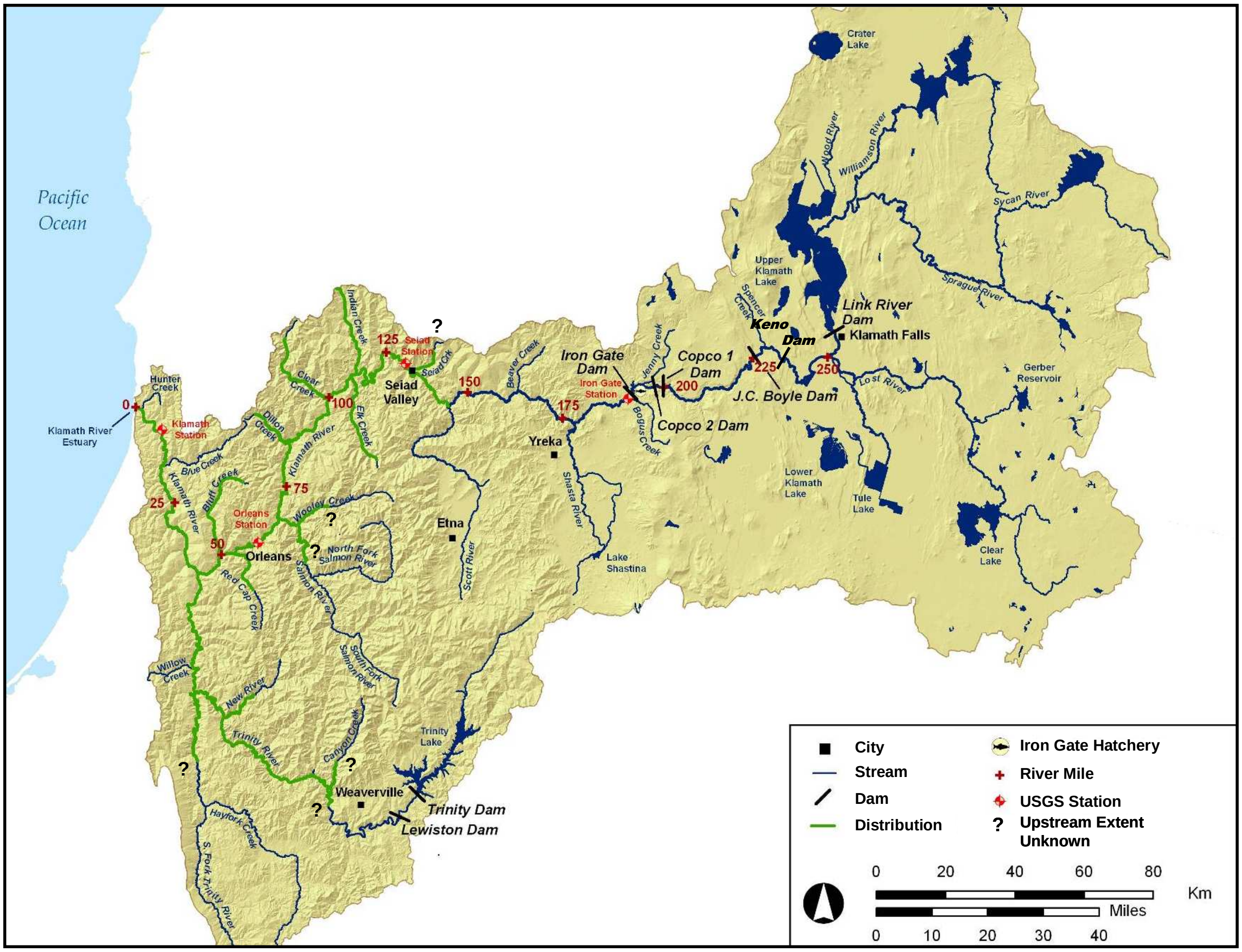

Figure 2. Summer steelhead distribution in the Klamath River basin.

Juveniles rear in the mainstem Klamath River, tributaries to the Klamath, or the estuary. It is thought that juveniles rearing in tributaries are typically distributed near spawning locations, typically upstream of winter steelhead distribution, although probably sympatric with coho salmon (NRC 2004). Based on analysis of available outmigrant trapping data (including Scheiff et al. 2001, Chesney 2000, Chesney and Yokel 2003), a little over half of the production of juveniles (of all runs) appears to be produced from tributaries upstream of the confluence with the Trinity River, consistent with spawning distribution (although there is much annual variation). There appears to be substantial mainstem rearing of steelhead juveniles into September, with 88% of pools surveyed containing steelhead, as compared with only 41% for Chinook salmon juveniles and 3% for coho salmon juveniles (T. Shaw, USFWS, unpubl. material, 2002, as cited in NRC 2004).

A significant migration of age-0 juvenile steelhead are observed migrating upstream into tributaries (including some that were dry during summer), off-channel ponds, and other winter refuge habitat in the lower Klamath River (near or within the estuary), including Waukell, Panther, Hunter, and McGarvey creeks (M. Hiner, Fisheries Biologist, Yurok Tribe, unpubl. data, 2008). This migration upstream out of the mainstem Klamath River occurs annually, mostly in October and November, but also in December through February. Smolts are captured in the mainstem and estuary throughout this period as well, although the peak outmigration is typically in spring and summer (USFWS 1998, Wallace 2004).

3.4 Population Trends

Detailed information on population trends of summer steelhead are not available in the Klamath River. Based on snorkel surveys conducted by the USFS Orleans and Happy Camp Ranger Districts between 500 and 2,500 adults and half pounders were observed annually from 1985 to 2009, although the locations of these surveys are not known.

Steelhead spring outmigrant abundance estimates at the Big Bar trap during 1997–2000 ranged from 14,456 in 2000, to 66,125 in 1998 (Sheiff et al. 2001). The majority of outmigrant steelhead were comprised of 13% age-0, 47% age-1, 37% age-2, and 3% age-3, with less than 1% of fish captured of hatchery origin.

3.5 Summer Steelhead Population Considerations

Summer steelhead in the Klamath River exhibit complex and diverse life history patterns. The primary difference between the various steelhead life history strategies relates to the time spent rearing in tributaries and mainstem, and the age and timing of outmigration. Although the majority of mid-Klamath steelhead outmigrants are age-1 (Sheiff, et al 2001), the most successful life history patterns for summer steelhead in the Klamath River appear to be those where juveniles spend 2 years rearing in fresh water prior to smolt outmigration the based on Hopelain 1998. The age (and size) at entry to salt water appears an important factor for being successful in the marine environment. As such, summer steelhead that smolt at age-1 do not appear to contribute substantially to the adult population. In addition, steelhead are generally more tolerant of high water temperature than other anadromous salmonids in the Klamath River (i.e., Chinook and coho).

3.5.1 Mainstem Klamath River downstream of Iron Gate Dam

The mainstem Klamath River is used primarily as a migration corridor for adult summer steelhead accessing holding and spawning habitat in tributaries to the Klamath River, and for juvenile steelhead outmigration from spring through fall. Under current conditions summer steelhead use the mainstem Klamath River downstream of Iron Gate Dam, however, adults are rare upstream of Seiad Valley, presumably due to high water temperatures. Juvenile rearing occurs in the mainstem Klamath River and estuary year-round. Conditions in the mainstem are generally suitable during adult upstream migration, however, high water temperatures in the late spring and summer may restrict the distribution of later-arriving adults. Habitat conditions for steelhead juveniles rearing in the mainstem are generally suitable, except for reaches upstream of Seiad Valley where summer water temperatures are considered stressful. Juvenile outmigrating peaks in the spring and extends through the summer and fall.

Density-independent factors affecting survival in the mainstem are primarily associated with high summer water temperatures and disease, especially upstream of the Scott River. Growth of juveniles rearing in the mainstem and their size at marine entry may also limit success in the marine environment. Density-dependant factors affecting survival are primarily associated with winter rearing and refuge habitat.

3.5.2 Tributary streams downstream of Iron Gate Dam

Summer steelhead predominately use tributaries downstream of the Scott River due to high temperatures upstream of Seiad Valley. Key tributaries for summer steelhead include: Bluff Creek, Red Cap Creek, Dillon Creek, Clear Creek, Indian Creek, Elk Creek, Wooley Creek, Salmon River, South Fork Trinity River, North Fork Trinity River, New River, and Canyon Creek (Roelofs 1983).

Summer steelhead in the Klamath River migrate upstream in the spring and hold in tributaries throughout the summer and fall. Summer water temperatures in tributaries are generally suitable for adult holding and juvenile rearing. Spawning occurs during early winter and spawning habitat quantity is not likely limiting, however, in some location increased fine sediment resulting from land use has likely degraded spawning habitat conditions and reduced egg-to-emergence survival. Redd scour resulting from high peak flows may also contribute to significant mortality in some years.

Juvenile summer steelhead rear in tributaries for up to three years before outmigrating and are, therefore, dependant on tributary habitat conditions. Based on Hopelain (1998), the most successful life history strategy in tributaries is for juveniles spend two years in fresh water prior to outmigration. Juveniles outmigrating from tributaries as age-0 and age-1 are reliant on mainstem habitat conditions for one or more years to reach an appropriate size for smolting.

Primary factors limiting population in tributaries includes density-independent mortality related to high summer water temperatures and the effects of fine sediment in spawning gravel, and density-dependant mortality related to summer rearing and winter refuge habitat limitations. In tributaries with suitable summer water temperatures, density-dependant factors limit population abundance. During winter, steelhead use the interstitial spaces in substrate when water temperatures are cold and for refuge from high flow. In tributaries with degraded habitat conditions where fine sediment has increased, winter refuge habitat is likely limiting. In tributaries with abundant winter refuge habitat, age-2 summer rearing habitat conditions may be limiting.

3.6 Population Response to Alternatives

Restoration actions likely to occur under each alternative are considered in Section 3.6 for coho salmon. These same actions are anticipated to influence steelhead populations in much the same way. In general, the benefits of the Dams-Out Alternative for summer steelhead are expected to improve steelhead VSP criteria. Steelhead have a higher temperature tolerance compared with other anadromous salmonids, and thus are less likely to benefit from actions in the mainstem to reduce water temperature. However, the effects of dam removal are expected to decrease the duration of stressful conditions for adult steelhead in late June, during the later period of adult migration. Dam removal is also expected to decrease the duration of severely stressful conditions for juvenile steelhead upstream of Seiad Valley. Improving water quality in the reach upstream of Seiad Valley is expected to primarily benefit rearing conditions for summer steelhead produced upstream of Iron Gate Dam since summer steelhead currently primarily utilize habitat downstream of the Scott River. These improvements are expected reduce the prevalence of conditions considered stressful to rearing steelhead and improve conditions for life history strategies relying on the mainstem for rearing. In addition, steelhead are more likely than other salmonids to benefit from the numerous proposed restoration actions to reduce sediment delivery to streams, since they use the interstitial spaces of cobble substrate as high-flow refuge habitat.

4 WINTER STEELHEAD

Moyle (2002) describes steelhead in the Klamath River Basin as having a summer and winter run. Some divide the winter run into fall and winter runs (Barnhart 1994, Hopelain 1998, USFWS 1998, Papa et al. 2007). In this report "winter steelhead" refers to both fall and winter runs except in cases when the distinction is pertinent to the discussion.

This section pertains to both the anadromous (steelhead) and resident (rainbow trout) life-history forms of the subspecies *Oncorhynchus mykiss irideus*. The vast majority of existing information from the Klamath Basin is in regards to steelhead rather than resident rainbow trout; this section primarily addresses steelhead as well, but juvenile habitat use and response to habitat degradation or enhancement is assumed to be similar for both life-history forms.

4.1 Legal Status

Klamath Basin summer and winter steelhead populations belong to the Klamath Mountain Province (KMP) Evolutionary Significant Unit. In 2001, NMFS determined that the KMP steelhead ESU did not warrant listing under the Endangered Species Act, despite acknowledging that their numbers are declining and they are in danger of extinction (NMFS 2001a).

4.2 Life History

In contrast to summer steelhead, winter steelhead are sexually mature upon freshwater entry. Adults typically enter the Klamath River from July to October (sometimes called the "fall run") and from November through March (the "winter run") (Table 4) (Hopelain 1998, USFWS 1998). The earlier portion of the run may hold in the mainstem Klamath River from a few weeks to nearly two months. It appears that fall steelhead adults utilize the mainstem Klamath River above Seiad Creek from September to December, and that winter steelhead adults utilize the same area from late December through mid-April (USFWS 1998).

Table 4. Life-history timing of winter steelhead in the Klamath River Basin downstream of Iron Gate Dam. Peak life history periods are shown in black.

Life stage (citations)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult migration												
Spawning[1, 9, 10]												
Incubation												
Emergence[1, 2]												
Rearing												
Juvenile outmigration												
Half-pounder residence[1, 3, 4, 5]												
Run-backs[11]												

[1] NRC (2004); [2] Dean (1994); [3] Busby et al. (1994), [4] Moyle (2002); [5] CDFG (1988, as cited in USFWS 1998); [9]KRSIC (1993, as cited in USFWS 1998); [10] West et al. (1990); [11] Nels Brownel (USFS, pers. comm., 1997, as cited in USFWS 1998)

Winter steelhead primarily spawn in tributaries, but also spawn in the mainstem, with peak spawn timing in February and March (ranging from January to April) (NRC 2004). In general, spawn timing of fall steelhead ranges from February through April, and from January through April for winter steelhead (KRSIC 1993, as cited in USFWS 1998). Spawning in tributaries to the Klamath River upstream of Seiad Creek occurs from mid-March to early May (West et al. 1990). Adults may repeat spawning in subsequent years after returning to the ocean.

Although there are little data on downstream migration of spawned adults, winter steelhead have been captured in May near the mouth of Beaver Creek (RM 259) (N. Brownel, USFS, pers. comm., 1997, as cited in USFWS 1998).

Fry emerge in spring (NRC 2004), with fry observed in outmigrant traps in Bogus Creek and Shasta River from March through mid-June (Dean 1994). Some juveniles rear in the mainstem during fall, and likely to some extent in the winter and spring. It is unclear if fish rearing in the mainstem during fall make migrations back into tributaries during winter, but age 0+ and 1+ year old juveniles have been captured in the mainstem until the end of trapping season in mid-December (USFWS 1998). Age 0+ steelhead were also observed rearing in the upper mainstem Klamath River mainstem from mid-May through mid-October (CDFG 1990a, 1990b, both as cited in USFWS 1998), and juveniles have also been captured in the estuary as late as September and October (when sampling ended) (Wallace 2004).

In tributaries to the Klamath River above Seiad Creek, age-0+ and 1+ juveniles have been captured in outmigrant traps in spring and summer (CDFG 1990a, 1990b, as cited in USFWS 1998), which means that these fish are likely rearing in the mainstem before leaving as age-2+ outmigrants. Upstream of the Trinity River confluence, around 13% of rearing juveniles (run is unknown) are age 0+, 47% are age 1+, 37% age 2+, and 3% are age 3+ (Scheiff et al. 2001). Similar proportions occur in Trinity River. Age-0 steelhead have been captured leaving the Shasta River and Bogus Creek from mid-April through early July, and age-1 steelhead were observed from January through June. Age 1+ and 2+ juveniles are typically captured in April and May at both the Big Bar rotary trap on the mainstem Klamath and the Willow Creek rotary trap on the Trinity River, and it is not uncommon for age-0 fish to be captured in May as well (Scheiff et al. 2001). Based on rotary screw trapping in the Trinity River, age 0+, 1+, and 2+ juvenile outmigrants were all captured as late as early December (Scheiff et al. 2001). In addition, there is evidence of downstream migration of age 1+ and 2+ juveniles in tributaries such as Bogus Creek and Shasta River as early as mid-January and throughout the entire trapping season ending in June (CDFG 1990a, 1990b, as cited in USFWS 1998). Age 3+ outmigrants are only captured in small numbers, but are typically captured from April to June in the mainstem Klamath River, and from April to May in the mainstem Trinity River. Peak abundance of juvenile steelhead in the estuary typically occurs in May and June (Wallace 2004).

Juvenile outmigration appears to primarily occur between May and September with peaks between April and June, although smolts are captured in the estuary as early as March and as late as October (Wallace 2004). Most adult returns (86%) originate from fish that smolt at age 2+, representing 86% of adult returns, in comparison with only 10% for age-1 juveniles and 4% for age 3+ juveniles (Hopelain 1998).

4.3 Distribution

Winter steelhead are widely distributed throughout the Klamath River and its tributaries downstream of Iron Gate Dam (Figure 3). The Trinity, Scott, Shasta, and Salmon rivers are the most important spawning streams for winter steelhead; no spawning has been documented in the mainstem. Escapement data on winter steelhead is lacking, primarily because of the logistical challenges of sampling adults during winter (NMFS 2001b, as cited in FERC 2006). Based on examination of the small amount of data available, it appears that greater than 80% of adults spawn in tributaries upstream of the confluence with the Trinity River.

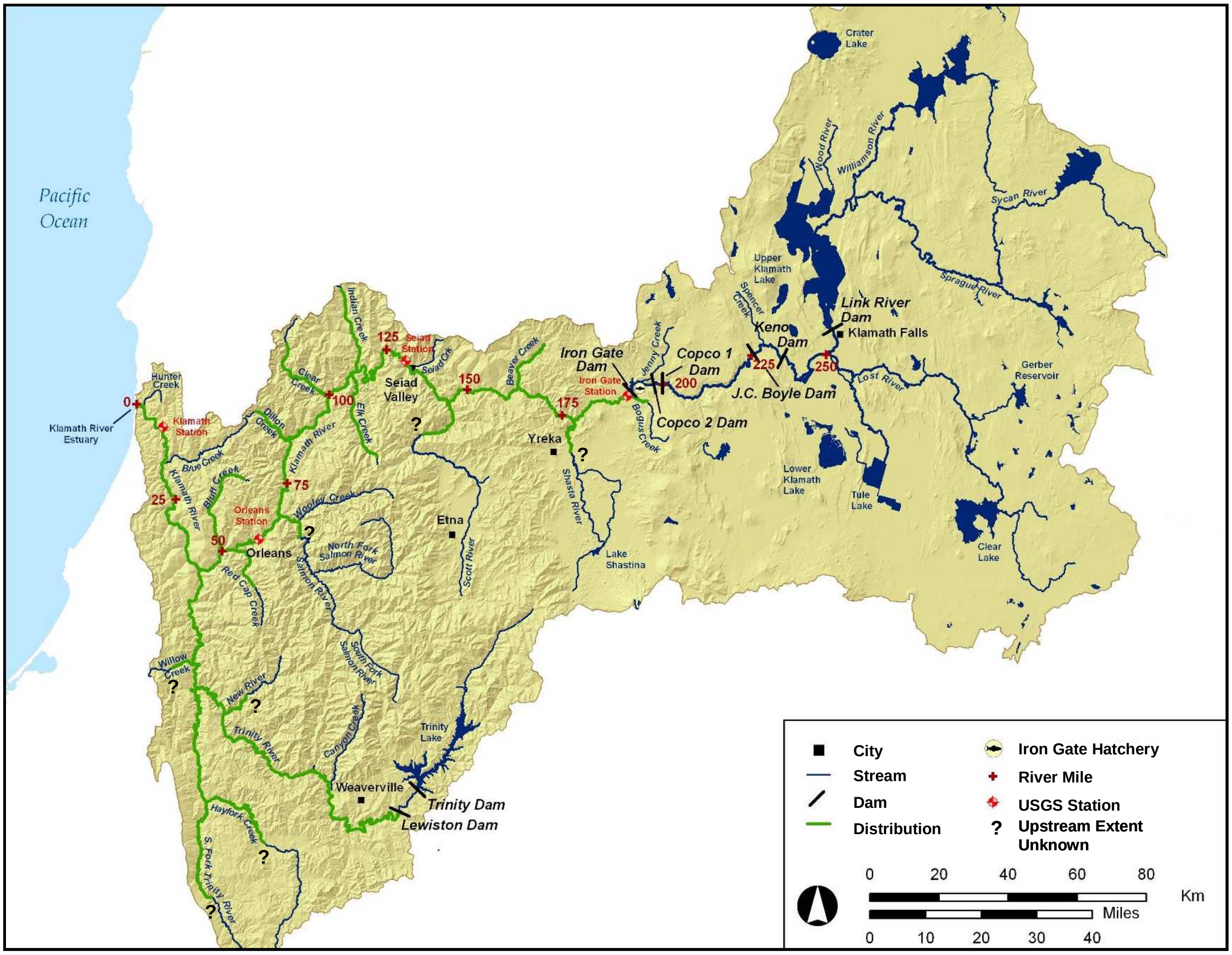

Figure 3. Winter steelhead distribution in the Klamath River basin.

Half-pounders typically utilize the mainstem Klamath River until leaving the following March (NRC 2004), although they also utilize larger tributaries such as the Trinity River (Dean 1994, 1995). Half-pounders are seen as far up in the mainstem as Beaver Creek from December through February (Bob Claypole, Klamath River guide, pers. comm., 1996, as cited in USFWS 1998). This life-history pattern is common within all tributaries, although it appears to be dominant for fall-run spawners in the mainstem Klamath River tributaries upstream of Weitchpec (mean incidence of 94% of all returning adults), and in the mainstem Trinity River (80% of returning adults) (Hopelain 1998). Winter-run steelhead apparently have a much lower incidence of the half-pounder life history in comparison with fall-run (18% compared with a mean of 94% based on 5 Klamath tributaries upstream of Weitchpec) (Hopelain 1998).

Half-pounders typically return to the river in September, and the majority reside in the lower Klamath River through March before returning to the ocean (NRC 2004). As the fall progresses, half-pounders appear to travel upstream along with fall-run Chinook salmon during their spawning migration (USFWS 1998). Half-pounders are also common in the Trinity River, although they typically represent a small fraction of all steelhead that are sampled at either the Junction City or Willow Creek weirs, possibly because they may be able to swim through the spaces between weir bars. In some years, they have represented over 20% of the steelhead entering Trinity River Hatchery, although this percentage likely includes resident trout (Dean 1994, 1995). The percentage exhibiting this life-history pattern appears to be influenced by spawning location. Hopelain (1998) found that nearly 80% of spawners in the mainstem Trinity River exhibited a half-pounder life history, although much lower percentages were determined for spawners in the North Fork and South Fork Trinity rivers (32% and 35%, respectively).

Fry and juveniles rear in the mainstem Klamath River, tributaries to the Klamath River, and in the estuary. Based on analysis of available outmigrant trapping data (including Scheiff et al. 2001, Chesney 2000, Chesney and Yokel 2003), a little over half of the production of juveniles (from all runs of steelhead) appear to be produced from tributaries upstream of the confluence with the Trinity River, although there is much annual variation. Large numbers of juveniles outmigrate from the Scott and Shasta rivers in early July (Chesney 2000, Chesney 2002, Chesney and Yokel 2003). There appears to be substantial mainstem rearing of steelhead juveniles into September, with 88% of pools surveyed containing steelhead, as compared with only 41% for Chinook salmon juveniles and 3% for coho salmon juveniles (T. Shaw, USFWS, unpubl. material, 2002, as cited in NRC 2004). A significant migration of age-0 juvenile steelhead migrate upstream into tributaries (including some that were dry during summer), off-channel ponds, and other winter refuge habitat in the lower Klamath River (near or within the estuary), including Waukell, Panther, Hunter, and McGarvey creeks (M. Hiner, Fisheries Biologist, Yurok Tribe, unpubl. data, 2008). This migration upstream out of the mainstem Klamath River occurs annually mostly in October and November, but also in December through February.

4.4 Population Trends

Winter steelhead population in the Klamath River (not including the Trinity River) were estimated to be about 170,000 in the 1960s, 129,000 in the 1970s, and 100,000 in the 1980s (Busby et al 1994, as cited in NRC 2004).

4.5 Winter Steelhead Population Considerations

4.5.1 Mainstem Klamath River downstream of Iron Gate Dam

Adult fall and winter steelhead generally use the mainstem Klamath River as a migration corridor to access tributary reaches for spawning and to return to the ocean subsequent to spawning. Spawning in the mainstem may occur but is not prevalent and has not been documented (NRC 2004, USFWS 1998). Half-pounders generally remain in the mainstem Klamath River and major tributaries from September through April. Juvenile winter steelhead rear year-round in the mainstem Klamath River although those rearing in the mainstem tend to use lower tributary reaches for overwintering. Juvenile outmigration generally occurs in the spring coincident with the spring snowmelt flow increase. Primary factors limiting winter steelhead populations in the mainstem Klamath River includes density-independent effects of high summer water temperature and disease on rearing juveniles and outmigrants.

4.5.2 Tributary streams downstream of Iron Gate Dam

Winter steelhead are the most widely distributed anadromous salmonid in Klamath River tributaries downstream of Iron Gate Dam. Key tributaries for winter steelhead include the Shasta River, Beaver Creek, Scott River, Indian Creek, Salmon River, Elk Creek, Clear Creek, Bluff Creek, and the Trinity River.

Spawning habitat quantity is not likely limiting, however, increased fine sediment resulting from land use (development, roads and logging) has degraded spawning habitat conditions in tributaries compared with historical conditions and reduced egg-to-emergence survival. Redd scour resulting from high flows can also contribute to significant mortality in some years.

Steelhead generally rear in tributaries for 2 years (range 1–3 years) before migrating to the ocean in spring which makes them dependant on tributary habitat conditions year-round. Summer rearing habitat is likely limiting in tributaries with high summer water temperatures, and winter habitat is likely limiting in tributaries where summer water temperatures are suitable. In tributaries with suitable summer water temperatures, density-dependant factors limit population abundance. During winter, steelhead use the interstitial spaces in substrate for refuge from high flow. Winter refuge habitat likely limits smolt production, especially in those tributary streams where fine sediment has increased. In tributaries with abundant winter refuge habitat, summer rearing habitat is likely limiting.

Juvenile steelhead outmigration from tributaries to mainstem Klamath River occurs in spring when water temperatures are generally suitable. Those outmigrating from tributaries during summer may be limited by warm water temperatures and disease in the mainstem Klamath River.

Primary factors limiting population in tributaries includes density-independent mortality related to high summer water temperatures, the effects of fine sediment in spawning and winter refuge habitat, and density-dependant mortality related to summer and winter rearing habitat limitations.

4.6 Population Response to Alternatives

Restoration actions likely to occur under each alternative are considered in Section 3.6 for coho salmon. These same actions are anticipated to influence steelhead populations in much the same way, especially since winter steelhead have similar life history timing as coho salmon. In general, the benefits of the Dams-Out Alternative for winter steelhead are expected to improve steelhead VSP criteria. Key differences include the wide distribution of winter steelhead in most tributaries and mainstem, the two-year freshwater residency of juvenile steelhead prior to smolting, and that steelhead have a higher temperature tolerance compared with other anadromous salmonids, and thus are less likely to benefit from actions in the mainstem to reduce water temperature. However, the effects of dam removal is expected to decrease the duration of stressful conditions for juveniles rearing in the mainstem, especially for individuals rearing upstream of Seiad Valley. These improvements are expected reduce the prevalence of conditions considered stressful to rearing steelhead and improve conditions for life history strategies relying on the mainstem for rearing. In addition, steelhead are more likely than other salmonids to benefit from the numerous proposed restoration actions to reduce sediment delivery to streams, since they use the interstitial spaces of cobble substrate as high-flow refuge habitat.

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Appendix

Table of Proposed Restoration Actions and Anticipated Benefits to Salmonids

MID-KLAMATH RIVER AND TRIBUTARIES (IRON GATE DAM TO WEITCHPEC)

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
1	**Floodplain rehabilitation**. Improve or restore connections between the channel and floodplain to create and maintain off-channel habitats accessible to overwintering juvenile salmonids. Enhance riparian and stream habitats through riparian planting and understory thinning to facilitate the development of mature riparian stands that can provide shading and large and small wood to stream channels and floodplains, with an emphasis on lower tributary reaches and their confluence with the mainstem. **Targeted mid-Klamath tributaries**: Aikens, Camp, Seiad, Horse, Little Horse, Cottonwood, and Tom Martin creeks. **Current Conditions Alternative** Large-scale channel restoration will occur in one miles of tributary habitat. **Dams-Out Alternative** Large-scale channel restoration will occur in two miles of tributary habitat.	**Winter rearing habitat**: Lack of cover and off-channel and other low-velocity habitats may increase juvenile overwintering mortality through displacement during high-flow events, predation, or stress. **Summer rearing habitat**: High temperatures occurring during summer low flows may cause direct mortality of juvenile rearing and outmigrating salmonids, make juvenile fish more susceptible to disease and predation, and reduce growth by increasing metabolism.	**Increases winter rearing habitat** by creating and restoring access to low-velocity habitats that provide refuge from high flows and displacement. **Increases summer rearing habitat** by increasing LWD cover and creating deeper pools that may serve as cool-water habitat during summer low flows. **Reduces summer and winter rearing mortality**: Increased LWD cover and pool depths may reduce predation mortality.	**Coho Salmon** Coho salmon are expected to benefit most due to their preference for off-channel habitats and LWD cover during winter. Action will likely increase the number of juvenile coho salmon able to rear for a full year in tributaries before moving to the mainstem or outmigrating to the estuary and Pacific Ocean. **Summer and Winter Steelhead** An increase in channel complexity and range of depths may increase the number of juvenile steelhead that remain to rear a second summer in tributaries. Age 2+ outmigrants have the highest rates of adult return; therefore, increasing the proportion of the population that remains to rear for a second summer will likely increase ocean survival and escapement.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
2	**Remove barriers at tributary mouths**. Continue to manually alter alluvial deposits and steep gradients at tributary outlets to allow for upstream and downstream passage of fish. **Targeted mid-Klamath tributaries**: Rogers, Ti, Boise, Aubrey, Elliot, Swillup, Cade, Chnia, Thompson creeks and others. **Current Conditions Alternative** Annual maintenance at 60 different tributaries to the mainstem for eight years. **Dams-Out Alternative** Annual passage improvement at 60 different tributaries to the mainstem for eight years.	**Adult upstream migration barriers**: aggradation of the channel at the mouths of tributaries can prevent the movement of adult salmon into their natal streams to spawn, reducing the amount of spawning habitat available and possibly resulting in pre-spawn mortality from exposure to high temperatures, predation, or stranding. **Barriers to seasonal movements** by juvenile fish: Juvenile salmonids may travel between their natal tributaries and the mainstem or other tributaries to find suitable summer or winter habitat. Barriers to such movements will likely limit rearing survival in tributaries lacking one or the other habitat. **Summer rearing habitat**: Gravel aggradation at the mouths of tributaries can prevent the flow of colder tributary water to pools formed at their confluence with the mainstem, which may be important as refuge from high temperatures during summer low flows.	**Maintains or restores access to spawning habitat** in the affected tributaries to reduce the potential for spawning habitat limitations and redd superimposition. Reduces potential for mortality caused by delay at tributary mouths, predation, or reduced fitness on the spawning grounds. **Maintains or restores habitat connectivity** between tributaries and mainstem, increasing the ability of juvenile fish to find and exploit seasonally appropriate habitats, thus increasing juvenile survival. **Maintains or enhances cold tributary outflow** to confluence pools in the mainstem, which may provide temperature refuge for juvenile or adult fish during summer low flows.	**Coho Salmon and Steelhead** All species are anticipated to benefit. Coho salmon and steelhead might benefit most due to their wide distribution in tributaries throughout mid-Klamath, and use of confluence pools as refuge habitat.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
3	**Upgrade culverts** to meet standards for fish passage. **Targeted mid-Klamath tributaries**: Portuguese, Fort Goff, Cade, Canyon, and Negro creeks **Current Conditions Alternative** Reasonably foreseeable that Caltrans will allocate roughly $10 million to replace approximately 6 culverts. **Dams-Out Alternative** Additional funds under KBRA to replace a total of approximately 8 culverts	**Adult upstream migration barriers**: Culverts can prevent the movement of adult salmon into their natal streams to spawn, reducing the amount of spawning habitat available. **Barriers to seasonal movements** by juvenile fish: Juvenile salmonids may travel between their natal tributaries and the mainstem or other tributaries to find suitable summer or winter habitat. Barriers to such movements will likely limit rearing survival in tributaries lacking one or the other habitat.	**Maintains or restores access** to spawning habitat in the affected tributaries to reduce the potential for spawning habitat limitations and redd superimposition. **Maintains or restores habitat connectivity** between tributaries and mainstem, increasing the ability of juvenile fish to find and exploit seasonally appropriate habitats, thus increasing juvenile survival.	**Coho Salmon and Steelhead** All species are anticipated to benefit. Coho salmon and steelhead might benefit most due to their wide distribution in tributaries throughout mid-Klamath, and use of confluence pools as refuge habitat.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
4 **5** **6**	**Add large woody debris** structure to reaches lacking floodplain connectivity, cover, or complexity. Place large wood and structures so as to activate the floodplain and create off-channel habitat. Mainstem placement will focus on enhancing cover in tributary confluence pools. **Targeted mainstem locations**: Confluence pools at Seiad, Horse, Beaver, Elliot, Little Grider, and Tom Martin, Elk, Indian, Red Cap, Clear, Slate, Thompson, Camp, Boise, and Sandy Bar creeks **Targeted tributary locations**: Stanshaw, Independence, Sandy Bar, Seiad, Bogus, Cottonwood, Willow, Barkhouse, Humbug, O'Neil, Beaver, Horse, Tom Martin, and Grider creeks **Current Conditions Alternative** No sources of funding are foreseeable in the immediate future. **Dams-Out Alternative** LWD structures in 28 mi of mainstem and 15 confluence pools. Structures average 30 pieces of wood each and approximately 30/mi will be placed in 28 miles of tributary habitat.	**Winter rearing habitat**: lack of cover and off-channel and other low-velocity habitats may increase juvenile overwintering mortality through displacement during high-flow events, predation, or stress. **Summer rearing habitat**: Loss of channel complexity and structure can reduce the availability of deep pools that may serve as temperature refugia at low flows.	**Increases winter rearing habitat** by creating low-velocity areas that provide refuge from high flows and displacement. **Increases summer rearing habitat** in mainstem by increasing LWD cover in tributary confluence pools that may serve as cool-water habitat during summer low flows. **Increases summer rearing habitat** in tributaries. Reaches with more LWD cover can often support higher densities of juvenile salmonids by breaking the line of sight between territorial individuals. **Reduces summer and winter rearing mortality**: increased LWD cover in tributaries and mainstem tributary confluence pools may reduce predation mortality.	**Coho Salmon** Coho salmon are expected to benefit most due to their preference for off-channel habitats and LWD cover during winter. Action will likely increase the number of juvenile coho salmon able to rear for a full year in tributaries before moving to the mainstem or outmigrating to the estuary and Pacific Ocean. **Summer and Winter Steelhead** An increase in channel complexity and range of depths may increase the number of juvenile steelhead that remain to rear a second summer. Age 2+ outmigrants have the highest rates of adult return; therefore, increasing the proportion of the population that remains to rear for a second summer will likely increase ocean survival and escapement.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
7	**Augment gravel** in the channel downstream of Iron Gate Dam on an annual basis. **Current Conditions Alternative** PacifiCorp is likely to provide funds for gravel augmentation. **Dams-Out Alternative** Augmentation will occur until dam removal is complete, and then no gravel augmentation is anticipated under this alternative due to restoration of natural sediment transport processes due to dam removal.	**Spawning habitat availability**: Dams prevent downstream transport of stream sediment, which may, depending on local circumstances, reduce spawning gravels in reaches downstream. In addition, the quality of spawning gravels and the channel bed downstream of the dam may be affected by increased fine sediment input from human activities or by altered hydrology. **Disease**: Sediment downstream of Iron Gate Dam provides silty habitat for polychaetes that are the host for the prevalent fish disease *Ceratomyxa shasta*. *C. shasta* reduces survival of upstream-migrating adults and downstream-migrating juveniles and smolts.	**Increases spawning habitat**: Gravel augmentation can increase spawning habitat in systems where there is redd superimposition, where spawning substrate is limited by capture behind the dam, or where spawning gravels have been adversely affected by sedimentation or armoring due to human activities. **Reduced disease incidence**: Potential reduced habitat for polychaetes and thus abundance of *C. shasta* by replacing silty habitat with gravel substrate.	**Fall-run Chinook Salmon** Fall-run Chinook salmon are the only species that will directly benefit from increased spawning habitat, since they are the only species and run observed to spawn in significant abundance downstream of Iron Gate Dam. **All species** All species will benefit from reduced disease incidence.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
8	**Purchase water rights from, or negotiate leases with, willing water rights owners**. **Targeted mid-Klamath tributaries**: Seiad Valley, Beaver Creek, Hornbrook, and other tributaries. **Current Conditions Alternative** Reasonable and likely to occur through implementation of State Code 5937. **Dams-Out Alternative** Reasonable and likely to occur through implementation of State Code 5937.	**Summer rearing habitat quality**: Reduced flows may increase water temperatures during summer. High temperatures and disease may cause direct mortality of adult, juvenile, and outmigrating salmonids, make fish more susceptible to disease and predation, and reduce growth of juvenile fish. **Summer rearing habitat quantity**: Reduced flows may reduce wetted area of stream channel available to juvenile salmonids, or may make some areas unsuitable for salmonids. **Adult upstream migration habitat**: Reduced flows can affect the ability of anadromous salmonids to pass natural obstacles such as falls or rapids. Adult salmon migration can be delayed by high water temperatures, which can result in pre-spawning mortality and reduced spawning success. The viability of eggs in adult salmonids exposed to high temperatures may also reduce spawning success. **Juvenile outmigration survival**: High water temperatures may reduce survival of outmigrating smolts.	**Increases summer rearing habitat** quantity and quality: Increased flows may reduce temperature- and disease-related stress and mortality of juvenile salmonids, and may increase the amount of rearing habitat available. Reducing temperatures can increase growth of juvenile salmonids, which may increase their ocean survival. **Enhances or restores habitat connectivity**: Increased flows during upstream migration may facilitate passage at natural obstacles; reduced water temperatures reduce the likelihood that upstream migration is delayed, and reduces the potential for mortality, stress, or disease of adult and juvenile salmon during upstream and downstream migrations.	**Coho Salmon** Coho salmon are expected to benefit most due to their low tolerance for increased temperature, and distribution in streams that have reduced instream flows. **All species** All species will benefit from improved passage of upstream migrating adults, particularly fall spawning spring-run Chinook salmon, coho salmon, and summer steelhead.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
9	**Use prescribed fire and thinning** in strategically selected watersheds to mimic some of the functions and characteristics historically provided by a natural fire regime. Prescribed burning and thinning will be used to reduce the potential for more catastrophic fires and the erosion that often follows. **Targeted mid-Klamath tributaries**: Red Cap, Boise, Camp, and Indian creeks; private lands in mid-Klamath basin. **Current Conditions Alternative** Anticipate prescribed burn in 40,000 acres of mixed conifer forest. **Dams-Out Alternative** Anticipate prescribed burn in 80,000 acres of mixed conifer forest.	Under historical conditions, fire played a large role in shaping forest ecosystems of northern California. The suppression of wildfire for long periods of time, however, can make the forest more vulnerable to catastrophic wildfires that, in turn, can gradually destabilize hillslope soils and result in debris flows that scour channels, landslides that may block stream channels with large amounts of sediment and debris, and result in overall elevated fine sediment input through chronic erosion. They are also more likely to affect riparian habitats. Anadromous salmonid habitat can be affected in many ways, including: • sedimentation of spawning gravels, • pool infilling, • scour of substrate and large wood from streams due to debris flows, • migration barriers, and • potential loss of riparian trees and vegetation.	Reduces potential for catastrophic fires: large fires can result in elevated fine sediment input and negative affects on spawning success. Impacts to rearing habitat are also possible, including: • reduced aquatic invertebrate productivity, • pool infilling, • substrate embeddedness, • loss of interstitial cover for juvenile fish, • debris flows that scour channels of large wood and other structure, and • loss of riparian vegetation that provides stream shading.	All species are anticipated to benefit.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
10	**Decommission and upgrade roads** and reduce road densities in areas with high risk for failure. **Targeted mid-Klamath tributaries**: China, Sandy Bar, Stanshaw, Cade, Ti, Walker Creek watersheds **Current Conditions Alternative** Anticipated treatment of 235 miles of roads in selected tributary watersheds. **Dams-Out Alternative** Anticipated treatment of 470 miles of roads in selected tributary watersheds.	**Spawning success**: Increased erosion and input of fine sediment to stream channels can reduce egg and alevin survival through deposition of fines onto or into the substrate. **Winter rearing habitat**: Increased sediment input may reduce the interstitial spaces between substrate particles used as cover by some juvenile salmonids. **Summer rearing habitat**: Increased sediment input may reduce habitat through infilling of pools.	**Increases spawning success**: Reductions in erosion and fine sediment input will likely increase egg and alevin survival. **Increases winter rearing habitat**: Reduced fine sediment input may increase overwintering habitat by reducing substrate embeddedness and restoring the interstitial spaces between substrate particles used as cover by juvenile salmonids.	**Chinook Salmon** Chinook salmon are more often limited by spawning habitat than coho salmon or steelhead, and thus increased spawning gravel quality potentially will likely benefit Chinook more than other salmonids. **Summer and Winter Steelhead** Survival of overwintering juvenile steelhead may increase due to reduced fine sediment that fills interstitial spaces between substrate particles used as cover by steelhead.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
11	**Livestock exclosures**. Exclude livestock from riparian areas to allow for regrowth of riparian forest. Mature riparian stands can provide shading and large and small wood to stream channels and floodplains **Targeted locations**: Portions of lower Klamath River mainstem; Horse, Cottonwood, Willow, Bogus, and Beaver creeks **Current Conditions Alternative**: Anticipated to treat 64 miles of fencing to exclude livestock from riparian zones. **Dams-Out Alternative**: Anticipated treatment of 84 miles to exclude livestock from riparian zones.	**Spawning success**: Grazing can increase erosion, banks can be cut back by trampling, and channels can erode due to lack of bank-stabilizing vegetation. Increased fine sediment resulting from these processes can reduce egg and alevin survival through deposition of fines onto or into the substrate. **Summer rearing habitat**: Grazing denudes riparian vegetation, prevents tree recruitment, and causes cut banks. Loss of stream channel shading and undercut banks can result in higher summer temperatures, which can cause direct mortality, make fish more susceptible to disease and predation, and reduce growth. **Winter rearing habitat**: Grazing may compact soils, reduce infiltration, and increase runoff. Grazing that maintains riparian vegetation in early-successional stages reduces LWD input into channels. Juvenile overwintering mortality may occur by displacement during high-flows. Increased sediment input may also reduce interstitial spaces in substrate used as cover by some juvenile salmonids.	**Increases spawning success**: Re-growth of riparian and upland vegetation will likely reduce livestock-related sediment input that may affect spawning success. **Increases summer rearing habitat**: Re-growth of riparian vegetation eventually increases wood input to stream channels, which can create pools through scouring that serve as cover from predation and temperature refugia. Increased shading along tributaries may mitigate high water temperatures in some areas. Reduced substrate embeddedness will likely increase aquatic invertebrate production. Terrestrial invertebrate input may increase and growth rates may benefit from cooler summer temperatures and an increase in lower-velocity feeding stations from which to feed on drift. **Increases winter rearing habitat**: Restoring late-seral forest characteristics in riparian areas restores input of more and larger wood to stream channels, increasing cover and habitat complexity. Large wood provides critical low-velocity refuge for juvenile salmonids that may otherwise be vulnerable to displacement during high flows.	**Coho Salmon** Coho salmon are well known for using large wood elements as cover and velocity refuge in stream channels, consequently they may benefit the most from re-growth of riparian forest vegetation. Coho salmon are expected to benefit due to their preference for off-channel habitats that can occur on functioning floodplain habitats. **Summer and Winter Steelhead** Steelhead often use the interstitial spaces between substrate particles as cover, which increased sediment input may reduce or eliminate.

LOWER KLAMATH RIVER AND TRIBUTARIES FROM WEITCHPEC TO MOUTH

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids from restoration action	Species-specific notes
12 13	**Floodplain rehabilitation**. Improve or restore connections between the channel and floodplain to create and maintain off-channel habitats accessible to overwintering juvenile salmonids. Enhance riparian and stream habitats through riparian planting and understory thinning to facilitate the development of mature riparian stands that can provide shading and large and small wood to stream channels and floodplains. **Targeted mainstem locations**: Lower Klamath River mainstem and estuary **Targeted tributary locations**: Blue, Salt, Hunter, Hoppaw, Waukell, Saugep, McGarvey, Terwer, Ah Pah, Johnsons, Tarup, Omagaar, and Tectah creeks **Current Conditions Alternative** Engineered channel reconfiguration in 0.8 miles of estuary and mainstem river habitat, and 2.5 miles in tributary habitat. **Dams-Out Alternative**: Engineered channel reconfiguration in 2 mi of estuary and mainstem river habitat, and 5 mi in tributary habitat.	**Summer rearing habitat**: high temperatures and disease occurring during summer low flows may cause direct mortality, make juvenile fish more susceptible to disease and predation, and reduce growth by increasing metabolism. **Winter rearing habitat**: lack of cover and off-channel and other low-velocity habitats may increase juvenile overwintering mortality through displacement during high-flow events, predation, or stress.	**Increases summer rearing habitat** by increasing LWD cover and creating deeper pools that may serve as cool-water habitat during summer low flows. **Increases winter rearing habitat** by creating and restoring access to low-velocity habitats that provide refuge from high flows and displacement. **Increased growth and reduced predation** in estuary: increased LWD cover in estuary habitats may increase growth and residency and reduce predation mortality from birds and other predators.	**Coho Salmon** Coho salmon are expected to benefit due to their preference for off-channel habitats and LWD cover during winter. Action will likely increase the number of juvenile coho salmon able to rear for a full year in mainstem and estuary prior to outmigrating. **Summer and Winter Steelhead** An increase in channel complexity and range of depths may increase the number of juvenile steelhead that remain to rear a second summer. Age 2+ outmigrants have the highest rates of adult return; therefore, increasing the proportion of the population that remains to rear for a second summer will likely increase ocean survival and escapement.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids from restoration action	Species-specific notes
14 15	**Add large wood structures**, engineered log jams, mobile wood to reaches that lack floodplain connectivity, suitable substrate (e.g. complex matrix with spawning gravels), cover, and complexity. Strategically place large wood and engineered log jams to activate the floodplain and create off-channel habitat. **Targeted mainstem locations**: Lower Klamath River mainstem and estuary **Targeted tributary locations:** All Lower Klamath River tributaries; Blue, Terwer, Ah Pah, Tectah, Hunter, McGarvey, Waukell, Tully, Bear, Johnsons, Roach, Mettah, Surpur, and High Prairie creeks **Current Conditions Alternative**: Will place engineered log jams in 10 miles of the mainstem Klamath River downstream of Weitchpec. **Dams-Out Alternative**: Will place engineered log jams in 20 miles of the mainstem Klamath River downstream of Weitchpec, including the estuary. In addition, 30 jams per mile with an average of 30 pieces per jam in 58 miles of tributary habitat.	**Winter rearing habitat**: lack of cover and off-channel and other low-velocity habitats may increase juvenile overwintering mortality through displacement during high-flow events, predation, or stress. **Summer rearing habitat**: high temperatures and disease occurring during summer low flows may cause direct mortality, make juvenile fish more susceptible to disease and predation, and reduce growth by increasing metabolism.	**Increases winter rearing habitat** by creating low-velocity areas that provide refuge from high flows and displacement. **Increases summer rearing habitat** in mainstem by increasing LWD cover in tributary confluence pools that may serve as cool-water habitat during summer low flows. **Increases summer rearing habitat** in tributaries. Reaches with more LWD cover can often support higher densities of juvenile salmonids by breaking the line of sight between territorial individuals. **Reduces summer and winter rearing mortality**: increased LWD cover in tributaries and mainstem tributary confluence pools may reduce predation mortality.	**Coho Salmon** Coho salmon are well known for using large wood elements as cover and velocity refuge in stream channels, as well as off-channel habitats, consequently, they may benefit the most from the addition of large wood into reaches where it is lacking. **Summer and Winter Steelhead** An increase in channel complexity and range of depths may increase the number of juvenile steelhead that remain to rear a second summer. Age 2+ outmigrants have the highest rates of adult return; therefore, increasing the proportion of the population that remains to rear for a second summer will likely increase ocean survival and escapement.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids from restoration action	Species-specific notes
16	**Decommission and upgrade roads** and decrease road densities in areas with high risk for failure. **Targeted lower Klamath locations**: All lower Klamath River tributaries; Ah Pah, Hunter, Terwer, Tectah, Waukell, McGarvey, Surpur, Blue, Hoppaw, Saugep, and Tarup creeks **Current Conditions Alternative**: Anticipated to treat 233 miles of roads in selected tributary watersheds. **Dams-Out Alternative:** Anticipated to treat 798 miles of roads in selected tributary watersheds.	**Spawning success**: Increased erosion and input of fine sediment to stream channels can reduce egg and alevin survival through deposition of fines onto or into the substrate. **Winter rearing habitat**: Increased sediment input may reduce the interstitial spaces between substrate particles used as cover by some juvenile salmonids. **Summer rearing habitat**: Increased sediment input may reduce habitat through infilling of pools.	**Increases spawning success**: Reductions in erosion and fine sediment input will likely increase egg and alevin survival. **Increases winter rearing habitat**: Reduced fine sediment input may increase overwintering habitat by reducing substrate embeddedness and restoring the interstitial spaces between substrate particles used as cover by juvenile salmonids. **Increases summer rearing habitat** by reducing the input of sediment into pools.	**Summer and Winter Steelhead** Steelhead often use the interstitial spaces between substrate particles as cover, which increased sediment input may reduce or eliminate.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
17 18	**Exclude livestock and remove feral cattle from riparian areas** in the lower mainstem and estuarine areas. Create conservation easements, fence off riparian areas, and/or provide landowners with incentives to eliminate cattle grazing on floodplains and in sensitive coastal habitats. **Targeted lower Klamath locations**: Lower Klamath River mainstem and estuary; Salt, Hunter, Mynot, Spruce, Hoppaw, Terwer, Pecwan, and Johnsons creeks **Current Conditions Alternative** Anticipated funding for fencing off 58 miles of the mainstem, and 18 miles of tributary habitat. **Dams-Out Alternative** Will coordinate with private landowners along the mainstem and tributaries to reduce livestock presence in riparian areas. Includes $2 million for acquiring conservation easements adjacent to the estuary and along the lower mainstem. Additional funds are provided for fencing off 62 miles of the mainstem, and 34 miles of tributary habitat.	**Winter rearing habitat**: Grazing on uplands may compact soils, reduce infiltration, and increase runoff. Banks can be cut back by trampling and channels can continue to erode banks due to lack of bank-stabilizing vegetation, resulting in degraded off-channel habitat. Grazing that maintains riparian vegetation in early successional stages reduces large wood input to stream channels. Both factors may increase juvenile overwintering mortality by displacement during high-flows. Increased sediment input may also reduce interstitial spaces in substrate used as cover. **Summer rearing habitat**: Grazing can denude riparian vegetation, prevent tree recruitment, and cause cut banks. Loss of stream channel shading and undercut banks can result in higher temperatures, which can cause direct mortality, make fish more susceptible to disease and predation, and reduce growth.	**Increases summer rearing habitat**: Re-growth of riparian trees eventually increases wood input to stream channels, which can create pools through scouring that serve as cover from predation and temperature refugia. Increased shading may mitigate high water temperatures in some areas. Reduced substrate embeddedness may increase aquatic invertebrate production. Terrestrial invertebrate input may increase and growth rates may benefit from cooler summer temperatures and an increase in lower-velocity feeding stations from which to feed on drift. **Increases winter rearing habitat**: Restoring off-channel habitat and late-seral forest characteristics in riparian areas restores input of more and larger wood to stream channels, increasing cover and habitat complexity. Large wood provides critical low-velocity refuge for juvenile salmonids. **Increased estuary habitat**: Preventing trampling of river banks and off-channel habitat, and allowing increased re-growth of riparian vegetation may improve estuary rearing habitat quality.	**Coho Salmon** Coho salmon are well known for using large wood elements as cover and velocity refuge in stream channels, consequently they may benefit the most from re-growth of riparian forest vegetation. **Summer and Winter Steelhead** Steelhead often use the interstitial spaces between substrate particles as cover, which increased sediment input may reduce or eliminate. **All species** All species benefit from improved rearing habitat in the estuary.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
19 **20**	**Riparian enhancement**. Use appropriate management techniques (e.g., understory thinning) to promote attainment of late-seral riparian conditions. Plant native conifers in selected areas. **Targeted lower Klamath tributaries**: Blue, Hunter, Hoppaw, Terwer, McGarvey, Tarup, Omagaar, Ah Pah, Bear, Surpur, Little Surpur, Tully, Waukell, Saugep, and Tectah creeks **Current Conditions Alternative** No sources of funding for this action are foreseeable in the immediate future. **Dams-Out Alternative** Will conduct restorative thinning of 7,500 acres in tributary watersheds. Will plant conifers on 200 acres of tributary watersheds.	**Summer rearing habitat**: Loss of stream channel shading can result in higher temperatures during low flows, which can cause direct mortality, make fish more susceptible to disease and predation, and reduce growth by increasing metabolism. **Winter rearing habitat**: Early successional riparian vegetation does not contribute large wood to stream channels. The lack of large wood as cover and velocity refuge may increase juvenile overwintering mortality by displacement during high-flows. **Adult upstream migration habitat**: Adult salmon migration can be delayed by high water temperatures, which can result in adult pre-spawning mortality and reduced spawning success of portions of the run. The viability of eggs in adult salmonids exposed to high temperatures may also reduce spawning success. **Juvenile outmigration survival**: High water temperatures may reduce survival of outmigrating smolts.	**Increases summer rearing habitat** by increasing LWD cover that may create deeper pools that serve as cool-water habitat during summer low flows. Increased shading may reduce temperature- and disease-related stress and mortality of juvenile salmonids, and may increase the amount of rearing habitat available. Reducing temperatures can increase growth of juvenile salmonids, which may increase ocean survival. **Increases winter rearing habitat** by gradually restoring input of large wood to channels from mature trees, creating and restoring access to low-velocity habitats that provide refuge from high flows and displacement. **Enhances or restores habitat connectivity**: Increased shading that reduces water temperatures reduces the likelihood that upstream migration will be delayed, and reduces the potential for temperature-related mortality, stress, or disease of adult and juvenile salmon during upstream and downstream migrations.	**Coho Salmon** Coho salmon are well known for using large wood elements as cover and velocity refuge in stream channels, as well as off-channel habitats, consequently, they may benefit the most from increased large wood in reaches where it is lacking. Coho salmon are also particularly sensitive to water temperatures, and are thus most likely to benefit from increased shading along tributary channels.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
21	**Use prescribed fire and thinning** in strategically selected watersheds to mimic some of the functions and characteristics historically provided by a natural fire regime. Prescribed burning and thinning will be used to reduce the potential for more catastrophic fires and the erosion that often follows. **Targeted lower Klamath locations**: All lower Klamath River tributaries; Blue, Ah Pah, Terwer, Hunter, Tectah, Surpur, Mettah, Pecwan, Bear **Current Conditions Alternative** No sources of funding for this action are foreseeable in the immediate future. **Dams-Out** Will conduct a prescribed burn in 20,000 acres of mixed conifer forest.	Under historical conditions, fire played a large role in shaping forest ecosystems of northern California. The suppression of wildfire for long periods of time, however, can make the forest more vulnerable to catastrophic wildfires that, in turn, can gradually destabilize hillslope soils and result in debris flows that scour channels, landslides that may block stream channels with large amounts of sediment and debris, and result in overall elevated fine sediment input through chronic erosion. They are also more likely to affect riparian habitats. Anadromous salmonid habitat can be affected in many ways, including: • sedimentation of spawning gravels, • pool infilling, • scour of substrate and large wood from streams due to debris flows, • migration barriers, and • potential loss of riparian trees and vegetation.	**Reduces potential for catastrophic fires**: large fires can result in elevated fine sediment input and negative affects on spawning success. Impacts to rearing habitat are also possible, including: • reduced aquatic invertebrate productivity • pool infilling • embeddedness and loss of interstitial cover for juvenile fish • debris flows that scour channels of large wood and other structure • loss of riparian vegetation that provides stream shading.	All species are anticipated to benefit.

SCOTT RIVER AND TRIBUTARIES

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
22	**Add large wood** (e.g. complex wood structures, engineered log jams, mobile wood) to reaches that lack floodplain connectivity, suitable substrate (e.g. complex matrix with spawning gravels), cover, and complexity. Strategically place large wood and engineered log jams to activate the floodplain and create off-channel habitat. **Targeted Scott River tributaries**: Shackleford/Mill Creeks, French Creek, Sugar Creek, Patterson Creek, South Fork Scott River, East Fork Scott River, Etna Creek, etc. **Current Conditions Alternative**: Anticipated to place engineered log jams in 22 miles of mainstem Scott River and tributary habitat. **Dams-Out Alternative**: Anticipated to place engineered log jams in 41 miles of mainstem Scott River and tributary habitat.	**Winter rearing habitat**: lack of cover and off-channel and other low-velocity habitats may increase juvenile overwintering mortality through displacement during high-flow events, predation, or stress. **Summer rearing habitat**: high temperatures and disease occurring during summer low flows may cause direct mortality, make juvenile fish more susceptible to disease and predation, and reduce growth by increasing metabolism.	**Increases winter rearing habitat** by creating low-velocity areas that provide refuge from high flows and displacement. **Increases summer rearing habitat in mainstem** by increasing LWD cover in tributary confluence pools that may serve as cool-water habitat during summer low flows. **Increases summer rearing habitat in tributaries**. Reaches with more LWD cover can often support higher densities of juvenile salmonids by breaking the line of sight between territorial individuals.	**Coho Salmon** Coho salmon are expected to benefit most due to their preference for off-channel habitats and LWD cover during winter. Action will likely increase the number of juvenile coho salmon able to rear for a full year in Scott River before moving to the mainstem. **Summer and Winter Steelhead** An increase in channel complexity and range of depths may increase the number of juvenile steelhead that remain to rear a second summer. Age 2+ outmigrants have the highest rates of adult return; therefore, increasing the proportion of the population that remains to rear for a second summer will likely increase ocean survival and escapement.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
23	**Floodplain rehabilitation**. Improve or restore connections between the channel and floodplain to create and maintain off-channel habitats accessible to overwintering juvenile salmonids. Enhance riparian and stream habitats through riparian planting and understory thinning to facilitate the development of mature riparian stands that can provide shading and large and small wood to stream channels and floodplains. **Targeted Scott River tributaries** Shackleford/Mill Creeks, French Creek, Sugar Creek, Patterson Creek, South Fork Scott River, East Fork Scott River, Etna Creek, etc. **Current Conditions Alternative** Engineered channel reconfiguration in 1.5 miles of mainstem Scott River and tributaries. **Dams-Out Alternative:** Engineered channel reconfiguration in 3.76 miles of mainstem Scott River and tributaries.	**Summer rearing habitat**: high temperatures and disease occurring during summer low flows may cause direct mortality, make juvenile fish more susceptible to disease and predation, and reduce growth by increasing metabolism. **Winter rearing habitat**: lack of cover and off-channel and other low-velocity habitats may increase juvenile overwintering mortality through displacement during high-flow events, predation, or stress.	**Increases summer rearing habitat** by increasing LWD cover and creating deeper pools that may serve as cool-water habitat during summer low flows. **Increases winter rearing habitat** by creating and restoring access to low-velocity habitats that provide refuge from high flows and displacement.	**Coho Salmon** Coho salmon are expected to benefit most due to their preference for off-channel habitats and LWD cover during winter. Action will likely increase the number of juvenile coho able to rear for full year in Scott River before moving to the mainstem or outmigrating to the estuary and Pacific Ocean. **Summer and Winter Steelhead** An increase in channel complexity and range of depths may increase the number of juvenile steelhead that remain to rear a second summer. Age 2+ outmigrants have the highest rates of adult return; therefore, increasing the proportion of the population that remains to rear for a second summer will likely increase ocean survival and escapement.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
24 25	Develop model to identify relationships between groundwater dynamics and surface flow in Scott Valley. Identify groundwater-springs relationships, and **focus restoration activities on reaches with coldwater presence or accretion**. Use results to **strategically purchase conservation easements and water rights** and educate water managers in conjunctive water management to improve spring, summer, and fall rearing conditions, especially coldwater refugia and fish passage. **Targeted Scott River locations**: Shackleford/Mill Creeks, French Creek, Sugar Creek, Patterson Creek, South Fork Scott River, East Fork Scott River, Etna Creek, and others. **Current Conditions:** Groundwater study likely to be funded by DWR. Anticipate acquiring approx. 3,500 acres of conservation easements, and purchasing 1,500 acres of land. **Dams-Out Alternative**: Groundwater study likely to be funded by DWR. Anticipate acquiring approx. 7,000 acres of conservation easements, and 3,000 acres of land.	**Summer rearing habitat quality**: Reduced flows often result in higher summer temperatures. Negative effects may include direct mortality from disease, early outmigration from tributaries to the mainstem, increased susceptibility to predation, and reduced growth of juvenile fish. Flow reductions can cause stranding and isolation of summer rearing pools. **Summer rearing habitat quantity**: Reduced flows may reduce habitat available to juvenile salmonids, or make some areas unsuitable for salmonids. **Adult upstream migration survival**: Reduced flows can affect ability of salmonids to pass obstacles . Adult salmon migration can be delayed by high water temperatures, which can result in adult pre-spawning mortality and reduced spawning success. The viability of eggs in adult salmonids exposed to high temperatures may also reduce spawning success. **Juvenile outmigration survival**: High water temperatures may reduce survival of outmigrating smolts.	**Increases summer rearing habitat** quantity and quality: Increased flows may reduce temperature- and disease-related stress and mortality of juvenile salmonids, and may increase the amount of rearing habitat available. Reducing temperatures can increase growth of juvenile salmonids, which may increase their ocean survival. **Enhances or restores habitat connectivity**: Increased flows during upstream migration may facilitate passage at natural obstacles; reduced water temperatures reduce the likelihood that upstream migration is delayed, and reduces the potential for mortality, stress, or disease of adult and juvenile salmon during upstream and downstream migrations.	**Coho Salmon:** Coho salmon in particular are anticipated to benefit from improved rearing conditions in the Scott River. A small population there suffers low summer survival from high water temperatures and stranding. It has also been observed that springtime (typically in April) increases in water diversions and agricultural operations increase water temperature and decrease available habitat, apparently leading to a pulse in outmigration of fry and juveniles into the mainstem Klamath River. Strategically improving instream flow conditions will likely result in increases in both rearing time (decreasing residence in mainstem where disease prevalence is high prior to migration), and possibly facilitate higher growth rates allowing fish to enter the mainstem at a larger size.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
26	**Exclude livestock from channels**, narrow channels, and stabilize and protect channels. **Targeted Scott River locations**: Shackleford/Mill Creeks, French Creek, Sugar Creek, Patterson Creek, South Fork Scott River, East Fork Scott River, Etna Creek, etc. **Current Conditions Alternative**: It is anticipated that 23 miles in the mainstem Scott River and tributaries will be fenced. **Dams-Out Alternative**: It is anticipated that 75 miles in the mainstem Scott River and tributaries will be fenced.	**Spawning success**: Grazing can increase erosion by reducing vegetation and exposing soil substrate on uplands. Banks can be cut back by trampling and channels can continue to erode banks due to lack of bank-stabilizing vegetation. Increased fine sediment resulting from these processes can reduce egg and alevin survival through deposition of fines onto or into the substrate. **Summer rearing habitat**: Grazing can denude riparian vegetation, prevent tree recruitment, and cause cut banks. Loss of stream channel shading and undercut banks can result in higher temperatures during low flows, which can cause direct mortality, make fish more susceptible to disease and predation, and reduce growth by increasing metabolism. **Winter rearing habitat**: Grazing may compact soils and increase runoff. Grazing that maintains riparian vegetation in early successional stages reduces large wood into stream channels. Both factors may increase juvenile overwintering mortality by displacement during high-flows. Increased sediment input may reduce interstitial spaces in substrate used as cover by some juvenile salmonids.	**Increases spawning success**: Re-growth of riparian and upland vegetation and establishment of later-succession riparian forest will likely reduce livestock-related sediment input that may affect spawning success. **Increases summer rearing habitat**: Re-growth of riparian trees increases wood input to channels, which can create pools that provide cover from predation and temperature refugia. Increased shading may mitigate high water temperatures in some areas. Reduced substrate embeddedness will likely increase aquatic invertebrate production. Terrestrial invertebrate input may increase and growth rates may benefit from cooler summer temperatures and an increase in lower-velocity feeding stations from which to feed on drift. **Increases winter rearing habitat**: Restoring late-seral forest characteristics in riparian areas restores input of more and larger LWD to stream channels, increasing cover and habitat complexity. LWD provides low-velocity refuge for juvenile salmonids that may otherwise be displaced by high flows.	**Coho Salmon:** Coho salmon in particular are anticipated to benefit from improved rearing conditions in the Scott River. A small population there suffers low summer survival from high water temperatures and stranding. It has also been observed that springtime (typically in April) increases in water diversions and agricultural operations increase water temperature and reduce available habitat, apparently leading to a pulse in outmigration of fry and juveniles into the mainstem Klamath River. Strategically improving instream flow conditions will likely result in increases in both rearing time (decreasing residence in mainstem where disease prevalence is high prior to migration), and possibly facilitate higher growth rates allowing fish to enter the mainstem at a larger size. **Summer and Winter Steelhead** Steelhead often use the interstitial spaces between substrate particles as cover, which increased sediment input may reduce or eliminate.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
27	**Treat road-caused sediment discharges** from federal, county, and private roads in the Scott River Basin; use the California Salmonid Stream Habitat Restoration Manual , Scott River TMDL Implementation Plan, and the 5 Counties Road Maintenance Manual for guidance. **Targeted Scott River location**: Scott River and its tributaries **Current Conditions Alternative** Anticipated 100 separate projects in various tributaries. **Dams-Out Alternative**: Anticipated 241 separate projects in various tributaries.	**Spawning success**: Increased erosion and input of fine sediment to stream channels can reduce egg and alevin survival through deposition of fines onto or into the substrate. **Winter rearing habitat**: Increased sediment input may reduce the interstitial spaces between substrate particles used as cover by some juvenile salmonids. **Summer rearing habitat**: Increased sediment input may reduce habitat through infilling of pools.	**Increases spawning success**: Reductions in erosion and fine sediment input will likely increase egg and alevin survival. **Increases winter rearing habitat**: Reduced fine sediment input may increase overwintering habitat by reducing substrate embeddedness and restoring the interstitial spaces between substrate particles used as cover by juvenile salmonids. **Increases summer rearing habitat** by reducing the input of sediment into pools.	**Summer and Winter Steelhead** Steelhead often use the interstitial spaces between substrate particles as cover, which increased sediment input may reduce or eliminate.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species-specific notes
28	**Use prescribed fire and thinning** in strategically selected watersheds to mimic some of the functions and characteristics historically provided by a natural fire regime. Prescribed burning and thinning will be used to reduce the potential for more catastrophic fires and the erosion that often follows. **Targeted Scott River locations**: Various tributaries to the Scott River **Current Conditions Alternative** No sources of funding for this action are foreseeable in the immediate future. **Dams-Out Alternative**: Anticipated to conduct prescribed burn in 1,000 acres of mixed conifer forest.	Under historical conditions, fire played a large role in shaping forest ecosystems of northern California. The suppression of wildfire for long periods of time, however, can make the forest more vulnerable to catastrophic wildfires that, in turn, can gradually destabilize hillslope soils and result in debris flows that scour channels, landslides that may block stream channels with large amounts of sediment and debris, and result in overall elevated fine sediment input through chronic erosion. They are also more likely to affect riparian habitats. Anadromous salmonid habitat can be affected in many ways, including: • sedimentation of spawning gravels, • pool infilling, • scour of substrate and large wood from streams due to debris flows, • migration barriers, and • potential loss of riparian trees and vegetation.	**Reduces potential for catastrophic fires**: large fires can result in elevated fine sediment input and negative affects on spawning success. Impacts to rearing habitat are also possible, including: • reduced aquatic invertebrate productivity • pool infilling • embeddedness and loss of interstitial cover for juvenile fish • debris flows that scour channels of large wood and other structure • loss of riparian vegetation that provides stream shading.	All species are anticipated to benefit.

SHASTA RIVER AND TRIBUTARIES

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species Specific Notes
29	**Add large wood** (e.g. complex wood structures, engineered log jams, mobile wood) to reaches that lack floodplain connectivity, suitable substrate (e.g. complex matrix with spawning gravels), cover, and complexity. Strategically place large wood and engineered log jams to activate the floodplain and create off-channel habitat. **Targeted Shasta River locations**: Big Springs Complex area, lower Parks Creek, Little Shasta River, lower Willow Creek, Yreka Creek, Hole in the Ground, and cold water reaches of the Shasta River **Current Conditions Alternative** Anticipated to fund engineered log jams (30 per mile) with an average of 30 pieces per jam within 10 miles of the mainstem Shasta River and tributaries. **Dams-Out Alternative** Anticipated to fund engineered log jams (30 per mile) with an average of 30 pieces per jam within 33 miles of the mainstem Shasta River and tributaries.	**Winter rearing habitat**: lack of cover and off-channel and other low-velocity habitats may increase juvenile overwintering mortality through displacement during high-flow events, predation, or stress. **Summer rearing habitat**: high temperatures and disease occurring during summer low flows may cause direct mortality, make juvenile fish more susceptible to disease and predation, and reduce growth by increasing metabolism.	**Increases winter rearing habitat** by creating low-velocity areas that provide refuge from high flows and displacement. **Increases summer rearing habitat** in mainstem by increasing LWD cover in tributary confluence pools that may serve as cool-water habitat during summer low flows. **Increases summer rearing habitat in tributaries**. Reaches with more LWD cover can often support higher densities of juvenile salmonids by breaking the line of sight between territorial individuals.	**Coho Salmon** Coho salmon are expected to benefit most due to their preference for off-channel habitats and LWD cover during winter. Action will likely increase the number of juvenile coho salmon able to rear for a full year in Shasta River before moving to the mainstem or outmigrating to the estuary and Pacific Ocean. **Summer and Winter Steelhead** An increase in channel complexity and range of depths may increase the number of juvenile steelhead that remain to rear a second summer. Age 2+ outmigrants have the highest rates of adult return; therefore, increasing the proportion of the population that remains to rear for a second summer will likely increase ocean survival and escapement.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species Specific Notes
30	**Floodplain rehabilitation**. Improve or restore connections between the channel and floodplain to create and maintain off-channel habitats accessible to overwintering juvenile salmonids. Enhance riparian and stream habitats through riparian planting and understory thinning to facilitate the development of mature riparian stands that can provide shading and large and small wood to stream channels and floodplains. **Targeted Shasta River locations**: Shasta River and its tributaries, especially Big Springs Complex. **Current Conditions Alternative**: Engineered channel reconfiguration in 0.71 miles of mainstem Shasta River and tributaries. **Dams-Out Alternative**: Engineered channel reconfiguration in 1.41miles of mainstem Shasta River and tributaries.	**Summer rearing habitat**: high temperatures and disease occurring during summer low flows may cause direct mortality, make juvenile fish more susceptible to disease and predation, and reduce growth by increasing metabolism. **Winter rearing habitat**: lack of cover and off-channel and other low-velocity habitats may increase juvenile overwintering mortality through displacement during high-flow events, predation, or stress.	**Increases summer rearing habitat** by increasing LWD cover and creating deeper pools that may serve as cool-water habitat during summer low flows. **Increases winter rearing habitat** by creating and restoring access to low-velocity habitats that provide refuge from high flows and displacement. **Reduces summer and winter rearing mortality**: increased LWD cover and pool depths may reduce predation mortality.	**Coho Salmon** Coho salmon are expected to benefit most due to their preference for off-channel habitats and LWD cover during winter. Action will likely increase the number of juvenile coho able to rear for full year in Shasta River before moving to the mainstem or outmigrating to the estuary and Pacific Ocean. **Summer and Winter Steelhead** Action will likely increase the numbers of juveniles successfully rearing for two summers before outmigrating.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species Specific Notes
31 32 33	**Instream flow studies** to determine minimum flows that protect and expand summer rearing habitat. Identify and improve tailwater reduction and management projects in priority areas. Use instream flow study results to determine suitable minimum flows, educate water managers in conjunctive water management to comprehensively improve spring, summer, and fall rearing conditions, especially cold water refugia, availability of rearing habitat, and fish passage. **Shasta River and its tributaries** **Current Conditions Alternative**: Instream flow study is likely to be funded by CDFG and OPC. An additional potential to acquire 3,500 acres of conservation easement, and 1,500 acres of land purchases. **Dams-Out Alternative**: Instream flow study is likely to be funded by CDFG and OPC. Anticipate up to $2 million for a variety of projects to reduce volume of irrigation water, and treat irrigation return water. An additional potential to acquire 7,000 acres of conservation easement, and 3,000 acres of land purchases.	**Summer rearing habitat quality**: Reduced flows often result in higher temperatures during summer. Negative effects may include: direct mortality as result of disease, early outmigration from tributaries to mainstem, increased susceptibility to predation, and reduced growth of juvenile fish. Flow reductions can cause fish stranding and isolation of summer rearing pools. **Summer rearing habitat quantity**: Reduced flows may reduce the amount of channel available to juvenile salmonids, or make some areas unsuitable for salmonids. **Adult upstream migration survival**: Reduced flows can affect the ability of anadromous salmonids to pass obstacles. Adult salmon migration can be delayed by high water temperatures, which can result in pre-spawning mortality and reduced spawning success. The viability of eggs in adult salmonids exposed to high temperatures may also reduce spawning success. **Juvenile outmigration survival**: High water temperatures may reduce survival of outmigrating smolts.	**Increases summer rearing habitat** quantity and quality: Increased flows may reduce temperature- and disease-related stress and mortality of juvenile salmonids, and may increase the amount of rearing habitat available. Reducing temperatures can increase growth of juvenile salmonids, which may increase their ocean survival. **Enhances or restores habitat connectivity**: Increased flows during upstream migration may facilitate passage at natural obstacles; reduced water temperatures reduce the likelihood that upstream migration is delayed, and reduces the potential for mortality, stress, or disease of adult and juvenile salmon during upstream and downstream migrations.	**Coho Salmon:** Coho salmon in particular are anticipated to benefit from improved rearing conditions in the Shasta River. A small population there suffers low summer survival from high water temperatures and stranding. It has also been observed that springtime (typically in April) increases in water diversions and agricultural operations increase water temperature and decrease available habitat, apparently leading to a pulse in outmigration of fry and juveniles into the mainstem Klamath River. Strategically improving instream flow conditions will likely result in increases in both rearing time (decreasing residence in mainstem where disease prevalence is high prior to migration), and possibly facilitate higher growth rates allowing fish to enter the mainstem at a larger size.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species Specific Notes
34	**Remove barriers**. Identify, prioritize and remove fish passage barriers. **Targeted Shasta River locations**: Water wheel at Big Springs Grenada Irrigation District MWCD diversion into Shastina, Novy-Rice, Lower Parks creeks **Current Conditions Alternative** No sources of funding for this action are foreseeable in the immediate future. **Dams-Out Alternative**: Passage improvement projects will be implemented at the water wheel at the Big Springs Grenada Irrigation District MWCD diversion into Shastina, Novy-Rice, Lower Parks creeks	**Adult upstream migration barriers**: Barriers to upstream migration prevent access to and use of historically available spawning habitat and may increase the potential for redd superimposition downstream of the barriers, both of which may reduce overall egg deposition and fry production. **Juvenile migration barriers**: Barriers to juvenile migration prevent access to and use of historically available rearing habitat and may decrease survival and carrying capacity of remaining habitat.	**Restoring access to historically available habitat** in the affected tributaries increases the amount of spawning and rearing habitat available and reduces the potential for spawning and rearing habitat limitations. Reduces potential for mortality caused by delay at barriers.	**Coho Salmon**: This action is specifically focused on increasing the amount of rearing habitat available to coho salmon.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species Specific Notes
35 **36**	**Exclude cattle from riparian areas** to allow for revegetation and reestablishment of riparian forest. Expand riparian habitat easement programs; identify priority floodplain areas that provide setback opportunities in cooperation with landowners; employ voluntary riparian easement programs to lease / acquire riparian easements prioritized for restoration. **Shasta River and its tributaries** **Current Conditions Alternative**: Anticipated funding for approximately 3 miles of riparian fencing in the mainstem Shasta River. **Dams-Out Alternative:** Anticipated funding for approximately 44 miles of riparian fencing in the mainstem Shasta River and tributaries. In addition, approximately 650 acres of conservation easements are expected to be acquired.	**Spawning success**: Grazing can increase erosion, banks can be trampled and cut back, and channels can continue to erode banks due to lack of bank-stabilizing vegetation. Increased fine sediment resulting from these processes can reduce egg and alevin survival through deposition of fines onto or into the substrate. **Summer rearing habitat**: Grazing can denude riparian vegetation, prevent tree recruitment, and cause cut banks. Loss of stream channel shading and undercut banks can result in higher temperatures during low flows, which can cause direct mortality, make fish more susceptible to disease and predation, and reduce growth by increasing metabolism. **Winter rearing habitat**: Grazing may compact soils and increase runoff. Grazing that maintains riparian vegetation in early successional stages reduces large wood into stream channels. Both factors may increase juvenile overwintering mortality by displacement during high-flows. Increased sediment input may reduce interstitial spaces in substrate used as cover by some juvenile salmonids.	**Increases spawning success**: Re-growth of riparian and upland vegetation and establishment of later-successional riparian forest will likely reduce livestock-related sediment input that may affect spawning success. **Increases summer rearing habitat**: Re-growth of riparian trees increases wood input to stream channels, which can create scour pools that serve as cover from predation and temperature refugia. Increased shading may mitigate high water temperatures. Reduced substrate embeddedness can increase aquatic invertebrate production. Terrestrial invertebrate input may increase and growth rates may benefit from cooler summer temperatures and an increase in low-velocity feeding stations from which to feed on drift. **Increases winter rearing habitat**: Restoring late-seral forest characteristics in riparian areas restores input of more and larger wood to channels, increasing cover and habitat complexity. LWD provides critical low-velocity refuge for juvenile salmonids that may otherwise be vulnerable to displacement during high flows.	**Coho Salmon:** Coho salmon in particular are anticipated to benefit from improved rearing conditions in the Shasta River. A small population there suffers low summer survival from high water temperatures and stranding. It has also been observed that springtime (typically in April) increases in water diversions and agricultural operations increase water temperature and reduce available habitat, apparently leading to a pulse in outmigration of fry and juveniles into the mainstem Klamath River. Strategically improving instream flow conditions will likely result in increases in both rearing time (decreasing residence in mainstem where disease prevalence is high prior to migration), and possibly facilitate higher growth rates allowing fish to enter the mainstem at a larger size.

SALMON RIVER AND TRIBUTARIES

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species Specific Notes
37	**Add LWD** (e.g., complex wood structures, engineered log jams, mobile wood) to reaches that lack floodplain connectivity, suitable substrate (e.g. complex matrix with spawning gravels), cover, and complexity. **Targeted Salmon River locations**: Salmon River (e.g. lower Methodist Creek, South Fork Salmon River, Cecil Creek, and the Little N. Fork Salmon River) **Current Conditions Alternative** Anticipated funding engineered log jams (30 per mile) with an average of 30 pieces per jam within 6 miles of the mainstem Salmon River and tributaries. **Dams-Out Alternative** Anticipated funding engineered log jams (30 per mile) with an average of 30 pieces per jam within 38 miles of the mainstem Salmon River and tributaries.	**Winter rearing habitat**: lack of cover and off-channel and other low-velocity habitats may increase juvenile overwintering mortality through displacement during high-flow events, predation, or stress. **Summer rearing habitat**: high temperatures and disease occurring during summer low flows may cause direct mortality, make juvenile fish more susceptible to disease and predation, and reduce growth by increasing metabolism. **Adult holding habitat**: A lack of suitable adult holding habitat can increase pre-spawn mortality by increasing stress, susceptibility to disease and predation, and increasing metabolism.	**Increases winter rearing habitat** by creating low-velocity areas that provide refuge from high flows and displacement. **Increases summer rearing habitat** in mainstem by increasing LWD cover in tributary confluence pools that may serve as cool-water habitat during summer low flows. **Increases summer rearing habitat** in tributaries. Reaches with more LWD cover can often support higher densities of juvenile salmonids by breaking the line of sight between territorial individuals.	**Spring Chinook salmon and Coho Salmon** Spring Chinook salmon in particular should benefit from improved rearing conditions in the Salmon River, which has the last wild population of spring Chinook in the Klamath River system. Spring Chinook salmon are expected to benefit from improved adult holding habitat with increased channel complexity. Spring Chinook salmon and coho salmon are expected to benefit from off-channel habitats and LWD cover during winter. Action will likely increase the number of juvenile spring Chinook salmon and coho salmon able to rear for a full year in Salmon River before moving to the mainstem or outmigrating to the estuary and Pacific Ocean. **Summer and Winter Steelhead** An increase in channel complexity and range of depths may increase the number of juvenile steelhead that remain to rear a second summer. Age 2+ outmigrants have the highest rates of adult return; therefore, increasing the proportion of the population that remains to rear for a second summer will likely increase ocean survival and escapement.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species Specific Notes
38	**Floodplain rehabilitation**. Improve or restore connections between the channel and floodplain to create and maintain off-channel habitats accessible to overwintering juvenile salmonids. Enhance riparian and stream habitats through riparian planting and understory thinning to facilitate the development of mature riparian stands that can provide shading and large and small wood to stream channels and floodplains. **Targeted locations**: Salmon River (e.g. lower Methodist Creek, South Fork Salmon River, Cecil Creek, and the Little N. Fork Salmon River) **Current Conditions Alternative** Anticipated funds for engineered channel reconfiguration in 0.5 miles of mainstem Salmon River habitat. **Dams-Out Alternative**: Anticipated funds for engineered channel reconfiguration in 1.1 miles of mainstem Salmon River and tributary habitat.	**Summer rearing habitat**: high temperatures and disease occurring during summer low flows may cause direct mortality, make juvenile fish more susceptible to disease and predation, and reduce growth by increasing metabolism. **Winter rearing habitat**: lack of cover and off-channel and other low-velocity habitats may increase juvenile overwintering mortality through displacement during high-flow events, predation, or stress.	**Increases summer rearing habitat** by increasing LWD cover and creating deeper pools that may serve as cool-water habitat during summer low flows. **Increases winter rearing habitat** by creating and restoring access to low-velocity habitats that provide refuge from high flows and displacement. **Reduces summer and winter rearing mortality**: increased LWD cover and pool depths may reduce predation mortality.	**Spring-run Chinook salmon and coho salmon** Spring Chinook salmon in particular are anticipated to benefit from improved rearing conditions in the Salmon River, which has the last wild population of spring Chinook salmon in the Klamath River system. Spring Chinook and coho salmon are expected to benefit from off-channel habitats and LWD cover during winter. Action will likely increase the number of juvenile spring Chinook and coho salmon able to rear for a full year in Salmon River before moving to the mainstem or outmigrating to the estuary and Pacific Ocean. **Summer and Winter Steelhead** Action will likely increase the numbers of juveniles successfully rearing for two summers before outmigrating.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species Specific Notes
39	**Improve riparian zones** through plantings, release of conifers, and control and removal of non-native competitors. **Targeted Salmon River locations**: South Fork Salmon River; Plummer, Mathews, Black Bear, S. Clair, Knownothing, and Nordhimer creeks; North Russian River, Little North Fork River, Crappo and Butler creeks. **Current Conditions:** Anticipated funding for thinning in 200 acres in tributary watersheds. **Dams-Out Alternative**: Anticipated funding for thinning in 420 acres in tributary watersheds. In addition, riparian planting in 150 acres in tributary watersheds.	**Summer rearing habitat**: Loss of stream channel shading can result in higher temperatures during low flows, which can cause direct mortality, make fish more susceptible to disease and predation, and reduce growth by increasing metabolism. **Winter rearing habitat**: Early successional riparian vegetation does not contribute large wood to stream channels. The lack of large wood as cover and velocity refuge may increase juvenile overwintering mortality by displacement during high-flows. **Adult upstream holding habitat**: Adult salmon migration can be delayed by high water temperatures, which can result in adult pre-spawning mortality and reduced spawning success of portions of the run. The viability of eggs in adult salmonids exposed to high temperatures may also reduce spawning success. **Juvenile outmigration survival**: High water temperatures may reduce survival of outmigrating smolts.	**Increases summer rearing habitat** by increasing LWD cover that may create deeper pools that serve as cool-water habitat during summer low flows. Increased shading may reduce temperature- and disease-related stress and mortality of juvenile salmonids, and may increase the amount of rearing habitat available. Reducing temperatures can increase growth of juvenile salmonids, which may increase ocean survival. **Increases winter rearing habitat** by gradually restoring input of large wood to channels from mature trees, creating and restoring access to low-velocity habitats that provide refuge from high flows and displacement. **Enhances or restores habitat connectivity**: Increased shading that reduces water temperatures reduces the likelihood that upstream migration will be delayed, and reduces the potential for temperature-related mortality, stress, or disease of adult and juvenile salmon during upstream and downstream migrations.	**Spring-run Chinook and Coho Salmon** Spring Chinook salmon in particular are anticipated to benefit from improved rearing conditions in the Salmon River, which has the last wild population of spring Chinook salmon in the Klamath River system. Spring Chinook salmon are expected to benefit from improved holding habitat with increased channel complexity. Coho salmon are well known for using large wood elements as cover and velocity refuge in stream channels, as well as off-channel habitats. Spring Chinook salmon use similar habitats during winter, and consequently, both may benefit the most from increased large wood in reaches where it is lacking. Coho and spring Chinook salmon are both particularly sensitive to water temperatures, and are thus most likely to benefit from increased shading along tributary channels.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species Specific Notes
40	**Restore natural fire regime** through thinning, prescribed burning, and fire use on fire prone (especially those watersheds that are important to coho salmon). **Targeted Salmon River locations**: South Fork Salmon River; Plummer, Mathews, Black Bear, S. Clair, Knownothing, and Nordhimer creeks; North Russian River, Little North Fork River, Crappo and Butler creeks. **Current Conditions Alternative** Anticipated funding to conduct prescribed burn in 15,000 acres of mixed conifer forest. **Dams-Out Alternative** Anticipated funding to conduct prescribed burn in 5,000 acres of mixed conifer forest.	Under historical conditions, fire played a large role in shaping forest ecosystems of northern California. The suppression of wildfire for long periods of time, however, can make the forest more vulnerable to catastrophic wildfires that, in turn, can gradually destabilize hillslope soils and result in debris flows that scour channels, landslides that may block stream channels with large amounts of sediment and debris, and result in overall elevated fine sediment input through chronic erosion. They are also more likely to affect riparian habitats. Anadromous salmonid habitat can be affected in many ways, including: • sedimentation of spawning gravels, • pool infilling, • scour of substrate and large wood from streams due to debris flows, • migration barriers, and • potential loss of riparian trees and vegetation.	**Reduces potential for catastrophic fires**: large fires can result in elevated fine sediment input and negative affects on spawning success. Impacts to rearing habitat are also possible, including: • reduced aquatic invertebrate productivity • pool infilling • embeddedness and loss of interstitial cover for juvenile fish • debris flows that scour channels of large wood and other structure • loss of riparian vegetation that provides stream shading.	All species are anticipated to benefit.

ID#	Proposed restoration action under alternatives	Stressors on population addressed by restoration action	Anticipated benefits to salmonids	Species Specific Notes
41	**Decommission and upgrade roads** and decrease road densities in areas with high risk for failure. **Targeted Salmon River locations**: South Fork Salmon River; Plummer, Mathews, Black Bear, S. Clair, Knownothing, and Nordhimer creeks; North Russian River, Little North Fork River, Crappo and Butler creeks. **Current Conditions Alternative** No sources of funding for this action are foreseeable in the immediate future. **Dams-Out Alternative** Anticipated funding to decommission roads in 60 miles in various tributaries.	**Spawning success**: Increased erosion and input of fine sediment to stream channels can reduce egg and alevin survival through deposition of fines onto or into the substrate. **Winter rearing habitat**: Increased sediment input may reduce the interstitial spaces between substrate particles used as cover by some juvenile salmonids. **Summer rearing habitat**: Increased sediment input may reduce habitat through infilling of pools.	**Increases spawning success**: Reductions in erosion and fine sediment input will likely increase egg and alevin survival. **Increases winter rearing habitat**: Reduced fine sediment input may increase overwintering habitat by reducing substrate embeddedness and restoring the interstitial spaces between substrate particles used as cover by juvenile salmonids. **Increases summer rearing habitat** by reducing the input of sediment into pools.	**Chinook salmon** Chinook salmon are more often limited by spawning habitat than coho salmon or steelhead, and thus increased spawning gravel quality potentially will likely benefit Chinook more than other salmonids. **Summer and Winter Steelhead** Steelhead often use the interstitial spaces between substrate particles as cover, which increased sediment input may reduce or eliminate.