37. Shasta River Population

- Interior Klamath Stratum
- Functionally Independent Core Population
- High Risk of Extinction
- 8,700 Spawners Required for ESU Viability
- 793 mi^2
- 435 IP km (270 mi) (60% high)
- Dominant Land Uses are Agricultural and moderate Timber Harvest
- Principal Stresses are 'Impaired Water Quality' and 'Impaired Estuary/Mainstem Function'
- Principal Threats are 'Agricultural Practices' and 'Dams/Diversions'

37.1 History of Habitat and Land Use

The Shasta Valley is situated on the western side of the Cascade Range in far northern California. The majority of this valley receives approximately 15 inches of annual precipitation, and its geology is influenced by Cascadian volcanism. Freshwater springs provide continuous flow of cool water originating primarily from Mt. Shasta, and this keeps the Shasta River watered throughout the year (Snyder 1931). The hydrology of the Shasta River has been and continues to be affected by Dwinnell Dam, surface water diversions, and interconnected alluvial groundwater pumping. Dwinnell Dam has blocked about 22 percent of Shasta River anadromous fish habitat since 1926 (National Research Council (NRC) 2004), and diverts flow from the upper Shasta River, Parks Creek, and Carrick Creek for irrigation and the local municipal water supply. The loss of woody debris, pools, side channels, springs, and accessible wetlands from land use conversions, have also contributed to reduced summer and winter rearing capacity for juvenile coho salmon. Further alterations to stream channel function from agricultural practices includes the loss of beaver ponds, which provide important impoundments and diverse channel margin habitat attractive to coho salmon, further simplifying instream habitat and reducing the quantity and quality of cold, deep pools needed for summer rearing.

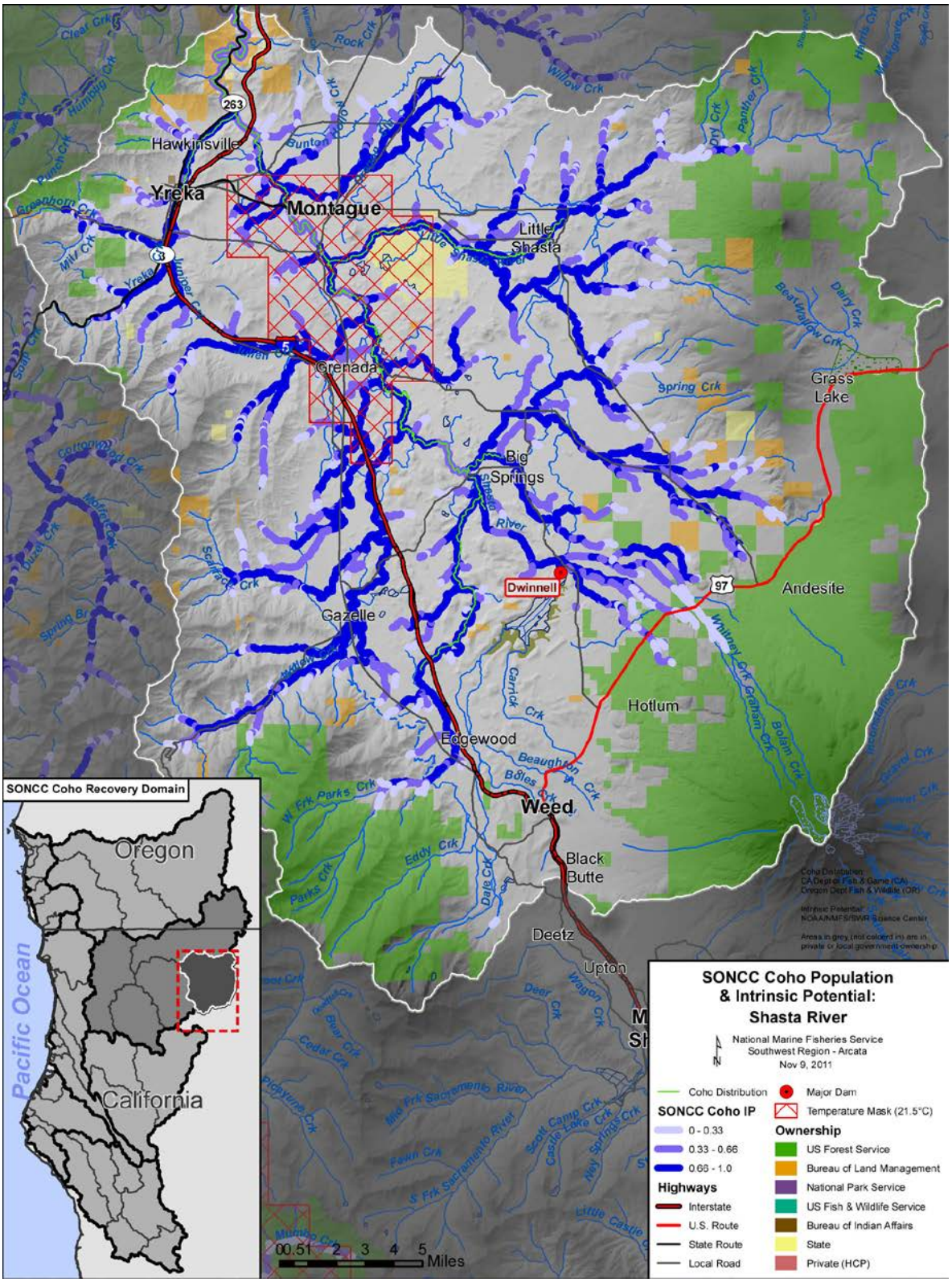

Figure 37-1. The geographic boundaries of the Shasta River coho salmon population. Figure shows modeled Intrinsic Potential of habitat (Williams et al. 2006), land ownership, coho salmon distribution (CDFG 2009a), and location within the Southern-Oregon/Northern California Coast Coho Salmon ESU and the Northern Coastal diversity stratum (Williams et al. 2006). Grey areas indicate private ownership.

Historic gold mining along Yreka Creek and the lower seven miles of the Shasta River occurred from the 1850s through the 1930s. Early mining activities were dependent on the development of water diversion systems to meet mining needs and gravel extraction was focused along the mainstem Shasta River. Large dredge mining activities ended around 1950 in the Shasta River basin, including Yreka Creek, but riparian areas remain poorly vegetated and erodible in these sites (Shasta Valley Resource Conservation District (SVRCD 2005)). These past operations continue to be a threat for coho salmon along the west side of the Shasta River Basin through legacy effects of remnant tailing piles, altered channel morphology, and areas of potential remaining pollution inputs.

Intensive logging of the region surrounding the Shasta River watershed began in the 1850s, reached a peak in the 1950s (Kier Associates 1991) and is currently occurring at a much reduced harvest rate and intensity. Extensive road networks were built to facilitate the intensive logging, and many of them are on steep, naturally fragile terrain. Increased sediment loads resulting from these roads and upslope timber harvesting (e.g., Parks Creek drainage) have accumulated in the Shasta Valley. This resulted in the covering of substrate, decreased availability of spawning gravel, and simplified pool and riffle habitats. This sediment has not been thoroughly flushed since construction of the Dwinnell Dam in 1926 and continues to be a threat to the Shasta River SONCC coho salmon population.

Wildland fire risk has increased in the Shasta River during the recent past due to fire suppression activities that have resulted in a buildup of understory fuels. These understory fuels were historically reduced by low-intensity fires that occurred every 12 to 19 years (Taylor and Skinner 1998). Fire suppression activities over the past 50 years have inadvertently created a new fire regime around the margins of the Shasta Basin, which can be characterized by frequent high intensity, stand replacing fires, replacing the natural fire regime that is characteristic of the region.

37.2 Historical Fish Distribution and Abundance

Information suggests that coho salmon abundance is depressed relative to historical population numbers but, until recently, actual run numbers could not be accurately estimated. Coho salmon runs in the Shasta Valley probably averaged a little more than 1,000 fish annually (Snyder 1931 and California Department of Fish and Game (CDFG) 1959) in the late 1950s and began to decline soon after. In the early 1960s, the runs were estimated to average 600 fish (CDFG 1979). More recently, data suggest (Figure 37-2) the 2001 adult returning brood year class is the strongest, although still lower than historical numbers. Returns for the 2002 and 2003 brood classes have been extremely depressed.

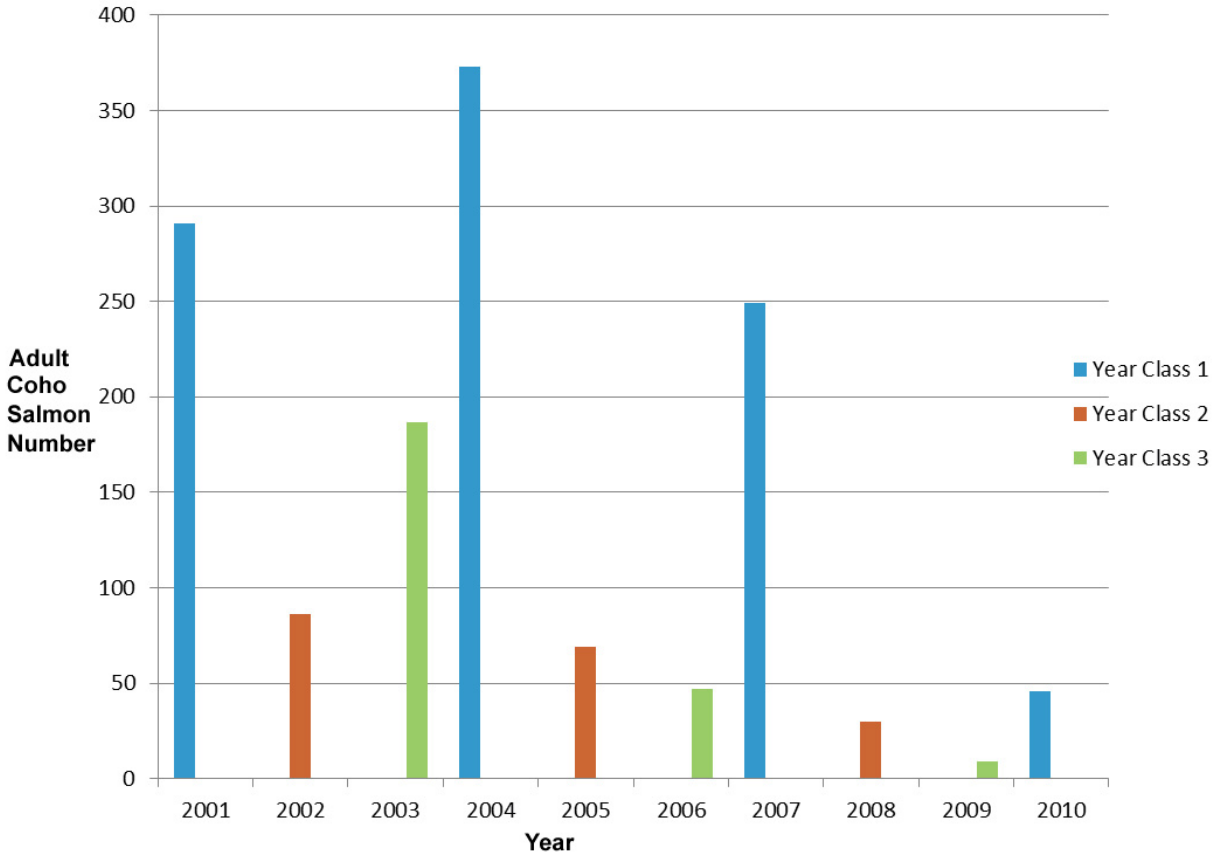

Figure 37-2. Video weir estimates of adult coho salmon in the Shasta River. Data are from 2001 to 2010 (Data from M. Knechtle, California Department of Fish and Game).

Adult coho salmon have been observed spawning in the Shasta River Canyon, lower Yreka Creek, throughout the Big Springs Complex area, and in lower Parks Creek. Juvenile coho salmon have been observed rearing in these same areas, continuing further upstream (Mount et al. 2008), and in the Little Shasta River. Potential coho salmon habitat is distributed throughout the Shasta River basin and IP data show the highest values (IP > 0.66) are throughout the Shasta Valley floor and low gradient reaches of tributaries to the Shasta River.

Table 37-1. Historical tributaries in the Shasta River population with instances of high IP reaches (IP > 0.66). (Williams et al. 2006).

Stream Name	**Stream Name**
Shasta River[1]	Yreka Creek[1]
Big Springs Creek[1]	Little Shasta River[1]
Parks Creek[1]	Willow Creek[1]
Oregon Slough	Juniper Creek
Dale Creek	Boles Creek
[1] Denotes a "Key Stream" as identified in the State of California's Coho Recovery Strategy	

37.3 Status of Shasta River Coho Salmon

Spatial Structure and Diversity

The diversity and complexity of the physical and environmental conditions found within the Shasta River basin created unique life history strategies and diverse coho salmon habitat. The Shasta River population is considered a Functionally Independent population within the SONCC Coho ESU (Williams et al. 2008). Historical instream river conditions, fostered by unique cold spring complexes, that created abundant summer rearing habitat, and abundant off channel overwintering habitat, aided in the success and survival of coho salmon utilizing the Shasta River basin.

The current distribution of coho salmon spawners is concentrated in the mainstem Shasta River from river mile 32 to river mile 38, Big Springs Creek, lower Parks Creek, and the Shasta River Canyon (river mile 0 to 7). Juvenile rearing is also currently occurring in these same areas, and occasionally in lower Yreka Creek (Baldwin 2002) and the upper Little Shasta River (Whelan 2006). This is both a small fragment of the current Shasta River stream network and of the IP.

The genetic diversity of Shastas River coho salmon is likely impacted by the continued operation of the Iron Gate Hatchery. Hatchery coho salmon adult straying into the Shasta River Basin has been estimated at 2, 73, 20, and 25 percent, for the years 2007, 2008, 2009, and 2010 respectively (Chesney and Knechtle 2010), with low adult return numbers contributing to this wide variation. Ackerman and Cramer (2006) estimated that hatchery origin adult coho comprise 16 percent of adult carcasses recovered in the Shasta River basin. These data suggest that hatchery effects may be considerable.

The Shasta River coho salmon population is at high risk of extinction because its spatial structure and diversity are very limited compared to historical conditions, and more than 5% of spawners are of hatchery origin.

Population Size and Productivity

The number of spawners in all three year classes is low, well below the depensation threshold. Productivity may also be impaired. Recent comparisons of estimated Shasta River yearling coho salmon production to returning adult Shasta River coho salmon have ranged from 4.4 to 38 (Chesney and Knechtle 2010, Table 37-2). By brood year, the number of yearlings produced per returning adult has been trending downwards, suggesting that in-river conditions have not improved sufficiently to initiate recovery of the Shasta River coho salmon population.

Adult spawning surveys and fish counting weir information started in 1934, and are conducted by the California Department of Fish and Game. These weir counts indicate that adult spawning coho salmon have varied between 0 to 400 for most years, with a high of approximately 900 returning adults in 1978 (Knechtle 2011). These brood year population estimates are low, and have not trended upward over time. Therefore, the Shasta River coho salmon population is at high risk of extinction given the unstable and low population size and presumed negative population growth rate.

Table 37-2 Adult coho salmon estimates. Yearling coho salmon production point estimates, and ratio of yearling coho salmon produced per adult return for the Shasta River population, brood years 2001-2008 (Chesney and Knechtle 2010)

Adult Brood Year	Adult Estimate	Yearling Year	Yearling Point Estimate	Yearlings Produced Per Adult
2001	291	2003	11,052	38
2002	86	2004	1,799	20.9
2003	187	2005	2,054	11
2004	373	2006	10,833	29
2005	69	2007	1,178	17.1
2006	47	2008	208	4.4
2007	255	2009	5,396	21.2
2008	31	2010	169	5.5
Average				**18.4**

Extinction Risk

Williams et al. (2008) determined that at least 20 coho salmon per-IP km of habitat are needed (8,700 spawners total) to approximate the historical distribution of Shasta River coho salmon and habitat. Based on Williams et al. (2008) criteria, the Shasta River population is at a high risk of extinction for two reasons. First, the number of spawners in the Shasta River is less than the depensation threshold of 531. Second, more than 5% of the spawners are of hatchery origin.

Role in SONCC Coho Salmon ESU Viability

The Shasta River population is considered a “Functionally Independent” population, meaning that it has been sufficiently large to be historically viable-in-isolation, and its demographics and extinction risk have been minimally influenced by immigrants from adjacent populations (Williams et al. 2006). Recent genetic analysis does indicate that coho salmon produced at Iron Gate Hatchery exhibit greater variation between brood years than currently exists between the various wild populations comprising the Interior Klamath stratum, which include the Upper Klamath, Shasta, Scott, Salmon, and Middle Klamath populations (Garza 2010). The Shasta River population, nevertheless, remains a core population and therefore its recovery target is the low risk of extinction; meeting the adjusted low risk spawner threshold (see Chapter 4). The low risk spawner threshold addresses the need for adequate spatial structure and diversity within the population (Williams et al. 2008). Besides its role in achieving demographic goals and objectives for recovery, the Shasta River population fulfills other needs within the Interior Klamath stratum. The Shasta River population may serve as a source population for the Middle and Lower Klamath River populations, and provides connectivity and diversity within the stratum.

37.4 Plans and Assessments

The Nature Conservancy

Shasta Valley Coordinated Resources Management and Planning (CRMP)

Shasta Valley Resource Conservation District

Shasta Valley RCD Strategic Plan

This strategic plan is being revised to meet the RCD's mission of enhancement, conservation, and economic stability of natural resources through support of landowner activities, education and project implementation. It will guide RCD program development, setting measures of success, identifying and acquiring necessary program resources, and evaluating program outcomes.

Klamath Basin Adaptive Management Plan (2002)

The primary goal of this NRCS-supported plan in the Shasta Valley RCD service area is to achieve a reliable water supply for agriculture. The core objectives are to: decrease water demand, increase water storage, improve water quality, and develop fish and wildlife habitat. Planning, design, and implementation of on-farm projects within the Shasta River basin are ongoing, and include assistance from a variety of NRCS programs.

Shasta Valley RCD/CRMP Monitoring

The Shasta CRMP began monitoring Shasta River water temperature, air temperature, and flow in the mid 1990s, and dissolved oxygen in the late 1990s. The Shasta Valley RCD/CRMP has provided support to help operate CDFG outmigrant screw traps, since 2005. The RCD has recently begun stream flow monitoring in support of its nascent Shasta Water Trust and a Shasta Valley RCD groundwater study began in 2004, completed Phase One in 2007, and is continuing now with Phase Two. The Shasta Valley RCD continues its streambank protection program, has revived its riparian planting program, and is implementing prioritized irrigation tailwater reduction strategies. Efforts have started to fund the lease/purchase of cold water for dedication to the Shasta River and Parks Creek. Efforts are also underway to expand accessible SONCC coho salmon habitat, especially in the Big Springs Complex area, Little Shasta River, and Upper Parks Creek. Approximately six miles of habitat is being restored along Big Springs Creek and the adjacent reach of the Shasta River. This restored area is already being used by SONCC coho and other salmonids. The Shasta River Coho Salmon Working Group is exploring alternatives to supplement the coho salmon population in the Shasta River Basin, working with a wide range of stakeholders and agencies.

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Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program
http://www.krisweb.com/biblio/gen_usfws_kierassoc_1991_lrp.pdf

In 1987, Congress adopted the "Klamath Act" (Public Law 99-552) which authorized a 20-year long Klamath River Basin Conservation Area Restoration Program to help rebuild anadromous fish populations in the basin. The "Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program" was produced by Kier Associates for the Task Force in 1991. This program includes work through the Jobs in the Woods Program, the Fish Passage Program, and the Partners for Fish and Wildlife Program. The Partners program is funded through the US Fish and Wildlife Service and provides funding for fish habitat restoration activities, planning and implementation, project monitoring, and education/outreach in the Klamath basin.

State of California

Recovery Strategy for California Coho Salmon
http://www.dfg.ca.gov/fish/Resources/Coho/SAL_CohoRecoveryRpt.asp

This report contains specific pilot program recovery recommendations for coho salmon in the Shasta River Watershed, and include: improved water management/water use efficiency, water augmentation, improved habitat management, protection, assessment and monitoring, and outreach and education.

Shasta River TMDL
http://www.swrcb.ca.gov/northcoast/

The Shasta River watershed was listed as impaired due to both high water temperatures and low dissolved oxygen under Section 303(d) of the Clean Water Act. Federal regulations require that a total maximum daily load (TMDL) be established for 303(d) listed water bodies for each pollutant of concern. In June 2006, a Total Maximum Daily Load (TMDL) was established for water temperature and dissolved oxygen in the Shasta River watershed, along with an action plan to implement it. The TMDL and Action Plan set load allocations and assigned implementation responsibilities. In September 2011, The Shasta Valley RCD provided the NCRWQCB with a five-year Shasta Valley TMDL Progress Report.

Shasta River Fish Counting Facility (SRFCF)

The Shasta River Fish Counting Facility is part of the Klamath River Project (KRP) of the California Department of Fish and Game (Department) and is responsible for estimating the number of fall-run Chinook salmon (Oncorhynchus tshawytscha) that return to the Shasta River. Although the primary responsibility of the KRP is to enumerate and describe fall-run Chinook

salmon populations with in the basin to assist harvest managers, data is recorded for other fish species observed at the SRFCF during its normal period of operation from September through the first week of November. Consistent with this effort, the KRP continues to operate the SRFCF beyond its normal period of operation in an effort to document migration of coho salmon into the Shasta River.

37.5 Stresses

Table 37-3. Severity of stresses affecting each life stage of coho salmon in the Shasta River. Stress rank categories and assessment methods are described in Appendix B, and the data used to assess stresses for the initial threats assessment (described in Appendix B) is presented in Appendix H.

Stresses (Limiting Factors)		Egg	Fry	Juvenile[1]	Smolt	Adult	Overall Stress Rank
1	Impaired Water Quality[1]	Very High	Very High	Very High[1]	Very High	Very High	Very High
2	Impaired Estuary/Mainstem Function	-	Low	High	Very High	Very High	Very High
3	Altered Hydrologic Function	Medium	Very High	Very High	Very High	Medium	Very High
4	Increased Disease/Predation/Competition	Low	Medium	Very High	Very High	Medium	Very High
5	Lack of Floodplain and Channel Structure[1]	High	High	High[1]	High	High	High
6	Adverse Hatchery-Related Effects	High	High	High	High	High	High
7	Degraded Riparian Forest Conditions	-	High	High	High	Medium	High
8	Altered Sediment Supply	Medium	Medium	Medium	Low	Medium	Medium
9	Barriers	-	Low	Medium	Medium	Low	Medium
10	Adverse Fishery Related Effects	-	-	-	-	Low	Low

[1] Key limiting factor(s) and limited life stage(s).

Limiting Stresses, Life Stages, and Habitat

The Shasta River coho salmon population evolved with areas of big spring complexes, which provided them with sustained sources of cold, clean, high quality water, and provided them with abundant areas for rearing during hot, dry summer months. With changes in land use to large scale water diversions and associated agricultural practices, these springs are no-longer adequate, or at times even accessible, to provide suitable cold water habitat essential to the survival of over summering coho salmon (Mount et al. 2009). Data indicates that impaired water quality and altered hydrologic function are the limiting stressors for the Shasta River coho salmon population, and that juveniles are the limiting life stage for the population, due to poor water quality and stressful conditions encountered during hot, dry summer months.

The most vital habitat in the Shasta River basin are its cold springs, which create cold water refugia for juvenile coho salmon, decrease overall water temperatures throughout the basin, and allow for successful summer rearing of individuals in natal and non-natal creeks and mainstem areas. Yreka Creek, Julian Creek, Willow Creek, Parks Creek, Dale Creek, Eddy Creek and the Shasta River upstream from Lake Shastina receive runoff from west side mountains. Boles Creek, Carrick Creek, Beaughton Creek and Big Springs Creek are all spring creeks originating from snowmelt percolating from Mt. Shasta. Recent UC Davis investigations have indicated the high potential productivity and capability of the Big Springs Creek system to support large salmonid populations (Mount et al. 2009). Known cool water refugia are listed in Table 37-4 They are all located in reaches with high IP values.

Table 37-4. Potential refugia areas within the geographic boundaries of the Shasta River population.

Subbasin	Stream Name	Subbasin	Stream Name
Shasta River	Big Springs Complex: Big Springs Creek, Hole in the Ground Springs and Creek, Clear Springs, and other unnamed springs downstream from Dwinnell Dam	Shasta River	Mainstem Shasta River, river mile 32 to 38
Shasta River	upper Little Shasta River	Shasta River	upper Yreka Creek
Shasta River	Parks Creek, and springs flowing into the lower reaches of Parks Creek: Shasta Springs, Kettle Springs and Creek, and Bridge Field/Black Meadow Springs and Bridge Field Creek	Shasta River	upper Greenhorn Creek (N.B. upstream from Greenhorn Dam)

Impaired Water Quality

Impaired water quality is a very high stress for all coho salmon life stages. Reduced quantity of instream flows creates extremely stressful water quality conditions for rearing juveniles, and decreases the cold water input from vital cold spring complexes throughout the basin. The hydrology in the Shasta River is dominated by a large spring complex that provides the majority of the water for the Shasta River, particularly during the summer. The water that emerges from the springs is very cold, high in nutrients, and provides for exceptionally high primary and secondary productivity. The flow of the river is enhanced by snow melt from Mt. Shasta that historically maintained a consistent cold water flow of at least 103 cubic feet per second (cfs) to the Klamath River during the summer (Mack 1958). This spring-fed system was noted for producing large runs of both spring-run and fall-run Chinook salmon, coho salmon, and steelhead (Snyder 1931).

Stream temperatures for summer rearing are poor throughout the mainstem Shasta River from its mouth to the Big Springs area, and upstream of Lake Shastina. At times water temperatures

become lethal to anadromous fish (Gwynne 1993, North Coast Regional Water Quality Control Board (NCRWQCB) 2006). The pH is poor (9.4) near the mouth of the Shasta River where during the summer conditions upstream are similar. In other areas of the basin, dissolved oxygen has been measured as poor (current indicator status 5.1 mg/L) near the mouth of the Shasta River. These conditions are created by low stream flows, increasing ambient temperatures from climate change, and decreases in riparian cover, which historically kept stream temperatures low, and refugia areas plentiful. Impaired water quality creates a very high stress for all life stages of coho salmon, and decreases survival and fitness of juveniles throughout the Shasta River watershed.

In undertaking annual Shasta River downstream migrant trapping studies, CDFG observed a relationship between reduced base flows, increasing water temperatures, and early outmigration of young-of-the-year (YOY) coho salmon (CDFG 2003b). In years when spring base flows were reduced early due to drought conditions and the onset of agricultural water deliveries, YOY coho salmon outmigration to the mainstem Klamath River occurred earlier than in years when Shasta River base flows were sustained at a higher level through the spring (CDFG 2003b). This suggests that juvenile coho salmon, while known to naturally exhibit non-natal rearing in the Klamath River, are prematurely forced to redistribute within the basin in response to diminishing spring flow conditions. It is noteworthy that the mainstem Klamath River below Iron Gate Dam is impaired by elevated nutrient levels, organic enrichment/low dissolved oxygen levels, elevated water temperatures (NCRWQCB 2008), and fish diseases (Stocking et al. 2006, Nichols and True 2007). Thermal impairment of lower Shasta River water in late summer/early fall can slso result in morbidity and mortality of in-migrating adult coho salmon, which occurred during the late September of 2009 in the lower Shasta River. This impairment therefore reduces the health and survival of both out-migrating and in-migrating Shasta River coho salmon.

Impaired Estuary/Mainstem Function

This stress refers to the estuary and mainstem conditions in the Klamath River, since this population is part of a larger basin containing multiple populations. Conditions in the Klamath River mainstem and estuary are important to this population since all salmon and steelhead that originate from the Shasta River migrate to and from the ocean through the mainstem Klamath River and the Klamath River estuary. The Klamath River estuary plays an important role in providing holding habitat, foraging and refuge opportunities for outmigrating juvenile coho salmon from the Shasta River. Previous studies have shown that naturally produced yearling coho salmon can have extended estuarine residence times, up to several weeks (Miller and Sadro 2003). Although the estuary is short and small compared to the large size of the watershed, it does provide numerous habitat types and vital rearing habitat for juvenile and smolting coho salmon (Wallace 1995). The degraded conditions that exist throughout the Klamath basin today may mean that the estuary plays an even more important role for all Klamath populations by providing the opportunity for juvenile and smolt growth and refugia prior to entering the ocean. The estuary, although relatively intact, suffers from poor water quality, elevated sedimentation and accretion, loss of habitat, and disconnection from tributary streams and the floodplain. Levees along the Lower Klamath and development on the floodplain have led to the loss and degradation of habitat in the estuary. More information about the Klamath River estuary can be found in Section 11.19.

Mainstem conditions in the Shasta and Klamath Rivers are stressful because of poor water quality, sedimentation, and degraded habitat. Because of the distance that this population must travel to and from the ocean, and the time spent in the mainstem Klamath River, this stress is especially significant for the Shasta River population. Juveniles, fry, and smolts transitioning through estuarine and mainstem habitat are stressed by the degraded conditions in these migratory habitats and suffer from the lost opportunity for increased growth and consequently a lower survival rate. The loss and degradation of estuarine and mainstem habitat is considered a high to very high stress for the population, with the most affected life stages being juveniles, smolts, and adults due to the degradation of rearing and migratory habitat.

Altered Hydrologic Function

Altered hydrologic function presents a very high stress to fry, juvenile, and smolt life history stages, a medium stress to the egg stage, and medium stress to adults. Dwinnell Dam and over 100 other adjudicated irrigation diversions now divert more than 110 cfs from the Shasta River from April 1 to October 1 (NRC 2004) providing irrigation for approximately 52,000 acres of land (about 10 percent of the watershed) during the growing season. Estimated consumptive use of irrigation water is approximately 100,000 acre feet per year. Shasta River surface water is over-allocated during the irrigation season, leaving inadequate summer instream flows of approximately 15 to 20 cfs in the lower Shasta River, sometimes dropping to 5 cfs in dry years (Hampton 2009). In response, the Shasta TMDL Implementation Plan set a target summer flow of 45 cfs of water cool enough to sustain salmonids at the the DWR Montague gage (NCRWQCB 2006). Water quantity/flow regime is generally good (fully functional) in the southern portion of the Shasta Valley including upper Parks Creek, the upper Shasta River, and tributaries originating from the flanks of Mt. Shasta: Dale, Boles, Broughton and Carrick creeks, but poor in other key areas from over allocated water diversions and Dwinnell Dam.

Hydrologic function is severely altered by a rapid decrease in flows beginning with the onset of the irrigation season, when large numbers of Shasta Valley irrigators begin diverting water simultaneously. The reduced discharge along the mainstem Shasta River forces rearing juvenile coho salmon to move either upstream towards spring-fed habitat, or downstream to the Klamath River. Reduced flows during the spring often result in decreases in summer rearing habitat and reduced opportunities for juvenile fish movement within the basin.

Increased Disease/Predation/Competition

Disease, predation, and competition present a very high stress for juveniles and smolts, a medium stress for adults and fry, and a low stress for egg. Disease does become a significant stressor to Shasta River coho salmon when they enter the Klamath River, where pathogens and toxins become pervasive during the late spring and summer. Pathogens that have caused diseases in juvenile fish include Ceratomyxa shasta (resulting in ceratomyxosis), *Flavobacterium columnare* (columnaris), aeromonid bacteria *Nanophyetus salmonicola*, and the kidney *myxosporean Parvicapsula minibicornis* (Federal Energy Regulatory Commission 2007). Actinospore concentrations of both *C. Shasta* and *P. minibicornis* in the mainstem Klamath River are often above the threshold necessary to induce infection and disease (Stocking et al. 2006, Nichols and True 2007). By late spring and summer, both diseased hatchery and natural-stock juveniles are seen dead or moribund in Klamath River screw traps. In addition to disease,

competition can occur when numerous, larger-sized hatchery fish displace wild juveniles in refugia along the Klamath River, take available prey, or eat undersized wild juvenile fish. Non-native piscivorous fish and amphibians also prey on juvenile coho salmon originating from the Shasta River population (Knechtle 2011).

Lack of Floodplain and Channel Structure

Lack of floodplain and channel structure presents a high stress for all life stages. Agricultural practices occurring adjacent to the mainstem Shasta River and several important tributaries has led to degradation and loss of rearing habitat, slackwater refugia, wetlands, and other off-channel habitats. The disconnection of the floodplain from the mainstem Shasta River and the conversion of riparian corridors to agricultural pastures has also altered instream channel morphology through accretion of sediment, increased winter flows, and changes in pool to riffle ratios. Loss of riparian vegetation cover throughout the Shasta Valley floor has caused the loss of LWD recruitment, channel margin degradation, and excessive sediment, decreasing available rearing summer and winter rearing habitat, pool depth, and instream cover. These impacts collectively limit the development of complex stream habitat necessary to sustain spawning and rearing throughout much of the high IP areas of the Shasta Valley.

Adverse Hatchery-Related Effects

The effects of hatchery fish on all life stages of coho salmon are described in Chapter 3. There are no hatcheries nor artificial propagation in the Shasta River basin, but there is a fish hatchery on the Klamath River at the base of Iron Gate Dam, approximately 13 miles (21 km) upstream of the mouth of the Shasta River. Approximately 75,000 coho salmon fry, along with 6,000,000 fall Chinook salmon and 200,000 steelhead yearlings are released from the Iron Gate Hatchery each year. As adults, some of these fish stray into the Shasta River basin when migrating back upstream, and there they can interbreed with wild Shasta River coho salmon, simplifying their genetics and in the long term decreasing the productivity of wild coho salmon. On average, 16 percent of adult carcasses recovered in the Shasta River basin in 2001, 2003, and 2004 were of hatchery origin (Ackerman and Cramer 2006). Coho returns to the Shasta River fish counting facility from 2001 to 2004 (Ackerman et al. 2006), and from 2007 to 2010 (Chesney and Knechtle 2011b), averaged 23 percent. Adverse hatchery-related effects pose a high stress to all life stages because hatchery origin adults make up greater than ten but less than 30 percent of the total number of adults (Appendix B).

Degraded Riparian Forest Conditions

Degraded riparian forest conditions pose a medium stress to adults, and a high stress to fry, juvenile, and smolt life stages. Stream corridor vegetation and cover is considered very good (fully functional) in the southern portion of the Shasta Valley including upper Parks Creek, Eddy Creek, and the upper tributaries of the Shasta River (Dale, Boles, Broughton and Carrick creeks) while the upper Little Shasta River has fair, partially functional stream corridor cover. The loss of riparian cover in other areas of the basin has, however, left the mainstem Shasta River and tributary riparian areas downstream of Dwinnell Dam exposed, degraded, and unable to sustain productive biotic communities. Riparian assessments of the Shasta River on the Nelson Ranch (Mount et al. 2008) and the Shasta Big Springs Ranch (Mount et al. 2009) indicate that highly

productive riparian habitat can be sustained and restored along portions of the Shasta River watershed, but natural recruitment of woody perennials is inconsistent, due to soil chemistry, current agricultural practices, and other anthropogenic changes in land use.

Altered Sediment Supply

Altered sediment supply presents a medium stress for the juvenile life stage, and a low stress for all other life stages. The Shasta Valley is geologically young and relatively stable (CH2M HILL 1985), and sediment that is delivered to the Shasta River derives from unstable sloughing stream banks, unpaved upland roads, and residential development. Alterations in sediment can simplify and fill in pool habitat, preclude the establishment and maintenance of riparian vegetation cover, cause embeddedness of gravels in spawning areas, and alter channel morphology. Since juvenile coho salmon rear for an extended period in freshwater environments, changes such as these can be detrimental to their fitness and ability to survive.

Barriers

Barriers present a medium stress for juvenile and smolt life stages and a low stress for fry and adult life history stages. There are two permanent dams that act as barriers in the Shasta River. Dwinnell Dam, blocks about 22 percent of Shasta River anadromous fish habitat, and in the 1950s a permanent dam was placed in Greenhorn Creek, a tributary to Yreka Creek, for municipal and industrial water storage. Greenhorn Dam blocks access to upstream areas in Greenhorn Creek, blocks the movement of gravel down Yreka Creek, and alters the Yreka Creek hydrograph. Multiple diversion dams, small impoundments, one small micro-hydro installation at the entrance to the Shasta River Canyon (Kier Associates 1991) and road/stream crossings also cause partial or complete barriers to high IP habitat in several Shasta River basin locations. Diversion dams reduce instream flows and allow impounded water to reach lethal temperatures during the summer, while the larger Dwinnell dam changes channel morphology, alters the hydrologic function of the mainstem Shasta River, but does serve to sustain water yield from some adjacent springs in the Big Springs Complex (Knechtle 2010). Diversion dams also create a pond-like environment, rich in nutrients, where algae bloom in abundance. Of the six flashboard summer irrigation dams on the mainstem Shasta River, four have been removed, locally improving the function and condition of the mainstem river.

Adverse Fishery-Related Effects

NMFS has determined that federally-managed fisheries in California are not likely to jeopardize the continued existence of the SONCC coho salmon ESU (Appendix B). The effects of fisheries managed by the state of California and Tribal governments on the continued existence of the SONCC coho salmon ESU have not been formally evaluated by NMFS (Appendix B).

37.6 Threats

Table 37-5. Severity of threats affecting each life stage of coho salmon in the Shasta River. Threat rank categories and assessment methods are described in Appendix B, and the data used to assess threats for the initial threats assessment (described in Appendix B) is presented in Appendix H.

Threats[1]		Egg	Fry	Juvenile	Smolt	Adult	Overall Threat Rank
1	Agricultural Practices	Very High	Very High	Very High	Very High	Very High	Very High
2	Dams/Diversion	Very High	Very High	Very High	Very High	Very High	Very High
3	Channelization/Diking	High	High	High	High	High	High
4	Roads	High	High	High	High	High	High
5	Hatcheries	High	High	High	High	High	High
6	Climate Change	Low	Low	Very High	High	Medium	High
7	Timber Harvest	Medium	Medium	Medium	Medium	Medium	Medium
8	High Intensity Fire	Medium	Medium	Medium	Medium	Medium	Medium
9	Mining/Gravel Extraction	Medium	Medium	Medium	Medium	Medium	Medium
10	Urban/Residential/Industrial	Medium	Medium	Medium	Medium	Medium	Medium
11	Road-Stream Crossing Barriers	-	Low	Low	Low	Low	Low
12	Fishing and Collecting	-	-	-	-	Low	Low

[1]Invasive Non-Native/Alien Species is not considered a threat to this population.

Agricultural Practices

Agricultural practices are a very high threat to all life stages of coho salmon. Many subbasins of the Shasta Valley have pasture/hay and cultivated crops, which together account for more than 10 percent of the land area. Agricultural areas adjacent to coho salmon habitat occur along the mainstem Shasta River downstream from Dwinnell Dam to the Shasta River Canyon entrance, the Little Shasta River, Parks Creek, Yreka Creek, and Big Springs Creek. Excessive fine sediment, low flows, and warm-water inputs damage spawning and rearing habitat and hinder migration. Erosion from agricultural practices can contribute fine sediment to the river. Livestock along the Shasta River can compound these problems by damaging stream banks and riparian vegetation, and by adding nutrients to the stream, thereby reducing oxygen levels. Beyond these system-wide impacts, there is considerable risk of trampling of redds in the upper portions of the Shasta Valley (Parks Creek and the upper Shasta River), where areas suitable for spawning are also frequently preferred by livestock for crossings and for in-channel grazing.

Livestock exclusion fencing now precludes these impacts on much of the Shasta Valley floor, with remaining unfenced reaches located along both the upper Shasta River near Dwinnell Dam and upper Parks Creek.

Water diversions and warm irrigation tailwater returns in scarce cool-water areas severely limits habitat values in critical refuge spawning and rearing areas. Even in areas where water temperatures are generally good, intermittent pulses of warm tailwater can overwhelm available cold water, forcing fish to relocate or killing them outright. The Shasta Valley RCD's Agricultural Water and Tailwater Management Program is improving on-farm management, beginning in high priority areas in the Big Springs Complex, including river miles 32 to 38 of the Shasta River and river mile 4 to 6 of Parks Creek: to reduce tailwater creation and to implement projects that contain, store, cool, and reuse agricultural tailwater.

The onset of the irrigation season in the Shasta River watershed has a dramatic impact on instream flows when large numbers of irrigators begin taking water simultaneously. This results in a rapid decrease in flows below the diversions, stranding coho salmon as channel margin and side channel habitat disappears (CDFG 1997a). Low stream flows can limit access to rearing areas and decrease rearing habitat for juvenile coho salmon. Diversion of surface water has limited the quantity of cold water from the spring complexes within the basin, causing water temperatures to rise above the lethal level of the 25.8ºC for salmon. Low dissolved oxygen levels also occur along the Shasta River, adversely affecting salmonids. Though much diminished since 1991, livestock access to the Shasta River contributes to these problems, by damaging stream banks and riparian vegetation that provide shade and cover, and by also adding excessive nutrients to the stream, contributing further to reduced dissolved oxygen levels. Warm, nutrient-rich tailwater entering cool-water reaches of the Shasta River severely degrade habitat quality in adjacent spawning and rearing areas that are already scarce.

Dams/Diversion

Dams, diversions, and associated reductions in water availability downstream, as well as the timing of that availability, are a very high threat to all life stages of coho salmon. In 1926 the Shasta River was dammed at River Mile 37 to form Dwinnell Reservoir (Lake Shastina), blocking about 22 percent of historic salmon habitat in the Shasta River basin (NRC 2004). In 1955, the capacity of the dam was increased, bringing the total storage capacity to 50,000 acre-feet. There are no instream flow release requirements from Dwinnell Dam, which further diminishes Shasta River flows during the summer irrigation season. During the winter Lake Shastina's capture of peak winter flows significantly reduces the ability of the Shasta River to flush fine sediment from spawning gravels and changes the hydrology downstream. In addition to Dwinnell Dam, another permanent dam was placed in Greenhorn Creek, a tributary to Yreka Creek, in the 1950s for municipal and industrial water storage. Greenhorn Dam blocks access to upstream areas in Greenhorn Creek, blocks the movement of gravel down Yreka Creek, and alters the Yreka Creek hydrograph. The City of Yreka does not routinely release water from this reservoir during the summer, and such releases could help maintain sufficient flow in Yreka Creek for coho salmon holding and rearing there.

Irrigation diversions block stream channels, reduce flows and often create riverine impoundments. These impoundments warm to lethal temperatures during the summer, become

rich in nutrients, and foster algae blooms. Additionally, if not screened, irrigation diversions can trap fish and create passage problems for juveniles looking for refugia. Diverted irrigation water becomes warmed and nutrient rich before it drains back into the river as tailwater. Pervasive diversion of irrigation water results in diminished peak flow events that historically inundated the valley floor and expanded juvenile rearing habitat. Two flashboard irrigation diversion dams remain on the Shasta River, and continue to create passage problems for juvenile and smolt coho salmon. There are also 15 smaller diversion dams listed in the California Fish Passage Assessment Database CalFish (2009), most of which are located in high IP areas. Dams and diversions which pose significant barriers to fish passage, including upstream juvenile migration, are listed in Table 37-6.

Other barriers associated with small water diversion have been observed in lower Parks Creek, an area with several small, cold water springs that are critically important for the survival of juvenile coho salmon. Adult radio tagging information since 2004 confirms that many coho salmon tracked in the upper Shasta River ultimately spawned in lower Parks Creek (CDFG 2008b), the southwest portion of the Big Springs Complex.

Table 37-6. List of dams/diversion barriers in the Shasta River basin.

IP priority	Stream Name	Dam/Diversion Name	Passage Assessment Database ID number	Miles of habitat blocked, or partially blocked (*)
1	Shasta River	Dwinnell Dam (Shasta River Dam & diversion)	100003	93
1	Yreka Creek	Greenhorn Dam	100674	4
1	Shasta River	Novy/Rice Dam		28 (*)
1	Shasta River	Grenade Irrigation District Dam		23 (*)
2	Little Shasta River	Hart Diversion Dam		4 (*)
1	Parks Creek	Cardoza Diversion Dam		9 (*)
2				
1				
1				
2	Little Shasta River	Blair Smith / Musgrave Dam (diversion)		3 (*)

Channelization/Diking

Channelization and diking pose a high threat to all life stages of coho salmon, and occur primarily along many reaches of Parks Creek, Willow Creek, the Little Shasta River, and the urban reach of Yreka Creek. Channelization and diking of rivers and streams has been shown to decrease the quantity and quality of winter rearing habitat by eliminating the availability of low

flow energy, off channel habitats: habitat which is already lacking in the Shasta River Basin. This channel alternation has resulted in the conversion of beaver-occupied wetlands to drained agricultural lands. In contrast, natural channel form and floodplain connectivity remain good (fully functional) in portions of the upper Shasta River and its other tributaries

Roads

Roads are a high threat to all life stages of coho salmon in the Shasta River population. Road density is very high (>3 miles of roads/sq. mile) in the following tributary subbasins, where high IP reaches predominate: upper Shasta River, upper Little Shasta River, Yreka Creek; and upstream of Dwinnell Dam/Reservoir in Boles Creek. Road density is high (2.5 to 3.0 miles of roads/sq. mile) in Eddy Creek, upper Parks Creek, Willow Creek, upper Juniper Creek; and upstream of Dwinnell Dam/Reservoir in Carrick Creek. The reaches occurring upstream from Dwinnell Reservoir currently have sediment mobilized from them captured in the reservoir. Road density improves downstream and is considered a medium to low threat throughout most of the Shasta Valley floor. Erosion potential from unmaintained roads is greatest in the upper portions of subbasins where heavy rain, and rain on snow occur in areas containing roads from past timber harvest activities. The associated increases in fine sediment from these conditions have been shown to suffocate redds, degrade pool quality, and decrease pool depth. Residential development on the Shasta Valley floor, and the increasing number of un-engineered private roads mobilize sediment to stream channels, thereby further increasing impacts to juvenile coho salmon rearing in adjacent streams.

Hatcheries

Hatcheries pose a high threat to all life stages. The rationale for these ratings is described under the “Adverse Hatchery-Related Effects” stress.

Climate Change

Climate change poses, in the balance, a high threat to this population. The impacts of climate change in this region will have the greatest impact on juveniles, smolts, and adults. The current climate is generally warm and modeled regional average temperature shows a large increase over the next 50 to 100 years (see Appendix B for modeling methods). Average temperature could increase by up to 3° C in the summer and by 1.3^{o} C in the winter. Annual precipitation on the Shasta Valley floor is already less than 20 inches, and is predicted to trend downward over the same time period. Snowpack in upper elevations of the basin will decrease with changes in temperature and precipitation (California Natural Resources Agency 2009). Changes will impact water yield of natural springs, which is an important component of the hydrologic regime of the Shasta River, and this will impact summer rearing habitat. The vulnerability of the Klamath estuary to sea level rise is low to moderate and therefore does not pose a significant threat to estuarine rearing habitat downstream. Juvenile and smolt rearing and migratory habitat in the Shasta River and Klamath mainstem is most at risk to climate change. Increasing temperatures and changes in the amount and timing of precipitation and snowmelt will impact water quality and hydrologic function in the summer and winter. Overall, the range and degree of variability in temperature and precipitation are likely to increase. Adults will also be negatively impacted

by ocean acidification and changes in ocean conditions and prey availability (Independent Science Advisory Board 2007, Feely et al. 2008, Portner and Knust 2007).

Timber Harvest

Timber harvest is a medium threat to all life stages of coho salmon, due primarily to residual impacts from logging-derived sediment mobilization issuing from west side drainages. Sediment is mobilized from faulty road ditches and water conveyance structures, unmaintained and/or undersized culverts, bare hillsides, and improperly designed and unmaintained roads. The volume of timber harvested on national forest land diminished in the early 1990s, and has remained low since the implementation of the Klamath National Forest's Land and Resource Management Plan in 1994 (USFS 1994b). General Forest Management Areas available for logging in the Shasta River basin are small and are confined to the western slopes of the Cascade Range. Small scale projects involving understory fuels reduction, hazard tree removal, and small commercial thinning projects are expected to continue at current rates into the future.

High Intensity Fire

High intensity fire, and the riparian habitat destruction and surface erosion it causes, is a medium threat to all life stages of coho salmon. Because of past timber harvest practices and fire-suppression efforts over the past century, understory forest fuel loads have become excessive and have severely altered the fire regime in the region. High intensity fires result from these excessive forest fuel loads and could occur in the uplands of the Shasta River watershed, creating erosion/ sedimentation problems, large areas of bare, unstable soil, and threatening riparian vegetation along stream banks. In addition, fire suppression activities could lead to impacts to coho salmon from misapplication of fire retardant, increased water withdrawals in summer months, and mobilization of sediment through the digging of fire lines and other fire prevention methods.

Mining/Gravel Extraction

Mining and gravel extraction are medium threats to all life stages of coho salmon. The legacy impacts of historic gold mining along Yreka Creek and the lower seven miles of the Shasta River continue to degrade habitat, through alterations in floodplain connectivity, changes in channel morphology, and continuing impacts from the historic removal of gravel. Gravel depletion remains a problem in the Shasta River downstream from Dwinnell Dam and in the depositional portions of many tributaries. Tailing piles and fill occupy large historic floodplains along Yreka and Greenhorn creeks, where riparian areas remain poorly vegetated and erodible (SVRCD 2005). Currently, neither suction dredging nor gravel mining commonly occur in the Shasta River basin, however, the legacy effects are long lasting and need to be addressed to decrease the threat to Shasta River coho salmon. A spawning gravel evaluation and enhancement plan for the Shasta River has been completed by McBain and Trush (2010), and can be used to inform and prioritize spawning gravel enhancement efforts in the basin.

Urban/Residential/Industrial Development

Urban, residential, and industrial development is a medium threat to all life stages. Within the Shasta Valley, modest densities of residences and urban development are located near Yreka,

Weed, Montague, Little Shasta, Big Springs, Grenada, and Gazelle. Overall, this threat is not expected to change into the foreseeable future, as population growth is currently stable in this area. The extent to which roads in these areas are a threat to coho salmon is considered under the Roads threat, above.

Road-Stream Crossing Barriers

Road related barriers are a low threat to all juvenile and adult life stages of coho salmon. Readily available information from CalFish (2009, http://www.calfish.org/portals/0/Programs/CalFishPrograms/FishPassageAssessment/tabid/83/Default.aspx) and Five Counties Salmonid Conservation Program (2008) indicate road/stream crossings that require further evaluation for improved fish passage (see Table 37-7).

Table 37-7. List of road/stream crossing barriers in the Shasta River basin

IP-based priority	Stream Name	Road Name	Subarea	Passage Assessment Database ID number	Miles of habitat blocked
1	South Fork Willow Creek	Gazelle-Callahan RD	Shasta Valley	705936	1.5
1	Willow Creek #1	Gazelle-Callahan Road	Shasta Valley	705935	6
1	Willow Creek #2	Gazelle-Callahan Road	Shasta Valley	705937	1
1	Willow Creek, Julien Creek	Culvert I-5	Shasta Valley	707151	
1	Modoc Gulch	Estimated Hwy 5 culvert (@ PM 24.2)	Shasta Valley	723848	
2	Uunamed Tributary to Schulmeyer Gulch	Estimated Hwy 5 culvert (@ PM 41.6)	Shasta Valley	723853	
2	Juniper Creek	Estimated Hwy 5 culvert (@ PM 44.0)	Shasta Valley	723852	
2	Unnamed Tributary to Shasta River	Estimated Hwy 5 culvert (@ PM 50.67)	Shasta Valley	723851	
2	Unnamed Tributary to Shasta River	Estimated Hwy 5 culvert (@ PM 51.4)	Shasta Valley	723850	

IP-based priority	Stream Name	Road Name	Subarea	Passage Assessment Database ID number	Miles of habitat blocked
1	Red Gulch, Yreka Creek	culvert	Shasta Valley	732272	
1	Tributary to the Little Shasta River	Forest Service Road	Shasta Valley	713343	
1	Dry Gulch, Shasta River	Estimated Hwy 5 culvert (@ PM 53.0)	Shasta Valley	723849	

Fishing and Collecting

California-managed fisheries for species other than coho salmon occur in estuaries, freshwater, and nearshore marine areas. In addition, tribal salmonid fisheries harvest has the potential to cause injury and death to coho salmon in the Klamath/Trinity basin. The effects of State of California, and Yurok and Hoopa Tribal fisheries management on the continued existence of the SONCC coho salmon ESU have not been formally evaluated by NMFS. NMFS has authorized future collection of coho salmon for research purposes in the Shasta River. NMFS has determined these collections are not likely to jeopardize the continued existence of the SONCC coho salmon ESU.

37.7 Recovery Strategy

Coho salmon in the Shasta River are depressed in abundance with a restricted distribution. Recovery activities in the watershed should continue to promote increased spatial distribution as well as increased productivity and abundance. Activities should occur throughout the watershed, with a focus on mainstem and tributary reaches with high IP values. Recovery actions that reduce stream temperatures, increase dissolved oxygen concentrations, and achieve sufficient instream flow targets through the summer should be a priority in the watershed. Addressing the limiting factor of inadequate summer rearing habitat for juveniles should be of top priority, and multi-faceted, long term solutions should be sought. Winter rearing and spawing habitat improvement is also a priority, and should include beaver enhancement, large/complex woody debris recruitment, and spawning substrate enhancement. Additionally, working collaboratively with stakeholders and others working to restore mainstem and estuary conditions in the Klamath River should expand, to assure that the Shasta River coho salmon population have the necessary habitat requirements for all freshwater life stages. Specific goals for each stressor are listed in the compilation of recovery actions in Chapter 6. These goals identify activities that are expected to reduce the stresses currently affecting the Shasta River SONCC coho salmon population.

Table 37-8 on the following page lists the recovery actions for the Shasta River population.

Table 37-8. Recovery action implementation schedule for the Shasta River population.

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID		***Step Description***				
SONCC-ShaR.3.1.1	Hydrology	Yes	Improve flow timing or volume	Increase instream flows	Population wide	2
SONCC-ShaR.3.1.1.1		*Identify, map, and quantify all surface water diversions*				
SONCC-ShaR.3.1.1.2		*Assess water diversions, prioritize, and adjust management to benefit life history requirements of coho, attaining a 55 cfs target summer base flow at the mouth of the Shasta River*				
SONCC-ShaR.3.1.1.3		*Secure dedicated unused water diversion rights*				
SONCC-ShaR.3.1.1.4		*Verify permitted water diversions*				
SONCC-ShaR.3.1.1.5		*Use real time flow, precipitation, snowpack, groundwater, and climate information to guide Water Trust work to augment surface flows at priority locations for coho, via water leases and dedications*				
SONCC-ShaR.3.1.2	Hydrology	Yes	Improve flow timing or volume	Monitor flow for compliance	Population wide	2
SONCC-ShaR.3.1.2.1		*Install flow measuring devices*				
SONCC-ShaR.3.1.2.2		*Maintain all flow measuring devices*				
SONCC-ShaR.3.1.2.3		*Install head gates and NOAA Fisheries compliant fish exclusion screens on all water diversions in coho salmon habitat*				
SONCC-ShaR.3.1.3	Hydrology	Yes	Improve flow timing or volume	Manage flow	Population wide	BR
SONCC-ShaR.3.1.3.1		*Sustain Watermaster District to ensure all irrigation water diversions are water mastered*				
SONCC-ShaR.3.1.3.2		*Implement water mastering allocations compliant with applicable water law, including place of use restrictions*				
SONCC-ShaR.3.1.4	Hydrology	Yes	Improve flow timing or volume	Increase instream flows	GID Ditch diversion, Dwinnell Dam diversion	2
SONCC-ShaR.3.1.4.1		*Reduce impacts to coho salmon from the GID ditch diversion.*				
SONCC-ShaR.3.1.4.2		*Assess the effects of relocating or redesigning the diversion point to Dwinnell Dam Reservoir to decrease the impacts to coho salmon.*				
SONCC-ShaR.3.1.4.3		*Relocate or redesign the diversion structure to Dwinnell Dam Reservoir guided by assessment results*				
SONCC-ShaR.3.1.5	Hydrology	Yes	Improve flow timing or volume	Improve water management techniques	Population wide	3
SONCC-ShaR.3.1.5.1		*Develop integrated water management plan and water budget, including groundwater surface flow dynamics, and drought year emergency contingencies*				
SONCC-ShaR.3.1.5.2		*Improve water use efficiency through the investigation and implementation of alternative agricultural crops and practices (e.g., grass fed beef, winter wheat, alternative pasture crops)*				
SONCC-ShaR.3.1.5.3		*Upgrade and expand alternative off-channel stock watering systems to increase instream flows*				

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID		***Step Description***				
SONCC-ShaR.3.1.5.4		*Develop and disseminate an on-farm water use efficiency monitoring system*				
SONCC-ShaR.3.1.6	Hydrology	Yes	Improve flow timing or volume	Improve irrigation practices	Population wide	3
SONCC-ShaR.3.1.6.1		*Apply a variety of techniques (e.g., Farm Irrigation Rating Index Model) to make irrigation system water use efficiency comparisons, and implement efficiency improvements*				
SONCC-ShaR.3.1.6.2		*Implement improved irrigation techniques and monitor associated flow and water quality enhancements*				
SONCC-ShaR.3.1.6.3		*Design an irrigation schedule to maximize cold water influence/extension from Clear Springs and other cold water sources*				
SONCC-ShaR.3.1.7	Hydrology	Yes	Improve flow timing or volume	Increase instream flows	Yreka Creek, Little Shasta River, Parks Creek, etc.	3
SONCC-ShaR.3.1.7.1		*Develop plans to detain stormwater runoff, increase infiltration, enhance floodplains, and deliver sub-surface flows*				
SONCC-ShaR.3.1.7.2		*Implement plans that increase groundwater recharge and connectivity*				
SONCC-ShaR.3.1.7.3		*Establish a water trust to sustain and reestablish flow connectivity.*				
SONCC-ShaR.3.1.8	Hydrology	Yes	Improve flow timing or volume	Educate stakeholders	Population wide	3
SONCC-ShaR.3.1.8.1		*Develop an educational program addressing water conservation programs, instream leasing and water dedication programs, and water diversion/screen hardware maintenance extension support information*				
SONCC-ShaR.3.1.9	Hydrology	Yes	Improve flow timing or volume	Improve regulatory mechanisms	Population wide	3
SONCC-ShaR.3.1.9.1		*Prioritize and provide incentives for use of CA Water Code Section 1707*				
SONCC-ShaR.3.1.10	Hydrology	Yes	Improve flow timing or volume	Improve regulatory mechanisms	Population wide	3
SONCC-ShaR.3.1.10.1		*Establish a categorical exemption under CEQA for water leasing*				
SONCC-ShaR.3.1.11	Hydrology	Yes	Improve flow timing or volume	Improve regulatory mechanisms	Population wide	3
SONCC-ShaR.3.1.11.1		*Establish a comprehensive statewide groundwater permit process*				
SONCC-ShaR.10.1.16	Water Quality	Yes	Reduce water temperature, increase disssolved oxygen	Increase flow	Big Springs Lake Dam, Parks Creek, Kettle Springs, Bridge Field Springs Complex, and the upper Shasta River	3
SONCC-ShaR.10.1.16.1		*Implement the flow strategy recommended by McBane and Trush (2011), that allows for the minimum diversion of water needed at Big Springs Lake and other spring complexes.*				

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID	***Step Description***					
SONCC-ShaR.10.1.16.2	*Ensure the protection of an identified minimum cfs flow from cold water springs, including Big Springs Creek at the waterwheel (McBane and Trush 2011).*					
SONCC-ShaR.10.1.17	Water Quality	Yes	Reduce water temperature, increase disssolved oxygen	Increase flow	Emmerson Ranch Properties	3
SONCC-ShaR.10.1.17.1	*Develop emergency action ranch management plan for Emmerson Ranch*					
SONCC-ShaR.10.1.17.2	*Create an irrigation diversion and water use operations manual that conserves as assists recovery of coho salmon*					
SONCC-ShaR.10.1.18	Water Quality	Yes	Reduce water temperature, increase disssolved oxygen	Increase cold water	Big Springs Lake Dam, Parks Creek, Kettle Springs, Bridge Field Springs Complex, Little Shasta River, and the upper Shasta River	3
SONCC-ShaR.10.1.18.1	*Evaluate quantity and quality of refugia habitat*					
SONCC-ShaR.10.1.18.2	*Conduct water rights assessment at spring complexes*					
SONCC-ShaR.10.1.18.3	*Dedicate cold water*					
SONCC-ShaR.10.1.19	Water Quality	Yes	Reduce water temperature, increase disssolved oxygen	Increase cold water	Dwinnell Dam, mainstem Shasta River and its downstream tributaries and springs	3
SONCC-ShaR.10.1.19.1	*Investigate feasibility of changing drawdown location on Dwinnell Dam to maximize cold water and dissolved oxygen*					
SONCC-ShaR.10.1.20	Water Quality	Yes	Reduce water temperature, increase disssolved oxygen	Reduce warm water inputs	Bridge Field Springs Complex, Kettle Springs, Upper Shasta River	3
SONCC-ShaR.10.1.20.1	*Develop a program that identifies, designs, and constructs projects that will reduce warm tailwater input to streams*					
SONCC-ShaR.10.1.20.2	*Implement tailwater reduction program*					
SONCC-ShaR.10.2.21	Water Quality	Yes	Reduce pollutants	Set standard	Population wide	3
SONCC-ShaR.10.2.21.1	*Continue implementation of TMDLs for 303(d) listed water bodies*					
SONCC-ShaR.1.2.48	Estuary	No	Improve estuarine habitat	Improve estuary condition	Klamath River Estuary	3
SONCC-ShaR.1.2.48.1	*Implement recovery actions to address strategy "Estuary" for Lower Klamath River population*					

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID	***Step Description***					
SONCC-ShaR.16.1.33	Fishing/Collecting	No	Manage fisheries consistent with recovery of SONCC coho salmon	Incorporate SONCC coho salmon VSP delisting criteria when formulating salmonid fishery management plans affecting SONCC coho salmon	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	3
SONCC-ShaR.16.1.33.1	*Determine impacts of fisheries management on SONCC coho salmon in terms of VSP parameters*					
SONCC-ShaR.16.1.33.2	*Identify fishing impacts expected to be consistent with recovery*					
SONCC-ShaR.16.1.34	Fishing/Collecting	No	Manage fisheries consistent with recovery of SONCC coho salmon	Limit fishing impacts to levels consistent with recovery	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	2
SONCC-ShaR.16.1.34.1	*Determine actual fishing impacts*					
SONCC-ShaR.16.1.34.2	*If actual fishing impacts exceed levels consistent with recovery, modify management so that levels are consistent with recovery*					
SONCC-ShaR.16.2.35	Fishing/Collecting	No	Manage scientific collection consistent with recovery of SONCC coho salmon	Incorporate SONCC coho salmon VSP delisting criteria when formulating scientific collection authorizations affecting SONCC coho salmon	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	3
SONCC-ShaR.16.2.35.1	*Determine impacts of scientific collection on SONCC coho salmon in terms of VSP parameters*					
SONCC-ShaR.16.2.35.2	*Identify scientific collection impacts expected to be consistent with recovery*					
SONCC-ShaR.16.2.36	Fishing/Collecting	No	Manage scientific collection consistent with recovery of SONCC coho salmon	Limit impacts of scientific collection to levels consistent with recovery	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	3
SONCC-ShaR.16.2.36.1	*Determine actual impacts of scientific collection*					
SONCC-ShaR.16.2.36.2	*If actual scientific collection impacts exceed levels consistent with recovery, modify collection so that impacts are consistent with recovery*					
SONCC-ShaR.2.2.27	Floodplain and Channel Structure	No	Reconnect the channel to the floodplain	Construct off channel ponds, alcoves, backwater habitat, and old stream oxbows	Population wide	2
SONCC-ShaR.2.2.27.1	*Identify potential sites to create refugia habitats. Prioritize sites and determine best means to create rearing habitat*					
SONCC-ShaR.2.2.27.2	*Implement restoration projects that improve off channel habitats as guided by assessment results*					
SONCC-ShaR.2.2.28	Floodplain and Channel Structure	No	Reconnect the channel to the floodplain	Restore natural channel form and function	Population wide	2

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID	***Step Description***					
SONCC-ShaR.2.2.28.1	*Identify and prioritize mining reaches, developing a plan to restore the floodplain and channel by removing tailing piles and reconstructing the channel*					
SONCC-ShaR.2.2.28.2	*Remove tailing piles and reconstruct the channel, guided by the restoration plan*					
SONCC-ShaR.2.2.46	Floodplain and Channel Structure	No	Reconnect the channel to the floodplain	Increase beaver abundance	Population wide	2
SONCC-ShaR.2.2.46.1	*Develop program to educate and provide incentives for landowners to keep beavers on their lands*					
SONCC-ShaR.2.2.46.2	*Implement beaver program (may include reintroduction)*					
SONCC-ShaR.26.1.25	Low Population Dynamics	No	Increase population abundance	Implement an enhancement program	Population wide	3
SONCC-ShaR.26.1.25.1	*Assess impacts and benefits associated with different enhancement programs such as captive broodstock, rescue rearing, supplementation, and conservation hatcheries*					
SONCC-ShaR.26.1.25.2	*Develop a facility to rear fish*					
SONCC-ShaR.26.1.25.3	*Operate enhancement program as a temporary strategy to 26.1*					
SONCC-ShaR.26.1.25.4	*Monitor fish populations at all life stages including juvenile snorkel counts, downstream migrant counts, spawning surveys, and PIT tagging*					
SONCC-ShaR.26.1.26	Low Population Dynamics	No	Increase population abundance	Reduce take of coho salmon	Population wide	2
SONCC-ShaR.26.1.26.1	*Develop an Incidental Take Prohibition program*					
SONCC-ShaR.26.1.26.2	*Implement Incidental Take Prohibition program*					
SONCC-ShaR.27.1.37	Monitor	No	Track population abundance, spatial structure, productivity, or diversity	Estimate abundance	Population wide	3
SONCC-ShaR.27.1.37.1	*Perform annual spawning surveys*					
SONCC-ShaR.27.1.38	Monitor	No	Track population abundance, spatial structure, productivity, or diversity	Track life history diversity	Population wide	3
SONCC-ShaR.27.1.38.1	*Describe annual variation in migration timing, age structure, habitat occupied, and behavior*					
SONCC-ShaR.27.1.38.2	*Develop comprehensive PIT tagging and retrieval project that assesses habitat use and survival*					

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID		***Step Description***				
SONCC-ShaR.27.1.39	Monitor	No	Track population abundance, spatial structure, productivity, or diversity	Track indicators related to the stress 'Fishing and Collecting'	Population wide	2
SONCC-ShaR.27.1.39.1		*Annually estimate the commercial and recreational fisheries bycatch and mortality rate for wild SONCC coho salmon.*				
SONCC-ShaR.27.2.40	Monitor	No	Track habitat condition	Track habitat indicators related to spawning, rearing, and migration	Population wide	3
SONCC-ShaR.27.2.40.1		*Measure indicators for spawning and rearing habitat. Conduct a comprehensive survey*				
SONCC-ShaR.27.2.40.2		*Measure indicators for spawning and rearing habitat once every 10 years, sub-sampling 10% of the original habitat surveyed*				
SONCC-ShaR.27.2.41	Monitor	No	Track habitat condition	Track habitat indicators related to the stress 'Lack of Floodplain and Channel Structure'	All IP habitat	3
SONCC-ShaR.27.2.41.1		*Measure the indicators, pool depth, pool frequency, D50, and LWD*				
SONCC-ShaR.27.2.42	Monitor	No	Track habitat condition	Track habitat indicators related to the stress 'Degraded Riparian Forest Condition'	All IP habitat	3
SONCC-ShaR.27.2.42.1		*Measure the indicators, canopy cover, canopy type, and riparian condition*				
SONCC-ShaR.27.2.43	Monitor	No	Track habitat condition	Track habitat indicators related to the stress 'Impaired Water Quality'	All IP habitat	3
SONCC-ShaR.27.2.43.1		*Measure the indicators, pH, D.O., temperature, and aquatic insects*				
SONCC-ShaR.27.2.44	Monitor	No	Track habitat condition	Track habitat indicators related to the stress 'Impaired Hydrologic Function'	All IP habitat	3
SONCC-ShaR.27.2.44.1		*Annually measure the hydrograph and identify instream flow needs*				
SONCC-ShaR.27.1.47	Monitor	No	Track population abundance, spatial structure, productivity, or diversity	Estimate juvenile spatial distribution	Population wide	3
SONCC-ShaR.27.1.47.1		*Conduct presence/absence surveys for juveniles (3 years on; 3 years off)*				

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID	***Step Description***					
SONCC-ShaR.27.1.49	Monitor	No	Track population abundance, spatial structure, productivity, or diversity	Refine methods for setting population types and targets	Population wide	3
SONCC-ShaR.27.1.49.1	*Develop supplemental or alternate means to set population types and targets*					
SONCC-ShaR.27.1.49.2	*If appropriate, modify population types and targets using revised methodology*					
SONCC-ShaR.5.1.13	Passage	No	Improve access	Reduce sediment barriers	Population wide, including Kettle Springs and Bridgefield Springs Complex	2
SONCC-ShaR.5.1.13.1	*Inventory and prioritize barriers formed by alluvial deposits*					
SONCC-ShaR.5.1.13.2	*Remove alluvial deposits, construct low flow channels, or reduce stream gradient to provide fish passage at all life stages*					
SONCC-ShaR.5.1.14	Passage	No	Improve access	Provide artificial passage	Grenada Irrigation District and other diversions	2
SONCC-ShaR.5.1.14.1	*Design and plan fish passage*					
SONCC-ShaR.5.1.14.2	*Provide fish passage, guided by plan*					
SONCC-ShaR.5.1.15	Passage	No	Improve access	Remove barriers	Greenhorn Dam, Cardoza Diversion, mainstem Shasta River and all tributaries	3
SONCC-ShaR.5.1.15.1	*Identify and prioritize all barriers and diversions, and develop a plan to provide short- and long-term passage*					
SONCC-ShaR.5.1.15.2	*Provide passage for all life stages, guided by plan*					
SONCC-ShaR.7.1.22	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Improve grazing practices	Population wide	2
SONCC-ShaR.7.1.22.1	*Assess grazing impact on sediment delivery and riparian condition, identifying opportunities for improvement*					
SONCC-ShaR.7.1.22.2	*Develop grazing management plans to meet objective*					
SONCC-ShaR.7.1.22.3	*Plant vegetation to stabilize stream bank*					
SONCC-ShaR.7.1.22.4	*Maintain fencing or fence livestock out of riparian zones*					
SONCC-ShaR.7.1.22.5	*Remove livestock watering sources away from riparian areas, including springs*					
SONCC-ShaR.7.1.23	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Improve protection and shading of spring complexes	Population wide	2
SONCC-ShaR.7.1.23.1	*Identify and prioritize locations for planting and thinning*					

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID	***Step Description***					
SONCC-ShaR.7.1.24	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Increase conifer riparian vegetation	Population wide, unvegetated areas	2
SONCC-ShaR.7.1.24.1	*Plant riparian vegetation to increase shade/cover and habitat complexity, guided by prescription*					
SONCC-ShaR.7.1.24.2	*Thin, or release riparian vegetation, guided by prescription*					
SONCC-ShaR.7.1.45	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Reestablish natural fire regime	Population wide, guided by recent assessment priorities (USFS WCF 2011)	3
SONCC-ShaR.7.1.45.1	*Identify areas prone to high intensity fire and develop a plan to reestablish a natural fire regime*					
SONCC-ShaR.7.1.45.2	*Carry out fuel reduction or modification projects such as thinning, prescribed burning, and piling, guided by the plan*					
SONCC-ShaR.8.2.29	Sediment	No	Increase spawning gravel	Enhance spawning substrate	Downstream of Dwinnell Dam, Parks Creek, and other tributary drainages	2
SONCC-ShaR.8.2.29.1	*Review the McBain and Trush (2010) spawning gravel plan that identifies quantity, quality, location, and timing of gravel supplements*					
SONCC-ShaR.8.2.29.2	*Supplement gravel, guided by the McBain and Trush (2010) spawning gravel plan for the Shasta River*					
SONCC-ShaR.8.1.30	Sediment	No	Reduce delivery of sediment to streams	Minimize mass wasting	Population wide	3
SONCC-ShaR.8.1.30.1	*Assess and map mass wasting hazards, prioritize treatment of sites most susceptible to mass wasting, and determine appropriate actions to deter mass wasting*					
SONCC-ShaR.8.1.30.2	*Implement plan to stabilize slopes and revegetate exposed areas including agricultural lands*					
SONCC-ShaR.8.1.31	Sediment	No	Reduce delivery of sediment to streams	Reduce road-stream hydrologic connection	Population wide, including both upslope and valley floor roads	3
SONCC-ShaR.8.1.31.1	*Assess and prioritize road-stream connection, and identify appropriate treatment to meet objective*					
SONCC-ShaR.8.1.31.2	*Decommission roads, guided by assessment*					
SONCC-ShaR.8.1.31.3	*Upgrade roads, guided by assessment*					
SONCC-ShaR.8.1.31.4	*Maintain roads, guided by assessment*					
SONCC-ShaR.10.1.12	Water Quality	No	Reduce water temperature, increase disssolved oxygen	Improve quality of water released from Dwinnell Reservoir	Dwinnell Dam	3
SONCC-ShaR.10.1.12.1	*Develop plan that includes range of alternatives to improve quality of water released from Dwinnell Reservoir to upper Shasta River*					
SONCC-ShaR.10.1.12.2	*Implement water quality improvement plan*					