19. Redwood Creek Population

Central Coastal Stratum

Core, Functionally Independent Population

High Extinction Risk

Population likely below depensation threshold

4,900 Spawners Required for ESU Viability

293 mi^2 watershed (41% Federal ownership)

151 IP-km (94 IP-mi) (38% High)

Dominant Land Uses are Timber Harvest and Agriculture

Key Limiting Stresses are 'Lack of Floodplain and Channel Structure' and 'Impaired Estuarine/Mainstem Function'

Key Limiting Threats are 'Channelization/Diking' and 'Roads'

Highest Priority Recovery Actions

• Address design deficiencies of the Redwood Creek Flood Control Project and improve estuarine, transition zone, and lower river habitat while providing flood protection for public safety and property • Increase riparian vegetation in lower Redwood Creek • Remove structural barriers in Strawberry Creek	• Increase large woody debris (LWD), boulders and other instream structure • Increase cool water and thermal refugia in the mainstem and tributaries • Reconnect floodplains, wetlands, and off channel habitat

19.1 Habitat and Land Use Changes in Redwood Creek

Timber harvest, road building, and the construction of flood control levees are the land uses that have had the most pronounced effect on coho salmon habitat in the Redwood Creek basin. Much of the upper and middle portions of the basin are owned by private timber companies and are used for timber production. In addition, livestock grazing occurs on some private lands, both in the middle and upper portions of the basin and in the lower basin, where flood control levees protect the town of Orick and grazing lands. Much of the lower basin is public parkland, managed for protection and restoration of the old-growth redwood forest ecosystem. However, much of the parkland was heavily logged and roaded prior to National Park Service ownership. The largest community in the basin, Orick, is located near the mouth of Redwood Creek. In this valley bottom, 3.4 miles of flood control levees were constructed in 1968 to protect the Orick community and surrounding farm/ranch lands from a 200-year flood event. While providing flood protection for the community, the levees reduced coho salmon habitat by confining Redwood Creek to a 250-foot wide channel and bisecting the estuary.

These past land uses, especially when combined with large floods, have resulted in impacts that have interacted to reduce available aquatic habitat throughout the basin. Increased sediment production from logged hillslopes and roads, especially during the 1955 and 1964 flood events, have choked Redwood Creek with sediment. However, much of the excess sediment deposited in the upper and middle basin in 1964 has since been flushed out of the upper reaches of Redwood Creek and most of the instream excess sediment is now found in the downstream-most reach of Redwood Creek (downstream of Elam Creek) (Madej and Ozaki 2009).

The loss of riparian vegetation has reduced shading, increased stream temperature, and created a lack of instream large wood.

These land uses have resulted in warm, shallow and wide instream habitat conditions that have severely impacted coho salmon and their habitat (Cannata et al. 2006). Most of the basin is now composed of forest stands of smaller diameter trees, with a greater percentage of hardwoods that provide different ecological functions than those found historically. Fortunately, some remaining late seral conifer stands are found within RNSP, particularly within the lower mainstem corridor of Redwood Creek and the Prairie Creek watershed. Redwood Creek is currently listed as both sediment and temperature impaired under the Clean Water Act (Section 303(d)) and three out of the four salmonid species found in the basin are federally listed as threatened under the Endangered Species Act.

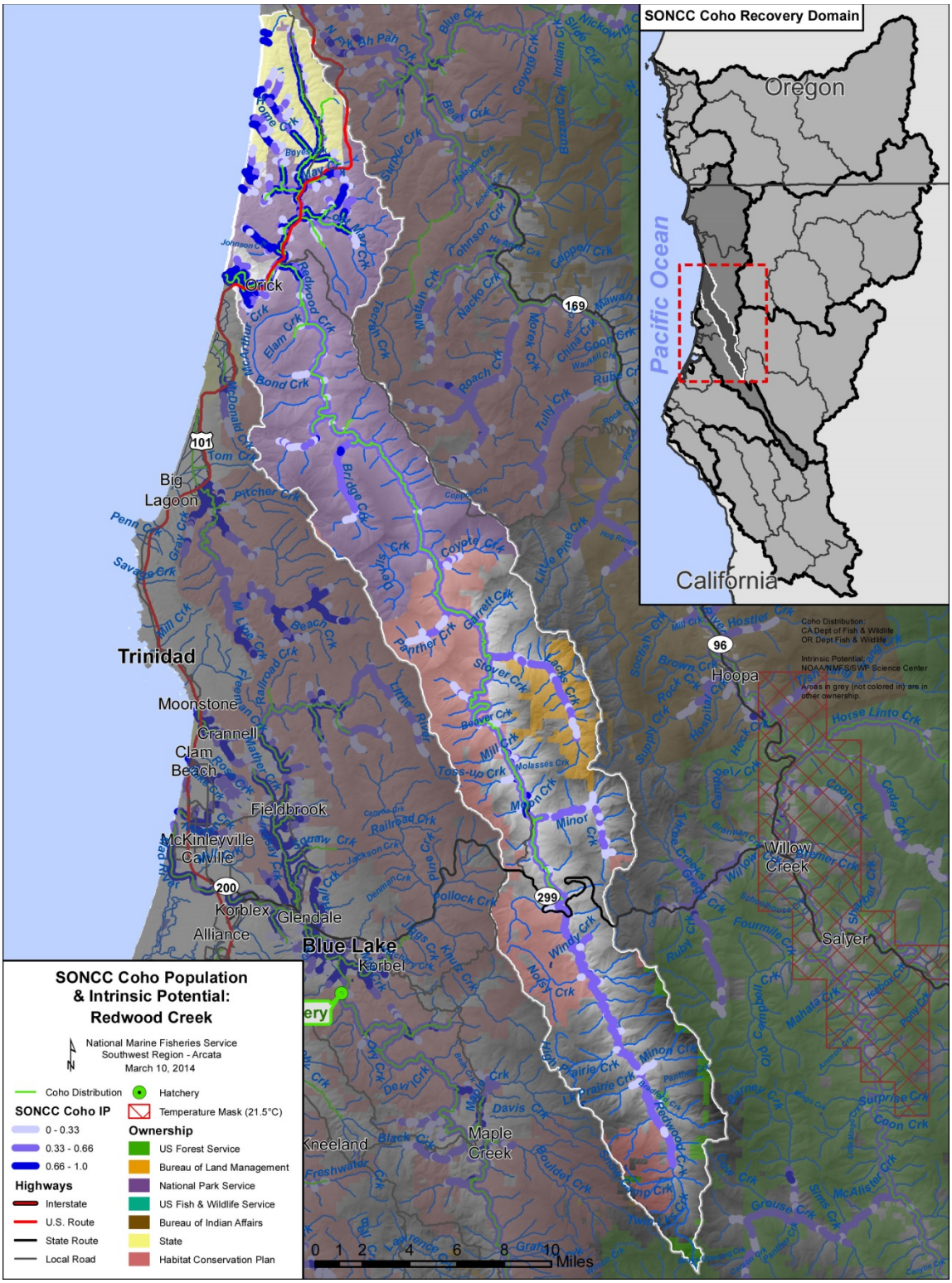

Figure 19-1. The geographic boundaries of the Redwood Creek coho salmon population. Figure shows modeled Intrinsic Potential of habitat (Williams et al. 2006), land ownership, coho salmon distribution (CDFG 2012a), and location within the Southern-Oregon/Northern California Coast Coho Salmon ESU and the Northern Coastal diversity stratum (Williams et al. 2006). Grey areas indicate private ownership.

The construction of flood control levees along the most downstream 3.4 miles of Redwood Creek has resulted in loss of estuarine area and habitat value (Cannata et al. 2006). In addition, gravel and riparian vegetation continue to be removed to maintain flood conveyance capacity.

Figure 19-2. Aerial photograph of the Redwood Creek estuary, before levees. This photo, taken in September 1948, prior to the construction of the levees, shows the size of the estuary and amount of riparian vegetation. Note that this photo is not prior to other land use impacts, such as timber harvest. Photo from Klamath River Information System (KRIS).

Figure 19-3. Aerial photograph of the Redwood Creek estuary, with levees. Photo shows the levees and continued gravel and vegetation removal for channel maintenance; note the much-reduced estuary size and reduction in habitat complexity. Redwood Creek estuary in 1988 from KRIS.

19.2 Historic Fish Distribution and Abundance

Aside from the data described in the assessment of population viability detailed further in this section and the IP data shown in Table 19-1, there is limited data that describe the historical coho salmon population in Redwood Creek. Potential coho salmon habitat is distributed throughout the basin. The IP model shows the highest values (IP > 0.66) in Prairie Creek and its tributaries, including Lost Man Creek, and in the most downstream 4 miles of mainstem Redwood Creek, including Strawberry Creek and Sand Cache Creek. The Prairie Creek watershed is almost all park lands managed by RNSP. The downstream 4 miles of Redwood Creek is mostly private land. Table 19-1 shows the areas with high IP. In addition, it is notable that almost the entire length of mainstem Redwood Creek is modeled as having moderate IP (IP between 0.33 and 0.66).

Table 19-1. Mainstem reaches and tributaries with high IP reaches (IP > 0.66) (Williams et al. 2006).

Stream Name	Stream Name	Stream Name
Prairie Creek	Larry Dam Creek	Boyes Creek
Lost Man Creek	All of the unnamed tributaries to Prairie Creek	Brown Creek
Little Lost Man Creek	Middle Mainstem Redwood Creek, near Toss-up Creek	Lower Mainstem Redwood Creek
North Fork and South Fork Lost Man creeks	Godwood Creek	Sand Cache Creek
Streelow Creek	Tom McDonald Creek	Strawberry Creek
Skunk Cabbage Creek	Bridge Creek	
May Creek	McArthur Creek	

Coho salmon have been detected in lower and middle mainstem Redwood Creek, as well as Prairie, Lost Man, Little Lost Man, Streelow, Strawberry, Lacks, Elam, Tom McDonald, Emerald (a.k.a. Harry Weir), McArthur, and Bridge creeks. The historic range includes Coyote, Panther, Minor, Karen (also known as Dolly Varden) and Pilchuck creeks in the Beaver Creek HSA, as well as Sand Cache Creek, tributary to the estuary. Summer dive surveys were conducted in middle mainstem Redwood Creek from 1993 to 1998, and again during 2008 (Weseloh 1996, 2008). These surveys documented juvenile coho salmon rearing in middle mainstem Redwood Creek from Chezem Road Bridge downstream to Stover Creek, although at low densities. Various investigators have found that coho salmon may also use some of the tributaries in the Lake Prairie HSA [Anderson 1988, Brown 1988, Neillands 1990, Pacific Coast Fish, Wildlife and Wetlands Restoration Association 1995, California Department of Fish and Game (CDFG) 2001 surveys, and RNSP unpublished data]. Redwood National and State Parks [RNSP] (2001) described historic presence of coho salmon juveniles and spawning adults in middle and upper mainstem Redwood Creek, including upstream of Highway 299.

Historic estimates of coho salmon abundance in Redwood Creek are scarce. In 1965, CDFG estimated an average run size of 5,000 Chinook salmon, 2,000 coho salmon and 10,000 winter steelhead (CDFG 1965 in Good et al. 2005) for the entire Redwood Creek basin. However, the CDFG report (1965) based the abundance estimates for Redwood Creek on numbers derived from the Eel River, and thus cannot be considered a reliable estimate for Redwood Creek. In addition, the CDFG report (1965) did not include a time period for the estimates of run size. Hallock et al. (1952) seined 9,610 juvenile coho salmon from Prairie Creek and its tributaries in 1951; however, this information does not include seining information from mainstem Redwood Creek and its other tributaries.

19.3 Status of Redwood Creek Coho Salmon

Spatial Structure and Diversity

Currently, except for Prairie Creek, coho salmon have limited distribution in the Redwood Creek basin, most likely due to habitat degradation and high water temperatures in mainstem Redwood Creek (Madej et al. 2006). Although much of the basin is accessible to adult and juvenile coho salmon, high summer water temperatures in the middle portion of mainstem Redwood Creek are believed to limit most of the current juvenile distribution to lower Redwood Creek and its tributaries, and to the Prairie Creek sub-watershed, where summer water temperatures are cooler than in the middle and upper portions of mainstem Redwood Creek (Madej et al. 2006). High summer water temperatures are likely to continue until streamside conifers mature and provide shade that helps to regulate summer water temperatures, and until the mainstem channel condition improves and channel complexity increases so that deep pools could be used as thermal refugia for coho salmon.

During the summer of 2003, RNSP conducted a juvenile coho salmon presence-absence snorkel survey of the lower half of mainstem Redwood Creek. During this survey, no coho salmon were observed in the main channel above river mile 13. A small number of juvenile coho salmon were observed in 9 locations in the section of Redwood Creek between river mile 4.8 and river mile 13 (Ozaki and Anderson 2005).

Additional distribution information is available from Sparkman (2008a, 2008b) who trapped 6 age 0+ coho salmon in mainstem Redwood Creek at river mile 33 in 2007. In addition, Sparkman (2010) trapped 32 age 0+ coho salmon and 7 age 1+ coho salmon at river mile 33 in 2008; the first year in 9 consecutive years of outmigrant trapping in which age 1+ coho salmon were caught in the middle portion of mainstem Redwood Creek. Research is currently ongoing in the Redwood Creek basin to investigate adult abundance and distribution of salmonids, using redds as the population metric. Based on preliminary investigations and professional judgment, coho salmon juveniles and adults are currently present in McArthur, Elam and Bridge creeks, all tributaries to lower to middle mainstem Redwood Creek (Ricker, S., pers. comm. 2011a). Bridge Creek in particular likely contains high quality coho salmon spawning habitat, although the quantity and quality of winter rearing habitat appears limited. Available information suggests limited distribution, particularly in the middle to upper portions of mainstem Redwood, indicating that that the current spatial structure is impaired compared to historic conditions.

Williams et al. (2008) determined that at least 32 coho salmon per-IP-km of habitat are needed (4,900 spawners total) to approximate the historical distribution of Redwood Creek coho salmon and habitat. Although the estimate of historical adult abundance from Williams et al. (2008) includes Redwood Creek and Prairie Creek, the current distribution of spawning adults appears mostly limited to the Prairie Creek sub-watershed. In addition, recent juvenile outmigrant data from Sparkman (2008a, 2008b) suggests that few adult coho salmon are returning to mainstem Redwood Creek each year to spawn.

Regarding life history diversity traits, Redwood Creek is one of the few places in California with documented variation in the period of freshwater juvenile coho salmon rearing. Coho salmon have been generally thought to rear for one year in northern California streams; a two-year

rearing period had only been observed farther north (Bell and Duffy 2007). However, Bell and Duffy (2007) observed that 28 percent of outmigrants from Prairie Creek reared in freshwater for two years. This variation in the length of the freshwater rearing period could be critical to coho salmon persistence in Redwood Creek, because it bolsters the population's resilience to environmental disturbance. The more diverse life history traits are expressed (or the more these traits are not restricted), the more diverse a population is, and the more likely that individuals, and therefore the species, would survive and reproduce in the face of environmental variation (McElhany et al. 2000). Bell and Duffy (2007) also found that the size of age 2 smolts from Prairie Creek was not as large as age 1 smolts from other healthy systems (Shapovalov and Taft 1954 *in* Bell and Duffy 2007), indicating that age 2 smolts from Prairie Creek would not mature precociously and return as jacks at any higher rate than age 1 smolts from Prairie Creek.

Population Size and Productivity

Williams et al. (2008) determined at least 151 coho salmon must spawn in the Redwood Creek basin each year to avoid effects of extremely low population size.

The CDFG has trapped outmigrants in mainstem Redwood Creek to provide information on the current viability of salmonid populations in the basin. Sparkman (2011a) has conducted outmigrant trapping in middle Redwood Creek since 2000, with the trap located at river mile 33 (known as the "upper trap"). Since 2004, Sparkman (2011b) has also conducted outmigrant trapping at river mile 4 (known as the "lower trap"), just upstream of where Prairie Creek enters mainstem Redwood Creek. From 2000 to 2006, Sparkman (2007) did not capture any out-migrating coho salmon at the upper trap, suggesting that coho salmon spawning in mainstem Redwood Creek and tributaries upstream of Prairie Creek may have had limited success for about 7 years. However, 6 age 0+ juveniles were captured at the upper trap in 2007 (Sparkman 2008a, 2008b), and 32 age 0+ and 7 age 1+ juveniles were caught at the upper trap in 2008 (Sparkman 2011b).

Low numbers of juvenile coho salmon have been captured at the lower trap during all of the study years. For example, in 2003, 110 age 0+ and 12 age-1+ were captured at the lower trap, in 2004, 202 age 0+ and 69 age-1+ juvenile coho salmon were captured at the lower trap (Sparkman 2004), and in 2010, 6 age 0+ coho salmon and 13 age 1+ coho salmon were captured at the lower trap (Sparkman 2011b). During 2011, Sparkman captured 226 age 0+ coho salmon and 24 age 1+ coho salmon at the lower trap and no coho salmon at the upper trap. Sparkman estimated juvenile population abundances for mainstem Redwood Creek (not including Prairie Creek) of 884 age 0+ coho salmon and 113 age 1+ coho salmon (Sparkman 2011c).

Sparkman (2011c) also began trapping out-migrants from Prairie Creek during 2011 and captured 198 age 0+ coho salmon and 2,449 age 1+ coho salmon at the Prairie Creek trap located at the mouth of Prairie Creek, just upstream from its confluence with Redwood Creek. For 2011, Sparkman estimated juvenile population abundances for Prairie Creek of 726 age 0+ coho salmon and 8,446 age 1+ coho salmon.

Additionally, Duffy (2011) has monitored juvenile and adult coho salmon populations and estimated juvenile and adult abundance in the Prairie Creek sub-watershed since 1998. Duffy

(2011) estimated juvenile abundance using a modified Hankin and Reeves (1988) approach as summarized in Table 19-2.

Using walking surveys to enumerate live fish, redd surveys and carcass mark-recapture studies, Duffy (2011) has also estimated escapement of adult coho salmon to Prairie Creek from 1999 to 2010. These estimates indicate mostly low to occasionally moderate numbers of returning adult coho salmon (Duffy 2011). Numbers of live fish ranged from 680 in 2001-2002 to 28 in 2009-2010 (Table 19-3; Duffy 2011) for the Prairie Creek sub-watershed. Other tributaries to mainstem Redwood Creek contain adult coho salmon (Ricker, S., pers. comm. 2011b) but at unknown abundance levels. Williams et al. (2008) estimated that the historic annual spawner abundance for the entire Redwood Creek population unit was about 4,900. All of the available information suggests that the overall number of coho salmon in the Redwood Creek basin is low compared to modeled historic abundance.

Table 19-2. Estimated abundance of juvenile coho salmon in the Prairie Creek sub-watershed of Redwood Creek (Duffy 2011).

		Pools		**Runs**		**Riffles**		**Total**	
Year	*Month*	*Avg*	*95% CI*	*Avg*	*95% CI*	*Avg*	*95% CI*	*Avg*	*95% CI*
1998	Oct	5080	75	1047	11	0	0	6127	67
1999	Aug	4256	63	1645	23	1229	240	7130	303
1999	Oct	5123	949	1703	27	537	95	7363	850
2000	Aug	2741	138	1733	17	20	0	4494	109
2000	Oct	2622	432	1443	21	22	0	4086	324
2001	Aug	1875	56	728	4	14	0	2617	40
2001	Oct	1588	83	805	8	0	0	2393	62
2002	Aug	4243	886	2919	17	1025	50	8187	657
2002	Oct	4500	2519	2764	32	465	63	7729	1826
2003	Aug	4481	435	2484	24	1699	801	8664	1126
2003	Oct	3709	81	2722	24	686	70	7117	144
2004	Aug	3134	260	1972	24	261	12	5367	231
2005	Aug	1460	93	1391	39	303	30	3154	122
2006	Aug	3870	84	2176	675	701	27	6747	578
2007	Aug	2950	77	1627	72	64	2	4641	107
2008	Aug	3276	217	1698	117	61	1	5035	242
2009	Aug	2465	80	1011	15	565	79	4041	148
2010	Aug	3102	112	1466	17	549	60	5117	153

Table 19-3. Escapement of adult coho salmon to the Prairie Creek sub-watershed during 1999-2011. Estimates are derived from AUC analysis of live fish observations. Year listed is the latter portion of the spawning season (e.g. 1999 = 1998/1999) (Duffy 2011).

Coho Salmon Estimated Adult Abundance		
Year	n	95% CI
1999	56	3.4
2000	84	6.7
2001	212	6.0
2002	680	19.4
2003	542	46.1
2004	268	12.4
2005	643	40.6
2006	349	27.6
2007	165	8.5
2008	466	44.5
2009	127	25.8
2010	28	4.1
2011	218	22.0

Monitoring data and population estimates from Sparkman (2008a, 2008b, 2011a, 2011b, 2011c) and Duffy (2010, 2011) show a negative population trend, as do the apparent long-term declines of coho salmon observed in Redwood Creek. Therefore, the Redwood Creek coho salmon population is at high risk of extinction given its small population size and likely negative trends in numbers of juveniles and adults.

Extinction Risk

The Redwood Creek population is at high risk of extinction because the ratio of the three consecutive years of lowest abundance within the last twelve years to the amount of IP-km in a watershed is less than one, the criterion described by Williams et al. (2008). NMFS' determination of population extinction risk is based on the viability criteria provided by Williams et al. 2008 (Table 3, pg. 17). These viability criteria reflect population size and rate of decline. As Williams et al. (2008) provided no viability criteria for assessing moderate and high risk based on spatial structure and diversity, spatial structure and diversity were not considered in NMFS' determination of population extinction risk.

Role in SONCC Coho Salmon ESU Viability

The Redwood Creek population is a core, Functionally Independent population within the Central Coastal diversity stratum; historically having had a high likelihood of persisting in isolation over 100-year time scales, and with population dynamics or extinction risk over a 100-year time period that are not substantially altered by exchanges of individuals with other populations (Williams et al. 2006). To contribute to stratum and ESU viability, the Redwood Creek core population needs to have at least 4,900 spawners. Sufficient spawner densities are needed to maintain connectivity and diversity within the stratum and continue to represent critical components of the evolutionary legacy of the ESU. Besides its role in achieving demographic goals and objectives for recovery, as a core population the Redwood Creek

population may serve as a source of spawner strays for nearby coastal populations. At present, the capacity of the Redwood Creek coho salmon population to provide recruits to adjacent independent populations is limited due to its low spawner abundance. Conversely, recruits straying from nearby rivers may enhance recovery of the Redwood Creek population.

19.4 Plans and Assessments

State of California

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

The Recovery Strategy for California Coho Salmon was adopted by the California Fish & Game Commission in February 2004. Redwood Creek is described as having periodic high temperatures in the estuary, elevated water temperatures in the mainstem and tributaries, reduction in habitat diversity by channel aggradation and lack of LWD, and high levels of fine sediment and turbidity. Additionally, there is a partial barrier located on Lost Man Creek which was associated with the former Prairie Creek Hatchery.

Redwood Creek Total Maximum Daily Load (TMDL)
http://www.swrcb.ca.gov/northcoast/

NCRWQCB identified Redwood Creek as water quality limited due to its high sediment loads, and designated the basin as a high priority for Total Maximum Daily Load (TMDL) development in accordance with Section 303(d) of the Clean Water Act. The Environmental Protection Agency and the NCRWQCB worked together to complete the sediment TMDL in 1998.

The North Coast Watershed Assessment Program (NCWAP)
http://coastalwatersheds.ca.gov

The NCWAPs Redwood Creek Basin Assessment (Cannata et al. 2006) identified limiting factors for anadromous salmonids including:

- Large reduction in area and habitat quality of the estuary/lagoon;
- Excessive sediment in stream channels, and excessive sediment delivery;
- Lack of large conifer contributions and lack of LWD in stream channels;
- High summer water temperatures; and
- General lack of structural components to create habitat diversity.

Redwood Creek Watershed Group

The Redwood Creek Integrated Watershed Strategy
http://co.humboldt.ca.us/planning/Prop 50/01_RWC_IWS%20Final.pdf

The watershed strategy integrates natural resource considerations with infrastructure needs at the basin scale. The strategy identified restoration of Strawberry Creek, wastewater treatment planning for the community of Orick and sediment source reductions as priority projects.

Redwood National and State Parks

Watershed Rehabilitation Plan (1981)

Management Alternatives of the Redwood Creek Estuary (1983)

Redwood National and State Parks, Humboldt and Del Norte Counties: Final General Management Plan/General Plan, environmental impact statement/environmental impact report - USDI National Park Service and California Department of Parks and Recreation (1999)

Road Strategy: Access and Treatment Priorities for Parkland in the Redwood Creek Watershed (2005)

Planning and strategy documents from RNSP focus on ecosystem restoration, especially road removal and forest restoration efforts. Between 1978 and 2010, the NPS removed 266 miles of roads from Park lands, with 114 miles of road remaining to be treated.

Bureau of Land Management, Arcata Field Office

Lacks Creek Management Area Management Plan

The plan identifies road upgrading and decommissioning opportunities within the Lacks Creek sub-watershed.

Green Diamond Resource Company (GDRC)

Green Diamond Habitat Conservation Plan (HCP)

The GDRC HCP (GDRC 2006) contains measures that will aid in conservation of aquatic species in the Redwood Creek basin. Approximately 25 percent of private land in the middle to upper portions of Redwood Creek basin is owned by GDRC, and managed according to the provisions of their HCP. The HCP has a number of provisions designed to protect coho salmon and salmon habitat on GDRC land. The plan was developed in accordance with section 10(a)(1)(B) of the ESA and contains a conservation strategy to minimize and mitigate the potential adverse effects of any authorized take of aquatic species that may occur incidental to GDRC's activities. The authorized take and its probable impacts will not appreciably reduce the likelihood of survival and recovery in the wild of aquatic species. Elements of the HCP are expected to contribute to efforts to reduce the need to list currently unlisted species in the future under the ESA by providing early conservation benefits to those species. More information about the GDRC HCP can be found in Section 3.2.5.

19.5 Stresses

Table 19-4. Severity of stresses affecting each life stage of coho salmon in Redwood Creek. Stress rank categories, assessment methods, and data used to assess stresses are described in Appendix B.

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

[1] Key limiting stresses and limited life stage.

Key Limiting Stresses, Life Stage, and Habitat

The key limiting stresses for this population are impaired estuarine function and lack of floodplain and channel structure as they have the greatest impact on population productivity. The juvenile life stage is the most limited and high quality winter and summer rearing habitat is lacking for the population. Except for the valuable habitat that the relatively undisturbed Prairie Creek sub-watershed provides (Cannata et. al. 2006), the majority of summer and winter rearing habitat within the basin is in a currently degraded state. Many of the important, high IP tributaries have legacy timber harvest effects, such as large quantities of sediment deposited within stream channels, lack of channel structure and lack of well-distributed large wood, which adversely affect both summer and winter rearing conditions. In mainstem Redwood Creek, high summer water temperatures, increased sediment supply, lack of channel structure, and a lower river and estuary that is disconnected from off-channel floodplain and slough habitat also combine to adversely affect summer and winter rearing habitat.

Lack of Floodplain and Channel Structure

Lack of floodplain and channel structure is a very high stress across all life stages. In general, the Prairie Creek sub-watershed contains the best habitat conditions, while the mainstem

Redwood Creek and its other tributaries contain the poorest habitat conditions. The mainstem channel is aggraded, and pool frequency and depth are ranked as poor throughout the mainstem (Cannata et al. 2006). Data on instream wood is limited; however given the poor riparian canopy conditions that exist throughout the mainstem, and based on discussions with RNSP, a lack of instream wood structure is limiting the development of complex habitat throughout much of the basin. The most downstream 3.4 miles of Redwood Creek is disconnected from its floodplain and confined to a channel width of 250 feet by flood control levees, resulting in a lower river channel and estuary that is disconnected from sloughs, wetlands and other low gradient tributaries that once provided important over-wintering rearing habitat. In addition, the lower river channel contains few pools and riffles and generally lacks complexity and structure that is important for rearing juvenile coho salmon.

Impaired Estuary/Mainstem Function

Impaired estuarine function is rated as a high stress for fry and adults, and a very high stress for juveniles and smolts. Prior to the construction of 3.4 miles of flood control levees in 1968, the Redwood Creek estuary was characterized by its size, depth, and complexity, with connected slough channels and estuarine tributaries. The flood control levees cut-off the last meander of Redwood Creek, now known as the south slough, and its tributary, Strawberry Creek. Currently, the estuary covers approximately half of its historic area (Janda et al. 1975). The levees bisect and terminate in the estuary and the estuary is disconnected from much of its historic off-channel rearing habitat. Water quality, water circulation, riparian vegetation, and pool and riffle habitat have all been greatly reduced (Anderson 1995, Cannata et al. 2006). Since the levees created a smaller estuary than what was historically present with less area for coastal processes such as waves and tides to sustain an open estuary, the timing of the closing of the mouth has also changed resulting in a closed lagoon for a longer period of time, which aggravates poor water quality conditions, and can affect juvenile fish passage in the summer and adult fish passage in the fall. The reduction in function of the estuarine system and lower river habitat, which once provided connected sloughs and tributaries for off-channel rearing, is a limiting factor to salmonid production in the basin. Reconfiguration of the levees (i.e., combination of levee setback and/or removal) to restore estuarine and lower river function is critical to recovery of the Redwood Creek coho salmon population (CDFG 2004b).

Impaired Water Quality

Impaired water quality is a very high stress for the fry, juvenile and smolt life stages and a high stress for adults. This stress ranks the severity of water quality issues, except for turbidity and suspended sediment, which are ranked under the altered sediment supply stress. High water temperature in the summer and early fall months stress rearing coho salmon. Redwood Creek is listed as temperature impaired under section 303(d) of the Clean Water Act. High water temperature in mainstem Redwood Creek, including the estuary, is one of the factors limiting coho salmon production in the basin (Sparkman 2006, Cannata et al. 2006). Madej et al. (2006) demonstrated that high summer water temperatures in mainstem Redwood Creek currently limits juvenile coho salmon distribution in the basin and hypothesized that this restriction did not exist historically. Sparkman (2006, 2009) has shown that in some years summer water temperatures are in the lethal range for juvenile coho salmon in the middle section of mainstem Redwood Creek.

Madej et al. (2006) reports that the greatest thermal complexity occurs in lower Redwood Creek upstream of the leveed reach. In this reach, Madej et al. (2006) measured with thermal infrared imaging many cool springs, seeps, side channels and tributaries, and where the water temperatures are influenced by the cooler coastal climate. During the 2003 presence-absence juvenile coho salmon survey (Ozaki and Anderson 2005), 7 of the 9 locations where coho salmon were observed were side pool locations (no coho salmon juveniles were observed upstream of river mile 13). Side pools were separated from the main channel by a gravel bar, but open to Redwood Creek on the downstream end. Many of the pools were influenced by cool seeps and springs, intragravel water flow, groundwater or small tributaries. These pool features were generally cooler than the mainstem of Redwood Creek (Madej et al. 2006). Water quality may also be impaired by pesticides, herbicides and fertilizers, particularly in the middle portion of the basin downstream of Redwood Valley, but the magnitude of this issue in Redwood Creek is currently unknown.

Degraded Riparian Forest Conditions

Degraded riparian forest conditions exist across the basin, and present a high stress to the fry, juvenile, and smolt life stages. Data from RNSP (2006) and the Green Diamond Aquatic Habitat Conservation Plan (GDRC 2006) show that streamside canopy cover conditions vary, with some good to very good conditions (70 percent to 100 percent shade) in tributaries, and poor cover and shade conditions in the mainstem channel of Redwood Creek. However, even where streamside canopy cover is in good condition, many of the riparian areas currently consist of open hardwood, and second-growth dominated forests. Hardwood and small conifer dominated riparian forests provide smaller or short-term large wood recruitment into Redwood Creek compared to historic conditions of large wood supply to the channel from once prevalent old-growth redwood forests. However, while hardwood dominated riparian forests may not contribute as valuable large wood recruitment to stream channels, hardwood riparian forests provide allochthonous contributions, a valuable source of food for salmonids. Hardwood and second growth conifers also provide shade to the stream channel.

Altered Sediment Supply

Altered sediment supply constitutes a high to very high stress across all life stages. Increased sediment delivery has aggraded and widened channels, filled pools and has simplified stream habitat throughout the basin, particularly within mainstem Redwood Creek and its low gradient tributaries. Based on channel surveys, much of this deposited sediment has now moved downstream out of the upper portions of Redwood Creek and has re-deposited in lower Redwood Creek (Madej and Ozaki 2009). Many tributary mouths also had accumulations of sediment that limited access for juveniles and adults (Anderson and Brown 1982), but based on field observations by RNSP, these accumulations or deltas are currently absent or diminished in size. Data from the Prairie Creek watershed suggests that sediment supply may be less of an issue there; for example, measurements suggest that some pools have less fine sediment accumulation than pools in other parts of the basin. However, most data collected on the sediment regime (e.g., high embeddedness) indicate that both stored sediment within the channels, and continued sediment delivery, are critical stresses affecting the population.

High turbidity levels in Redwood Creek are believed to occur more frequently and persist longer than historically (Cannata et al. 2006). RNSP has been measuring turbidity levels in Lost Man Creek at numerous locations since 2002, and has found elevated turbidity from legacy road and stream crossing sediment sources and from first and second year adjustments of recently implemented road removal projects (Klein et al. 2006). In addition, contemporary timber harvest results in elevated turbidity and suspended sediment, particularly with high rates of harvest (Klein et al. 2012). Effects to coho salmon from elevated turbidity include an impaired ability to find food, gill abrasion, food assemblage changes, smothering of eggs and filling of pools with fine sediment.

Increased Disease/Predation/Competition

Increased disease/predation/competition is a medium stress for fry, juvenile, and smolt life stages. Coho salmon are most susceptible to predation in areas that lack cover and channel structure, such as the estuary, particularly when the bar has closed in the summer. Typically, coho have outmigrated prior to the bar closing, however coho using alternative life history strategies may rear in the estuary or outmigrate as smolts later in the season. Because the estuary lacks complexity such as large wood, tidal channels, off channel ponds, or access to the floodplain, coho are vulnerable to predation from birds and possibly larger salmonids. Additionally, the invasive New Zealand mud snail has been documented in the Redwood Creek estuary and lower river (Benson 2011). Since being documented, the population of NZ mud snails has significantly increased and increased their range to the Highway 101 Bridge. New Zealand mud snail colonies disrupt the base of the food chain by consuming algae and competing with native macroinvertebrates (Kerans et al. 2005). A population decline of macroinvertebrates may result from the invasion of New Zealand mud snails, which may in turn reduce the abundance of preferred prey available to coho rearing in the estuary. Further research on *P. antipodarum* is needed to assess the effects of New Zealand mud snails on coho salmon.

Altered Hydrologic Function

Altered hydrologic function is a medium stress for egg, fry, and adult life stages. Low summer stream flows are problematic where increased stored sediment has aggraded the channel, contributed to subsurface flows, and reduced the amount of available rearing habitat. Summer low flows have decreased in Redwood Creek since the 1970s (Madej 2011). This may be due to more water going subsurface in aggraded stream reaches, the re-growth of conifers that use more groundwater, and water diversions.

Reduced hydrologic function (i.e., poor water circulation, changes in the timing of the mouth closing off, low dissolved oxygen) due to the flood control levees also contributes to a significant reduction in available rearing habitat in the lower most 3.4 miles of Redwood Creek. Low fall stream flows can impede adult migrations and low summer stream flows may be aggravated by authorized and unauthorized water diversions, affecting the availability of summer rearing habitat. The high road density in the basin may also be affecting hydrologic function by increasing peak discharges. Another factor in hydrologic function may be the conversion of extensive areas from conifer-dominated to dense hardwood forests (e.g., tan oak). This vegetation change may have influences on summer low flows; however, we are unaware of any studies examining this in Redwood Creek.

Adverse Fishery- and Collection-Related Effects

Based on estimates of the fishing exploitation rate, as well as the status of the population relative to depensation and the status of NMFS approval for any scientific collection (Appendix B), these activities pose a low stress to juveniles, smolts, and adults.

Barriers

Physical road and stream crossing barriers are a low stress for all life stages except eggs, which do not require access to other portions of the stream network. RNSP has documented road-related barriers or partial barriers within the park, and is in the process of upgrading or removing these culverts and replacing them with bridges, such as the recently completed opening of access in Streelow Creek and the North Fork of Lost Man Creek. The levees also act as barriers, the south levee allows only partial access to Strawberry Creek and the north levee aggravates sand accumulation at the mouth of the north slough, impeding passage into the slough and Sand Cache Creek (Anderson 1995). Invasive reed canary grass also hampers access in Strawberry and Sand Cache Creeks by choking the stream channel with non-native vegetation. Reed canary grass is currently being removed from Strawberry Creek and native riparian vegetation is being planted that will eventually provide shaded conditions that hamper reed canary grass re-growth. In addition, unnaturally large log jams caused by historic timber harvest practices in tributaries such as Bridge and Lost Man creeks impede coho salmon passage (RNSP 2006, Ricker, S., pers. comm. 2011a).

Adverse Hatchery Related Effects

The Prairie Creek Fish Hatchery produced coho salmon that were stocked into Redwood Creek until 1992. The genetic effect of this hatchery on coho salmon produced in Redwood Creek is unknown. No hatchery fish are currently stocked into Redwood Creek. Hatchery-origin coho salmon may stray into Redwood Creek; however, the proportion of adults that are of hatchery origin is likely less than five percent and there is no hatchery in the basin producing other species of salmonids. Therefore, adverse hatchery-related effects pose a low risk to all life stages. (Appendix B).

19.6 Threats

Table 19-5. Severity of threats affecting each life stage of coho salmon in Redwood Creek. Threat rank categories, assessment methods, and data used to assess threats are described in Appendix B.

Threats		Egg	Fry	Juvenile[1]	Smolt	Adult	Overall Threat Rank
1	Roads[1]	Very High	Very High	Very High[1]	Very High	High	Very High
2	Channelization/Diking[1]	High	Very High	Very High[1]	Very High	High	Very High
3	Mining/Gravel Extraction	-	High	High	High	Medium	High
4	Timber Harvest	Medium	Medium	Medium	Medium	Low	Medium
5	Agricultural Practices	Medium	Medium	Medium	Medium	Medium	Medium
6	Dams/Diversion	Low	Medium	Medium	Medium	Medium	Medium
7	High Severity Fire	Medium	Medium	Medium	Medium	Medium	Medium
8	Invasive Non-Native/Alien species	Medium	Medium	Medium	Medium	-	Medium
9	Urban/Residential/Industrial Dev.	Medium	Medium	Medium	Medium	Medium	Medium
10	Climate Change	Low	Low	Medium	Medium	Medium	Medium
11	Fishing and Collecting	-	-	-	Low	Low	Low
12	Hatcheries	Low	Low	Low	Low	Low	Low
13	Road-Stream Crossing Barriers	-	Low	Low	Low	Low	Low
[1]Key limiting threats and limited life stage							

Key Limiting Threats

The two key limiting threats, those which most affect recovery of the population by influencing stresses, are roads and channelization/diking.

Roads

Roads are a very high threat across all life stages, except for adult, which is rated as a high threat. Information found in Cederholm et al. (1981) suggests that sediment availability increases in basins with more than three miles of road per square mile of area. As of 2006, Cannata et al. found that the Redwood Creek basin has an average of approximately 4.8 miles of road per square mile of area. Cannata et al. (2006) also found that the road density drops to 2.15 miles of road per square mile of area within the Prairie Creek and lower river sub-basins, and that private lands in the middle and upper portions of the Redwood Creek basin average over 8 miles of road

per square mile of area. Although many of the roads in the middle and upper portion of the basin were built prior to current road construction standards, there is an active road improvement program in this area with the goal of reducing sediment delivery to stream channels. Even with active road removal and upgrade efforts, roads, particularly abandoned and unmaintained roads, are a significant source of both chronic and catastrophic sediment input to streams, affecting the quality and quantity of available coho salmon habitat in Redwood Creek and its tributaries. The high road density in Redwood Creek has likely also resulted in an increase in the frequency of road-related landslides in the basin and has increased the sediment yield of landslides. Roads can also affect fish passage where road-stream intersections have not been adequately designed to allow fish passage.

Erosion from roads has been identified by RNSP as the largest controllable source of sediment in the watershed and preventing sediment from reaching the stream is critical. Once sediment is deposited in the stream channels it may take decades to transport out of the stream and can impact many salmonid life-cycles (Madej and Ozaki 2009).

In addition, road building for access to marijuana cultivation sites is common in many areas of the SONCC coho salmon recovery domain. It is likely that many of these roads are unpermitted and contribute excessive amounts of fine sediment to coho salmon streams.

Channelization/Diking

Channelization and diking is a very high threat overall and a very high threat to fry, juvenile and smolt life stages. As previously discussed, the flood control levees and associated channel maintenance activities significantly reduce available habitat in the estuary and lower portion of Redwood Creek. Ecosystem function within the flood control reach will continue to be impaired by the levees and channel maintenance activities until the levees are reconfigured and the design deficiencies of the levees and flood control project are addressed.

Mining/Gravel Extraction

Instream gravel extraction is a high threat to fry, juvenile and smolt life stages, and a medium threat to adult coho salmon. Gravel extraction is not a threat to eggs because gravel extraction does not occur in coho salmon spawning habitat in Redwood Creek. Gravel extraction occurred sporadically between 1968 and 2000, and annually between 2004 and 2010 within the flood control reach of the most downstream 3.4 miles of Redwood Creek. Most gravel extraction occurred as part of Humboldt County's channel conveyance maintenance program required by the Army Corps of Engineers' (Corps) Operations and Maintenance Manual for the flood control levees. Some commercial gravel extraction also occurred prior to 2000 within this reach.

The gravel extraction that occurs as channel maintenance is permitted by the Corps and the permit contains numerous measures to reduce the effects on fish habitat, such as a head-of-bar buffer to provide for channel steering around skimmed gravel bars, and a 2-foot vertical offset from summer low flow water surface elevations to provide low to moderate channel confinement. However, even with minimization measures, gravel extraction reduces overall habitat complexity and reduces the quality and quantity of available pool and velocity refuge habitat. Given the sensitivity of the channel to disturbance (i.e., current lack of floodplain and channel structure), and the potential use of the gravel extraction reach by coho salmon juveniles

for summer rearing (e.g., if habitat is restored in this reach) due to relatively cooler summer water temperatures than upstream, gravel extraction is a significant threat to rearing juveniles and a moderate threat to adults who require resting habitat in pools during upstream migration.

Timber Harvest

Timber harvest is a medium threat to the coho salmon population in Redwood Creek. Many of the changes in instream and riparian conditions in Redwood Creek are a result of intensive timber harvest in previous decades. Although current timber harvest practices are more protective of coho salmon habitat than previous practices, timber harvest continues to affect coho salmon in Redwood Creek by increasing sediment yield and by reducing streamside shading and potential large wood recruitment. Approximately half of the basin is in private ownership as industrial timber land, and timber harvest continues in the middle and upper portions of Redwood Creek. In addition, forest lands are being cleared and graded to create new marijuana cultivation sites. In many cases the land disturbance is not regulated, and likely contributes excessive amounts of fine sediment to coho salmon streams.

Agricultural Practices

Grazing occurs in the lowest reaches of Redwood Creek as well as in the middle and upper portions of the basin and may contribute to increased sediment generation and delivery and decreased riparian vegetation. However, specific information on the magnitude of the threat is limited. Water withdrawals for agricultural uses are discussed in the "Dam/Diversions" section, and the effects of the channelization and dikes, which were installed in the lower reaches of Redwood Creek partly to control flooding on agricultural land, are considered in the "Channelization/diking" section of this profile. Marijuana cultivation has become abundant in many areas of the SONCC coho salmon recovery domain. Although the magnitude in Redwood Creek is unknown, the herbicides, pesticides, and fertilizers used to support these plants are likely impairing water quality.

Dams/Diversions

Dams and diversions are of medium threat to the Redwood Creek coho salmon population. Water withdrawals (authorized and unauthorized) for domestic and agriculture use occur in the Orick area, in Redwood Valley and in the upper basin. The water withdrawals affect stream flow quantity in the summer, affecting the availability of summer rearing habitat. From the 1950s through 2002 summer dams were constructed in the Redwood Valley area, but these dams have been denied permits by CDFG since 2003 and summer dams are not a current threat to passage. However, there may be legacy effects from summer dam construction in the form of fine sediment deposition in stream gravels and reduced invertebrate production at the previous dam sites.

Marijuana cultivation has become abundant in many areas of the SONCC coho salmon recovery domain. Although the number and magnitude of diversions in Redwood Creek is unknown, the water diversion required to support these plants is placing a high demand on a limited supply of water (Bauer 2013a). Most diversions for marijuana cultivation occur at headwater springs and streams, thereby removing the coldest, cleanest water at the most stressful time of the year for

coho salmon (Bauer 2013b). Based on an estimate from the medical marijuana industry, each marijuana plant may consume 900 gallons of water per growing season (Bauer 2013b).

High Severity Fire

The vegetation characteristics throughout the basin present a moderate threat for high severity fires that could alter the sediment delivery regime as well as riparian vegetation characteristics. Most of the basin contains forests of small diameter trees that are close together. These types of previously logged forests burn with greater intensity than late seral forest stands, and high severity forest fires create an erosion hazard. The increased sediment yield from high severity fires would likely deliver sediment to coho salmon habitat in the basin, filling pools and reducing habitat complexity. Conversion of extensive conifer-dominated forests to dense hardwood stands has also likely increased fire risk. However, the Prairie Creek sub-watershed that offers the best habitat available for coho salmon within the basin contains predominately old growth redwood trees that burn with a lower intensity than the second growth found throughout much of the rest of the basin.

Invasive Non-Native/Alien Species

New Zealand mud snails (NZMS) were discovered within lower Redwood Creek in late 2009. This invasive non-native species has very high secondary production (Hall et al. 2006), may out-compete native invertebrates, and provides little food value for juvenile salmonids (Vinson et al. 2007). In addition, Strawberry and Sand Cache creeks, low gradient tributaries to the estuary, contain reed canary grass that is choking the channel, outcompeting native riparian vegetation and adversely affecting water quality, passage and access for coho salmon (Love 2008).

Urban/Residential/Industrial Development

Rural population growth will continue to present a medium threat to coho salmon in Redwood Creek. Such growth can result in removal of vegetation, increased sediment generation and delivery, introduction of exotic species, water withdrawals from stream channels and inadequate septic facilities and pesticide use that affect water quality. Some of the rural growth is in the middle to upper basin, and much of the rural growth is in the Orick area, with some of the growth planned for the floodplain in the flood control levee reach of lower Redwood Creek.

Climate Change

Climate change poses a medium threat to this population. The impacts of climate change in this region will have the greatest impact on juveniles and adults. The current climate is generally cool near the coast and moderately hot inland. Modeled regional average temperature shows a moderate increase over the next 50 years (see Appendix B for modeling methods). Average temperature could increase by up to 1.6 °C in the summer and by up to 1 °C in the winter. Annual precipitation in this area is predicted to change little over the next century. The vulnerability of the estuary and coast to sea level rise is moderate in this population. Juvenile and smolt rearing and migratory habitat is most at risk to climate change. Increasing temperatures and changes in the amount and timing of precipitation will affect water quality and hydrologic function in the summer and winter. Rising sea level will affect the quality and extent of estuarine rearing habitat for juveniles and smolts. Overall, the range and degree of variability

in temperature and precipitation is likely to increase in all populations. Also, as with all populations in the ESU, adults will be negatively impacted by ocean acidification and changes in ocean conditions and prey availability (Independent Science Advisory Board 2007, Portner and Knust 2007, Feely et al. 2008). In addition, the frequency and distribution of coastal fog, which is important for maintaining the redwood ecosystem, may be reduced with climate change (Johnstone and Dawson 2010).

Fishing and Collecting

Based on estimates of the fishing exploitation rate, as well as the status of the population relative to depensation and the status of NMFS approval for any scientific collection (Appendix B), these activities pose a low threat to juveniles, smolts, and adults.

Hatcheries

Hatcheries pose a low threat to all life stages of coho salmon in the Redwood Creek population area. The rationale for these ratings is described under the "Adverse Hatchery-Related Effects" stress.

Road-Stream Crossing Barriers

Road-stream crossing barriers are a low threat to the population. Most of the existing road-stream crossing barriers occur in high gradient tributaries upstream of coho salmon habitat.

19.7 Recovery Strategy

Coho salmon in the Redwood Creek basin are severely depressed in abundance, and restricted in spatial distribution. Recovery activities in the basin should promote increased spatial distribution, particularly in the mainstem of Redwood Creek and tributaries such as Bridge Creek, as well as increased productivity and abundance. Efforts to increase distribution will also likely yield increases in diversity, abundance and productivity. Secondly, preservation of observed life history diversity (i.e., two years of freshwater rearing) should be encouraged.

Activities should occur basin-wide, with a focus on Prairie Creek and its tributaries, and lower mainstem Redwood Creek and its tributaries, where much of the low gradient habitat exists. Top priorities in the basin include restoring estuarine function and river connectivity to sloughs, wetlands, tributaries and floodplain habitat through levee reconfiguration, reducing summer stream temperatures in mainstem Redwood Creek by the addition of channel complexity features that will promote pool development and thermal refuge (such as large wood), especially near cooler tributaries, springs and cool seeps, and reducing sediment sources that have a high risk of delivering sediment to stream channels. Road removal and upgrades, improvements in riparian vegetation, reduction of effects from timber harvest, and improvement in channel structure are priorities in the upper basin.

Other important actions include restoring wetlands, low gradient channels, off-channel habitat, sloughs and tributaries in lower Redwood Creek, including Strawberry Creek, and the north slough channel (Sand Cache Creek), reducing gravel removal that is associated with design deficiencies of the levees, and vegetation removal associated with levee maintenance, and

minimizing timber harvest impacts on riparian corridors to promote large wood delivery to stream channels. The effects of fishing on this population's ability to meet its viability criteria should be evaluated.

Table 19-6 on the following page lists the recovery actions for the Redwood Creek population.

Table 19-6. Recovery action implementation schedule for the Redwood Creek population. Recovery actions for monitoring and research are listed in tables at the end of Chapter 5.

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-RedC.1.2.5	Estuary	Yes	Improve estuarine habitat	Address the Corps' design deficiencies of the Redwood Creek Flood Control Project and improve estuarine, transition zone, and lower river habitat while providing flood protection for public safety and property.	3.4 miles each side of Redwood Creek from mouth upstream to end of levees	1
SONCC-RedC.1.2.5.1	*Develop a plan to address the design deficiencies of the flood control project, modify or reconfigure the levees, and restore the estuary and natural stream channel habitat*					
SONCC-RedC.1.2.5.2	*Obtain authorization (including Congressional authorization, if needed) to modify or reconfigure the flood control project in order to address design deficiencies, reduce levee maintenance, and improve estuarine, transition zone, and lower river habitat. Modification or reconfiguration could include a new flood protection level, and a modified Operations and Maintenance Manual.*					
SONCC-RedC.1.2.5.3	*Acquire land or conservation easements from willing sellers/owners to support levee reconfiguration or modification*					
SONCC-RedC.1.2.5.4	*Implement reconfiguration or modification of the levees to restore the form and function of the estuary, transition zone and lower river habitat, and to connect the channel with tributaries, sloughs, wetlands and other off-channel habitat, while still providing flood protection.*					
SONCC-RedC.1.2.5.5	*Improve instream habitat after levee modification with additional channel structure, such as LWD and boulders*					
SONCC-RedC.7.1.38	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Increase riparian vegetation	Lower Redwood Creek, 3.4 miles each side	1
SONCC-RedC.7.1.38.1	*Assess the influence of vegetation on the Redwood Creek levees for levee structural integrity*					
SONCC-RedC.7.1.38.2	*If needed, develop a variance to the Army Corps policy that provides for levee structural integrity and habitat improvement*					
SONCC-RedC.7.1.38.3	*Maintain and/or improve riparian vegetation in lower Redwood Creek, which could include implementation of a variance to the typical Army Corps vegetation on levees policy, or alteration of other Army Corps standards*					
SONCC-RedC.1.2.32	Estuary	Yes	Improve estuarine habitat	Assess and improve estuary and tidal wetland habitat	Estuary	2a
SONCC-RedC.1.2.32.1	*Identify parameters to assess condition of estuary and tidal wetland habitat*					
SONCC-RedC.1.2.32.2	*Determine amount of estuary and tidal wetland habitat needed for population recovery and develop a plan for restoration*					
SONCC-RedC.1.2.32.3	*Restore estuary and tidal wetland habitat guided by the plan*					
SONCC-RedC.2.1.4	Floodplain and Channel Structure	Yes	Increase channel complexity	Increase LWD, boulders, or other instream structure	All streams where coho salmon would benefit immediately	2a
SONCC-RedC.2.1.4.1	*Assess habitat to determine beneficial location and amount of instream structure needed, focus assessment on stream locations impaired by past land use practices and/or floods*					
SONCC-RedC.2.1.4.2	*Place instream structures, guided by assessment results*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-RedC.2.1.58	Floodplain and Channel Structure	Yes	Increase channel complexity	Increase LWD, boulders, or other instream structure	Population wide	2b
SONCC-RedC.2.1.58.1	*Assess habitat to determine beneficial location and amount of instream structure needed, focus assessment on stream locations impaired by past land use practices and/or floods*					
SONCC-RedC.2.1.58.2	*Place instream structures, guided by assessment results*					
SONCC-RedC.2.2.36	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Construct off channel habitats, alcoves, backwater habitat, and old stream oxbows	All streams where coho salmon would benefit immediately	2a
SONCC-RedC.2.2.36.1	*Assess habitat to determine where potential exists for floodplain connection. Prioritize sites and determine best means for improving floodplain connection or increasing off-channel habitat at each site*					
SONCC-RedC.2.2.36.2	*Implement restoration projects that improve off channel habitats to create refugia habitat, as guided by assessment results*					
SONCC-RedC.2.2.59	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Construct off channel habitats, alcoves, backwater habitat, and old stream oxbows	Population wide	2b
SONCC-RedC.2.2.59.1	*Assess habitat to determine where potential exists for floodplain connection. Prioritize sites and determine best means for improving floodplain connection or increasing off-channel habitat at each site*					
SONCC-RedC.2.2.59.2	*Implement restoration projects that improve off channel habitats to create refugia habitat, as guided by assessment results*					
SONCC-RedC.2.2.40	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Modify the operation of the diversion structure located at mouth of Strawberry Creek/South Slough to increase access to off-channel and tributary habitat.	Strawberry Creek	2a
SONCC-RedC.2.2.40.1	*Assess the timing and operation of the diversion structure to determine impacts to coho salmon*					
SONCC-RedC.2.2.40.2	*If needed, modify the timing and operation of the diversion structure to increase the connectivity between Strawberry Creek and Redwood Creek*					
SONCC-RedC.5.1.10	Passage	No	Improve access	Remove structural barriers	Known barriers (5) in Strawberry Creek	2a
SONCC-RedC.5.1.10.1	*Assess culverts and develop a plan to provide passage at all life stages through the upgrade of the culverts*					
SONCC-RedC.5.1.10.2	*Upgrade culverts, guided by the plan*					
SONCC-RedC.8.1.13	Sediment	No	Reduce delivery of sediment to streams	Reduce erosion	Population wide	2a
SONCC-RedC.8.1.13.1	*Update sediment source inventories as needed, include abandoned and unmaintained roads*					
SONCC-RedC.8.1.13.2	*Prioritize the sediment sources that have the most potential to deliver sediment to Redwood Creek, such as Lacks, Minor and Toss-Up creeks, and also prioritize based on the likelihood of successfully controlling the sediment source (e.g., reducing sediment generated from road related landslides is difficult, whereas sediment from unmaintained roads is easier to treat and control).*					
SONCC-RedC.8.1.13.3	*Implement sediment treatments, guided by assessment and prioritization results*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-RedC.10.1.41	Water Quality	No	Reduce water temperature, increase dissolved oxygen	Increase cool water and thermal refugia	Mainstem Redwood Creek and its tributaries, and all streams where coho salmon would benefit immediately	2a
SONCC-RedC.10.1.41.1	*Assess sources of cool water and develop techniques to protect and/or improve cool water habitat*					
SONCC-RedC.10.1.41.2	*Add LWD, boulders, or sources of structure as guided by assessment to augment habitat at cool water sources*					
SONCC-RedC.10.1.41.3	*Increase riparian vegetation and shading at sources of cool water*					
SONCC-RedC.10.1.56	Water Quality	No	Reduce water temperature, increase dissolved oxygen	Increase cool water and thermal refugia	Population wide	2b
SONCC-RedC.10.1.56.1	*Assess sources of cool water and develop techniques to protect and/or improve cool water habitat*					
SONCC-RedC.10.1.56.2	*Add LWD, boulders, or sources of structure as guided by assessment to augment habitat at cool water sources*					
SONCC-RedC.10.1.56.3	*Increase riparian vegetation and shading at sources of cool water*					
SONCC-RedC.27.2.35	Monitor	No	Track habitat condition	Determine best indicators of estuarine condition	Estuary	2a
SONCC-RedC.27.2.35.1	*Determine best indicators of estuarine condition*					
SONCC-RedC.2.1.6	Floodplain and Channel Structure	Yes	Increase channel complexity	Increase conifer riparian vegetation	Population wide	2b
SONCC-RedC.2.1.6.1	*Assess riparian zone for size and distribution of conifers and hardwoods, include assessment of canopy closure over stream channels*					
SONCC-RedC.2.1.6.2	*Develop an appropriate timber harvest management plan for benefits to coho salmon habitat*					
SONCC-RedC.2.1.6.3	*Where current near-stream forest canopy is dominated by hardwoods and conditions are appropriate, consider cautious thinning of hardwoods, or small crowded conifers, to hasten the development of larger conifers and more extensive conifer canopy and large wood recruitment. Plant riparian vegetation as needed.*					
SONCC-RedC.2.1.6.4	*Pursue land conservation tools (e.g., easements) in Redwood Creek and tributaries to protect near-stream areas and to retain large conifers in the riparian zone*					
SONCC-RedC.2.1.6.5	*Use THP review process or other planning processes to promote growth of riparian conifers and recruitment to the stream channel*					
SONCC-RedC.5.1.11	Passage	No	Improve access	Increase passage by reducing invasive species	Within mainstem Prairie Creek and its tributaries, and within the channels, tributaries and sloughs in Strawberry, Dorance, and Sand Cache creeks.	2b
SONCC-RedC.5.1.11.1	*Eradicate reed canary grass*					
SONCC-RedC.5.1.11.2	*Plant, or encourage growth of, native vegetation to shade out emergent reed canary grass*					
SONCC-RedC.5.1.11.3	*Monitor treatment areas to ensure eradication was successful*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-RedC.5.1.61	Passage	No	Improve access	Increase passage by reducing invasive species	Population wide	2d
SONCC-RedC.5.1.61.1	*Eradicate reed canary grass*					
SONCC-RedC.5.1.61.2	*Plant, or encourage growth of, native vegetation to shade out emergent reed canary grass*					
SONCC-RedC.5.1.61.3	*Monitor treatment areas to ensure eradication was successful*					
SONCC-RedC.7.1.14	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Improve timber harvest practices	Population wide	2b
SONCC-RedC.7.1.14.1	*Apply best management practices for timber harvest*					
SONCC-RedC.7.1.14.2	*Assess and track the rate of timber harvest in the Redwood Creek basin*					
SONCC-RedC.7.1.14.3	*Generate a map of harvest rates by sub-watershed to use in timber harvest planning and evaluation*					
SONCC-RedC.26.1.55	Low Population Dynamics	No	Increase population abundance	Rescue and relocate stranded juveniles	Population wide	2b
SONCC-RedC.26.1.55.1	*Survey coho-bearing tributaries and relocate juveniles stranded in drying pools*					
SONCC-RedC.8.1.16	Sediment	No	Reduce delivery of sediment to streams	Improve regulatory mechanisms	Population wide	2b
SONCC-RedC.8.1.16.1	*Develop grading ordinance for maintenance and building of private and County roads that minimizes effects to coho salmon*					
SONCC-RedC.8.1.12	Sediment	No	Reduce delivery of sediment to streams	Reduce risk of catastrophic fire	Population wide	2b
SONCC-RedC.8.1.12.1	*Identify forested stands for fire hazard reduction*					
SONCC-RedC.8.1.12.2	*Based on assessment, apply appropriate management techniques (e.g. thinning, burning) to reduce risks of high severity fire while also minimizing the risk of sediment delivery associated with the fuels management technique.*					
SONCC-RedC.8.1.15	Sediment	No	Reduce delivery of sediment to streams	Reduce road-stream hydrologic connection	Focus in mainstem Redwood Creek and its tributaries, and all streams where coho salmon would benefit immediately	2b
SONCC-RedC.8.1.15.1	*Continue to assess, update, and prioritize road-stream connection, and identify appropriate treatment to meet objective*					
SONCC-RedC.8.1.15.2	*Decommission roads, guided by assessment*					
SONCC-RedC.8.1.15.3	*Upgrade roads, guided by assessment*					
SONCC-RedC.8.1.15.4	*Maintain roads, guided by assessment*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-RedC.8.1.64	Sediment	No	Reduce delivery of sediment to streams	Reduce road-stream hydrologic connection	Population wide	2d
SONCC-RedC.8.1.64.1	*Continue to assess, update, and prioritize road-stream connection, and identify appropriate treatment to meet objective*					
SONCC-RedC.8.1.64.2	*Decommission roads, guided by assessment*					
SONCC-RedC.8.1.64.3	*Upgrade roads, guided by assessment*					
SONCC-RedC.8.1.64.4	*Maintain roads, guided by assessment*					
SONCC-RedC.7.1.54	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Increase riparian vegetation	Lower Redwood Creek, 3.4 miles each side	2c
SONCC-RedC.7.1.54.1	*Exclude livestock from riparian areas*					
SONCC-RedC.7.1.7	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Improve long-range planning	Population wide	3a
SONCC-RedC.7.1.7.1	*Review General Plan or City Ordinances to ensure coho salmon habitat needs are accounted for. Revise if necessary*					
SONCC-RedC.7.1.7.2	*Develop watershed-specific guidance for managing riparian vegetation, and limiting removal of wood from stream channels*					
SONCC-RedC.7.1.9	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Improve timber harvest practices	Private, non-HCP lands	3a
SONCC-RedC.7.1.9.1	*Amend California Forest Practice Rules to include regulations which describe the specific analysis, protective measures, and procedure required by timber owners and CalFire to demonstrate timber operations described in timber harvest plans meet the requirements specified in 14 CCR 898.2(d) prior to approval by the Director (similar to a Spotted Owl Resource Plan).*					
SONCC-RedC.10.2.42	Water Quality	No	Reduce pollutants	Reduce water pollutants not described in TMDLs	Population wide	3a
SONCC-RedC.10.2.42.1	*Assess current water quality and develop a plan to improve water quality as needed*					
SONCC-RedC.10.2.42.2	*Implement the plan to improve water quality and reduce pollutants*					
SONCC-RedC.10.1.45	Water Quality	No	Reduce water temperature, increase dissolved oxygen	Develop and implement TMDLs	Population wide	3a
SONCC-RedC.10.1.45.1	*Develop temperature TMDL for water bodies listed under Clean Water Act Section 303(d)*					
SONCC-RedC.10.1.45.2	*Implement sediment TMDL for water bodies listed under Clean Water Act Section 303(d)*					
SONCC-RedC.10.1.45.3	*Implement temperature TMDL for water bodies listed under Clean Water Act Section 303(d)*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-RedC.5.1.37	Passage	No	Improve access	Improve access to habitat	Known barriers in Prairie Creek, Skunk cabbage creek, all streams where coho salmon would benefit immediately	3b
SONCC-RedC.5.1.37.1	*Assess and prioritize barriers. Develop a plan for removal*					
SONCC-RedC.5.1.37.2	*Remove barriers, based on evaluation*					
SONCC-RedC.5.1.62	Passage	No	Improve access	Improve access to habitat	Population wide	3d
SONCC-RedC.5.1.62.1	*Assess and prioritize barriers. Develop a plan for removal*					
SONCC-RedC.5.1.62.2	*Remove barriers, based on evaluation*					
SONCC-RedC.3.1.39	Hydrology	No	Improve flow timing or volume	Assess water diversions and effects to instream flows	All streams where coho salmon would benefit immediately	3b
SONCC-RedC.3.1.39.1	*Assess the effects of water diversions on instream flows*					
SONCC-RedC.3.1.39.2	*Using regulatory mechanisms, modify water diversion practices to ensure adequate instream flows*					
SONCC-RedC.3.1.60	Hydrology	No	Improve flow timing or volume	Assess water diversions and effects to instream flows	Population wide	3c
SONCC-RedC.3.1.60.1	*Assess the effects of water diversions on instream flows*					
SONCC-RedC.3.1.60.2	*Using regulatory mechanisms, modify water diversion practices to ensure adequate instream flows*					
SONCC-RedC.3.1.46	Hydrology	No	Improve flow timing or volume	Determine effects of marijuana cultivation	Population wide	3b
SONCC-RedC.3.1.46.1	*Assess cumulative effects (e.g., flow, water quality) of marijuana cultivation*					
SONCC-RedC.3.1.46.2	*If needed, develop plan to reduce effects of marijuana cultivation*					
SONCC-RedC.3.1.46.3	*Implement plan*					
SONCC-RedC.7.1.8	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Improve grazing practices	All areas where coho salmon would benefit immediately	3b
SONCC-RedC.7.1.8.1	*Assess grazing impact on sediment delivery and riparian condition, identifying opportunities for improvement*					
SONCC-RedC.7.1.8.2	*Develop grazing management plans to improve water quality and coho salmon habitat*					
SONCC-RedC.7.1.8.3	*Plant vegetation to stabilize stream bank*					
SONCC-RedC.7.1.8.4	*Fence livestock out of riparian zones*					
SONCC-RedC.7.1.8.5	*Remove instream livestock watering sources*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-RedC.7.1.63	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Improve grazing practices	Population wide	3d
SONCC-RedC.7.1.63.1	*Assess grazing impact on sediment delivery and riparian condition, identifying opportunities for improvement*					
SONCC-RedC.7.1.63.2	*Develop grazing management plans to improve water quality and coho salmon habitat*					
SONCC-RedC.7.1.63.3	*Plant vegetation to stabilize stream bank*					
SONCC-RedC.7.1.63.4	*Fence livestock out of riparian zones*					
SONCC-RedC.7.1.63.5	*Remove instream livestock watering sources*					
SONCC-RedC.16.1.19	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	3b
SONCC-RedC.16.1.19.1	*Determine impacts of fisheries management on SONCC coho salmon in terms of VSP parameters*					
SONCC-RedC.16.1.19.2	*Identify level of fishing impacts that does not limit attainment of population-specific viability criteria*					
SONCC-RedC.16.1.20	Fishing/Collecting	No	Manage fisheries consistent with recovery of SONCC coho salmon	Reduce fishing impacts to levels that do not limit recovery	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	3b
SONCC-RedC.16.1.20.1	*Determine actual fishing impacts from freshwater and ocean fisheries*					
SONCC-RedC.16.1.20.2	*If actual fishing impacts limit attainment of population-specific viability criteria, modify management so that fishing does not limit attainment of population-specific viability criteria*					
SONCC-RedC.16.2.21	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	3b
SONCC-RedC.16.2.21.1	*Determine impacts of scientific collection on SONCC coho salmon in terms of VSP parameters*					
SONCC-RedC.16.2.21.2	*Identify level of scientific collection impact that does not limit attainment of population-specific viability criteria*					
SONCC-RedC.16.2.22	Fishing/Collecting	No	Manage scientific collection consistent with recovery of SONCC coho salmon	Reduce impacts of scientific collection to levels that do not limit recovery	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	3b
SONCC-RedC.16.2.22.1	*Determine actual impacts of scientific collection*					
SONCC-RedC.16.2.22.2	*If actual scientific collection impacts limit attainment of population-specific viability criteria, modify collection so that impacts do not limit attainment of population-specific viability criteria*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-RedC.10.7.53	Water Quality	No	Restore nutrients	Add marine-derived nutrients to streams	All streams where coho salmon would benefit immediately	3c
SONCC-RedC.10.7.53.1	*Develop a plan to supply appropriate amounts of marine-derived nutrients to streams (e.g. carcass placement, pellet dispersal)*					
SONCC-RedC.10.7.53.2	*Supply marine-derived nutrients to streams guided by the plan*					
SONCC-RedC.10.7.57	Water Quality	No	Restore nutrients	Add marine-derived nutrients to streams	Population wide	3d
SONCC-RedC.10.7.57.1	*Develop a plan to supply appropriate amounts of marine-derived nutrients to streams (e.g. carcass placement, pellet dispersal)*					
SONCC-RedC.10.7.57.2	*Supply marine-derived nutrients to streams guided by the plan*					

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