Lower Subbasin

The Lower Subbasin includes the area above the confluence of Redwood and Prairie creeks upstream to the confluence of Redwood and Devil's creeks including Devil's Creek watershed (Table IV- 35 and Figure IV-23). The Lower Subbasin includes the planning watersheds of McArthur Creek, Bond Creek, Bridge Creek, Copper Creek, and Devils Creek. The lands within the Lower Subbasin are in public ownership and managed by RNSP. Lower Subbasin streams support populations of Chinook, coho, steelhead and coastal cutthroat trout.

Table IV- 35. Lower Subbasin notable features.

Square Miles	69.51
Total Acreage	44,488
Private Acres	275
Public Acres	44,212
Principal Communities	none
Predominant Land Use	Park land
Predominant Vegetation Type	Redwood forest
Miles of Anadromous Stream	24.5
Low Elevation	~10 ft.
High Elevation	1,286

Geology

The Redwood Creek schist (KJfr) dominates the bedrock in the Lower Subbasin. The incoherent unit of Coyote Creek (KJfc) and the coherent unit of Lacks Creek (KJfl) form two relatively narrow bands immediately east of the Grogan Fault. The incoherent unit of Coyote Creek is relatively weak, pervasively sheared shale containing isolated intact blocks of sandstone/shale and other exotic rocks and forms the lower, earth flow-dominated slopes close to Redwood Creek. The coherent unit of Lacks Creek is a hard, competent package of interbedded sandstone and shale (turbidites). It stands steeply and creates rugged topography forming debris slide amphitheaters.

Seventy-one percent of the Lower Subbasin falls into the high- to very high mass wasting potential category (Table IV- 36). Most of the planning watersheds share the same proportional distribution of mass wasting potential, but Copper Creek has approximately twice the proportion of active landslides than the other planning watersheds in this subbasin. The number of active landslides appears to be driven by the incoherent unit of Coyote Creek underlying most of the eastern portion of the subbasin.

Dormant landslide features occupy approximately 12% of the subbasin and these occur primarily in the Bridge, Bond, and Copper Creek planning watersheds (Table IV- 36). The other planning watersheds have approximately 1 to 2% of their area involved in dormant landslide features. McArthur Creek appears to be more stable than the other planning watersheds in the subbasin and has a greater proportion of area in the very low to moderate mass wasting potential category. This mass wasting potential probably occurs because the upper portion of the planning watershed has a relatively flat-floored valley and marine terraces occupy the crests of the major ridges to the northwest and southeast (Plate A, Sheet 1, CGS appendix).

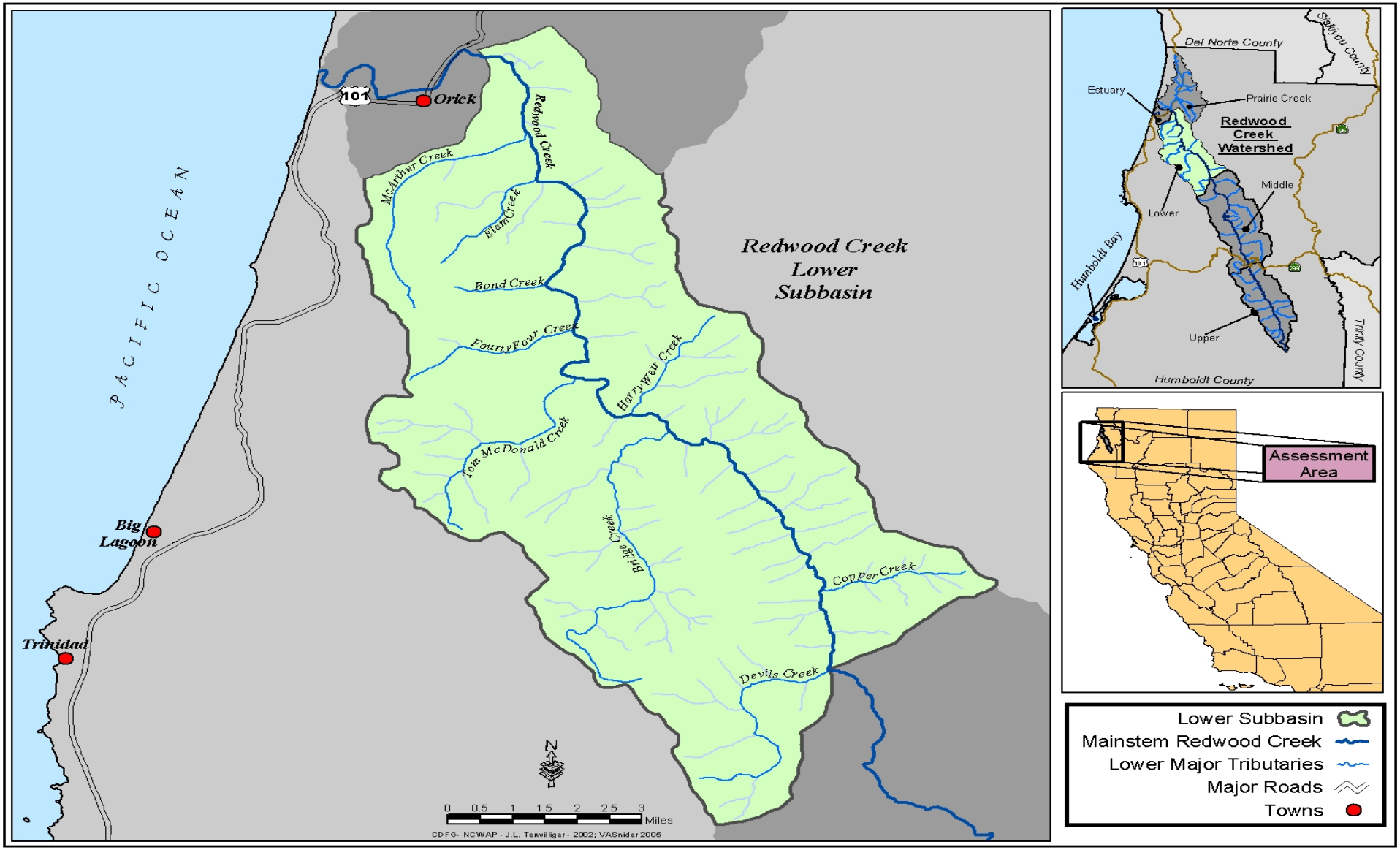

Figure IV- 23. Map of the Lower Subbasin of Redwood Creek.

Table IV- 36. Lower Subbasin summary of relative landslide potential and landslide features.

Factor	Subbasin		Planning Watersheds									
	Lower RC		Bond Creek		Bridge Creek		Copper Creek		Devil's Creek		McArthur Creek	
Relative Landslide Potential	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Very Low	2,666	6	389	4.8	780	5.2	266	2.7	226	5.1	1,005	14.8
Low	3,028	7	378	4.6	1,033	6.9	630	6.3	347	7.9	640	9.4
Moderate	7,259	16.3	1,273	15.6	2,326	15.5	1,740	17.4	738	16.7	1,182	17.4
High	17,431	39.2	3,359	41.1	6,146	40.9	3,239	32.4	2,087	47.3	2,600	38.2
Very High	14,033	31.6	2,783	34.0	4,731	31.5	4,134	41.3	1,011	22.9	1,374	20.2
High/Very High Subtotal	31,464	71	6,142	75	10,877	72	7,373	74	3,098	70.3	3,974	58
GRAND TOTAL	**44,417**	**100%**	**8,182**	**100%**	**15,016**	**100%**	**10,009**	**100%**	**4,409**	**100%**	**6,801**	**100%**
Landslide and Selected Geomorphic Features	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Historically Active Landslide Features Total [1]	2,662	6.0	477	5.8	985	6.6	1,149	11.5	8	0.2	43	0.6
Earthflow	1,762	4.0	271	3.3	363	2.4	1,126	11.3	2	0.0	0	0.0
Rock Slide	740	1.7	174	2.1	538	3.6					28	0.4
Debris Slide	82	0.2	21	0.3	29	0.2	19	0.2	4	0.1	9	0.1
Debris Flow	78	0.2	11	0.1	55	0.4	4	0	2	0	6	0.1
Dormant Landslide Features Total	5,263	11.8	1,296	15.8	2,101	14.0	1,683	16.8	104	2.4	79	1.2
Selected Geomorphic Features Total	5,540	12.5	898	11.0	1,017	6.8	2,244	22.4	671	15.2	709	10.4
Disrupted Ground	2,831	6.4	128	1.6	128	0.9	2,115	21.1	461	10.4	0	0.0
Debris Slide Slope	2,472	5.6	770	9.4	770	5.1	88	0.9	201	4.6	643	9.5
Inner Gorge (area)	236	0.5			119	0.8	41	0.4	10	0.2	66	1.0
Total of All Above Features	**13,465**	**30.3%**	**2,671**	**33%**	**4,103**	**27.3%**	**5,076**	**50.7%**	**783**	**17.8%**	**831**	**12.2%**

[1]Areas of disrupted ground are not included as active landslide features in this analysis.

Streamside Landslides

RNSP staff field mapped streamside landslides throughout the mainstem channel in 1980 at a scale of 1:6,000, using enlarged aerial photographs from 1978 (Kelsey and others 1981; Madej 1984a, b). Park staff also mapped storm landslides from 1997 aerial photos (1:6,000) following the 12-year storm of 1996/1997, to show landslides active during the storm. This was the largest storm event in Redwood Creek since 1975. "Although the number of landslides associated with roads was about the same as those not associated with roads, road-related landslides were larger and accounted for a much greater volume of sediment than non-road-related landslides." (M. Madej USGS, RNSP, Written Communication).

The Redwood Creek channel from Devils Creek to Bridge Creek is the area with some of the largest debris slides in the entire basin. These inner gorge debris slides were first noted in 1978 air photos and some extend 500 to 1000 feet upslope. The abundance of debris slides along the relatively straight reach may be related to a combination of steep slopes and a zone of weak, sheared rocks close to the Grogan fault. Another cause may be elevated groundwater levels, lowered evapotranspiration, and increased runoff related to extensive harvest operations which occurred immediately prior to this area's addition into the Park. Lower evapotranspiration, interception, and resultant higher groundwater may have combined with flooding during the 1975 storm season.

The northeast-facing slope above this section of channel stands strikingly out from the rest of the basin as it is relatively uniform and has few large landslides. The upper Bridge Creek channel may be structurally controlled because it closely follows a lineament (observed in aerial photographs) that extends south to Panther Creek.

Bond Creek showed a 64% increase in the number of small active landslides between 1984 and 2000; Copper Creek showed a 41% decrease in small active streamside landslides, while McArthur Creek did not change (Table IV- 37). If the number of active landslides were a simple predictor of future sediment storage in the channel, then Bond Creek would gain sediment in storage in its lower gradient reaches as a result of its high number of landslides in 2000. Bridge Creek contained the lowest density of small active landslides per acre or per unit length of stream, and showed little change between 1984 and 2000. Overall, there was a slight increase

in streamside landslides in the subbasin. A simplified map of streamside landslides along a portion of the Lower Subbasin is presented in Appendix C.

Table IV- 37. Lower Subbasin active streamside slides, slide index, and change in index, 1984 and 2000.

Subbasin or Planning Watershed Unit of Analysis	Analysis Unit Area (sq. km.)	1984 # of Active* Slides Along Streams	2000 # of Active* Slides Along Streams	1984 Indexed** Active Slides	2000 Indexed** Active Slides	% Change 1984-2000
Lower Redwood Subbasin	180.1	249	260	138	144	4
Bond Creek	33.2	44	72	133	217	64
Bridge Creek	60.9	55	53	90	87	-4
Copper Creek	40.6	107	63	264	155	-41
Devil's Creek	17.8	0	18	0	101	∞
McArthur Creek	27.6	43	54	156	196	26

**Index = (# slides/analysis unit area) X 100

Vegetation

The Lower Subbasin contains 34,716 acres of forested landscape. The Lower Subbasin supports old growth and second growth redwood forests (16,663 acres or 37% of the subbasin) and mixed redwood /Douglas-fir (19,567acres or 44% of the subbasin) (Table IV- 38 and Figure IV- 24). Douglas-fir dominated stands (2,057 acres or 5% of the subbasin) are also present. Approximately 6,189 acres is grassland and 4,067 acres are stocked with hardwoods, mainly red alder. Areas of Oregon white oak are found along the upper ridges of the subbasin in association with grasslands. Timber stands within this area exhibit growth in the site II or site III classification for productivity. Areas classed as barren (408 acres) are located along the lower portion of Redwood Creek. These areas are mostly gravel bars, which do not support vegetation at this time.

Table IV- 38. Generalized cover type by subbasin and planning watershed.

Subbasin or Planning Watershed	Cover Type								
	Agriculture	Barren	Conifer	Hardwood	Grassland	Shrub	Developed	Water	Total
Lower Subbasin	0	408	39,037	3,805	1,244	19	5	0	44,518
Bond Creek	0	108	7,388	702	4	0	0	0	8,202
Bridge Creek	0	99	13,668	1,112	169	3	0	0	15,051
Copper Creek	0	66	8,110	795	1,059	3	0	0	10,033
Devil's Creek	0	8	4,129	270	0	4	0	0	4,411
McArthur Creek	0	127	5,742	926	12	9	5	0	6,821

Land Use

The land within the Lower Subbasin is managed by the RNSP. The RNSP land management strategies include: 1) perpetuation of the redwood forest and associated ecosystems as prime resources; 2) perpetuate ongoing natural influences on the basis of natural values and visitor use; and 3) protect threatened and endangered species and species of special concern (USDOI 1999).

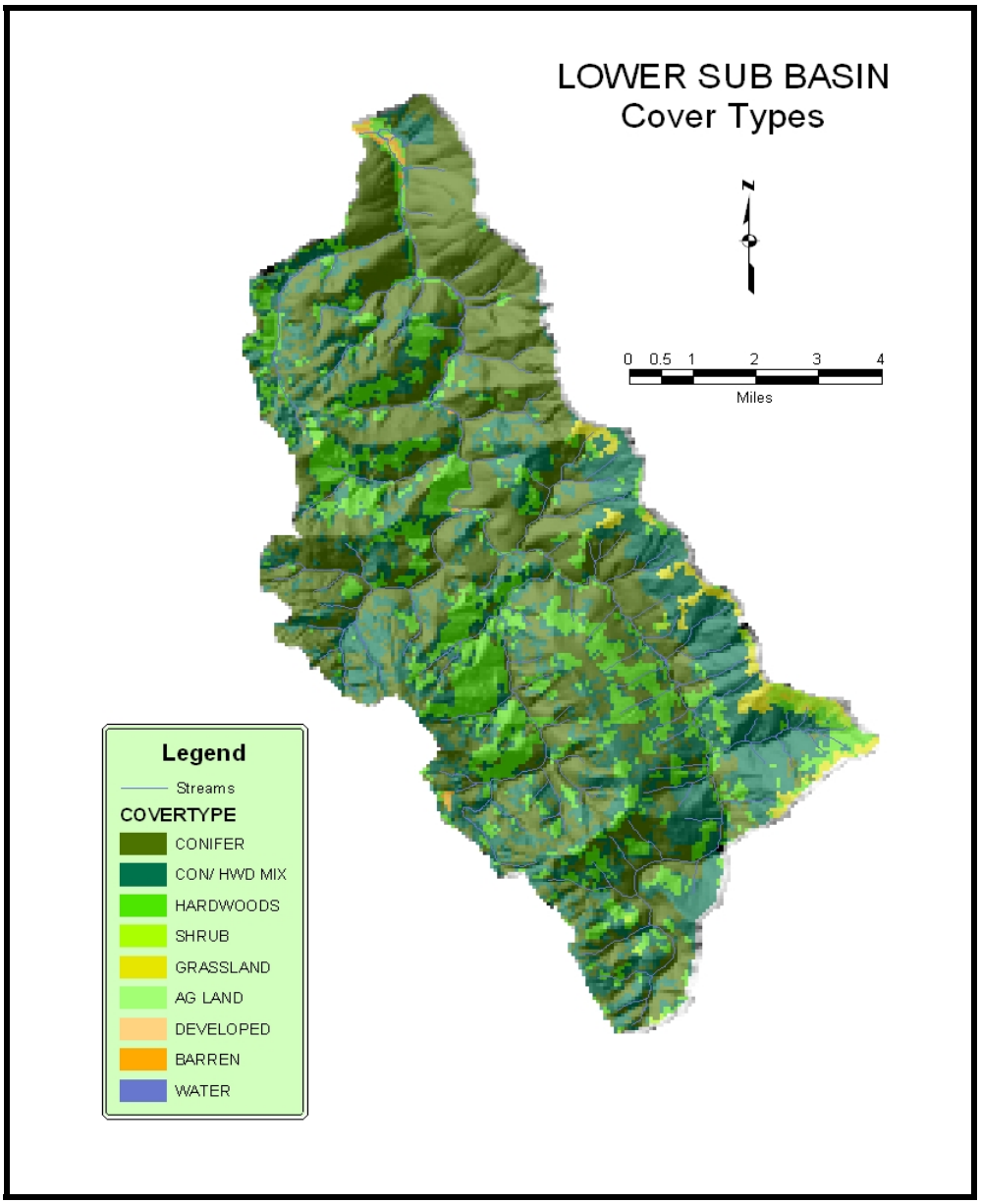

Figure IV- 24. Lower Subbasin vegetation map showing cover types.

Timber Harvests

Until 1978 the Lower Subbasin was under private ownership and was managed for timber production. Commercial timber harvests in the Lower Subbasin ended with the expansion of RNSP in 1978. Road removal, erosion control, and recreation are now major land use activities in the Lower Subbasin.

Approximately 30,215 acres of the Lower Subbasin were harvested between 1950 and 1978, or about 68% of the subbasin area (Table IV- 39 and Figure IV- 25). Prior to 1955, harvest rates were relatively low in the subbasin. Bridge Creek, Devil's Creek, and Bond Creek planning watersheds had the highest percentages of area harvested; McArthur Creek had the smallest.

Timber harvest technology and methods have evolved over the years as can be seen by inspection of time series air photos. Logging prior to 1942 in the headwaters of Devil's Creek and Panther Creek was mostly accomplished with the use of steam donkey skidding systems. Some harvest areas also used tractors including the area above Orick along the Bald Hills Road and areas of Tom McDonald Creek and Devils Creek. During the decades of the 1950s and 1960s, clear cuts were very large and extensive. The majority of these cuts employed tractor yarding. The use of tractor constructed skid trails is evident in aerial photographs, especially

on steeper slopes. Ground disturbance resulting from these prolonged operations was extensive, with some areas showing over 75% of the ground disturbed. Clear-cut units in the mid 1970s and later were much smaller, with buffer zones between the cut blocks. With the introduction of cable systems in 1972 the road networks were built along the ridges and mid-slope locations. Although old roads were still located along channel bottoms, there was no new road construction in these areas.

Table IV- 39. Lower Subbasin timber harvest history, 1950-2000.

Subbasin or Planning Watershed	Harvest Acres by Period							
	1950 - 1964	1965 - 1974	1975 - 1978	1978 - 1992	1992 - 2000	Total Harvested	Total Acres	Percent Area Harvested
Lower Subbasin Total	12,470	13,436	4,308	0	0	30,214	44,505	67.9
Bond Creek	1,718	3,095	889	0	0	5,702	8,200	69.6
Bridge Creek	6,671	3,822	1,479	0	0	11,972	15,056	79.5
Copper Creek	2,216	2,625	837	0	0	5,678	10,028	56.6
Devil's Creek	848	1,539	725	0	0	3,112	4,407	70.6
McArthur Creek	1,017	2,355	378	0	0	3,750	6,814	55.0

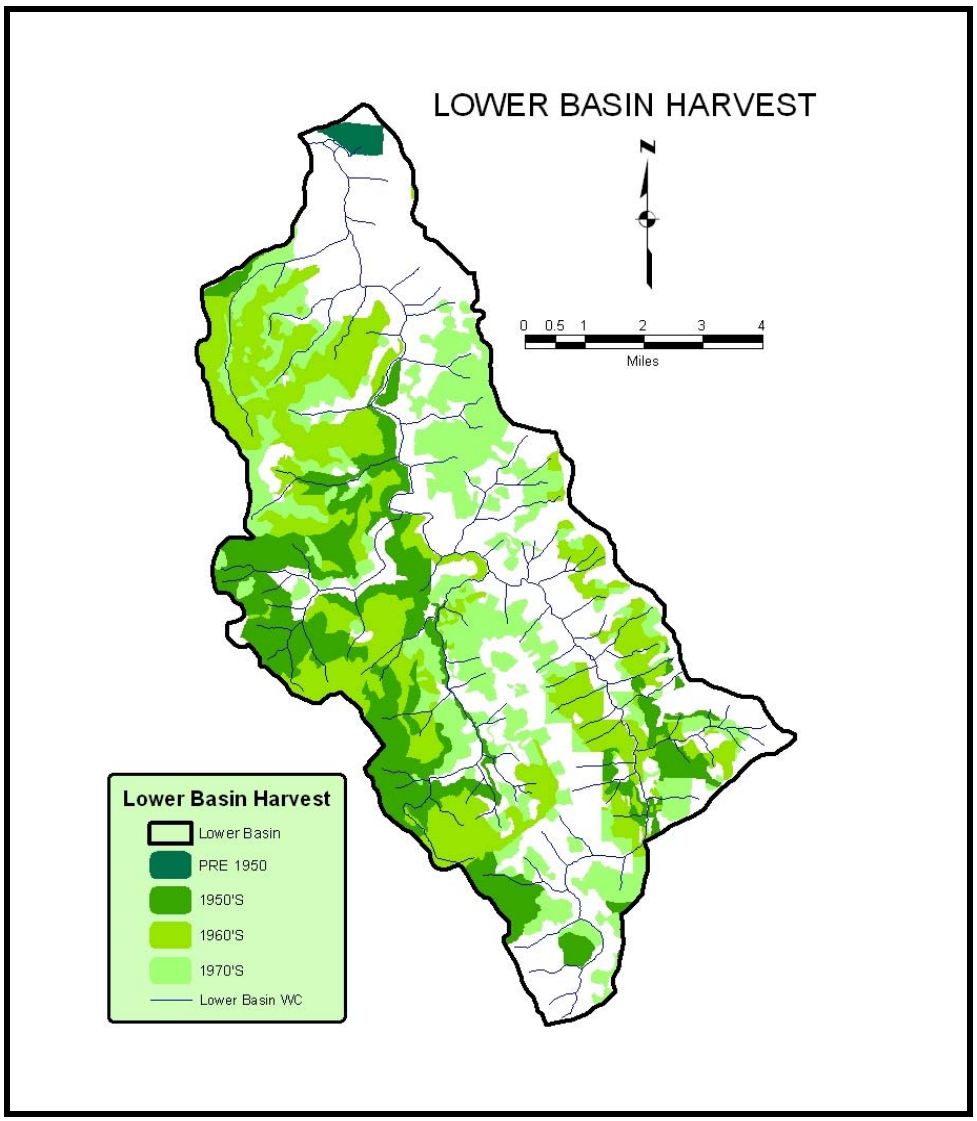

Figure IV- 25. Lower Subbasin timber Harvest.

Roads

As of 2001, the Lower Subbasin had an estimated 138 miles of roads, or a road density of about 2.0 miles of road per square mile. This low road density reflects the Park's aggressive efforts to remove roads in the subbasin. An estimated 76% of the road miles are on areas of high or very high relative landslide potential. The Copper Creek Planning Watershed has the lowest road density, at 0.6 road miles per square mile, and the Devil's Creek Planning Watershed has the highest, at 3.9 road miles per square mile. Recent road removal projects have reduced the number of road miles to near zero in the Lower Subbasin (Greg Bundros, RNSP, personal communication).

Fire and Fuels

Fire and fuels rankings in the Lower Subbasin (Table IV- 40 and Figure IV- 26) are dominated by areas in the high rank, with patches of small areas in the very high rank along the eastern border of the unit. The Copper Creek Planning Watershed stands out as having a relatively large percentage of area in the very high fuel rank, compared to the other planning watersheds on the subbasin. However, given the relatively cool temperatures and moist conditions of the Lower Subbasin, only under rare, severe weather conditions would fuel conditions pose as high a risk to fire as their rankings imply.

Table IV- 40. Lower Subbasin fuel ranks summary for planning watersheds.

Subbasin or Planning Watersheds	Fuel Rank								Total Acres
	Moderate		High		Very High		Not Mapped		
	acres	%	acres	%	acres	%	acres	%	
Lower Redwood Creek Subbasin	17,134	38	24,672	55	2,533	6	168	<1	44,507
McArthur Creek Planning Watershed	1,573	23	4,988	73	187	3	66	1	6,814
Bond Creek Planning Watershed	2,459	30	5,278	64	430	5	34	<1	8,201
Bridge Creek Planning Watershed	6,594	44	7,799	52	611	4	52	<1	15,056
Copper Creek Planning Watershed	4,503	45	4,382	44	1,133	11	11	<1	10,029
Devil's Creek Planning Watershed	2,005	45	2,226	51	171	4	5	<1	4,407

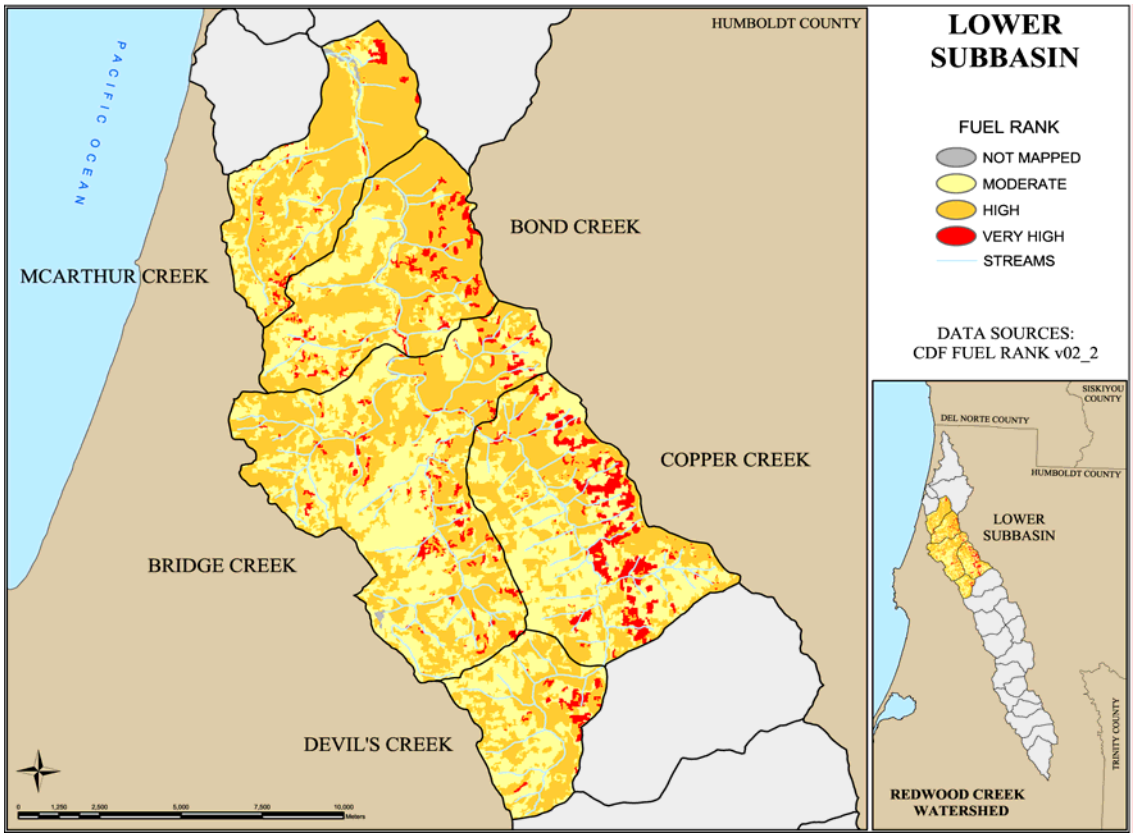

Figure IV- 26. Lower Subbasin fuel ranking map.

Fluvial Geomorphology

Within the Lower Subbasin, there are approximately 17 miles of mainstem Redwood Creek and 122 miles of blue line tributary stream channel (Table IV- 41). The lower reach of Redwood Creek is straight and follows the Grogan fault zone between confluences of Devil's Creek (~RM 21) and Dolason Creek (~RM 15). Streamside landslides are abundant along this reach within the fault zone. Below the mouth of Dolason Creek, the course of Redwood Creek veers westward into the Redwood Creek Schist. Below Bridge Creek, Redwood Creek widens. This lower, wider, and flatter stretch contains massive stream bars and some terraces, including the terrace of the Tall Trees Grove. Downstream, near the confluence with Prairie Creek the main stem makes its final westward bend toward the ocean.

The stream network in the lower part of Redwood Creek basin consists of roughly equal proportions of response, transport, and source reaches. Response reaches dominate the mainstem and provide the most habitat for anadromous fish. Source reaches dominate the tributaries, comprising about 44% of the total blue-line stream lengths of the whole subbasin. Sediment generated in the steeper reaches moves downstream and can be deposited in lower gradient, anadromous fish bearing habitat.

Studies show that the mainstem channel in the Lower Subbasin accumulated sediment from storms in 1955, 1964, 1972, and 1975 (RNSP 1999). Channel-bed elevations increased (Madej and Ozaki 1996) and the capacity of the channel to convey peak flows was reduced. The channel adjusted its width to accommodate flood peaks by eroding its banks (Janda and others 1975). As the locus of deposition of sediment shifted progressively downstream between 1974 and 1981, streambanks eroded along the lower reach (Nolan and Marron 1995) and streamside redwoods fell.

Table IV- 41. Lower Subbasin planning watershed area and miles of blue line streams.

Planning Watershed	Area (acres)	Miles of Blue-line streams	Miles of Redwood Creek Mainstem	Number of Blue-line Tributary Segments (Number of these that drain directly into Redwood Creek)
McArthur Creek	6,814	14.4	2.7	8 (6)
Bond Creek	8,200	18.4	4.6	12 (9)
Bridge Creek	15,056	45	3.1	37 (5)
Copper Creek	10,028	32.7	6.3	32 (19)
Devils Creek	4,407	11.8	0	8 (1)

Tall Trees Grove and the adjacent channel of Redwood Creek were affected by the storms as well as by the downstream movement of excess sediment from upstream roads and timber harvest areas. Aerial and ground photographs, channel cross sections, and interviews with lumber company workers employed during the 1940s through the 1970s (Milestone, J.F. 1979, Redwood National Park, written communication) all indicate that the channel bed near the grove aggraded by roughly 5 feet sometime after the 1955 flood. The channel banks eroded enough to endanger old-growth trees. In 1979, in the Tall Trees Grove, park staff mapped four fallen redwood trees and five redwoods with roots exposed by bank erosion (Milestone, J.F., Redwood National Park, written comm., 1979).

RNSP and the USGS began to monitor cross sections of mainstem Redwood Creek in the 1970s. Madej and Ozaki (1996) noted that the mainstem channel has aggraded and degraded across its entire active channel width including the thalweg and low unvegetated bars, rather than becoming incised and narrowing. Just below Panther Creek, channel width increases from 100 ft. to 160 ft. and channel gradient decreases from 1.4% to 0.3% along the reach that contains the first 14 cross sections in the Lower Subbasin. This reach, from Panther Creek to just below Harry Weir Creek, aggraded more than three feet after the 1975 flood. Within the next reach, between Harry Weir Creek and Tall Trees Grove, bankfull widths are as much as 500 ft. and channel gradient is 0.2%. Six cross sections have been monitored. The channel fluctuated between aggradation and degradation following the storms in the early 1970s. The third reach includes 10 cross sections, distributed along the mainstem channel from Tall Trees Grove downstream to Elam Creek. In this reach the mainstem channel aggraded during the entire period of monitoring discussed by Madej and Ozaki (1996). Bankfull width was 200-375 ft and channel gradient was reported as 0.2%. Downstream from the last park cross section, the river has fluctuated between aggradation and degradation due to the increase in width of the alluvial valley,

construction of levees, and gravel extraction (Madej and Ozaki 1996). This information is discussed in more detail in Appendix E.

CDFG stream survey crews measured channel cross sections during 2001 in the tributaries and the mainstem of Redwood Creek. CGS compared channel parameters with regional curves developed by Rosgen and Kurz (2000, written communication) for North Coast streams. Areas along the lower mainstem of Redwood Creek do not fit predictions of the regional curves, which indicates that the lower mainstem channel is excessively wide with respect to its drainage area. Furthermore, CDFG crews in the field observed the excessive width of the channel in the spots they studied and recorded the observation in their field notes. Two specific locations were noted along the mainstem of Redwood Creek near the confluences with Tom McDonald Creek (392 ft. wide) and Bond Creek (308 ft. wide).

Stream Disturbance

In the Lower Subbasin, stream disturbance features showed a net decrease in overall length from 26.8 mi to 13.4 mi, between photo years 1984 and 2000. However, elevated sediment left steeper tributaries and accumulated in the mainstem channel, so the lowest part of the lower subbasin actually deteriorated with respect to stream disturbance features.

The changes in stream disturbance are discussed below by planning watersheds and by individual tributaries. This is important, because within a planning watershed, there were places of net improvement and places simultaneously showing net deterioration. The general trend between photo years 1984 and 2000 was for stream disturbance to decrease in tributaries and become confined to the mainstem of Redwood Creek.

Overall, the Lower Subbasin saw a decrease of 43% in disturbance features by length (Table IV- 42). Copper and Bridge Creeks show improvement in both negative stream features and streamside landslides, whereas McArthur Creek shows deterioration. Bond Creek shows an increase in streamside landslides, but a significant decrease in elevated sediment in the channel, suggesting that most sediment may be rapidly transported downstream.

Some planning watersheds straddle Redwood Creek, meaning that they include tributaries that enter the mainstem from both the east and the west. The Noisy Creek planning watershed in the upper subbasin, gained stream disturbance features. The gain was due solely to conditions on Noisy Creek, on the west side of the planning watershed. The tributaries on the east side improved, and the mainstem of Redwood Creek remained about the same.

Only McArthur Creek did not contribute to the improvement and showed an increase in the length of negative stream features. McArthur Creek may have been more affected by the 1996/1997 storm, which seems to have caused more erosion and sediment yield in that planning watershed. Correspondingly, the number of streamside landslides increased by 26% in McArthur Creek. Copper Creek saw a significant decrease of 71% in negative stream features.

Water Quality

Temperature

Temperature data in the Lower Subbasin were collected from 1997 to 2001 at four locations, two along the mainstem, and two at tributaries (Table IV-43). The tributary streams generally provide suitable water temperatures year-round for anadromous salmonids while the mainstem Redwood Creek has higher than desirable water temperatures during summer and early fall seasons. Cooler water refuge areas do provide habitat for juvenile salmonids in the mainstem over summer months when ambient stream temperatures may be highly stressful or preclude salmonids. A few thermally stratified pools form where cold intergravel flow, tributary flow, or springs seep into the stream channel (Ozaki 1988).

Table IV- 42. Length of negative stream features, negative stream feature index, and percent change for 1984 to 2000.

Planning Watershed	Creek Name	Stream Disturbance (m)		Stream Disturbance (ft)		Stream Disturbance (mi)		Stream Disturbance (%)	
		1984	2000	1984	2000	1984	2000	1984	2000
McArthur Creek	Hayes Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Unnamed trib, east side, south of Hayes Creek	0.0	580.0	0.0	1902.9	0.0	0.4	0.0	2.5
	McArthur Creek	357.2	374.6	1172.0	1229.0	0.2	0.2	1.5	1.6
	Elam Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Redwood Creek	3159.6	5282.1	10370.0	28450.0	2.0	5.4	13.6	22.8
	Total	**3516.8**	**6236.7**	**11542.0**	**31581.9**	**2.2**	**6.0**	**15.1**	**26.9**
Bond Creek	Oscar Larson Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	East side trib unnamed, no blue line	427.4	0.0	1402.1	0.0	0.3	0.0	1.4	0.0
	Cloquet Creek	1514.5	0.0	4968.7	0.0	0.9	0.0	5.1	0.0
	Bond Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Miller Creek	2764.8	0.0	9070.9	0.0	1.7	0.0	9.3	0.0
	Fortyfour Creek	2306.0	360.3	7565.6	1182.0	1.4	0.2	7.8	1.2
	Cole Creek	1013.2		3324.1	0.0	0.6	0.0	3.4	0.0
	Redwood Creek	4298.6	3944.3	14103.1	12940.6	2.7	2.5	14.5	13.3
	Total	**12324.4**	**4304.6**	**40434.5**	**14122.7**	**7.7**	**2.7**	**41.6**	**14.5**
Bridge Creek	Tom McDonald Creek	3782.4	0.0	12409.4	0.0	2.4	0.0	5.3	0.0
	Harry Weir/Emerald Cr.	1560.6	0.0	5120.0	0.0	1.0	0.0	2.2	0.0
	Bridge Creek	4357.3	4587.5	14295.6	15050.8	2.7	2.9	6.1	6.4
	Redwood Creek	3817.6	2504.9	12525.0	8218.2	2.4	1.6	5.3	3.5
	Total	**13517.9**	**7092.4**	**44350.0**	**23269.0**	**8.4**	**4.4**	**18.8**	**9.9**
Copper Creek	Dolason Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	G Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Airstrip Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Slide Creek	1562.1	0.0	5125.1	0.0	1.0	0.0	3.0	0.0
	Maneze Creek	1236.1	0.0	4055.3	0.0	0.8	0.0	2.4	0.0
	Copper Creek	1719.2	1030.5	5640.4	3381.0	1.1	0.6	3.3	2.0
	Lyons Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Elf Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Redwood Creek	8786.1	2953.0	28825.8	9688.4	5.5	1.8	16.7	5.6
	Total	**13303.5**	**3983.5**	**43646.7**	**13069.4**	**8.3**	**2.5**	**25.3**	**7.6**
Devils Creek	Devils Creek	452.7	0.0	1485.3	0.0	0.3	0.0	2.4	0.0
	Total	**452.7**	**0.0**	**1485.3**	**0.0**	**0.3**	**0.0**	**2.4**	**0.0**

The NW/SE aspect of the basin and lack of riparian shading have a large influence on mainstem water temperature in this subbasin. On the mainstem Redwood Creek, maximum weekly average temperature (MWAT) cools slightly from approximately 72ºF above the confluence with Lacks Creek in the Middle Subbasin to a range of 67 -70ºF , near the confluence of Tom McDonald Creek, 15 miles downstream. MWATs are consistently slightly cooler in the Lower Subbasin than in the Middle Subbasin, but temperature data from the past four years exceed the desirable range for salmonids even with contributions from cold water tributaries and fog influence. Redwood Creek flows through patches of giant trees in this part of the subbasin, however this does not significantly lower water temperature because the mainstem channel is often too wide for trees to provide shade over the flowing stream or create a microclimate. The coastal fog belt does not influence water temperature for much more than a mile upstream the confluence with Prairie Creek. Contributions from cool water tributaries also may reduce water temperature in localized patches of the mainstem. These confluence sites may provide small, thermal refuge areas for salmonids during hot summer months.

Tributaries have cooler MWATs than the mainstem. For example, Bridge Creek has steadily resided between 60º and 61ºF MWAT from 1996 to 2001. This consistent MWAT may be a result of canopy and channel protection and restoration by the RNSP. Water temperature in Tom McDonald Creek had an MWAT of 58ºF in 2001.

Table IV- 43. Lower Subbasin streams MWATS.

Site ID	Site	Subbasin	Period of Record	Max MWAT year	Max MWAT (F)
40, Tmcd	Tom McDonald Creek1	Lower	2001	2001	58
3014, RwTtg	*RedCrk upstm Tom McD Crk5, 1	Lower	1997-99, 2001	1998	70
3002, Bri	Bridge Creek5, 1	Lower	1996-2001	1999	61

Maximum daily temperatures recorded during the summers of 1996 to 2001 for the sites in the Lower Subbasin were between 70 and 75ºF along the mainstem and 60 and 65ºF on the tributaries. These readings indicate that at least one day during the hottest part of the year, temperatures in the lower mainstem approach the lethal limit of 75º F and may remain hot for some hours thus causing stress and damage to salmonids.

Water Column Chemistry

USGS monitored 26 sites in the Lower Subbasin between 1970 and 1980. Most of the sites were sampled from 1974-1975. Three sites were along the mainstem and 23 sites on tributaries. Samples collected from the lower watershed area show near compliance for all parameters with Basin Plan current water quality objectives and no noticeable trends were observed. Data for dissolved oxygen ranged from 7-13mg/L (water quality objective >8mg/L), pH ranged from 5.5 to 8.5 (water quality objective 6.5-8.5), and conductivity ranged from 25-250umhos (water quality objective <220umhos), slightly exceeding objective goals. See Appendix C for water chemistry data from Lower Subbasin.

In-Channel Sediment

In-channel sediment was sampled by RNSP for median particle size (D_{50}) and percent of fine materials at five sites in the mainstem of Redwood Creek of the Lower Subbasin from 1979 to 1995. Median particle size of in-channel sediment was sampled by RNSP on a point bar just downstream of the confluence with Miller Creek in 1982, 1985, 1988, and 1991. See Appendix C for the D_{50} data. These data showed a large increase in D_{50} particle size from 3 to 21mm between 1985 and 1988. The minimum TMDL target of >37mm for D_{50} was not met between 1982 and 1991 at this site. Information from the CGS fluvial geomorphology assessment shows the point bar grew from 1984 to 2000, suggesting that sediment was stored here during that time. The assessment also notes an excess of sediment in the Miller and Fortyfour creek tributaries from the RNSP examination of 1980 and 1997 air photos. The in-channel sediment data, along with the CGS and RNSP fluvial geomorphology assessment confirm an elevated amount of sediment on the mainstem at the confluence with Miller Creek from 1980 to 2000.

Another mainstem site in this subbasin sampled for in-channel sediment by RNSP is located upstream from the confluence with Harry Wier (Emerald) Creek (approx. RM 14). Data show the D50 size increasing from 11mm in 1979 to 16mm 1982. The minimum TMDL target of >37mm for D_{50} was not met between 1979 and 1982 at this site. See Appendix C for the D_{50} data. There was a streamside slide and tributary fan evident in 1993 photos at the mainstem confluence with Bridge Creek, which is upstream of the sample site. Data show a peak in D_{50} particle size in 1995 perhaps reflecting this slide. CGS fluvial geomorphology analysis located this site at the downstream end of a stream bar. Their photo analysis showed the bar eroded slightly at the sample site and enlarged at the opposite end between 1984 and 2000. This site is also opposite and downstream of mainstem slides that were mapped in 1980 photos by the RNSP. These slides could have contributed to the shaping and formation of the stream bar at the sample site. Comparisons of in-channel sediment data with the fluvial geomorphology assessment by CGS help to create a picture of sediment transport in this reach. See the fluvial geomorphology section of the CGS appendix (Appendix E) for more detailed information about this cross section.

The Lower Subbasin of Redwood Creek was sampled in 1979 and 1994 at 6 sites to determine the amount of fine materials present in the channel by the RNSP and USGS. Unfortunately, due to different methods of analysis the RNSP and USGS data cannot be compared to TMDL targets at this time (See the In-Channel Sediment section of Part 2 for more information). However, the gravimetrically measured data presented in Appendix C shows that the <2mm size class fluctuated the most between 1979 and 1994. Without current data it is difficult to make conclusions from these studies about the distribution of in-stream sediments and how they impact salmonid habitat in the lower subbasin.

Salmonid Habitat

Fish Habitat Relationship

The Lower Subbasin supports populations of Chinook salmon, coho salmon, steelhead, and coastal cutthroat trout (Table IV- 44). The entire lower reach of Redwood Creek (17 miles) is used by anadromous salmonids for upstream and downstream migrations and is also used for seasonal spawning and rearing habitat.

Within the 14 known fish bearing tributary streams in the Lower Subbasin, only 9.5 miles of habitat is accessible to anadromous salmonids (Brown 1988). The steep channel gradient limits access to anadromous salmonids to only the lowermost reaches of these tributary streams. The most important tributary streams (based on amount of available habitat) in the Lower Subbasin for anadromous salmonids are Bridge, Emerald (Harry Weir), Tom McDonald, and McArthur Creeks. These four creeks comprise 78% of the tributary stream habitat available to anadromous salmonids in the Lower Subbasin. Resident populations of coastal cutthroat and rainbow trout are found upstream of anadromous tributary reaches. It is unclear how these resident populations interact with anadromous stocks.

Table IV- 44. Lower Subbasin stream species present, and number of stream miles accessible to anadromous salmonids.

Stream	Species Observed		Stream Length Access (mi.)	References
Bridge Creek	Chinook coho coastal cutthroat steelhead sculpin sp.	Pacific lamprey yellow-legged frog western toad Pacific giant salamander	4.5	CDFG 2001 & 1966 Stream Surveys, Brown 1988 (Hofstra personal communication), USFS/RNSP barrier study notes.
Emerald (Harry Wier)	steelhead coastal cutthroat coho	Sculpin spp. Pacific giant salamander	1.8	Ridenhour and Hofstra 1994, Brown 1988, and RNSP/USFS-RSL revisit of 1981 thesis sites
Tom McDonald Creek	Chinook coho steelhead cutthroat/steelhead coastal cutthroat	pacific lamprey sculpin spp. Pacific giant salamander	1.30	RNP 2000 surveys, , Neillands 1990, Brown 1988, RNP/USFS-RSL revisit of 1981 thesis sites field notes, CDFG 1966 stream survey
McArthur Creek	coho steelhead coastal cutthroat cutthroat/steelhead sculpin spp.	Pacific giant salamander tailed frog yellow-legged frog	0.50	RNSP 2001, Forest Science Project 2000, RNSP/USFS-RSL barrier study - 1995 notes, Neillands 1990, Brown 1988
Copper Creek	steelhead		0.31	Brown 1988
Elam Creek	coho coastal cutthroat steelhead	cutthroat/rainbow sculpin sp.	0.31	RNSP 2001, Forest Science Project 2000, Neillands 1990, Brown 1988
Cloquet Creek	coastal cutthroat steelhead sculpin sp.	tailed frog yellow-legged frog	N/A	RNSP 2000
Devils Creek	steelhead Pacific giant salamander	tailed frog yellow-legged frog	0.19	Neillands 1990 and Brown, 1988
Fortyfour Creek	cutthroat trout steelhead sculpin sp.	Pacific giant salamander	0.19	USFS/RNSP barrier study notes, CDFG 2001 stream surveys, Neillands 1990, Brown 1988
Hayes Creek	steelhead coastal cutthroat	Pacific giant salamander yellow-legged frog		USFS/RNSP Barrier study notes 1996
Bond Creek	coastal cutthroat steelhead	cutthroat/rainbow trout	0.12	Neillands 1990, Brown 1988
Slide Creek	steelhead		0.12	Brown 1988
Dolason Creek	steelhead		0.12	Brown 1988
Miller Creek	steelhead		0.12	Brown 1988
Redwood Creek	Chinook coho coastal steelhead	steelhead eulachon	17.2	CDFG 2001 Stream Surveys, Gerstrung 2001, RNSP 2001, 1989, Anderson 2000, Ridenhour and Hofstra 1994, Brown 1988, Hallock et al. 1952.

Past Surveys

Based on review of air photos, CDFG reports, and anecdotal accounts, it is clear that historic conditions of the Lower Subbasin were quite different than today. In the past, the mainstem channel was cooler, narrower and riparian forests containing large redwoods lined the riverbanks. Shade from these large trees likely worked in

combination with cool tributary inflows, a cooler mainstem from upstream sources, and other cool water sources to provide desirable water temperatures for summer rearing salmonids. The large trees also provided a source of LWD to help maintain channel diversity, complexity, and nutrient inputs to the aquatic ecosystem.

Hallock et al. (1952) described how the lower mainstem was once a productive year round salmonid nursery area. In an effort to collect juvenile coho salmon for a three-state fingerling marking program, they noted that "Little River and Redwood Creek were both excellent silver (coho) salmon streams, but were not seined extensively because in the few places where they could be reached by road, the pools were so deep as to make netting impractical". "However, these streams made good planting places and received more fish than were taken from them." More than 10,000 marked YOY coho were released (May 14 through July, 21 1951) into the mainstem Redwood Creek (Hallock et al. 1952). This information suggests that juvenile coho were rearing during summer in the lower mainstem Redwood Creek. Water temperature in Redwood Creek was cold enough to support coho salmon in July 1951, and that pools along the lower reach of Redwood Creek were deep. This is a significant difference compared to present conditions.

Following the major flood of December 1964, conditions in Redwood Creek changed drastically. Fisk et al. (1966) stated that the lower mainstem of Redwood Creek was "in a severely damaged condition" and was "largely unsuitable" as a nursery for young salmon and steelhead. As a result of sediment deposition, "the streambed has widened and rose" and pools were filled.

In 1966, CDFG surveyed the lower four miles of Bridge Creek and reported that fish presence was limited to a few steelhead and cutthroat trout in lower reach. There was a "moderate abundance of resident cutthroat in last mile of survey." The lower three miles contained scarce pools, logging debris in the channel, little streamside canopy, and the bottom was 26-50% covered by silt. The upper mile contained better habitat conditions. There was a low abundance of aquatic insects. A large debris jam located approximately 0.8 miles up stream of the confluence with Redwood Creek blocked anadromous fish passage for the remaining 3.7 miles of anadromous fish habitat. Similar to other debris jams in the basin, a large store of sediment had accumulated behind the structure (in 1971 over 20,000 cubic yards was estimated). Prior to the jam formation, timber harvest activities occurred along upper reaches of Bridge Creek. Roads were built along the stream bank, and logs were tractor yarded through the channel (RNSP staff personal communication). Modifications to remove the debris jam were made between 1971 and 1990. The final treatment in 1990 consisted of the development of a fishway, removal of seven feet of debris to moderate movement of sediment downstream into salmonid spawning habitat, and placement of LWD at four sites to scour excessive sediments stored above the debris jam and develop pool habitat. During spawner surveys conducted in the fall of 1990, adult Chinook and coho salmon were seen above the former migration barrier. The presence of anadromous salmonids above the former barrier showed successful removal of a passage barrier and return of lost habitat to the fish. Additional past stream survey summaries of Lower Subbasin tributaries are provided in Appendix D.

Present Surveys

Stream habitat inventories were conducted in September 2001 at nine randomly selected sampling sites located in the Lower Subbasin. Three sites were located on tributary streams (Bridge, Elam, and Fortyfour creeks) and six sites were located along the mainstem Redwood Creek (Figure IV- 28). The sampling sites were inventoried using CDFG protocols, sampling 100% of the selected reach. Unlike the typical CDFG stream inventory of anadromous reaches (Flosi et al. 1998), these data only attribute specific to sample sites and not entire stream reaches available to anadromous salmonids. Results from select stream habitat components for Redwood Creek and tributary sites are summarized below. Further discussions of present conditions of Lower Subbasin streams are provided in Appendix D.

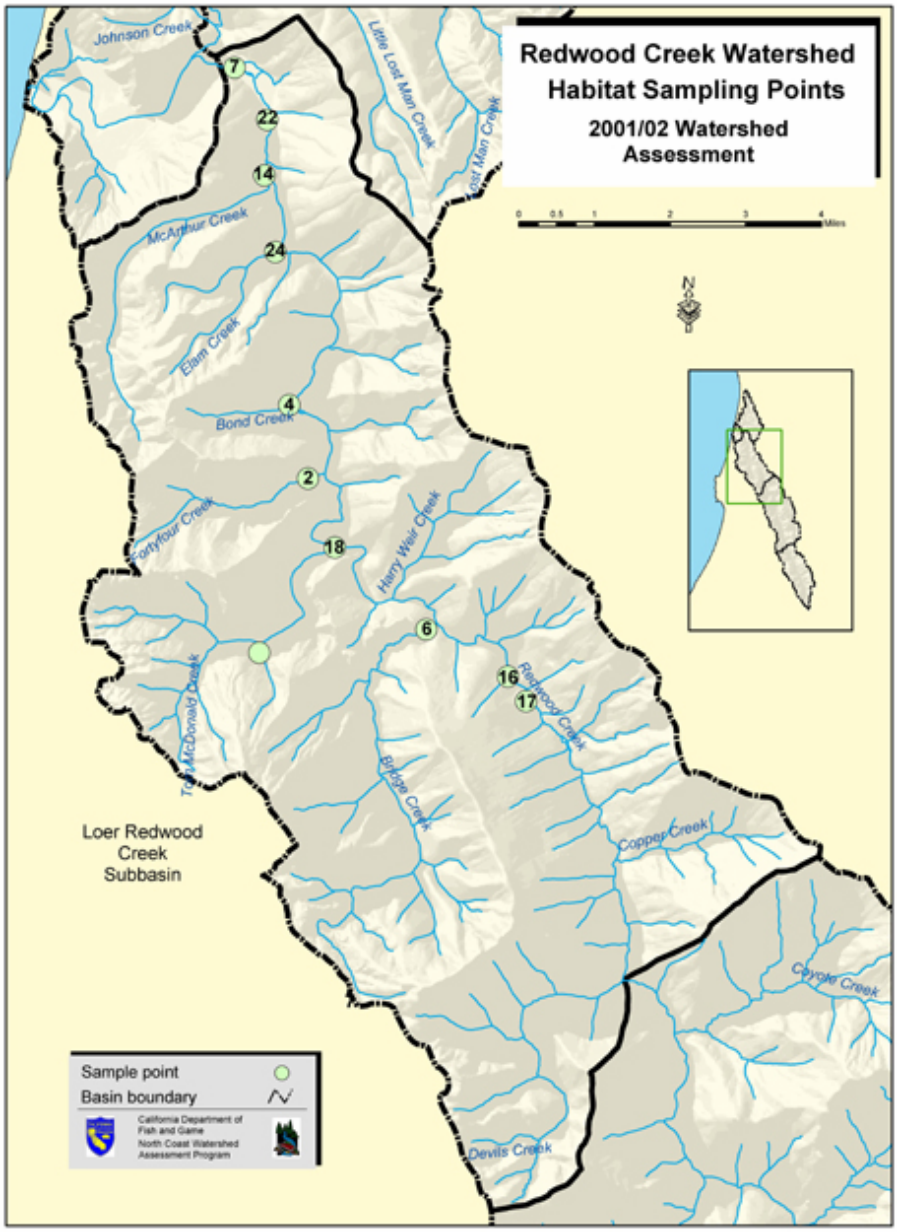

Figure IV- 27. Lower Subbasin instream habitat sampling points.

Stream Reach Characteristics

Pool:Riffle:Run Relationships

Significance: Productive anadromous streams are composed of a balance of pool, riffle and run habitat and each plays an important role as salmonid habitat. Looking cumulatively at pool, riffle, and run relationships and bank full width (BFW) to pool frequency ratios helps characterize the status of these habitat types and also provides a measure of stream habitat diversity and suitability for fish. A pool: riffle ratio of approximately 1:1 is suggested as a desirable condition for most wadable, anadromous, fish bearing streams, but it is not applicable for evaluating salmonid suitability of all stream reaches and channel types (Rosgen 1996). However, pool:riffle relationships showing an over abundance of riffles or runs that may indicate aggraded channel conditions or lack of scour objects needed for pool formation. Pool frequency can be measured as a ratio of the number of bank full widths (BFW) per pool in a stream reach. Pool to pool spacing in many redwood forest streams ranges from approximately 2 to 7 BFWs and is often controlled by LWD (Keller and MacDonald 1981). In straight and meandering streams, pools are also often spaced more or less regularly at a repeating distance of 5 to 7 BFWs (Leopold 1994).

In mainstem Redwood Creek sample reaches, run type habitat was the most abundant habitat type. The mean percent length for the Redwood Creek sites was 16% pools, 10% riffle, 57% run, and 15% dry (Table IV- 45). Sites 4 and 17 had the largest amount of pool habitat of all the Redwood Creek sites of the Lower Subbasin. The other sites showed a general lack of pool habitat. The stream survey team found that the lowermost Redwood Creek sample site 7 was completely dewatered on September 16, 2001. This is likely due to a low water year and the aggraded channel conditions. The BFW to pool ratios generally appear within a desirable range, however BFW to pool ratios may be perplexed, due to the present widened condition of the mainstem Redwood Creek influencing the ratio calculations.

The three tributary sampling sites in the Lower Subbasin yielded a mean length of 27% pool, 37% riffle, and 35% run habitat (Table IV- 45). The 27% of stream length in pools is below a desirable range for amount of pool habitat (40%) according to Flosi (1998). The pool frequency of approximately 31% of habitat units by occurrence and the mean BFW to pool ratio of 4:1 for tributary sample sites are within the desirable range suggested by the NCWAP team. These data suggest that the number of pools is within a desirable range, but the pools are somewhat short in length.

Table IV- 45. Lower Subbasin percent occurrence and percent by length of pool, run, riffle, and dry habitats in the.

Stream Reach	Stream Order	Reach Length (ft.)	Pool, Rifle, Run% Occurrence	Pool: Riffle: Run% total length	Estimated BFW (ft)	BFW to Pool ratio	Dry (% total length)
Bridge Creek Site 8	3	1,249	31 : 36 :31	29 : 38 : 32	61	2 : 1	0
Elam Creek Site 24	2	513	31 : 23 : 46	30 : 21 : 49	16	4 : 1	0
Fortyfour Creek Site 2	2	597	32 : 41 : 27	19 : 50 : 31	21	4 : 1	0
Tributaries Mean			**31 : 33 : 35**	**27 : 37 : 35**		**3 : 1**	**0**
Redwood Creek Site 14	4	1,819	25 : 0 : 75	14 : 0 : 86	78	23 : 1	
Redwood Creek Site 7	4	1,500	Dry channel	-	NA*	-	100
Redwood Creek Site 22	4	2,065	17 : 33 : 50	3 : 17 : 80	NA	-	
Redwood Creek Site 4	4	1,608	35 : 24 : 41	41 : 19 : 40	308	0.4 : 1	
Redwood Creek Site 18	4	1,566	23 : 41 : 26	8 : 18 : 74	392	1 : 1	
Redwood Creek Site 17	4	1,508	27 : 14 : 59	32 : 6 : 61	105	2 : 1	
Redwood Creek Mean			**25 : 22 : 50**	**16 : 10 : 57**		**7 :1**	**15**

* BFW Not Available

Pool Depth

***Significance*:** Pool depth and frequency are fundamental attributes of channel morphology and are largely dependent on the presence of large roughness elements such as large woody debris (LWD), bedrock, and boulders in addition to channel type, stream gradient, sinuosity, and channel width. Evaluating the amount of deep pool habitat in a stream reach helps assessment of important channel characteristics for salmonids. Deep pools are especially important as year round rearing habitat for coho salmon, summer steelhead, coastal cutthroat trout and holding habitat for adult salmonids of all species (especially summer steelhead) returning to spawn. Lack of deep pools in forest streams may indicate a disruption to channel forming processes by a lack of LWD and/or elevated levels of stored sediments.

The percent of stream reach of the mainstem Redwood Creek composed of moderately deep pools was below the desirable range at all sample sites in the Lower Subbasin (Figure IV- 28 and Table IV- 46). The mean maximum depth for all pools measured on Redwood Creek was 3.4 feet. The deepest pool (11.8 ft.) was found at Redwood Creek site 17. Redwood Creek site 7 was surveyed as a dry channel, therefore no pools were measured. Redwood Creek site 4 had the most pool type habitat, but the majority of pools were less than 3 feet maximum depth.

The mean maximum depth for all pools measured from the 2nd order tributary sites was 1.9 feet. However the Elam Creek site had two pools greater than 3 feet maximum depth which accounted for approximately 18% of the survey length. Bridge Creek, a 3rd order site, had a mean maximum pool depth of 2.9 feet. The shortage of deep pool habitat is indicative of channel aggradation due to accumulations of sediments and a deficiency of LWD, boulders or other scour objects to create and maintain desirable pool habitat. Some stream reaches may not meet the general target values for pool depths, but still may provide important fish habitat.

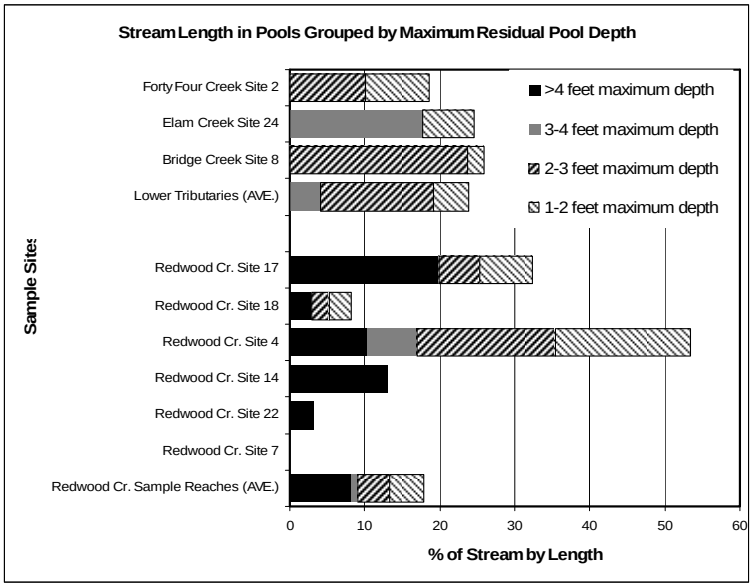

Figure IV- 28. Lower Subbasin percent of sample reaches in pools.
Grouped by maximum residual pool depth and tributaries combined and all sample sites on lower Redwood Creek combined.

Table IV- 46. Lower Subbasin mean maximum pool depths for sample reaches 2001.

Lower Subbasin Maximum Pool Depths	1st & 2nd Order streams (Elam and Fortyfour)	3rd Order stream (Bridge Creek)	4th Order stream (Redwood Creek)
Mean Maximum Depth	1.9	2.25	3.4
Standard Error	0.230	0.128	0.4196
Minimum Max Depth	0.9	1.5	1.3
Maximum Depth	3.2	2.9	11.8
Number of Pools Measured	13	10	28

Pool Shelter

***Significance*:** The pool shelter rating is a relative measure of the quantity and percent composition of LWD, root wads, boulders, undercut banks, bubble curtains, and submersed or overhanging vegetation in pool habitats. These elements serve as instream habitat, create areas of diverse velocity, provide protection from predation, and separate territorial units to reduce density related competition. The ratings are measured in pool and flatwater habitat units. The rating does not consider factors related to changes in discharge, such as water depth.

Sampling sites located in Elam, Fortyfour Creeks, and Redwood Creek sample sites were generally lacking in pool shelter complexity (Figure IV- 29). The Bridge Creek sample site had the highest amount of shelter elements. The pool shelter elements were dominated by woody debris and boulders (Table IV- 47). Stream habitat improvement work was recently done in Bridge Creek to increase pool habitat and shelter complexity, but this work was not within the sampling site boundaries.

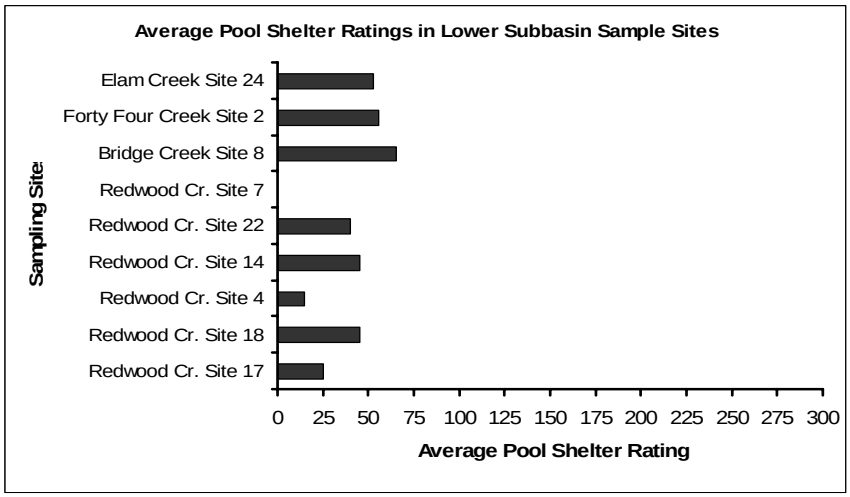

Figure IV- 29. Average pool shelter ratings.

From CDFG Sample Reaches, Lower Subbasin. Average pool shelter ratings exceeding 100 are considered desirable and average pool shelter ratings less than 30 are viewed as unsuitable.

Table IV- 47. Summary of mean percent cover.

Lower Subbasin	Undercut Banks	Woody Debris	Terrestrial Vegetation	Aquatic Vegetation	White-water	Boulders	Bedrock Ledges
Tributary Streams							
Bridge Creek		2				1	
Elam Creek		1	2				
Fortyfour Creek		1				2	
Mainstem Redwood Creek							
Redwood Ck site 18	2	1				2	
Redwood Ck site 17					2	1	
Redwood Ck site 4		2				1	
Redwood Ck site 22		1				2	
Redwood Ck site 14	2					1	

Dominant (1) and subdominant (2) shelter types in pool and flatwater units in the Lower Subbasin. See figures located in Appendix D for detailed explanation.

Streamside Canopy Density

***Significance*:** Streamside canopy density is a measure of the percentage of wetted stream that is shaded by riparian tree canopy. Tree canopy provides shade to reduce direct sun light from warming water, provides a source of nutrients in the form of terrestrial insects, organic debris, and leaf litter, and contributes to LWD loading to stream channels. The roots of riparian vegetation also help maintain soil and stream bank stability. Generally, riparian management projects are considered when canopy density is less than 80% or when a low percent of the canopy is composed of coniferous trees in forested streams (Flosi et al. 1998).

The average canopy density over the mainstem Redwood Creek was only 30% (Figure IV- 30). The wide channel of the mainstem and the historical harvest of streamside conifers have prevented the riparian canopy from providing shade on large areas of Redwood Creek. Early timber harvest typically removed large and shade producing near stream conifers. The lack of old growth Douglas-fir and redwood resulted in less shade along the channel and contributed to increasing water temperatures (Urner and Madej 1998). The low percent of canopy from coniferous trees along the Redwood Creek mainstem and in Elam Creek also means the future supply of coniferous LWD to the channel will be low. Conifers are preferred LWD because hardwoods that fall into stream channels are smaller, decay faster, and are less capable of providing enduring stream forming structures. However, the riparian corridor is undergoing recovery as trees become re-established and grow within the near stream forests. But many years are needed for conifers to achieve the large size need to provide shade and LWD that will function in the mainstem.

The average stream canopy density at the Bridge Creek, Elam Creek, and Fortyfour Creek sites are all above the 80% standard considered sufficient to moderate the direct heating from direct sunlight on stream water (Figure IV- 30).

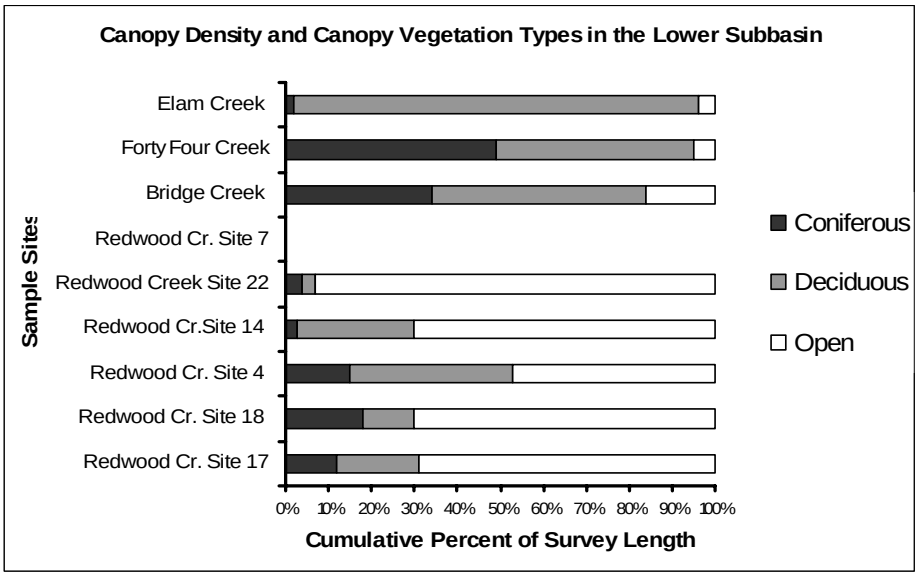

Figure IV- 30. Lower Subbasin percent stream canopy density and percent vegetation type contributing to shade canopy.

Spawning Cobble Embeddedness

***Significance*:** Percent cobble embeddedness estimates substrate suitability for spawning, egg incubation, and fry emergence. Generally, cobble embeddedness of 0-25% is considered good quality for spawning (Flosi et al. 1998). Excessive accumulations of fine sediments (>50%) reduce water flow (permeability) through gravels in redds which may suffocate eggs or developing embryos. Excessive levels of fine sediment accumulations over gravel and cobble substrate also may alter insect species composition and food availability for growing fish. High embeddedness ratings also may indicate elevated levels of erosion occurring in the watershed. The percent of fine sediments is higher in watersheds where the geology, soils, precipitation, or topography favor erosional processes (Duncan and Ward, 1985). Fine sediments also are typically more abundant where land use activities such as road building or land clearing expose soil to erosion and increase mass wasting (Cederholm et al. 1981; Swanson et al. 1987; Hicks et al. 1991). Sedimentation resulting from land use activities is recognized as a fundamental cause of salmonid habitat degradation (FEMAT, 1993). Other factors such as bed mobility are also important to determine the quality of spawning substrate.

The majority (> 70%) of pool tails measured from the mainstem Redwood Creek sites were in the 25 to 50% cobble embeddedness range (Figure IV- 31). Only one pool tail sampled from the Redwood Creek sites was in favorable condition and considered good salmonid spawning habitat as measured by embeddedness estimates. This pool tail was located in site 14.

Only 10% of pool tails in Bridge Creek are considered in favorable condition. All of the pool tails sites sampled in Fortyfour Creek were either in poor condition with highly embedded, small gravels or unusable for spawning because of the presence of bedrock substrate. The relatively highly embedded substrate observed from pool tails in tributary sample sites are indicative of excessive fine sediments entering tributary stream channels. These sediment sources should be identified and treated to reduce sediment generation and delivery to streams. Other tributary streams in the subbasin may have similar cobble embeddedness levels and they also may need sediment reduction treatments.

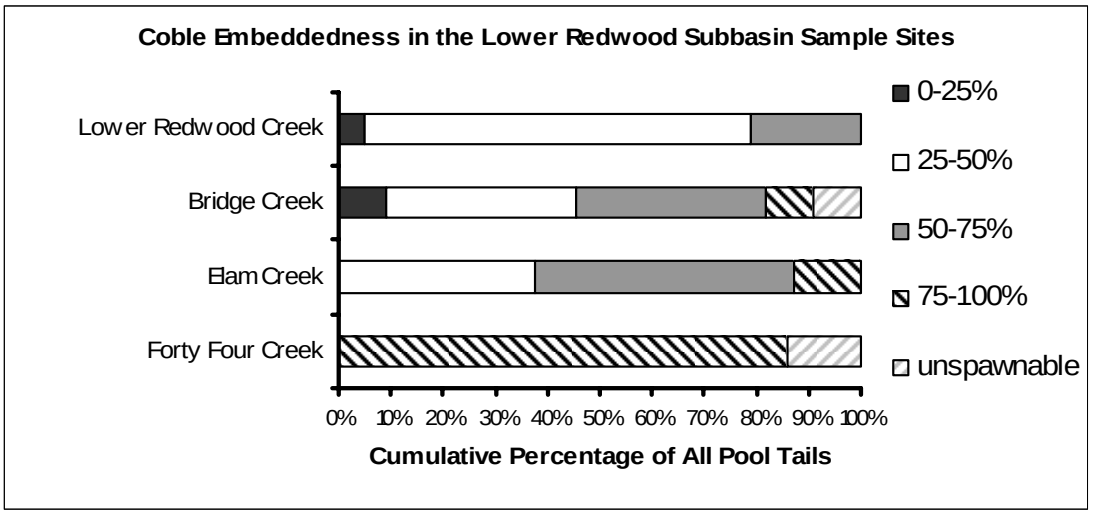

Figure IV- 31. Lower Subbasin cobble embeddedness categories measured at pool tail crests, sampling sites.
Unspawnable is due to factors other than embeddedness (e.g. logs, sand substrate, or bedrock).

Salmonid Fishery Resources

Chinook Salmon

Chinook salmon were observed throughout spawning survey efforts performed on Bridge and Tom McDonald creeks by RNSP staff from 1982- 1994 (Table IV- 48 and

Table IV- 49). The greatest numbers of live Chinook were counted in the 1985/1986 and 1987/1988 seasons, 272 and 94 respectively. The 1985/86 counts of Chinook reflect large returns of Chinook coast wide. As noted in the Prairie Creek Subbasin, Chinook numbers observed during spawner surveys in the Lower Subbasin declined during the drought years of 1988 through 1994 when from 0 to 20 Chinook were observed. No recent spawner surveys have been conducted in these streams.

Small numbers of YOY Chinook salmon were noted by IFWM survey crews in the lower portions of Bridge and Tom McDonald Creeks in 2001 and 2002 surveys (D. McCanne and B. Reisberger, IFWM personal communication). Four YOY Chinook were observed from Bridge Creek August 22, 2001 and seven were observed on September 18, 2002. Four YOY Chinook were observed on Tom McDonald Creek July 3, 2001 and ten were noted on August 27, 2002 (D. McCanne and B. Reisberger personal communication). Juvenile Chinook rearing in streams over summer is a behavioral strategy that has been recently observed in few streams of Redwood Creek. These fish may have been too small to perform downstream migrations in the spring. The importance of this behavior is unclear, however maintaining diversity of juvenile life history strategies, such as over summer rearing, helps to insure survival of any given year class and may be important to sustain the species.

Steelhead

Steelhead are the most widely distributed salmonid species in the Lower Subbasin. They are found in all fourteen anadromous fish bearing tributary streams in the subbasin and in the mainstem Redwood Creek. CDFG crews conducting stream surveys for NCWAP in 2001 reported that juvenile steelhead densities appeared relatively low in Lower Subbasin sampling sites located in Fortyfour Creek (site 2), Bridge Creek (site 8), and Elam Creek (site 24) (Appendix D). Currently there is little known about population abundance or population trends for steelhead of the Lower Subbasin.

Coho Salmon

Generally coho populations appear depressed in Lower Subbasin streams. Past surveys have produced varying numbers of juvenile coho salmon in Bridge, Emerald Tom McDonald, McArthur, Elam, and Redwood creeks. Fish surveys conducted in 2001 by the CDFG and the Institute for Forest and Watershed Management (IFWM)

using CDFG ten-pool-protocol observed 536 juvenile coho salmon in Tom McDonald Creek and 280 in 2002. In Bridge Creek, juvenile population estimates using single pass snorkel counts were 24 in 2001 and 1,264 ± 513 in 2002 (D. McCanne, IFWM personnel communication).

During adult spawner surveys conducted on Bridge Creek only three live adult coho were seen in twelve seasons (1985/86 – 1992/93) and only two live coho were observed on Tom MacDonald Creek (Table IV- 48 and Table IV- 49). No coho carcasses were noted 1982-1993 in either stream. Spawner surveys have not been conducted from 1994 to 2001 on Tom McDonald Creek. Bridge Creek was surveyed once on December 3, 1997 and March 4, 1998 (D. Anderson, RNSP, personal communications). During that survey one female coho carcass was found at the mouth of Bridge Creek. Little is known about population abundance or population trends for coho of the Lower Subbasin.

Table IV- 48. Bridge Creek spawning survey results 1982-1994.

Spawning Season	# of Surveys	Live Fish				Carcass Type												Redds	
						Chinook			Coho			Steelhead			Unknown				
		Chin	Coho	Shd	Unk	F	M	Unk	F	M	Unk	F	M	Unk	F	M	Unk	Def	?
1982/1983	3	8			12	1	2											1	
1983/1984	4	19		33		4	1	4										4	
1984/1985	11	16		126			1							1			2	6	
1985/1986	8	272		6		23	20	4							4			4	
1986/1987	2	6		4		1	1											6	
1987/1988	9	94		4	5	15	5							1			7	16	
1988/1989	5	6		12		1		1									1	8	
1989/1990	4			7													1	7	1
1990/1991	4	8		8	1	1	1											5	3
1991/1992	3	1	1	7	3	1	1	1					1					15	6
1992/1993	4	4		8	4			1										10	1
1993/1994	4	20	2	1	17	1	1											22	3

chin = Chinook salmon, Coho = coho salmon, Shd = steelhead trout, Unk = unknown species or sex; F = female, M = male, and Unk = unknown sex; Def = definite and ? = questionable
Summarized from RNSP surveys.

Table IV- 49. Spawning survey results for Tom McDonald Creek, 1982-1994.

Spawning Season	# of Surveys	Live Fish				Carcasses				Redds
		Chin	Coho	Shd	Unk	Chinook	Coho	Steelhead	Unknown	
1982/1983	3	4	0	0		0	0			1
1983/1984	2	4	0	0		7	0			0
1984/1985	1	1	0	0		1	0			0
1985/1986	0	No surveys performed								
1986/1987	0	No surveys performed								
1987/1988	3	3	0	3		3	0			4
1988/1989	0	No surveys performed								
1989/1990	0	No surveys performed								
1990/1991	0	No surveys performed								
1991/1992	2	0	0			0	1			16
1992/1993	1	0	0	2		0	0			7
1993/1994	3	0	2			0	0	1		9

chin = Chinook salmon, Coho = coho salmon, Shd = steelhead trout, Unk = unknown species or sex; F = female, M = male, and Unk = unknown sex; Def = definite and ? = questionable Summarized from RNSP surveys.

Lower Subbasin General Issues

The current land use is primarily for preservation and protection of natural resource values and recreation:

- The Lower Redwood Creek Subbasin was made part of the Redwood National and State Park system in 1978.

Prior to 1978, approximately 68% of the landscape was harvested for timber resources:

- Adverse impacts from legacy timber harvests are still affecting mainstem and tributary stream habitat.

The lower reach of Redwood Creek is a low gradient, depositional reach which accumulates excessive sediments derived from upstream sources:

- The aggraded channel condition contributes to elevated water temperatures, a widened channel, and an overall lack of channel diversity and complexity in Redwood Creek;
- During the summer months of recent low rain years (2001 and 2002) the lowermost reach of Redwood Creek became intermittent or dry from the Highway 101 bridge up to the confluence with Hayes Creek, loosing connection with the estuary. In a recent newspaper article in the McKinleyville Press (2002), it was noted by a local resident since 1945 that Redwood Creek has never been so low.

Impairments to freshwater habitat needed to complete salmonid freshwater life cycles have been identified as a leading factors in the decline of Redwood Creek's anadromous salmonids:

- Mainstem Redwood Creek water temperatures exceed favorable limits for salmonid production;
- Anecdotal accounts by long time residents indicate that water temperature was much colder in Redwood Creek before 1964;
- Lower Subbasin tributaries provide water temperature that supports salmonids;
- A lack of instream large woody debris (LWD) contributes to poor aquatic habitat structure including a low number of deep, complex pools;
- LWD recruitment potential to Lower Subbasin appears low at most locations;
- Stream habitat conditions in the Lower Subbasin can be improved.

Integrated Analysis and Cumulative Effects

Between 1950 and 1978 approximately 70% of the Lower Subbasin was harvested for timber and many miles of poorly designed road were constructed. The subbasin has been managed by RNSP since 1978, so no recent timber harvests have occurred. Removal of haul roads has been a major focus of RNSP management activities. Although these treated roads still show evidence of erosion features, sediment yields to streams are less than from the abandoned roads prior to treatments (Madej 2000).

Comparisons of the planning watersheds shows historically active landslide features are not evenly distributed across the subbasin (Table IV- 50). The characteristics of the underlying bedrocks units on each side of the Grogan Fault are factors influencing the distribution and type of landslide features. The Copper Creek Planning Watershed has almost twice the percentage of area in historically active landslide features as the subbasin as a whole. These are primarily earth flows which are not considered as significant contributors of sediments to streams over the short term. However land use on earth flows can exacerbate debris flows and debris slides which are believed the source of most recent sediment delivery to streams. In total, about 160 acres (0.4%) of the subbasin was identified as debris flows and debris slides. The Bridge Creek Planning Watershed has the largest area (84 acres) in debris flows and debris slides in the subbasin. Bridge Creek and Copper Creek planning watersheds had the most land in timber harvests prior to the park expansion suggesting a link between land use activities and debris flow and debris slides occurrence.

Table IV- 50. Acres and percent area of historically active landslide features associated with land type or use.

Subbasin or Planning Watershed	Historically Active Landslide Feature[1]	Entire Subbasin or Planning Watershed		Woodland and Grassland[2]		THPs 1991 – 2000		Timberland, No Recent Harvest		Roads [3]	
		Area (acres)	% of Area	Area (acres)	% of Area	Area (acres)	% of Area	Area (acres)	% of Area	Length (miles)	% of Total Length
Lower Redwood Creek Subbasin (44,479 acres) (137.9 road miles)	Earthflow	1,762	4.0	270	0.6	0	0.0	1,485	3.3	3.7	2.7%
	Rock Slide	740	1.7	0	0.0	0	0.0	740	1.7	2.9	2.1%
	Debris Slide	82	0.2	3	0.0	0	0.0	75	0.2	0.2	0.1%
	Debris Flow	78	0.2	0	0.0	0	0.0	77	0.2	0.1	0.1%
	All Features	2,662	6.0	274	0.6	0	0.0	2,377	5.3	7.0	5.0%
Bond Creek (8,196 acres) (27.2 road miles)	Earthflow	271	3.3		0.0		0.0	271	3.3	1.9	7.2%
	Rock Slide	174	2.1		0.0		0.0	174	2.1	0.7	2.5%
	Debris Slide	21	0.3		0.0		0.0	19	0.2	0.1	0.2%
	Debris Flow	11	0.1		0.0		0.0	11	0.1	0.0	0.0%
	All Features	477	5.8	0	0.0	0	0.0	475	5.8	2.7	9.9%
Bridge Creek (15,047acres) (40.1 road miles)	Earthflow	363	2.4		0.0		0.0	363	2.4	1.1	2.9%
	Rock Slide	538	3.6		0.0		0.0	538	3.6	2.1	5.2%
	Debris Slide	29	0.2		0.0		0.0	28	0.2		0.0%
	Debris Flow	55	0.4		0.0		0.0	55	0.4	0.0	0.1%
	All Features	985	6.5	0	0.0	0	0.0	984	6.5	3.3	8.2%
Copper Creek (10,022 acres) (8.6 road miles)	Earthflow	1,126	11.2	270	2.7		0.0	849	8.5	0.6	7.6%
	Rock Slide		0.0		0.0		0.0		0.0		0.0%
	Debris Slide	19	0.2	3	0.0		0.0	14	0.1	0.0	0.1%
	Debris Flow	4	0.0	0	0.0		0.0	3	0.0		0.0%
	All Features	1,149	11.5	274	2.7	0	0.0	867	8.7	0.7	7.6%
Devil's Creek (4,404 acres) (27.2 road miles)	Earthflow	2	0.0		0.0		0.0	2	0.0%		0.0%
	Rock Slide		0.0		0.0		0.0		0.0%		0.0%
	Debris Slide	4	0.1		0.0		0.0	4	0.1%	0.1	0.5%
	Debris Flow	2	0.0		0.0		0.0	2	0.0%		0.0%
	All Features	8	0.2	0	0.0	0	0.0	8	0.2%	0.1	0.5%
McArthur Creek (6,810 acres) (34.9 road miles)	Earthflow		0.0		0.0		0.0		0.0%		0.0%
	Rock Slide	28	0.4		0.0		0.0	28	0.4%	0.2	0.5%
	Debris Slide	9	0.1		0.0		0.0	9	0.1%		0.0%
	Debris Flow	6	0.1		0.0		0.0	6	0.1%	0.0	0.1%
	All Features	43	0.6	0	0.0	0	0.0	42	0.6%	0.2	0.6%

[1] Refer to Plate 1 and California Geological Survey appendix. Areas of disrupted ground are not included as active landslide features in this analysis. These areas are likely underlain by earthflow or rockslide complexes. If so, this would substantially increase the miles of roads and area of land type and land use on active landslide features.
[2] Woodland and grassland includes areas mapped in 1998 as grassland and non-productive hardwood.
[3] Table IV- 50 does not accurately represent the present number of road miles in the subbasin. Most of the logging roads in the Lower Subbasin have been removed by the RNSP (G. Bundros RNSP, personal communication).

Areas of high and very high relative landslide potential comprise about 71% of the subbasin (Table IV- 51). The vast majority occurs on forestlands (68%). Looking across the subbasins, McArthur Creek stands out for having a relatively low percentage (58.4%) of its area in the high and very high landslide potential classes.

Table IV- 51. Lower Subbasin acres and percent of area by relative landslide potential and land use or type classes.

Subbasin or Planning Watershed	Relative Landslide Potential[1]	Entire Subbasin or Planning Watershed		Woodland or Grassland[2]		THPs 1991 – 2000		Timberland, No Recent Harvest[3]		Roads	
		Area (acres)	% of Area	Area (acres)	% of Area	Area (acres)	% of Area	Area (acres)	% of Area	Length (miles)	% of Total Length
Lower Redwood Creek Subbasin (44,479 acres) (137.9 road miles)	Very Low	2,666	6.0	92	0.2			2,172	4.9	17.7	12.8
	Low	3,028	6.8	96	0.2			2,905	6.5	14.0	10.2
	Moderate	7,259	16.3	96	0.2			7,144	16.1	30.6	22.2
	High	17,431	39.2	676	1.5			16,734	37.6	49.7	36.0
	Very High	14,033	31.5	25	0.1			13,468	30.3	26.0	18.9

Subbasin or Planning Watershed	Relative Landslide Potential[1]	Entire Subbasin or Planning Watershed		Woodland or Grassland[2]		THPs 1991 – 2000		Timberland, No Recent Harvest[3]		Roads	
		Area (acres)	% of Area	Area (acres)	% of Area	Area (acres)	% of Area	Area (acres)	% of Area	Length (miles)	% of Total Length
	High/Very High Subtotal	31,464	70.7	701	1.6			30,202	67.9	75.7	54.9
	TOTAL	44,417	100%	985	2%	0	0%	42,423	95%	138.0	100%
Bond Creek (7,678 acres) (27.2 road miles	Very Low	389	4.7	1	0.0			295	3.6	2.0	7.3
	Low	378	4.6	1	0.0			374	4.6	1.7	6.2
	Moderate	1,273	15.5	0	0.0			1,267	15.5	5.4	19.8
	High	3,359	41.0	1	0.0			3,353	40.9	10.7	39.2
	Very High	2,783	34.0		0.0			2,778	33.9	7.5	27.5
	High/Very High Subtotal	6,142	74.9	1	0.0			6,131	74.8	18.2	66.7
	TOTAL	**8,182**	**100%**	**3**	**0%**	**0**	**0%**	**8,067**	**98%**	**27.3**	**100%**
Bridge Creek (15,047 acres) (40.1 road miles)	Very Low	780	5.2	8	0.1			647	4.3	6.0	15.0
	Low	1,033	6.9	18	0.1			999	6.6	4.6	11.5
	Moderate	2,326	15.5	5	0.0			2,313	15.4	12.0	29.9
	High	6,146	40.8	129	0.9			6,002	39.9	10.7	26.7
	Very High	4,731	31.4	9	0.1			4,708	31.3	6.9	17.2
	High/Very High Subtotal	10,877	72.3	138	0.9			10,710	71.2	17.6	43.9
	TOTAL	**15,016**	**100**	**169**	**1%**	**0**	**0%**	**14,669**	**97%**	**40.2**	**100%**
Copper Creek (10,022 acres) (8.6 road miles)	Very Low	266	2.7	73	0.7			143	1.4	1.7	19.8
	Low	630	6.3	73	0.7			551	5.5	1.3	15.1
	Moderate	1,740	17.4	89	0.9			1,648	16.4	1.6	18.6
	High	3,239	32.3	540	5.4			2,697	26.9	2.8	32.6
	Very High	4,134	41.2	14	0.1			3,609	36.0	1.2	14.0
	High/Very High Subtotal	7,373	73.6	554	5.5			6,306	62.9	4.0	46.5
	TOTAL	**10,009**	**100**	**789**	**8%**	**0**	**0%**	**8,648**	**86%**	**8.6**	**100%**
Devil's Creek (4,404 acres) (27.2 road miles)	Very Low	226	5.1	5	0.1			224	5.1	0.8	2.9
	Low	347	7.9	2	0.0			344	7.8	2.0	7.4
	Moderate	738	16.8	1	0.0			736	16.7	5.6	20.6
	High	2,087	47.4	3	0.1			2,086	47.4	14.1	51.8
	Very High	1,011	23.0	1	0.0			1,001	22.7	4.6	16.9
	High/Very High Subtotal	3,098	70.3	4	0.1			3,087	70.1	18.7	68.8
	TOTAL	**4,409**	**100%**	**12**	**0%**	**0**	**0%**	**4,391**	**100%**	**27.1**	**100%**
McArthur Creek (6,810 acres) (34.9 road miles)	Very Low	1,005	14.8	5	0.1			863	12.7	7.2	20.6
	Low	640	9.4	2	0.0			637	9.4	4.4	12.6
	Moderate	1,182	17.4	1	0.0			1,180	17.3	6.0	17.2
	High	2,600	38.2	3	0.0			2,596	38.1	11.4	32.7
	Very High	1,374	20.2	1	0.0			1,372	20.1	5.8	16.6
	High/Very High Subtotal	3,974	58.4	4	0.1			3,968	58.3	17.2	49.3
	TOTAL	**6,801**	**100%**	**12**	**0.1%**	**0**	**0%**	**6,648**	**98%**	**34.8**	**100%**

[1] Refer to Plate 1 and California Geological Survey appendix.
[2] Woodland and grassland includes areas mapped in 1998 as grassland and non-productive hardwood.
[3] Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
The number of miles of roads in this table does not accurately reflect present conditions in all listed planning watersheds. The majority or in some planning watersheds all of roads in the Lower subbasin have been removed by RNSP.

Table IV- 52 provides an integrated information summary for the lower Redwood Creek subbasin and its planning watersheds. It provides the reader the opportunity to compare a large number of factors across the watershed and subbasins and to look at potential interactions between disturbance factors and instream fish habitat.

Table IV- 52. Lower Subbasin integrated information summary.

Factor	Lower Redwood Subbasin		Planning Watersheds									
			Bond Creek		Bridge Creek		Copper Creek		Devil's Creek		McArthur Creek	
Relative Landslide Potential[1]	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Very Low	2,666	6%	389	4.8%	780	5.2%	266	2.7%	226	5.1%	1,005	14.8%
Low	3,028	7%	378	4.6%	1,033	6.9%	630	6.3%	347	7.9%	640	9.4%
Moderate	7,259	16.3%	1,273	15.6%	2,326	15.5%	1,740	17.4%	738	16.7%	1,182	17.4%
High	17,431	39.2%	3,359	41.1%	6,146	40.9%	3,239	32.4%	2,087	47.3%	2,600	38.2%
Very High	14,033	31.6%	2,783	34.0%	4,731	31.5%	4,134	41.3%	1,011	22.9%	1,374	20.2%
High/Very High Subtotal	31,464	71%	6,142	75%	10,877	72%	7,373	74%	3,098	70.3%	3,974	58%
GRAND TOTAL	**44,417**	**100%**	**8,182**	**100%**	**15,016**	**100%**	**10,009**	**100%**	**4,409**	**100%**	**6,801**	**100%**
Landslide and Selected Geomorphic Features	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Historically Active Landslide Features Total	2,662	6.0%	477	5.8%	985	6.6%	1,149	11.5%	8	0.2%	43	0.6%
Earthflow	78	0.2%	11	0.1%	55	0.4%	4		2		6	0.1%
Rock Slide	82	0.2%	21	0.3%	29	0.2%	19	0.2%	4	0.1%	9	0.1%
Debris Slide	1,762	4.0%	271	3.3%	363	2.4%	1,126	11.3%	2	0.0%	0	0.0%
Debris Flow	740	1.7%	174	2.1%	538	3.6%					28	0.4%
Dormant Landslide Features Total	5,263	11.8%	1,296	15.8%	2,101	14.0%	1,683	16.8%	104	2.4%	79	1.2%
Selected Geomorphic Features Total	5,540	12.5%	898	11.0%	1,017	6.8%	2,244	22.4%	671	15.2%	709	10.4%
Disrupted Ground	2,831	6.4%	128	1.6%	128	0.9%	2,115	21.1%	461	10.4%	0	0.0%
Debris Slide Slope	2,472	5.6%	770	9.4%	770	5.1%	88	0.9%	201	4.6%	643	9.5%
Inner Gorge (area)2	236	0.5%			119	0.8%	41	0.4%	10	0.2%	66	1.0%
Total of All Above Features	**13,465**	**30.3%**	**2,671**	**33%**	**4,103**	**27.3%**	**5,076**	**50.7%**	**783**	**17.8%**	**831**	**12.2%**
Other Land Uses	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Grazing	29	0.1%					29	0.3%				
Agriculture	0	0.0%										
Development	4	0.0%									4.1	0.1%
Timberland, No Recent Harvest	38,032	85.6%	8,067	99%	14,669	98%	8,648	86%			6,648	98%
TOTAL	**38,065**	**85.7%**	**8,067**	**99%**	**14,669**	**98%**	**8,677**	**87%**	**0**	**0.0%**	**6,652**	**98%**
Roads[5]												
Road Density (miles/sq. mile)	2.0		2.2		1.7		0.6		4.0		3.3	
Density of Road Crossings (#/stream mile)	0.1		0.1		0.1		0.1		0.3		0.4	
Roads within 200' of Stream (miles/stream mile)	0.1								0.1		0.2	
Factor	**Lower Redwood Subbasin**		**Planning Watersheds**									
			Bond Creek		**Bridge Creek**		**Copper Creek**		**Devil's Creek**		**McArthur Creek**	
Streams	**% stream length**		**% stream length**		**% stream length**		**% stream length**		**% stream length**		**% stream length**	
% Stream by Gradient												
< 1% (Response Reach)		17.8%		18.9%		7.7%		26.7%		0.0%		35.2%
1-4% (Response Reach)		10.4%		5.3%		14.1%		9.5%		0.0%		19.4%
4-20% (Transport Reach)		31.7%		47.3%		41.9%		30.5%		70.9%		32.2%
>20% (Source Reach)		40.1%		29.2%		36.2%		33.3%		29.1%		13.1%
Historically Active and Dormant Landslide and Selected Geomorphic Features[4]	% area	% stream length	% area	% stream length	% area	% stream length	% area	% stream length	% area	% stream length	% area	% stream length
Within 180' of Blue Line Stream	4.2%	16.1%	2.1%	0.0%	5.1%	21.9%	7.8%	11.1%	1.9%	7.3%	1.0%	36.7%

[1] Refer to California Geological Survey appendix for landslide map (Plate 1), relative landslide potential map (Plate 2) and description. Areas of disrupted ground are not included as active landslide features in this analysis. These areas are likely underlain by earthflow or rockslide complexes. If so, this would substantially increase the miles of roads and area of land type and land use on active landslide features.

[2] Area based on inner gorges captured as polygons plus inner gorges captured as linear features, which are treated as having an average width of 100 feet.

[3] Category 1 includes clearcut, rehab, seed tree step, and shelterwood seed step prescriptions; Category 2 includes shelterwood prep step, shelterwood removal step, and alternative prescriptions; Category 3 includes selection, commercial thin, sanitation salvage, transition, and seed tree removal step prescriptions.

[4] Landslide features and selected geomorphic features include earthflow, rock slide, debris slide, debris flow, debris slide slopes, disrupted ground, eroding banks and inner gorges.

[5]The number of miles of roads in this table does not accurately reflect present conditions in all listed planning watersheds. The majority or in some planning watersheds all of roads in the Lower subbasin have been removed by RNSP.

EMDS Potential Sediment Production Results

Table IV- 53 to IV- 56 present the results of the EMDS potential sediment production model for the Lower Subbasin. While we believe that this model has utility in its current state, we caution that it be interpreted only as indicative of relative conditions and not as a definitive assessment of absolute conditions.

Table IV- 53 presents results from the top three levels of the EMDS sediment model. Natural sources of sediments are potentially high in Copper Creek Planning Watershed due to a relatively large amount of its area close to streams in active landslide features and due to the amount of area in the very high landslide potential classes. Subsequent tables looking deeper into the model will help to provide more insight into the sources of these condition rankings. The results in Table IV- 54 suggest that roads in the Lower Subbasin are less a factor for concern relative to other subbasins for road related surface erosion. The Park's aggressive work to remove roads and to upgrade remaining roads likely is a major factor in these favorable relative ratings. However, the effects from past timber harvest activities may still contribute to surface erosion, particularly in Bridge and Bond creek planning watersheds.

Table IV- 53. EMDS ratings for potential stream sediment production; top three levels of model.

Subbasin or Planning Watershed	All Sources	Natural Processes				Management-Related Sources			
		All	Surface Erosion	Streamside Erosion	Mass Wasting	All	Surface Erosion	Streamside Erosion	Mass Wasting
Lower Redwood Subbasin	+	+	U	+	+	+	-	++	+
Bond Creek	+	+	U	+	+	+	-	++	+
Bridge Creek	+	+	U	-	+	+	-	++	-
Copper Creek	-	--	U	--	-	+	-	++	+
Devil's Creek	++	++	U	++	+++	+	+	++	+
McArthur Creek	++	++	U	++	+++	+	+	+	++

A 'U' represents there is a lack of data to categorize.
The "+++" score represents the least amount of potential sediment delivery to streams on a relative scale; the "---" score represents the most potential sediment delivery to streams.

Table IV- 54. Potential stream sediment production from management related surface erosion sources.

Subbasin or Planning Watershed	All Mgmt.-Related Surface Sources	Road Related			Land Use Related	
		All Road Related	Density of Roads by Hillslope Position	Density of Roads Proximate to Streams	All Land Use Related	Timber Land Use
Lower Redwood Subbasin	-	+	++	++	-	--
Bond Creek	-	++	+++	+++	--	--
Bridge Creek	-	++	+++	+++	---	---
Copper Creek	-	++	+++	+++	--	+
Devil's Creek	+	+	+	++	+	-
McArthur Creek	+	+	++	+	+	-

The "+++" score represents the least amount of potential sediment delivery to streams on a relative scale; the "---"score represents the most potential sediment delivery to streams.

Table IV- 55 looks at potential sediment production from road related streamside erosion. These relative ratings show that the lower Redwood Creek subbasin and its planning watersheds are in favorable condition for management related streamside erosion.

Table IV- 55. Potential stream sediment production from management related streamside erosion sources.

Subbasin or Planning Watershed	All Management-Related Streamside Sources	Road Related	
		Density of Roads Proximate to Streams	Density of Road Crossings
Lower Redwood Subbasin	++	++	++
Bond Creek	++	+++	+++
Bridge Creek	++	+++	+++
Copper Creek	++	+++	+++
Devil's Creek	++	++	++
McArthur Creek	+	+	++

The "+++" score represents the least amount of potential sediment delivery to streams on a relative scale; the "---" score represents the most potential sediment delivery to streams.

Table IV- 56 examines potential sediment production from management related mass wasting. The column combining all management related mass wasting shows at least somewhat favorable relative conditions for the entire subbasin and all planning watersheds except Bridge Creek. As in the other EMDS sediment results for this subbasin, roads have a favorable relative rating throughout the subbasin, while land uses—timber land use, legacy effects from tractor logging in particular—appear to have a high likelihood to produce sediment from mass wasting processes. Timber land use has these relatively unfavorable rankings at the subbasin level and for all the planning watersheds except Copper Creek.

Table IV- 56. Potential stream sediment production from management related mass wasting sources.

Subbasin or Planning Watershed	All Mgmt. Related Mass Wasting Sources	Road Related				Land Use Related	
		All Road Related	Density of Roads Crossings	Density of Roads by Hillslope Position	Density of Roads on Unstable Slopes	All Land Use Related	Timber Land Use
Lower Redwood Subbasin	+	++	++	++	++	-	--
Bond Creek	+	++	+++	+++	++	--	--
Bridge Creek	-	+++	+++	+++	+++	---	---
Copper Creek	+	+++	+++	+++	+++	--	+
Devil's Creek	+	+	++	+	+	+	-
McArthur Creek	++	++	++	++	++	+	-

The "+++" score represents the least amount of potential sediment delivery to streams on a relative scale; the "---" score represents the most potential sediment delivery to streams.

Stream Reach Condition EMDS Results and Limiting Factors

The overall reach condition of the sample sites located in the Lower Subbasin were all rated "somewhat unsuitable" for salmonid production by EMDS (Table IV- 57 and Figure IV- 32). Readers should refer back to the Fish Habitat Relationships section above for detailed information describing physical factors affecting salmonid habitat.

Canopy density evaluations were "fully suitable" at the Elam Creek and Fortyfour Creek sites. On the mainstem Redwood Creek, canopy density was generally unsuitable for providing shade benefits to salmonid habitat. The wide channel of the mainstem Redwood Creek and the historical harvest of streamside conifers have prevented the riparian canopy from providing shade on large areas of the stream. However, it is likely that the riparian corridor is undergoing recovery as trees become re-established and grow within the near stream forests.

The somewhat unsuitable rating for stream condition is largely due to the lack of deep, complex pools observed from the tributary sites (Elam, Bridge, and Fortyfour Creeks), a lack of high quality spawning substrate, and the lack of deep, complex pools and lack riparian canopy density affecting the lower mainstem Redwood Creek sites. A deficiency in the EMDS model likely contributed to negative evaluations of the pool depth attribute throughout the basin. However, shallow pool conditions are often found in low gradient reaches within small watersheds that lack sufficient discharge to deeply scour the channel. Assessments of the amount of deep pools are also discussed in the Fish Habitat Relationships section above.

Overall, warm summer water temperature is a primary limiting factor to salmonid production in the mainstem Redwood Creek in the Lower Subbasin. In addition, habitat factors that received negative evaluation scores by the EMDS should be considered as potential limiting factors to salmonid production in the Lower Subbasin.

The average embeddedness ratings for the five sample sites in Redwood Creek and three tributary sample sites indicate that overall pool tail spawning substrate contains more than the desirable levels of fine sediment. Although, site 14 located on Redwood Creek received a "fully suitable" evaluation by EMDS, the result was due to only one pool tail measured in the sample reach. Pool tail substrate at Sites 22 and 18 located on Redwood Creek were generally 25-50% embedded with fines which places them into the EMDS "undetermined" evaluation category. All tributary sites evaluated to "moderately unsuitable" for pool tail embeddedness. Excessive sediments in pool tails is an indicator of upslope erosion and sediment inputs to stream channels.

Table IV- 57. Summary of results from the Lower Subbasin EMDS stream reach evaluation.

Stream	Reach Length (ft)	Reach Condition	Canopy Density	Pool Quality	Residual Pool Depth	Pool Shelter	Embeddedness
Elam Creek site24	513	-	+++	- -	- -	-	- -
Fortyfour Creek Site 2	597	-	+++	- -	- - -	-	- - -
Bridge Creek Site 8	1373	-	++	- -	- - -	0	- -
Redwood Creek Site 7	1500	*	*	*	*	*	*
Redwood Creek Site 22	2065	-	- - -	- -	- - -	- -	0
Redwood Creek Site 14	1819	-	- - -	- -	- - -	- -	+ + +
Redwood Creek Site 4	1608	-	- -	- - -	- - -	- - -	- -
Redwood Creek Site 18	1566	-	- - -	- -	- - -	- -	0
Redwood Creek Site 17	1508	-	- - -	- - -	- - -	- - -	-

+++ Fully Suitable ++ Moderately Suitable + Somewhat Suitable
- - - Fully Unsuitable - - Moderately Unsuitable - Somewhat Unsuitable 0 Uncertain * Dry reach, not sampled

The stream habitat components are categorized with respect to suitability for anadromous salmonid production. The scores* represent a range from fully suitable conditions to fully unsuitable conditions. These overall scores provide a general overview of current stream conditions and may be used to identify limiting factors and focus on areas for habitat improvement strategies.

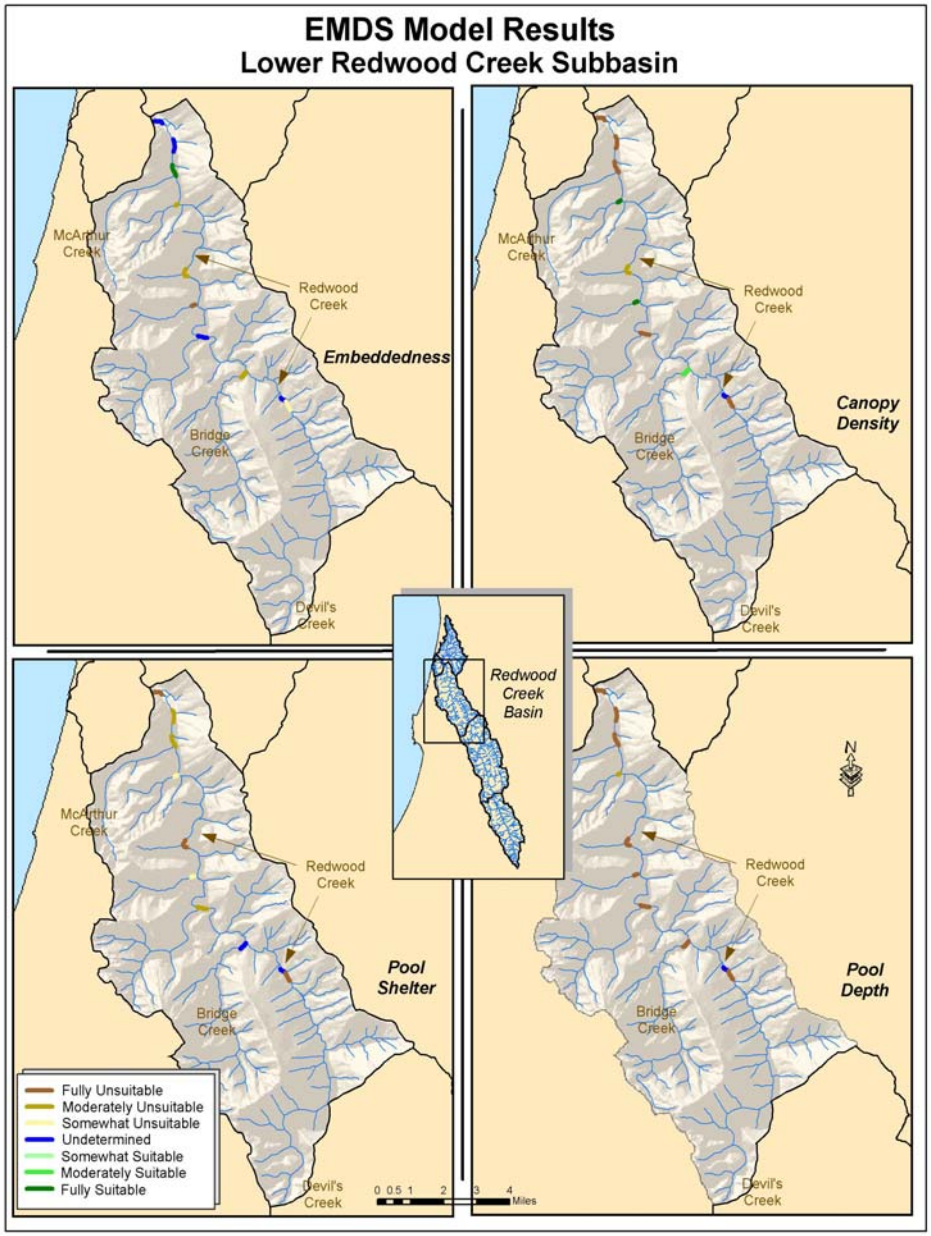

Figure IV- 32. Lower Subbasin EMDS results for selected stream reach factors.

Refugia Areas

The NCWAP interdisciplinary team characterized refugia habitat in the Lower Redwood Creek subbasin by using criteria developed for north coast watersheds. The majority of fish bearing tributary streams of the lower subbasin received designations as high potential refugia habitat or critical contributing areas (Table IV- 58). The high potential refugia designations were based on the presence of more than one species of anadromous salmonid in the watershed, low risk from future human caused disturbance, cool water temperatures in tributaries, and a high propensity for improvement. The critical contributing areas are known to contribute cool water to the lower reach of the mainstem. Redwood Creek received a potential refugia designation as problems with water temperature, habitat structure, and the likelihood of improvement potential lowered its refugia value.

Table IV- 58. Lower Subbasin anadromous salmonid refugia designations.

Stream	Refugia Categories				Other Categories		
	High Quality	High Potential	Potential	Low Quality	Passage Barrier Limited	Critical Contributing Area/Function	Data Limited
Bridge Creek		X					
Emerald Creek (Harry Weir)		X					
Tom McDonald		X					
McArthur Creek			X				
Copper Creek		X					
Elam Creek		X					
Cloquet Creek							X
Devils Creek						X	
Fortyfour Creek		X				X	
Hayes Creek						X	
Bond Creek		X				X	
Slide Creek						X	
Dolason Creek							X
Miller Creek							X
Redwood Creek			X				

Responses to Assessment Questions

<u>What are the history and trends of the size, distribution, and relative health and diversity of salmonid populations?</u>

- The Lower Subbasin supports populations of Chinook and coho salmon and steelhead and coastal cutthroat trout;
- Anadromous salmonid populations are believed to be well below historic levels of abundance and less widely distributed than in the past;
- Indications that the lower mainstem of Redwood Creek was once a productive salmonid nursery area is found in a discussion in Hallock et al. (1952). They noted that "Redwood Creek was an excellent silver (coho) salmon stream." Coho salmon have not been observed rearing in the mainstem during the summer months for decades;
- A review of spawner survey data collected 1982-1994 in Tom McDonald and Bridge creeks indicates small runs of Chinook and coho are returning to spawn in Lower Subbasin tributary streams;
- Although no quantitative estimates are available, juvenile salmonid densities appear relatively low in Bridge, Elam, and Fortyfour creeks;
- Juvenile coho have been recently identified in Bridge, Harry Wier (Emerald), Tom McDonald, Elam, and McArthur creeks;
- Steelhead and coastal cutthroat are present in the majority of the lower Redwood Creek tributaries and in the mainstem;

- Resident populations of coastal cutthroat and rainbow trout are found above the upstream limits of anadromous fish in tributary reaches. The status of these resident populations is unknown.

What are the current salmonid habitat conditions? How do these conditions compare to desired conditions?

- The Lower Subbasin provides critical habitat for anadromous salmonids;
- Fish habitat conditions in the Lower Subbasin differ between mainstem Redwood Creek and tributary streams;
- Water temperatures in mainstem Redwood Creek are generally too warm to support juvenile salmonids (especially coho) during summer months. A few cool water patches form where cold intergravel flow, tributary flow, or springs seep into the Redwood Creek channel. These thermally stratified pools or other forms of cool water refugia provide habitat for juvenile steelhead and possibly adult summer steelhead during summer months;
- Tributary streams have suitable summer water temperatures for rearing salmonids. In general, streams with cool water (MWAT below 64°F) provided habitat for coho salmon. These include Bridge Creek, Elam Creek, Fortyfour, and Tom McDonald Creek;
- Deep, complex pools are lacking in sample reaches in Redwood, Bridge, Elam, and Fortyfour Creeks;
- There is a low amount of instream LWD in mainstem Redwood Creek;
- The existing streamside shade canopy and the future supply of LWD and is limited by a lack of large, nearstream conifers along mainstem Redwood Creek;
- Streamside tree canopy providing shade over the water was generally suitable for the tributary reaches. However, the supply of LWD needed to maintain channel diversity and complexity may be limited by a general lack of large conifers growing near the Lower Subbasin tributaries;
- High embeddedness levels in spawning gravels in Bridge, Elam, and Fortyfour Creeks potentially limit successful egg incubation and the development and emergence of salmonid fry;
- The relatively highly embedded substrate observed from pool tails in the tributary sample sites are indicative of excessive fine sediments entering their stream channels;
- In-channel sediment data from mainstem Redwood Creek at the confluence with Miller and Harry Wier (Emerald) creeks show that median stream bed particle size did not meet minimum TMDL targets between 1982 and 1991 at Miller Creek and between 1979 and 1995 at Harry Wier (Emerald) Creek.

What are the past and present relationships of geologic, vegetative, and fluvial processes to stream habitat conditions?

- Through air photo interpretation, review of CDFG reports, and anecdotal accounts, it is clear that historic conditions of the lower reach of Redwood Creek were quite different than we see today. In the past, riparian forests containing large redwoods lined the riverbanks and deep pools and complex flatwaters supported salmonids (including coho) year round;
- Past descriptions of lower Redwood Creek suggest that water temperature in Redwood Creek was cold enough to support coho salmon. Pools along the lower reach of Redwood Creek were numerous and deep;
- Excessive sediment accumulation and changes in stream morphology and near stream forest condition have had adverse and long-lasting effects on salmonid habitat in lower Redwood Creek;
- Following the major flood of December 1964, the lower mainstem of Redwood Creek was in a severely damaged condition and became largely unsuitable as a nursery for young salmon and steelhead;
- Sediment transported from tributaries and from upstream reaches has contributed to a substantial accumulation of sediment in the Redwood mainstem channel;

- Chronic erosion from upstream hillslopes contributes to prolonged turbidity and high suspended sediment loads;
- The Redwood Creek stream channel is anomalously wide, as compared to regional curves of channel width vs. drainage area;
- The lack of large Douglas-fir and redwood results in less overstory shade along the channel and contributes to high water temperatures along the mainstem of Redwood Creek;
- Conifers large enough to provide LWD to the channel formation processes are absent in many anadromous fish bearing reaches;
- The flow of warm water from upstream reaches, combined with the wide condition of the stream channel and lack of large conifers providing shade contribute to elevated water temperatures of Redwood Creek;
- The relatively highly embedded substrate observed from pool tails in the tributary sample sites are indicative of excessive fine sediments entering the stream channels;
- The number of active landslides appears to be driven by the incoherent unit of Coyote Creek and land use;
- The largest streamside debris slides in the subbasin were observed along the Redwood Creek channel between Devils and Bridge Creeks, where the mainstem of Redwood Creek coincides with the Grogan fault. The abundance in number and volume of debris slides coincides with the zone of weak, sheared rocks of the Grogan fault;
- Although Bond Creek shows an increase in streamside landslides, it also shows a significant decrease in disturbance features in the channel, suggesting that most sediment is rapidly transported downstream;
- The lack of stream flow in lower Redwood Creek in 2001 and 2002 is likely a cumulative impact from low rainfall in spring and aggraded channel condition.

How has land use affected these natural processes?

- Past logging activities, particularly the construction of roads and skid trails and the removal of vegetative ground cover, have been a major factor contributing to erosion and sediment delivery to streams;
- As a result of land use, the lower reach of Redwood Creek has accumulated sediments, the channel has widened, aggraded and lost channel diversity;
- Large clear cut areas of the past resulted in accelerated runoff rates and increased suspended sediment loads;
- Legacy impacts from non-engineered side cast roadway fills constructed on marginally stable ground delivered large amounts of sediment into the stream network in Bridge Creek and possibly other streams;
- Many road watercourse crossings were poorly constructed and lacked backup drainage structures to prevent the diversion of runoff when culverts overflowed. Stream diversions often carve large gullies and transport scoured sediments to streams. These gullies may still be a source of sediment inputs to streams;
- The harvest of near stream, large conifers contributed to a loss of shade needed to help cool water temperature;
- The harvest of near stream, large conifers has contributed to reduced LWD loading potential. Reduced amounts of organic debris has likely impacted nutrient cycles and food web dynamics.

Based upon these conditions, trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?

- Elevated water temperature is the most significant factor limiting salmonid production in the lower Mainstem Redwood Creek;
- Lack of channel diversity and adequate supply of shelter elements also are factors that limit juvenile anadromous salmonid use of the lower reaches of the mainstem Redwood Creek;

- The lack of diverse and complex aquatic habitat and shelter elements likely limits anadromous salmonid production in the Lower Subbasin tributaries;
- The supply of LWD needed to maintain channel diversity and complexity is limited by a general lack of large conifers growing near the Lower Subbasin streams;
- Elevated levels of fine sediment reduce the amount of suitable spawning habitat and may limit or impair survival of developing salmon eggs and embryos in both the mainstem and tributary streams of the lower subbasin;
- Nutrients levels needed to fuel the aquatic food web, contributed by decaying organic debris and salmonid carcasses, are likely below historic levels;
- The decline in abundance of salmonids has likely caused a corresponding decrease in reproductive potential. Populations will likely require several years to rebuild.

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Barriers to Fish Passage

- Modify or remove potential barriers such as deltas or boulder and/or debris accumulations that may impede upstream fish passage into tributary streams for spawning.

Flow and Water Quality Improvement Activities:

- Promote near stream conifer growth to reduce solar radiation and to moderate air temperatures along stream corridors. This will reduce heat inputs to Redwood Creek and its tributaries and help to keep water cool.

Erosion and Sediment Delivery Reduction Activities:

- Any reduction of sediment from upstream sources will benefit the lower mainstem Redwood Creek;
- In order to reduce sediment delivery to Redwood Creek and its tributaries RNSP should continue efforts such as road improvements (e.g., upgrading crossings, rocking native surface roads, outsloping, ensuring surface drainage does not flow directly into watercourses, etc.) and decommissioning (e.g., removing unstable fills, removing drainage structures and fills, restoring natural contours, blocking vehicle access, etc.) throughout the Redwood Creek Basin;
- To address accumulations of fine sediments observed in Elam, Bridge, and Fortyfour creeks, Sediment sources from eroding stream banks and adjacent hillslopes should be identified and treated.

Riparian and Stream Habitat Improvement Activities:

- Where appropriate, land managers should use tree planting, thinning from below, and other vegetation management techniques to promote the development of large near stream conifers along mainstem Redwood Creek, Bridge Creek or other stream reaches with a low coniferous component in the riparian zone. Thinning to encourage conifer growth should be done with consideration of maintaining adequate shade canopy over stream channels;
- Instream LWD is needed for channel maintenance and shelter complexity;
- Strategically add wood into pools and flatwater units to increase pool depth and overall shelter complexity in Bridge, and Elam, Fortyfour creeks and other streams within the subbasin that lack deep complex pools;
- Consider adding shelter complexity with wood to existing cool temperature refuge sites on Redwood Creek, and lower reaches of tributary sites. This could be done even on a temporary basis using small woody debris to provide escape cover for juvenile salmonids during summer season. The cool patches may be located in temperature stratified pools or adjacent to cool water inputs from tributary flows at Bridge Creek or near springs, and seeps.

Education, Research, and Monitoring Activities:

- The range of habitat conditions within the Lower Subbasin provides an opportunity to monitor channel and salmonid habitat recovery rates using habitat improvement treatments within a variety of channel types and conditions;
- Perform stream habitat surveys in tributaries throughout the Lower Subbasin to identify excessive erosion areas, assess salmonid stream habitat, identify deltas or boulder and/or debris accumulations that may impede passage for spawning, and to identify potential sites for improving habitat with restoration techniques;
- Monitoring in-channel sediment by measuring sediment size distribution, turbidity, V*, photo points should be increased; tracking of streambed levels with stream channel cross sections should be continued along the mainstem reach of lower Redwood Creek;
- A long term, concerted monitoring effort between the land owners, interested parties and responsible agencies is needed to determine the status and trends of anadromous fish populations in Lower Subbasin streams;
- Land managers and responsible agencies should increase continuous temperature monitoring efforts along the mainstem and at additional tributary locations to determine the impact of cold-water inputs from tributary and ground water sources;
- Although there were no formal stream reach surveys for LWD; observations of crews and findings regarding pool complexity indicate that there is limited instream LWD. Formal surveys for LWD loadings could be done to verify these observations.

Subbasin Conclusions

The lower mainstem of Redwood Creek is an important migratory route for anadromous salmonids as it provides access to Lower Subbasin tributaries and upstream spawning areas. The mainstem also may serve as spawning habitat for Chinook salmon during low water years. Elevated water temperature and lack of channel complexity are factors most limiting juvenile anadromous salmonid use of the lower reaches of the mainstem Redwood Creek during the summer months.

Juvenile Chinook, coho, steelhead, and coastal cutthroat have been observed in Lower Subbasin tributaries. These streams provide important salmonid spawning and year round rearing habitat. Water temperature is generally suitable in the tributaries year round. However, tributary streams lack sufficient area in deep, complex pools. Spawning gravels were moderately to highly embedded in fine sediments, which is considered unfavorable for successful incubation salmonid eggs.

The Lower Subbasin offers opportunities for both implementing and effectiveness monitoring of stream and riparian habitat improvement activities. Based on the survey sample sites, appropriate stream habitat improvement activities for Lower subbasin streams include reducing sediment inputs by stabilizing stream bank and hillslope erosion, increasing depth and complexity to existing pool habitats, promoting near stream conifer growth, and adding shelter complexity to cool water refuge sites.