Middle Subbasin

The Middle Subbasin includes the area above the confluence of Redwood and Devil's creeks, up to the confluence of Redwood and Lupton creeks, including the Lupton Creek watershed (Table IV- 59 and Figure IV-33). The predominant land use in the Middle Subbasin is timber production and in addition, some livestock grazing occurs in Redwood Valley. The Middle Subbasin includes the following Planning watersheds:

Coyote Creek	Panther Creek	Lower Lacks Creek	Upper Lacks Creek
Roaring Gulch	Toss-up Creek	Minor Creek	Lupton Creek

Principal features within the Middle Subbasin include coniferous forestland, the Park Protection Zone, and rural developments in Redwood Valley. The Park Protection Zone was established on private lands in 1978 and includes lands within Coyote, Panther, and Upper and Lower Lacks creek planning watersheds. The Park protection zone enables RNSP staff to participate in the State's timber harvest plan process and to develop cooperative relationships with private land owners. Approximately 2,300 acres in the Lacks Creek watershed is managed by the Bureau of Land Management (BLM) as late successional reserves. Other notable features of the subbasin are presented in Table IV- 59.

Approximately 24 miles of mainstem Redwood Creek and 161 miles of blue line tributary stream channel drain the surrounding landscape. The twenty-four miles of mainstem Redwood Creek and approximately 19 miles of tributary channels are accessible to anadromous salmonids. Anadromous fishery resources of the Middle Subbasin include Chinook and coho salmon, steelhead and coastal cutthroat trout.

Table IV- 59. Middle Subbasin summary.

Square Miles	100.14
Total Acreage	64,088
Private Acres	57,843
Federal Acres	5,838
State Acres	0
Principal Communities	Redwood Valley
Predominant Land Use	Timber production and livestock grazing
Predominant Vegetation Type	Douglas-fir forest/ hardwoods
Miles of Anadromous Stream	43.0
Low Elevation (feet)	325
High Elevation (feet)	4,091

Geology

The Middle Subbasin has more complex bedrock structure and more mass wasting than in the lower parts of the watershed. The Middle Subbasin may be the least stable in the entire Redwood Creek watershed. Eighty-one percent of the subbasin falls within the high to very high mass wasting potential categories (Table IV- 61). The high level of potential instability appears to be related to weak rocks underlying the subbasin.

Along the east side of the Grogan Fault large earth flow amphitheaters are common south of Coyote Creek in the incoherent unit of Coyote Creek (KJfc). They appear formed over many thousands of years by multiple generations of overlapping earth flow scars. These features contain active earthflow complexes and areas of disrupted ground. In the far eastern part of the Middle Subbasin the coherent unit of Lacks Creek (KJfl) underlies some of the steepest slopes in the Redwood Creek watershed and is predominantly a source of debris slides, debris flows, and small bedrock landslides, although occasional rotational landslides are also present in this unit (Plate A, Sheet 2, CGS appendix E). The first of a complex series of large cross-faults occurs immediately south of Minor Creek. The direction of movement on these faults is unknown, but they appear to be younger than the Grogan Fault because they are mapped as offsetting it. Rocks associated with the sandstone and mélange unit of Snow Camp Mountain (KJfs) first appear along the extreme west margin of the watershed in this area. For further detail, please refer to geologic maps in Appendix E.

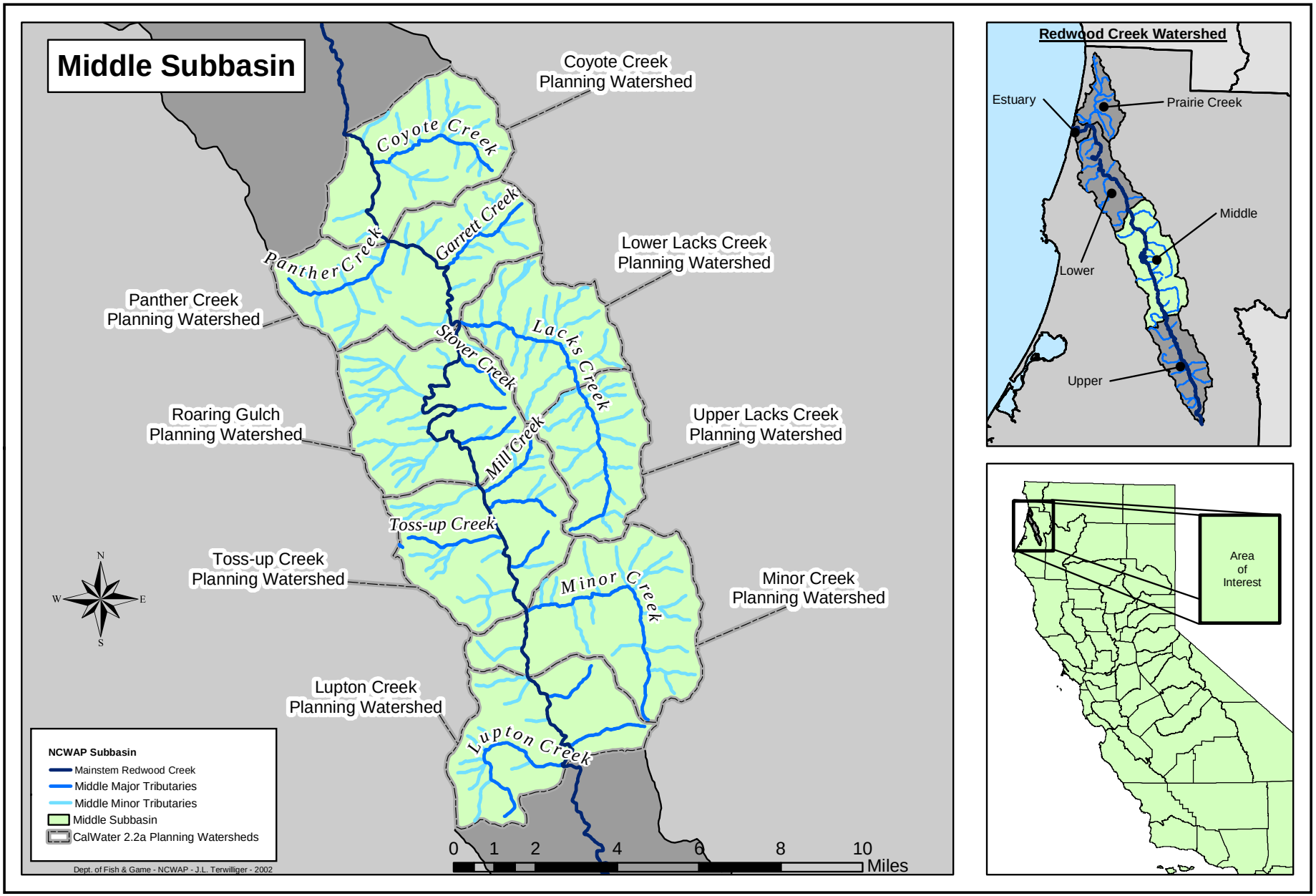

Figure IV- 33. Middle Subbasin and its tributaries, Redwood Creek.

The typical modes of mass wasting west of the Grogan Fault are large rotational landslides and debris slides. The rotational landslides are typically subdued and appear to be very old, possibly thousands of years. Some smaller active bedrock slides also are present in this area. The Redwood Creek schist (KJfr) near "the meanders" has several broad, shallow amphitheaters containing numerous, small watercourses in fan shaped arrays. These amphitheaters may be the eroding floors of fully evacuated ancient landslides. The west side of the subbasin above this section of the channel is bounded by a series of large, faceted spur-ridges. These are seen as a series of large triangular slope faces extending approximately 3000-4000 feet upslope of the channel. These slope faces may represent remnants of the original topography (ancient canyon wall) or be largely a series of ancient mass wasting features (as mapped). Corresponding facets are not present on the east side of the channel and this may be due to the weakness of the incoherent unit of Coyote Creek underlying this area.

Streamside Landslides

Table IV- 60 shows the numbers (not sizes) of small, active, streamside landslides observed in 1984 and 2000 aerial photos of the Middle Subbasin. Overall, the number of landsides increased 18%, from 376 to 442 over the 16 year period. The number of active streamside landslides increased in four of the 8 planning watersheds: Upper and Lower Lacks Creek, Panther Creek, and Roaring Gulch. Some of the highest densities of active streamside landslides in the basin occur along the channels of Lacks and Minor Creeks. The upper reaches of both watercourses follow the contact between the incoherent unit of Coyote Creek and the south facies of the coherent unit of Lacks Creek. These are probably the weakest and strongest rocks, respectively, in the watershed. The Lacks and Minor Creek planning watersheds also have the highest landslide potential of the basin, having 91-94% of their areas within the high to very high mass wasting potential categories. Lower Lacks Creek showed the most dramatic increase from 39 in 1984 to 125 small active streamside landslides in 2000. These slides probably contributed to the elevated sediment stored in the lower reach of Lacks Creek. This elevated sediment supply may adversely affect habitat for salmonids. The number of active streamside landslides decreased in three planning watersheds: Lupton, Minor and Toss-up Creeks, and stayed the same in Coyote Creek.

Table IV- 60. Middle Redwood 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	% Change 1984-2000
Middle Redwood Subbasin	259.2	376	442	+18
Coyote Creek	31.1	74	74	0
Lower Lacks Creek	24.0	39	125	+ 221
Upper Lacks Creek	20.5	76	97	+ 21
Lupton Creek	32.6	27	12	- 56
Minor Creek	40.3	65	6	- 91
Panther Creek	39.4	31	52	+ 68
Roaring Gulch	36.0	31	46	+ 48
Toss-up Creek	35.3	33	30	-9

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

Table IV- 61. Middle Subbasin summary of relative landslide potential and landslide features.

Factor	Middle Subbasin		Planning Watersheds															
			Lupton Creek		Minor Creek		Toss-up Creek		Upper Lacks		Roaring Gulch		Lower Lacks		Panther Creek		Coyote Creek	
Relative Landslide Potential	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Very Low	2,689	4.2	551	6.9	231	2.3	589	6.7%	141	2.8%	791	8.9%	59	1.0%	210	2.2%	117	1.5%
Low	3,868	6.0	650	8.1	327	3.3	606	6.9%	279	5.5%	828	9.3%	288	4.9%	642	6.6%	248	3.2%
Moderate	6,002	9.4	1,140	14.2	374	3.8	906	10.4%	38	0.8%	1,248	14.0%	22	0.4%	1,680	17.3%	594	7.7%
High	20,402	31.9	2,769	34.4	3,075	30.9	2,778	31.8%	1,096	21.7%	2,709	30.4%	1,222	20.6%	3,928	40.4%	2,825	36.8%
Very High	31,023	48.5	2,930	36.4	5,929	59.7	3,847	44.1%	3,507	69.3%	3,325	37.4%	4,327	73.1%	3,274	33.6%	3,884	50.7%
High/Very High Subtotal	51,425	80.4	5,699	70.9	9,004	90.6	6,625	75.9%	4,603	91.0%	6,034	67.8%	5,549	93.8%	7,202	74.0%	6,709	87.5%
GRAND TOTAL	**63,984**	**100%**	**8,040**	**100%**	**9,936**	**100%**	**8,726**	**100%**	**5,061**	**100%**	**8,901**	**100%**	**5,918**	**100%**	**9,734**	**100%**	**7,668**	**100%**
Landslide and Selected Geomorphic Features	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Historically Active Landslide Features Total	4,166	6.5	569	7.1	831	8.4	153	1.8	168	3.3	267	3.0	1,062	17.9	302	3.1	814	10.6
Earthflow	3,187	5.0	406	5.1	774	7.8	118	1.4	89	1.8	181	2.0	572	9.7	261	2.7	785	10.2
Rock Slide	654	1.0	133	1.7	4	0.0	0	0.0	36	0.7	33	0.4	448	7.6	0	0.0	1	0.0
Debris Slide	257	0.4	29	0.4	46	0.5	16	0.2	38	0.7	45	0.5	31	0.5	33	0.3	19	0.2
Debris Flow	68	0.1	1	0	7	0.1	19	0.2	4	0.1	8	0.1	11	0.2	9	0.1	9	0.1
Dormant Landslide Features Total	15,150	23.7	2,249	28.0	2,487	25.0	2,275	26.1	198	3.9	2,843	31.9	1,365	23.1	2,205	22.7	1,528	19.9
Selected Geomorphic Features Total	13,495	21.1	2,010	25.0	2,581	26.0	961	11.0	1,247	24.6	182	2.1	706	11.9	2,934	30.1	2,874	37.5
Disrupted Ground	10,099	15.8	1,932	24.0	1,586	16.0	923	10.6	3	0.1	163	1.8	2	0.0	2,674	27.5	2,817	36.7
Debris Slide Slope	2,943	4.6	19	0.2	884	8.9	0	0.0	1,155	22.8	0	0.0	638	10.8	211	2.2	35	0.5
Inner Gorge (area)2	453	0.7	59	0.7	111	1.1	38	0.4	89	1.8	19	0.2	66	1.1	49	0.5	22	0.3
Total of All Above Features	**32,811**	**51.3%**	**4,828**	**60%**	**5,900**	**59.4%**	**3,389**	**38.8%**	**1,612**	**31.9%**	**3,292**	**37%**	**3,134**	**52.9%**	**5,441**	**55.9%**	**5,215**	**68.0%**

Vegetation

Middle Subbasin vegetation consists of 46,766 acres of conifer-dominated forestland (73% of the subbasin) and 11,861 acres (19% of the subbasin area) of hardwood forests (Table IV- 62). Although pure conifer stands are found within the subbasin, most of the forested landscape is comprised of mixed conifer-hardwood stands. Douglas-fir is by far the dominant forest type, with 44,352 acres or 69% of the subbasin area (Figure IV- 34). The Middle Subbasin has the greatest amount and proportion of tanoak stands of the Redwood Creek Basin. There are 4,771 acres of tanoak, or over 7% of the subbasin. These stands are largely the result of early conifer harvests that did not successfully re-establish conifer stands. Grassland covers 4,102 acres (6% of the subbasin). In addition small areas, scattered throughout the subbasin are covered with brush. Blueblossom (*ceanothus spp*.) along with coyote brush is found in the dryer south facing sites.

Productive timberland covers approximately 58,400 acres, or 91% of the subbasin. Productive timberland includes conifer, hardwood, and mixed forests and is defined as land capable of producing 20 cubic feet or more of commercial timber products per acre per year. Recent timber harvest units within the subbasin appear to be restocked and very productive. Since the onset of restocking requirements for timber harvests, the Department of Forestry and Fire Protection's forest practice program has indicated all harvest units within the subbasin meet the stocking standards of the Forest Practice Rules.

Table IV- 62. Generalized cover type by subbasin and planning watershed.

Subbasin or Planning Watershed	Covertype								
	Agriculture	Barren	Conifer	Hardwood	Grassland	Shrub	Developed	Water	Total
Middle Subbasin	25	277	46,766	11,861	4,102	771	11	0	63,813
Coyote Creek	0	8	4,654	1,793	1,117	80	0	0	7,652
Panther Creek	0	21	7,427	1,368	702	160	0	0	9,678
Lower Lacks Creek	0	0	2,466	2,899	573	0	0	0	5,938
Upper Lacks Creek	0	0	3,808	1,187	80	0	0	0	5,075
Roaring Gulch	25	17	7,458	1,040	269	62	11	0	8,882
Toss-up Creek	0	96	7,446	643	361	141	0	0	8,687
Minor Creek	0	3	7,198	2,081	506	130	0	0	9,918
Lupton Creek	0	132	6,309	850	494	198	0	0	7,983

Timber Harvest

Timber harvesting within the Middle Subbasin was observed on the 1948 air photo series. By the time of the 1964 flood, 50% (32,406 acres) of the subbasin area had been harvested. Even-aged silviculture has been and is still widely utilized within the subbasin. Recent operations have centered on the re-establishment of former conifer stands that, as the result of earlier harvesting, had become dominated by tanoak.

Based on aerial photo analysis and THPs, as of 2001, timber harvest had occurred on an area of 81,023 acres, equal to 126% of the total subbasin area (Table IV- 63). Multiple harvests were conducted on some portions of the subbasin (Figure IV- 35). Areas of timber harvests during 1977-2000 are shown in Figure IV- 36. As of 2001, approximately 36% (20,561 acres) of the previously harvested area (56,476 acres) within the Middle Subbasin had been harvested with a second entry. Also at this time, about 7% (3,976 acres) of the previously harvested area had received a third harvest entry. Second entries often occurred when the first entry removed the Douglas-fir component of the stand, and then a second entry was made during which the redwood trees were harvested. A second stand entry also could be made to remove the hardwoods previously occupied by a conifer stand. Removal and regeneration of a completely established "second growth" timber stand is the third reason that a second entry occur. Commercial thinning of stands also is reflected in these second and third harvest entry figures.

Table IV- 63. Timber harvest history for the Middle Subbasin planning watersheds, 1950-2000.

Subbasin or Planning Watershed	Harvest Acres by Period							
	1950 - 1964	1965 - 1974	1975 - 1983	1984 - 1992	1992 - 2000	Total Harvested	PWS Total Acres	% Harvested
Middle Subbasin	32,406	11,991	12,616	13,999	10,011	81,023	64,122	126.4
Coyote Creek	2,933	2,311	2,344	1,935	0	9,523	7,683	123.9
Lupton Creek	3,980	1,185	545	2,026	1,985	9,721	8,055	120.7
Lower Lacks Creek	1,622	981	1,396	420	163	4,582	5,939	77.2
Minor Creek	4,916	1,282	822	3,370	3,223	13,613	9,965	136.6
Panther Creek	5392	2,408	4,544	1189	1,581	15,114	9,751	154.9
Roaring Gulch	5,833	2,047	1571	890	1,375	11,716	8,911	131.4
Toss-up Creek	5,700	657	617	2535	1,475	10,984	8,739	125.7
Upper Lacks Creek	2,030	1,120	777	1634	209	5,770	5,079	113.6

Table IV- 64. Middle Subbasin multiple harvest acres.

Harvest Entry	Harvest Acres
First	56,476
Second	20,561
Third	3,976

Yarding methods employed on timber harvest plans from 1980-1999 within the Middle Subbasin are comprised of three separate systems. Ground based tractor skidding accounts for 85% of this total on an area basis. Of the approximately 28,000 acres harvested during that period, 24,095 were yarded with ground-based equipment. Cable yarding systems were used on an additional 1,660 acres (6% of the harvest area). Helicopter yarding was utilized for the 5% of the harvest area. Most of the helicopter yarding was used in clear-cut or shelterwood removal units and has occurred since 1995. Ground based yarding has been used in all types of silviculture units.

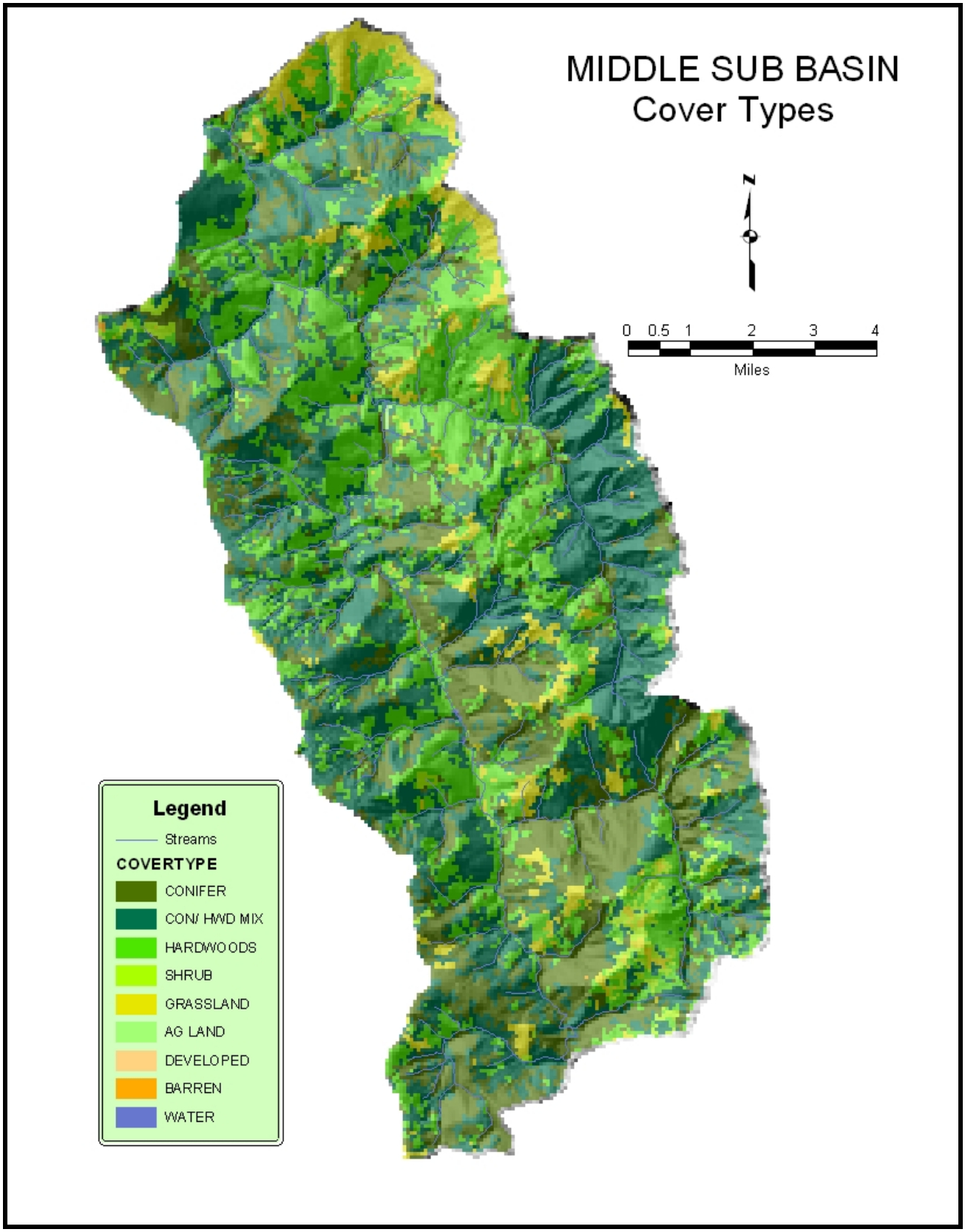

Figure IV- 34. Middle Subbasin map showing vegetation cover types.

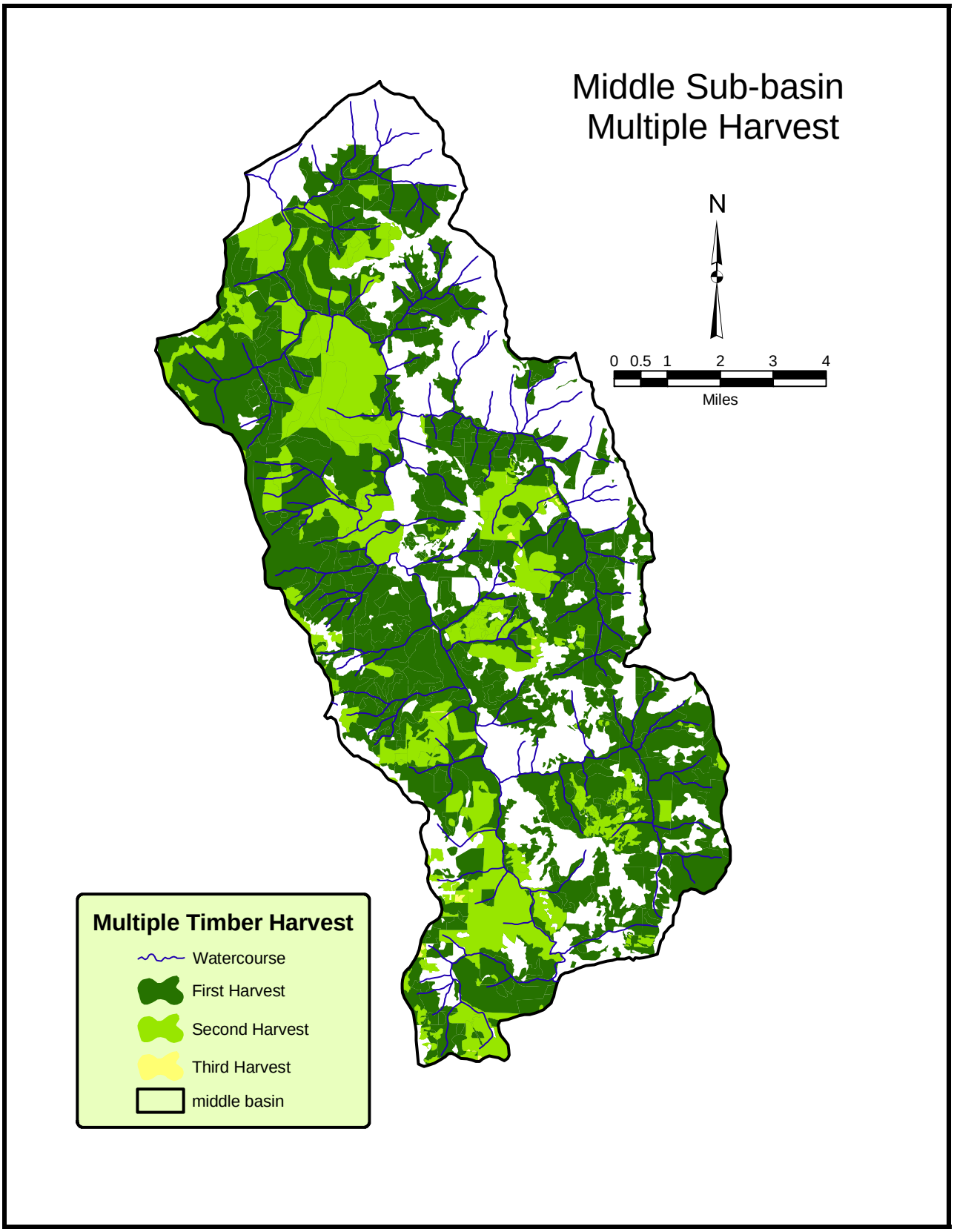

Figure IV- 35. Middle Subbasin multiple timber harvest entry map.

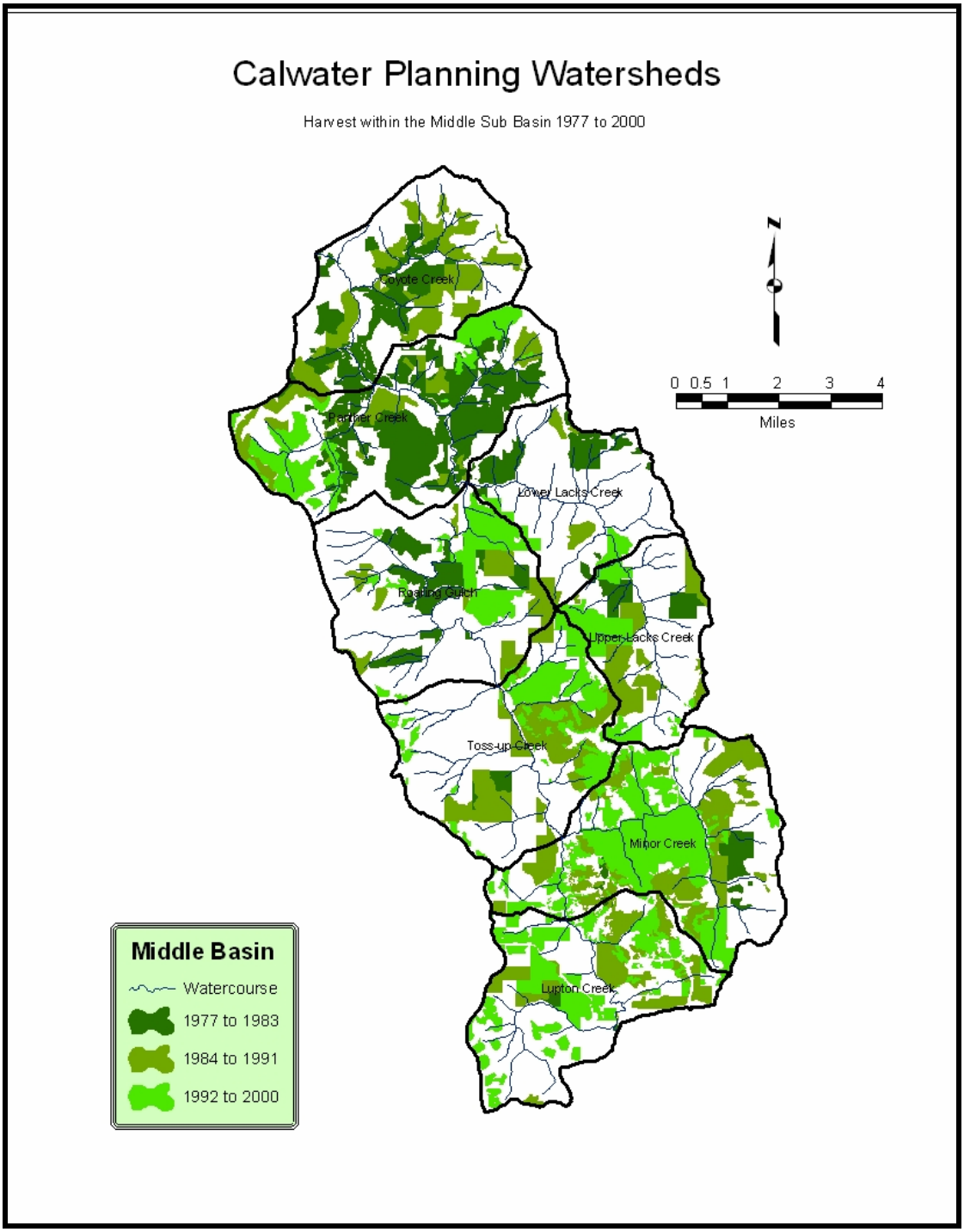

Figure IV- 36. Middle Subbasin timber harvest from 1977 to 2000.

Roads

There are 811 miles of roads and road density of 8.1 miles of road per square mile of land base within the Middle Subbasin (Figure IV- 37). Approximately 51% of the total road miles were constructed prior to 1958 (Figure IV- 38). Pre-1958 road construction standards were very different from standard practices of today. Roads built in that era generally were built with undersized culverts, did not have compacted road fills, were built over-width, and lacked sufficient cross drains and ditches. Approximately 47% of the road miles are classified as abandoned. Abandoned roads are constructed features that are no longer in use and do not normally receive any maintenance. Most of the abandoned road miles are located in the lower portions of the canyons and/or within close proximity to watercourses. Roads built close to streams and to older standards

generally have a higher likelihood to deliver significant quantities of sediment to streams than do roads located further from streams and built to current standards. Erosion-proofed abandoned roads generally contribute much less fine sediment than roads used and/or maintained through out the year. Twenty-three percent of the total road miles within the subbasin receive maintenance. Only 34 miles (4%) of the roads within the Middle Subbasin were built to the standards of the Forest Practice Rules.

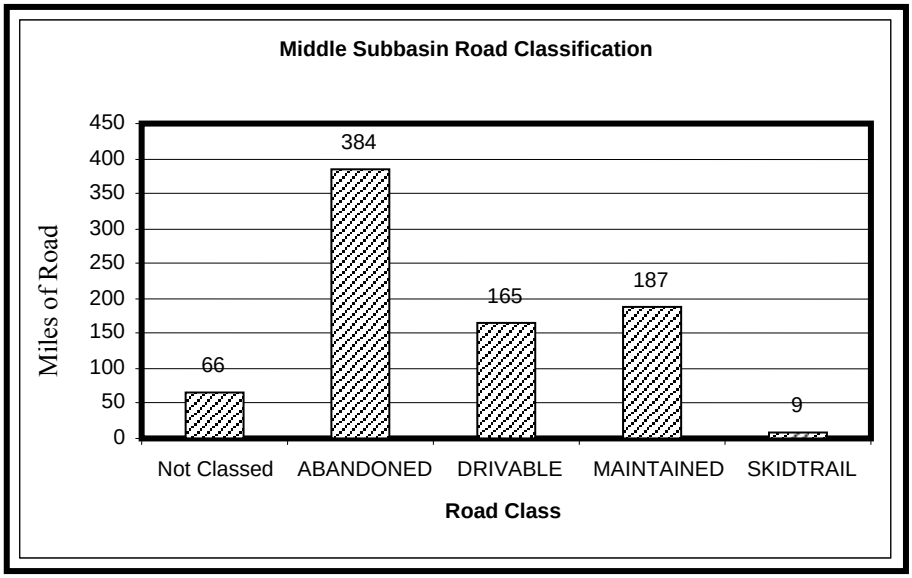

Figure IV- 37. Middle Subbasin classification of roads.

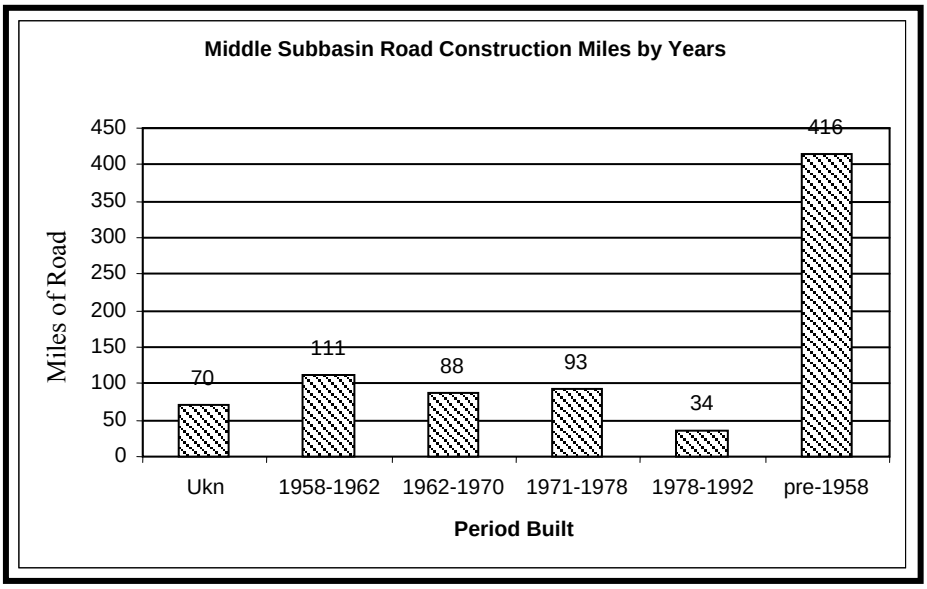

Figure IV- 38. Middle Subbasin miles of roads constructed by years.

Fire and Fuels

The Middle Subbasin is almost evenly split between moderate and high fuel rank areas, with small discontinuous zones of very high rank scattered throughout (Table IV- 65 and Figure IV- 39). On a percentage basis, the Roaring Gulch planning watershed appears to have the lowest fuel rankings and Upper Lacks Creek planning watershed the highest.

Table IV- 65. Fuel ranks summary for the Middle Subbasin and its planning watersheds.

Area of Analysis	Fuel Rank								Total Acres
	Moderate		High		Very High		Not Mapped		
	Acres	%	Acres	%	Acres	%	Acres	%	
Middle Subbasin	29,675	46	31,121	49	3,220	5	110	<1	64,126
Coyote Creek Planning Watershed	4,422	58	2,906	38	350	5	6	<1	7,683
Panther Creek Planning Watershed	5,745	59	3,597	37	395	4	15	<1	9,751
Lower Lacks Creek Planning Watershed	2,444	41	3,202	54	286	5	7	<1	5,939
Upper Lacks Creek Planning Watershed	1,195	24	3,459	68	415	8	10	<1	5,080
Roaring Gulch Planning Watershed	5,729	64	2,841	32	313	4	29	<1	8,912
Toss-Up Creek Planning Watershed	3,631	42	4,626	53	460	5	22	<1	8,740
Minor Creek Planning Watershed	3,231	32	5,983	60	740	7	11	<1	9,966
Lupton Creek Planning Watershed	3,278	41	4,507	56	261	3	10	<1	8,056

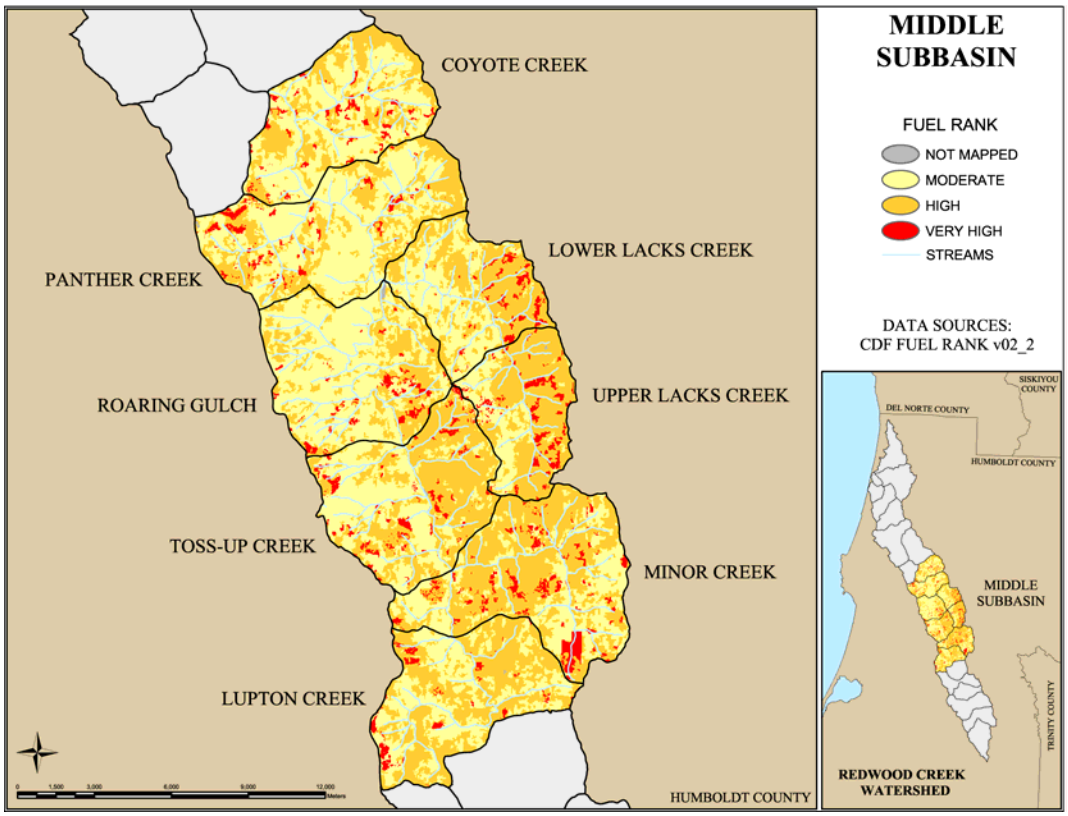

Figure IV- 39. Middle Subbasin fuel ranking map.

Fluvial Geomorphology

The middle reach of Redwood Creek closely follows the Grogan fault zone from Highway 299 Bridge to the confluence with Beaver Creek. Then the valley containing the mainstem channel widens significantly below the mouth of Minor Creek to form Redwood Valley. Here stream bars and terraces, which are characteristic of a depositional stream reach, are more abundant and voluminous than in upstream reaches. Sediment storage predominates and the multiple terraces show that has been the case for thousands of years. Streamside landslides in Redwood Valley appear to be less frequent compared to upstream and downstream reaches within the subbasin.

Down stream from Beaver Creek, the mainstem narrows and meanders tightly to the west of the Grogan fault zone and flows through the Redwood Creek schist. The tight meanders beginning near Roaring Gulch are not typical of this coastal mountain stream, and appear to be remnants of earlier, gentler (antecedent) valley topography west of the fault. Madej (1995) suggested that there were Pleistocene-aged river terraces in this area. Inner gorge debris slides are rare along this section of channel indicating that the underlying bedrock is relatively stable and resistant. Downstream, beyond the meanders, streamside landslides are once again

abundant near the mouths of Panther and Coyote Creeks. Here again, the main stem veers westward into the Redwood Creek schist and away from the zone of the Grogan fault.

In the upper, wider portion of the Middle Subbasin, mainstem bankfull widths are 75-416 feet and floodplain widths are up to 660 ft (Madej and Ozaki 1996). In the lower reaches, bankfull widths are 80-115 ft and the floodplain generally is less than 165 ft wide. Channel gradient at both ends of the middle basin is a low (0.4%).

After the 1964 flood, channel-stored sediment increased by 32% (Madej and Ozaki 1996); 62% of these flood deposits were transported downstream within 16 years (Madej 1984a, b). Further decreases in stored sediment were observed between 1980 and 2000 at Redwood Creek channel cross section number 34, near the middle of the subbasin, and cross section number 40, at the upstream end of the subbasin. At both of these stations, between 1980 and 2000, there was still a cumulative loss of bed elevation in the range of -1.3 to -1.6 ft (-0.4 to -0.5 m) (see appendix E).

The abundance of steep tributary source reaches in the Middle Subbasin provides a ready supply of sediment to overload the mainstem channel and its downstream reaches during large storms (Table IV- 66). The situation can be exacerbated by land management practices on the steep slopes. Source reaches concentrated in the upper parts of the tributaries comprise more than 53% of the stream reaches in the Middle Subbasin. Consequently, the lower gradient, potential fish habitat reaches along the mainstem and lower parts of tributaries in the can be overwhelmed with sediment from surrounding steep areas, filling pools, widening banks and aggrading channels. Transport reaches are 32% and response reaches, mostly in the mainstem, are 15% of the reaches in the Middle Subbasin.

Table IV- 66. Middle Subbasin stream miles by planning watersheds.

Planning Watershed	Planning Watershed Area (acres)	Miles of tributary blue-line streams	Miles of Redwood Creek mainstem	Number of blue-line tributary segments (number of these that drain directly into Redwood Creek)
Coyote Creek	7,683	17.3	3.7	17 (4)
Panther Creek	9,751	22.7	3.3	25 (7)
Roaring Gulch	8,911	23	7	24 (11)
Lower Lacks	5,939	21	0	19 (1)
Upper Lacks	5,079	16	0	15 (0)
Toss-up Creek	8,739	21.7	3.3	20 (7)
Minor Creek	9,965	23.3	1.7	15 (2)
Lupton Creek	8,055	15.7	2.8	13 (7)

% Stream by Gradient	Middle Redwood Subbasin	Lupton Creek	Minor Creek	Toss-up Creek	Upper Lacks	Roaring Gulch	Lower Lacks	Panther Creek	Coyote Creek
< 1% (Response Reach)	11.6%	18.3%	7.7%	14.2%	0.0%	22.1%	2.1%	14.1%	14.6%
1-4% (Response Reach)	5.1%	5.3%	9.2%	2.6%	5.8%	3.9%	10.4%	2.7%	4.4%
4-20% (Transport Reach)	31.1%	47.3%	18.2%	27.2%	33.4%	17.7%	25.8%	38.4%	27.6%
>20% (Source Reach)	52.3%	29.2%	65.6%	56.0%	60.7%	56.4%	61.6%	44.7%	53.4%
Historically Active and Dormant Landslide and Selected Geomorphic Features4	% stream length	% stream length	% stream length	% stream length	% stream length	% stream length	% stream length	% stream length	% stream length
Within 180' of Blue Line Stream	20.5%	26.0%	36.4%	12.3%	45.8%	5.1%	25.2%	15.1%	10.7%

Observations of a sequence of aerial photographs showed changes in Redwood Creek at the mouth of Lacks Creek after the storm of 1964. In 1948, the mainstem channel contained point bars; in 1965 the channel was widened with sediment from the 1964 storm and lacked discrete stream bars. In 2000, discrete stream bars reappeared in Redwood Creek, however, the channel remained wider than it was in 1948.

Observations from photo year 2000 showed that the channel of Lower Lacks Creek contained large quantities of stored sediment. Lacks Creek, near the confluence with Redwood Creek, is a very low-gradient response reach (<1%). The planning watersheds of Roaring Gulch, Panther, and Devils Creek appeared not to contain excessive amounts of stored sediment. The mainstem of Redwood Creek contained the most stored sediment near Toss Up and Lacks Creeks and the least amounts stored sediment near Panther and Coyote Creeks.

Stream Disturbance

Between years 1984 and 2000, streams of the Middle Subbasin showed an overall decrease of 76% (52.7 mi. to 12.8 mi.) in length of stream disturbance features (Table IV- 67). The large change suggests that the sediment delivery has decreased and excess sediment has moved downstream. This could be due to the lack of major storms (except a 12 year event in 1997) and the 16-year period of gradual transport of elevated sediment downstream.

However, A few reaches showed increases, for example the mainstem Redwood Creek within the Toss Up and Roaring Gulch planning watersheds show an increase in lateral bars. New disturbance in Toss up and Pilchuck Creeks suggest new, post-1984 sediment sources. Air photo analysis indicates that the number of streamside landslides and length of negative stream features increased in Lacks Creek while decreasing in Minor Creek between years 1984 and 2000. Lupton and Minor Creeks appear to have improved, because they showed a decrease in streamside landslides and a decrease in length of disturbance features between 1984 and 2000.

Table IV- 67. Length of observed stream disturbance features and percent change in planning watershed streams 1984 to 2000.

Planning Watershed	Creek Name	Stream Disturbance features (ft)		% Change in Stream Disturbance features between 1984 and 2004
		1984	2000	
Coyote Creek	Unnamed east side trib	794.8	0.0	- 100
	Coyote Creek	18495.5	2700.8	- 85
	Joplin Creek	0.0	0.0	0.0
	Unnamed west side no blue line	548.9	0.0	- 100
	Redwood Creek	11625.0	539.2	- 95
	Total	31464.3	3240.0	- 90
Panther Creek	Panther Creek	0.0	0.0	0.0
	Johnson Prairie Creek	1106.4	0.0	- 100
	Garrett Creek	471.7	0.0	- 100
	Monroe Flat Creek	2444.0	0.0	- 100
	George Creek	0.0	0.0	- 100
	Redwood Creek	6380.2	1318.1	- 79
	Total	10402.3	1318.1	- 87
Roaring Gulch	Stover Creek	0.0	0.0	0.0
	Dolly Varden	0.0	0.0	0.0
	Lee Creek	0.0	0.0	0.0
	Roaring Gulch	0.0	0.0	0.0
	Garcia Creek	0.0	0.0	0.0
	Cashmere Creek	0.0	0.0	0.0
	Beaver Creek	10635.2	0.0	- 100
	Redwood Creek	8247.4	9020.5	+ 9
	Total	18882.6	9020.5	- 52
Lower Lacks Creek	Lower Lacks Creek	18553.1	7439.8	- 60
	Total	18553.1	7439.8	- 60
Upper Lacks Creek	Upper Lacks Creek	9199.0	3403.1	- 63
	Total	9199.0	3403.1	- 63
Toss-Up Creek	Pilchuck Creek	0.0	1728.0	NA
	Mill Creek	4676.0	0.0	- 100
	Molasses Creek	6254.7	0.0	- 100
	Unnamed east side trib - no blue line	2553.0	0.0	- 100
	Toss-up Creek	0.0	927.6	NA
	June Creek	2086.6	0.0	- 100
	Moon Creek	5291.5	0.0	- 100
	Unnamed east side trib - no blue line	3697.0	0.0	- 100

Planning Watershed	Creek Name	Stream Disturbance features (ft)		% Change in Stream Disturbance features between 1984 and 2004
		1984	2000	
	Wiregrass Creek	723.0	0.0	- 100
	Redwood Creek	8789.0	11276.3	+ 28
	Total	89574.8	35617.7	- 60
Minor Creek	Minor Creek	59083.2	0.0	- 100
	Lion Creek	0.0	0.0	0.0
	Redwood Creek	4471.7	2319.2	- 48
	Total	63555.0	2319.2	- 96
Lupton Creek	Santa Fe Creek	0.0	0.0	0.0
	Greenpoint Creek	0.0	0.0	0.0
	Sweathouse Creek	14210.1	0.0	- 100
	Captain Creek	9689.6	0.0	- 100
	Lupton Creek	6537.8	1610.0	- 75
	Redwood Creek	6001.6	3773.1	- 37
	Total	36439.0	5383.1	- 85

Water Quality

Temperature

Continuous temperature data have been collected in the Middle Subbasin streams since 1996. The mainstem is monitored at one site, upstream from the confluence with Lacks Creek. Water temperature is monitored on the following 10 tributaries: Lupton, Sweathouse, Minor, Moon, Molasses, Mill, Beaver, Lacks, Panther, and Coyote Creeks.

The summer MWAT in the mainstem of Redwood Creek typically increases only slightly from 71 to 72ºF as it flows downstream through the subbasin from the O'Kane station to just above the confluence with Lacks Creek (Table IV- 68). The measured MWATs of Redwood Creek peak at the Lacks Creek site. This suggests that most of the heat input to Redwood Creek is derived from the Upper Subbasin and it is maintained throughout the Middle Subbasin. The MWAT measured in the mainstem is well above a desirable water temperature range for salmonids of less than 64ºF MWAT.

Upper reaches of the tributaries are generally cool and are within the desirable range over summer rearing of juvenile salmonids. The lower reaches of the tributary streams were usually warmer than the upper reaches, reaching MWAT levels above 65ºF (Table IV- 68). Contributing flows from tributaries do not decrease mainstem Redwood Creek temperatures through the middle portion of the basin. However, tributary flows likely help to moderate water temperature from reaching higher levels and may provide localized cooler areas in the mainstem at their confluences. The mainstem would likely benefit if the tributaries maintained and contributed the cooler temperatures observed from their upper reaches. Many factors contribute to the warm water in the mainstem including: warm water flowing from the Upper Subbasin, high air temperatures, lack of shade canopy cover, and the basin's NW/SE aspect.

Maximum daily temperatures recorded during the summers of 1994 to 2001 for the sites in the Middle Subbasin ranged from 57 to 77ºF in the tributaries and 80ºF on the mainstem (Table IV- 68). These data indicate that at least one day during the hottest part of the year, temperatures in the middle mainstem and the larger tributaries approach or exceed the lethal limit of 75ºF for salmonids. The temperature may remain hot for several hours, thus causing stress and damage or death to salmonids.

Table IV- 68. Middle Subbasin maximum MWATs and seasonal maximum temperatures.

Site ID	Site	Period of Record	Max MWAT year	Max MWAT (F)
824	Coyote Creek5	1994	1994	61
50	Panther3	1974	1974	66
984	Panther mouth5	1998	1998	58
2019	Upper Panther Creek5	1994-95	1995	57
3004, Lac	Lacks Creek5, 1	1997-2001	1997	67
1144	Upper Lacks Creek5	1998	1998	61
3011	*RedCrk upstm Lacks Creek5	1997-98	1998	72
1118	Beaver Creek5	1997-98	1998	62

Site ID	Site	Period of Record	Max MWAT year	Max MWAT (F)
1119, Mill	Mill Creek5, 1	1997-98, 2001	1998	61
1120	Molasses Creek5	1997-98	1998	63
1121	Moon Creek5	1998	1998	68
3006, 1145, Min	Minor Creek5, 1	1997-99, 2001	1999	65
1123	Minor Creek Trib5	1998	1998	59
1124	Upper Minor Creek5	1997-98	1998	61
1125	Sweathouse Creek5	1998	1998	62
957	Lupton Creek5	1997-98	1998	59

From 1974-2001.Data sources: 1RNSP (2001), Woods (1975), Lewis T. et al. (2000), Simpson (2000) (*) indicates locations on mainstem Redwood Creek.

Table IV- 69. Middle Subbasin annual maximum temperatures from 1994-2001.

Site	Stream Location	1994	1995	1996	1997	1998	1999	2000	2001
824	Coyote Cr.	63							
984	Panther Cr. mouth					61			
2019	Upper Panther Cr.	56	59						
3004	Lacks Cr.				73	72	72	72	73
1144	Upper Lacks Cr.					65			
3011	Redwood Cr upstm Lacks				80	80			
1118	Beaver Cr.				65	66			
1119	Mill Cr.				63	64			62
1120	Molasses Cr.				67	70			
1121	Moon Cr.					79			
3006	Minor Cr.				74	73	77		70
1123	Minor Cr. Trib					63			
1124	Upper Minor Cr.				64	63			
1125	Sweathouse Cr.					65			
957	Lupton Cr.				62	62			

Data sources: RNSP (2001), Lewis T. et al. (2000), Simpson (2000).

Water Column Chemistry

USGS monitored water quality at four sites in the Middle Subbasin from 1973 to 1977. Three sites were on mainstem Redwood Creek and two were tributary sites on Highslope and Lacks creeks. Data for dissolved oxygen ranged from 8-12mg/L (water quality objective >8mg/L), pH ranged from 6.5-8.5 (water quality objective 6.5-8.5), and conductivity ranged from 40-260umhos (water quality objective <220umhos), slightly outside the objective goal. These data collected from the Middle Subbasin are quite old, but were in compliance with Basin Plan water quality objectives. See Appendix C for chemistry data from the Middle Subbasin.

In-Channel Sediment

In-channel sediment was sampled for median particle size and percent of fine materials at five sites in the Middle Subbasin between 1979 and 1994. Pebble counts to determine D50 particle size were collected on the mainstem upstream from Panther Creek seven times between 1979 and 1994. McNeil core samples were collected upstream from Panther Creek in 1983 and 1987 and Panther, Lacks and Molasses creeks, were sampled at various times between 1974 and 1994.

The RNSP and USGS sampled mainstem Redwood Creek for D50 particle size at a cross section through a gravel bar located upstream from Panther Creek. Of the seven samples taken between 1979 and 1994, three met the TMDL minimum D50 target of >37mm (see Appendix C for the D50 data). These samples were taken in 1989, 1991 and 1994. According to the CGS fluvial geomorphology assessment of the Middle Subbasin, this mainstem site received a large amount of sediment from numerous streamside landslides to the mainstem seen in 1984 air photos. The D_{50} data show an increase in particle size from 17mm in 1979 to 34mm in 1982. A decrease to 26mm occurred in 1985 followed by a large increase to 48mm in 1989 then to 60mm in 1991. The D_{50} particle size in 1994 dropped again to 42mm. The large increase in the median particle size from 1985 to 1989 may reflect a decrease in stored sediment noted by CGS. As a gravel bar erodes away, the D_{50} particle size is expected to increase as finer particles are washed downstream leaving larger ones behind which will raise the median. The D_{50} particle size sample from 1994 shows a decrease from the 1991 sample, which may reflect the

beginning of the destruction of the gravel bar. The gravel bar did not show in the 2000 photos examined by CGS. Unfortunately, because this site was not sampled after 1994 we cannot determine trends in sediment composition of the gravel bar. The CGS assessment of 1997 and 2000 photos noted no active streamside slides at this site or upstream. Another point to note is that there was a large concrete bridge across the channel at this site. It was destroyed in 1997 and a road now crosses through the channel during summer low flows where the bridge once was. Pebble count surveys conducted anytime after 1997 will show changes to in-channel sediment resulting from the bridge removal and will contribute to a more accurate and current assessment of this site. It will be important to know if the D_{50} particle size is meeting the minimum TMDL target today, since a downward trend was noted in 1994 when the last sample was taken.

Panther Creek was sampled for fine sediment using core samplers by the RNSP, USGS, and Woods (1975). The percentage of fine sediment presented in data from the RNSP and USGS are not comparable to TMDL targets due to different methods of analysis. A slight increase can be noted from the RNSP and USGS samples between the two years sampled at each site, however only two years of data were examined so a trend can not be defined (See Appendix C for data from these sampling events). Subsurface sediment data from Woods (1975) are directly comparable to TMDL targets because the samples were analyzed volumetrically. In 1974, the percent of fine sediment at Panther Creek was 30%. This sample exceeded the TMDL target of <14% for the <0.85mm size class.

Salmonid Habitat

Streams of the Middle Subbasin provide spawning and rearing habitat for populations of Chinook, coho, steelhead, summer steelhead, coastal cutthroat trout, and other valuable fishery resources (Table IV- 70). Approximately 25 miles of mainstem Redwood Creek and 19 miles of tributary channel are accessible to anadromous salmonids within the subbasin. The 25 mile reach of mainstem Redwood Creek in the Middle Subbasin contains important spawning habitat for Chinook salmon and provides a migratory route to approximately 20 miles of tributary spawning and rearing habitat for salmonids. The tributaries that provide the most anadromous salmonid habitat are Lacks, Minor, Coyote, and Panther creeks. Coho have been observed during past CDFG surveys of Panther, Coyote, Dolly Varden (Karen), Pilchuck, Minor and Redwood creeks. Coho were not observed in Middle Subbasin tributaries during 2001 surveys. Summer steelhead may be the most threatened of all salmonid stocks of the Redwood Basin. They rely on deep, cool, and sheltered pools in the mainstem and lower reaches of a few tributaries for holding habitat over summer and fall seasons. These cool and complex pools are now rarely found in the basin.

Table IV- 70. Middle Subbasin streams, species present, and number of stream miles accessible to anadromous salmonids.

Stream	Species Observed		Stream Length Access (miles)	References
Lacks Creek	Chinook coho coastal cutthroat steelhead	Pacific lamprey rainbow trout Pacific giant salamanders	4.54	CDFG 2001 & 1966 stream surveys, Ridenhour and Hofstra 1994, Brown 1988, RNSP/USFS-RSL revisit of 1981 thesis sites field notes
Minor Creek	Chinook coho steelhead		2.92	CDFG 2001 & 1966 stream surveys, Ridenhour and Hofstra 1994, and Brown 1988, PCFWWRA 1995.
Coyote Creek	coho coastal cutthroat steelhead brook trout	Pacific lamprey yellow legged frog Pacific giant salamander	2.44	CDFG 2001 & 1966 stream surveys, Brown 1988, and USFS/RNP barrier study notes
Panther Creek	coho coastal cutthroat steelhead	rainbow trout Pacific giant salamander	1.74	CDFG 1975 & 2001 stream surveys, Brown 1988, and RNP/USFS-RSL revisit of 1981 thesis sites field notes
Wiregrass Creek	steelhead		1.12	CDFG 2001 stream surveys and Brown 1988
Dolly Varden Creek	steelhead	coho	0.94	CDFG 2001 stream surveys, Brown 1988
Toss Up Creek	steelhead pacific giant salamander	yellow-legged frog	0.75	CDFG 2001 stream surveys, carcass surveys 1998 and 1999, RNP/USFS-RSL revisit of 1981 thesis sites field notes, and Brown 1988
Garrett Creek	steelhead		0.56	CDFG 2001 stream surveys and Brown 1988
Lupton Creek	steelhead		0.56	Brown 1988
Sweathouse Creek	steelhead		0.37	CDFG 2001 stream surveys and Brown 1988

Stream	Species Observed		Stream Length Access (miles)	References
Pilchuck Creek	steelhead	coho	0.31	CDFG 2001 stream surveys, Ridenhour and Hofstra 1994, Brown 1988
Mill Creek	steelhead	Pacific giant salamanders	0.25	CDFG 2001 stream surveys, carcass surveys 1998,99, RNP/USFS-RSL revisit of 1981 thesis sites field notes, and Brown 1988
Molasses Creek	steelhead		0.25-0.5	CDFG 2001 stream surveys and Brown 1988
Captain Creek	steelhead rainbow trout	Pacific giant salamander	0.25	CDFG 2001 stream surveys and Brown 1988
Garcia Creek	Steelhead		0.25	Brown 1988
Beaver Creek	steelhead	Pacific giant salamanders	0.19	CDFG 2001 stream surveys and Brown 1988
Cashmere Creek	steelhead		0.25	Brown 1988
Roaring Gulch	steelhead		0.12	Brown 1988
Loin Creek	steelhead		0.12	Brown 1988
Santa Fe Creek	steelhead		0.06	Brown 1988
Redwood Creek	Chinook salmon coho salmon coastal cutthroat steelhead summer steelhead	speckled dace lamprey spp three-spine stickleback sculpin spp Sacramento sucker	24.7	Weseloh, T., personal communications. CDFG 2001 stream surveys, Gerstrung 2001, RNSP 2001 and 1989, Anderson 2000, and Brown 1988; Sparkman 2001

Stream Surveys 1966–1995

Fish habitat conditions in the Middle Subbasin were by the CDFG and others between 1965 and 1995. The tributary surveys conducted in the mid 1960s to late 1970s indicated various degrees of channel disturbance from logging activities, but often noted the presence of abundant numbers of juvenile salmonids. Coyote, Panther, Garrett, Mill, and Molasses creeks were surveyed by CDFG from 1975-1977. These assessments used standard survey rating forms along with written summaries to describe both key aquatic habitat components and the status of fishery resources. A summary table of past surveys is presented in Appendix D.

In 1966, Redwood Creek, Minor Creek, and Lacks Creek were surveyed by CDFG to determine the extent of damage associated with past logging impacts (Fisk et al 1966). The 1966 survey documents the affects of the December 1964 flood on Redwood Creek. In 1966, Redwood Creek was considered "severely damaged" as pools were almost non-existent, there were large deposits of silt, sand and gravel, and a near total loss of shelter for fish, making the river channel largely unsuitable as a nursery for young salmon and steelhead (Fisk et al 1966). The lower reach of Minor Creek was considered "moderately damaged" by accumulations of "logging debris and flood damage" (Fisk et al. 1966). Minor Creek had considerable accumulations of silt, a loss of pools, and loss of streamside canopy, and instream shelter was lacking (Fisk et al. 1966). Lacks Creek was considered "lightly damaged," showing partial decline of habitat quality due to loss of shelter, increased siltation, loss of pools and canopy. However, fingerling salmonids were observed in high abundance in Minor Creek and in moderate to high abundance in Lacks Creek.

The middle reach of Redwood Creek experienced drastic changes in size, frequency, and distribution of pool, riffle, and run habitats after the flood of December 1964 (peak discharge estimated at 50,500 cfs at Orick, a 50-year flood). The flood occurred during the era when much of the Redwood Creek basin had recently experienced and was undergoing unregulated timber harvests. Those timber harvest activities contribute to destabilization of the land and faster runoff rates causing severe erosion and severe damage to Redwood Creek including channel widening and filling of most pools with sediments (Taft 1933, Fisk et al. 1966, Janda et al. 1975, and Wahrhaftig 1976). An earlier 50-year flood occurred in 1955, but much less stream damage was noted by CDFG personnel than was noted in 1965 (Van Kirk 1994) and there was much less land disturbance at that time.

The years of 1972 and 1975 each had floods with peak discharge of approximately 50,000 cfs. Following the 1975 flood and associated landsliding, the channel bed of Redwood Creek was almost flat and featureless in many reaches, as a pulse of new sediment entered the system. From 1976 to 1996, stream flows never exceeded a five-year reoccurrence interval in Redwood Creek, sediment inputs declined, and the channel began to organize into discrete bedforms (Madej 1999; 2001). Channel cross-section monitoring studies conducted by RNSP scientists between 1977 and 1996 showed an increase in depth and frequency of pools and a general

decrease in bed elevations, as sediments were transported downstream (Madej and Ozaki 1996, Madej 1999). However in 1997, a winter storm brought heavy precipitation, a peak discharge of over 40,000 cfs (a 12-year flood). The rains initiated landsliding which delivered large inputs of sediment to the streams. This was the first aggradation, decrease in water depth, and loss of bed variability measured in Redwood Creek since channel cross section monitoring began in 1977 (Madej 2001).

A CDFG stream survey of the lower reach of Panther Creek in 1975 found good habitat conditions with a high abundance of fingerlings, including many coho salmon (CDFG 1975). Stream habitat was composed of many small pools up to six feet in depth, abundant shelter provided by fallen logs and boulders, good spawning gravels, and good streamside canopy. Surveys found that Stover Creek ran through a culvert under Redwood Creek Road 10 feet upstream from its confluence with Redwood Creek. The stream drops 20 feet from the culvert, forming an impassable barrier to anadromous fish (CDFG 1975). This culvert is still creates a barrier to fish passage. The culvert has not been addressed because of the high repair costs compared to the amount of useable stream habitat available upstream (S. Downie CDFG personal communication).

In 1995, stream surveys of Lacks, Minor, Mill, Molasses, Toss Up, Roaring Gulch, Stover and Redwood creeks were conducted by Pacific Coast Fish, Wildlife and Wetlands Restoration Association (PCFWWRA) using CDFG stream current survey protocols described in Flosi (1998). These surveys provide data that is comparable to surveys conducted in 2001 (for this assessment) and can help determine short term trends in key habitat conditions. Results from the 1995 surveys show development of some favorable fish habitat in terms of pool riffle and run relationships in tributary streams.

Comparisons of primary habitat components in Lacks Creek between the 1995 and 2001 surveys are provided below (Figure IV- 40, Figure IV- 41). A general reduction of deep pool habitat occurred along survey reaches as shown in a comparison of 1995 and 2001 for the Middle Subbasin tributaries (Figure IV- 42). Sediment inputs and associated erosion that occurred in the flood of 1997 are responsible for these changes (Madej 2001). Further discussion and graphic presentations of the 1995 and 2001 stream survey data and summaries of all past stream survey reports are presented in Appendix D.

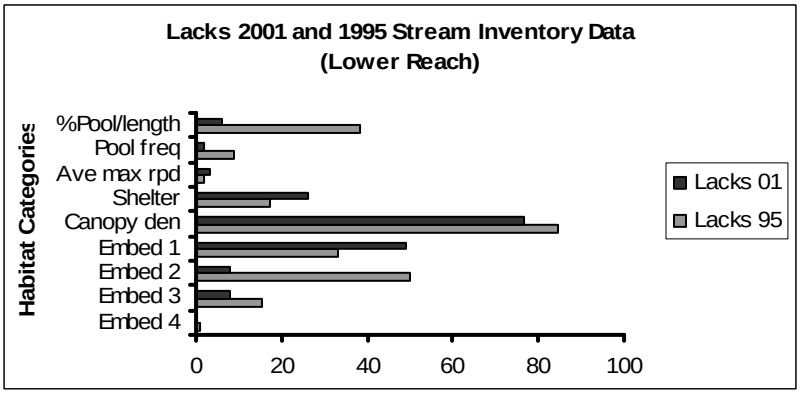

Figure IV- 40. Comparison of habitat conditions in lower Lacks Creek 1995 and 2001.

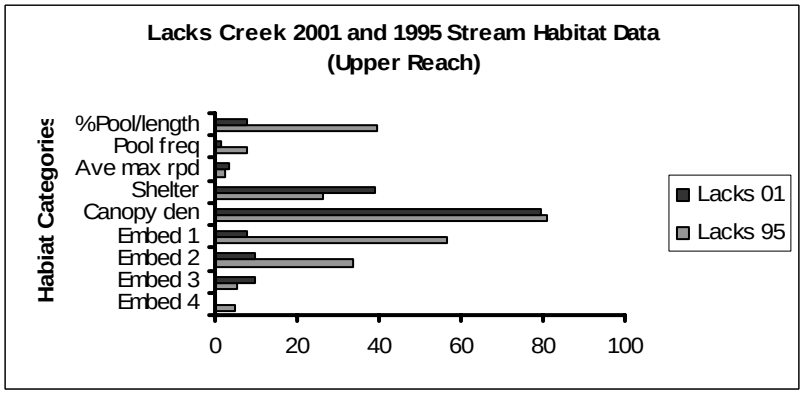

Figure IV- 41. Comparison of habitat conditions in upper Lacks Creek 1995 and 2001.

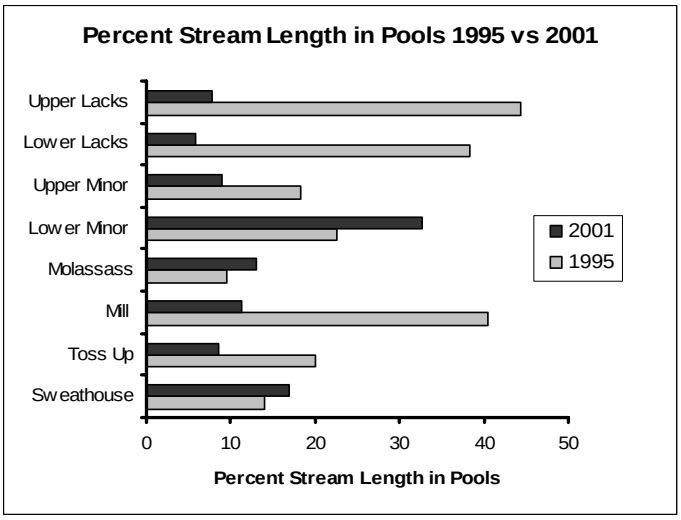

Figure IV- 42. Comparison of amount of pool habitat for survey years 1995 and 2001 in tributary streams.

Stream Surveys 2001

In 2001, CDFG crews surveyed approximately 25 miles of mainstem Redwood Creek and 19 miles of tributary habitat in the Middle Subbasin (Figure IV- 43). The 2001 survey data were collected using protocols presented in Flosi et al (1998). For analysis purposes, Redwood Creek was divided into 5 reaches, each approximately 5 miles in length. Abbreviated report summaries generated from stream surveys are provided in Appendix D.

Results from stream surveys are summarized below. This section begins with a comparison of general channel features between the 1995 and 2001 survey results.

Pool:Riffle:Run

***Significance*:** Productive anadromous streams are generally composed of a balance of pool:riffle:run habitat, each plays an important role as salmonid habitat. These channel features are influenced by slope, channel bed and bank materials, sinuosity, discharge, flow obstructions such as LWD and boulders, and disturbance from episodic events such as major floods and large sediment inputs (Leopold 1994 and Madej 1999).

In 1995, Lacks, Mill and Toss Up creeks were comprised of approximately 40% pools by occurrence and length (Table IV- 71). Only 811 feet of Stover Creek was surveyed because a culvert forms a barrier to anadromy limits upstream passage of salmonids.

Table IV- 71. Middle Subbasin percent by occurrence and length of pool, run, riffle, and dry habitats in anadromous fish reaches summer 1995.

Stream	Survey Length (ft.)	Pool:Riffle:Flatwater % Occurrence [(1)]	Pool:Riffle:Flatwater % Total Length [(1)]	Dry % Total Length	Culvert % Total Length
Lacks Creek 95	15,147	43 : 15 : 41	41 : 9 : 49		
Mill Creek 95	2,468	45 : 20 : 35	40 : 14 : 46		
Minor Creek 95	14,046	25 : 31 : 45	21 : 26 53		
Molasses Creek 95	2,806	18 : 36 : 46	10 : 36 : 54		
Stover Creek 95	811	38 : 22 : 28	32 : 17 : 34	8	9 *
Toss Up Creek 95	2,922	39 : 34 : 27	39 : 34 : 27		

[1] Includes side channel and secondary channel habitats
*Culvert barrier to fish passage

A comparison of tributary stream surveys from 1995 and 2001 shows a general reduction of pool percent occurrence, percent pool length, and an increase riffle habitat in Lacks, Mill and Toss Up creeks in 2001(Table IV- 71 and Table IV- 72). It appears that 1997 winter storm and associated upslope erosion and sediment inputs reduced the amount of pool habitat in these streams. The number of pools declined, but the percent length of stream in pool habitat shows a greater decline.

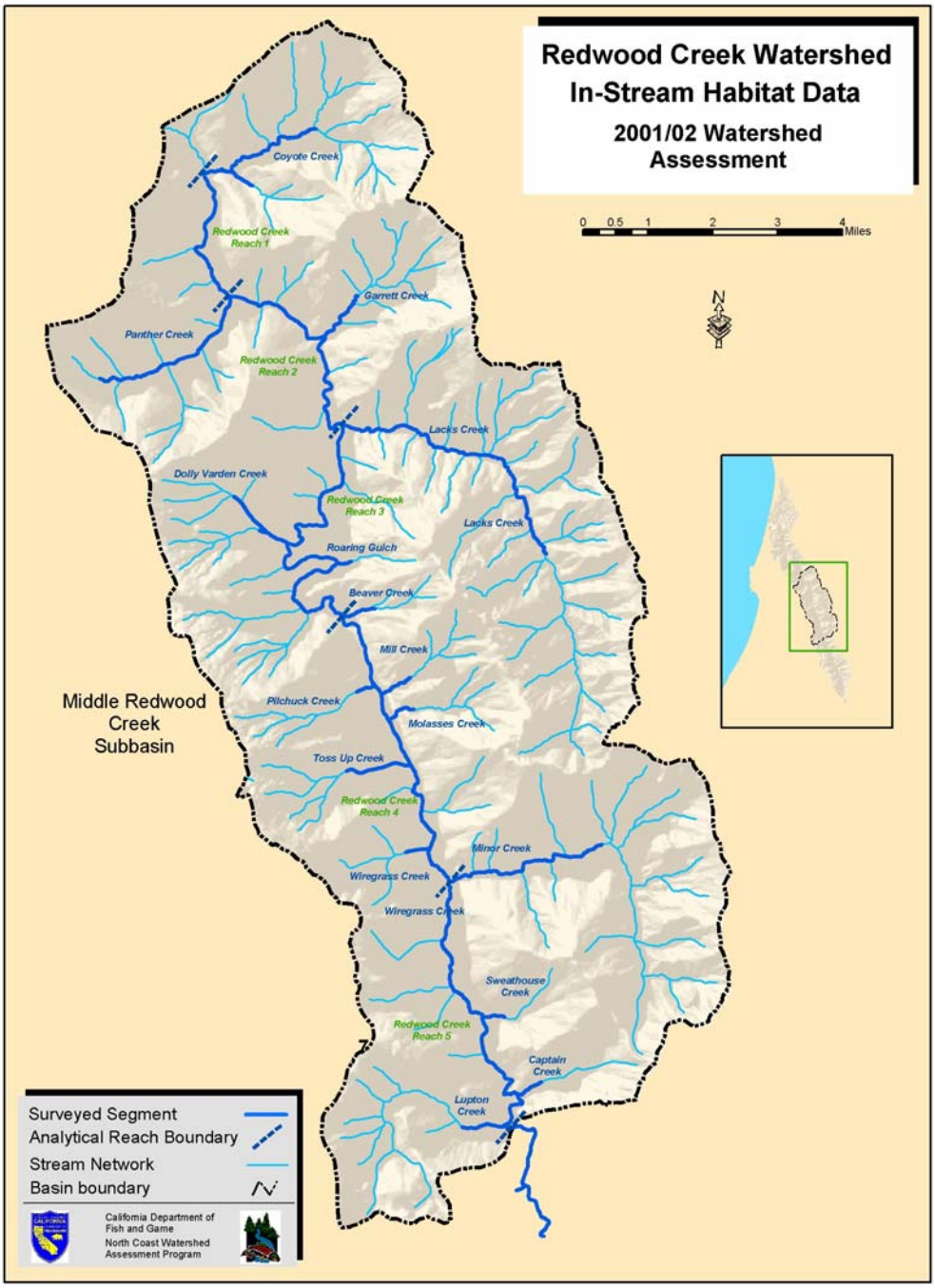

Figure IV- 43. 2001 Middle Subbasin habitat survey reaches are shown in dark blue.
The five mainstem reach boundaries are delineated by dotted lines.

In 2001, Panther and Garrett creeks and an unnamed tributary to Coyote Creek had at least 30% of the survey reach length of pools. In general, the other tributary streams lack pool habitat. A general pattern observed is the pool percent occurrence is generally higher than pool percent of total reach length, indicating that under present conditions, pools on average are shorter in length than runs and riffle habitats. In 2001, the middle mainstem of Redwood Creek averaged 52% by length in pool habitat, with the five reaches ranging from 27 to 66% pools by reach length.

Table IV- 72. Middle Subbasin percent by occurrence and length of pool, run, riffle, and dry habitats in anadromous fish reaches summer 2001.

Stream	Survey Length (ft.)	Pool:Riffle:Flatwater % Occurrence [1]	Pool:Riffle:Flatwater % Total Length [1]	Dry % Total Length	Culvert % Total Length
Beaver Creek	2,731	32 : 38 : 28	11 : 44 : 43		2*
Captain Creek	2,360	25 : 40 : 35	10 : 60 : 31		
Coyote Creek	11,282	37 : 33 : 28	26 : 33 : 37	5	
Coyote Ck. Trib 1	2106	48 : 35 : 17	36 : 44 : 20		
Dolly Varden Creek	5,968	44 : 27 :28	27 : 24 : 46	1	
Garrett Creek	4,779	46 : 22 : 30	31 : 21 : 46	1	
Lacks Creek	24,262	15 : 52 : 33	8 : 63 : 29		
Lupton Creek	3,832	42 : 38 : 16	42 : 25 : 18	2	13*
Mill Creek	2,788	34 : 30 : 36	11 : 34 : 54		
Minor Creek	14,418	28 : 39 : 33	17 : 44 : 38		
Molasses Creek	2,556	31 : 33 : 36	13 : 24 : 62		
Panther Creek	14,504	46 : 35 : 17	33 : 37 : 28	1	**
Pilchuck Creek	1,617	29 : 49 : 22	18 : 52 : 30		
Sweathouse Creek	1611	25 : 41 : 31	14 : 8 : 56	22	
Toss up Creek	5,462	30 : 43 : 27	23 : 48 : 29		
Wiregrass Creek	2,000	43 : 17 : 40	13 : 15 : 71		
Redwood Creek 1 (1)	12,202	37 : 26 : 37	27 : 16: 57		
Redwood Creek 2 (1)	20,886	46 : 21 : 34	38 : 15 : 48		
Redwood Creek 3 (1)	35,904	63 : 10 : 27	56 : 6 : 38		
Redwood Creek 4 (1)	34,110	55 : 17 : 29	47 : 12 : 41		
Redwood Creek 5 (1)	41,377	68 : 15 : 17	66 : 15 : 19		
Redwood Creek Total	130,874	59 : 16 : 25	52 : 12 : 36		

[1] Includes side channel and secondary channel habitats
* Culverts impede or are fish passage barriers
** Culvert replaced with bridge Sept. 2001

Pool Characteristics

***Significance*:** Pool depth, pool area, pool frequency, and pool shelter complexity are fundamental attributes of channel morphology and are largely dependent on stream gradient, discharge, the presence of instream large woody debris (LWD) or boulders, channel width, and channel type. Moderately deep pools that provide shelter are often preferred rearing habitat for juvenile salmonids and are necessary holding and resting habitat for adult salmonids during spawning migrations. Streams of the Middle Subbasin have a high degree of variation in pool characteristics, but overall, pool quantity and quality (depth and shelter complexity) could improve with addition of LWD and pool enhancement structures to meet desirable conditions for anadromous salmonid production.

Pool Depth

***Significance*:** Deep pools are important as year round rearing habitat for coho salmon and coastal cutthroat trout and holding habitat for all adult salmonids during spawning migrations. Flosi et al. (1998) suggest that pool enhancement projects should be considered when pools with maximum depths of 2 feet (for 1st and 2nd order streams) or 3 feet (for 3rd order streams) comprise less than 40% of the length of total stream habitat. A shortage of deep pools may indicate a disruption to channel forming processes which may be caused by a lack of LWD and/or elevated levels of stored sediments.

Results from stream surveys conducted in 2001 show that most tributary streams lack adequate deep pool habitat. The pools of tributary streams were generally shallow except for a few pools in reaches of Coyote Creek, Lacks Creek, and Minor Creek (Figure IV- 44). Lupton Creek has a few long and deep pools in the lower reach which account for 10% of the total survey length. Lacks Creek has few pools, but these pools are relatively deep compared to other tributary streams of the subbasin (Figure IV- 45). Redwood Creek shows mixed results for pool depths. Reaches 2 and 3 contained deep pools while reaches 1 and 5 provided few deep pools. Overall, in the middle reach of Redwood Creek, the mean maximum residual pool depth was 4.0 feet with 55% of pools having maximum residual pools depths of four feet or less shows the distribution of residual pool depths in the middle reach of Redwood Creek.

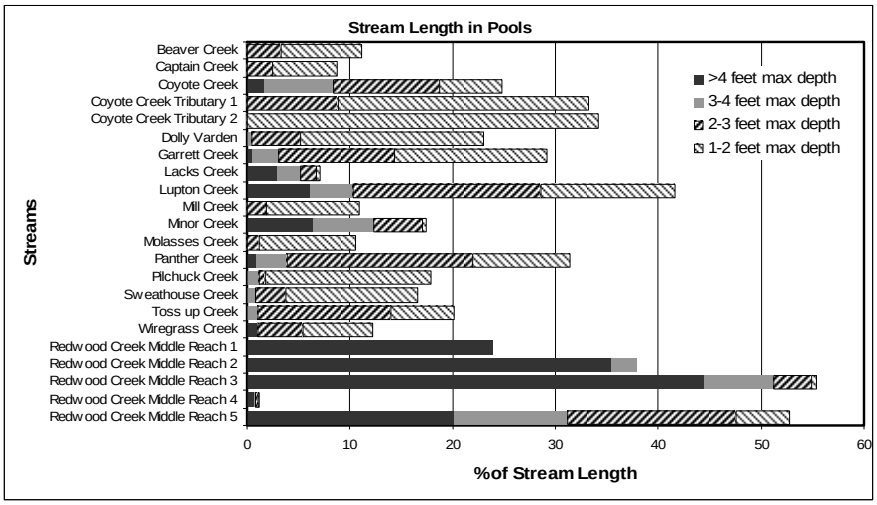

Figure IV- 44. Middle Subbasin percent stream lengths at various pool depths surveyed, 2001.

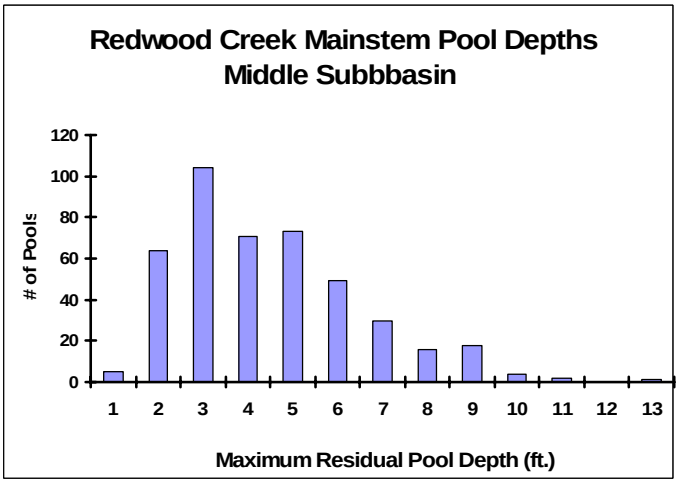

Figure IV- 45. 2001 Middle Subbasin mainstem Redwood Creek maximum residual pool depths.

Pool Frequency

***Significance*:** Pool frequency is measured as a ratio of the number of bank full widths (BFW) per pool in a stream reach. Using this metric, 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 often spaced more or less regularly at a repeating distance of 5 to 7 BFWs (Leopold 1994). This pool frequency metric may be confounded by BFWs that have increased from excessive bank erosion or by inaccurate BFW measurements. Bank full width measurements were only measured at pool-tail-crests during CDFG stream surveys which may underestimate the actual average bank full channel width.

Most tributary streams in the Middle Subbasin fit the general pool frequency range of one pool for every two to seven BFWs (Table IV- 73). Six stream reaches were well outside the desirable frequency range indicating a low number of pools, most notably Lacks, Beaver, Mill and Molasses creeks. Pool frequency was not estimated for Redwood Creek, because there were not sufficient BFW measurements collected to develop the ratio.

Table IV- 73. Stream order, pool frequency, and mean residual pool depths in Middle Subbasin tributaries.

Stream	Stream Order	Reach Length (ft.)	Estimated Bank Full Width (ft.)	Pool Count	BFW: Pool ratio	Mean Residual Max Pool Depth (ft.)
Coyote trib	1	2106	21	26	4 : 1	1.5
Panther Creek	1	5413	18.8	77	4 : 1	1.4
Mill Creek	1	2788	17	34	5 : 1	1.2
Pilchuck Creek	1	1617	26	13	5 : 1	1.4
Molasses Creek	1	2556	18.2	11	13 : 1	1
Toss Up Creek	1	3555	21.6	32	5 : 1	1.7
Wiregrass Creek	1	2000	24.9	19	4 : 1	1.4
Sweathouse Creek	1	1859	28	8	8 : 1	1.9
Captain Creek	1	2360	30.8	10	8 : 1	1.6
Lupton Creek	1	3832	32.2	19	6 : 1	1.6
Coyote Creek	2	2013	44.5	18	3 : 1	2.4
Garret Creek	2	4779	37.3	58	2 : 1	1.8
Panther Creek	2	9176	28.3	52	6 : 1	2
Lacks Creek	2	12982	38	20	17 : 1	3
Dolly Varden Creek	2	5833	23	77	3 : 1	1.3
Beaver Creek	2	2608	11.8	19	12 : 1	1.3
Toss Up Creek	2	1907	29.2	38	2 : 1	1.6
Minor Creek	2	14418	42.3	34	10 : 1	2.8
Coyote Creek	3	9269	40.5	58	4 : 1	2
Lacks Creek	3	11280	47.4	20	12 : 1	3.1
Redwood Creek	4	126720	na	437	na	3.7

Data collected during CDFG stream surveys, 2001.

Pool Shelter Complexity

***Significance*:** The pool shelter rating is a relative measure of the quantity and composition of LWD, root wads, boulders, undercut banks, bubble curtain, and submersed or overhanging vegetation. These elements serve as instream habitat, create areas of diverse velocity, provide protection from predation, and separation of territorial units to reduce density related competition. The rating does not consider factors related to changes in discharge, such as water depth. A pool shelter rating of approximately 100 is desirable (Flosi et al. 1998).

Pool shelter ratings were generally below desirable targets for all tributaries and Redwood Creek (Figure IV-46). The low pool shelter ratings indicate the lack of LWD, undercut banks, and other shelter elements in fish bearing streams of the Middle Subbasin.

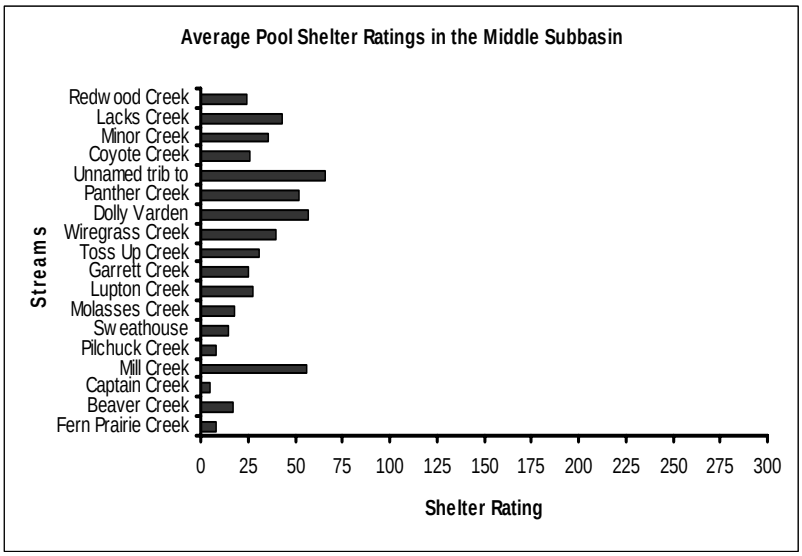

Figure IV- 46. Middle Subbasin average pool shelter ratings from 2001 CDFG Stream Surveys.

Average pool shelter ratings of 100 are considered desirable.

Pool Shelter Composition

Boulders are the dominant shelter elements in the tributaries and mainstem of Redwood Creek and woody debris is the subdominant element (Table IV- 74). Boulders ranked highest in 14 of the 17 tributaries and highest in all of the mainstem reaches. Woody debris was consistently the next most common shelter type, ranking either second or first in all but two tributaries and one mainstem reach. However, few pools formed by the presence of wood were noted in the 2001 stream surveys. In forested streams of the North Coast, it would be expected that large woody debris would contribute to forming many pools and be a more dominant cover element than boulders. Taken together, the lack of pools formed by wood, the dominance by boulders and the general unsuitability of shelter ratings indicate a lack of large woody debris within many Middle Subbasin stream channels.

Table IV- 74. Middle Subbasin summary of shelter composition.

Streams	Undercut Banks	Woody Debris	Terrestrial Vegetation	Aquatic Vegetation	White-water	Boulders	Bedrock Ledges
Beaver Ck	2					1	
Captain Ck		2				1	
Coyote Ck		2				1	
Trib. to Coyote Ck		1				2	
Dolly Varden Ck		1				2	
Fern Prairie Ck		2				1	
Garrett Ck		2				1	
Lacks Ck		2				1	
Lupton Ck		2				1	
Mill Ck		2				1	
Minor Ck		2				1	
Molasses Ck		2				1	
Panther Ck		2				1	
Pilchuck Ck		1				2	
Sweathouse Ck	2					1	
Toss Up Ck		2				1	
Wiregrass Ck		2				1	
Mainstem Redwood Ck							
Reach 1		2				1	
Reach 2		2				1	
Reach 3	2					1	
Reach 4		2				1	
Reach 5						1	2

Dominant (1) and Subdominant (2) shelter types in pool and flatwater units in the Middle Subbasin. See figures located in Appendix D for details.

Spawning Cobble Embeddedness

***Significance*:** Measures of percent cobble embeddedness helps determine suitability of substrate for spawning, egg incubation, and fry emergence. Cobble embeddedness of 25% or less is considered high quality spawning habitat (Flosi et al. 1998). An excessive accumulation of fine sediments causes high cobble embeddedness which also reduces 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 may indicate elevated levels of erosion occurring somewhere in the watershed.

Embeddedness ratings showed mixed results for both tributaries and mainstem Redwood Creek. The most high quality spawning substrate was observed in reaches of Molasses, Minor, upper Lacks, and Coyote creeks (Figure IV- 47). The highest level of embeddedness was observed in Toss up, Panther, Lupton, Sweathouse Creeks, and mainstem Redwood Creek. Lacks, Pilchuck, and Captain Creek and others had pool tails rated as unspawnable because the dominate substrate was predominantly composed of boulders or sometimes silt. In some cases the spawning substrate at pool tails was in good condition, but these sites were few in number due to the lack of pools in the survey reach.

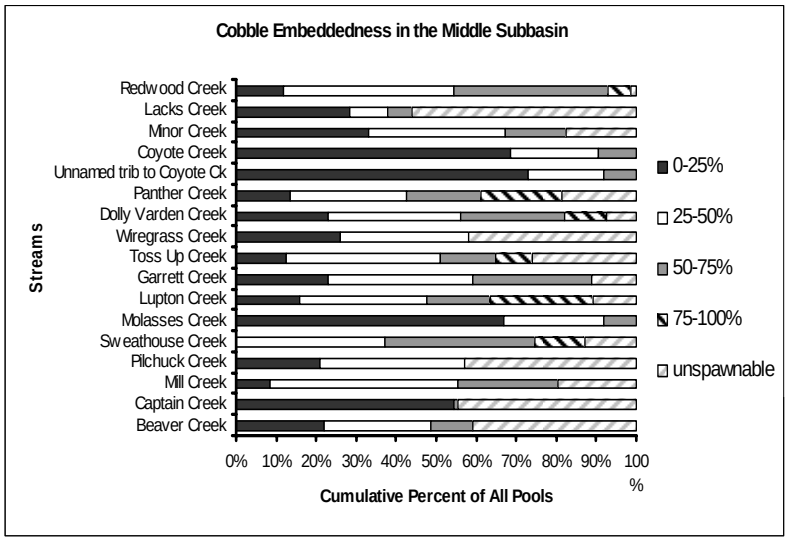

Figure IV- 47. Percent cobble embeddedness in Middle Subbasin streams.
Cobble embeddedness of 0-25% is considered high quality salmonid spawning substrate. The unspawnable category includes pool tails composed of bedrock or silt or contain boulders or logs that prohibit spawning.

Streamside Canopy Density

Significance: Streamside canopy density is a measure of the percentage of wetted stream that is influenced by nearstream forest 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 recruitment. The roots of riparian vegetation also help maintain soil and stream bank stability. The riparian trees providing streamside canopy in the subbasin are typically composed of mixed hardwood and coniferous tree species. Generally, riparian management projects are considered when canopy density is less than 80% (Flosi et al. 1998).

The average canopy density over the mainstem Redwood Creek of the Middle Subbasin was approximately 40% (Figure IV- 48). The wide channel of the mainstem and historical harvest of streamside conifers (Urner and Madej 1998) impair riparian and nearstream forest canopy from providing shade on large areas of mainstem Redwood Creek. Lack of shade over the water contributes to high water temperature.

The average canopy densities along most tributary streams provide sufficient shade to moderate the heating effects from direct sunlight on stream water. Portions of Lacks, Captain and Coyote creeks show the lowest amount of canopy cover. A closer review of the data shows that the great majority of the shade canopy was formed by deciduous trees (Figure IV- 48). The small fraction of conifer tress providing shade is considerably less than desirable considering these are coniferous forest streams. The lack of large sized conifers impairs processes such as LWD loading potential and moderating air temperature along most Middle Subbasin tributary streams and along the mainstem of Redwood Creek.

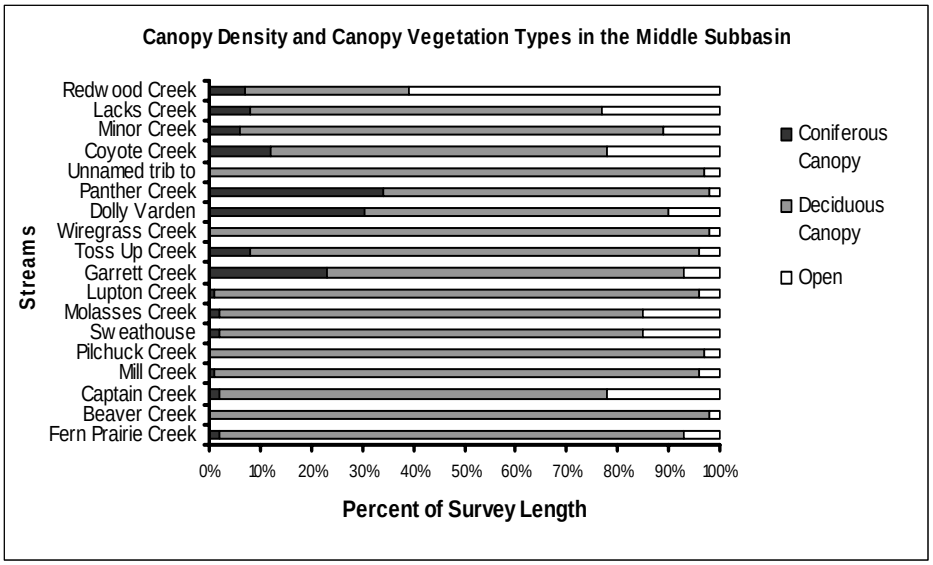

Figure IV- 48. Middle Subbasin percent canopy density and percent vegetation type contributing to stream shade cover.

Barriers to Fish Passage

Culverts that impede fish passage were noted on Beaver, Lupton, Stover, and Panther creeks. Large debris accumulations (LDA) and a sediment delta that impede fish passage were found on Panther Creek. The culvert on Panther Creek was replaced with a bridge in September, 2001 and the LDAs were modified to accommodate fish passage in 2003-04. However, fish passage through the mouth and lowermost reach of Panther Creek is impaired by an accumulation of small boulders or a perched delta (Figure IV- 49). The stream flow is spread across the channel and through spaces between the boulders making adult fish passage near impossible during low to moderate stream flows. The delta is perched to a height several feet above the mainstem channel and is accessible to spawners only during the highest mainstem and tributary stream flows which generally occur after the peak of coho and Chinook spawning runs. For this reason Chinook and coho are only likely to gain access to Panther Creek for spawning in years with early rains of sufficient intensity to raise mainstem Redwood Creek and create sufficient surface flow in Panther Creek to provide upstream passage. Redwood Creek is unusually wide at this location so it is difficult for the water surface elevation to rise significantly. These features are typically not noted using present CDFG stream survey protocols. The perched deltas and associated passage problems may be found on other streams of the Middle Subbasin.

Figure IV- 49. Example of perched delta at mouth of Panther Creek, summer 2004.

Stream is flowing under boulder accumulations. The delta accumulations impede fish passage into Panther Creek during upstream spawning migrations at all but the highest flows. Juvenile coho salmon were noted as numerous in 1975 in Panther Creek. Coho were not detected here in 2001. The perched deltas and associated passage problems may be found on other streams of the Middle Subbasin.

Salmonid Fishery Resources

Coho Salmon

A review of past and present spawner and redd counts and surveys for juvenile salmonids concludes that coho salmon have declined in abundance and distribution in the Middle Subbasin. Coho populations of the Middle Subbasin have been adversely impacted by multiple factors. Droughts of 1976-78 and 1988-1993, barriers, aggraded channels, and associated loss of habitat diversity and complexity have all contributed to a decline in coho numbers and distribution.

In the 1970s and 1980s, juvenile coho were observed during surveys of Coyote, Panther, Dolly Varden (Karen), Pilchuck, Lacks, Minor and Redwood creeks in (CDFG 1975, Brown 1988;). Spawning surveys conducted in 1986-87 reported several adult coho in Redwood Creek in the Redwood Valley area (Personal communications, Mitch Farro 2002). In the mid 1990's juvenile coho salmon were observed during snorkel surveys in cool water patches found in Redwood Creek at the confluences with Minor and Lacks creeks and in the impoundment behind the Chezem dam (Weseloh 1994; 1995; 1996;). Juvenile Coho were also observed in 1995 stream surveys in Minor Creek (PCFWWRA 1995). However, juvenile coho were not observed from any Middle Subbasin streams during 2001 electrofishing surveys designed to detect coho presence. Two adult coho were observed in Redwood Creek just above the confluence with Toss Up Creek during a spawning survey in 2000 (PCFWWRA 2001). However, juvenile coho were not observed during the four years of downstream trapping (1999-2003) studies on mainstem Redwood Creek (near Toss Up Creek) (Sparkman 2003).

Chinook Salmon

Chinook salmon typically use the middle reach of Redwood Creek, and the lower reaches of Lacks and Minor creeks for spawning. These are some of the best spawning areas for Chinook salmon in the Redwood Creek Basin (USFWS 1960 and M. Farro, PCFWWRA, written communications, 2002).

The peak migration period out of the Middle Subbasin for Chinook juveniles is generally from Mid April to early May (Sparkman 2000; 2001; 2002; 2003, 2004). Juvenile Chinook arrive in the estuary soon after leaving the Middle Subbasin at size of (50-60 mm FL). Water temperatures in the middle reach of Redwood Creek are generally too warm to support salmonids over the summer months. However, juvenile Chinook were observed rearing in lower Lacks Creek (August 2002) (B. Reisberger, IFWM, personal communications) where temperatures are cooler than the mainstem.

Spawner surveys conducted in the 2001-2002 season along an approximately 10 mile reach of Redwood Creek mainstem (between Lacks and Toss Up creeks) yielded 113 Chinook redds or 11.3 redds per mile. A total of 265 live Chinook, 83 Chinook carcasses, were also observed in this reach (M. Farro 2002 written communications). More information on spawner surveys is presented in the general discussion of Chinook salmon in the Fishery Resources of section III of this report.

Beginning in 2000 a rotary screw trap was operated on mainstem Redwood Creek just upstream of Toss Up Creek. The trapping efforts provided a basis for estimating numbers of juvenile Chinook produced in the approximately the upper third of the Redwood Creek Basin, which includes the upper half of the Middle Subbasin. Population estimates ranged from 987 in 2003 to over 500,000 in 2002. The trapping results show inter-annual variation in Chinook spawning success in Redwood Creek (Sparkman 2000; 2001; 2002; 2003). Details of the trapping counts are presented in the general discussion of Chinook salmon in the Fishery Resources of section III of this report.

Steelhead

Steelhead is the most commonly observed salmonid species found in the anadromous reaches of the Middle Subbasin streams. They are found in the mainstem Redwood Creek and in 22 tributary streams of the Middle Subbasin. During electrofishing surveys in Middle Subbasin tributaries Coyote, Panther, Lacks, Minor and Toss Up creeks produced the highest numbers of steelhead YOY per unit effort (#fish / seconds e-fished) (Appendix D). The presence and abundance of YOY indicates successful spawning and hatching. Beaver Sweathouse and Wiregrass creeks produced the least number of YOY steelhead per unit of effort. Panther and Coyote creeks produced the highest numbers of age 1 and older steelhead. Beaver, Sweathouse, Pilchuck, and Dolly Varden creeks produced the lowest numbers of yearling and older steelhead. The presence and abundance of steelhead age 1 and older in a stream provide some insight into stream habitat suitability for different age classes. Thus streams supporting abundant numbers and all age classes may be viewed as good steelhead streams. Conversely, the presence of large numbers of sub-yearling steelhead, but very few age 1 and older fish may indicate a bottleneck or habitat factor that is limiting the advancement to older age classes.

Summer Steelhead

The summer steelhead is a unique stock of steelhead that migrates from the ocean into Redwood Creek from March through June, but do not spawn until the following rainy season. Summer steelhead depend upon deep, complex and cool pools of the Middle Subbasin for over summer habitat as they wait for the fall rains to complete the spawning run.

Counts of adult summer steelhead collected by RNSP 1981-2000 from dive surveys of Redwood Creek ranged from 3 fish in 2000 to 37 fish in 1997. The low counts of summer steelhead indicate that they are likely the most threatened by extirpation of all the anadromous stocks in the Redwood Creek Basin. In addition, it has been noted that the current numbers of adult spawners may be less than the minimum size needed to sustain a viable summer steelhead population (Meffe 1986 and Nehlsen 1991).

Primary reasons for the decline in summer steelhead numbers include the reduction of deep, complex pools, and cool water temperature needed for summer holding habitat, and perhaps competition for suitable juvenile rearing habitat. Most of the pool habitat loss occurred after the flood of December 1964 (Fisk et al 1966) and this

condition persisted for many years. The summer steelhead population likely declined abruptly without the deep, sheltered, and cool pool habitat needed to sustain adults over the summer season.

Coastal Cutthroat

The full range of coastal cutthroat of the Middle Subbasin is not known. Coastal cutthroat have been observed in Redwood Creek during past surveys as well as Lacks, Coyote, and Panther creeks. However, Panther Creek produced the only positively identified coastal cutthroat from Middle Subbasin streams during 2001 electrofishing surveys in anadromous reaches. Young coastal cutthroat are very difficult to distinguish from young steelhead and resident rainbow trout. Their numbers may be underestimated, but older age classes become easier to separate from the steelhead or rainbow trout. Like coho, coastal cutthroat prefer cool water and a high amount of shelter complexity including LWD. The high water temperatures and lack of habitat complexity may preclude coastal cutthroat from residing in the middle reach of Redwood Creek.

Resident populations of coastal cutthroat are found above the anadromous reach of Panther Creek (B. Michaels personal communication 2002) and likely occur in other streams. Only 17 coastal cutthroats were captured during the three years of rotary screw trapping efforts on the mainstem Redwood Creek (Sparkman 2002). No large coastal cutthroats have been reported during recent summer steelhead dive surveys (Weseloh 1994, 1995, 1996).

Middle Subbasin General Issues

Salmonid populations have declined from historic levels, prompting listings under the state and federal ESAs:

- There is a decline in abundance and distribution of coho salmon and coastal cutthroat trout in the Middle Subbasin;
- Coho salmon were not observed in 2001 fish surveys;
- The summer steelhead population has declined to critically low levels of abundance;
- Chinook salmon show variable spawning success among years.

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:

- Mixed conditions for salmonid spawning and rearing success exist in the subbasin;
- There is a lack of shade canopy along mainstem Redwood Creek;
- High summer water temperature along the mainstem Redwood Creek and lower reaches of Lacks and Minor creek impairs juvenile rearing habitat and adult holding habitat for summer steelhead;
- There is a lack of deep and complex pools in tributary streams and mainstem Redwood Creek;
- A lack of instream LWD impairs fish habitat;
- Stream habitat conditions in the Middle Subbasin can be improved.

The Middle Subbasin terrain is highly susceptible to erosion:

- High potential exists for large sediment inputs from disturbed and unstable hillslopes;
- High levels of sediment are stored in mainstem and some tributary channels;
- Historically active landslide features cover 4,200 acres (6.5%) of the subbasin. These features are critical sources of sediment inputs to stream channels.

Land management can influence watershed processes:

- Land use has made the Middle Subbasin's terrain more susceptible to erosion;

- High road density of both abandoned and useable roads adds to sediment delivery potential;
- Debris slides and debris flows are often initiated by management activities (such as road construction) that take place on existing earthflows or rockslides.

Riparian and near stream forests have been altered by timber harvests and bank erosion:

- Timber harvests have caused significant levels of disturbance to riparian and near stream forest areas causing a reduction in both overstory shade canopy and LWD input potential;
- In response to aggraded channels, stream banks erode, channels widen, and riparian vegetation becomes less affective to provide shade over the water;

The Chezem summer dam alters aquatic habitat during dam construction and decommissioning;

- Dam construction increases suspended sediment levels to downstream reaches;
- Mutes changes in diurnal water temperatures to downstream reaches;
- Inundates approximately one mile of stream habitat.

Integrated Analysis

Integrated Analysis and Cumulative Effects

The Middle Subbasin is located inland from the coastal fog belt so it has a warmer summer climate and cooler winter climate than the Prairie Creek and Lower subbasins. The warm and dry summer climate influences the distribution of both terrestrial and aquatic biota. Conifer forests are dominated by Douglas fir instead of redwoods and hardwood forests also become more expansive than within the coastal areas. The warmer climate also affects water temperatures. In mainstem Redwood Creek average water temperatures are above desirable levels for anadromous salmonids throughout the mainstem reach. Cool water is found in thermally stratified pools or near patches of cool water, which may be located at the confluence of tributaries. Cool water habitat, needed by salmonids during summer months is found in most tributaries.

Subbasin-wide, 6.5% or 4,166 acres of the area is comprised of historically active landslide features with earthflows as the predominant landslide feature type (Table IV- 75). Lower Lacks Creek Planning Watershed has the highest percentage of area (18%) in historically active landslide features followed by Coyote Creek (10.6%) and Minor Creek (8.3%) planning watersheds. These three planning watersheds are located on the east side of the Grogan Fault and their underlying bedrock is largely composed of the incoherent unit of Coyote Creek. This bedrock is highly erodible, contains active earthflows, and is very susceptible to land sliding. Ground disturbance adds to the tendency for landsliding on this unstable geology. Toss Up, Roaring Gulch, and Panther Creek planning watersheds have the lowest percentages of area (1.7, 3.0, and 3.1% respectively) in historically active landslide features in the Middle Subbasin. These planning watersheds are located mostly on the west side of the Grogan Fault. There, the underlying bedrock is composed of Redwood Creek schist. The schist is generally more stable than the bedrock of the eastern portion of the subbasin and most erosion in the form of debris slides on steep slopes.

Subbasin-wide, woodland and grassland underlain by historically active landslides accounts for 2.8% of the area or 1,802 acres. Lower Lacks Creek Planning Watershed has the highest percentage (12.5%) of its area in woodland and grassland on historically active landslides; Toss Up Creek has the lowest at 0.3%. Debris slides and debris flows cover 325 acres (0.5%) of the subbasin. These features are critical sources of sediment inputs to stream channels. Debris slides and debris flows are often initiated by management activities (such as road construction) on earthflows or rockslides. These features may be prevented by recognizing their potential for erosion and planning management activities to minimize or avoid decreasing slope stability.

Streamside landslides are often included in the debris slide or debris flow categories but also may be considered rock slides in Table IV- 75. The number of active stream side landslides recently increased by 18% (from 376 in 1984 to 442 in 2001) within the Middle Subbasin. The largest increase was observed in Lower Lacks Creek (+221%) and Panther Creek (+68%) planning watersheds. The winter storm of 1997 contributed to the increase

in landslides. The largest decline in numbers of active stream side landslides was in Minor Creek (-91%) and Lupton Creek (-56%) planning watersheds.

Recent THPs on historically active landslide features comprise 1.3% of the subbasin, or 852 acres. The Panther Creek planning watershed had the lowest percentage (essentially zero) of its area in recent THPs on historically active landslide features. Minor Creek has the highest percentage (5.0%) of its area in recent THPs on historically active landslide features. Considering past timber activities, over half (44,400 acres) of the timber harvest in the Middle Subbasin occurred between 1950 and 1974, before modern harvest management rules were implemented. Another 26,600 acres were harvested between 1974 and 1991. Table IV-77 does not consider the relationships from these past harvest activities and these slides. The pre 1974 harvests generated more ground disturbance from road construction and skid trails than most re-entry harvests of recent years. Much of the recent harvest involved second and third entry silvicultural prescriptions (including hardwood removal) and used the existing road system. Second and third entry harvests do not usually have the same level of impacts as the initial entries.

Table IV- 75 broadens the view of potential slope instability and land use interactions by addressing relative landslide potential. Eighty percent of the subbasin falls into high and very high relative landslide potential classes. The bulk of this area is comprised of timberlands with no recent harvest (54%), followed by recent THPs (13.6%) and woodland or grassland (13%). Looking across the planning watersheds, Lower Lacks Creek has the greatest percentage (93.5%) of area in the highest two classes, followed by Upper Lacks Creek (90.7%), Minor Creek (90.4%), and Coyote Creek (87.4%). The planning watersheds with the smallest percentages of their area in the highest two relative landslide potential classes are Roaring Gulch (67.8%) and Lupton Creek (70.8%).

Table IV- 75. Acres and percent area of historically active landslide features associated with recent land use and vegetation type

Subbasin or Planning Watershed	Historically Active Landslide Feature[1]	Entire Subbasin or Planning Watershed		Woodland and Grassland[2]		THPs 1991 - 2000[5]		Timberland, No Recent Harvest[3]		Roads[4]	
		Area (acres)	% Area	Area (acres)	% Area	Area (acres)	% Area	Area (acres)	% Area	Length (miles)	% Total Length
Middle Redwood Creek Subbasin (64,082 acres) (716.1 road miles)	Earthflow	3,187	5.0	1,392	2.2	818	1.3	1,184	1.8	31.9	4.5
	Rock Slide	654	1.0	376	0.6	0	0.0	277	0.4	7.0	1.0
	Debris Slide	257	0.4	23	0.0	28	0.0	205	0.3	2.6	0.4
	Debris Flow	68	0.1	11	0.0	6	0.0	51	0.1	0.8	0.1
	All Features	**4,166**	**6.5**	**1,802**	**2.8**	**852**	**1.3**	**1,717**	**2.7**	**42.3**	**5.9**
Coyote Creek (7,678 acres) (79.6 road miles)	Earthflow	785	10.2	445	5.8		0.0	334	4.3	8.6	10.8
	Rock Slide	1	0.0	0	0.0		0.0	0	0.0	0.0	0.0
	Debris Slide	19	0.2	2	0.0		0.0	17	0.2	0.3	0.4
	Debris Flow	9	0.1	2	0.0		0.0	7	0.1	0.1	0.1
	All Features	**814**	**10.6**	**449**	**5.8**	**0**	**0.0**	**358**	**4.7**	**9.0**	**11.3**
Lower Lacks Creek (5,935 acres) (47.3 road miles)	Earthflow	572	9.6	359	6.0	40	0.7	173	2.9	3.8	8.0
	Rock Slide	448	7.5	376	6.3		0.0	72	1.2	4.2	8.8
	Debris Slide	31	0.5	7	0.1	2	0.0	23	0.4	0.1	0.2
	Debris Flow	11	0.2	1	0.0	2	0.0	8	0.1	0.1	0.1
	All Features	**1,062**	**17.9**	**742**	**12.5**	**43**	**0.7**	**276**	**4.7**	**8.1**	**17.2**
Lupton Creek (8,050 acres) (116.4 road miles)	Earthflow	406	5.0	112	1.4	154	1.9	139	1.7	3.5	3.0
	Rock Slide	133	1.7		0.0	0	0.0	132	1.6	1.8	1.5
	Debris Slide	29	0.4	0	0.0	4	0.0	24	0.3	0.5	0.4
	Debris Flow	1	0.0		0.0	0	0.0	1	0.0	0.0	0.0
	All Features	**569**	**7.1**	**112**	**1.4**	**158**	**2.0**	**297**	**3.7**	**5.8**	**4.9**
Minor Creek (9,959 acres) (122.2 road miles)	Earthflow	774	7.8	281	2.8	477	4.8	185	1.9	9.4	7.7
	Rock Slide	4	0.0		0.0		0.0	4	0.0		0.0
	Debris Slide	46	0.5	2	0.0	14	0.1	31	0.3	0.6	0.5
	Debris Flow	7	0.1		0.0	2	0.0	5	0.0	0.1	0.1
	All Features	**831**	**8.3**	**283**	**2.8**	**493**	**5.0**	**224**	**2.2**	**10.1**	**8.3**
Panther Creek (9,745 acres) (94.1 road miles)	Earthflow	261	2.7	83	0.9		0.0	177	1.8	2.4	2.5
	Rock Slide		0.0		0.0		0.0		0.0		0.0
	Debris Slide	33	0.3	6	0.1	0	0.0	24	0.2	0.2	0.2

Subbasin or Planning Watershed	Historically Active Landslide Feature[1]	Entire Subbasin or Planning Watershed		Woodland and Grassland[2]		THPs 1991 - 2000[5]		Timberland, No Recent Harvest[3]		Roads[4]	
		Area (acres)	% Area	Area (acres)	% Area	Area (acres)	% Area	Area (acres)	% Area	Length (miles)	% Total Length
	Debris Flow	9	0.1	1	0.0	1	0.0	8	0.1	0.1	0.1
	All Features	**302**	**3.1**	**90**	**0.9**	**1**	**0.0**	**208**	**2.1**	**2.7**	**2.8**
Roaring Gulch (8,906 acres) (108.0 road miles)	Earthflow	181	2.0	48	0.5	105	1.2	74	0.8	1.5	1.4
	Rock Slide	33	0.4		0.0		0.0	32	0.4	0.4	0.3
	Debris Slide	45	0.5	3	0.0	5	0.1	37	0.4	0.5	0.4
	Debris Flow	8	0.1	1	0.0		0.0	7	0.1	0.1	0.1
	All Features	**267**	**3.0**	**53**	**0.6**	**110**	**1.2**	**151**	**1.7**	**2.4**	**2.2**
Toss-up Creek (8,734acres) (94 road miles)	Earthflow	118	1.4	20	0.2	37	0.4	62	0.7	1.6	1.7
	Rock Slide		0.0		0.0		0.0		0.0		0.0
	Debris Slide	16	0.2	1	0.0	1	0.0	14	0.2	0.2	0.2
	Debris Flow	19	0.2	6	0.1		0.0	12	0.1	0.2	0.2
	All Features	**153**	**1.7**	**27**	**0.3**	**38**	**0.4**	**88**	**1.0**	**2.0**	**2.1**
Upper Lacks Creek (5,076 acres) (54.4 road miles)	Earthflow	89	1.8	45	0.9	5	0.1	40	0.8	1.3	2.3
	Rock Slide	36	0.7		0.0		0.0	36	0.7	0.7	1.3
	Debris Slide	38	0.7	0	0.0	2	0.0	36	0.7	0.3	0.5
	Debris Flow	4	0.1	0	0.0	1	0.0	3	0.1	0.1	0.1
	All Features	**168**	**3.3**	**45**	**0.9**	**8**	**0.2**	**114**	**2.3**	**2.3**	**4.2**

[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] Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
[4] Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
[5] THPs are complete or active between the 1991 and 2000 timeframe.
Empty cells denote zero.
Percent of area is based on the unit of analysis: subbasin or planning watershed.

Recent THPs (1991-2000) on the higher relative landslide potential classes comprise 13.6% of the Middle Subbasin area (Table IV- 76). On a planning watershed basis, the Coyote Creek Planning Watershed had no THPs on these lands. The Minor Creek planning watershed had 30.5% of its area in THPs on the high and very high relative landslide potential classes during the 1991-2000 decade. This relatively high rate of harvest on areas of high relative landslide potential is a cause for concern and further investigation, though keeping in mind the mitigation measures built into the THP process for addressing such concerns and the type of harvest. The discussion above regarding THPs on historically active landslide feature raised a similar concern. Lupton Creek planning watershed also had a relatively high level (18.2%) of timber harvest on areas of high and very high relative landslide potential. Lower Lacks Creek (5.6%) and Panther Creek (8.5%) had relatively low levels of recent harvests on the highest two classes of relative landslide potential, but yielded the highest increase in recent landslide activity.

Roads on areas of higher relative landslide potential also merit exploration as potential risk factors for slope instability and sediment generation. At the subbasin level, 74.4% (524 miles) of the road length is on areas of high or very high relative landslide potential (Table IV- 76). This appears to indicate a fairly high potential for road failure due to slope instability. Looking across the planning watersheds, the highest percentage of road length on the highest two classes of relative landslide potential are on Lower Lacks Creek (89.0% or 42.1 miles), Minor Creek (88.2% or 108.0 miles), and Upper Lacks Creek (86.0% or 46.8 miles). Roaring Gulch Creek planning watershed has the lowest percentage of roads on the highest two classes of relative landslide potential (60.9% or 65.8 miles). The roads located on the high landslide potential area may be priority candidates for road improvement projects.

Table IV- 77 presents an integrated information summary for the Middle Subbasin. It provides the reader the opportunity to compare a large number of factors across the watershed and subbasins and, for some of the subbasins, to look at potential interactions between disturbance factors and watershed condition.

Table IV- 76. Middle 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[4]		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
Middle Redwood Creek Subbasin (64,082 acres) (716.1 road miles)	Very Low	2,689	4.2%	375	0.6%	334	0.5%	1,840	2.9%	44.5	6.2%
	Low	3,868	6.0%	454	0.7%	571	0.9%	2,803	4.4%	57.4	8.0%
	Moderate	6,002	9.4%	209	0.3%	849	1.3%	4,851	7.6%	81.4	11.4%
	High	20,402	31.8%	3,040	4.7%	2,836	4.4%	14,409	22.5%	241.3	33.7%
	Very High	31,023	48.4%	5,133	8.0%	5,859	9.1%	20,192	31.5%	291.6	40.7%
	High/Very High Subtotal	51,425	80.2%	8,173	12.8%	8,695	13.6%	34,601	54.0%	532.9	74.4%
	TOTAL	**63,984**	**100%**	**9,211**	**14%**	**10,448**	**16%**	**44,095**	**69%**	**716.2**	**100%**
Coyote Creek (7,678 acres) (79.6 road miles)	Very Low	117	1.5%	58	0.8%	0	0.0%	55	0.7%	2.4	3.0%
	Low	248	3.2%	50	0.7%	0	0.0%	195	2.5%	3.4	4.3%
	Moderate	594	7.7%	5	0.1%		0.0%	587	7.6%	5.9	7.4%
	High	2,825	36.8%	938	12.2%	0	0.0%	1,878	24.5%	30.5	38.3%
	Very High	3,884	50.6%	998	13.0%	0	0.0%	2,780	36.2%	37.3	46.9%
	High/Very High Subtotal	6,709	87.4%	1,936	25.2%	0	0.0%	4,658	60.7%	67.8	85.2%
	TOTAL	**7,668**	**100%**	**2,049**	**27%**	**0**	**0%**	**5,495**	**72%**	**79.5**	**100%**
Lower Lacks Creek (5,935 acres) (47.3 road miles)	Very Low	59	1.0%	16	0.3%	4	0.1%	34	0.6%	1.1	2.3%
	Low	288	4.9%	124	2.1%	28	0.5%	134	2.3%	3.9	8.2%
	Moderate	22	0.4%	6	0.1%		0.0%	16	0.3%	0.2	0.4%
	High	1,222	20.6%	530	8.9%	73	1.2%	642	10.8%	11.7	24.7%
	Very High	4,327	72.9%	1,468	24.7%	257	4.3%	2,639	44.5%	30.4	64.3%
	High/Very High Subtotal	5,549	93.5%	1,998	33.7%	330	5.6%	3,281	55.3%	42.1	89.0%
	TOTAL	**5,918**	**100%**	**2,144**	**36%**	**362**	**6%**	**3,465**	**58%**	**47.3**	**100%**
Lupton Creek (8,050 acres) (116.4 road miles)	Very Low	551	6.8%	47	0.6%	64	0.8%	435	5.4%	10.1	8.7%
	Low	650	8.1%	57	0.7%	179	2.2%	404	5.0%	13.0	11.2%
	Moderate	1,140	14.2%	56	0.7%	413	5.1%	647	8.0%	19.5	16.8%
	High	2,769	34.4%	270	3.4%	738	9.2%	1,765	21.9%	40.2	34.5%
	Very High	2,930	36.4%	350	4.3%	731	9.1%	1,860	23.1%	33.7	29.0%
	High/Very High Subtotal	5,699	70.8%	620	7.7%	1,469	18.2%	3,625	45.0%	73.9	63.5%
	TOTAL	**8,040**	**100%**	**780**	**10%**	**2,124**	**26%**	**5,111**	**63%**	**116.5**	**100%**
Minor Creek (9,959 acres) (122.2 road miles)	Very Low	231	2.3%	37	0.4%	78	0.8%	109	1.1%	4.8	3.9%
	Low	327	3.3%	51	0.5%	97	1.0%	179	1.8%	4.0	3.3%
	Moderate	374	3.8%	21	0.2%	44	0.4%	310	3.1%	5.6	4.6%
	High	3,075	30.9%	336	3.4%	873	8.8%	1,772	17.8%	41.9	34.2%
	Very High	5,929	59.5%	747	7.5%	2,160	21.7%	3,018	30.3%	66.1	54.0%
	High/Very High Subtotal	9,004	90.4%	1,083	10.9%	3,034	30.5%	4,790	48.1%	108.0	88.2%
	TOTAL	**9,936**	**100%**	**1,192**	**12%**	**3,252**	**33%**	**5,388**	**54%**	**122.4**	**100%**
Panther Creek (9,745 acres) (94.1 road miles)	Very Low	210	2.2%	26	0.3%	26	0.3%	135	1.4%	4.2	4.5%
	Low	642	6.6%	63	0.6%	70	0.7%	498	5.1%	7.3	7.8%
	Moderate	1,680	17.2%	17	0.2%	239	2.4%	1,397	14.3%	20.3	21.6%
	High	3,928	40.3%	549	5.6%	503	5.2%	2,850	29.2%	38.0	40.4%
	Very High	3,274	33.6%	487	5.0%	328	3.4%	2,447	25.1%	24.3	25.8%
	High/Very High Subtotal	7,202	73.9%	1,036	10.6%	831	8.5%	5,297	54.4%	62.3	66.2%
	TOTAL	**9,734**	**100%**	**1,142**	**12%**	**1,166**	**12%**	**7,327**	**75%**	**94.1**	**100%**
Roaring Gulch (8,906 acres) (108 road miles)	Very Low	791	8.9%	68	0.8%	15	0.2%	677	7.6%	11.2	10.4%
	Low	828	9.3%	20	0.2%	23	0.3%	768	8.6%	11.9	11.0%
	Moderate	1,248	14.0%	52	0.6%	69	0.8%	1,099	12.3%	19.0	17.6%
	High	2,709	30.4%	127	1.4%	215	2.4%	2,390	26.8%	34.5	31.9%
	Very High	3,325	37.3%	396	4.4%	840	9.4%	2,246	25.2%	31.3	29.0%
	High/Very High Subtotal	6,034	67.8%	523	5.9%	1,055	11.8%	4,636	52.1%	65.8	60.9%
	TOTAL	**8,901**	**100%**	**663**	**7%**	**1,162**	**13%**	**7,180**	**81%**	**107.9**	**100%**
Toss-Up Creek (8,734 acres) (94 road miles)	Very Low	589	6.7%	113	1.3%	81	0.9%	331	3.8%	8.0	8.5%
	Low	606	6.9%	56	0.6%	84	1.0%	457	5.2%	9.4	10.0%
	Moderate	906	10.4%	42	0.5%	81	0.9%	771	8.8%	10.4	11.1%
	High	2,778	31.8%	125	1.4%	232	2.7%	2,366	27.1%	30.3	32.2%
	Very High	3,847	44.0%	325	3.7%	1,023	11.7%	2,491	28.5%	35.9	38.2%
	High/Very High Subtotal	6,625	75.9%	450	5.2%	1,255	14.4%	4,857	55.6%	66.2	70.4%
	TOTAL	**8,726**	**100%**	**661**	**8%**	**1,501**	**17%**	**6,416**	**73%**	**94.0**	**100%**
Upper Lacks Creek (5,076 acres) (54.4 road miles)	Very Low	141	2.8%	10	0.2%	66	1.3%	64	1.3%	2.7	5.0%
	Low	279	5.5%	33	0.7%	90	1.8%	168	3.3%	4.5	8.3%
	Moderate	38	0.7%	10	0.2%	3	0.1%	24	0.5%	0.5	0.9%
	High	1,096	21.6%	165	3.3%	202	4.0%	746	14.7%	14.2	26.1%
	Very High	3,507	69.1%	362	7.1%	520	10.2%	2,711	53.4%	32.6	59.9%
	High/Very High Subtotal	4,603	90.7%	527	10.4%	722	14.2%	3,457	68.1%	46.8	86.0%
	TOTAL	**5,061**	**100%**	**580**	**11%**	**881**	**17%**	**3,713**	**73%**	**54.5**	**100%**

[1] Refer to Plate 1 and California Geological Survey appendix. Empty cells denote zero.
[2] Woodland and grassland include 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.
[4] THPs are complete or active between the 1991 and 2000 timeframe. Percent of area is based on the unit of analysis: subbasin or planning watershed.

Table IV- 77. Middle Subbasin integrated information summary.

Factor	Middle Redwood Subbasin		Planning Watersheds															
			Lupton Creek		Minor Creek		Toss-up Creek		Upper Lacks		Roaring Gulch		Lower Lacks		Panther Creek		Coyote Creek	
Relative Landslide Potential1	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Very Low	2,689	4.2%	551	6.9%	231	2.3%	589	6.7%	141	2.8%	791	8.9%	59	1.0%	210	2.2%	117	1.5%
Low	3,868	6.0%	650	8.1%	327	3.3%	606	6.9%	279	5.5%	828	9.3%	288	4.9%	642	6.6%	248	3.2%
Moderate	6,002	9.4%	1,140	14.2%	374	3.8%	906	10.4%	38	0.8%	1,248	14.0%	22	0.4%	1,680	17.3%	594	7.7%
High	20,402	31.9%	2,769	34.4%	3,075	30.9%	2,778	31.8%	1,096	21.7%	2,709	30.4%	1,222	20.6%	3,928	40.4%	2,825	36.8%
Very High	31,023	48.5%	2,930	36.4%	5,929	59.7%	3,847	44.1%	3,507	69.3%	3,325	37.4%	4,327	73.1%	3,274	33.6%	3,884	50.7%
High/Very High Subtotal	51,425	80.4%	5,699	70.9%	9,004	90.6%	6,625	75.9%	4,603	91.0%	6,034	67.8%	5,549	93.8%	7,202	74.0%	6,709	87.5%
GRAND TOTAL	**63,984**	**100%**	**8,040**	**100%**	**9,936**	**100%**	**8,726**	**100%**	**5,061**	**100%**	**8,901**	**100%**	**5,918**	**100%**	**9,734**	**100.0%**	**7,668**	**100.0%**
Landslide and Selected Geomorphic Features	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% area**	**acres**	**% Area**	**acres**	**% Area**
Historically Active Landslide Features Total	4,166	6.5%	569	7.1%	831	8.4%	153	1.8%	168	3.3%	267	3.0%	1,062	17.9%	302	3.1%	814	10.6%
Earthflow	68	0.1%	1	0.0%	7	0.1%	19	0.2%	4	0.1%	8	0.1%	11	0.2%	9	0.1%	9	0.1%
Rock Slide	257	0.4%	29	0.4%	46	0.5%	16	0.2%	38	0.7%	45	0.5%	31	0.5%	33	0.3%	19	0.2%
Debris Slide	3,187	5.0%	406	5.1%	774	7.8%	118	1.4%	89	1.8%	181	2.0%	572	9.7%	261	2.7%	785	10.2%
Debris Flow	654	1.0%	133	1.7%	4	0.0%	0	0.0%	36	0.7%	33	0.4%	448	7.6%	0	0.0%	1	0.0%
Dormant Landslide Features Total	15,150	23.7%	2,249	28.0%	2,487	25.0%	2,275	26.1%	198	3.9%	2,843	31.9%	1,365	23.1%	2,205	22.7%	1,528	19.9%
Selected Geomorphic Features Total	13,495	21.1%	2,010	25.0%	2,581	26.0%	961	11.0%	1,247	24.6%	182	2.1%	706	11.9%	2,934	30.1%	2,874	37.5%
Disrupted Ground	10,099	15.8%	1,932	24.0%	1,586	16.0%	923	10.6%	3	0.1%	163	1.8%	2	0.0%	2,674	27.5%	2,817	36.7%
Debris Slide Slope	2,943	4.6%	19	0.2%	884	8.9%	0	0.0%	1,155	22.8%	0	0.0%	638	10.8%	211	2.2%	35	0.5%
Inner Gorge (area)2	453	0.7%	59	0.7%	111	1.1%	38	0.4%	89	1.8%	19	0.2%	66	1.1%	49	0.5%	22	0.3%
Total of All Above Features	**32,811**	**51.3%**	**4,828**	**60.0%**	**5,900**	**59.4%**	**3,389**	**38.8%**	**1,612**	**31.9%**	**3,292**	**37.0%**	**3,134**	**52.9%**	**5,441**	**55.9%**	**5,215**	**68.0%**
Timber Harvest 1991 -2000[3]	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Silviculture Category 1																		
Tractor	3,375	5.3%	881	11.0%	1,082	10.9%	780	8.9%	82	1.6%	337	3.8%	1	0.0%	213	2.2%	0	0.0%
Cable	896	1.4%	141	1.7%	325	3.3%	177	2.0%	45	0.9%	80	0.9%	13	0.2%	115	1.2%		
Helicopter	112	0.2%	10	0.1%	97	1.0%									5	0.0%		
TOTAL	**4,383**	**6.9%**	**1,031**	**12.8%**	**1,504**	**15.1%**	**957**	**11.0%**	**126**	**2.5%**	**417**	**4.7%**	**14**	**0.2%**	**333**	**3.4%**	**0**	**0.0%**
Silviculture Category 2																		
Tractor	1,761	2.8%	156	1.9%	204	2.1%	424	4.9%	132	2.6%	583	6.5%	243	4.1%	19	0.2%		
Helicopter	79	0.1%	6	0.1%	30	0.3%	6	0.1%	11	0.2%	26	0.3%				0.0%		
Cable	203	0.3%			172	1.7%									31	0.3%		
TOTAL	**2,043**	**3.2%**	**162**	**2.0%**	**406**	**4.1%**	**430**	**4.9%**	**143**	**2.8%**	**609**	**6.8%**	**243**	**4.1%**	**50**	**0.5%**	**0**	**0.0%**
Silviculture Category 3																		
Tractor	3,129	4.9%	849	10.6%	530	5.3%	245	2.8%	581	11.5%	144	1.6%	13	0.2%	766	7.9%		
Helicopter	582	0.9%	38	0.5%	313	3.2%			30	0.6%			92	1.5%	109	1.1%		
Cable	689	1.1%	102	1.3%	583	5.9%	4	0.0%										

TOTAL	4,400	6.9%	989	12.3%	1,426	14.4%	250	2.9%	611	12.1%	144	1.6%	105	1.8%	876	9.0%	0	0.0%
GRAND TOTAL	10,826	16.9%	2,182	27.1%	3,336	33.6%	1,636	18.8%	880	17.4%	1,170	13.1%	362	6.1%	1,258	12.9%	0	0.0%
Other Land Uses	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Grazing	1,301	2.0%	237	3.0%	126	1.3%	144	1.7%			159	1.8%	44	0.7%	491	5.0%	99	1.3%
Agriculture	24	0.0%									24	0.3%						
Development	11	0.0%									11	0.1%						
Timberland, No Recent Harvest	44,095	68.9%	5,111	63.6%	5,388	54.2%	6,416	73.5%	3,713	73.4%	7,180	80.7%	3,465	58.6%	7,327	75.3%	5,495	71.7%
TOTAL	**45,430**	**71.0%**	**5,348**	**66.5%**	**5,514**	**55.5%**	**6,560**	**75.2%**	**3,713**	**73.4%**	**7,373**	**82.8%**	**3,509**	**59.3%**	**7,818**	**80.3%**	**5,594**	**73.0%**
Factor	**Middle Redwood Subbasin**		**Planning Watersheds**															
			Lupton Creek		**Minor Creek**		**Toss-up Creek**		**Upper Lacks**		**Roaring Gulch**		**Lower Lacks**		**Panther Creek**		**Coyote Creek**	
Roads																		
Road Density (miles/sq. mile)	7.2		9.3		7.9		6.9		6.9		7.8		5.2		6.2		6.8	
Density of Road Crossings (#/stream mile)	1.1		1.2		1.2		1.1		2.0		1.4		1.4		0.9		0.9	
Roads within 200' of Stream (miles/stream mile)	0.2		0.3		0.3		0.2		0.2		0.2		0.2		0.2		0.2	

[1] Refer to California Geological Survey appendix for landslide map (Plate 1), relative landslide potential map (Plate 2) and description.
[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 earth flow, rock slide, debris slide, debris flow, debris slide slopes, disrupted ground, eroding banks and inner gorges.

EMDS Potential Sediment Production Results

Table IV- 78 to Table IV- 81 look at the results of the EMDS potential sediment production model for the Middle Subbasin. While we believe that this model has utility based on the model structure, we caution that it be interpreted only as being indicative of relative conditions and not as a definitive assessment of absolute conditions. We encourage readers to see the EMDS Appendix to review the sediment production model structure, hierarchy, and weighting system. Table IV- 78 presents the top three levels of the EMDS sediment model. This analysis shows potential sediment production is related to both natural processes and land management sources. A review of the following tables helps explain the results for natural processes and management related potential sediment sources.

Table IV- 78. EMDS Ratings for potential sediment production and delivery to streams; 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
Middle Redwood Subbasin	-	-	U	+	-	-	-	-	-
Coyote Creek	-	--	U	--	---	-	-	-	-
Lower Lack's Creek	-	--	U	-	---	+	++	-	+
Lupton Creek	-	-	U	-	-	-	-	-	-
Minor Creek	--	-	U	-	--	--	--	-	--
Panther Creek	-	-	U	+	-	+	+	-	+
Roaring Gulch	-	+	U	++	+	-	-	-	--
Toss-Up Creek	+	+	U	++	+	-	-	-	-
Upper Lacks Creek	-	-	U	++	--	-	+	-	-

The sediment production potential rating is assigned with respect to suitability for anadromous salmonid production. 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. A 'U' represents a lack of data to categorize.

Table IV- 79 takes a closer look at potential sediment production from management related surface erosion. These relative ratings vary widely across the individual factors and planning watersheds, though the general direction among these is for relatively higher sediment production potentials. Road related sources generally are rated as having higher relative sediment production levels than are land use related sources. Lower Lacks Creek and Upper Lacks Creek stand out as having relatively low sediment production potential related to land use because the timber harvest used cable yarding systems and did not use tractor logging techniques. Cable yarding is not considered to promote erosion by the EMDS model while tractor logging is considered to initiate surface erosion. Minor Creek stands out as having the highest relative sediment production potential of all the planning watersheds; timber management appears to be an important contributing factor.

Table IV- 79. 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
Middle Redwood Subbasin	-	-	--	-	-	+
Coyote Creek	-	-	-	-	+	+
Lower Lack's Creek	++	+	+	+	++	++
Lupton Creek	-	-	---	--	+	+
Minor Creek	--	-	--	--	---	--
Panther Creek	+	-	-	-	+	-
Roaring Gulch	-	-	--	-	--	+
Toss-Up Creek	-	-	-	-	+	++
Upper Lacks Creek	+	-	-	-	++	++

The "+++" score represents the least amount of sediment delivery to streams on a relative scale; the "---"score represents the most sediment delivery to streams. Upper and Lower Lacks creeks Planning Watersheds received positive scores because timber harvest used high line cable systems. The model considered only tractor logging harvest methods to generate and deliver surface erosion sediments to stream channels.

Table IV- 80 examines potential sediment production from management related streamside erosion processes. These relative ratings show a somewhat high potential for sediment production from road related sources across

the subbasin and planning watersheds. The density of stream crossings on Upper Lacks Creek planning watershed appears to be a particularly high potential sediment source.

Table IV- 80. 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
Middle Redwood Subbasin	-	-	-
Coyote Creek	-	-	-
Lower Lack's Creek	-	+	--
Lupton Creek	-	--	-
Minor Creek	-	--	-
Panther Creek	-	-	+
Roaring Gulch	-	-	--
Toss-Up Creek	-	-	-
Upper Lacks 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.

The results from the management related sources and mass wasting show a somewhat high relative rating for sediment production potential across the subbasin and planning watersheds (Table IV- 81). Model results show the high road density and high number of stream crossings as the major sources of potential sediment delivery to streams. Land use related sources have a somewhat low relative sediment production potential. This result is partially due to areas of timber harvests using cable yarding systems that were not considered to generate sediment by the model.

Table IV- 81. 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
Middle Redwood Subbasin	-	-	-	--	--	-	+
Coyote Creek	-	-	-	-	--	+	+
Lower Lack's Creek	+	-	--	+	-	++	++
Lupton Creek	-	-	-	---	+	+	+
Minor Creek	--	--	-	--	---	---	--
Panther Creek	+	-	+	-	-	+	-
Roaring Gulch	--	--	--	--	-	--	+
Toss-Up Creek	-	-	-	-	--	+	++
Upper Lacks 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. Upper and Lower Lacks creeks Planning Watersheds received positive scores because timber harvest used high line cable systems. The model considered only tractor logging harvest methods to generate and deliver mass wasting sources of sediments to stream channels.

EMDS Stream Reach Condition Results and Limiting Factors Analysis

The overall reach condition of the streams located in the Middle Subbasin were all rated "somewhat unsuitable" for salmonid production by EMDS. The maps displays (Table IV- 82) results at the stream reach scale while Table IV-84 shows the average condition for each stream. These stream habitat elements that receive a negative (-) EMDS evaluation score should be considered as potential limiting factors to salmonid production in the Middle Subbasin.

The somewhat unsuitable condition rating is largely due to the lack of deep pools and a lack of pool shelter complexity in the tributary streams and the lack of shelter in pools and shade canopy over the mainstem Redwood Creek. 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.

In some instances, the EMDS results alone do not provide the most accurate description of the stream condition. For example, the mainstem Redwood Creek Reach 5 had over 50% of it s length in pools, 20% of the reach length was in pools ≥ 4 feet in maximum residual pool depth. The 20% of reach length in deep pools is at the lower limit of the EMDS suitability curve for a fourth order streams, thus the reach received the lowest EMDS rating of fully unsuitable. A closer examination of the pool depths provided in the Fish Habitat Relationships section above provides a better description of pool status than the indicated by the EMDS results and that overall, pools depths are not as poorly suited for anadromous salmonids as the EMDS scores indicate.

Table IV- 82. Summary of the results from the Middle Subbasin EMDS Stream Reach Evaluation.

Subbasin and Reach	Reach Length	Reach Condition	Canopy Density	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Redwood Middle Basin		-					
Beaver Creek	2608	-	+++	- - -	- - -	- - -	+
Captain Creek	2360	-	+ +	- - -	- - -	- - -	+ +
Coyote Creek	13379	-	+ +	- -	- -	- -	+ +
Dolly Varden Creek	5833	-	+++	-	0	-	-
Fern Prairie Creek	852	-	+ + +	- - -	- - -	- - -	0
Garrett Creek	4779	-	+ + +	- - -	- - -	- - -	-
Lacks Creek	24262	-	+	- -	- - -	- -	+ +
Lupton Creek	3832	-	+ + +	- -	-	- - -	-
Mill Creek	2788	-	+ + +	- -	- - -	- -	-
Minor Creek	14418	-	+ +	- -	- -	- -	+
Molasses Creek	2556	-	+ + +	- - -	- - -	- - -	+ +
Panther Creek	14589	-	+ + +	- -	- - -	-	-
Pilchuck Creek	1617	-	- - -	- - -	- - -	- - -	0
Sweathouse Creek	1859	-	+ + +	- - -	- - -	- - -	- -
Toss up Creek	5462	-	+ + +	- -	- - -	- -	-
Wiregrass Creek	2000	-	+ + +	- -	- - -	- -	+ +
Mid Basin Tribs Wt. Avg.	103194	-	+ +	- -	- -	- -	+
Redwood Creek Mid 1	12002	-	- -	- -	-	- - -	+
Redwood Creek Mid 2	19919	-	- - -	-	+	- - -	-
Redwood Creek Mid 3	32044	-	- - -	0	+ + +	- - -	- -
Redwood Creek Mid 4	28724	-	- - -	- - -	- - -	- - -	- -
Redwood Creek Mid 5	29406	-	- - -	- - -	- - -	- - -	-
Redwood Creek Mid Wt. Ave	130520	-	- -	- -	-	- - -	-

+ Somewhat Suitable ++ Moderately Suitable +++ Fully Suitable
- Somewhat Unsuitable -- Moderately Unsuitable --- Fully Unsuitable 0 Uncertain

These scores provide a general overview of current stream conditions and may be used to identify limiting habitat factors to anadromous salmonid production and to focus on areas for habitat improvements.

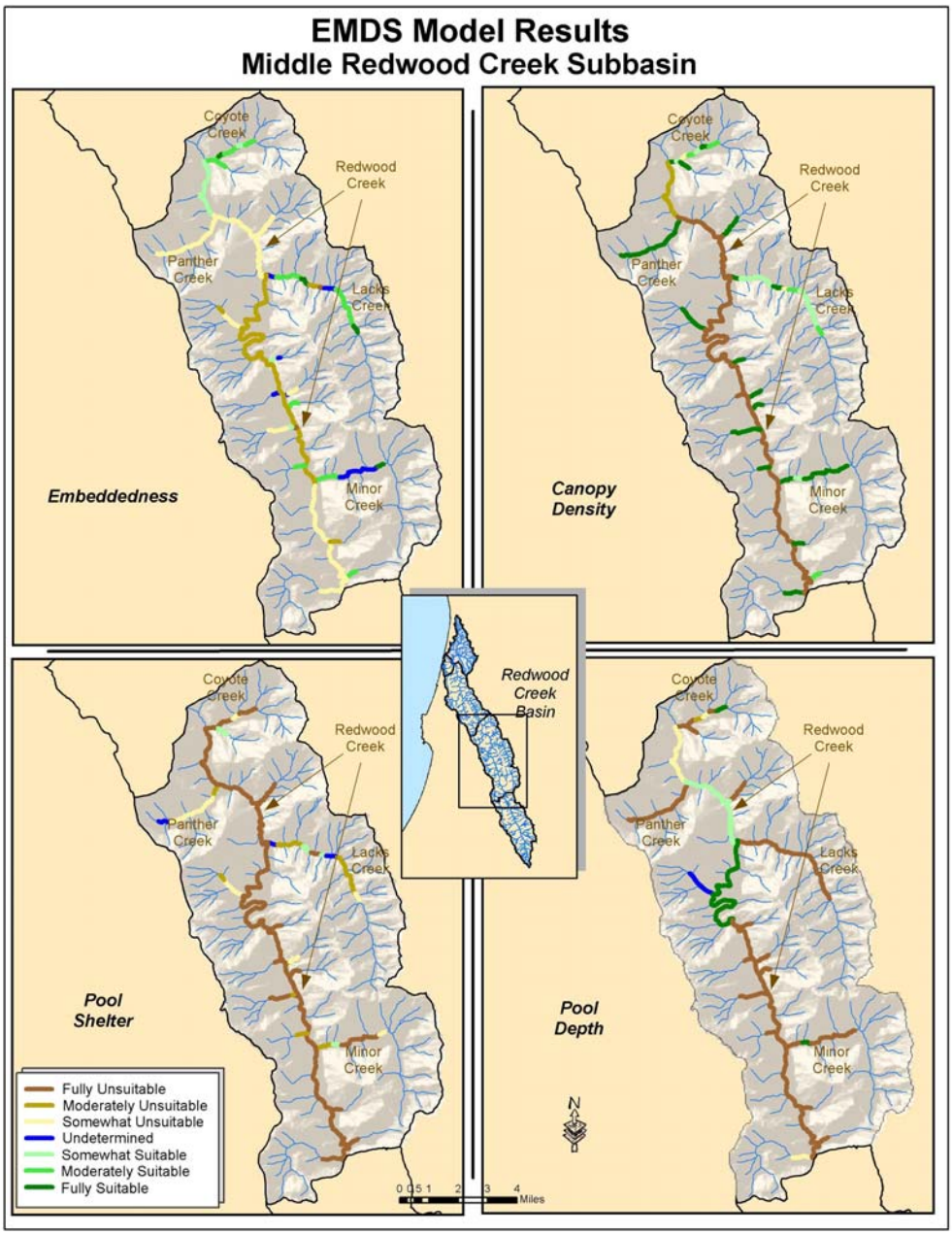

Figure IV- 50. Middle Subbasin EMDS map results for selected stream reach factors.

Stream Habitat Improvement Recommendations

Stream habitat improvement recommendations were developed based on results from stream surveys conducted along anadromous salmonid bearing stream reaches in 2001. Therefore the recommendations do not directly consider stream conditions above the limits of anadromy. Because the majority of tributary streams provide less than one-half mile anadromous salmonid habitat, there is a considerable amount of area that was not surveyed in the Middle Subbasin. A full list of recommendations for each stream in the Middle Subbasin can be found in Appendix D.

The most frequently listed recommendation category across the subbasin is to improve instream habitat factors pool frequency, depth, and shelter complexity followed by erosion/sediment and riparian/temperature treatments (Table IV- 83 and Table IV- 84). In Mainstem Redwood Creek, work should be focused on reducing water temperature and increasing pool depths and shelter complexity. In Lupton, Panther, and Dolly Varden creeks large debris accumulations may need to be modified to facilitate fish passage and reduce stored sediments that fill pool habitat. In addition accumulations of small boulders or (perched deltas) within the lowermost reach of streams like Panther Creek impair fish passage into tributaries during spawning migrations.

Table IV- 83. Top three ranking recommendation categories by number of tributaries and mainstem reaches in the Redwood Creek basin.

Basin Target Issue	Related Table Categories	Count
Erosion / Sediment	Bank / Roads	11
Riparian / Water Temp	Canopy / Temp	9
Instream Habitat	Pool / Cover	41
Gravel / Substrate	Spawning Gravel / LDA	7
Other	Livestock / Barrier	3

Lacks and Minor Creeks have suitable water temperatures for salmonids in their upper reaches, but their lower reaches have temperatures above desirable targets (MWATs of 65°F or more). A reduction in temperature will likely occur as the result of increasing pool frequency and depth, controlling erosion and increasing the coniferous component of the riparian zone.

In general, the recommendations that involve erosion and sediment reduction by treating roads and failing stream bank and near stream vegetation improvements, and temperature reduction precede the instream recommendations for pool development and spawning gravel projects. The various project treatment recommendations can be made concurrently if watershed and stream conditions warrant. Fish passage problems, especially in situations where favorable stream habitat reaches are being separated by a man-caused feature (e.g., culvert), deltas, or debris jams are usually a treatment priority. Specific treatment strategies are presented in Flosi et al. (1998).

Table IV- 84. Prioritization of steps to address limiting factors.

Survey Streams	Survey Length (Ft)	Temperature	Pool	Cover	Bank	Roads	Canopy	Spawning Gravel	LDA	Live Stock	Access
Lacks Creek	24,262	4	2	1	3	5	6	7			
Minor Creek	14,418	5	3	1	2	6	4	7			
Coyote Creek	11,282		5	1	2	3	4				
Panther Creek	14,504		4	3		5		6	1		2
Wiregrass Creek	2,000		2	1		3	4				
Dolly Varden Creek	5.968		1	3		4	5		2		
Toss Up Creek	5,462		3	1	2	4	5	6			
Garrett Creek	4,779		4	1	2	3		5			
Lupton Creek	3,832		4	1	5	2	6	7	8		3
Sweathouse Creek	1,611		2	1	6	3	5	4			
Pilchuck Creek	1,617		2	1	5	4		3			
Mill Creek	2,788		1	2		4	3	5			
Molasses Creek	2,556		1	2	5	4	3				
Captain Creek	2,360	1	4	3		5	4	7	6		2
Beaver Creek	2,731		2	3	6	4	5	7			1
Middle Subbasin Tributaries (total)	103,194	3	14	15	6	1	2	4	2		2
Redwood Creek	130,520	1	4	2	5	6	3	7			

Key to fields: Temp = summer water temperatures seem to be above optimum for salmon and steelhead; Pool = pools are below target values in quantity and/or quality; Cover = escape cover is below target values; Bank = streambanks are failing and yielding fine sediment into the stream; Roads = fine sediment is entering the stream from the road system; Canopy = shade canopy is below target values; Spawning Gravel = spawning gravel is deficient in quality and/or quantity; LDA = log debris accumulations are retaining large amounts of gravel and could need modification; Livestock = there is evidence that stock is impacting the stream or riparian area and exclusion should be considered; Access = there are human made barriers to fish migration in the stream.

Refugia Areas

Most of the streams of the Middle Subbasin are classified as potential refugia based on the status of watershed conditions, stream habitat conditions, salmonid populations, and risk from land use (Table IV- 85). Although, the majority of streams support populations of anadromous salmonids, 2001 fish numbers appear low compared to past assessments. The instream conditions were also considered in need of improvement to increase salmonid populations. Addressing limiting habitat factors with the treatments identified in Table IV- 85 should improve the refugia designations for Middle Subbasin streams.

Table IV- 85. Middle Subbasin anadromous salmonid refugia designations for streams.

Stream	Refugia Categories:				Other Categories:		
	High Quality	High Potential	Potential	Low Quality	Passage Barrier Limited	Critical Contributing Area/Function	Data Limited
Lacks Creek			X				
Minor Creek			X				
Coyote Creek		X					
Panther Creek			X				
Dolly Varden Creek (Karen)		X			X	X	
Wiregrass Creek			X				
Garcia Creek							X
Toss Up Creek				X			
Garrett Creek							
Lupton Creek					X	X	
Sweathouse Creek			X				
Mill Creek			X				
Molasses Creek			X				
Captain Creek			X				
Beaver Creek			X		X		
Pilchuck Creek				X			
Cashmere Creek							X
Roaring Gulch							X
Loin Creek							X
Santa Fe Creek							X
Redwood Creek			X				

Responses to Assessment Questions

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

- The Middle Subbasin supports populations of Chinook salmon, steelhead, summer steelhead, and coastal cutthroat trout;
- Recent trapping studies show that Chinook salmon are successfully spawning in the middle reach of mainstem Redwood Creek, although spawning success varies considerably among years;
- Coho were once noted as present or abundant in Coyote, Panther, Dolly Varden (Karen), Pilchuck, Minor and Redwood creeks. Surveys conducted in 2001and 2002 failed to detect coho presence in any Middle Subbasin streams; indicating a decline in coho distribution and abundance within the Redwood Creek Basin;
- A comparison of 1966, 1975 -77 to 2001 fish surveys found that the Middle Subbasin tributaries contained higher species diversity and higher numbers of salmonids in the past than were observed in 2001 surveys. Most of the past surveys, particularly from the 1966 and 1975 survey years, gave indications of abundant salmonids (mostly juvenile steelhead and coho);
- Juvenile steelhead are the most widely distributed and abundant salmonid found throughout the middle subbasin;
- Summer steelhead populations are greatly reduced from historic abundance. Anecdotal information from the 1920s indicated the presence of deep pools containing numerous, large summer steelhead;
- As few as 3 summer steelhead were observed in recent annual snorkel surveys of mainstem Redwood Creek above Lacks Creek;
- Coastal cutthroat were identified only in Panther Creek and Redwood Creek during 2001 surveys;
- Consistent, long term data are not available to quantify the population size of adult anadromous salmonids.

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

- The Middle Subbasin provides critical habitat for anadromous salmonids;
- Many pools in mainstem Redwood Creek and its tributaries are relatively shallow and lack shelter complexity;
- Tributary reaches have less than the desirable amount of pool habitat;
- Anecdotal information and past studies indicate that water temperatures in the mainstem were cooler prior to the flood of 1964;
- Stream temperatures along the middle reach of Redwood Creek exceed the suitable range for salmonids. MWATs reach >72°F and daily maximums reach 80°F;
- A few discrete cool water patches within Redwood Creek create thermal refuge for salmonids during periods of heat stress;
- There is a lack of streamside tree canopy providing shade over the water along most of mainstem Redwood Creek;
- Most tributary streams that were monitored for temperature were within desirable ranges. Temperatures measured by MWATs were below 64°F;
- Lower reaches of Lacks and Minor creeks had MWATs of 65 and 67°F respectively and maximum daily temperatures approached lethal limits;
- In most tributaries, the amount of shade over the water is within desired conditions;
- LWD is in low supply in most stream channels across the subbasin;
- The near term recruitment potential for coniferous LWD is low in the mainstem of the Middle Subbasin;
- The size of most near stream conifers is too small to provide full benefits of overstory shade and LWD loading;
- Only approximately 25% of the pool tails sampled in the Middle Subbasin are considered high quality spawning substrate;
- The majority of pool tail spawning substrate in Panther, Dolly Varden, Toss Up, Garrett, Lupton, Sweathouse, and Mill creeks is highly embedded with fine sediment. The majority of pool tail spawning substrate in Redwood Creek were also highly embedded with fine sediment;
- Turbidity levels are high and prolonged. Anecdotal information suggests that prior to 1964, Redwood Creek ran much cleaner and high turbidity episodes were of short duration;
- Construction and operation of the Chezem Dam on Redwood Creek may have adverse impacts to fishery resources and their habitat.

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

- The Middle Subbasin terrain is naturally unstable. Approximately 80% of the Upper Subbasin is classified in either high or very high relative landslide potential;
- Upon receiving heavy winter rains the subbasin becomes prone to erosion and is a source of sediment inputs to stream channels;
- Excessive amounts of sediment in mainstem Redwood Creek have adversely impacted salmonid habitat in the Middle Subbasin for decades;
- Excessive sediment input to streams initiates a sequential series of adverse changes to stream habitat. These include aggraded stream channels, filling of pools, channel widening, stream bank erosion, raising

water table, stream side landslides, loss of shade canopy, increase of width to depth ratio, elevated water temperature, intermittent surface water flows, and loss of connectivity between surface flows and ground water;

- The middle reach of Redwood Creek experienced drastic changes in distribution of pool, riffle, and run habitats after the flood of December 1964 (a 50-year flood). In 1955 a similar 50-year flood occurred, but much less stream damage was noted by CDFG personnel than was noted in 1965 because of less ground disturbance in the basin;
- The overall result of the 1964 flood was a severe alteration of stream habitat conditions associated with excessive sediment inputs;
- Following the 1975 flood, the channel bed of Redwood Creek was left almost flat and featureless in many reaches, as a pulse of new sediment entered the system;
- Relatively minor actions, such as undercutting the toes of slopes, increasing the duration of ground saturation, or reducing soil shear strength by a relatively small amount, can trigger extensive landslides in this subbasin;
- The number of active stream side landslides recently increased by 18% (from 376 in 1984 to 442 in 2001) within the Middle Subbasin. The largest increase was observed in Lower Lacks Creek (+221%) and Panther Creek (+68%) planning watersheds;
- A trend of decreasing stored in channel sediments and an increase in channel diversity occurred through the middle reach of Redwood Creek during low to moderate rain years (1977 to 1996). During a recent high rain year (1997), erosion within the basin's uplands resulted in elevated erosion and sediment delivery, channel aggradation, and loss diversity in the mainstem channel. Since 1997, the decreasing trend in stored in channel sediment has resumed during moderate years of rains and stream flows;
- Large portions of the mainstem reach, such as in Redwood Valley, have unconfined channels and low channel gradients, which are prone to sediment accumulations;
- There were more active streamside landslides observed from aerial photos in Upper and Lower Lacks Creek, Roaring Gulch and Panther Creek planning watersheds in 2000 compared to 1984. No change was detected in Coyote Creek and a decrease in the number of active streamside landslides was observed in the remaining planning watersheds in the Middle Subbasin;
- Tributary flows may help to moderate mainstem temperature from reaching higher levels and provide localized patches of cool water, but do not significantly decrease mainstem Redwood Creek temperatures in the Middle Subbasin;
- The measured MWATs of Redwood Creek change from 71 to 72 in the Middle Subbasin and peak near the confluence with Lacks Creek. This suggests that most of the heat input to Redwood Creek occurs in the Upper Subbasin;
- The middle reach of Redwood Creek is subjected to direct solar hearting due to a lack of shade canopy;
- Large conifer trees that once lined the stream banks were removed during timber harvests. Much of the beneficial characteristics attributed to large trees in the near stream conifer forest (including shade, microclimate, and LWD recruitment potential) are not provided by existing vegetation;
- Although stream buffers are re-growing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function as LWD in channel formation processes have not yet been reestablished.

How has land use affected these natural processes?

- Much of the erosion of the Middle Subbasin that occurred during recent winter storms is attributed to land use;
- 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;

- Between 1950 and 1964, approximately 40% (32,000 acres) of the Middle Subbasin was logged for timber without rules to protect watersheds. There were at least 625 miles of poorly constructed roads and numerous miles of tractor skid trails across the unstable geology of the subbasin. As a result of this large amount of ground disturbance concentrated over a short period of time, the subbasin was highly susceptible to erosional processes exacerbated by the rain on snow storm event and ensuing flood of December 1964 and other recent storm events;
- Cumulative affects from winter storms in 1964, 1972, 1975 and continued land use have caused excessive erosion and excessive amounts of sediment to be delivered to stream channels. These impacts impaired salmonid habitat in the Middle Subbasin for decades;
- Excessive sediment inputs exacerbated by land use has aggraded channel beds, covered salmonid spawning habitat with fine sediment, filled pools with sediments, widened channels, eroded banks;
- The removal of large conifers during timber harvests has reduced near stream forest shade canopy density, reduced root strength to hold soils, reduced LWD loading potential and accelerated storm runoff rates in the Middle Subbasin;
- There are 524 miles of roads located on areas of high or very high relative landslide potential within the Middle Subbasin. High road density on unstable slopes and poor road maintenance practices has caused slope failures, stream diversion, gully erosion, and increased sediment input to streams;
- The density of stream crossings on Upper Lacks Creek planning watershed appears to be a particularly high potential sediment source;
- Historic livestock overgrazing in upper Redwood Valley may have lead to loss of native grasses, loss of top soils, and increased erosion and creation of gullies;
- The construction and operation of Chezem dam affects water flow and mutes temperature regimes in downstream reaches of mainstem Redwood Creek. The reservoir also inundates over a mile of stream channel.

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

- High water temperatures (MWAT of 72°F and daily maximum of 80°F) severely limit salmonid production in Redwood Creek and high water temperature (MWAT 67°F and daily maximum of 77°F) likely limits production in the lower reaches of Lacks and Minor creeks;
- Anadromous salmonid production is also likely limited by low abundance of deep pools with complex shelter in Redwood Creek, Lacks Creek, Minor Creek, Mill Creek, Molasses Creek, and Beaver Creek;
- The sparse amount of instream LWD in Redwood Creek and most anadromous fish bearing tributary reaches limits pool development, nutrient inputs, and channel diversity and complexity needed to increase carrying capacity and increase production of anadromous salmonids;
- The low recruitment potential for LWD in Redwood Creek and many of the tributary streams will impede future pool formation, sediment routing and likely act to constrain channel diversity and complexity for decades;
- Spawning success may be impaired by excessive amounts of fine sediments in some streams;
- The naturally steep channel gradient of the tributary streams limits anadromous salmonid distribution to the lower reaches of many tributaries in the Middle Subbasin;
- The decline in abundance of spawning salmon has likely caused a corresponding decrease in nutrients and organic matter available to streams. The nutrients contributed to streams by eggs and decaying carcasses may be needed to maintain historic salmonid production levels in the middle subbasin.

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

Barriers to fish passage

- Investigate improving fish passage through 500 foot long culvert under HWY 299 on Lupton Creek;
- Modify sediment deltas or boulder accumulations that impede upstream migration into tributaries. A sediment delta formed by boulder accumulations is located within the lowermost reach of Panther Creek and possibly other tributaries;
- Modify large debris accumulations that may impede fish passage on Panther Creek and other tributaries (completed by Green Diamond and the California Conservation Corps in 2004).

Flow and Water Quality Improvement Activities:

- Reducing water temperature is essential to improve anadromous salmonid habitat in the Middle Subbasin. A long term goal should be to reduce water temperature in the middle reach of Redwood Creek and the lower reaches of tributary streams including Panther, Coyote, Minor and Lacks creeks;
- A reduction in temperature will likely occur as the result of increasing pool frequency and depth, controlling erosion, increasing the coniferous component of the riparian zone and allowing near stream conifers to obtain large size for development of microclimate benefits;
- Functional nearstream conifer forests need to be developed and/or maintained along Redwood Creek in the Middle Subbasin. Large near stream conifers are needed to help increase shade canopy, moderate air temperatures, and to promote LWD loading. This may require more than the minimum protection provided by present Forest Practice Rules;
- Increase shelter complexity in existing cool water refuge sites;
- Managers should explore methods to develop cool water refuge sites on Redwood Creek and the lower reaches of Panther, Lacks, and Minor and other creeks. Methods should include using pool scour elements, and increasing connectivity to cool ground water sources.

Erosion and Sediment Delivery Reduction Activities:

- In streams where the majority of pool tail spawning substrate is highly embedded with fine sediment, sediment sources should be located, rated according to their potential sediment yields, and treated;
- Upgrade or decommission roads in accordance with existing or future road assessment surveys. This work should be done especially on older roads built below current standards on unstable slopes and roads near streams in Upper and Lower Lacks, Minor, Lupton, Panther, and Coyote and Roaring Gulch planning watersheds;
- For timber management in Lacks, Minor, Coyote and other planning watersheds, with active landslides or on steep and/or potentially unstable slopes (slopes ≥ 35%) we recommend the use of lower impact silvicultural prescriptions to maintain vegetative cover, root strength, and the use of cable systems or helicopter yarding to reduce the potential for mass wasting and sediment production;
- Land management activities adjacent to all streams, particularly in the inner gorge, head walls, and on slopes 35% (19 degrees) or greater, must be carefully evaluated and designed to avoid generation and delivery of sediment to stream systems;
- Timberland managers should decrease the use of tractor or ground lead yarding on all slopes steeper than 35% (19 degrees); and use fully suspended (skyline) cable or helicopter yarding on steep and unstable slopes;
- RNSP and private landowners 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 reduce sediment delivery to Redwood Creek and its tributaries;

- A qualified, licensed geologist or engineer should be consulted before initiating any project that involves road construction, timber harvest, or building. The NCWAP Landslide Potential maps should be reviewed before modifying hillslopes to avoid creating, or contributing to, hillslope instability and excessive, human-induced erosion through mass wasting or creation of gullies.

Riparian and Stream Habitat Improvement Activities:

- To increase overstory shade and to promote input of large woody debris, encourage near stream conifers to grow to large sizes and retain them along Redwood Creek and all tributary streams in the subbasin;
- Where there is adequate shade canopy along Lacks, Minor, Molasses, and Coyote Creeks, land managers should consider thinning hardwoods from below in riparian areas to hasten the development of large near stream conifers;
- Trees large enough to function as LWD need to be allowed to grow and recruit to stream channels from riparian and near stream forest areas;
- Consider adding pool forming structures to increase the number of pools in Redwood, Lacks, Minor, Lupton, Molasses, Panther, Mill, and Beaver creeks;
- Deepen and increase the size of existing pools in Dolly Varden, Toss Up, Garret, Lupton creeks and in lower reach of Coyote Creek;
- Add wood into pools and flatwater units to increase shelter complexity especially where the average size of near stream conifers is less than 2 feet DBH in Redwood, Lacks, Minor, Lupton, Panther, Coyote and Molasses creeks;
- Consider adding shelter complexity to existing temperature refuge sites on Redwood Creek;
- Consider the use of conservation easements along Redwood Creek to protect valuable riparian and near stream forest from development or timber harvests.

Education, Research, and Monitoring Activities:

- Water temperature monitoring should continue at the current locations to observe changes in temperature as effects from aggradation, degradation, channel widening, and riparian condition adjust over time;
- Identify potential perched sediment deltas and/or debris accumulations that may impede passage for spawning into Panther Creek and other Middle Subbasin tributaries;
- A long term, concerted monitoring effort between land owners, interested parties and responsible agencies is needed to determine the status, abundance and trends of anadromous fish populations of the Middle Subbasin streams;
- Investigate impacts from fine sediments on salmonid spawning success and aquatic insect community structure;
- Formal stream reach surveys were not done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD. Formal survey for LWD loadings could be done to verify these observations;
- Monitoring in-channel sediment routing and storage(e.g., sediment size distribution, turbidity, V*, photo points, etc.) should be increased and tracking of streambed levels (i.e., stream channel cross sections) should be continued;
- Summer steelhead dive counts should be conducted on an annual basis on the middle reach of mainstem Redwood Creek and in the lower reach of Lacks and Minor creeks;

- Continue monitoring juvenile fish population trends such as downstream migrant trapping operations on mainstem Redwood Creek;
- Investigate possible improvements to cool water refugia and potential to increase such areas;
- Further study of the effects of Chezem summer dam on fish and fish habitat is warranted;
- Ensure that CEQA-compliant environmental assessment is conducted prior to issuance of the Fish and Game Code 1603 streambed alteration permits and Corps of Engineers or NOOA Fisheries permitting requirements are complete for any summer dams on Redwood Creek.

Subbasin Conclusions

Middle Subbasin streams provide important spawning and rearing habitat for anadromous salmonids. Steelhead and coastal cutthroat predominate in the tributary streams year round while Chinook depend mostly on the mainstem for spawning habitat and temporary juvenile rearing. Coho once noted as present in some tributaries were not observed during 2001 surveys. Summer steelhead are likely the most threatened salmonid stock inhabiting the Redwood Creek Basin.

The mainstem Redwood Creek has slowly adjusted from destructive impacts related to intensive land use and the 1964, 1972, 1975 floods. These storms occurred during an era when much of the Redwood Creek basin was undergoing unregulated timber harvests. Timber harvest activities contributed to destabilization of the land and increased runoff rates causing severe erosion, and severe damage to Redwood Creek including aggradation, widened channel, streambank erosion, and filling of pools with sediments. Presently, sediments are moving from the active channel of tributaries and upper and middle reaches of Redwood Creek, but they tend to accumulate in lowest gradient and unconfined reaches. An increase in channel structure has recently been observed, however this has not occurred without setbacks related to landslides induced by moderate storm events. Because of the combination of natural instability across the Middle Subbasin, legacy land disturbances effects, and land use that results in new ground disturbance, winter storms still pose risks for excessive erosion and sediment inputs to anadromous salmonids streams. This was shown during the winter of 1997 when an increase in landslides and associated sediment inputs were measured at RNSP cross sections.

High water temperature is likely the most limiting factor to salmonid production in mainstem Redwood Creek. The high water temperature is related to the lack of shade over the water along middle and upper mainstem reaches. Other significant factors affecting salmonids production in the mainstem are related to excessive sediment inputs and include lack of pools and lack of instream shelter complexity. Trees large enough to function as LWD, need to be allowed to grow and recruit to stream channels from riparian and near stream forest areas. Tributary streams generally provide good water temperature, except in lower reaches of Lacks and Minor creeks. Tributaries also showed a lack of deep pool habitat and instream shelter complexity.

The Middle Subbasin offers opportunities for implementing watershed habitat improvement activities. Watershed management strategies aimed at reducing erosion and developing functional near stream forests will help address landscape issues. This will help to reduce water temperature, increase bank stability, provide a source of LWD, and reduce sediment inputs to stream channels. Stream habitat improvement activities should focus on increasing depth and complexity to existing pool habitats, and adding shelter complexity to cool water refuge sites.