Upper Subbasin

The Upper Subbasin drains approximately 68 square miles of the CalWater 2.2 Lake Prairie Hydrologic Area and includes the land and waterways from the confluence of Lupton Creek upstream to the headwaters of Redwood Creek (Table IV- 86 and Figure IV- 51). This subbasin has the highest relief and greatest proportion of natural prairies of all Redwood Creek subbasins. The predominant land use is timber production and rural developments. The Upper Subbasin has the most area of all the Redwood Creek Basin in small land ownerships. The Upper Subbasin includes the following Planning Watersheds:

Windy Creek	Noisy Creek	Cloney Gulch
High Prairie Creek	Bradford Creek	Twin Lakes Creek

Approximately 19 miles of mainstem, and 21 miles of blue line perennial tributary streams drain the subbasin. The Upper Subbasin supports populations of Chinook salmon, steelhead, and coastal cutthroat. It is unclear if coho salmon have ever spawned or reared in the Upper Subbasin.

Table IV- 86. Upper Subbasin summary.

Square Miles	67.72	
Total Acreage	43,344	
Private Acres	40,640	
Federal Acres	2,240	
State Acres	0	
Principal Communities	None	
Predominant Land Use	Timber Production	
Predominant Vegetation Type	Hardwoods / Douglas-fir forest	
Miles of Anadromous Stream	23.0	
Low Elevation (feet)	866	
High Elevation (feet)	5,322	
Fish Species	steelhead coastal cutthroat trout	Chinook salmon coho salmon? Pacific lamprey

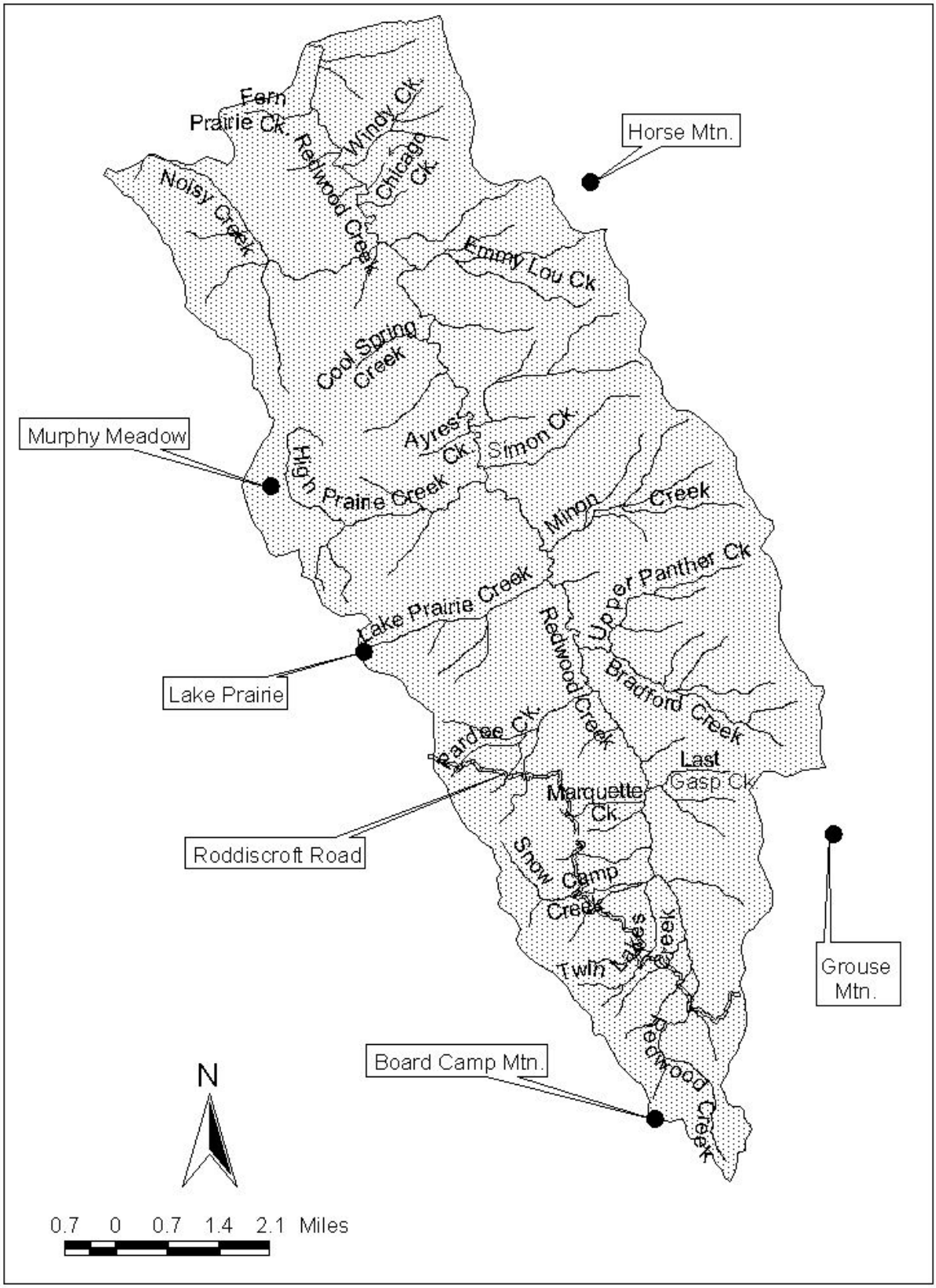

Figure IV- 51. Upper Subbasin and its tributaries.

Geology

The lower portion of the Upper Subbasin starts near Fern Prairie Creek to the west and Captains Creek to the east. The channel of Captains Creek closely follows a mapped cross-fault. The Coherent Unit of Lacks Creek (KJfl) and Incoherent Unit of Coyote Creek (KJfc) rocks are offset along this fault. The cross fault continues into the Schist of Redwood Creek, but does not appear to offset its western contact with the Sandstone and Mélange of Snow Camp Mountain (KJfsc).

The upper mainstem of Redwood Creek lies within a narrow channel that follows the trace of the Grogan Fault zone. Abundant streamside landslides flank the narrow main stem channel, or inner gorge. These slides appear to have delivered sediment directly into the creek (Madej 1984).

The Grogan Fault Zone widens to nearly 0.75 miles at the Captains Creek cross fault. From this point south 4.5 miles, the Redwood Creek channel exhibits a striking series of sharp zigzag bends that appear to be structurally controlled. The dominant orientations appear to be southwest and northwest and nearly orthogonal to one another. These channel sections may follow major fracture sets in the underlying Grogan Fault Zone rocks.

Murphy Meadow is a large, gently east-sloping ridge-top basin straddling the western boundary of the drainage. A fault separating the Sandstone and Mélange Unit of Snow Camp Mountain (KJfs) from the Schist of Redwood Creek (KJfr) bounds the basin on the northwest and the Snow Camp Mountain Lineaments (a parallel pair of prominent aerial photograph lineaments) bound the southwest and northeast sides of the basin.

Given the type offset on a majority of the faults along this part of North America, this feature could be a fault-bounded pull-apart basin (see Appendix E for an illustration). Prior field reconnaissance by CDMG personnel identified numerous ridge-top depressions (perhaps Sackungen; see Appendix E) and marshy areas along this part of Snow Camp Ridge. Local ranchers have modified many of these features for use as stock ponds.

The cross-faulting and aerial photograph lineaments appear to continue south to the head of Redwood Creek where they culminate in the Snow Camp Creek fault zone (separates the Schist of Redwood Creek (KJfr) from the Sandstone and Mélange Unit of Snow Camp Mountain (KJfs) to the south). The Grogan Fault Zone does not appear to be offset by the Snow Camp fault zone and is mapped as continuing southeastward, partially obscured by a 0.25 mile wide, 2-mile long earth flow complex. The source of this earth flow is not clear, but it appears to have issued from what is now a deeply eroded, broad amphitheater. The major modes of mass wasting are typically rotational slides, earth flows and debris slides. Well developed gully networks are common within the more active earthflow areas and these are considered a significant sediment sources because they are directly connected to the drainage system.

The Upper Subbasin has approximately 73% of its area considered as high and very high landslide potential (Table IV- 87). Proportionally, the Windy Creek Planning Watershed has 2 to 3 times more area involved in historically active landslides than the other planning watersheds in the subbasin. The incoherent unit of Coyote Creek underlies most of this area.

Streamside Landslides

Active streamside landslides were mapped from the 1984 and 2000 air photos and their density was coarsely analyzed per acre, total stream length, and drainage density (Table IV- 88 and Figure IV- 52, Figure IV- 53, and Figure IV- 54). The size of these slides was not considered in this preliminary analysis, though volume of landslides is important.

Table IV- 87. Upper Subbasin summary of relative landslide potential and landslide features.

Factor	Upper Subbasin		Planning Watersheds											
			Twin Lakes		Bradford		High Prairie		Cloney Gulch		Noisy Creek		Windy Creek	
Relative Landslide Potential	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Very Low	3,302	7.6	363	4.0	427	6.1	1,076	10.4	375	7.3	807	11.9	254	5.3
Low	4,318	10.0	889	9.7	535	7.6	1,227	11.8	426	8.3	969	14.3	272	5.6
Moderate	4,243	9.8	515	5.6	655	9.3	995	9.6	644	12.6	989	14.6	445	9.2
High	12,328	28.5	2,505	27.5	2,096	29.9	3,207	30.9	1,493	29.2	1,992	29.3	1,035	21.5
Very High	19,069	44.1	4,853	53.2	3,304	47.1	3,878	37.3	2,180	42.6	2,036	30.0	2,818	58.4
High/Very High Subtotal	31,397	72.6	7,358	80.6	5,400	77.0	7,085	68.2	3,673	71.8	4,028	59.3	3,853	79.9
GRAND TOTAL	**43,260**	**100%**	**9,125**	**100%**	**7,017**	**100%**	**10,383**	**100%**	**5,118**	**100%**	**6,793**	**100%**	**4,824**	**100%**
Landslide and Selected Geomorphic Features	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Historically Active Landslide Features Total	2,892	6.7	682	7.5	410	5.8	618	6.0	235	4.6	205	3.0	742	15.4
Earthflow	2,492	5.8	474	5.2	331	4.7	592	5.7	199	3.9	194	2.9	701	14.5
Rock Slide	227	0.5	95	1.0	22	0.3	25	0.2	36	0.7	11	0.2	38	0.8
Debris Slide	9	0	4	0	3	0	0	0	0	0	0	0	2	0
Debris Flow	165	0.4	109	1.2	55	0.8	1	0.0	0	0.0	0	0.0	0	0.0
Dormant Landslide Features Total	15,702	36.3	5,055	55.4	2,159	30.8	2,951	28.4	2,134	41.7	2,033	29.9	1,370	28.4
Selected Geomorphic Features Total	9,070	21.0	1,414	15.5	1,329	18.9	3,094	29.8	825	16.1	767	11.3	1,641	34.0
Disrupted Ground	5,219	12.1	737	8.1	979	14.0	1,488	14.3	296	5.8	376	5.5	1,343	27.8
Debris Slide Slope	2,780	6.4	383	4.2	233	3.3	1,335	12.9	380	7.4	269	4.0	179	3.7
Inner Gorge (area)	1,071	2.5	295	3.2	116	1.7	271	2.6	149	2.9	122	1.8	118	2.4
Total of All Above Features	**27,664**	**63.9%**	**7,151**	**78.4%**	**3,898**	**55.5%**	**6,663**	**64.2%**	**3,194**	**62.4%**	**3,006**	**44.2%**	**3,752**	**77.8%**

Table IV- 88. Number and indices of streamside slides by watershed, subbasins, and planning watersheds.

Subbasin or Planning Watershed Unit of Analysis	Analysis Unit Area (sq. km.)	1984 # of Active* Slides Along Streams	2000 # of Active* Slides Along Streams	1984 Indexed** Active Slides	2000 Indexed** Active Slides	% Change 1984-2000
Upper Redwood Subbasin	175.5	274	365	156	208	33
Bradford Creek	20.7	42	45	203	217	7
Cloney Gulch	42.1	24	34	57	81	42
High Prairie Creek	27.6	28	69	101	250	146
Noisy Creek	37.1	0	24	0	65	∞
Twin Lakes Creek	19.6	155	175	791	893	13
Windy Creek	28.4	25	18	88	63	-28

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

Results show an increase in streamside landslides in all planning watersheds except Windy Creek. The most numerous small landslides were in Twin Lakes Creek, both in 1984 and 2000. If the density of small landslides were a predictor of future sediment storage, then elevated sediment will increase in Twin Lakes Creek (beyond its already high relative amount). Some tributaries, such as Snow Camp and Twin Lakes creeks, appear to have deteriorated between 1984 and 2000. Both tributary basins showed increases in streamside landslides and elevated sediment in channels.

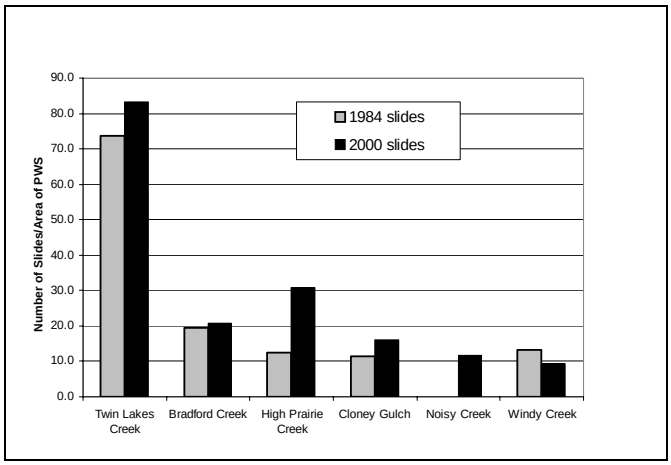

Figure IV- 52. Upper Subbasin relative density of active streamside landslides by Planning Watersheds (PWs) 1984 and 2000.

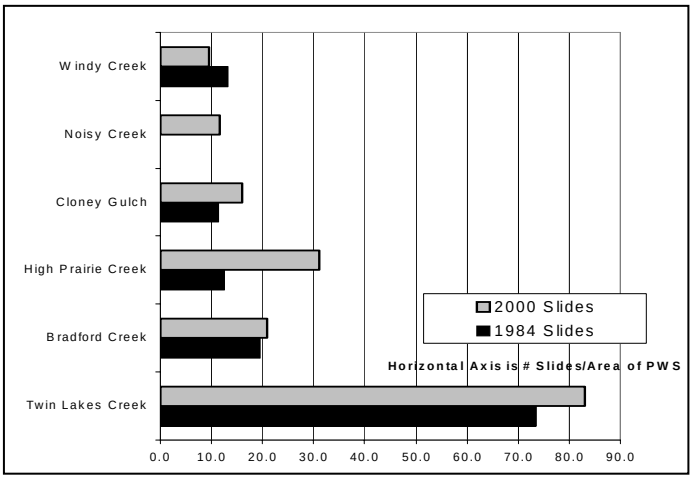

Figure IV- 53. Number of active streamside landslides mapped from 1984 and 2000 Aerial Photographs.

Plotted versus area of planning watershed (m/sq m) to make a streamside landslide "index." This chart does not indicate volumes of landslides. Twin Lakes Creek has the highest concentration of streamside landslides in both years.

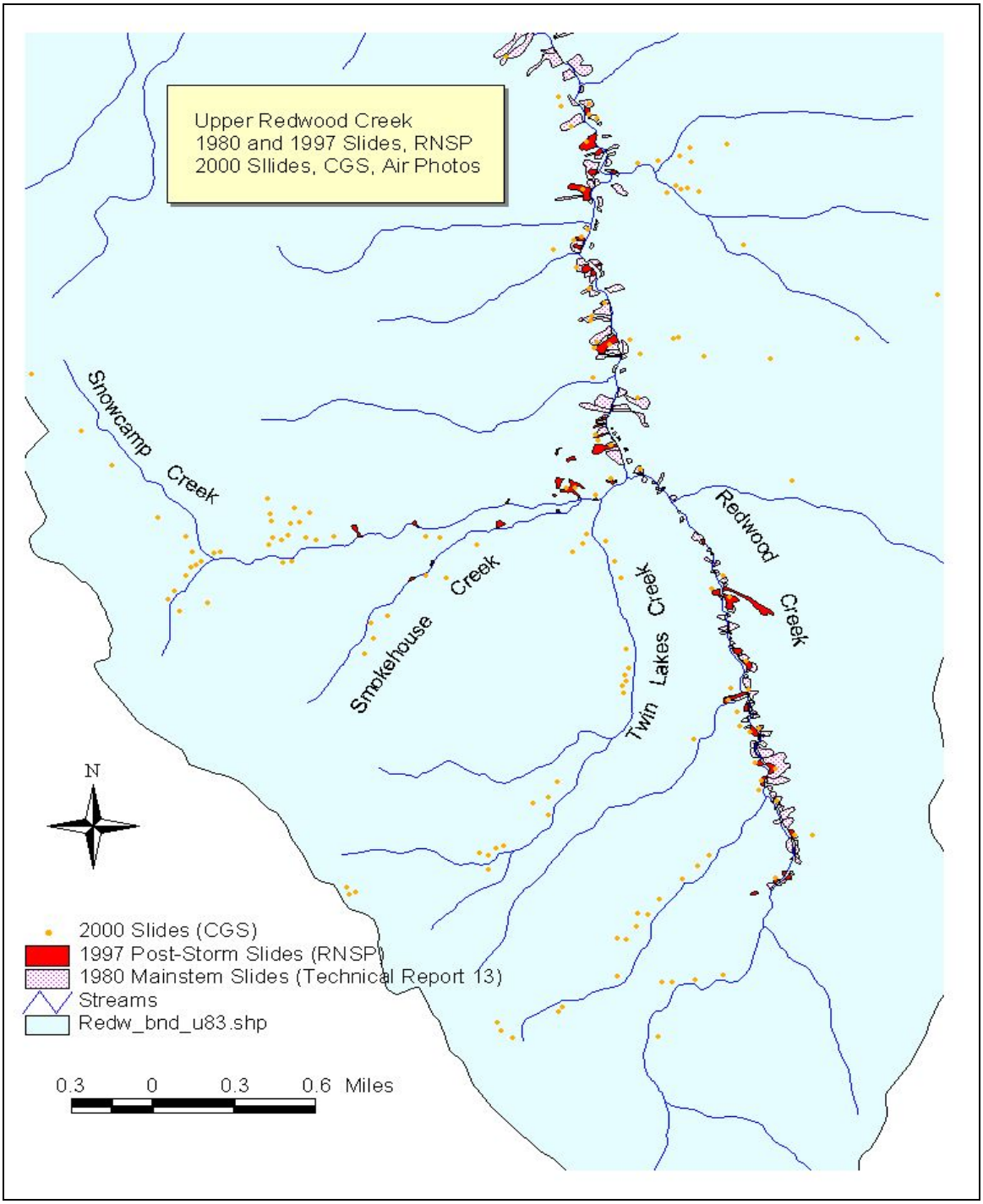

Figure IV- 54. Streamside slides in Upper Basin.
Data from CGS and RNSP.

Vegetation

Conifer dominated forests cover approximately 30,618 acres (73% of the area) within the Upper Subbasin (Table IV- 89 and Figure IV- 55). Hardwoods cover 7,308 acres (17% of the area) and grassland accounts for 3,624 acres (9% of the subbasin area). Douglas-fir is the dominant conifer cover type in the subbasin, with about 25,192 acres or 60% of the subbasin area. Pine in association with Douglas-fir form a larger component of the stands (297 acres or about 1% of the area) in this subbasin compared to other Redwood Creek subbasins. No significant barren areas are located within this subbasin. Based on field observation by CDF, The overall

forest stand condition of the Upper Subbasin appears to be in good health. Productive timberland in the subbasin covers approximately 37,600 acres, or about 89% of the subbasin.

Table IV- 89. Upper Subbasin generalized cover type.

Subbasin or Planning Watershed	Cover Type								
	Agriculture	Barren	Conifer	Hard-wood	Grass-land	Shrub	Developed	Water	Total
Upper Subbasin	0	270	30,618	7,308	3,624	331	0	34	42,185
Windy Creek	0	10	3,344	955	497	4	0	6	4,816
Noisy Creek	0	22	5,172	979	495	30	0	7	6,705
Cloney Gulch	0	10	3,356	1,154	353	56	0	0	4,929
High Prairie Creek	0	61	7,025	1,716	1,437	31	0	17	10,287
Bradford Creek	0	136	4,552	1,590	404	78	0	0	6,760
Twin Lakes Creek	0	31	7,169	914	438	132	0	4	8,688

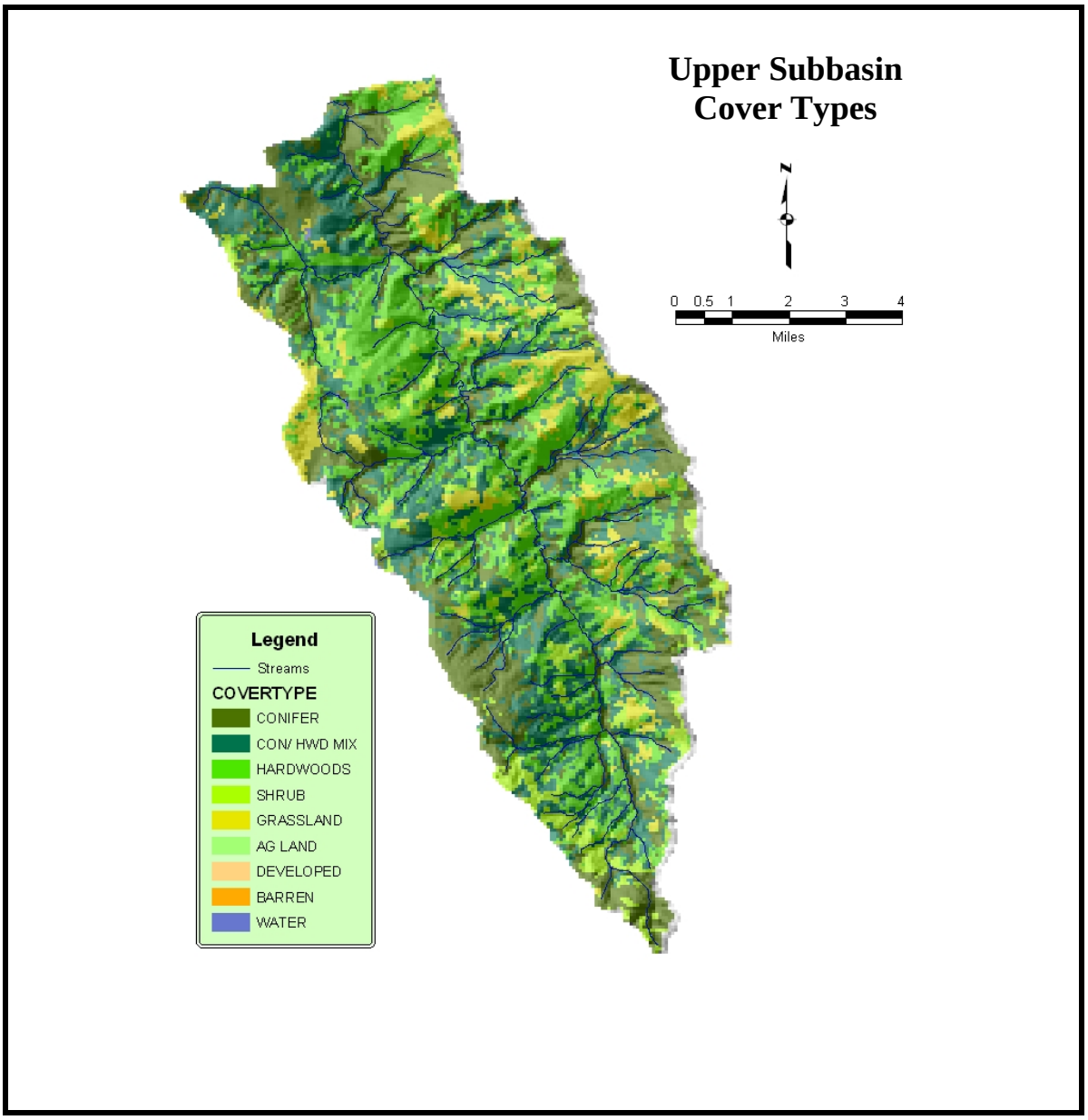

Figure IV- 55. Upper Subbasin vegetation map showing cover types.

Timber Harvest

From 1950 to 2000, 28,700 acres (94% of conifer forest) in the Upper Subbasin have had first entry timber harvests. Approximately 19% of the harvested area (5,524 acres) has been harvested with a second entry, (Table IV- 90, Table IV- 91, and Figure IV- 56). An additional 273 acres, or about 1%, of the previously harvested area has received a third harvest entry. Of the six planning watersheds within the Upper Subbasin, Windy Creek had the highest percentage of acres harvested, equivalent to over 104% of the planning watershed area. High Prairie Creek has the lowest percentage of harvested acres, 60%. This does not necessarily indicate that the area was less intensively harvested compared to some of the other planning watersheds. The planning watersheds with the lower percentage of harvested acres also support a larger land base of non-conifer vegetation types such as grasslands and oak woodlands. For the most part all portions of these planning watersheds that support conifer-growing areas have been subjected to timber harvest operations.

Clearcutting is the most common silviculture method used on the subbasin. Prior to 1978, 22,540 acres (74%) of the 30,618 acres of coniferous forest was clearcut (Best 1984). The second most utilized treatment was rehabilitation of understocked areas, i.e., converting hardwood-dominated stands to conifer stands. Yarding methods employed for timber harvesting within the Upper Subbasin are divided into three separate types for the 1990-2001 period. Ground-based skidding accounts for 86% of this total, or approximately 5,000 out of 5,800 acres.

Table IV- 90. Upper Subbasin timber harvest history, 1950-2000.

Subbasin or Planning Watershed	Harvest Acres by Period							
	1950 to 1964	1965 to 1974	1975 to 1983	1984 to 1992	1992 to 2000	Total Harvested	Total Acres	Percent Harvested
Upper Subbasin	12,958	8,393	2,829	6,494	3,857	34,531	43,336	79.7
Bradford Creek	1,747	1,455	144	1,133	451	4,930	7,032	70.1
Cloney Gulch	972	477	531	952	404	3,336	5,123	65.1
High Prairie Creek	2,200	930	107	1,232	1,780	6,249	10,405	60.0
Noisy Creek	1,723	2,857	562	873	791	6,806	6,815	99.9
Twin Lakes Creek	4,836	1005	316	1,697	310	8,164	9,162	94.0
Windy Creek	1,480	1,669	1,169	607	121	5,046	4,835	104.4

Table IV- 91. Upper subbasin multiple harvest acres.

Upper Subbasin	
Harvest Entry	Harvest Acres
First	28,734
Second	5,524
Third	273

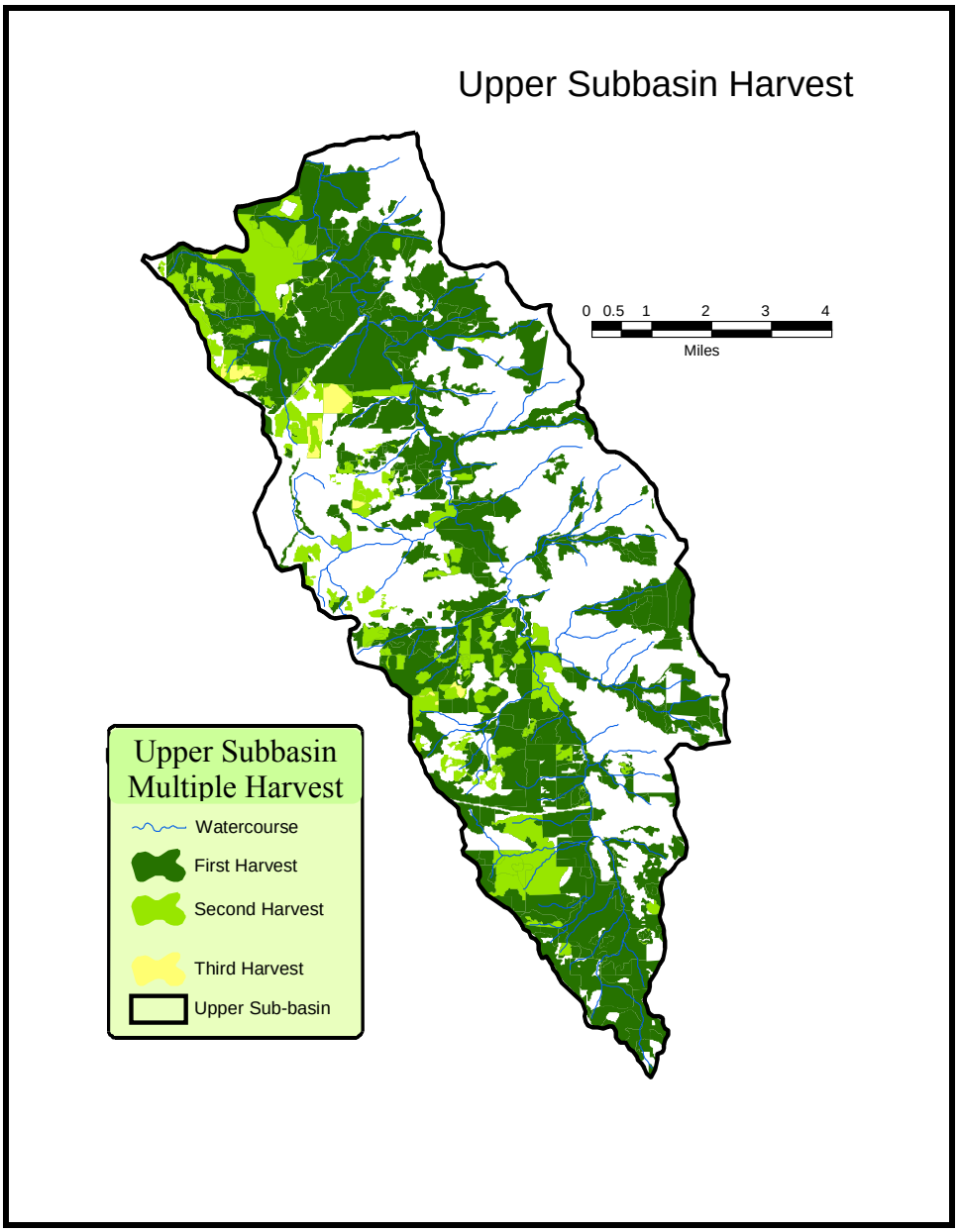

Figure IV- 56. Upper Subbasin multiple timber harvest.

Roads

Assessment of the road network in the Upper Subbasin was completed with information provided by the road assessment program in Redwood Creek. There are 553 miles of roads, of all classifications, within the Upper Subbasin of Redwood Creek. This mileage represents a relatively high road density of 8.2 miles of road per square mile of land base. Approximately 228 miles or 41% of the roads are classified as abandoned. Abandoned roads are no longer in use and do not 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. Approximately 246 miles or 44% of the total road miles were constructed prior to 1958 (Figure IV- 57). Pre-1958 road construction standards were very different from the standard practices of today. Roads built in that era generally lacked sufficient culvert sizing, did not have compacted road fills, were built wider than today's standards, and lacked sufficient cross drains and ditches. Roads built to these older standards, absent any upgrading and maintenance can produce and deliver significant amounts of sediment to the stream system. About 81% of the roads were constructed prior to modern Forest Practice Rule standards and 41% of the roads miles are abandoned.

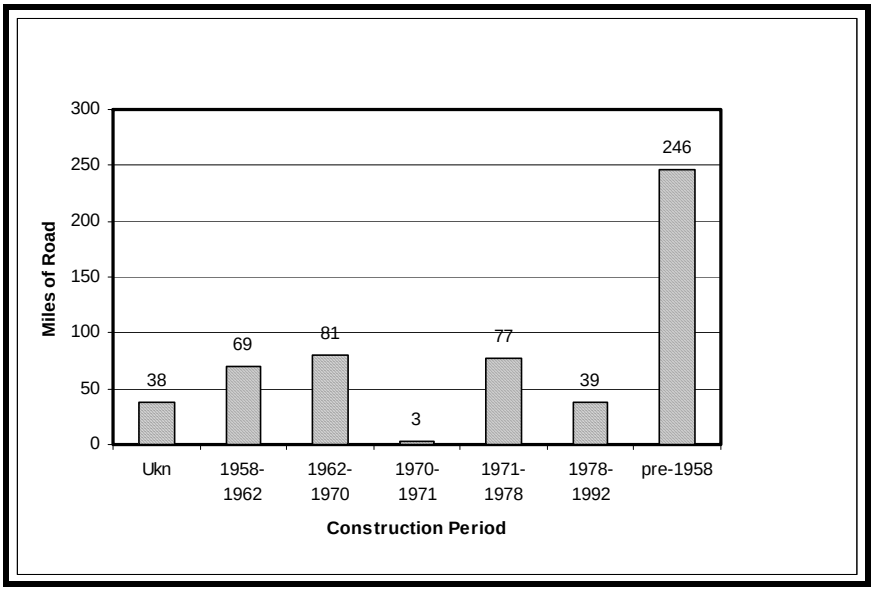

Figure IV- 57. Upper Subbasin miles of road construction by period.

Location of roads within 50 feet of a watercourse also was assessed. Abandoned roads within 50 feet of a watercourse total 52.4 miles. Approximately 67.5% of the roads near a watercourse were constructed before 1962. From this review of roads, it appears that the current road system in the Upper Subbasin has a high potential to generate and deliver sediment to stream channels.

Fire and Fuels

Looking at fire and fuels issues, the Upper Subbasin is dominated by fuels classed in the high (55% of the area) and moderate (36% of the area) ranks (Table IV- 92and Figure IV- 58). The Cloney Gulch planning watershed appears to have the largest contiguous areas of very high ranked fuels.

Table IV- 92. Upper Subbasin fuel ranks summary.

Area of Analysis	Fuel Rank								Total Acres
	Moderate		High		Very High			Not Mapped	
	Acres	% Acres	Acres	% Acres	Acres	% Acres	Acres	% Acres	
Upper Redwood Creek Subbasin	15,588	36	24,027	55	3,678	8	80	<1	43,373
Windy Creek Planning Watershed	1,841	38	2,895	60	92	2	7	<1	4,835
Noisy Creek Planning Watershed	2,440	36	3,966	58	392	6	17	<1	6,815
Cloney Gulch Planning Watershed	1,597	31	2,918	57	603	12	5	<1	5,123
High Prairie Creek Planning Watershed	3,730	36	5,848	56	806	8	21	<1	10,405
Bradford Creek Planning Watershed	2,405	34	3,789	54	828	12	10	<1	7,032
Twin Lakes Creek Planning Watershed	3,576	39	4,611	50	956	10	19	<1	9,163

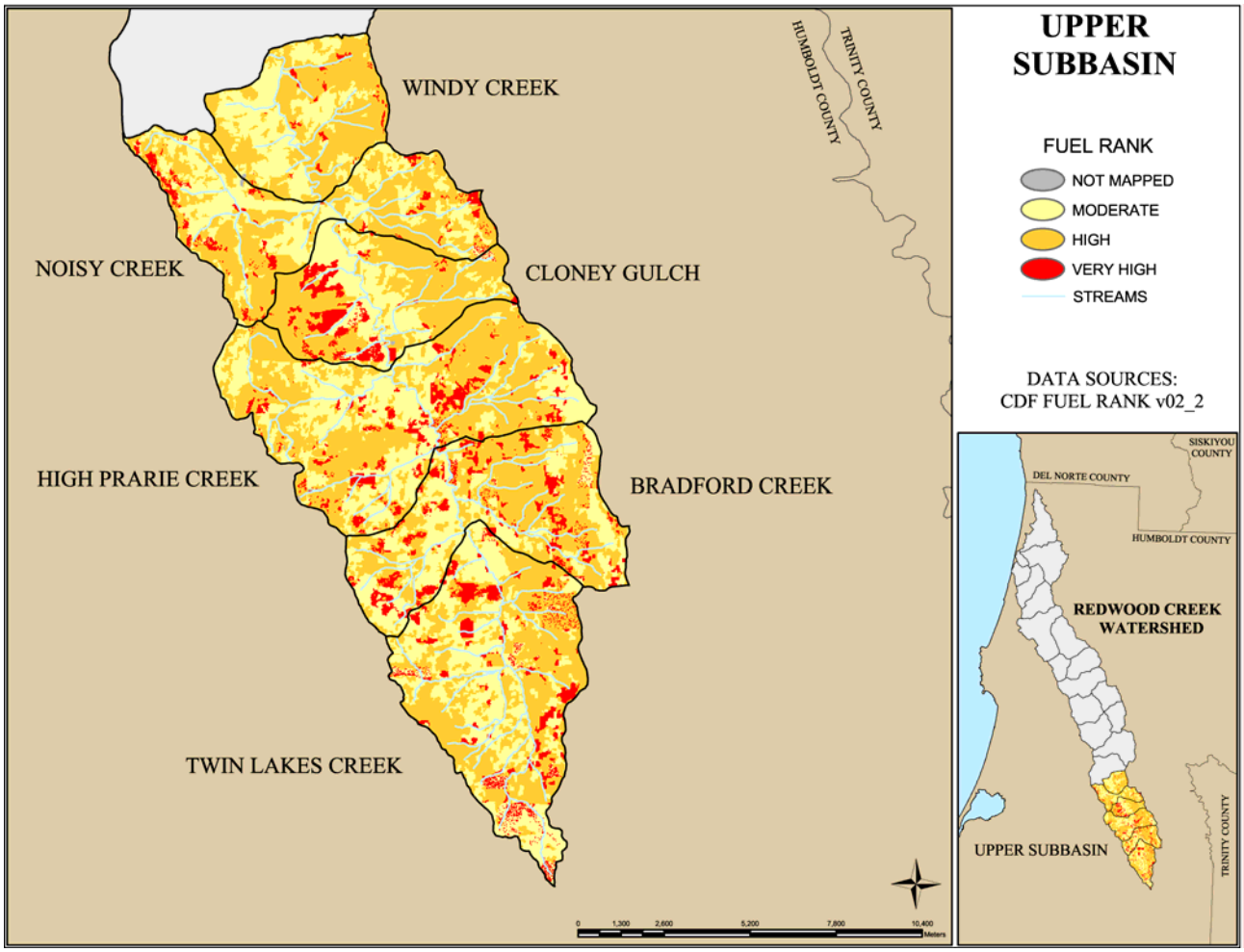

Figure IV- 58. Upper Subbasin fuel ranking map.

Fluvial Geomorphology

The Upper Subbasin contains about 120 miles of blue line tributary streams and 21 miles of mainstem Redwood Creek channel (Table IV- 93). Of these stream miles, 41% are source reaches 45% are considered transport reaches (by length). The miles of source and transport reaches in tributary streams have the potential to deliver sufficient sediment to overload the mainstem channel during large rain events, as occurred in 1964 and to some extent in smaller flood events. Response reaches are only about 14% of the total stream length and are mostly found in Redwood Creek mainstem All but the uppermost three to four miles of the mainstem channel gradient is <4% which allows anadromous fish passage to spawning areas high into the basin.

Table IV- 93. Upper Subbasin stream miles.

Planning Watershed	Area (Acres)	Miles of Blue Line Streams	Miles of Redwood Creek Mainstem	Number of Blue line Tributary Segments (Number of these that drain directly into Redwood Creek)
Windy Creek	4,835	12.8	3.7	10 (8)
Noisy Creek	6,815	14	3.2	9 (3)
Cloney Gulch	5,123	14.2	3.2	8 (5)
High Prairie Creek	10,405	28	2	12 (4)
Bradford Creek	7,032	21	1.8	13 (3)
Twin Lakes Creek	9,162	30	7.4	19 (12)

The flood of December 1964 introduced enormous volumes of sediment into the upper part of Redwood Creek (Janda and others 1975). Cut logs were washed from steep slopes into the mainstem channel (Kelsey and others

1981) to form massive log jams, which backed up sediment to depths of 20-30 ft. More than 600 streamside landslides delivered sediment directly into Redwood Creek (Kelsey and others, 1981). Channel-bed elevations increased (Madej and Ozaki 1996) and the capacity of the channel to convey peak flows was reduced. The mainstem channel banks eroded and widened in an attempt to accommodate flood peaks (Janda and others 1975). Portions of the mainstem channel in the middle and upper parts of Redwood Creek doubled in width because impacts associated with the storm and flood of 1964 (Nolan and Marron 1995).

Since 1974, the mainstem channel bed in the Upper Subbasin has degraded as large quantities of sediment were transported downstream and exposing bedrock. In 1980, staff of RNSP mapped the channel in great detail and reported their findings in a park technical report (Kelsey and others 1981). They mapped every gravel bar and streamside landslide at a scale of 1: 6,000, much as NCWAP did twenty years later and at a much smaller scale. By 1980, the flood deposits left in December of 1964 were eroded enough to expose the 1964 riparian trees killed in the flood (Madej and Ozaki 1996).

By 1984, much sediment had been transported out of the upper basin mainstem channel. A few active bars and several larger vegetated bars were apparent in aerial photographs of the uppermost parts of the basin. The large vegetated bars may be remnants from the waning stages of the pre-1984 floods, particularly the flood of 1964.

North of Roddiscroft Road, by inspection of time series photographs, channel condition appears generally similar between 1984 and 2000. However, conditions of Noisy and Twin Lakes creeks showed increases in streamside landslides (Table IV- 88 above) and elevated sediment in channels. In 1948, the area was unharvested and roadless. In the 1965 photo, the east side of the basin had been heavily harvested; steep lower eastside slopes were riddled with logging roads. The mainstem channel of 1965 was filled with continuous unvegetated sediment along its length; discrete stream bars were not visible. New streamside landslides appeared that had not existed in 1948. By 1984, discrete stream bars had formed. By 2000, revegetation hid many road scars. Compared with the 1948 photos, the 2000 channel appears wider, gravel bars appear bigger, and canopy is decreased.

Based on air-photo mapping of year 2000 photos at 1:24,000, Twin Lakes Creek, High Prairie Creek, and Noisy Creek planning watersheds in the Upper Subbasin showed an elevated amount of stored sediment. In contrast, Lake Prairie Creek appeared to have relatively less stored sediment in its channels. The mainstem contained an abundance of sediment in the area of Twin Lakes Creek and much less stored sediment downstream in the areas of Bradford and High Prairie Creeks. Farther downstream, stored sediment increased to moderate amounts along the mainstem of Redwood Creek.

The length of stream disturbance features decreased overall in the Upper Subbasin between photo years 1984 and 2000, from 23.9 mi to 15.9 miles (Table IV- 94). However, a number of tributaries gained in net stream disturbance during this time period, as described in more detail below. Tributaries that deteriorated and probably contained post-1984 sediment sources include Noisy, High Prairie, Minon, Snow Camp, Twin Lakes, and Lineament Creeks.

An example of how land use can exacerbate mass wasting was observed in Lake Prairie Creek, located in the High Prairie Creek Planning Watershed. In 1997, soon after intensive timber harvests, a bridge failure during a stressing storm is believed to be the initial cause of a debris torrent that affected Lake Prairie Creek. The bridge was deteriorating and was scheduled for replacement, but the storm came first.

The debris torrent removed riparian vegetation along the stream banks and resulted in 8 -15 feet of scour in the channel. A tremendous amount of sediment was delivered to the mainstem Redwood Creek. A large debris jam formed just upstream of the Lake Prairie Creek mouth and a large mass of sediment accumulated upstream of the jam. The debris jam and sediment accumulation at the creek mouth became a barrier to anadromous salmonids and the scouring off of riparian vegetation left the stream flow open to direct solar heating.

Comparing the number of active streamside landslides (Table IV- 88) and lengths of negative sediment (Table IV- 94) mapped in each planning watershed in 1984 and 2000. Only Windy Creek shows an improvement in both tables, decreasing in both elevated sediment and number of streamside slides. In contrast, High Prairie, Noisy, and Twin Creeks show deterioration between 1984 and 2000, with increases in both streamside landslides and negative stream features.

Table IV- 94. Upper Subbasin negative stream features, negative stream feature index, and percent change for 1984 to 2000.

Subbasin or Planning Watershed Unit of Analysis	Analysis Unit Area (sq. km.)	Negative Features 1984 (m)	Negative Features 2000 (m)	Indexed Negative Features 1984*	Indexed Negative Features 2000*	% Change 1984-2000
Upper Subbasin	175.5	37,152	27,063	212	154	-27
Bradford Creek	28.4	6,906	1,511	243	53	-78
Cloney Gulch	20.7	10,206	1,177	493	57	-88
High Prairie Cr	42.1	3,607	3,688	86	88	2
Noisy Creek	27.6	2,163	5,633	78	204	160
Twin Lakes Cr	37.1	8,384	13,427	226	362	60
Windy Creek	19.6	5,886	1,627	300	83	-72

* Index = (length of negative features in meters/area of unit of analysis in square kilometers)

Water Quality

Water Column Chemistry

Water chemistry in the Upper Basin was sampled from 1973-1975 at the USGS O'Kane gauging station at the Highway 299 bridge at the lower end of the subbasin. Data show that dissolved oxygen ranged from 8-12mg/L (water quality objective >8mg/L), pH data ranged from 7-8.5 (water quality objective 6.5-8.5) and conductance ranged from 50-150umhos (water quality objective <220umhos). This headwaters area provides important information on the base level water quality for the Redwood Creek basin. Impacts to this area may have lasting affects to water quality downstream and throughout the watershed. Although rough terrain and steep channels make sampling difficult, an effort should be made to characterize the water chemical parameters in this area, especially to monitor the potential impacts of land use activities such as herbicide applications. Data from the upper watershed obtained for this assessment show compliance with Basin Plan water quality objectives and no noticeable trends were observed. See data for the O'Kane site in the NCRWQCB Appendix.

Temperature

Water temperature of Redwood Creek in the Upper Subbasin has been monitored upstream of the confluence with Minon Creek (RM 55) and upstream of Lupton Creek at the O'Kane USGS gauging station (RM 44). Mainstem Redwood Creek water temperatures are coolest in the reach above Minon Creek, where the recent maximum MWAT was 65ºF and maximum daily temperature was 71ºF (Table IV- 95 and Table IV- 96). These temperatures are one degree above desirable levels for salmonids, but are the lowest temperatures recorded in Redwood Creek over the entire basin. The relatively cool temperatures are likely due to cold water inputs from tributaries, riparian shading, and close proximity to the cool, headwater source area. Water temperatures rise quickly along the 11.5 mile reach between Minon and O'Kane gauging station. In 1997-2001 the MWAT was 71ºF and maximum daily temperature rose to 80º F at the O'Kane site. Although these are high, this may be showing a declining trend for water temperatures. There is a lack of riparian shade along this reach below Minon Creek and the stream is exposed to direct sunlight. These high temperatures may cause stress, damage, or death to salmonids or limit their summer habitat to cool refuge sites that may occasionally occur in the Upper Subbasin.

Upper Subbasin tributaries had MWATs of 54 to 62ºF which are within a desirable range to support anadromous salmonids (Table IV- 95). Maximum daily temperatures recorded during the summers of 1996 to 2001 for the tributary sites were between 57 and 65ºF, which are considered generally good for salmonids (Table IV- 96). The highest MWAT and maximum daily temperatures are from Minon Creek and Lake Prairie Creek. The debris torrent in Lake Prairie Creek removed a large area of riparian vegetation from the banks during the winter of 1997 which led to increasing water temperature. As the riparian vegetation and shade canopy grows back, a reduction of water temperature in Lake Prairie Creek should follow.

Table IV- 95. MWATs for Upper Subbasin sites.

Site ID	Site	Subbasin	Period of Record	Max MWAT year	Max MWAT (°F)
3007, RwMin	*RedCrk upstm Minon Creek5	Upper	1997-99	1998	65
3008, RwOkn	*O'Kane gauging station RedCrk upstm Lupton Creek5, 1	Upper	1997-99,2001	1998	71
608	High Prairie Creek5	Upper	1998	1998	56
614	Upper High Prairie Creek5	Upper	1998	1998	56
611	Minon Creek mainstem5	Upper	1998	1998	62
612	Upper Minon trib5	Upper	1998	1998	54
613	Upper Minon Creek5	Upper	1998	1998	54
5041901	Lake Prairie Creek6	Upper	1996-99	1998	60
5043201	Pardee Creek6	Upper	1996-99	1996	58

Table IV- 96. Seasonal maximum temperatures for Upper Subbasin sites 1996-2001.

Site	Stream Location	Stream	Subbasin	Yr96	Yr97	Yr98	Yr99	Yr00	Yr01
3007	RedCrk upstm Minon	Redwood Creek	Upper		70°F	69°F	71°F		
3008	RedCrk@O'Kane	Redwood Creek	Upper		80°F	79°F	78°F		77°F
608	High Prairie	High Prairie	Upper			57°F			
614	Upper High Prairie	High Prairie	Upper			57°F			
611	Minon mnstm	Minon	Upper			65°F			
612	Upper Minon	Minon	Upper			57°F			
613	Upper Minon trib	Minon	Upper			57°F			
5041901	Lake Prairie	Lake Prairie	Upper	59°F	65°F	64°F	63°F		
5043201	Pardee	Pardee	Upper	59°F	59°F	59°F	58°F		

In-Channel Sediment

In-channel sediment data sampled by the RNSP on mainstem Redwood Creek upstream from Lupton Creek near the O'Kane Bridge, showed a decreasing trend in median particle size from 1979 to 1995. The D_{50} met the TMDL target of >37mm in 1979 and 1981, but fell below the target from 1982 to 1995. A decrease in particle size is often associated with an oversupply of sediment. Observations by CGS from air photo analysis indicate an increase in the amount of sediment in storage from 1984 to 2000, in the vicinity of the D_{50} sampling sites, which appears to corroborate the D_{50} findings. However, the amount and consequence of that storage at this site is not known at this time. See Appendix C for the D_{50} data from this site.

The site at the O'Kane gauging station was sampled for fine subsurface sediment in 1979, 1983 and each year from 1989 to 1992 by the RNSP and USGS. The percentage of fine sediment data presented by the RNSP and USGS are not comparable to TMDL targets due to different methods of analysis. No noticeable trends can be seen from the data at this site. See Appendix C for data from the sampling events. Without current data it is difficult to make conclusions about the distribution of in-stream sediments and how they impact salmonid habitat in the Upper Subbasin.

Salmonid Habitat

Fish Habitat Relationships

The Upper Subbasin supports populations of Chinook salmon, coastal cutthroat trout and steelhead, and summer steelhead. Chinook salmon use mainstem reaches for spawning and juvenile rearing. Although the mainstem and some tributaries may provide suitable habitat for coho salmon, there is no recent account of their presence in Upper Subbasin streams.

Approximately 17 miles of mainstem Redwood Creek are available to anadromous salmonids for spawning and juvenile rearing in the Upper Subbasin. Anadromous salmonid access is blocked by a 45-foot cascade near the confluence of Snow Camp Creek, approximately 65 miles from the river mouth. "A boulder roughs section about 2,500 feet above Pardee Creek (~RM 62) may be a barrier to salmon but not to steelhead" (CDFG 1986).

Only about 5.5 miles of tributary stream habitat are accessible to anadromous salmonids. The steep channel gradients limit access by anadromous salmonids to only the lowermost reaches of the tributary streams (Table IV- 97). Most tributaries support populations of steelhead as they are able to ascend steeper gradient streams than Chinook or coho. Coastal Cutthroats are found in both anadromous reaches and above barriers to anadromous salmonids.

Based on length of accessible habitat, the most important tributary streams in the Upper Subbasin for anadromous salmonids are Minon, Bradford (Upper Panther), Noisy, Gunrack and High Prairie Creeks. These five creeks comprise 65% of the tributary stream habitat available to anadromous salmonids in the Upper Subbasin. The remaining eleven named creeks each provide 0.3 miles or less of habitat available to anadromous fish. The smaller streams may support resident salmonid populations, but also contribute cool water, sediment, and other watershed products to the mainstem Redwood Creek.

Table IV- 97. Upper Subbasin streams, species present, and number of stream miles accessible to anadromous salmonids.

Stream	Species Observed	Stream Length Access (miles)	References
Minon Creek	steelhead Pacific giant salamander Pacific lamprey	1.1	CDFG 2001 & 1966 stream surveys, RNP/USFS-RSL revisit of 1981 thesis sites field notes, and Brown 1988
Bradford/Up. Panther Creek	steelhead	0.99	Brown 1988
Noisy Creek	steelhead	0.50	Brown 1988
Gunrack Creek	steelhead coastal cutthroat	0.50	Brown 1988
High Prairie Creek	steelhead coastal cutthroat	0.43	Brown 1988, CDFG 2002.
Lake Prairie Creek	steelhead pacific giant salamander tailed frog	0.31	Brown 1988, CDFG 2002
Emmy Lou Creek	Steelhead	0.25	Brown 1988
Windy Creek	steelhead	0.25	Brown 1988
Squirrel Tail Creek	steelhead	0.25	Brown 1988
Snowcamp/ Smokehouse Creek	steelhead	0.19	Brown 1988
Pardee Creek	steelhead	0.19	Brown 1988
Simion Creek	steelhead	0.19	Brown 1988
Cut-off Meander Creek	steelhead	0.19	Brown 1988
Fern Prairie Creek	None	0.16	CDFG 2001 stream surveys and Brown 1988
Jena Creek	steelhead	0.12	Brown 1988
Xmas Prairie Creek	None	0.06	Brown 1988
Redwood Creek	Chinook steelhead Coastal cutthroat	17.2	CDFG 2001 stream surveys, Gerstrung 2001, Anderson 2000, and Brown 1988

Past Surveys

Data describing historic fish habitat conditions are scarce for the Upper Subbasin, but based on air photo interpretation, review of CDFG reports, and anecdotal accounts, it is clear that historic conditions were quite different than we see today. In the past, riparian forests containing large conifers lined the river banks and water temperatures were likely cooler as stream reaches with closed canopy were common throughout the subbasin.

Stream surveys from 1966 and 1972 noted severe erosion of hill slopes and stream banks, and numerous log jams in the uppermost anadromous reaches of Redwood Creek (Fisk et al. 1966, CDFG 1966, CDFG 1972, Hatzimanolis 1972). The condition of upper Redwood Creek mainstem after the 1964 flood was assessed by Fisk et al. (1966) as “severely damaged” in 1966 (CDFG 1966). In 1966 and 1972 surveys also described pools as scarce with little cover and that streams lacked in aquatic insects. The surveys also noted the spawning gravels were filled in with sand and silt while other spawning sites were considered in good condition. Fisk et al. (1966) stated that “Logging activities, particularly the construction of roads and skid trails and the removal of vegetative ground cover, have been a major factor contributing to increased erosion and land slippage” resulting in the near complete loss of pools and shelter for fish as a result of excessive sediment inputs. Hatzimanolis (1972) reiterated this as he wrote: “Redwood Creek has little to offer resident trout or juvenile salmon in using it as a nursery.”

2001 Surveys

In 2001, the CDFG performed stream surveys in the Upper Subbasin along two reaches of Redwood Creek (upper reach and a lower reach), and along the anadromous reaches of Fern Prairie Creek, and Minon Creek. Limited crew access and time constraints prevented a broader survey in the Upper Subbasin. Analysis of the 2001 stream surveys and a comparison with 1966 and 1972 surveys suggest that overall stream reach characteristics in Redwood Creek have improved compared to past reports. However, the condition of most of the tributaries was not assessed. Results from the 2001 surveys are discussed below.

Pool:Riffle:Run Ratios

Significance: Productive anadromous streams are generally composed of a balance of pool, riffle and run habitat, and each plays an important role as aquatic habitat. All salmonids require access to pools, runs, and riffles for feeding, seasonal rearing or spawning to fulfill their freshwater life history requirements. 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).

A review of the pool, riffle, and run ratios shows that Minon Creek has a suitable ratio of pools by percent occurrence but the pools are generally short in length compared to riffles and runs (Table IV- 98). Fern Prairie Creek has a fair number of pools but they comprise only 8% of the survey channel length. In contrast, the lower survey reach of Redwood Creek in the Upper Subbasin is composed of approximately two thirds pools by both occurrence and by stream length. This reach is among the best of all streams surveyed in the entire Redwood Creek basin in terms pool frequency and percent reach length of pool habitat.

Table IV- 98. Upper Subbasin percent by occurrence, length of pool:run:riffle, and dry habitats in anadromous fish reaches summer 2001.

Stream	Survey Length (ft.)	Pool:Riffle:Flat water % Occurrence (1)	Pool:Riffle:Flatwater % Total Length (1)	Dry (% Total Length)	Culvert (% Total Length)
Minon Creek	6,179	34 : 27 : 35	17 : 22 : 52	9	0
Fern Prairie Creek	876	25 : 50 : 25	8 : 54 :38	0	0
Lower reach Redwood Creek	10,748	66 : 16 : 18	64 : 15 : 21	0	0
Upper reach Redwood Creek	13,996	37 : 26 : 36	26 : 52 : 21	1	0

[1] Includes side channel and secondary channel habitats

Pool Depth

Significance: Evaluating the amount of deep pool habitat in a stream reach helps assessment of important channel characteristics for fish. Deep pools are important as year round rearing habitat for salmonids and especially important as winter habitat for coho salmon and coastal cutthroat trout and adult summer steelhead summer. Lack of deep pools may indicate a disruption to channel forming processes due to a lack of LWD or elevated levels of stored sediments.

The lower survey reach (a 4th order reach) of Redwood Creek is composed of approximately 65% pool habitat. Approximately 20% of the reach is composed of pools with maximum depths of 4 feet or greater (Figure IV-59). The combination of the number, length, and depth of pools makes this reach among the best for pool habitat in the Redwood Creek Basin. The survey reaches in Upper reach of Redwood Creek, Fern Prairie, and Minon creeks were generally lacking in deep pool habitat. Pools in Minon Creek only occupy 17% of the stream length and only a little over one-third of these had maximum depths greater than two feet. Fern Prairie Creek had approximately 6% of its length in pools and all of the pools were less than two feet deep.

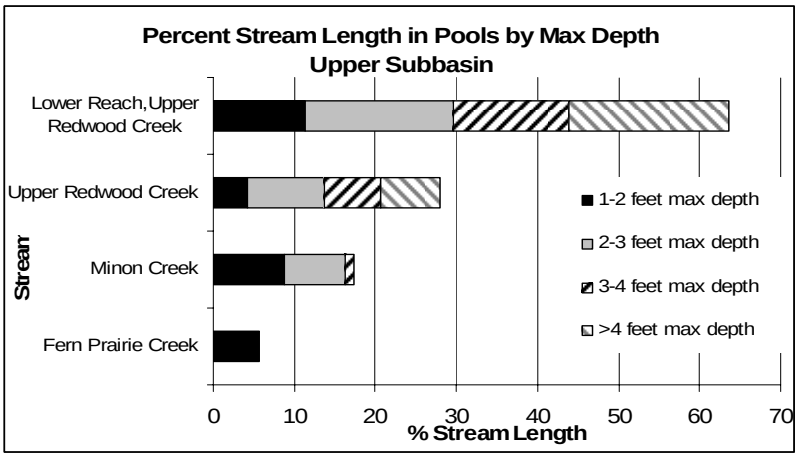

Figure IV- 59. Upper Subbasin percent survey reach in pools, grouped by maximum depth.

Pool Shelter

Significance: The pool shelter rating is a relative measure of the quantity and composition of LWD, root wads, boulders, undercut banks, bubble curtains, and submersed or overhanging vegetation. These elements serve as instream habitat, create areas of diverse velocity, provide protection from predation, and separates territorial units to reduce density related competition. The rating ranges from 0-300 do 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).

The average shelter rating values for pools surveyed in the Upper Subbasin was far below the desirable value of 100 (Figure IV- 60). Shelter in the two tributaries and two mainstem reaches of Redwood is dominated by boulders. Woody debris shelter was the subdominant cover type in all reaches except the lower reach of Redwood Creek where bedrock ledges were subdominant (Table IV- 99). Similar to most streams in Redwood Creek basin, cover in the form of woody debris is lacking in pools of the Upper Subbasin.

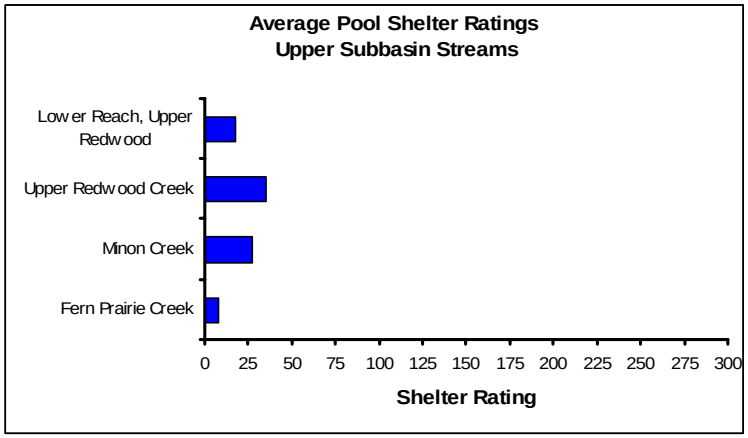

Figure IV- 60. Upper Subbasin mean shelter rating for pools surveyed.

Table IV- 99. Upper Subbasin summary of mean percent cover of dominant (1) and subdominant (2) shelter types in pool and flatwater units.

Streams	Undercut Banks	Woody Debris	Terrestrial Vegetation	Aquatic Vegetation	White-water	Boulders	Bedrock Ledges
Minon Creek		2				1	
Fern Prairie Creek		2				1	
Lower reach Redwood Creek						1	2
Upper reach Redwood Ck		2				1	

Streamside Canopy Density

Significance: Streamside canopy density is a measure of the percentage of wetted stream that is influenced by riparian tree canopy. Tree canopy provides shade to reduce direct sun light from warming water, provides a source of nutrients in the form of organic debris, and leaf litter, terrestrial insects, and is an important source of woody debris for instream habitat. The roots of riparian vegetation also help maintain soil and stream bank stability. A desirable streamside canopy should average at least 80% over a survey reach and generally be composed of a mix of coniferous and deciduous trees (Flosi et al. 1998). A shade canopy of coniferous trees is desirable because they are taller, may provide a grater amount of shade, and the overstory canopy helps moderate air temperatures and keep streams cool. Additionally LWD from large sized conifers may stay in channels and resist decay much longer than smaller deciduous or other hardwood trees.

The overall canopy density along Minon and Fern Prairie creeks provides good shade over the water, but the coniferous component is small (Figure IV- 61). Shade canopy over Redwood Creek is below desirable levels at 63% and 50% for the upper and lower reach of Redwood Creek respectively. Furthermore, the coniferous component is also small. Lack of shade over the mainstem Redwood Creek allows direct heating of water by solar radiation. The positive affects from large nearstream conifers are lacking in all surveyed streams.

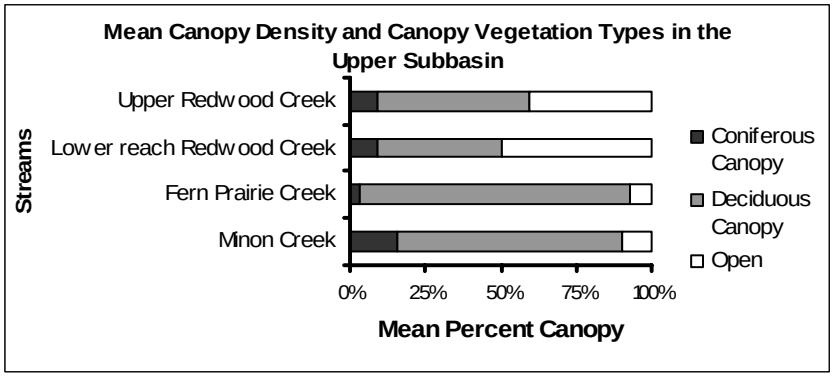

Figure IV- 61. Upper Subbasin mean canopy density and canopy vegetation types from streams surveyed.

Spawning Cobble Embeddedness

Significance: Percent cobble embeddedness helps determine suitability of substrate for salmonid spawning, egg incubation, and fry emergence. Clean gravels and cobbles, free of fine sediment are best for spawning success. Substrate less than 25% embedded in fine sediments is considered high quality salmonid spawning habitat (Flosi et al. 1998). Highly embedded spawning substrate generally indicates excessive stream bank or hillslope erosion occurring upstream and fine sediments entering the stream channel.

The majority of spawning substrate observed in pool tails of the Upper Subbasin was above 25% embedded (Figure IV- 62). Minon Creek had the highest percentage of suitable quality spawning substrate, with approximately 30% of the sample sites considered good spawning habitat.

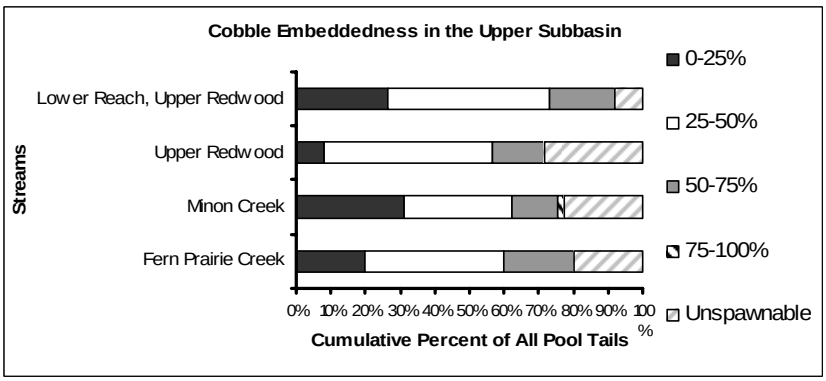

Figure IV- 62. Cobble embeddedness in Upper Subbasin streams.

Salmonid Fishery Resources

Coho Salmon

Coho were not observed in Upper Subbasin streams during 2001 surveys or in the downstream migrant trap located near the confluence of Toss Up Creek years 2000 -2003. Past stream reports do not cite evidence of coho presence in Upper Subbasin streams. Because the mainstem Redwood Creek has less than 3% gradient until the boulder roughs section about 2,500 feet above Pardee Creek (~RM 62), coho could utilize the upper mainstem and tributaries for spawning and juvenile rearing habitat. Prior to the 1964 flood, the Upper Subbasin mainstem may have supported coho. No records or anecdotal reports of their presence in the Upper Subbasin were found in our data search, but little information of any kind describing historic fish presence in the Upper subbasin is available.

Chinook Salmon

Chinook utilize the mainstem Redwood Creek of the Upper Subbasin for spawning and juvenile rearing. Although older stream reports do not cite evidence of Chinook presence in the Upper Subbasin tributary streams, it is likely that they occasionally use the lower reaches of some tributaries for spawning.

Ninety-five Chinook redds or 5.3 redds per mile were counted in eighteen miles of surveyed reach above Toss Up Creek in 2000-2001. The uppermost eight of these miles are within the Upper Subbasin which represents approximately half of the total length of spawning habitat available to Chinook in the Upper Subbasin. In general, fewer redds were observed per mile as surveyors proceeded upstream. The survey reach ended before the end of available Chinook spawning habitat. Further discussions of recent Chinook studies that include the Upper Subbasin are provided in the Middle Subbasin and Watershed Profile sections of this report.

Steelhead

Steelhead have been observed in 16 tributary streams and are the most commonly observed and widely distributed species found in the anadromous reaches of the Upper Subbasin streams. The best mainstem Redwood Creek juvenile steelhead rearing habitat is thought to be above Minon Creek. Water temperatures in this reach are generally considered good for steelhead production.

Electrofishing efforts in 2001 in the Upper Subbasin tributaries were limited to Minon Creek. The survey efforts yielded 109 steelhead (73 age 0+, 34 age 1+, and 2 age 2+) for approximately 400 feet of electrofishing in pool type habitat exclusively. These data indicate that the relatively modest amount of pool habitat present in Minon creek is suitable for the advancement of 0+ to 1+ year classes. However, the advancement of age 1+ to 2+ may be limited by habitat conditions in Minon Creek. Alternatively, due to the shortage of deep pool habitat, the larger and older steelhead of Minon Creek may move downstream and take up residence in the suitable reaches of mainstem Redwood Creek.

Summer Steelhead

The summer steelhead is a unique stock of steelhead that migrate 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 Upper Subbasin for over summer habitat, as they wait for the fall rains to complete the spawning run.

Dive surveys of Redwood Creek from 1981-2000 produced counts of adult summer steelhead that ranged from 3 fish in 2000 to 37 fish in 1997 (see Figure III-44). The low counts of summer steelhead indicates that they are likely the most threatened by extirpation of all the anadromous stocks in the Redwood Creek basin. The main reason for the decline is summer steelhead is likely due to a drastic reduction of deep, complex pools that persisted for years after the flood of December 1964 and other similar events. Elevated water temperatures and loss of juvenile rearing habitat may also play a role in their decline.

Coastal Cutthroat

The abundance and distribution of coastal cutthroat in the Upper Subbasin is not well known. They have been observed in mainstem Redwood Creek, Gunrack and High Prairie creeks, but it is unclear whether these are resident or anadromous stocks. Resident populations of coastal cutthroat and rainbow trout are found upstream of anadromous tributary reaches in High Prairie Creek. The downstream migrant trapping efforts in the Middle Subbasin yielded 17 cutthroats from the 2000 to 2002 trapping years.

Upper Subbasin General Issues

The Upper Subbasin is highly susceptible to erosion:

- Seventy-two percent of the subbasin has high or very high land slide potential;
- Land use such as timber harvest activities exacerbate erosion potential;
- Recently the Upper Subbasin has produced more sediment than the Middle and Lower Subbasins combined;
- The Upper Subbasin generates and exports sediments that contribute to aggradation and persistent impairment of salmonid habitat in the Lower and Estuary subbasins.

Land management can influence watershed processes:

- Land uses, such as timber harvest activities, increase erosion potential over much of the Upper Subbasin;
- High road density of both abandoned and useable roads adds to instream 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.

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:

- Water temperatures increase quickly to above desirable levels in the upper mainstem Redwood Creek due to the widened stream channel and lack of riparian shade canopy;
- Water temperature in monitored tributary streams is generally suitable for anadromous salmonids;
- Mainstem Redwood Creek, Fern Prairie Creek and Minon Creek provide some deep pools, but these streams are below desirable target levels for amount of deep pool habitat;
- Instream shelter is lacking in Redwood, Minon, and Fern Prairie creeks.

Integrated Analysis and Cumulative Effects

The Upper Subbasin includes approximately 19 miles of Redwood Creek beginning in the headwaters and extending through the Windy Creek Planning Watershed near the Highway 299 Bridge. Due to its inland location, the Upper Subbasin is generally not influenced by coastal fog or marine air masses. Thus, air temperatures of the Upper Subbasin vary between over 100°F in the summer to below freezing in the winter months. The Upper Subbasin receives an average of 98 inches of rainfall per year. The high elevations the Upper Subbasin are also capable of receiving and storing a substantial amount of snowfall. The high amount of precipitation, unstable geology, and steep relief make the Upper Subbasin vulnerable to landsliding and other

forms of mass wasting. Land uses, such as timber harvest activities, increase erosion potential over much of the Upper Subbasin.

These land use and weather factors came together in December of 1964 when the rain on snow flood, triggered landslides, road failures, gully erosion, and other erosion processes across the recently clear cut timber lands of the Upper Subbasin. Excessive amounts of sediment were delivered to the mainstem channel. In order to maintain channel capacity and accommodate flood flows, stream banks eroded and the channel within the Upper Subbasin widened up to 150% from its former width. In addition, newly formed gravel terraces grew so voluminous that riparian vegetation was buried and many trees near the stream banks died.

Presently the Redwood Creek channel has returned to pre 1964 bed elevations over much of its length as much of the instream sediment has moved to downstream reaches. However, compared to conditions prior to 1964, the channel is still considerably wider, the stream is shallower, shade over the stream is largely absent, and large stores of sediment that impair re-growth of tress are still present in terraces adjacent to the stream channel.

A cumulative effect from the wide and shallow mainstem channel and lack of shade canopy is the stream is exposed to direct dun light which rapidly heats stream flows during the summer months. Water temperatures measured by MWATs increase from 65°F just above Minon Creek to 71°F at the O'Kane gauging site (near Highway 299) which is well above desirable target values to support salmonids. The distance between the two sites is approximately 11.5 miles. Most of the warming of all Redwood Creek occurs along this reach. There is a series of pools located along the lower reach within the Upper Subbasin that would provide better salmonid habitat if the cool water extended to the O'Kane site.

Subbasin-wide, 2,892 acres or 6.7% of the area is comprised of historically active landslide features with earthflows as the predominant landslide feature type (Table IV- 100). Sixty-one percent of the active landslide features are located on grasslands and woodlands and the remaining 39% is located on forestlands. Windy Creek Planning Watershed has the highest percentage of area (15%) in historically active landslide features followed by Twin Lakes Creek (7%). Noisy Creek Planning Watershed has the least percentage of area in active landslide features (3%). The majority of recent timber harvests on active landslide features have been conducted in the Windy Creek (90 acres) and High Prairie (45 acres) creek planning watersheds.

There are approximately 22 miles of roads located on active landslide features within the Upper Subbasin or five miles of roads per square mile. The highest road density on active landslide features is in the Windy Creek Planning Watershed where there are approximately eight miles of road per square mile of active landslide features.

Analysis and comparisons at the planning watershed scale are complicated because the planning watersheds span across the Grogan fault and are composed of more than one major bedrock units. However, these data suggest a potential concern because of the amount of current land use and the amount of active landslide features within the planning watersheds. Windy Creek Planning Watershed has the highest percentage of active landslide features in the subbasin and with its high road density on landslide features and highest amount of recent timber harvest activity on landslide features.

Table IV_ 101 broadens the view of potential slope instability and land use interactions by addressing relative landslide potential. Seventy-two percent of the Upper Subbasin falls into high and very high relative landslide potential classes. The bulk of this area is comprised of timberlands with no recent harvest (48%), followed by recent THPs (18%) and woodland or grassland (5%). Windy and Twin Lakes planning watersheds share the greatest percentage (80%) of area in the two highest relative landslide potential classes, followed by Bradford Creek (77%). The planning watershed with the smallest percent of their area in the highest two relative landslide potential classes is Noisy Creek (59%). Approximately 75% of the high and very high landslide potential terrain is located on forestlands leaving 25% on grasslands and woodlands.

Ten percent of the Upper Subbasin was in recent THPs (1991– 2000) with half of the harvest on areas with high or very high relative landslide potential. The Lake Prairie Planning Watershed had the most timber harvest activity with 18% of the planning watershed in recent THPs during the 1991-2000 decade. In the Lake Prairie Planning Watershed 12% of the area in THPs is on land in the highest landslide potential classes. Three percent of the Windy Creek Planning Watershed was recently in THPs while Noisy Creek had 9% of its area in THPs.

Table IV- 100. Upper Subbasin acres and percent area of historically active landslide features associated with land type or use.

Subbasin or Planning Watershed	Historically Active Landslide Feature[1]	Subbasin or Planning Watershed		Woodland and Grassland[2]		THPs 1991 - 2000[5]		Timberland, No Recent Harvest[3]		Roads[4]	
		Area (acres)	% of Area	Area (acres)	% of Area	Area (acres)	% of Area	Area (acres)	% of Area	Length (miles)	% of Total Length
Upper Redwood Creek Subbasin (43,343 acres) (501.2 road miles)	Earthflow	2,492	5.7%	1,743	4.0%	137	0.3%	542	1.3%	18	3.5%
	Rock Slide	165	0.4%	4	0.0%	0	0.0%	160	0.4%	1	0.3%
	Debris Slide	227	0.5%	8	0.0%	10	0.0%	208	0.5%	2	0.5%
	Debris Flow	9	0.0%	1	0.0%	0	0.0%	9	0.0%	0	0.0%
	All Features	2,892	6.7%	1,756	4.1%	147	0.3%	919	2.1%	22	4.3%
Bradford Creek (7,027 acres) (72.3 road miles)	Earthflow	331	4.7%	267	3.8%	0	0.0%	52	0.7%	1.5	2.1%
	Rock Slide	55	0.8%		0.0%		0.0%	55	0.8%	0.4	0.6%
	Debris Slide	22	0.3%	0	0.0%		0.0%	21	0.3%	0.5	0.6%
	Debris Flow	3	0.0%	0	0.0%		0.0%	3	0.0%	0.1	0.1%
	All Features	410	5.8%	267	3.8%	0	0.0%	130	1.9%	2	3.5%
Cloney Gulch (5,119 acres) (55.5 road miles)	Earthflow	199	3.9%	104	2.0%		0.0%	31	0.6%	1.5	2.6%
	Rock Slide		0.0%		0.0%		0.0%		0.0%		0.0%
	Debris Slide	36	0.7%	1	0.0%	0	0.0%	35	0.7%	0.2	0.4%
	Debris Flow	0	0.0%		0.0%		0.0%	0	0.0%		0.0%
	All Features	235	4.6%	105	2.0%	0	0.0%	66	1.3%	2	3.0%
High Prairie (10,398 acres) (113.3 road miles)	Earthflow	592	5.7%	487	4.7%	44	0.4%	87	0.8%	0.7	0.7%
	Rock Slide	1	0.0%		0.0%		0.0%	1	0.0%	0.0	0.0%
	Debris Slide	25	0.2%	2	0.0%	2	0.0%	22	0.2%	0.2	0.2%
	Debris Flow	0	0.0%		0.0%		0.0%	0	0.0%		0.0%
	All Features	618	5.9%	489	4.7%	45	0.4%	110	1.1%	1	0.8%
Noisy Creek (6,810 acres) (86.9 road miles)	Earthflow	194	2.9%	115	1.7%	3	0.0%	71	1.0%	1.2	1.4%
	Rock Slide		0.0%		0.0%		0.0%		0.0%		0.0%
	Debris Slide	11	0.2%		0.0%		0.0%	11	0.2%	0.0	0.0%
	Debris Flow		0.0%		0.0%		0.0%		0.0%		0.0%
	All Features	205	3.0%	115	1.7%	3	0.0%	82	1.2%	1	1.4%
Twin Lakes Creek (9,156 acres) (104.3 road miles)	Earthflow	474	5.2%	270	3.0%	1	0.0%	184	2.0%	4.7	4.5%
	Rock Slide	109	1.2%	4	0.0%	0	0.0%	104	1.1%	1.0	0.9%
	Debris Slide	95	1.0%	2	0.0%	7	0.1%	85	0.9%	0.7	0.6%
	Debris Flow	4	0.0%	0	0.0%		0.0%	4	0.0%	0.0	0.0%
	All Features	682	7.4%	277	3.0%	9	0.1%	377	4.1%	6	6.1%
Windy Creek (4,831 acres) (68.8 road miles)	Earthflow	701	14.5%	499	10.3%	90	1.9%	118	2.4%	8.0	11.6%
	Rock Slide		0.0%		0.0%		0.0%		0.0%		0.0%
	Debris Slide	38	0.8%	4	0.1%		0.0%	35	0.7%	0.8	1.2%
	Debris Flow	2	0.0%	0	0.0%		0.0%	1	0.0%	0.0	0.0%
	All Features	742	15.3%	503	10.4%	90	1.9%	154	3.2%	9	12.8%

[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.

Of the 500 miles of roads in the subbasin, 316 miles (7.4 mi/ mi^2) are located on slopes with high or very high relative landslide potential. Twin Lakes and Lake Prairie planning watershed have the most roads built in the highest relative landslide potential classes, with 76 miles (6.4 mi/mi^2) and 63 miles (5.7 mi/mi^2) respectively.

Table IV- 101. Upper Subbasin acres and percent of area by relative landslide potential and land use classes.

Subbasin or Planning Watershed	Relative Landslide Potential[1]	Entire Subbasin or Planning Watershed		Woodland or Grassland[2]		THPs 1991 - 2000[5]		Timberland, No Recent Harvest[3]		Roads[4]	
		Area (acres)	% of Area	Area (acres)	% of Area	Area (acres)	% of Area	Area (acres)	% of Area	Length (miles)	% of Total Length
Upper Redwood Creek Subbasin (43,343 acres) (501.2 road miles)	Very Low	3,302	7.6%	533	1.2%	521	1.2%	2,012	4.6%	57.3	11.4%
	Low	4,318	10.0%	530	1.2%	672	1.6%	2,966	6.8%	67.8	13.5%
	Moderate	4,243	9.8%	397	0.9%	603	1.4%	3,159	7.3%	60.0	12.0%
	High	12,328	28.4%	2,418	5.6%	1,121	2.6%	8,557	19.7%	145.9	29.1%
	Very High	19,069	44.0%	5,300	12.2%	1,235	2.9%	12,259	28.3%	170.2	34.0%
	High/Very High Subtotal	31,397	72.4%	7,718	17.8%	2,357	5.4%	20,816	48.0%	316.1	63.1%
	TOTAL	**43,260**	**100%**	**9,178**	**21%**	**4,153**	**10%**	**28,953**	**67%**	**501.2**	**100%**
Bradford Creek (7,027 acres) (72.3 road miles)	Very Low	427	6.1%	20	0.3%	90	1.3%	262	3.7%	8.2	11.3%
	Low	535	7.6%	34	0.5%	103	1.5%	359	5.1%	9.5	13.1%
	Moderate	655	9.3%	46	0.7%	179	2.5%	388	5.5%	8.4	11.6%
	High	2,096	29.8%	368	5.2%	199	2.8%	1,442	20.5%	20.2	27.9%
	Very High	3,304	47.0%	1,073	15.3%	28	0.4%	2,121	30.2%	26.1	36.1%
	High/Very High Subtotal	5,400	76.8%	1,441	20.5%	227	3.2%	3,563	50.7%	46.3	64.0%
	TOTAL	**7,017**	**100%**	**1,541**	**22%**	**599**	**9%**	**4,572**	**65%**	**72.4**	**100%**
Cloney Gulch (5,119 acres) (55.5 road miles)	Very Low	375	7.3%	20	0.4%	94	1.8%	239	4.7%	4.7	8.5%
	Low	426	8.3%	64	1.3%	74	1.4%	263	5.1%	6.0	10.8%
	Moderate	644	12.6%	57	1.1%	100	2.0%	464	9.1%	8.4	15.1%
	High	1,493	29.2%	468	9.1%	104	2.0%	900	17.6%	16.2	29.2%
	Very High	2,180	42.6%	678	13.2%	123	2.4%	1,309	25.6%	20.1	36.2%
	High/Very High Subtotal	3,673	71.8%	1,146	22.4%	227	4.4%	2,209	43.2%	36.3	65.4%
	TOTAL	**5,118**	**100%**	**1,287**	**25%**	**496**	**10%**	**3,175**	**62%**	**55.4**	**100%**
High Prairie Creek (10,398 acres) (113.3 road miles)	Very Low	1,076	10.3%	366	3.5%	215	2.1%	459	4.4%	16.7	14.7%
	Low	1,227	11.8%	275	2.6%	304	2.9%	662	6.4%	18.1	16.0%
	Moderate	995	9.6%	142	1.4%	193	1.9%	660	6.3%	15.5	13.7%
	High	3,207	30.8%	673	6.5%	549	5.3%	2,054	19.8%	36.9	32.6%
	Very High	3,878	37.3%	1,377	13.2%	658	6.3%	1,996	19.2%	25.9	22.9%
	High/Very High Subtotal	7,085	68.1%	2,050	19.7%	1,207	11.6%	4,050	38.9%	62.8	55.4%
	TOTAL	**10,383**	**100%**	**2,833**	**27%**	**1,919**	**18%**	**5,831**	**56%**	**113.1**	**100%**
Noisy Creek (6,810 acres) (86.9 road miles)	Very Low	807	11.9%	69	1.0%	113	1.7%	574	8.4%	15.1	17.4%
	Low	969	14.2%	97	1.4%	158	2.3%	688	10.1%	15.5	17.8%
	Moderate	989	14.5%	111	1.6%	108	1.6%	762	11.2%	13.7	15.8%
	High	1,992	29.3%	466	6.8%	112	1.6%	1,409	20.7%	23.3	26.8%
	Very High	2,036	29.9%	430	6.3%	103	1.5%	1,490	21.9%	19.3	22.2%
	High/Very High Subtotal	4,028	59.1%	896	13.2%	215	3.2%	2,899	42.6%	42.6	49.0%
	TOTAL	**6,793**	**100%**	**1,173**	**17%**	**594**	**9%**	**4,923**	**72%**	**86.9**	**100%**
Twin Lakes Creek (9,156 acres) (104.3 road miles)	Very Low	363	4.0%	19	0.2%	9	0.1%	272	3.0%	8.0	7.7%
	Low	889	9.7%	47	0.5%	33	0.4%	737	8.0%	13.3	12.8%
	Moderate	515	5.6%	17	0.2%	23	0.2%	465	5.1%	7.5	7.2%
	High	2,505	27.4%	235	2.6%	153	1.7%	1,938	21.2%	31.7	30.4%
	Very High	4,853	53.0%	704	7.7%	206	2.3%	3,678	40.2%	44.0	42.2%
	High/Very High Subtotal	7,358	80.4%	939	10.3%	360	3.9%	5,616	61.3%	75.7	72.6%
	TOTAL	**9,125**	**100%**	**1,022**	**11%**	**424**	**5%**	**7,090**	**77%**	**104.5**	**100%**
Windy Creek (4,831 acres) (68.8 road miles)	Very Low	254	5.3%	39	0.8%		0.0%	206	4.3%	4.6	6.7%
	Low	272	5.6%	13	0.3%		0.0%	257	5.3%	5.4	7.8%
	Moderate	445	9.2%	24	0.5%		0.0%	420	8.7%	6.5	9.4%
	High	1,035	21.4%	208	4.3%	4	0.1%	814	16.8%	17.6	25.6%
	Very High	2,818	58.3%	1,038	21.5%	117	2.4%	1,665	34.5%	34.8	50.6%
	High/Very High Subtotal	3,853	79.8%	1,246	25.8%	121	2.5%	2,479	51.3%	52.4	76.2%
	TOTAL	**4,824**	**100%**	**1,322**	**27%**	**121**	**3%**	**3,362**	**70%**	**68.9**	**100%**

[1] Refer to Plate 1 and California Geological Survey appendix.
[2] Woodland and grassland includes areas mapped in 1998 as grassland and non-productive hardwood.
[3] Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
[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.

Table IV- 102 presents an integrated information summary for the upper 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 potential disturbance factors and watershed condition.

Table IV- 102. Upper Subbasin integrated information summary for the.

Factor	Upper Redwood Subbasin		Planning Watersheds											
			Twin Lakes		Bradford		High Prairie		Cloney Gulch		Noisy Creek		Windy Creek	
Relative Landslide Potential[1]	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Very Low	3,302	7.6%	363	4.0%	427	6.1%	1,076	10.4%	375	7.3%	807	11.9%	254	5.3%
Low	4,318	10.0%	889	9.7%	535	7.6%	1,227	11.8%	426	8.3%	969	14.3%	272	5.6%
Moderate	4,243	9.8%	515	5.6%	655	9.3%	995	9.6%	644	12.6%	989	14.6%	445	9.2%
High	12,328	28.5%	2,505	27.5%	2,096	29.9%	3,207	30.9%	1,493	29.2%	1,992	29.3%	1,035	21.5%
Very High	19,069	44.1%	4,853	53.2%	3,304	47.1%	3,878	37.3%	2,180	42.6%	2,036	30.0%	2,818	58.4%
High/Very High Subtotal	31,397	72.6%	7,358	80.6%	5,400	77.0%	7,085	68.2%	3,673	71.8%	4,028	59.3%	3,853	79.9%
GRAND TOTAL	**43,260**	**100%**	**9,125**	**100%**	**7,017**	**100%**	**10,383**	**100%**	**5,118**	**100%**	**6,793**	**100%**	**4,824**	**100%**
Landslide and Selected Geomorphic Features	**Acres**	**% Area**	**Acres**	**% Area**	**acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Historically Active Landslide Features Total	2,892	6.7%	682	7.5%	410	5.8%	618	6.0%	235	4.6%	205	3.0%	742	15.4%
Earthflow	9	0.0%	4	0.0%	3	0.0%	0	0.0%	0	0.0%	0	0.0%	2	0.0%
Rock Slide	227	0.5%	95	1.0%	22	0.3%	25	0.2%	36	0.7%	11	0.2%	38	0.8%
Debris Slide	2,492	5.8%	474	5.2%	331	4.7%	592	5.7%	199	3.9%	194	2.9%	701	14.5%
Debris Flow	165	0.4%	109	1.2%	55	0.8%	1	0.0%	0	0.0%	0	0.0%	0	0.0%
Dormant Landslide Features Total	15,702	36.3%	5,055	55.4%	2,159	30.8%	2,951	28.4%	2,134	41.7%	2,033	29.9%	1,370	28.4%
Selected Geomorphic Features Total	9,070	21.0%	1,414	15.5%	1,329	18.9%	3,094	29.8%	825	16.1%	767	11.3%	1,641	34.0%
Disrupted Ground	5,219	12.1%	737	8.1%	979	14.0%	1,488	14.3%	296	5.8%	376	5.5%	1,343	27.8%
Debris Slide Slope	2,780	6.4%	383	4.2%	233	3.3%	1,335	12.9%	380	7.4%	269	4.0%	179	3.7%
Inner Gorge (area)[2]	1,071	2.5%	295	3.2%	116	1.7%	271	2.6%	149	2.9%	122	1.8%	118	2.4%
Total of All Above Features	**27,664**	**63.9%**	**7,151**	**78.4%**	**3,898**	**55.5%**	**6,663**	**64.2%**	**3,194**	**62.4%**	**3,006**	**44.2%**	**3,752**	**77.8%**
Timber Harvest 1991 -20003	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**acres**	**% area**	**acres**	**% area**	**acres**	**% area**
Silviculture Category 1														
Tractor	2,006	4.6%	113	1.2%	298	4.3%	919	8.9%	314	6.1%	361	5.3%		
Cable	227	0.5%	91	1.0%	4	0.1%	102	1.0%	29	0.6%	2	0.0%		
Helicopter	380	0.9%	69	0.8%	21	0.3%	271	2.6%	19	0.4%				
TOTAL	**2,613**	**6.0%**	**273**	**3.0%**	**323**	**4.6%**	**1,292**	**12.4%**	**362**	**7.1%**	**363**	**5.3%**	**0**	**0.0%**
Silviculture Category 2														
Tractor	582	1.3%	142	1.6%	57	0.8%	75	0.7%	55	1.1%	132	1.9%	121	2.5%
Helicopter	0	0.0%												
Cable	24	0.1%					24	0.2%						
TOTAL	**606**	**1.4%**	**142**	**1.6%**	**57**	**0.8%**	**100**	**1.0%**	**55**	**1.1%**	**132**	**1.9%**	**121**	**2.5%**
Silviculture Category 3														
Tractor	949	2.2%	55	0.6%	224	3.2%	494	4.8%	76	1.5%	99	1.5%		
Helicopter	17	0.0%	8	0.1%	9	0.1%								
Cable	47	0.1%	6	0.1%	4	0.1%	34	0.3%	4	0.1%				

Factor	Upper Redwood Subbasin		Planning Watersheds											
			Twin Lakes		Bradford		High Prairie		Cloney Gulch		Noisy Creek		Windy Creek	
TOTAL	**1,013**	**2.3%**	**69**	**0.8%**	**236**	**3.4%**	**528**	**5.1%**	**79**	**1.6%**	**99**	**1.5%**	**0**	**0.0%**
TOTAL SILVICULTURE	**4,232**	**9.8%**	**485**	**5.3%**	**616**	**8.8%**	**1,921**	**18.5%**	**495**	**9.7%**	**594**	**8.7%**	**121**	**2.5%**
Other Land Uses	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**	**Acres**	**% Area**
Grazing	986	2.3%	104	1.1%			630	6.1%	69	1.4%	146	2.2%	36	0.7%
Agriculture	0	0.0%												
Development	0	0.0%												
Timberland, No Recent Harvest	28,953	66.9%	7,090	77.7%	4,572	65.2%	5,831	56.2%	3,175	62.0%	4,923	72.5%	3,362	69.7%
TOTAL	**29,939**	**69.2%**	**7,194**	**78.8%**	**4,572**	**65.2%**	**6,461**	**62.2%**	**3,244**	**63.4%**	**5,069**	**74.6%**	**3,398**	**70.4%**
Roads														
Road Density (miles/sq. mile)	7.4		7.4		6.6		7.0		6.9		8.2		9.2	
Density of Road Crossings (#/stream mile)	1.2		1.7		1.4		1.5		1.0		1.1		1.3	
Roads within 200' of Stream (miles/stream mile)	0.3		0.3		0.2		0.2		0.2		0.3		0.3	
Factor	**Upper Redwood Subbasin**		**Planning Watersheds**											
			Twin Lakes		**Bradford**		**High Prairie**		**Cloney Gulch**		**Noisy Creek**		**Windy Creek**	
Streams	**% stream length**		**% stream length**		**% stream length**		**% stream length**		**% stream length**		**% stream length**		**% stream length**	
% Stream by Gradient														
< 1% (Response Reach)		7.0%		1.3%		0.0%		1.9%		20.1%		4.1%		30.8%
1-4% (Response Reach)		9.8%		9.1%		12.4%		16.5%		9.0%		4.1%		1.9%
4-20% (Transport Reach)		43.7%		38.2%		40.7%		60.1%		43.7%		47.8%		20.4%
>20% (Source Reach)		39.5%		51.4%		46.8%		51.4%		27.2%		43.9%		47.0%
Historically Active and Dormant Landslide and Selected Geomorphic Features4	**% Area**	**% Stream Length**	**% Area**	**% Stream Length**	**% area**	**% stream length**	**% area**	**% stream length**	**% area**	**% stream length**	**% area**	**% stream length**	**% area**	**% stream length**
Within 180' of Blue Line Stream	6.8%	70.2%	5.9%	45.0%	4.1%	83.0%	6.8%	79.4%	4.3%	55.3%	10.6%	80.2%	7.6%	74.2%

[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

The EMDS potential stream sediment production model is based on the data distribution of factors at the planning watershed level. 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- 103 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, but a greater potential was indicated for streamside erosion due to management related sources compared to natural process. A review of the following tables helps explain the results for natural processes and management related potential sediment sources.

Table IV- 103. Upper Subbasin EMDS ratings for potential stream sediment production; top three levels of model.

Subbasin or Planning Watershed	All Sources	Natural Processes				Management-Related Sources			
		All	Surface Erosion	Streamside Erosion	Mass Wasting	All	Surface Erosion	Streamside Erosion	Mass Wasting
Upper Redwood Subbasin	-	-	U	+	-	-	-	-	-
Bradford Creek	-	--	U	+	---	-	+	-	-
Cloney Gulch	-	-	U	+	-	-	-	-	--
High Prairie Creek	-	-	U	-	-	-	+	-	-
Noisy Creek	+	+	U	+	+	-	+	-	+
Twin Lakes Creek	-	+	U	+	+	-	-	--	--
Windy Creek	--	--	U	--	---	-	-	--	-

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 data that lie in between suitable and unsuitable conditions, or there is a lack of data to categorize.

In terms of potential surface erosion, all planning watersheds show a relatively high potential for sediment delivery from roads, and most show relatively high sediment production potential from timber land use (Table IV- 104). The Windy Creek Planning Watershed stands out as having the high density of roads close to stream and on steep hillslopes. Cloney Gulch Planning Watershed shows the greatest sediment delivery potential from timber harvests. Potential stream sediment production from management related streamside erosion sources only considers roads as sediment sources (Table IV- 105). The high density of road crossings and roads near streams are both relatively high potential sediment delivery sources in the Upper Subbasin especially in Windy Creek and Twin Lakes Creek planning watersheds. Potential sediment delivery from timber harvest and road related mass wasting sources are highest in Twin Lake Creek and Cloney Gulch planning watershed (

Table IV- 106).

Table IV- 104. Upper Subbasin 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
Upper Redwood Subbasin	-	-	--	--	-	-
Bradford Creek	+	-	-	-	+	+
Cloney Gulch	-	-	-	-	--	--
High Prairie Creek	+	-	-	-	+	-
Noisy Creek	+	-	--	--	++	-
Twin Lakes Creek	-	-	--	--	-	+
Windy Creek	-	--	---	---	-	-

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

Table IV- 105. Upper Subbasin 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
Upper Redwood Subbasin	-	--	--
Bradford Creek	-	-	--
Cloney Gulch	-	-	-
High Prairie Creek	-	-	--
Noisy Creek	-	--	-
Twin Lakes Creek	--	--	---
Windy Creek	--	---	--

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

Table IV- 106. Upper Subbasin 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
Upper Redwood Subbasin	-	-	--	--	-	-	-
Bradford Creek	-	--	--	-	-	+	+
Cloney Gulch	--	-	-	-	-	--	--
High Prairie Creek	-	-	--	-	-	+	-
Noisy Creek	+	-	-	--	++	++	-
Twin Lakes Creek	--	--	---	--	-	-	+
Windy 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.

EMDS Stream Reach Condition Results and Limiting Factors Analysis

The overall reach condition for streams of the Upper Subbasin is considered "somewhat unsuitable" for salmonid production by EMDS. The maps display (Figure IV-63) results at the stream reach scale while Table IV- 107 shows the average condition for each stream. In the tributaries, the somewhat unsuitable rating is largely due to the lack of deep, complex pools. The Canopy density generally evaluated as suitable and pool tail substrate embeddedness was in mixed condition.

In some instances, the EMDS results alone do not provide the most accurate description of the stream condition in terms of pool depth. For example, the lower reach (a 4th order reach) of mainstem Redwood Creek Reach had over 65% of its length in pools, 20% of the reach length was in pools ≥ 4 feet in maximum residual pool depth (Figure IV- 63). This was at the lower limit of the suitability curve for a fourth order streams, thus the reach received the lowest EMDS rating of fully unsuitable. Considering that an additional 12% of the pools have depths of 3 to 4 feet, the EMDS evaluation for pool depth is conservative. Therefore the amount of deep pool habitat in the lower mainstem reach should not be viewed as fully unsuitable as the EMDS indicates and the amount of deep pool habitat should probably evaluate to a slightly more positive value. Overall, the lack of deep, complex pools and lack riparian canopy density contributed to the EMDS results for the mainstem Redwood Creek.

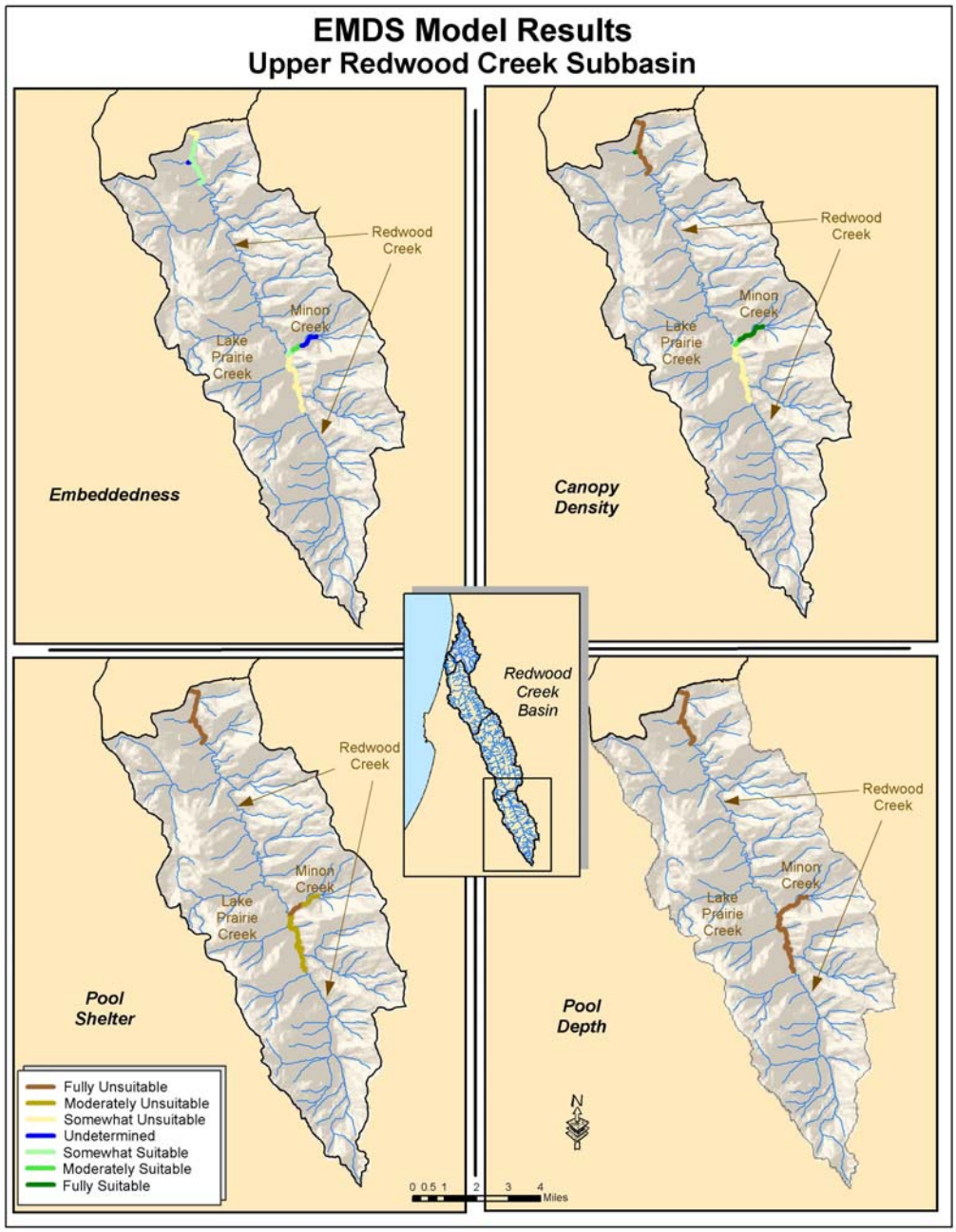

Figure IV- 63. Upper Subbasin EMDS results.

Table IV- 107. Summary results from the Upper Subbasin EMDS stream reach evaluation.

Stream	Reach Length (ft)	Reach number	Reach Condition	Canopy Density	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Fern Prairie Creek	852	1	-	+ + +	- - -	- - -	- - -	0
Minon Creek	1101	1	-	+ +	- - -	- - -	- - -	+
Minon Creek	1784	2	-	+ + +	- - -	- - -	- - -	+ +
Minon Creek	3294	3	-	+ + +	- -	- - -	- -	0
Redwood Creek (lower)	8425	1	-	- - -	- - -	- - -	- - -	+
Upper Redwood Ck	13996	2	-	-	- -	- - -	- - -	-

\+ 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.

Refugia Areas

The NCWAP team and staff from RNSP and Green Diamond Timber Company classified the streams of the Upper Subbasin in terms of refuge habitat for anadromous salmonids. The upper reach of Redwood Creek (above Minon Creek) provides the best refuge type habitat of the mainstem (Table IV- 108). This reach provides the coolest water of all Redwood Creek, but lacks in the number of deep, complex pools. The reach below Minon Creek has some good pools, but is currently too warm. There is potential to cool water by increasing shade canopy over this reach which would increase its refugia value. Simon, Minon, and Fern Prairie creeks were also classed as potential refuge based on the cool water temperature and fair condition of the stream habitat. Lake Prairie Creek is passage barrier limited as a large debris jam exists at the mouth of the creek. Most tributary streams could not be assigned a refugia class because of data limitations.

Table IV- 108. Upper 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
Minon Creek			X				
Fern Prairie Creek			X				
Bradford/Up. Panther Creek							
Noisy Creek							X
Gunrack Creek							X
High Prairie Creek							X
Lake Prairie Creek					X		
Emmy Lou Creek							X
Windy Creek							X
Squirrel Tail Creek							X
Snowcamp/Smokehouse Creek							X
Pardee Creek							X
Simon Creek		X					
Cut-off Meander Creek							X
Jena Creek							X
Xmas Prairie 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?

- Streams in the Upper Subbasin support populations of Chinook salmon, steelhead, summer steelhead and coastal cutthroat trout;
- The mainstem provides suitable habitat for coho salmon in the uppermost reach, but there is no recent account of their presence in the Upper Subbasin streams;
- Neither the historic abundance or current trends of anadromous salmonid populations of the Upper Subbasin are well documented by anecdotal accounts or by scientific studies;
- Recent trapping studies and spawning surveys have shown that Chinook salmon are successfully spawning in the upper reach of mainstem Redwood Creek, although the spawning success varies considerably among years;
- Juvenile steelhead are the most widely distributed and abundant salmonid found throughout the upper subbasin;
- Resident rainbow trout populations exist above barriers to anadromous salmonids. The status of resident rainbow trout is not known;

- Summer steelhead is a unique stock of steelhead that depends upon deep pools of the upper subbasin mainstem Redwood Creek for over summer habitat. Summer steelhead populations are greatly reduced from historic abundance;
- Coastal cutthroat are found within and above upstream limits of anadromous tributary reaches. The status of coastal cutthroat is unknown.

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

- The Upper Subbasin provides critical habitat for anadromous salmonids;
- Much of Redwood Creek that flows through the Upper Subbasin is considerably wider today than it was before the flood of December 1964;
- Riparian vegetation is less capable of shading due to the channel widening and also from removal of large conifers during timber harvests;
- Mainstem Redwood Creek water temperatures are coolest in the reach above the confluence with Minon Creek, where a recent MWAT was 65ºF and maximum daily temperature was 71ºF. A MWAT of < 64 ºF is desirable for salmonids;
- Approximately 11 miles downstream from Minon Creek (at O'Kane gauging site) the temperature rises to a MWAT of 71°F, which is well above desirable levels. Maximum daily temperatures on the mainstem Redwood Creek at the O'Kane gauging site ranged from 77 to 80 °F in 1997 to 2001, exceeding lethal limits;
- There is little information to make statements about habitat condition in most tributary streams;
- Suitable water temperatures (MWATs) were noted in the tributaries High Prairie, Minon, Lake Prairie and Pardee creeks;
- Streamside canopy providing shade over tributaries is sufficient, to provide shade in Fern Prairie and Minon creeks, but overstory canopy provided by large conifers is lacking;
- Over 60% of lower reach length of Redwood Creek in the Upper Subbasin is pool habitat, but these pools are relatively shallow, and lack shelter elements;
- Minon and Fern Prairie creeks are generally lacking in the desirable numbers of deep pools with adequate shelter complexity;
- Approximately 30% of the pool tail substrate in the lower reach of Redwood Creek is considered in high quality for salmonid spawning. Approximately 10% of the pool tail substrate in the upper reach of Redwood Creek is considered high quality for salmonid spawning;
- Approximately 30% of the pool tail substrate in Minon Creek is considered in good quality for salmonid spawning. Approximately 10% of pool tail substrate in Fern Prairie Creek is considered in good quality for salmonid spawning;
- There is a debris jam at the mouth of Lake Prairie Creek which is a passage barrier to anadromous salmonids. The jam originated from a debris torrent that impacted miles of Lake Prairie Creek habitat.

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

- The Upper Subbasin terrain is naturally unstable. Approximately 73% of the Upper Subbasin is classified in either high or very high relative landslide potential;
- Upon receiving heavy winter rains, much of the subbasin becomes prone to erosion;
- 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 flood of December 1964 introduced enormous volumes of sediment into the upper part of Redwood Creek. More than 600 streamside landslides delivered sediment directly into Redwood Creek. Cut logs were washed from steep slopes into the mainstem channel forming jams, which backed up sediment to depths of 20-30 ft. As channel-bed elevations increased and the capacity of the channel to convey peak flows was reduced, the mainstem channel banks eroded and widened up to 150% in an attempt to accommodate flood flows;
- Well developed gully networks are common within the more active earthflow areas and these are considered significant sediment sources because they are directly connected to the drainage system;
- Gravel terraces built during the 1964 flood were so voluminous and riparian vegetation was buried so deep, many trees in the flood plain died;
- Much of the warm character of the mainstem Redwood Creek comes from the lack of shade and widened channel as it flows through the Upper Subbasin;
- Much of the benefits (including shade, microclimate, and LWD recruitment potential) from a mature near stream forest are lacking in most Upper Subbasin mainstem and the surveyed tributary streams;
- The major modes of mass wasting in the Upper Subbasin are earthflows and near-channel debris slides. Abundant near channel debris slides flanking the mainstem Redwood Creek are major sources of sediment delivery to stream channels;
- The large earthflow at the confluence of Twin Lakes and Redwood Creeks has a long history of recurrent streamside slides along both creeks (particularly the mainstem) that deliver sediment to both channels on an ongoing basis. Small active debris slides were mapped in Twin Lakes Creek and Bradford Creek;
- The Upper Subbasin contains the highest length of stream channels adjacent to landslides in the Redwood Creek Basin. Overall, the Upper Subbasin showed a 33% increase in the number of streamside slides observed on aerial photos, from 274 in 1984 to 365 in 2000;
- The Upper Subbasin is comprised of (by length) about 41% source reaches, 45% transport reaches and 14% response reaches;
- The Upper Subbasin has begun to yield more suspended sediment to the mainstem of Redwood Creek than the middle and lower subbasins combined;
- In photo year 2000, excessive amounts of sediment was present in Cloney Gulch, High Prairie Creek, Minon, Snow Camp, Twin Lakes, and Windy creeks.

How has land use affected these natural processes?

- Past logging activities, particularly the construction of roads and skid trails and the removal of vegetative ground cover, have been a major factor contributing to erosion and sediment delivery to streams;
- Road construction, timber harvest activities, and other land use exacerbate slope instability and contribute to chronic and episodic sediment input to the stream system;
- There are 553 miles of roads, of all classifications, within the Upper Subbasin. This represents a relatively high road density of 8.2 miles of road per square mile of land base. Approximately 228 miles or 41% of roads are classified as abandoned and do not 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 where they may contribute to streamside landslides, gullies or other forms of sediment delivery;
- Twin Lakes and Lake Prairie planning watersheds have the most roads built in the highest relative landslide potential classes with 76 miles (6.4 mi/mi2) and 63 miles (5.7 mi/mi2) respectively;
- Approximately 80% of the Upper Subbasin was tractor logged between 1948 and 1978;
- Large conifer trees that once grew along the mainstem stream banks were removed during timber harvests. Much of the beneficial characteristics attributed to a mature near stream conifer forest (including shade, microclimate, and LWD recruitment potential) are not provided by existing vegetation;

- The change in riparian and near stream forest conditions contributes to an increase in summer stream temperatures that affect the entire length of Redwood Creek.

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 temperature in portions of mainstem Redwood Creek is the most critical limiting factor affecting salmonid production in the Upper Subbasin;
- The lack of shelter complexity and lack of deep pools in mainstem likely limits anadromous fish production;
- Lack of deep pools and shelter complexity provided by LWD may be limiting factors to salmonid production in Fern Prairie and Minon creek and other tributaries of the Upper Subbasin;
- 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 fine sediments in some streams;
- The naturally steep channel gradient limits the amount of habitat in tributary streams to approximately 9 miles.

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

Barriers to Fish Passage

- Modify sediment deltas or boulder and/or debris accumulations that impede upstream migration into tributaries. A barrier is located at the confluence of Lake Prairie Creek. Consider building step pools in the lower reaches where sediment accumulations may restrict or delay access to migrating salmonids.

Flow and Water Quality Improvement Activities:

- Maintaining and improving good water temperatures in tributaries and in the upper reach of Redwood Creek is essential to improve of salmonid habitat condition in the Upper Subbasin and also will provide benefits to downstream reaches;
- A high priority should be placed on re-establishing riparian shade and reducing the channel width along portions of the upper reach of Redwood Creek. This will help extend the benefits of cool water flowing from the headwaters reach.

Riparian and Instream Improvement Activities:

- In appropriate locations along the upper reach of mainstem Redwood Creek, consider installing live willow baffles or other habitat structure to help establish shade over water and to encourage channel width reduction;
- The riparian corridor and near stream forest along the upper reach of Redwood Creek should be managed to encourage growth and retention of coniferous trees. The shade provided by large trees will help maintain cool water temperatures, their stems will provide large woody debris and provide nutrient inputs to the stream, and roots will add stability to banks and buffer against sediment delivery. This may require more than the minimum protection provided by Forest Practice Rules;
- In tributaries with an abundance of shade, consider cautious thinning from below of hardwoods in riparian areas to hasten the development of large near stream conifers;

- Design and engineer pool enhancement structures to increase the number of pools or increase the size, deepen, or add shelter complexity to existing pools in Redwood Creek and Fern Prairie Creek and Minon Creek and other tributaries;
- Consider adding shelter complexity with wood and large boulders to existing cool temperature refuge sites on upper Redwood Creek. This could be done on a seasonal basis using small woody debris to provide escape cover for adult summer steelhead and juvenile salmonids during summer season. The cool patches may be located in temperature stratified pools or adjacent cool water inputs from tributary flows, springs, and seeps;
- To address the lack of complex pools add large woody debris in Redwood and Minon and Fern Prairie creeks, consider direct placement of large woody debris in existing pool habitat, especially where the average size of near stream conifers is less than 2 feet DBH;
- Consider the use of conservation easements along the upper reach of Redwood Creek to protect valuable riparian and near stream forest from development or timber harvests.

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, especially roads located on unstable slopes and roads near streams. These are found throughout the subbasin but are most frequent in Windy Creek, Twin Lakes Creek, Bradford Creek, and High Prairie Creek Planning Watersheds;
- Consider bank stabilization projects in tributary streams throughout the Upper Subbasin;
- Throughout the Upper Subbasin, timberland managers should avoid the use of tractor yarding on slopes steeper than 35% (19 degrees) and instead use full suspension cable or helicopter yarding on steep and/or highly unstable slopes.

Education, Research, and Monitoring Activities:

- Conduct stream surveys in tributaries and mainstem reaches not addressed in this report;
- Continue temperature monitoring at the current locations to observe changes in temperature as effects from mainstem fluvial conditions, such as aggradation, degradation, channel widening, and riparian function adjust through time;
- Monitoring for in-channel sediment (e.g., sediment size distribution, turbidity, V*, photo points, etc.) should be continued and tracking of streambed levels (i.e., stream channel cross sections) should be continued at upper Redwood Creek study sites;
- A long term, concerted monitoring effort between the land owners, interested parties and responsible agencies is needed to determine the abundance and trends of anadromous fish populations of Upper Subbasin streams;
- Summer steelhead dive counts should be conducted on an annual basis along the upper reach of mainstem Redwood Creek.

Subbasin Conclusions

The Upper Subbasin provides important spawning grounds and year round rearing habitat for anadromous salmonids. High water temperature and a shortage of deep, complex pool habitat are factors limiting salmonid production in the mainstem Redwood Creek below Minon Creek. The lack of deep and complex pool habitat was also identified as potential limiting factors in tributary streams.

The Upper Subbasin was severely affected by the combination of intensive land use activity and the 1964 and other recent flood events. The channel more than doubled in width and shade benefits of riparian vegetation and moderating air temperatures from near stream forests were lost leading to increased water temperatures. Habitat impairments associated with channel widening and high stream temperature still adversely effect habitat suitability throughout much of the upper Redwood Creek mainstem.

While habitat conditions certainly differ from those of pre-management days, it does appear that aspects of the upper mainstem have recovered from the impacts of land management and floods. Much sediment has moved downstream, pools have re-formed and the channel substrate has improved in spawning suitability. However, excessive erosion continues to be a problem as the Upper Subbasin currently yields more suspended sediment to the mainstem of Redwood Creek than the Middle and Lower subbasins combined.

The Upper Subbasin offers good opportunities for implementing watershed improvement activities. Watershed management strategies aimed at reducing sediment inputs by reducing erosion will help address landscape issues that contribute to impairment of aquatic habitat. Stream habitat improvement projects should focus on preserving cool water flowing from the headwaters reach of Redwood Creek re-establishing riparian shade and reducing the channel width along mainstem Redwood Creek. Restoration projects such as tree planting and adding LWD and shelter complexity to stream channels may increase the rate of stream recovery. Adding shelter complexity to cool water refuge sites will provide summer steelhead protective cover needed during their summer holding stage. In tributary watersheds, stream habitat improvement activities should focus on increasing frequency, depth and complexity to pool habitats, adding instream shelter complexity, and promoting nearstream coniferous forest growth retention.