Middle Subbasin

Mainstem Big River in 2002. Photo by Steve Cannata

The Middle Subbasin includes the watershed area of the mainstem Big River just above its confluence with Peterson Gulch up until its confluence with the South Fork Big River, not including the North Fork Big River (Figure 88). Stream elevations range from 40 feet at boundary with the Coastal Subbasin to 210 feet at the confluence with the North Fork Big River. The highest point in the subbasin is above Dietz Gulch at approximately 1,560 feet. The Middle Subbasin is the smallest of the three Big River Subbasins at 17.9 square miles and occupies 9.9% of the total basin area. Most of the subbasin is owned by Hawthorne Timber Company and Mendocino Redwood Company and is managed for timber production.

Climate

The Middle Subbasin has average annual rainfall ranging from 55 inches closer to the coast to 65 inches farther inland. Temperatures are typically cooler in the winters and warmer in the summers than in the Coastal Subbasin, although the marine influence still moderates temperatures and prevents extremes. Temperatures average from 40 to 45°F.

Hydrology

The Middle Subbasin is made up of two CalWater Units (Figure 88). There are 11.8 perennial stream miles in 14 perennial tributaries in this subbasin. There are an additional 14.2 miles of the mainstem Big River (Table 120). The mainstem Big River in the Middle Subbasin is a fourth order river using the Strahler (1964) classification. The tributaries to the mainstem in this subbasin are first and second order streams with drainage areas ranging from less than one square mile to just over five square miles (Figure 89).

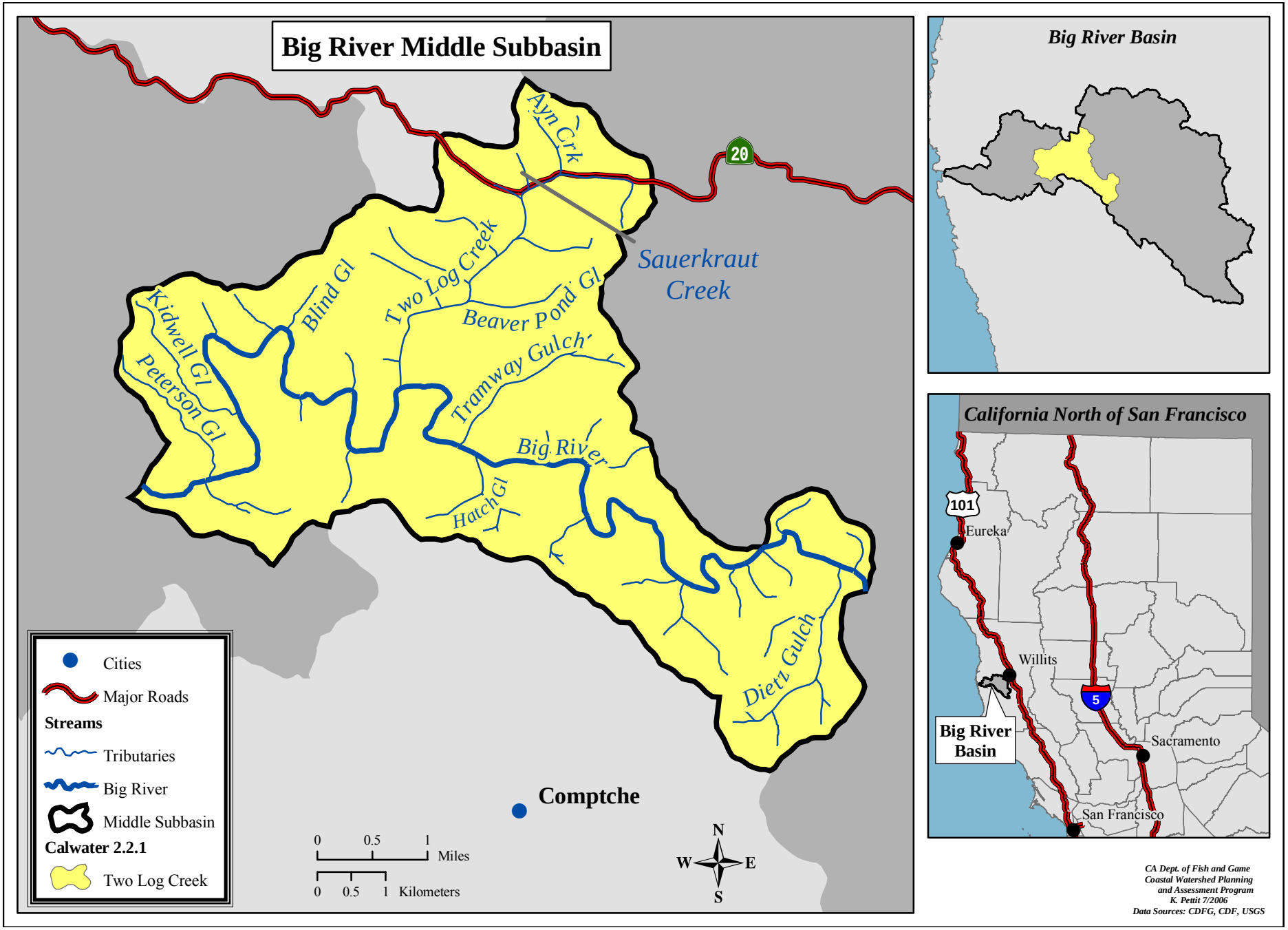


Figure 88. Middle Subbasin and CalWater 2.2a planning watersheds.

Table 120. Tributaries to the Big River in the Middle Subbasin by river mile from 7.5 minute topographic maps.

CalWater Planning Watershed	R.M.	Bank (L,R)	Stream	Perennial (Miles)	Intermittent (Miles)	Stream Order
Two Log Creek	17.6	L	Peterson Gulch		1.7	Intermittent
	19.1	L	Kidwell Gulch	1.9		1
	20.1	L	Unnamed Tributary		0.5	Intermittent
	20.9	L	Unnamed Tributary		0.6	Intermittent
	21.0	L	Blind Gulch	0.5	0.2	1
	21.9	R	Unnamed Tributary		0.9	Intermittent
	22.5	L	Unnamed Tributary		0.4	Intermittent
	23.1	R	Unnamed Tributary	0.5	0.1	Intermittent
	24.1	L	Two Log Creek	2.5	2.0	2
			Saurkraut Creek		0.4	Intermittent
			Ayn Creek		0.8	Intermittent
	25.5	L	Tramway Gulch	1.7	0.6	1
	25.7	R	Unnamed Tributary/Hatch Gulch	1.0	0.4	1
	26.5	L	Unnamed Tributary	0.5	0.1	1
	26.8	L	Unnamed Tributary	0.5	0.2	1
	26.9	L	Unnamed Tributary	0.4	0.1	1
	27.4	R	Unnamed Tributary	0.6	0.1	1
	29.4	R	Unnamed Tributary	0.4	0.3	1
	29.4	R	Unnamed Tributary	0.8	0.4	1
	31.2	L	Unnamed Tributary	0.3	0.3	1
	32.0	R	Dietz Gulch	0.1	3.6	1
	32.1	L	Unnamed Tributary		0.6	Intermittent

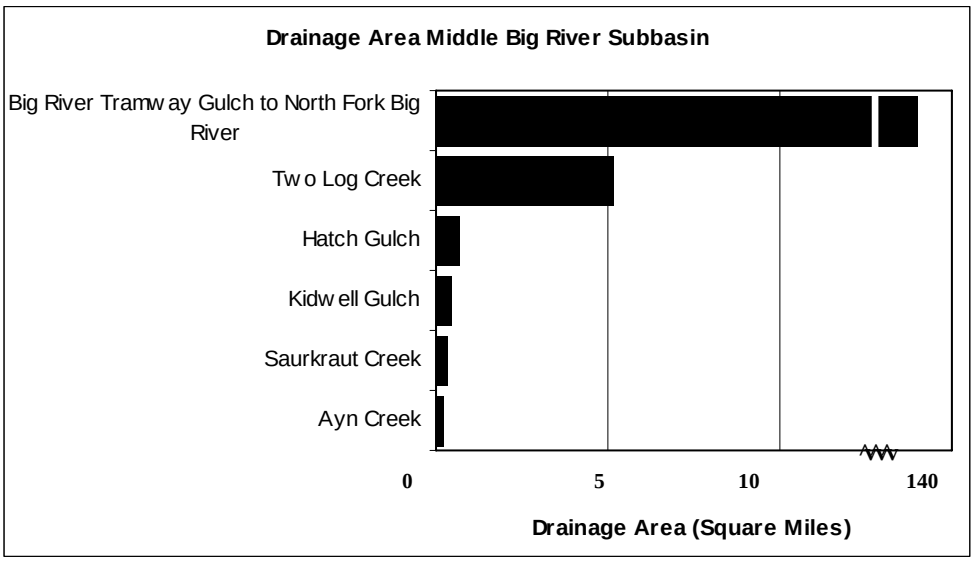


Figure 89. Drainage area of streams surveyed by CDFG in the Middle Subbasin.

Geology

The Middle Subbasin has a high percentage of area in low slope classes. The predominant geologic type is Coastal Belt Franciscan.

Landsliding

A GMA (2001) analysis of landslides by time period found that about 8.2% of the number of slides across the entire basin were in the Middle Subbasin. The period from 1953 to 1965 had the highest number of landslides (Table 121).

Table 121. Middle Subbasin number of delivering slides by study period and PW (GMA 2001a).

Planning Watershed	1937-1952		1953-1965		1966-1978		1979-1988		1989-2000		Total All Periods	
	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)
Two Log Creek	49	25.1	69	35.4	22	11.3	25	12.8	30	15.4	195	100

Landslide volume estimates from the same time periods showed that 6.7% of sediment delivered to streams across the Big River Basin occurred in the Middle Subbasin (GMA 2001a) (Table 122). The period from 1953 to 1965 had the highest volume of sediment delivered.

Table 122. Volume of delivering slides by study period by PW in the Middle Subbasin (GMA 2001a).

Planning Watershed	1937-1952		1953-1965		1966-1978		1979-1988		1989-2000		Total	
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%f or Entire Watershed For Entire Period
Two Log Creek	114,506	22.4	271,379	53.2	40,550	7.9	58,623	11.5	25,398	5.0	510,455	6.7

The CGS (2005) landslide potential map classified 49% of the Middle Subbasin in the high and very high potential categories (Table 123).

Table 123. Landslide Potential in the Middle Subbasin.

Landslide Potential Category	Area (Sq. Miles)	% of Subbasin
Very Low	1.6	9
Low	4.2	23
Moderate	3.3	18
High	6.8	38
Very High	2.0	11

RC Ownership

The MRC Watershed Analysis found a total of 257 landslides in the MRC ownership of the Middle Subbasin. Of that total, 220 were shallow-seated landslides (debris slides, torrents, or flows) and 37 were deep-seated landslides (rockslides) (Table 124). Most landslides in the study period occurred in the 1970s.

Table 124. Shallow-seated landslide summary for lands under MRC ownership in the Middle Subbasin.

Planning Watershed	Number of Landslides			
	1970s	1980s	1990s	Total
Two Log Creek	84	57	79	220

MRC 2003

The majority of landslides in the MRC ownership are debris slides and rockslides. Only about 4% of shallow landslides observed were debris flows and debris torrents while none were earth flows (Table 125).

Table 125. Percent of landslides by type and PW for lands under MRC ownership in the Middle Subbasin.

Planning Watershed	Debris Slides	Debris Torrents	Debris Flows	Rockslides	Earth Flows
Two Log Creek	81%	3%	1%	16%	0%

MRC 2003

MRC also delineated Mass Wasting Map Units across their ownership, to represent general areas of similar geomorphology, landslides processes, and sediment delivery potential for shallow-seated landslides. For more details, see the Geology Appendix.

MRC found that 89% of the shallow-seated landslides within their ownership in the Middle Subbasin delivered sediment to a watercourse. A total of 154,042 tons of mass wasting sediment delivery was estimated for the study period, or 97 tons/square mile/year. Over their entire ownership, MRC found that 34% of mass wasting sediment delivery occurred in the 1970s, 19% occurred in the 1980s, and 48% occurred in the 1990s. The relatively high amounts of sediment delivered in the 1990s are thought to be related to high rainfall events in the 1990s.

Fluvial Geomorphology

Out of 12 stream reaches surveyed by CDFG in the Middle Subbasin, the most common Rosgen channel types were B4 and G4 (Table 126). There were seven different channel types present.

Table 126. Channel types in surveyed streams of the Middle Subbasin.

Stream	Reach	Survey length (Miles)	Channel Type
Kidwell Gulch	1	0.6	F4
	2	0.2	B4
	3	0.1	A4
Two Log Creek	1	1.4	B4
	2	0.1	B3
	3	1.3	B4
	4	0.1	G1
	5	<0.1	G6
Saurkraut Creek	1	0.1	G4
Ayn Creek	1	0.3	G4
Big River Tramway Gulch to North Fork Big River	1	4.7	F4
Hatch Gulch	1	0.5	G4

Of the seven stream segments surveyed by MRC in this subbasin, the most common Rosgen channel type was F4 (Table 127). There were six channel types present. MRC measured various stream channel characteristics and grouped channels across their ownership into different geomorphic units. MRC plans to use the geomorphic unit classification to examine habitat-forming processes within the channels.

Table 127. Channel Types in streams surveyed by the MRC on their ownership in the Middle Subbasin.

Stream	Segment	Survey Length (Miles)	Channel Type
Big River	BT1	0.3	F4
	BT2	0.3	F4
Two Log Creek	BT4	0.1	Cb4,F4
	BT4(2)	0.1	F4
Beaver Pond Gulch	BT5	0.0	B4,G4
Tramway Gulch	BT12	0.0	E4,C4
Dietz Gulch	BT26	0.1	E4,C4

MRC 2003

Vegetation

Redwood-Douglas-fir forests cover 85% of the Middle Subbasin, with the remainder made up mostly of tan oak, madrone, and alder (Table 128). Almost 70% of tree stands are composed of small trees (Table 129) and just over half of the subbasin is covered by trees with 90% crown canopy density (Table 130).

Table 128. Acreage and proportion of area of vegetation classes in the Middle Subbasin.

Class	Acres	%
Redwood - Douglas-fir	9,652	85
Douglas-Fir	219	2
Tan Oak, Madrone, Alder	1,032	9
White, Black or Live Oak & Bay Laurel	40	0
Blueblossom Ceanothus	150	1
Manzanita, Chamise, Scrub Oak	0	0
Bishop Pine, Pygmy Cypress, Willow	0	0
Grass	180	2
Wet Meadows	0	0
Water	0	0
Barren / Rock	151	1
Urban/Developed	0	0
Totals	**11,424**	**100%**

Table 129. Vegetation size class in the Middle Subbasin.

Planning Watershed	Sapling (<6 inches dbh)		Pole (6-11 inches dbh)		Small Tree (12-24 inches dbh)		Medium/Large Tree (24-40 inches dbh)		Large Tree (>40 inches dbh)	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Two Log Creek	64	0.6	317	2.9	7,647	69.9	2,872	26.2	42	0.4

Table 130. Density of vegetation in the Middle Subbasin.

Planning Watershed	Percent Crown Canopy Density										Total Acres
	0%		10-69%		70%		80%		90%		
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
Two Log Creek	482	4	720	6	2,237	20	1,550	14	6,436	56	11,424

Total density of all species - conifers and hardwoods. Most of the 0 percent density crown canopy is grasslands, water, and shrub species.

Fire and Fuels

Areas of high and very high fuel rank dominate the Middle Subbasin, with areas of moderate fuel rank in the higher elevations. The 1931 Comptche fire burned 1,851 acres in the southwest corner of the subbasin and the smaller 2000 McGuire fire burned 14 acres along the northern border.

Land Use

The Middle Subbasin is composed mostly of large sized parcels owned by the Hawthorne Timber and Mendocino Redwood companies. A small section of the JDSF and some 40-1,500 acre parcels make up the remainder of the subbasin.

On September 16, 1874, Daniel Milliken closed his logging camp at the Piers. He then opened a hand logging camp (no animals) at Two Log (Crossing) Creek. Indian trails had crossed that tributary at two different places, hence the original name.

The predominant landuse in this subbasin is timber harvest. Recently, some of the timber land has been considered for sale to conservation groups (Eilperin 2006). An additional land use is rock quarries. A rock quarry in the Two Log Creek watershed was mined in 2000, resulting in the deposition of sediment into the Creek (EPA 2001).

Forest Management

For the past 250 years timber harvest has dominated the history of the Middle Subbasin. Almost 75% of the subbasin was harvested by 1944 (Table 131). Hawthorne Timber Company and Mendocino Redwood Company currently own 90% of the subbasin.

Table 131. Timber harvest in the Middle Subbasin.

Time Period	Acres Harvested	Percent of Subbasin Harvested
1852-1944	8,256	72.3
1945-1964	2,794	24.5
1965-1974	1,241	10.9
1975-1984	715	6.3
1985-1992	4,580	40.1
1993-2001	4,316	37.8
Total	**21,903**	

Early timber harvest activities across the subbasin consisted mostly of clear cuts and fire, while recent harvests are a mix of harvest techniques including single or group tree selections, shelterwood removal, seed tree removal, and commercial thinning (Figure 90). Yarding methods have also changed over time, from predominantly cable ground before World War II, to tractor yarding in the post war years, and increasingly towards cable suspended and helicopter since 1985 (Figure 91).

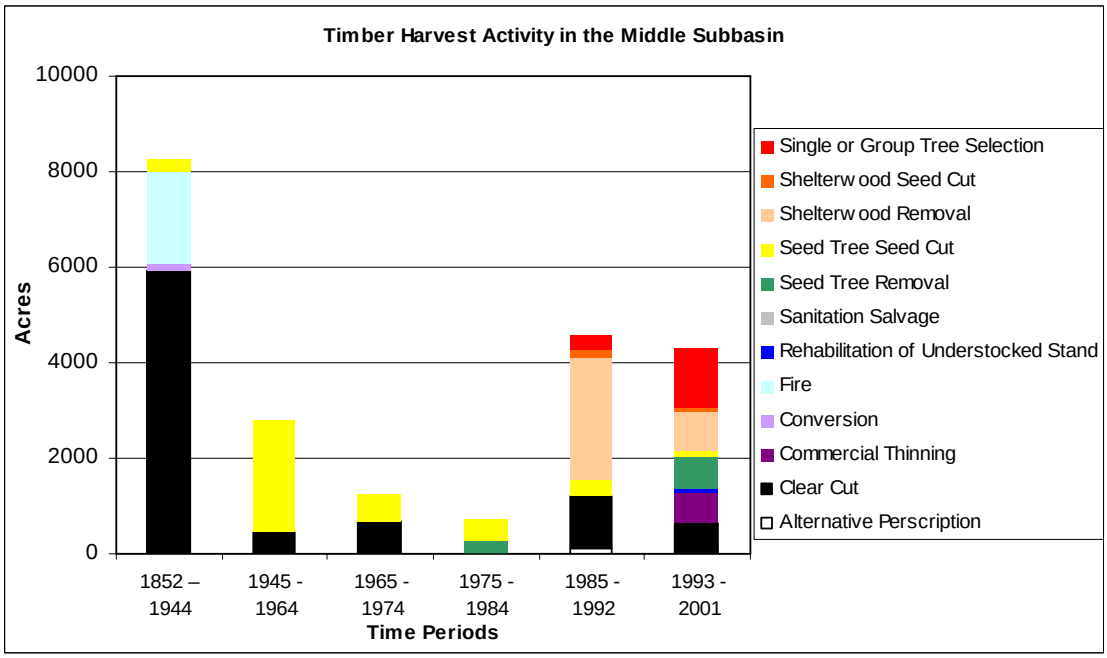


Figure 90. Acres of timber harvest activities in the Middle Subbasin.

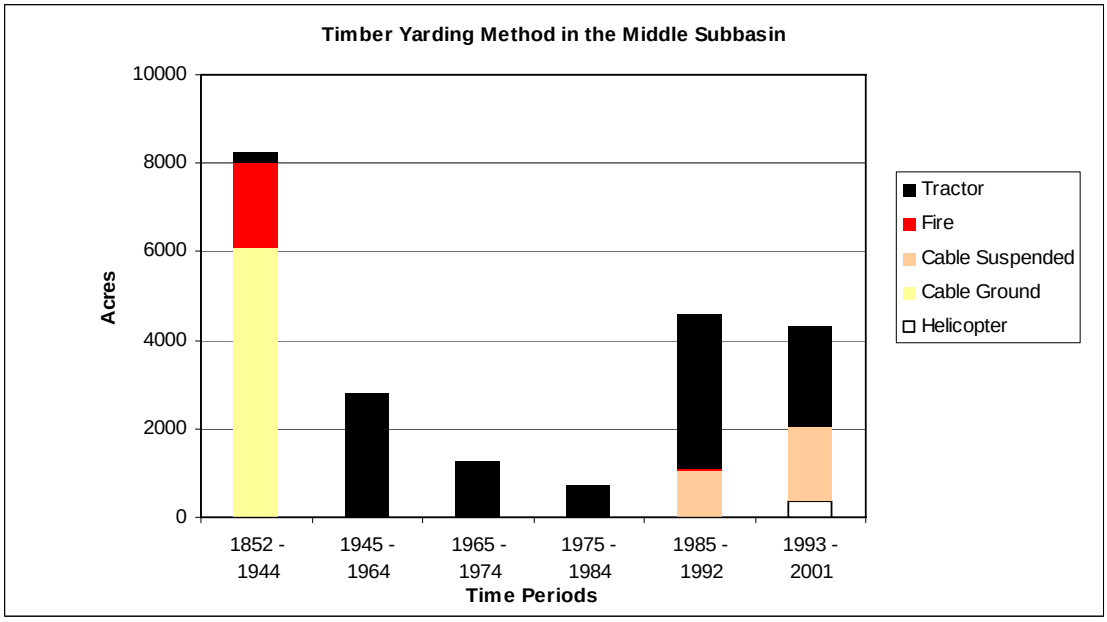


Figure 91. Acres of timber harvest yarding methods in the Middle Subbasin.

GMA (2001) calculated the harvest density, a measure of the acres of timber harvested in a given time period divided by the total acreage in the watershed, for 1937-1951, 1952-1964, 1965-1977, 1978-1987, and 1988-2001. The most intense harvesting occurred from 1989 to 2000 when 41% of the watershed was harvested. Over the entire study period, an estimated 113% of the Middle Subbasin was harvested, with roughly 36% of that happening from 1989-2000. The percentage harvest exceeds 100% because some areas were harvested multiple times. Of the harvesting that occurred in the 1989-2000 time period, it was reported that approximately 18% was clear-cut and 80% partial cut, with 2% skid trails.

A CDF analysis of disturbance levels across this subbasin found high disturbance level activities occurring on more acres before 1974 (Figure 92). Activities after 1974, shifted to low and moderate disturbance levels, but occurred over more acres per year than in the past.

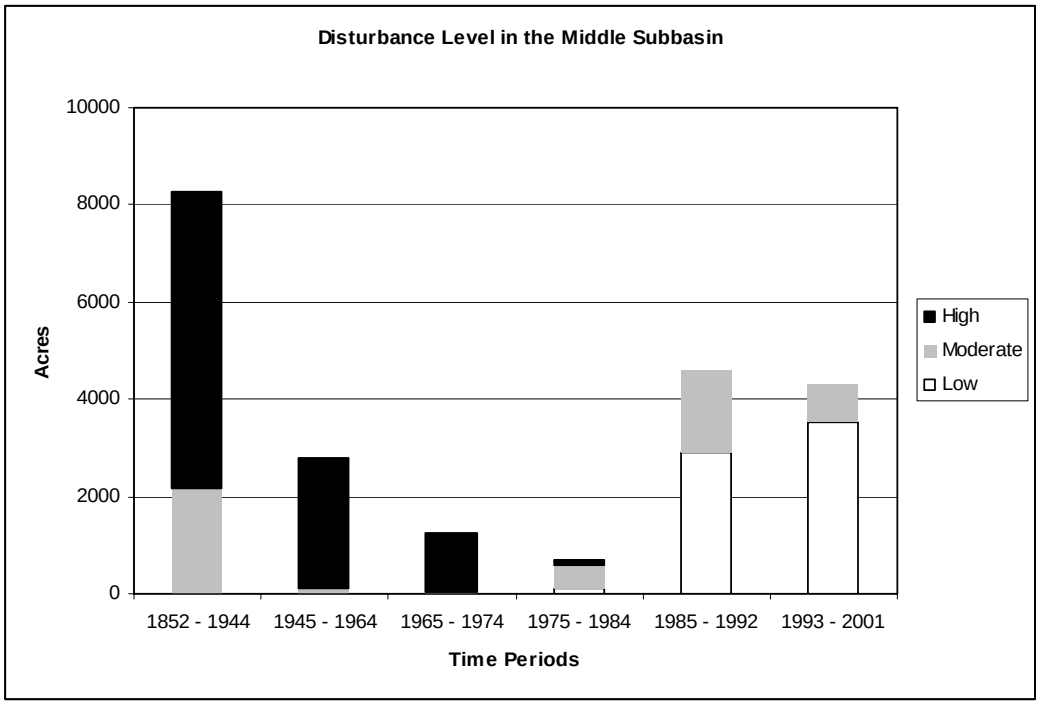


Figure 92. Acres by disturbance level in the Middle Subbasin.

Roads

The Middle Subbasin has a total of 154.2 miles of roads, the vast majority of which are not paved (Table 132). This is the lowest total number of road miles of the three Big River subbasins. However, overall road density is 8.6 miles per square mile, which is the highest of all the subbasins. Road construction has increased since 1988, with increasing timber harvest.

Table 132. Length of truck roads by period and road surface.

Period	Total Length in Miles				Length in Miles per Sq Mile			
	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
Up thru 1936	7.0	2.2	4.3	13.5	0.4	0.1	0.2	0.8
1937 - 1952	17.2		2.4	19.7	1.0		0.1	1.1
1953 - 1965	26.1		14.8	40.9	1.5		0.8	2.3
1966 - 1978	6.6		0.8	7.4	0.4		0.0	0.4
1979 - 1988	19.4		0.2	19.5	1.1		0.0	1.1
1989 - 2000	51.9		1.3	53.2	2.9		0.1	3.0
Total	**128.3**	**2.2**	**23.8**	**154.2**	**7.2**	**0.1**	**1.3**	**8.6**

Lengths are roads constructed in time period, not cumulative.

Water Quality

In the Middle Subbasin temperature monitoring records were available for the Big River mainstem and nearly all of the major tributaries due largely to participation by Mendocino Redwood Co. (MRC), Hawthorne Timber Company (HTC), and the CDF at JDSF. Sediment records were available for bulk, permeability, and, though not represented in the IA tables, by a sediment source analysis conducted by Graham Mathews Associates (GMA). GMA also performed subsurface sediment (gravel) permeability measurements at one station in the mainstem below the North Fork Big River. D50 (pebble counts) were completed at four cross sections in the mainstem below the North Fork Big River, however, the counts were only conducted at the head's of riffles and therefore not comparable to traditionally conducted pebble counts that encompass the length and width of entire riffles. Physical-chemical water quality data were completely lacking.

Temperature

Continuous water temperature data logging devices were deployed by HTC and MRC at a total of nine (9) locations in the Middle Subbasin (Figure 94). With the exception of 1997, water temperature was monitored in one or more locations in the Middle Subbasin during the years 1993 to 2001.

During the initial data review, the several potential issues with the water temperature data were noted. Data were reviewed according to the criteria established in the Water Quality Criteria section, with the intent that only data that appeared representative of stream conditions were used. In the Middle Subbasin, all but three of the available water temperature data sets met the data quality criteria and were used for this assessment.

The three data sets that were not used were excluded because either the period of record was too short or the loggers began recording too late or stopped recording too early. In each of these cases, there is evidence that the peak temperatures and MWATs were missed based on more complete records at other sites during the same season.

There are a total of three monitoring sites on Two Log Creek (HTC BIG5, HTC BIG4, and MRC 76-2). These monitoring sites are all located in the middle and lower reaches of Two Log Creek. HTC BIG5 was monitored for one year, HTC BIG4 was monitored for five years, and MRC 76-2 was monitored for two years. Based on data from the middle Two Log Creek (HTC BIG5) site, the water temperature was fully suitable with a maximum observed MWAT of 60ºF (Figure 93). Data collected at the two lower Two Log Creek Sites (HTC BIG4 and MRC 76-2), indicated water temperatures between fully suitable with a minimum observed MWAT of 58ºF and undetermined with a maximum observed MWAT of 64ºF. The only tributary to Two Log Creek that was monitored was Beaver Pond Gulch (MRC 76-20), which was monitored for one year. Based on these data, the water temperatures at this site were fully suitable with a maximum MWAT of 56°F. This may contribute to lower water temperatures in Two Log Creek if flows are sufficient. However, based on the flat peaks in the thermograph for MRC 76-20, the temperatures recorded may be more representative of a thermally stratified pool or a site with a significant groundwater component. It does appear that Two Log Creek does provide some cooling effect to the mainstem Big River.

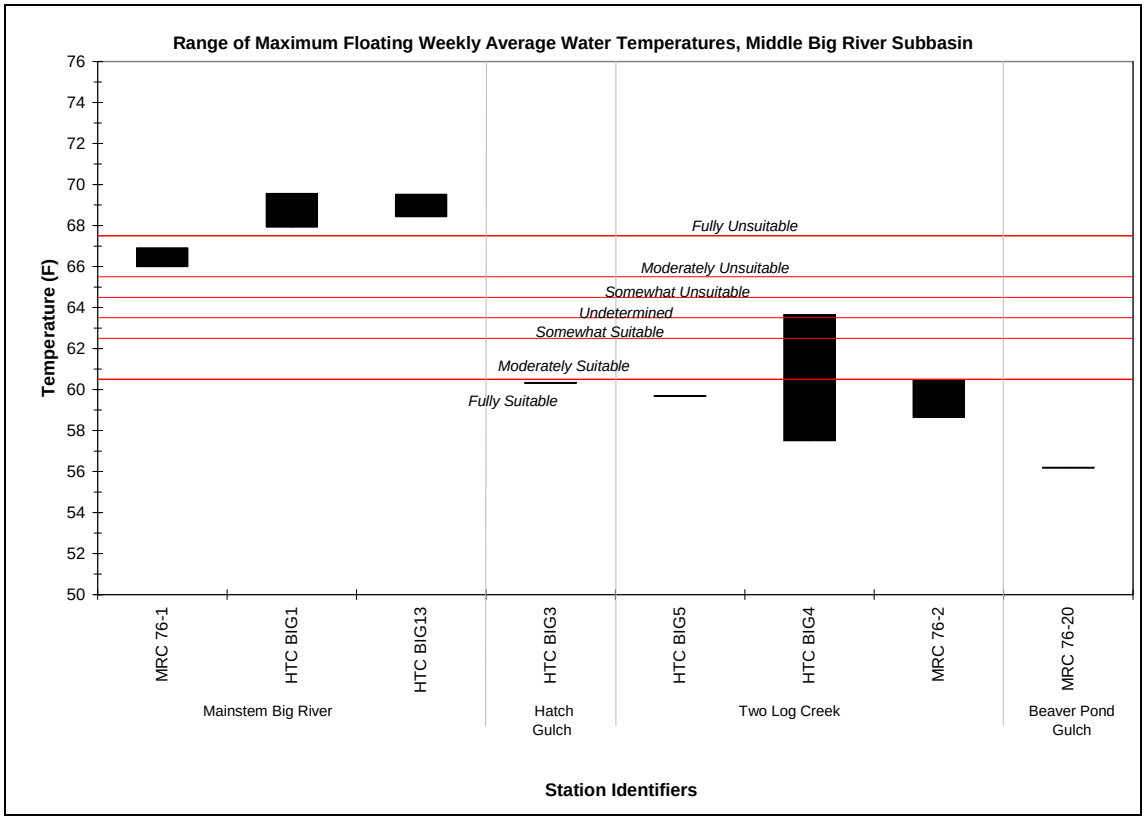


Figure 93. Range of MWATs, Middle Subbasin.

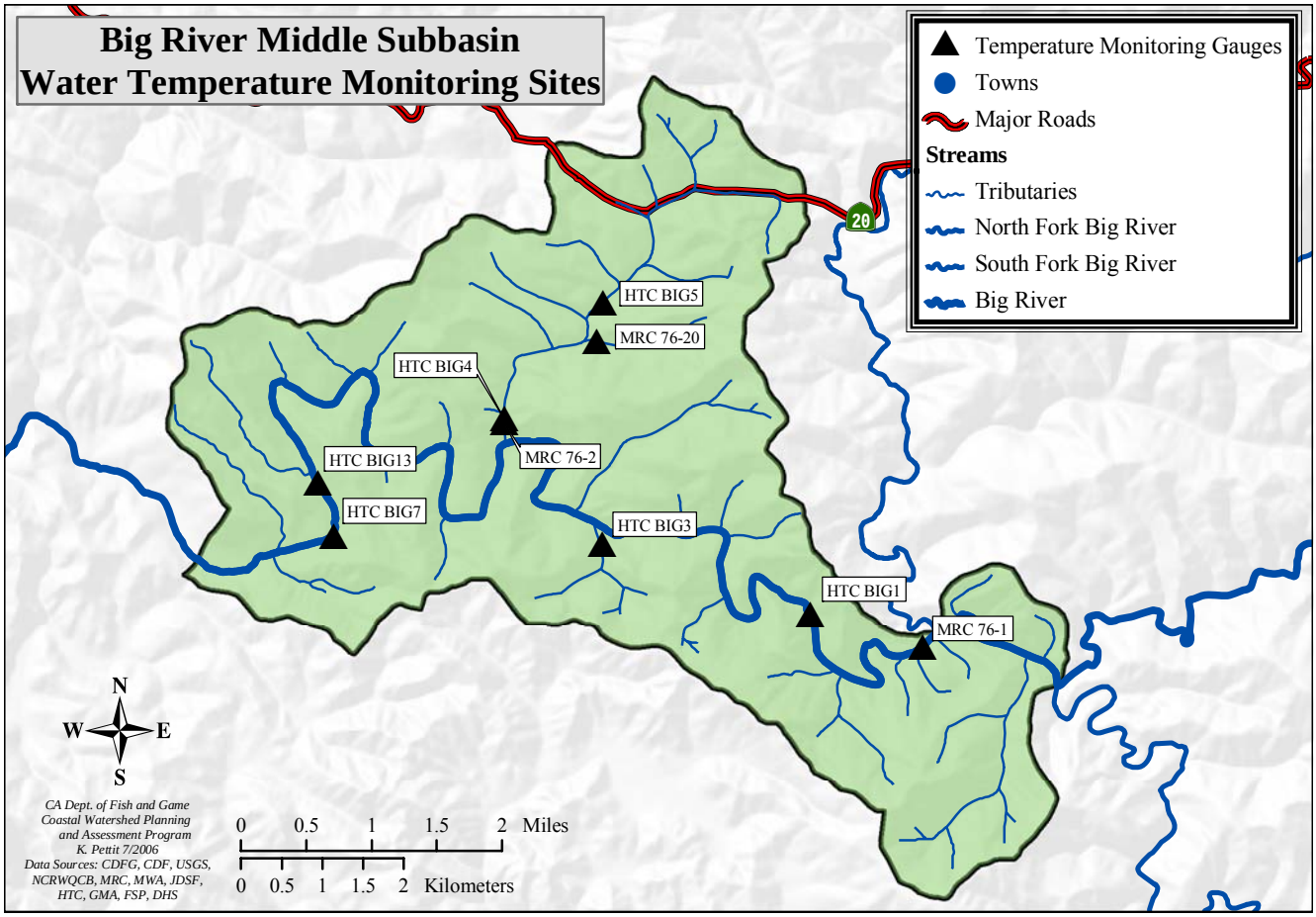


Figure 94. Water temperature monitoring sites, Middle Subbasin.

With the existing information, there is no apparent trend in water temperatures in Two Log Creek as it moves downstream. This is evident in Figure 93. However, large diurnal temperature fluctuations (6.7-12.0°F) were recorded at both lower Two Log Creek sites (MRC 76-2 and HTC BIG4). In addition, there also appears to be a downward trend in MWATs at the lower Two Log Creek sites, which may reflect canopy re-growth. Available THP maps (KRIS Big River) indicate that harvesting occurred in the vicinity of these sites in approximately 1988 and 1993. A 1994 Landsat map (KRIS Big River) shows open areas and small trees near these monitoring sites, but a map of the change in vegetation between 1994 and 1998 did not indicate a loss or gain of vegetation. However, this relationship should be explored further in the Big River Synthesis Report.

There are a total of three monitoring sites on mainstem Big River (MRC 76-1, HTC BIG1, and HTC BIG13). One site is located after the confluence with the North Fork (MRC 76-1) and was monitored for three years. The next site downstream is located between the North Fork and Two Log Creek (HTC BIG1) and was monitored for seven years. The last site is located below the confluence with Two Log Creek (HTC BIG13) and was monitored for three years.

The monitoring site below the confluence with the North Fork (MRC 76-1) recorded water temperatures that were moderately unsuitable with a maximum observed MWAT of 67ºF. In addition, the maximum water temperature recorded was 73ºF, slightly below the lethal limit for salmonids (75ºF). The diurnal fluctuations (9.7-12.8ºF) at this site also suggest poor cover and/or low flows.

USFWS monitored one site on the mainstem Big River at the confluence with the North Fork Big River in 1973 (Perry 1974). The monitoring site recorded water temperatures that were moderately unsuitable with a MWAT of 66ºF. In addition, the maximum water temperature recorded was 81ºF, over the lethal limit for salmonids (75ºF). Comparison of 1973 data with recent monitoring at the same location (MRC 76-1) appears to show average water temperatures remaining similar.

The monitoring site on the mainstem Big River between the North Fork and Two Log Creek (HTC BIG1) recorded water temperatures that were fully unsuitable with a maximum observed MWAT of 70ºF. In addition,

the maximum water temperature recorded was 76ºF, above the lethal limit for salmonids (75ºF). The diurnal fluctuations at this site (7.5-11.4°F) suggest poor canopy and/or flow conditions.

The monitoring site on the mainstem Big River below Two Log Creek (HTC BIG13) recorded water temperatures that were fully unsuitable with a maximum observed MWAT of 70ºF. In addition, the maximum water temperature recorded was 77ºF, above the lethal limit for salmonids (75ºF). The diurnal fluctuations at this site (10.8-11.1°F) suggest poor canopy and/or flow conditions.

A site on Hatch Gulch (HTC BIG3), a tributary to the mainstem Big River between the North Fork and Two Log Creek (but below HTC BIG1), was monitored for one year. Monitoring at this site recorded water temperatures that were fully suitable with a maximum observed MWAT of 60ºF. The diurnal fluctuations at this site were minimal. It is likely that Hatch Gulch provides some cooling effect to the mainstem Big River.

In general, water temperatures appear to increase between MRC 76-1 and HTC BIG1. While there are no significant tributaries between these sites, it appears that poor canopy in the vicinity of MRC 76-1 may be contributing to the apparent rise in water temperature. Available THP maps (KRIS Big River) indicate that harvesting occurred in the vicinity of this site in approximately 1997. A 1994 Landsat map (KRIS Big River) shows open areas and small trees near these monitoring sites, and a map of the change in vegetation between 1994 and 1998 indicated a loss of vegetation in the area. However, this relationship should be explored further in the Big River Synthesis Report.

The summary values for each of the monitoring sites in the middle Big River are presented in Table 133.

Table 133. Water temperature summary, Middle Subbasin.

SITE	MAX MWAT	MWAT Trend	range of max diurnal fluctuations		Seasonal Max	Years of Data
Fully Suitable (50-60ºF)						
MRC 76-20	56	NA	4.2	4.2	57	1
HTC BIG5	60	NA	3.9	3.9	62	1
HTC BIG3	60	NA	5.6	5.6	62	1
MRC 76-2	60	-1.8	6.7	7.6	64	2
Moderately Suitable (61-62ºF)						
—	—	—	—	—	—	—
Somewhat Suitable (63ºF)						
—	—	—	—	—	—	—
Undetermined (64ºF)						
HTC BIG4	64	-2.2	6.7	12.0	68	5
Somewhat Unsuitable (65ºF)						
—	—	—	—	—	—	—
Moderately Unsuitable (66-67ºF)						
MRC 76-1	67	0.9	9.7	12.8	73	31
Fully Unsuitable (68ºF)						
HTC BIG13	70	-1.1	10.8	11.1	77	3
HTC BIG1	70	-1.5	7.5	11.4	76	7

1 Only 2 years diurnal.

Sediment

In 1996 and 1997, the Hawthorne Timber Company collected McNeil samples at one site in the Middle Subbasin (BIG 4), located on Lower Two Log Creek (Figure 95). In 2001, GMA collected McNeil core samples at two locations (GMA 10 and GMA 11). MRC collected McNeil core samples in one location in 2000 (MRC S5), including permeability measurements, thalweg profiles, and stream cross-sections.

The HTC McNeil core samples were collected using a volumetric method, and are therefore directly comparable to the Big River TMDL targets. In general, four McNeil cores were collected at each of the two riffles sampled. A summary of McNeil data collected at BIG 4 is shown in (Table 134). Raw data were not available for this assessment.

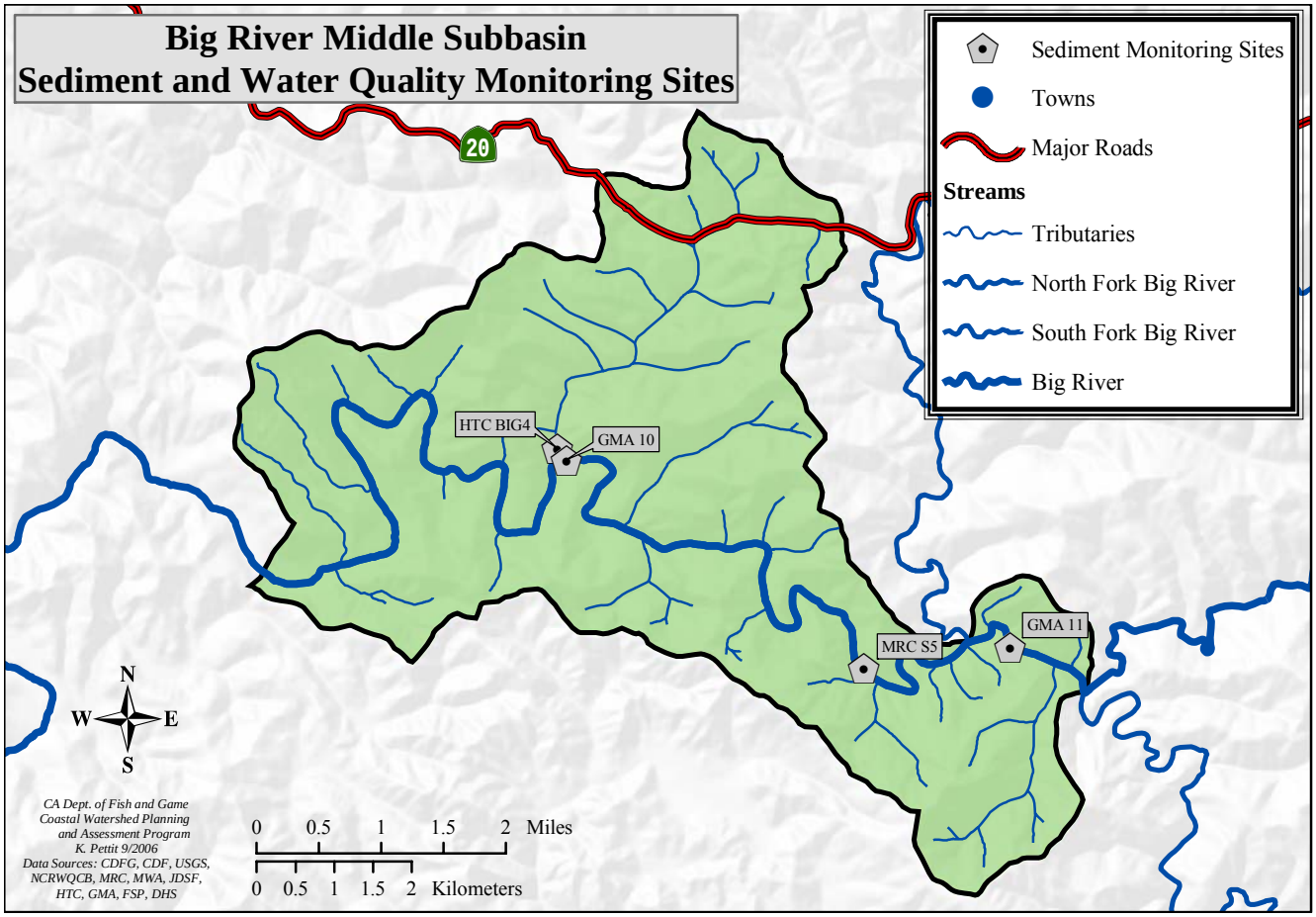


Figure 95. In-stream sediment and water quality monitoring sites, Middle Subbasin.

Table 134. Bulk sediment data summary (volumetric), Two Log Creek (HTC).

Site Name	Site Location	Year	Sieve Size (mm)	Median Percent Less Than
BIG 4	Lower Two Log Creek	1996	4.0	29.8%
			0.85	18.3%
		1997	4.0	27.0%
			0.85	20.2%

Based on the summary data shown in Table 134, the sediment in the sub 6.5 mm size class may have met the Big River TMDL target of ≤ 30% in 1996 and 1997. Because a 4-mm sieve was used, the comparison was made with the 4-mm value instead of 6.5 mm. Therefore, the actual percentage less than 6.5 mm is likely somewhat higher. The sediment in the sub 0.85 mm size class exceeded the Big River TMDL target of ≤ 14% in both 1996 and 1997. In the sub 0.85 mm size class, the amount of fine sediment appeared to increase between 1996 and 1997. However not enough data are available to establish a trend and it could be due to sample variability.

In 2001, GMA collected McNeil core samples in the Middle Subbasin at two sites. One site is located on the Big River, just upstream of the confluence with Two Log Creek (GMA 10). The other site is also located on the Big River, downstream of the confluence with the South Fork Big River and upstream of the confluence with the North Fork Big River (GMA 11). In all size classes, more fine sediment was present at the mainstem Big River site above Two Log Creek (GMA 10) than was present at the site above the confluence with the North Fork Big River (GMA 11). However, because the core samples were collected using the gravimetric method (dry sieve), it is not comparable to the Big River TMDL target for fine sediment.

MRC also collected McNeil core samples at one site in the Middle Subbasin in 2000. The site is located below the confluence with the North Fork Big River on the mainstem of the Big River (MRC S5). As with the GMA McNeil data, MRC also collected the McNeil cores using the gravimetric method. As a result, these data were not comparable to Big River TMDL target for fine sediment.

MRC also recorded permeability measurements at pool tail-outs in the same stream segments where bulk sediment samples, cross-sections, and thalweg profiles were collected. In the stream segments measured, a total of 25 or 26 median permeability values were recorded. The 25th, 50th, and 75th percentile values for each of these stream segments were then plotted. The mainstem Big River site (MRC S5) had moderate median permeability values. Using the empirical formula (McBain and Trush 2000), this stream segment was expected to have roughly 31-38% survival to emergence. The McNeil sample collected in the same stream segment also suggests relatively good fine sediment conditions when compared to other MRC samples in other subbasins.

Discussion

Collectively, temperature data at the thirteen stations monitored show that the Big River Mainstem is unsuitable for salmonids when MWATs are considered, and nine out of thirteen temperature records are suitable when peak seasonal maximum temperature thresholds are considered. Tributaries to the mainstem had seven of ten MWAT records in the Middle Subbasin that were found suitable for salmonids. All of the seasonal peak maximum temperatures, ten records, were found suitable for salmonids during those seasons monitored.

Bulk sediment sampling results by MRC and GMA at three stations using the gravimetric method in the Big River mainstem were found to be suitable for salmonids when referenced to the thresholds for fine sediment <0.85 mm of 14% and < 6.4 mm at 30%. HTCs bulk sampling results, calculated using the volumetric method, showed that gravel size classes were barely within suitable criteria for survival to emergence, but exceeded that for egg incubation within stream locations where it is likely salmonids would build redds. Gravel permeability was only conducted in the Big River mainstem below the NF Big River. The results of the permeability data were calculated to have a 22% survival to emergence for salmonids. Interestingly, data gathered by Kondolf, 2001, calculate a 50% survival to emergence of salmonids when percent fines <0.85mm = 14%; at this site for this metric all of the <0.85 mm sediment sizes (three samples) were below this 14% threshold but, through permeability calculations, would have a survival to emergence expectation of 22%, less than half of Kondolf's calculations.

Riparian Conditions

There are 1,104 acres in the Middle Subbasin in stream buffers, which includes the areas between the water and gravel bars in the lower reaches (Table 135). Across the subbasin, the area around the watercourses is well vegetated, as indicated by the 70 to 100% density class which accounts for 97% of the area (Table 136). Also 73% of the buffer area is in 80% canopy density or better, and 53% of the area is in the 90-100% canopy closure class. These numbers are substantiated by high canopy densities found along stream reaches surveyed by CDFG and discussed in *Fish Habitat Relationships*.

Table 135. Density of riparian vegetation in the Middle Subbasin by planning watershed.

Planning Watersheds	Acres by Percent Crown Canopy Density										Acres in Buffer
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	
Two Log Creek	15	6	2	10		2	3	255	222	589	1,104

Table 136. Percentage of stream buffer area in higher canopy closure classes in the Middle Subbasin.

Planning Watersheds	Percent of Buffer Area by Crown Canopy Density				
	70%	80%	90%	70%+	80%+
Two Log Creek	23	20	53	97	73

As shown in Table 137, 67% of the trees in the watercourse buffer zone are small, which are 12 to 24 inch dbh trees. Small, medium/large and large trees (>12 inches dbh) could be recruited to streams as LWD. Overall, 95% of the buffer zone area in the basin is in these size classes.

Table 137. Acres by vegetation size class in watercourse buffer zone in the Middle Subbasin.

Planning Watersheds	Sapling (<6 inches dbh)		Pole (6-11 inches dbh)		Small Tree (12-24 inches dbh)		Medium/Large Tree (24-40 inches dbh)		Large Tree (>40 inches dbh)	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Two Log Creek	0	0	44	4	735	67	303	27	6	1

MRC examined LWD recruitment potential on their ownership in the Middle Subbasin. They found that LWD recruitment potential is poor in their ownership (Figure 96). An exception is the Two Log Creek watershed,

where most stands have high or moderate recruitment potential ratings. Past harvesting in riparian areas has lead to small-sized, open stands composed of mixed conifer hardwood species.

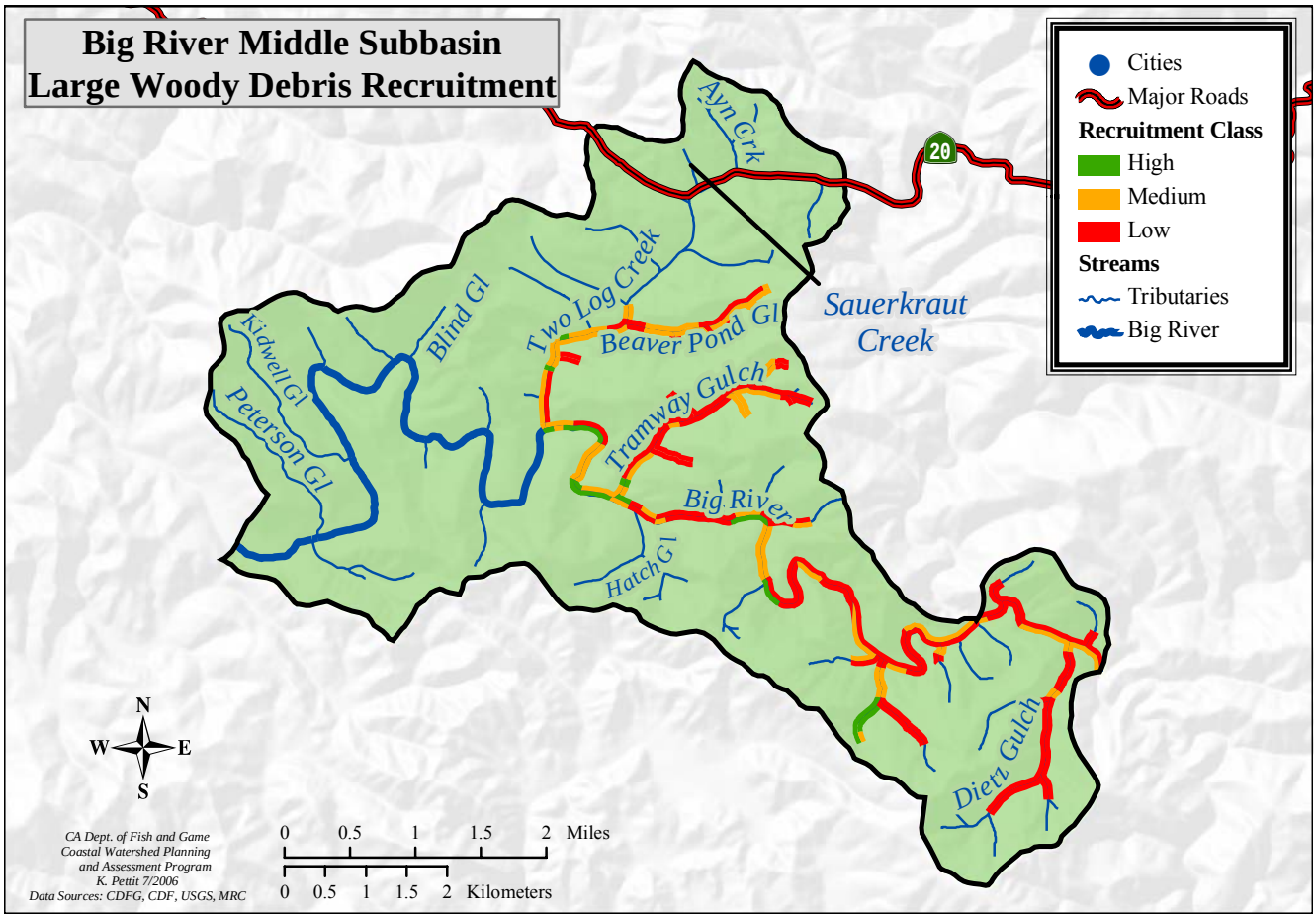


Figure 96. Map of LWD recruitment potential classes on MRC ownership in the Middle Subbasin (MRC 2003).

Fish Habitat Relationship

Past Habitat Conditions

CDFG stream surveys were conducted for three tributaries in the Middle Subbasin from 1950 to 1966. The results of the historic stream surveys are not quantitative and can not be used in comparative analyses with current habitat inventories; however, they do provide a description of habitat conditions. The data from these stream surveys provide a snapshot of the conditions at the time of the survey. Terms such as excellent, good, fair and poor were based upon the opinion of the biologist or scientific aid conducting the survey.

Surveys describe good spawning habitat, shallow pools, and good cover in Two Log Creek and Tramway Gulch (Table 138). Many debris jams were described on both streams as well. A 1958 CDFG flyover survey of two tributaries found no significant fish passage barriers.

Table 138. Habitat comments from surveys conducted in the Middle Subbasin from 1950-1966.

Tributary	Date Surveyed	Habitat Comments	Barrier Comments
Two Log Creek	10/16/1958 (flyover)	Streambed not visible due to heavy conifer cover	
	7/28/1959	Substrate mostly gravel with some rubble and bedrock with occasional patches of sand; good spawning, stream has long stretches of adequate spawning gravel present throughout; pools average 10 feet long and 6 feet wide and 1 foot deep, range from 6 feet deep to 1 foot deep; good shelter in the form of heavy to tree shade and undercut banks; average water temperature 54°F	17 log jams; many barriers
	6/20/1966	Pool substrate mostly fine gravel with some coarse gravel; pools upstream have more fine gravel and less sand; riffle substrate generally fine gravel with a little coarse gravel; pool areas from poor to good - appears to be more shallow riffle area than pool area; normal pool 2 feet deep; fair shelter provided by undercut banks, tree stumps, log jams, logs, a few large rocks, and some overhanging terrestrial plants; water temperatures ranged from 60-65°F	No barriers observed; two log jams near the mouth
Dietz Gulch	circa 1950	Poor and short sections for fisheries	
	10/16/1958 (flyover)	Appeared unimportant to fish life	
Tramway Gulch	10/16/1958 (flyover)	Streambed not visible due to heavy canopy cover	
	Undated (1950s?)	Substrate mostly gravel, some sand, little rubble; good spawning areas, extensive stretches of gravel throughout; small, fairly frequent pools, average size 6 feet long and 2 feet wide and 6 inches deep; Good shelter provided by undercut banks, logs, and some rocks; average water temperature 58°F	Infrequent old log jams, only partial barriers
	8/5/1966	The first half mile of stream presently suitable for spawning steelhead; average pools are 15 inches deep; an occasional pool was 2 feet deep; pool frequency is less than that of riffles; pools caused by log jams, current, undercut banks, single logs wedged crosswise to the direction of flow, and a few scattered boulders and some bedrock; 1:2 pool to riffle ratio; shelter adequate in first half mile; water temperature 59°F	First log jam not presently a total barrier, but may silt in soon- approximately 100 yards above mouth; first complete total barrier approximately 2-300 yards above first jam- very small jam but evidently stopped spawners as no fry could be observed above, consists of some silted in logs that the adults apparently cannot pass over; upstream from total barrier- large log jam, another total barrier, water drops about 12 to 15 feet over silted in jam; above there are several small jams; however, are in logged area and stream intermittent

Current Conditions

Habitat Inventory Surveys

CDFG stream inventories were conducted for 9.4 miles on 13 reaches of five tributaries and the mainstem Big River in the Middle Subbasin since 1993 (Table 139, Figure 97). Additionally, the Two Log Creek was surveyed in 1996 through 1998 as well as 2002. Stream attributes that were collected during stream inventories included canopy cover, embeddedness, percent pools, pool depth, and pool shelter.

Table 139. Surveyed streams in the Middle Subbasin.

Stream	Survey Date	Reach	Survey Length (Miles)
Kidwell Gulch	June 2002	1	0.6
	June 2002	2	0.2
	June 2002	3	0.1
Two Log Creek	June 2002	1	1.4
	June 2002	2	0.1
	June 2002	3	1.3
	June 2002	4	0.1
	June 2002	5	<0.1
Saurkraut Creek	July 1998	1	0.1
Ayn Creek	July 1998	1	0.3
Big River Tramway Gulch to North Fork Big River	July 2002	1	4.7
Hatch Gulch	July 1996	1	0.5

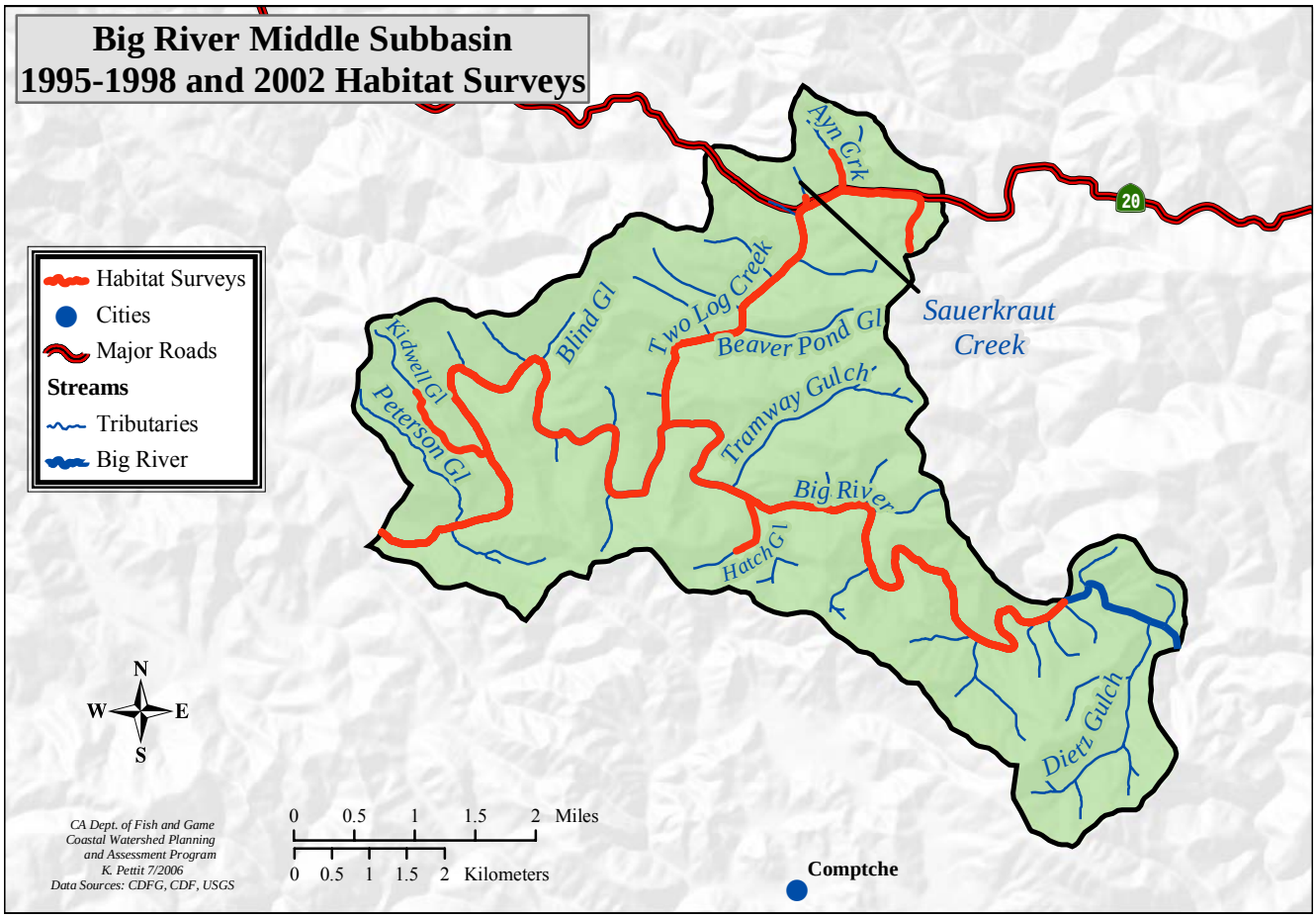


Figure 97. CDFG surveyed streams in the Middle Subbasin.

Stream attributes tend to vary with stream size. For example, larger streams generally have more open canopy and deeper pools than small streams. This is partially a function of wider stream channels and greater stream energy due to higher discharge during storms. Surveyed streams in the Middle Subbasin ranged in drainage area from 0.2 to 137.7 square miles (Table 140).

Canopy cover, and relative canopy cover by coniferous versus deciduous trees were measured at each habitat unit during CDFG stream surveys. Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Furthermore, canopy levels provide an indication of the potential present and future recruitment of large woody debris to the stream channel, as well as the insulating capacity of the stream and riparian areas during winter.

In general, the percentage of stream canopy cover increases as drainage area, and therefore channel width, decrease. Deviations from this trend in canopy may indicate streams with more suitable or unsuitable canopy relative to other streams of that subbasin. All of surveyed tributary reaches of the Middle Subbasin except for Hatch Gulch showed percent canopy levels that meet target values for maintaining water temperature to support anadromous salmonid production (Figure 98). Surveyed reaches of the mainstem Big River did not meet target values; however, as the mainstem Big River is a fourth-order river in this subbasin, the target values do not apply. Kidwell Gulch has the highest canopy cover values of Middle Subbasin.

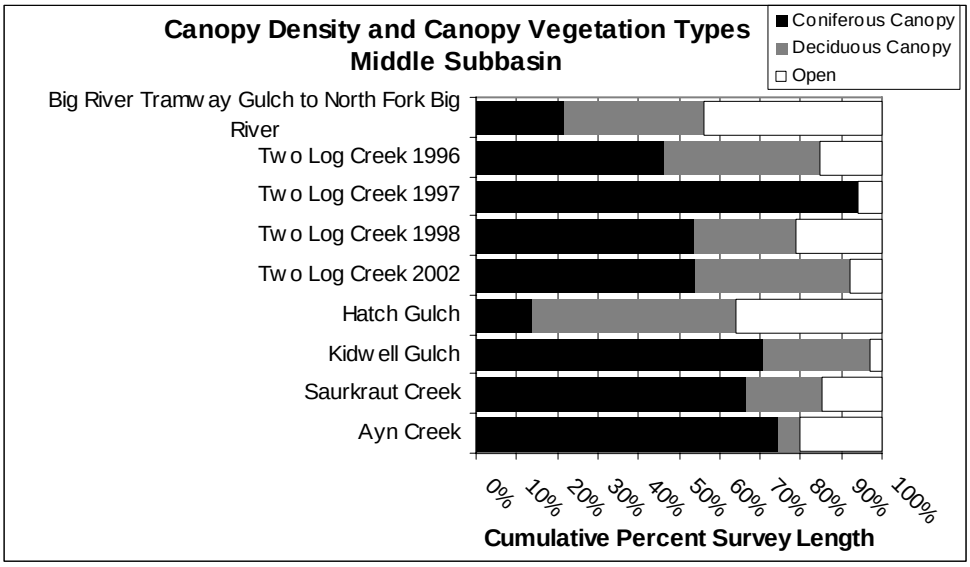


Figure 98. The relative percentage of coniferous, deciduous, and open canopy covering surveyed streams in the Middle Subbasin.

Averages are weighted by unit length to give the most accurate representation of the percent of a stream under each type of canopy. Streams are listed in descending order by drainage area (largest at the top).

Cobble embeddedness was measured at each pool tail crest during CDFG stream surveys. Embeddedness values in the Middle Subbasin generally do not meet target values for successful salmonid egg and embryo development. However, Figure 99 illustrates how stream reaches rated as unsuitable overall may actually have some suitable spawning gravel sites distributed through the stream reach. Additionally, cobble embeddedness meets target values in Sauerkraut Creek and the mainstem Big River from Tramway Gulch to North Fork Big River.

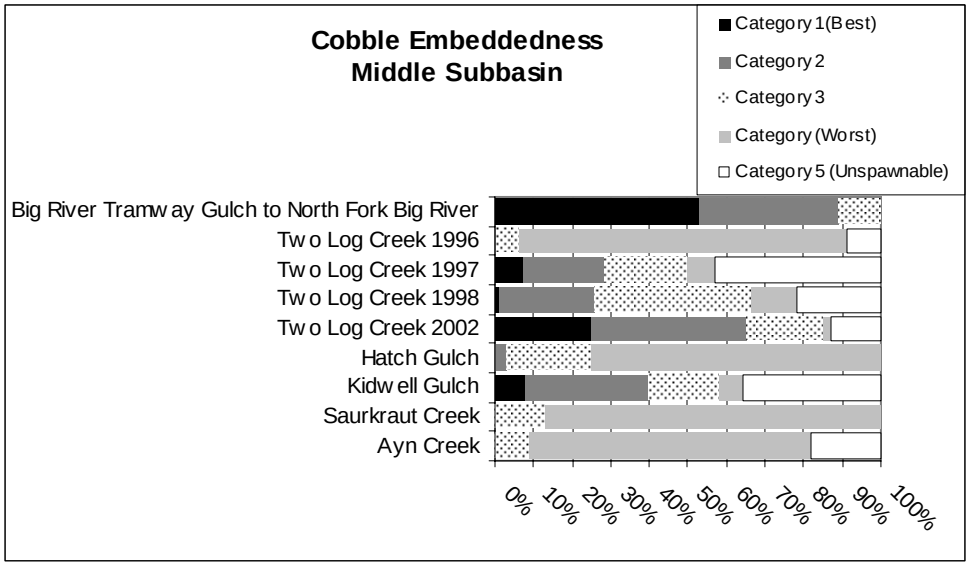


Figure 99. Cobble embeddedness categories as measured at every pool tail crest in surveyed streams in the Middle Subbasin.

Cobble embeddedness is the % of an average sized cobble piece at a pool tail out that is embedded in fine substrate: Category 1 = 0-25% embedded, Category 2 = 26-50% embedded, Category 3 = 51-75% embedded, Category 4 = 76-100%, and Category 5 = unsuitable for spawning due to factors other than embeddedness (e.g. log, rocks). Streams are listed in descending order by drainage area (largest at the top).

Pool, flatwater, and riffle habitat units observed were measured, described, and recorded during CDFG stream surveys. During their life history, salmonids require access to all of these types of habitat. A balanced proportion of these habitat types is desirable. Most of the surveyed Middle Subbasin streams have greater than 20% pool habitat by length (Figure 100). Dry units were measured, and obviously indicate poor conditions for fish. Several culverts were also measured on Ayn Creek.

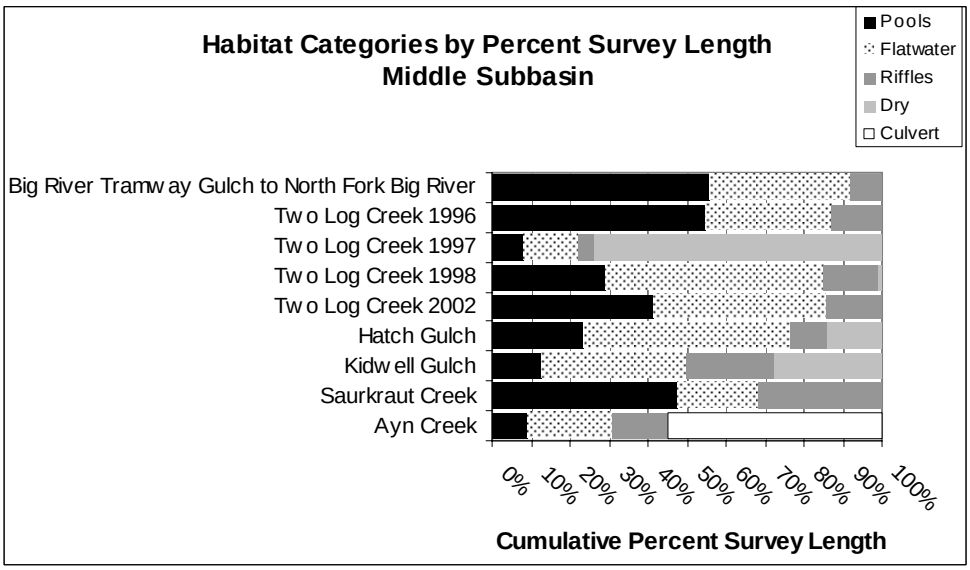


Figure 100. The percentage of pool habitat, flatwater habitat, riffle habitat, dewatered channel, and culverts by survey length in the Middle Subbasin.

Streams are listed in descending order by drainage area (largest at the top).

Pool depths were measured during CDFG surveys. Primary pools are determined by a range of pool depths, depending on the order (size) of the stream. A reach must have 30 – 55% of its length in primary pools for its stream class to meet target values for supporting salmonids. Generally, larger streams have deeper pools. Deviations from the expected trend in pool depth may indicate streams with more suitable or unsuitable pool depth conditions relative to other streams of that subbasin. Most surveyed tributaries in this subbasin have less

than 20% pools greater than two feet deep by length (Table 140). The mainstem Big River from Tramway Gulch to North Fork Big River has the most pool habitat with maximum depth greater than two feet.

Table 140. Percent length of a survey composed of pools in the Middle Subbasin. Streams are listed in descending order by drainage area.

Stream	Drainage Area (Sq. Miles)	Stream Order	Percent Pools by Survey Length	Percent Pools >2.0 by Survey Length	Percent Pools >2.5 by Survey Length	Percent Pools >3.0 by Survey Length	Percent Pools >4.0 by Survey Length
Big River Tramway Gulch to North Fork Big river	137.7	4	57.0	56.5	55.4	49.3	35.4
Two Log Creek 1996	5.2	2	54.9	25.4	17.1	12.2	3.8
Two Log Creek 1997	5.2	2	7.3	0.8	0.0	0.0	0.0
Two Log creek 1998	5.2	2	27.2	19.2	13.4	8.2	1.8
Two Log Creek 2002	5.2	2	41.5	28.4	19.9	11.4	1.6
Hatch Gulch	0.7	1	24.0	24.0	0.0	0.0	0.0
Kidwell Gulch	0.5	1	13.4	1.1	0.8	0.5	0.0
Saurkraut Creek	0.3	1	47.6	9.1	3.9	0.0	0.0
Ayn Creek	0.2	1	9.3	3.0	3.0	1.3	0.0

Pool shelter was measured during CDFG surveys. Pool shelter rating illustrates relative pool complexity, another component of pool quality. Ratings range from 0-300. Shelter scores greater than 100 meet target values for supporting salmonids. Pool shelter ratings in the Middle Subbasin only meet target values in Sauerkraut Creek (Figure 101).

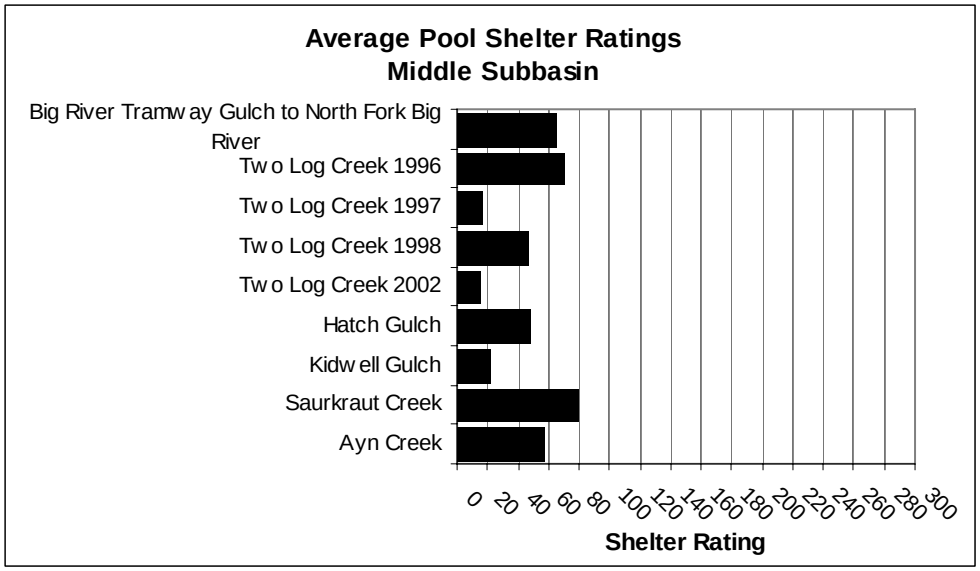


Figure 101. Average pool shelter ratings from CDFG stream surveys in the Middle Subbasin.

Streams are listed in descending order by drainage area.

Pool shelter is composed of those elements within a stream channel that provide salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered by nine different cover types was made during stream surveys. The mean percent of pool shelter cover in each cover type was calculated for each surveyed stream. The predominant pool cover types in most Middle Subbasin tributaries are undercut banks, woody debris, root masses, and terrestrial vegetation (Table 141).

Table 141. Mean percent of shelter cover types in pools for surveyed tributaries in the Middle Subbasin. Streams are listed in descending order by drainage area.

Stream	Undercut Banks	Small Woody Debris	Large Woodsy Debris	Root Mass	Terrestrial Vegetation	Aquatic Vegetation	Whitewater	Boulders	Bedrock Ledges
Big River Tramway Gulch to North Fork Big River	9.9	9.4	10.3	11.3	15.6	23.8	0.1	9.1	11.1
Two Log Creek 1996	34.84	19.19	4.35	8.71	6.13	0.0	0.32	11.61	14.84
Two Log Creek 1997	15.0	32.5	22.5	0.0	17.5	0.0	0.0	12.5	0.0
Two Log Creek 1998	33.1	7.3	10.6	14.1	9.7	2.5	2.8	6.3	13.6
Two Log Creek 2002	34.7	10.3	1.8	20.8	4.1	6.2	5.9	15.6	0.6
Hatch Gulch	1.7	0.0	86.7	0.0	0.0	0.0	1.7	6.7	3.3
Kidwell Gulch	20.2	32.5	43.1	0.0	2.1	0.4	1.3	0.4	0.0
Saurkraut Creek	16.7	16.7	30.0	0.0	30.0	0.0	0.0	6.7	0.0
Ayn Creek	8.0	30.0	46.0	0.0	2.0	0.0	8.0	6.0	0.0

MRC Habitat Surveys

MRC inventoried and assessed salmonid habitat along seven stream segments on four tributaries and the mainstem Big River across their ownership in the Middle Subbasin in 2000 (Table 142).

Table 142. Surveyed stream segments on MRC ownership in the Middle Subbasin (MRC 2003).

Stream Segment	Segment ID	Survey Length (feet)
Big River	BT1	1766
Big River	BT2	1628
Two Log Creek	BT4	480
Two Log Creek	BT4(2)	494
Beaver Pond Gulch	BT5	224
Tramway Gulch	BT12	218
Dietz Gulch	BT26	328

Canopy Closure

Canopy closure measured on stream segments across the MRC's ownership in the Middle Subbasin ranged from less than 40% on the mainstem Big River to greater than 90% on all the tributaries surveyed (Figure 102). Low canopy density is expected on higher order streams such as Big River.

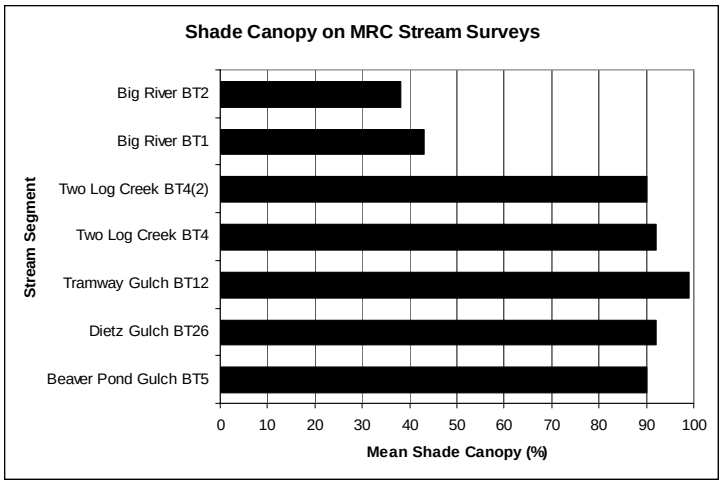


Figure 102. Stream Canopy closure on stream segments in the MRC ownership of the Middle Subbasin (MRC 2003).

Pools

The number of pools measured on stream segments across the MRC's ownership in the Middle Subbasin ranged from five to seven (Table 143). The percentage of pools with mean residual pool depths greater than 3 feet was less than 50% in all segments surveyed. Most pools were bank forced.

Table 143. Pool characteristics measured on stream segments in the MRC ownership of the Middle Subbasin (MRC 2003).

Stream	Segment	% Pool:Riffle: Flatwater by stream length	Total # of pools	Pool Spacing (reach length/bank full/#pools)	Shelter rating	Mean residual pool depth (feet)	% of all pools with residual depth ≥3 ft.	Key LWD + rootwads / 328 ft. with Debris Jams	Pool Mechanism			
									Free	LWD forced	Boulder forced	Bank forced
MRC 'Good' Target		>50%pools	NA	≤ 2.9	>120	NA	>50%	>6.6 in streams >40 feet BFW >3.9 in streams <40 feet BFW	NA			
Big River	BT1	34:10:56	5	4.6	66	1.8	14	0	2	2	0	1
Big River	BT2	48:41:11	7	3.0	71	2.9	30	0	0	0	0	7
Two Log Creek	BT4	60:37:3	5	4.4	55	1.6	16	0.7	0	3	0	2
Two Log Creek	BT4(2)	81:19:0	7	3.5	83	1.4	14	1.3	2	3	0	2
Beaver Pond Gulch	BT5	50:50:0	5	3.8	136	0.7	0	2.9	1	2	0	2
Tramway Gulch	BT12	49:51:0	5	5.5	41	0.7	0	1.5	0	3	0	2
Dietz Gulch	BT26	49:51:0	6	6.6	20	1.0	0	0	2	0	0	4

Spawning Gravel

The amount of spawning gravel measured on stream segments across the MRC's ownership in the Middle Subbasin ranged from 1.5 to greater than 3% (Table 144); the target of greater than three percent was reached on three stream segments. MRC characterized spawning gravels as fair quality on all segments surveyed.

Table 144. Spawning gravel characteristics measured on stream segments in the MRC ownership of the Middle Subbasin.

Stream	Segment	Spawning gravel quantity (%)	% Embeddedness	Sub-surface fines	Gravel Quality	% Over-wintering substrate
MRC 'Good' Target		>3%	<25%	1.0-1.6	1.0-1.6	>40% of units cobble or boulder dominated
Big River	BT1	>3	25-50	Fair	Fair	0
Big River	BT2	>3	25-50	Fair	Fair	0
Two Log Creek	BT4	>3	25-50	Fair	Fair	0
Two Log Creek	BT4(2)	1.5-3	>50	Fair	Fair	10
Beaver Pond Gulch	BT5	1.5-3	>50	Poor	Fair	60
Tramway Gulch	BT12	1.5-3	>50	Fair	Fair	11
Dietz Gulch	BT26	1.5-3	>50	Poor	Fair	0

MRC 2003

Large Woody Debris

MRC (2003) examined LWD loading and demand in 7 stream segments across their ownership in the Middle Subbasin (Table 145). Only one segment on Beaver Pond Gulch made the MRC target value for key LWD. The target value set was 3.3 pieces of LWD per 100 meters for streams with bankfull widths greater than 45 feet; 3.9 with bankfull widths 35-45 feet; 4.9 with bankfull widths 15-35 feet; and 6.6 with bankfull widths less than 15 feet.

Table 145. MRC LWD survey results in the Middle Subbasin (MC 2003).

Stream	# of Segments Surveyed	Pieces of Functional LWD		Total Volume of LWD		Key LWD	Jams	
		Number Including Jams	Number per 328 feet (including jams)	Cubic Yards (including jams)	Cubic Yards per 328 feet (including jams)	Number Including Jams	% of LWD pieces in jams	% of volume in jams
Big River	2	42	3.9-4.2	44.3	1.8-6.6	0	0	0
Two Log Creek	2	28	9.3-9.6	27.9	7.2-11.5	3	0	0
Beaver Pond Gulch	1	49	71.8	33.2	48.6	7	37	60
Tramway Gulch	1	9	13.5	7.3	10.9	1	0	0
Dietz Gulch	1	5	5.0	1.2	1.2	0	0	0

Although debris jams were scarce, they did contain a significant portion of the LWD present when they occurred. MRC also found that a considerable amount of the LWD observed was at least partially buried and thus could not be quantified. LWD was dominated by redwood, which is more stable than hardwood species.

Nearly all surveyed segments contained LWD that was not recently recruited to the stream. It did not appear that much LWD had been contributed within the past ten years. Low recruitment in recent years could be a result of timber harvest practices.

MRC gave surveyed stream segments in the Middle Subbasin low quality LWD ratings (Figure 103, Table 146). Only Tramway Gulch was rated marginal. Combined with the low LWD recruitment potential discussed in the Riparian Conditions section, the low quality LWD ratings across the MRC ownership show that much of the streams are badly in need of LWD. Major channels, such as the mainstem Big River are especially in need of LWD.

Table 146. Instream LWD quality ratings for major streams and sections of streams in MRC ownership in the Middle Subbasin.

Stream	Instream LWD Quality Rating
Big River in Two Log Creek PW	Deficient
Two Log Creek	Deficient
Tramway Gulch	Marginal

MRC 2003

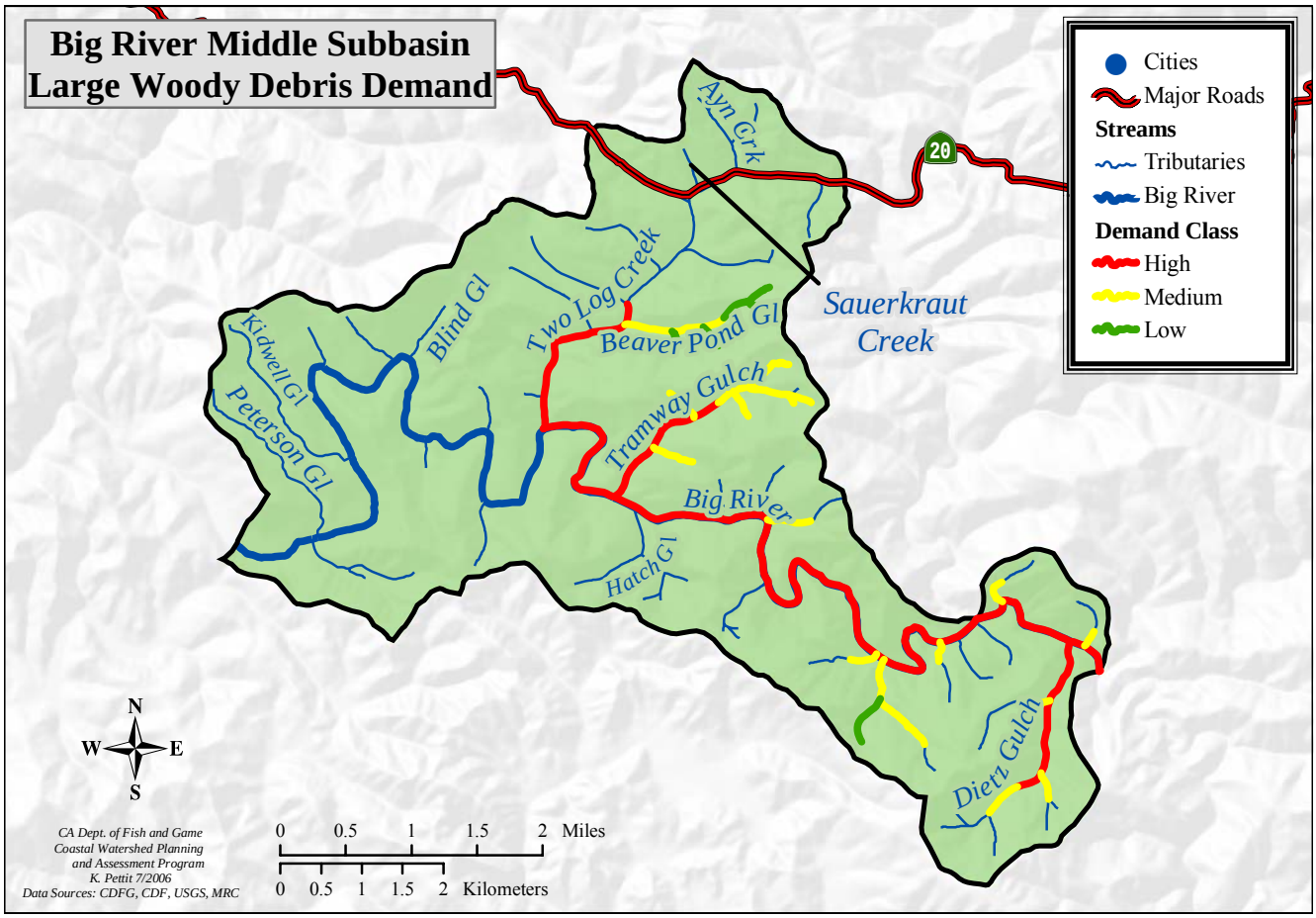


Figure 103. Map of instream LWD demand in MRC ownership in the Middle Subbasin (MRC 2003).

Fish Passage Barriers

Stream Crossings

Although no stream crossings were surveyed in the Middle Subbasin as a part of the coastal Mendocino County culvert inventory and fish passage evaluation conducted by Ross Taylor and Associates (2001), CDFG stream surveys noted culverts on one tributary, Ayn Creek.

Dry Channel

CDFG stream inventories were conducted for 9.4 miles on 13 reaches of five tributaries and the mainstem Big River in the Middle Subbasin. A main component of CDFG Stream Inventory Surveys is habitat typing, in which the amount and location of pools, flatwater, riffles, and dry channel is recorded. Although the habitat typing survey only records the dry channel present at the point in time when the survey was conducted, this measure of dry channel can give an indication of summer passage barriers to juvenile salmonids. Dry channel conditions in the Big River Basin generally become established from late July through early September. Therefore, CDFG stream surveys conducted outside this period are less likely to encounter dry channel.

Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems. Juvenile salmonids need well-connected streams to allow free movement to find food, escape from high water temperatures, escape from predation, and migrate out of their stream of origin. The amount of dry channel reported in surveyed stream reaches in the Middle Subbasin is 3.5% of the total length of streams surveyed. This dry channel was found in two streams (Figure 104,

Table 147). Dry habitat units occurred in the middle reaches and at the upper limit of anadromy in both tributaries. Dry channel in the middle reaches of a stream disrupts the ability of juvenile salmonids to forage and escape predation. Lastly, dry channel in the upper reaches of a stream indicates the end of anadromy.

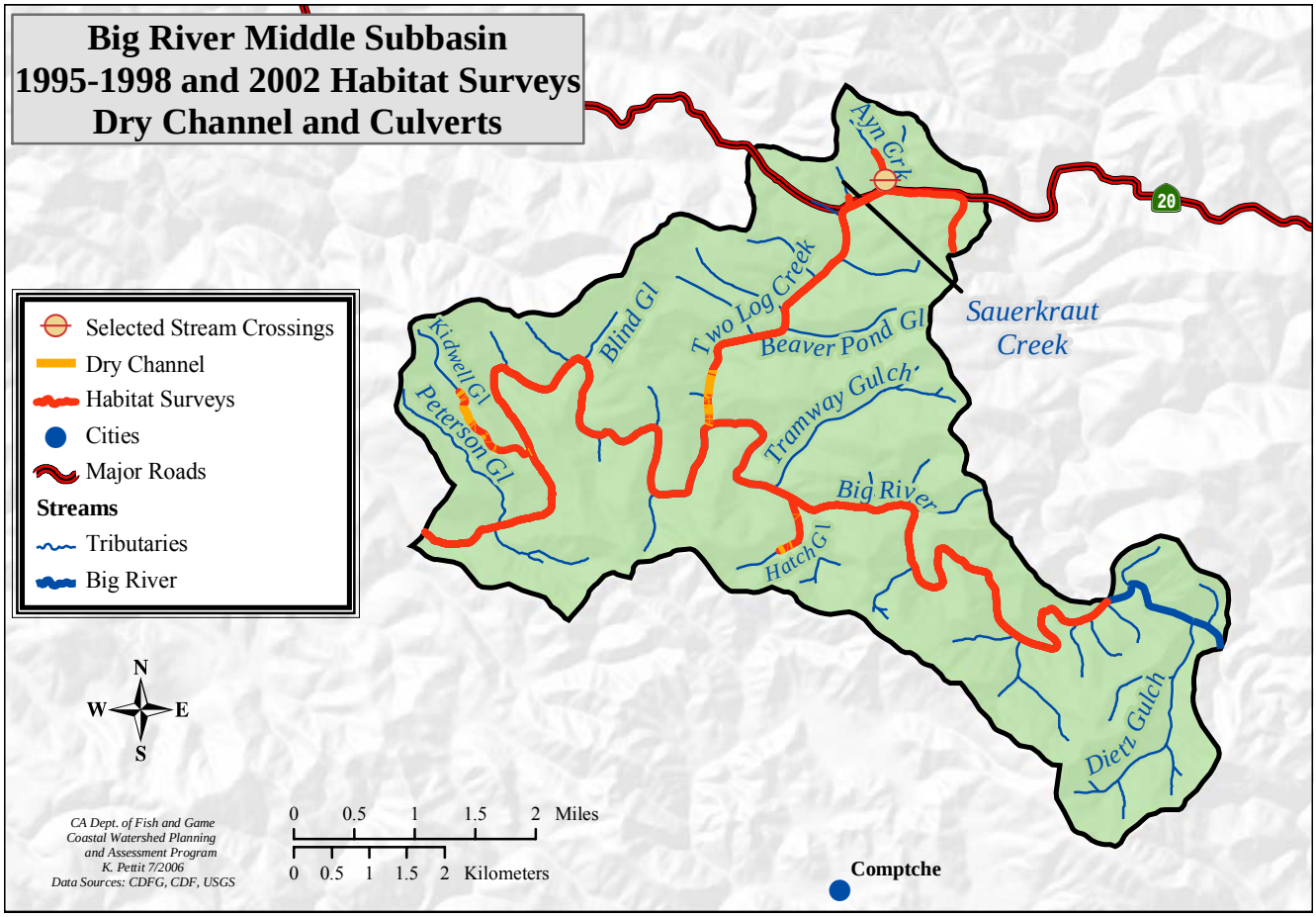


Figure 104. Dry and wetted channel and culverts reported during CDFG stream surveys and culverts reported by MRC (2004) in the Middle Subbasin.

Table 147. Dry channel recorded in CDFG stream surveys in the Middle Subbasin.

Stream	Survey Period	# of Dry Units	Dry Unit Length (ft)	% of Survey Dry Channel
Kidwell Gulch	June 2002	13	1343	27.7
Two Log Creek	June 2002	0	0	0.0
Saurkraut Creek (Two Log Creek Tributary)	July 1998	0	0	0.0
Ayn Creek (Two Log Creek Tributary)	July 1998	0	0	0.0
Big River (Tramway Gulch to North Fork Big River)	July 2002	0	0	0.0
Hatch Gulch	July 1996	5	391	13.6

Restoration Programs

The CDFG Fisheries Restoration Grants Program funded a project on Beaver Pond Gulch in the Middle Subbasin. The project leader was the E-Center and it was carried out from 2000 to 2001. The project details included:

- Fish barrier removed, log jam removed;
- Fish barrier removed, stream bank stabilized: log revetment installed, log jam removed, conifers planted;
- Fish barrier removed, stream bank stabilized: log revetment installed, log jam removed;
- Road ditch and drainage culvert maintenance (removing debris) log jam removal, fish barrier removal, bank stabilization, and road maintenance.

HTC has carried out a large woody debris restoration program on their ownership in Two Log Creek in recent years. Large wood has been added to the creek in various locations and configurations. Some of the wood was anchored and some not anchored. All wood was labeled with inventory tags so it can be tracked in the case of displacement by storm flows.

Changes in Habitat Conditions from 1960 to 2001

Streams surveyed in the 1950s and 1960s and habitat inventory surveyed in the 1990s or 2002 were compared to indicate changes between historic and current conditions. Data from 1960s stream surveys provide a snapshot of the conditions at the time of the survey. Terms such as excellent, good, fair, and poor are based on the judgment of the biologist or scientific aid who conducted the survey. The results of historic stream surveys are qualitative and cannot be used in comparative analyses with quantitative data provided by habitat inventory surveys with any degree of accuracy. However, the two data sets can be compared to show general trends.

Habitat data were available from both older stream surveys and recent stream inventories for Two Log Creek and the mainstem Big River (Table 148). It appeared that spawning habitat and pool habitat increased in the mainstem Big River and remained similar Two Log Creek. Shelter decreased in Two Log Creek and increased in the mainstem Big River.

Table 148. Comparison between historic habitat conditions with current habitat inventory surveys in the Middle Subbasin.

Stream	Canopy Cover		Spawning Conditions		Pool Depth/Frequency		Shelter/Cover		Summary of Changes from Historic to Current
	Historic	Current	Historic	Current	Historic	Current	Historic	Current	
Kidwell Gulch	ND*	Suitable	ND	Unsuitable	ND	Fully Unsuitable	ND	Fully Unsuitable	ND
Two Log Creek	ND	Fully Suitable	Good	Suitable	Average one foot deep, range from six to one foot deep	Unsuitable	Good	Unsuitable	Shelter decreased
Saurkraut Creek	ND	Fully Suitable	ND	Fully Unsuitable	ND	Fully Unsuitable	ND	Suitable	ND
Ayn Creek	ND	Suitable	ND	Fully Unsuitable	ND	Fully Unsuitable	ND	Unsuitable	ND
Tramway Gulch	ND	ND	Good	ND	Small, fairly frequent pools	ND	Good	ND	ND
Big River Tramway Gulch to North Fork Big River	ND	Unsuitable	Poor to fair	Suitable	Uncommon	Fully Suitable	Only undercut banks and log jams for cover	Suitable	Spawning habitat, pool habitat, and shelter increased
Hatch Gulch	ND	Fully Suitable	ND	Fully Unsuitable	ND	Fully Unsuitable	ND	Suitable	ND

*ND= No Data
If more than one year of historic data were available, the oldest data were used.

Fish History and Status

Historically, the Middle Subbasin supported runs of Chinook salmon, coho salmon, and steelhead trout. CDFG stream surveys were conducted for three tributaries in the Middle Subbasin from 1959 to 1966 (Table 149). Coho salmon and steelhead trout were observed in Two Log Creek in 1959; however, only steelhead trout were observed in 1966. No salmonids were described in Tramway and Dietz gulches in the 1950s surveys. A 1966 survey of Tramway Gulch detected about 20 steelhead trout per habitat unit near the mouth of the stream.

Table 149. Summary of all electrofishing, snorkel survey, and bank observation surveys conducted in the Middle Subbasin.

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified salmonids
Kidwell Gulch	2002	CDFG	Electrofishing		Present	
Two Log Creek - Lower	1994	MRC	Electrofishing		Present	
	1995	MRC	Electrofishing	Present	Present	
	1996	MRC	Electrofishing	Present	Present	
	2000	MRC	Electrofishing	Present	Present	
	2001	MRC	Electrofishing	Present	Present	
	2002	MRC	Snorkel Survey	Present	Present	
Two Log Creek - Middle	1994	MRC	Electrofishing		Present	
	1995	MRC	Electrofishing		Present	
	1996	MRC	Electrofishing			
	2000	MRC	Electrofishing	Present	Present	
	2001	MRC	Electrofishing	Present		
Two Log Creek - Upper	2002	MRC	Electrofishing	Present	Present	
Two Log Creek	1959	CDFG	Visual Observation	Present	Present	
	1966	CDFG	Visual Observation		Present	
	1983	CDFG	Electrofishing	Present	Present	
	1993	HTC	Electrofishing		Present	
	1994	HTC	Electrofishing		Present	
	1995	HTC	Electrofishing		Present	
		NMFS	Electrofishing	Present	Present	
		NMFS	Electrofishing	Present	Present	
	1996	HTC	Electrofishing		Present	
		NMFS	Electrofishing	Present	Present	
		NMFS	Electrofishing	Present	Present	
	1997	HTC	Electrofishing		Present	
		CDFG	Electrofishing	Present		
		NMFS	Electrofishing	Present	Present	
	1998	CDFG	Electrofishing	Present	Present	
		HTC	Electrofishing		Present	
	1999	HTC	Electrofishing		Present	
	2000	HTC	Electrofishing		Present	
		NMFS	Snorkel Survey	Present	Present	
	2001	HTC	Electrofishing		Present	
	2002	CDFG	Electrofishing	Present	Present	
Saurkraut Creek	1998	CDFG	Visual Observation			
Ayn Creek	1998	CDFG	Visual Observation			
		CDFG	Electrofishing		Present	
Beaver Pond Gulch - Lower	2001	MRC	Electrofishing			
	2002	MRC	Electrofishing			
Beaver Pond Gulch - Upper	1995	MRC	Electrofishing			
	1996	MRC	Electrofishing			
	2000	MRC	Electrofishing			
Big River-Below Tramway Gulch	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey	Present	Present	
	2000	MRC	Electrofishing	Present	Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Tramway Gulch	circa 1950	CDFG	Visual Observation			
	1966	CDFG	Visual Observation	Present		
	1995	NMFS	Electrofishing		Present	
	1996	NMFS	Electrofishing		Present	
	2001	CDFG	Coho Inventory			
Tramway Gulch - Lower	1994	MRC	Electrofishing		Present	
	1995	MRC	Electrofishing		Present	

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified salmonids
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing			
	2001	MRC	Electrofishing			
	2002	MRC	Electrofishing	Present	Present	
Tramway Gulch - Upper	1994	MRC	Electrofishing			
	1995	MRC	Electrofishing		Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing			
	2001	MRC	Electrofishing			
	2002	MRC	Electrofishing			
Big River from Tramway Gulch to North Fork Big River	2002	CDFG	Snorkel Survey	Present	Present	
Hatch Gulch	1988	CDFG	Electrofishing	Present	Present	
	1996	CDFG	Snorkel Survey		Present	
		HTC	Visual Observation			Present
Dietz Gulch	circa 1950	CDFG	Visual Observation			
Big River-Below North Fork Confluence	1994	MRC	Snorkel Survey		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2002	MRC	Snorkel Survey		Present	

*CDFG = Department of Fish and Game survey; CI = Department of Fish and Game Coho Inventory; CEMR = Center for Education and Manpower Resources; MRC = Mendocino Redwood Company Report; HTC = Hawthorne Timber Company; SONAR = School of Natural Resources at Mendocino High School; NMFS = National Marine Fisheries Service (Jones 2000)

CDFG, Hawthorne Timber Company, and MRC studies have continued to document the presence of coho salmon and steelhead trout in the Middle Subbasin.

CDFG electrofishing surveys of Two Log Creek in 1983 and Hatch Gulch Creek in 1988 found both coho salmon and steelhead trout.

Electrofishing and snorkel surveys documented by NMFS (Jones 2000) found steelhead trout and coho salmon in Two Log Creek from 1995 to 1997 and 2000. Electrofishing also found steelhead trout in Tramway Gulch in 1995 and 1996.

Georgia Pacific began electrofishing surveys on the Two Log Creek as part of a monitoring program in 1993. The monitoring has been continued by the Hawthorne Timber Company. The sample site was electrofished annually and steelhead trout young of the year and 1+ were consistently detected (Figure 105). No steelhead trout 2+ were detected. Coho salmon were detected in each year except for 1994.

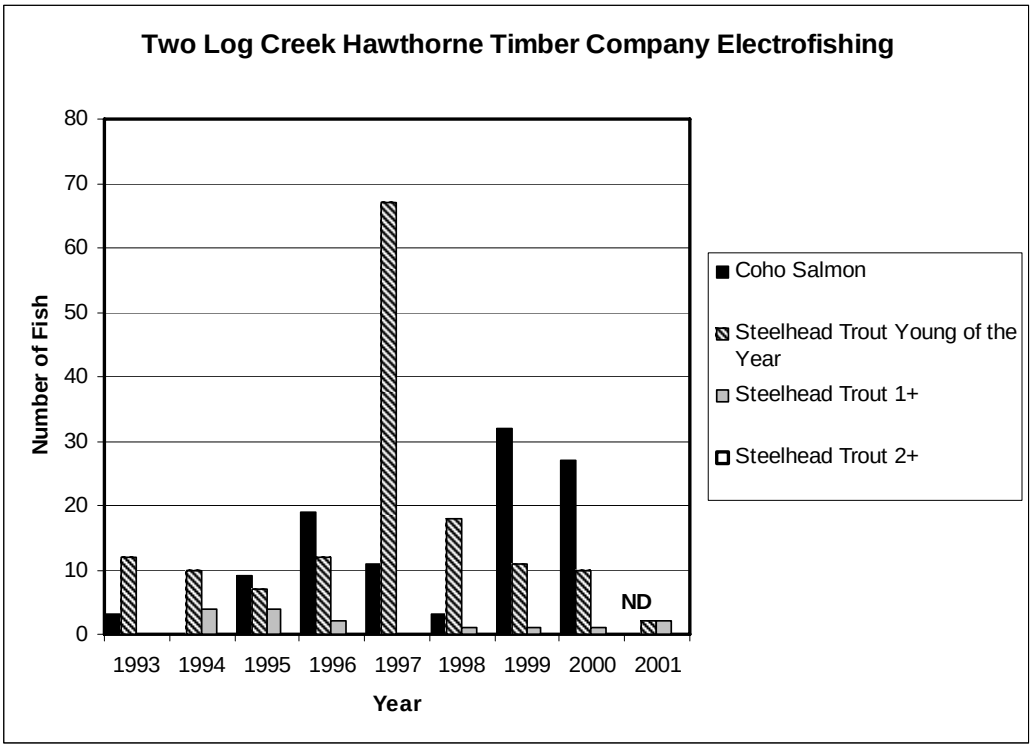


Figure 105. Electrofishing results from 1993-2000 for Two Log Creek (surveys by Georgia-Pacific).

MRC has collected single-pass electrofishing or snorkel counts of many sites in the Middle Subbasin in the years 1994-1996, and 2000-2002. The sites were surveyed for the purpose of detecting the presence of fish species. These data do not enable the assessment of fish health or abundance, but do provide a look at fish community structure, and specifically the presence of coho or other species. Coho salmon were found in Two Log Creek and mainstem Big River below Tramway Gulch consistently, while they were found in Tramway Gulch only in 2002 (Table 149). Steelhead trout were detected in Two Log Creek, mainstem Big River below Tramway Gulch, Tramway Gulch, and mainstem Big River below North Fork Big River consistently. No salmonids were detected in Beaver Pond Gulch.

Georgia Pacific used streamside visual observation and electrofishing to detect salmonids during stream surveys conducted in Two Log Creek and Hatch Gulch in 1996. Steelhead trout were detected in Two Log Creek but no salmonids were detected in Hatch Gulch.

A 1996 CDFG snorkel survey in Hatch Gulch did detect steelhead trout. Visual observations as a part of 1998 CDFG stream inventory surveys in Saurkraut Creek and Ayn Creek did not detect salmonids, though an electrofishing survey in Ayn Creek detected steelhead trout. The 2001 CDFG Coho Inventory did not detect coho salmon in Tramway Gulch.

CDFG stream inventory surveys in Two Log Creek found coho salmon in 1997, 1998, and 2002 and steelhead trout in 1998 and 2002. Steelhead trout were also detected in Kidwell Gulch and mainstem Big River from Tramway Gulch to North Fork Big River in 2002, but coho salmon were only found in mainstem Big River in these surveys. More detailed summaries of stream surveys and fisheries studies in the Middle Subbasin are provided in the CDFG Appendix.

Middle Subbasin Issues

From the various disciplines' assessments and constituent input, the following issues were developed for the Middle Subbasin. These must be considered in context of the Big River Basin's Franciscan mélange geology and the many low gradient depositional reaches in this subbasin.

- Water temperatures are thought to be unsuitable for salmonids in the mainstem Big River;
- There is concern that road related failures are contributing large amounts of sediments to stream channels during major storms;
- Moderate to high levels of fine material in streams are a concern.

Middle Subbasin Integrated Analysis

The following section provides a dynamic, spatial picture of watershed conditions for the freshwater lifestages salmon and steelhead. Different watershed factors are analyzed together to examine their combined effects on stream channels. The interactions between geology, vegetation, landuse, water quality, and stream channels indicate the quantity and quality of the freshwater habitat for salmon and steelhead.

Landsliding Interactions

GMA (2001) calculated the unit volume of delivering landslides, comprised of the total of delivering landslides in unmanaged forest, brush and grasslands, roads and timber harvest areas, to be 119 tons/square mile/year for 1989-2000. In the Middle Subbasin, it was reported that 100% of the landslides occurred in timber harvest areas or were related to roads (Figure 106, Table 150). Of the delivering landslides from harvest related activities and roads, it was estimated that 41% were related to roads and 59% were related to timber harvesting (including skid trails). Results over the entire study period (1937-2000) showed that 56% of the delivering landslides were road related, 44% were related to timber harvesting (including skid trails), and none were related to grassland areas or unmanaged forest.

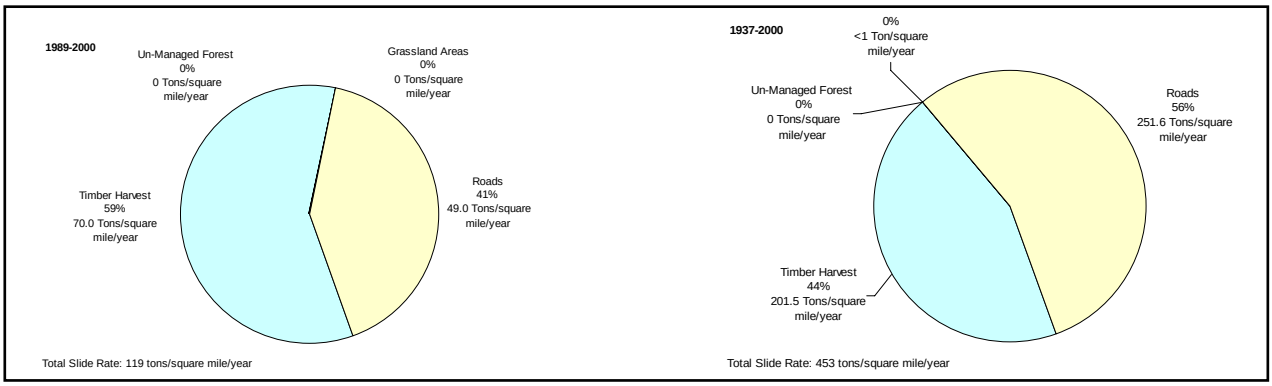


Figure 106. Delivering landslides by category, Middle Subbasin (GMA 2001a).

Table 150. Volumes of delivering slides by land use by PW for entire study period in the Middle Subbasin in tons and percentage of subbasin total (GMA 2001a).

PW	Forest	Brush & Grassland	Harvest-Related					Road-Related	Total
			Partial Or Clear Cut	Harvest (<20 Yrs)	Harvest (>20 Yrs)	Skid Trails	Total		
Middle Big River	0 0.0%	25 <0.1%	6,759 1.3%	35,973 7.1%	154,730 30.3%	29,439 5.8%	226,900 44.5%	283,213 55.5%	510,139

Thus, when comparing the 1989-2000 time period to that of the entire study period, the percentage of delivering landslides due to roads increased while those due to timber harvesting decreased. This may primarily be the result of timber harvesting methods that are less disruptive, or it may be the result of years of building roads that are now triggering more landslides. It is important to note that the total estimated slide rate decreased from 453 (1937-2000) to 119 tons/square mile/year (1989-2000), a substantial drop in sediment input by landslides.

The Middle Subbasin was harvested intensely fairly early, and extensive landslides related to early harvests were observed. Since the 1952 study period, sediment production from landslides related to all landuse has decreased (Table 151).

Table 151. Volume of delivering slides by land use, PW, and year in the Middle Subbasin in tons.

Year	Forest	Brush & Grassland	Harvest-Related					Road-Related	Study Period Total
			Partial Or Clear Cut	Harvest < 20 Years	Harvest > 20 Years	Skid Trail	Total		
1952	0	0	0	15,545	88,386	0	103,931	10,575	114,506
1965	0	25	2,651	2,446	33,645	25,824	64,566	206,788	271,379
1978	0	0	0	4,964	20,353	1,118	26,435	13,798	40,233
1988	0	0	3,663	3,056	7,781	2,498	16,998	41,625	58,623
2000	0	0	445	9,961	4,564	0	14,971	10,427	25,398
Total:	0	25	6,759	35,974	154,730	29,439	226,900	283,213	510,139

GMA 2001a

It should also be noted that background landslides, other than what was observed in unmanaged forest, has not been included in the direct comparisons discussed thus far (and shown in Figure 106). Background landslide estimates are discussed separately because they were estimated from past studies, rather than through direct observation in aerial photographs. Background landslide rates were estimated based on previous observation of natural "background" landslides in the South and North Fork of Caspar Creek (Matthews 2001). However, this presented a potentially significant difference in data quality and could be misleading if compared directly.

The background landslide rate for the 1989-2000 time period was estimated to be 159 tons/mi^2/yr. The background landslide rate for the 1921-2000 time period was estimated to be 175 tons/mi^2/yr. Regardless of data quality concerns, these estimates point to background landslides as a potentially significant component of sediment input. As a point of reference, all other landslides during the 1989-2000 time period contributed an estimated 119 tons/mi^2/yr. This would indicate that background landslides may have contributed roughly 43% of the total sediment input by all categories of landslides.

When compared to the TMDL load allocations for each category of landslide, there is no reduction needed for background landslides, as it is naturally occurring. However, each category of landslide that is related to human management has been assigned a load allocation (US EPA 2001). The overall goal of the load allocation is to limit sediment input to no more than 125% of naturally occurring background levels by reducing sediment input from the various categories accordingly. These are charted in Figure 107 for comparison to the estimated landsliding rates during the 1989-2000 time period. Note that estimated values and TMDL load allocations for timber harvest also include landslides related to skid trails. Based on these preliminary comparisons, it appears as though landsliding related to roads and timber harvesting need to be addressed to meet the TMDL load allocation goals. Grassland areas are not a significant problem.

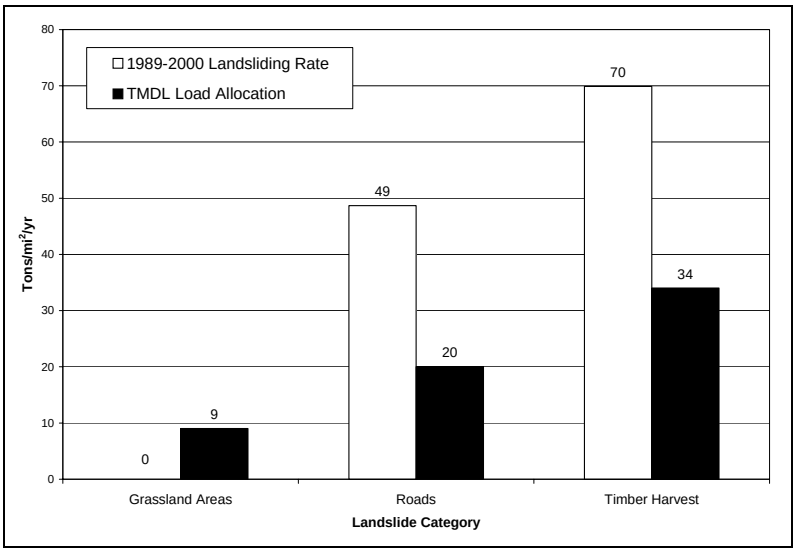


Figure 107. Landslide rate vs. TMDL load allocations, Middle Subbasin (GMA).

The MRC Watershed Analysis found that of the 257 shallow-seated landslides observed in the MRC ownership of the Middle Subbasin, 136, or 53%, were road-associated. Road associated mass wasting was found to have contributed about 98,000 tons (490 tons/square mile/year) in the study period. This is 64% of the total mass wasting sediment inputs for the MRC ownership in the Middle Subbasin. Road associated mass wasting was a major sediment source.

Slope Interactions

An analysis of different types of roads on slopes of varying percent showed that most road miles are on slopes from 31 to 50% in this subbasin (Table 152). When GMA (2001) grouped slopes into categories, they found that most of the roads are mid-slope, followed by riparian, and then ridge-top (Table 153). It was estimated that 20% of roads are located in the riparian zone.

Table 152. Length of truck roads by side slope and road surface.

Side Slope in Percent	Total Length in Miles				Miles per Sq Mile				Proportion of Length			
	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
0 -15	19	1	5	24	1.1	0.0	0.3	1.4	12		3	16
16 - 30	38	1	5	44	2.1	0.1	0.3	2.5	25	1	3	29
31 - 50	47	0	7	55	2.6	0.0	0.4	3.1	30		5	35
51 - 65	17	0	3	21	1.0	0.0	0.2	1.2	11		2	13
Greater than 65	7		3	11	0.4		0.2	0.6	5		2	7
Total	**129**	**2**	**24**	**155**	**7.2**	**0.1**	**1.3**	**8.7**	**83**	**1**	**15**	**100**

Table 153. Middle Subbasin roads by location and surface type.

	Paved	Rocked	Un-surfaced
Ridgetop			
Miles	0.1	2.8	24.9
% Total Basin Miles	0.1	1.8	16.1
Mid-slope			
Miles	0.5	10.5	84.4
% Total Basin Miles	0.3	6.8	54.7
Riparian			
Miles	1.7	10.5	19.0
% Total Basin Miles	1.1	6.8	12.3

Total subbasin roads = 154.2 miles, 8.6 miles/square mile
Blue categories have the lowest potential for road surface erosion (2.2%). Orange categories have medium potential for surface erosion (24.3%). Magenta categories have the highest potential for surface erosion (73.8%). Road surface erosion is a source of fine sediment that can be delivered to streams, which is deleterious to fish habitat

The MRC Watershed Analysis found that about 88% of field observed shallow landslides inventoried on MRC land in the Middle Subbasin were initiated on slopes greater than or equal to 60% gradient. About 75% of shallow landslides initiated on slopes greater than or equal to 70% gradient. Of the field observed landslides occurring on slopes with gradients less than 70%, all were road related. This suggests that few landslides are occurring on slopes less than 70% gradient unless triggered by a road or skid trail.

Shallow-seated landslides were in the greatest concentration in inner gorge and steep streamside areas. Combined, these two locations accounted for 58% of the shallow-seated landslides; 17% inner gorge and 41% steep streamside slopes. Headwall swells accounted for 10%, and the remainder occurred in midslope areas, often as a result of roads, landings, and skid trails.

In the MRC's ownership, low slope class roads make up 47% of all the contributing road area (Table 154). Low slope class roads delivered 810 tons/year, compared to 1010 tons/year for middle slope class roads and 180 tons/year on high slope class roads. This indicates the importance of monitoring low and mid-sloped roads.

Table 154. Surface and point source erosion estimates by slope class for MRC ownership in the Middle Subbasin.

PW	Low-Slope			Mid-Slope			High-Slope		
	Contributing Road Area (acres)	Percent Roads	Surface and Point Source Erosion (tons/year)	Contributing Road Area (acres)	Percent Roads	Surface and Point Source Erosion (tons/year)	Contributing Road Area (acres)	Percent Roads	Surface and Point Source Erosion (tons/year)
Two Log Creek	6.0	47%	810	5.3	42%	1010	1.3	11%	180

MRC 2004

Road Interactions

GMA (2001) estimated that road surface erosion across the Middle Subbasin increased significantly from 1937 to 2000, coinciding with an increased amount of roads (Table 155). Roads in 2000 were estimated to produce 106.9 tons of sediment per square mile per year across the subbasin, an increase over 1952 rates.

Table 155. Computed road surface erosion by study period by PW in the Middle Subbasin.

PW	Computed Surface Erosion From Roads By Period (Tons/Yr)					Total By PW For Entire Period	% Total Watershed Road Surface Erosion	Entire Study Period Average Unit Area Road Surface Erosion	2000 Unit Area Road Surface Erosion
	1937-1952	1953-1965	1966-1978	1979-1988	1989-2000	(Tons)	(%)	(Tons/Mi2/Yr)	
Two Log Creek	447.7 (23.5%)	1068.2 (56.0%)	1162.2 (60.9%)	1357.8 (71.2%)	1907.4 (100.0%)	72,818.2	11.0%	64.7	106.9

GMA 2001a

GMA (2001) estimated that sediment production from skid roads across the subbasin was small (Table 156). The analysis suggested a peak in surface erosion at the time of high harvest rates using high-density tractor logging methods from 1953-1978.

Table 156. Summary of total surface erosion estimates in tons from harvest areas by study period.

Planning Watershed	1937-1952	1953-1965	1966-1978	1979-1988	1989-2000	1937-2000 Total
Two Log Creek	782.5	10,179.8	761.5	2,380.7	1,881.4	15,985.9

GMA 2001a

As can be seen in Figure 108, estimates of surface erosion from roads and timber harvest areas (including skid trails) indicate that both also exceed the TMDL load allocation for surface erosion. In particular, surface erosion related to roads appears to be a significant problem. The increase in surface erosion from roads in the 1989-2000 time period versus the entire study period (1937-2000) is likely due to continued road building through the years which has resulted in greater road surface area.

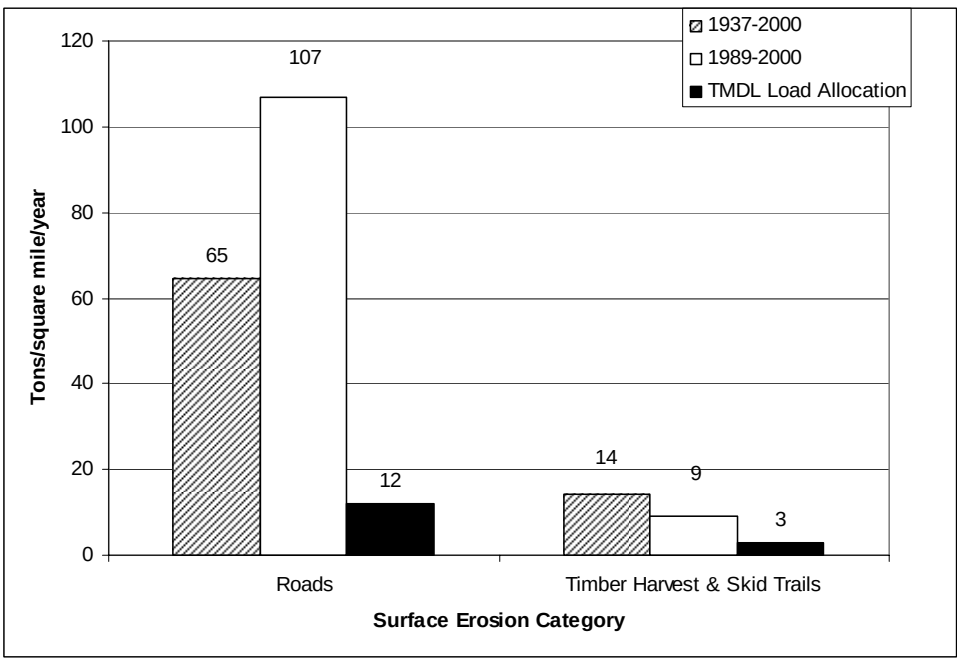


Figure 108. Surface erosion rate vs. TMDL load allocations, Middle Subbasin (GMA).

Roads within MRC's ownership in the Middle Subbasin were estimated to generate 300 tons/square mile/year of sediment from road associated surface and point erosion (MRC 2003) (Table 157). The surface erosion rate was higher than the point source erosion rate.

Table 157. Road associated surface and point source erosion estimates for MRC ownership in the Middle Subbasin.

PW	Total Road Associated Erosion (tons/year)	MRC owned acres	Road Associated Erosion Rate (tons/square mile/year)	Surface Erosion Rate (tons/square mile/year)	Point Source Erosion Rate (tons/square mile/year)
Two Log Creek	2000	4275	300	220	80

MRC 2003

MRC found that the high level of tractor based yarding used for timber harvest in the 1940s, 1950s, and 1960s on their ownership produced a high level of sediment delivery (Table 158 and Figure 109). However, the widespread geographic extent of skid trails in the 1970s and 1980s produced the most total skid trail area and

the highest sediment delivery rates. The peak in sediment delivery rate from skid trails in the Middle Subbasin occurred in the 1970s. Skid trail delivery rates diminished across the MRC ownership in the 1990s with less harvest activity and stricter regulations.

Table 158. Skid trail use in acres for MRC ownership in the Middle Subbasin.

Planning Watershed	1940s	1950s	1960s	1970s	1980s	1990s
Two Log Creek	233	525	1663	2379	2129	133

MRC 2003

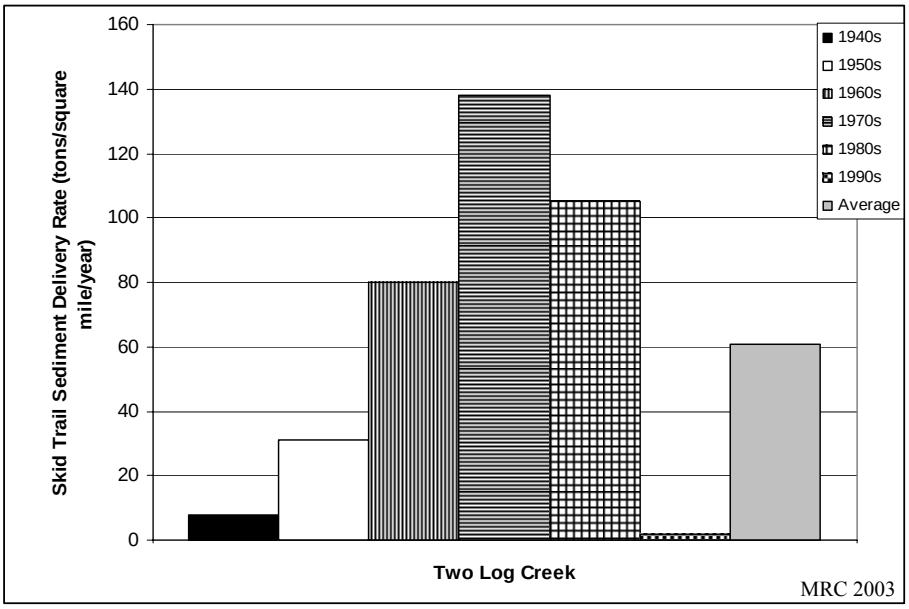


Figure 109. Skid trail sediment delivery estimates for MRC ownership in the Middle Subbasin.

MRC (2003) estimated the total sediment inputs for their ownership in the Middle Subbasin. The average estimated sediment input for the past 30 years was 1150 tons/square mile/year (Table 159). Road associated erosion was the dominant sediment contributing process in the MRC ownership in the Middle Subbasin, making up 54% of the sediment inputs. When skid trail erosion is included in road-associated erosion totals the percentage increases to 76%.

Table 159. Estimated sediment inputs by input type for the MRC ownership.

PW	Road Surface Erosion	Road Point Source Erosion	Road Associated Mass wasting	Hillslope Mass wasting	Skid Trail Erosion	Total
Two Log Creek	220	80	320	280	250	1150

Averaged from 1970-2000. MRC 2003.

Road Crossings

Today there are 20.4 miles of roads in the watercourse buffer zone (Table 160). Seventy eight percent were built before 1979 (Table 161). While the data show 12.5 miles as native road surface, the Forest Practice Rules require that landowners that use roads for harvesting timber reduce the potential for sediment transport, so many are being surfaced with rock. There are almost 21 streams crossings per square mile in this subbasin (Table 162).

Table 160. Length of truck roads in near proximity to watercourse by watercourse classification and road classification.

Watercourse Class	Total Length in Miles				Length in Miles per Sq Mile			
	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
w/in 150' of FPR Class I or USGS Perennial	5.1	0.6	5.3	11.0	0.29	0.04	0.30	0.62
w/in 75' of FPR Class II or USGS Intermittent	5.0	0.2	1.4	6.6	0.28	0.01	0.08	0.37
w/in 25' of FPR Class III	2.4	0.0	0.3	2.8	0.14		0.02	0.16
Total	**12.5**	**0.9**	**7.1**	**20.4**	**0.70**	**0.05**	**0.40**	**1.14**

Table 161. Length of truck roads in near proximity to watercourse by period of construction and road classification.

Period	Total Length in Miles				Length in Miles per Sq Mile			
	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
pre - 1937	1.6	0.9	1.4	3.8	0.09	0.05	0.08	0.21
1937 - 1952	2.0		0.3	2.3	0.11		0.02	0.13
1953 - 1965	4.0		5.2	9.2	0.22		0.29	0.51
1966 - 1978	0.6		0.0	0.7	0.04			0.04
1979 - 1988	0.8			0.8	0.05			0.05
1989 - 2000	3.5		0.2	3.7	0.19		0.01	0.20
Total	**12.5**	**0.9**	**7.1**	**20.4**	**0.70**	**0.05**	**0.40**	**1.14**

Table 162. Number of watercourse truck road crossings by watercourse and road classification in the Middle Subbasin.

Watercourse Class	Total Crossings				Crossings per Sq Mile			
	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
FPR Class I or CFF Perennial	9		11	20	0.5	0	0.6	1.1
FPR Class II or CFF Intermittent	64	2	14	80	3.6	0.1	0.8	4.5
FPR Class III	217	6	43	266	12.2	0.3	2.4	14.9
Total	290	8	68	366	16.2	0.4	3.8	20.5

Fluvial Erosion

GMA (2001) estimates of bank erosion and small streamside mass wasting found little sediment from these sources.

Table 163. Bank erosion and small streamside mass wasting.

Planning Watershed	Bank Erosion and Small Streamside Mass Wasting		Total Tons/Year
	Class 1 (Tons/Year)	Class 2 (Tons/Year)	
Two Log Creek	513	535	1,047

GMA 2001a

Stream Interactions

The products and effects of the watershed delivery processes examined in the geologic, slope, and landsliding Integrated Analyses tables are expressed in the stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead. Several key aspects of salmonid habitat in the Big River Basin are presented in the Stream Interactions Integrated Analysis. Channel and stream conditions are not necessarily exclusively linked to their immediate surrounding terrain, but may in fact be both spatially and temporally distanced from the sites of the processes and disturbance events that have been blended together over time to create the channel and stream's present conditions. Instream habitat data presented here were compiled from CDFG stream inventories described in more detail in the Fish Habitat Relationships sections of this report.

Primary Pools

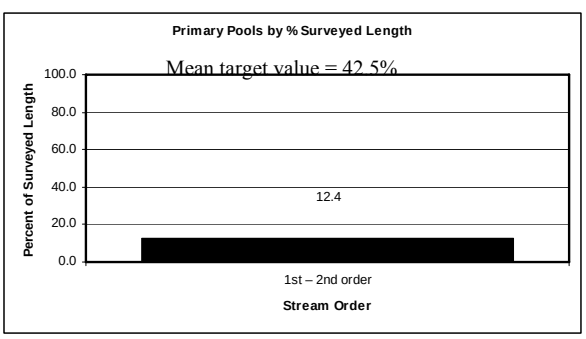


Figure 110. Primary Pools in the Middle Subbasin.

Pools greater than 2 feet deep in 1st and 2nd order streams and greater than 3 feet deep in 3rd and 4th order streams are considered primary pools.

Significance: Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach should have 30-55% of its length in primary pools to be suitable for salmonids. In first and second order streams, a primary pool is described as being at least two feet deep. In third and fourth order streams, a primary pool is described as being at least three feet deep.

Comments: The percent of primary pools by length in the Middle Subbasin is generally below target values for salmonids.

Spawning Gravel Quality

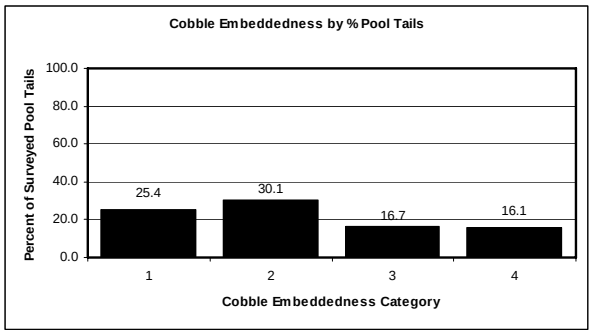


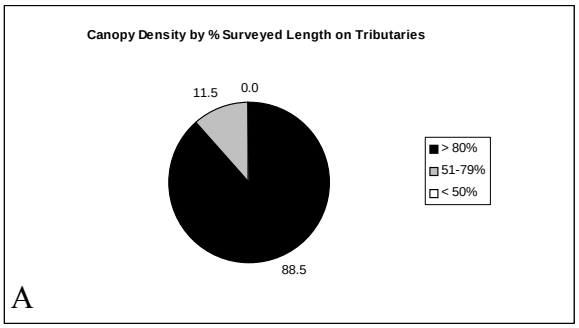
Figure 111. Cobble Embeddedness in the Middle Subbasin.

Cobble Embeddedness will not always sum to 100% because Category 5 (not suitable for spawning) is not included

Significance: Successful salmonid egg and embryo survival diminishes when spawning occurs in streambeds with excessive silt, clay, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble at a pool tail out embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded and category 4 is 76%-100% embedded. Cobble embeddedness categories 3 and 4 are not within the suitable range for successful use by salmonids. Category 5 describes pool tail outs with unspawnable substrate such as bedrock, log sills, or boulders.

Comments: More than one half of the surveyed stream lengths within the Middle Subbasin have cobble embeddedness in categories 1 and 2, which meets spawning gravel target values for salmonids. This subbasin has the highest percent of suitable cobble embeddedness values in surveyed streams of the Big River Subbasins.

Shade Canopy



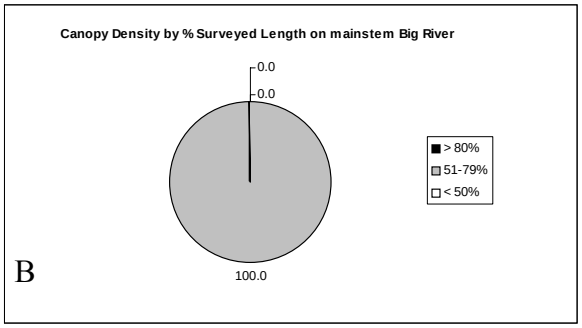


Figure 112. Canopy Density in the Middle Subbasin.

A. Tributaries. B. Mainstem Big River

Significance: Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50% by survey length is unsuitable and greater than 80% is fully suitable.

Comments: All of the surveyed tributaries within the Middle Subbasin have canopy densities greater than 50% and over 80% of the surveyed lengths have canopy densities greater than 80%. This is above the canopy density target values for salmonids. Canopy density on the mainstem Big River is lower, as is expected on a forth order stream.

Fish Passage

Table 164. Juvenile salmonid passage in the Middle Subbasin.

Feature/Function		Significance	Comments
Juvenile Summer Passage	**Juvenile Winter Refugia**	Dry channel recorded in the Middle Subbasin during stream surveys has the potential to disrupt the ability of juv3enile salmonids to forage and escape predation in three tributaries. Juvenile salmonids seek refuge from high winter flows, flood events, and cold temperatures in the winter. Intermittent side pools, back channels, and other areas of relatively still water that become flooded by high flows provide valuable winter refugia.	
0.3 Miles of surveyed channel dry	No Data		
3.5% of survey channel dry			

1993-2002 CDFG stream surveys, CDFG Appendix

Pool Shelter

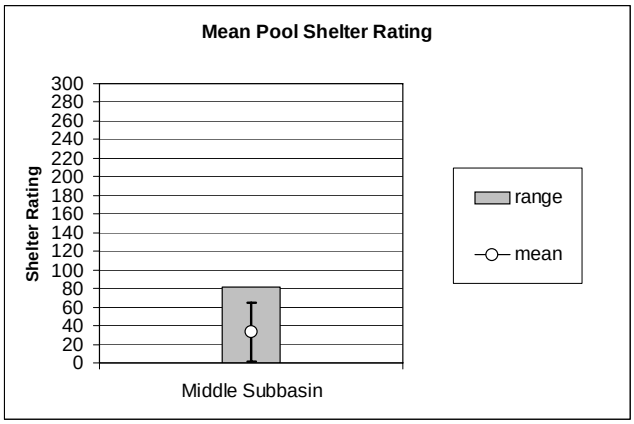


Figure 113. Pool shelter in the Middle Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described and rated in CDFG surveys.

Significance: Pool shelter provides protection from predation and rest areas from high velocity flows for salmonids. Shelter ratings of 100 or less indicate that shelter/cover enhancement should be considered.

Comments: The average mean pool shelter rating in the Middle Subbasin is 33.1. This is below the shelter target value for salmonids.

Large Woody Debris

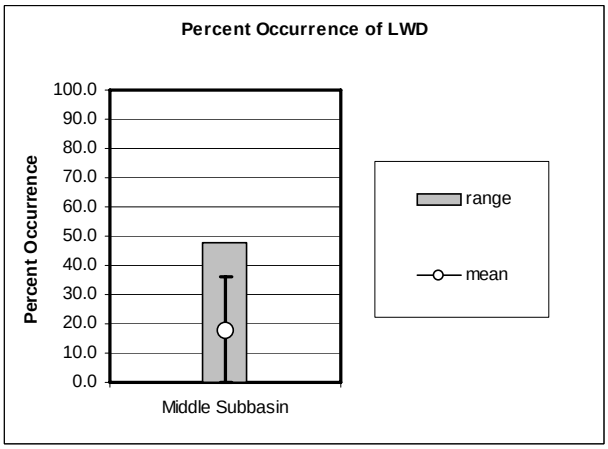


Figure 114. Large Woody Debris (LWD) in the Middle Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described in CDFG surveys. The dominant shelter type is determined and then the percentage of a stream reach in which the dominant shelter type is provided by organic debris is calculated.

Significance: Large woody debris shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids. There are currently no target values established for the percent occurrence of LWD.

Comments: A 17.9 average percent occurrence of large woody debris is low compared to the range of values recorded throughout the entire Big River Basin, which is 0 to 62. The dominant shelter types recorded in most stream reaches were boulders, large woody debris, and undercut banks.

Although instream habitat conditions for salmonids varied across the Middle Subbasin, several generalities can be made. Instream habitat conditions were generally good within this subbasin at the time of CDFG surveys. Cobble embeddedness was the most suitable for salmonids of any of the Big River Subbasins. Canopy density levels were above 50%, additionally, when surveyed reaches of the mainstem Big River were not considered, 88.5% of surveyed tributary length had canopy densities greater than 80%. However, the percentage of primary pools by survey length was generally below target values as found in CDFGs California Salmonid Stream Habitat Restoration Manual and calculated by the EMDS. Additionally, the percent occurrence of large woody debris was in the lower range of values recorded in the Big River Basin. In addition, dry channel occurred in 0.3 miles of surveyed stream (3.5% of the surveyed stream length).

Stream Reach Conditions EMDS

The anadromous reach condition EMDS evaluates the conditions for salmonids in a stream reach based upon water temperature, canopy cover, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG Stream Inventories. Currently, data exist in the Big River Basin to evaluate overall reach, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. More details of how the EMDS functions are in the EMDS Appendix. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time of individual survey.

EMDS stream reach scores were weighted by stream length to obtain overall scores for tributaries and the entire Middle Subbasin. Weighted average reach conditions on surveyed streams in the Middle Subbasin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 165, Figure 115). Suitable conditions exist for canopy across the entire subbasin. Big River from Tramway Gulch to North Fork Big River has suitable conditions for pool quality, pool depth, pool shelter, and embeddedness. Suitable conditions also exist for pool shelter in Hatch Gulch, and embeddedness in Two Log Creek.

One tributary, Two Log Creek, had four years of data, 1996, 1997, 1998, and 2002. A comparison of EMDS results from 1998 and 2002 shows an increase in the suitability of canopy, pool depth, and cobble embeddedness.

Table 165. EMDS Anadromous Reach Condition Model results for the Middle Subbasin.

Stream		Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Middle Subbasin (excluding the mainstem Big River		- (-)	U (U)	+ (++)	U (U)	- (-)	- (--)	+ (--)	- (--)	+ (-)
Kidwell Gulch		-	U	++	U	-	---	---	---	-
Two Log Creek	1998	-	U	++	U	-	--	---	--	--
	2002	-	U	+++	U	-	--	--	--	+
Saurkraut Creek (Two Log Creek Tributary)		-	U	+++	U	-	-	---	+	---
Ayn Creek (Two Log Creek Tributary)		-	U	++	U	-	--	---	-	---
Big River (Tramway Gulch to North Fork Big River)		+	U	--	U	+	++	+++	+	++
Hatch Gulch		-	U	+++	U	-	-	---	+	---

Key:
+++ ++ + Highest Suitability
U: Insufficient Data or Undetermined
- -- --- Lowest Suitability

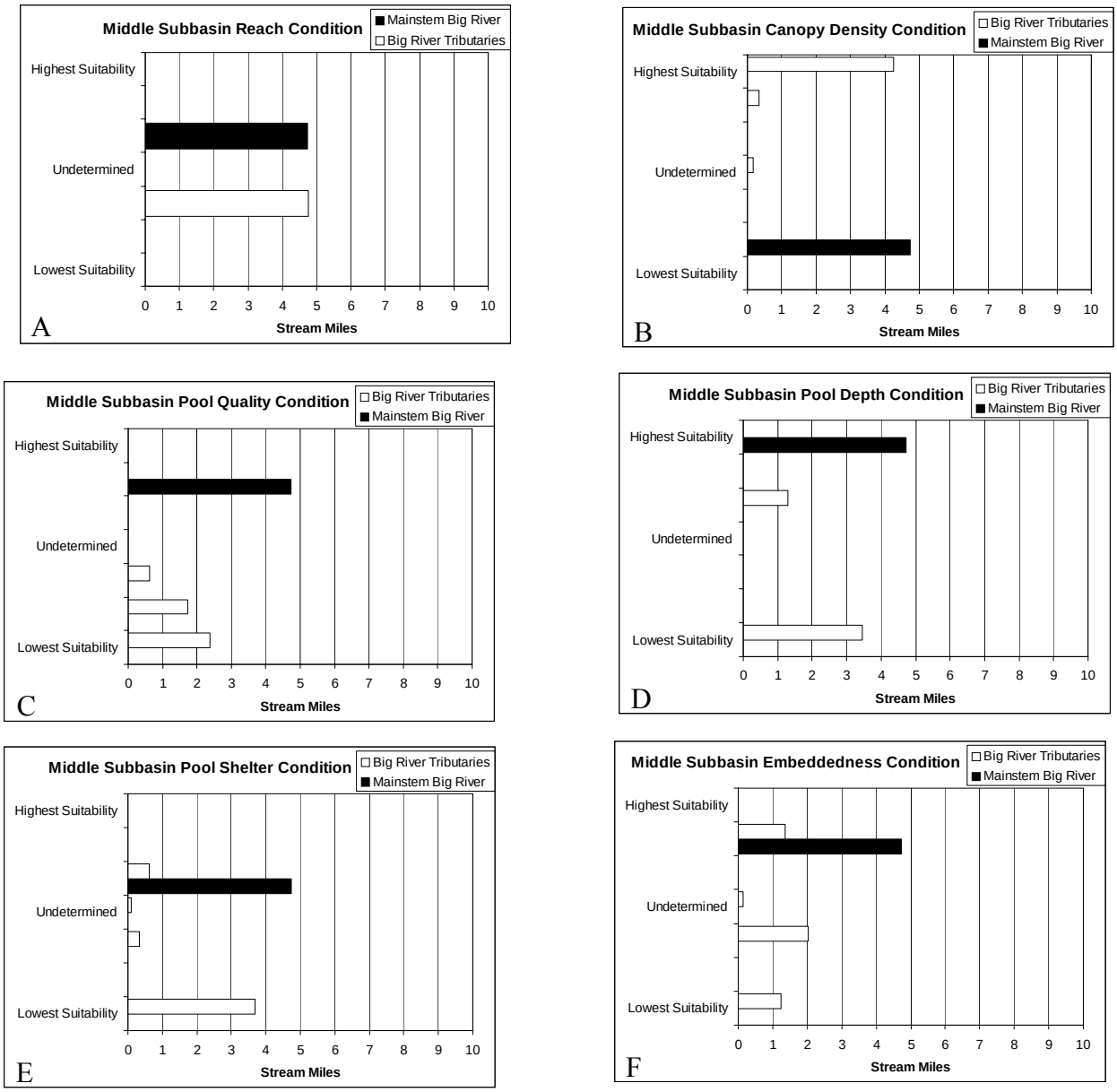


Figure 115. EMDS Reach Condition model results for the Middle Subbasin by surveyed stream miles.

In streams with multiples years of data, the most current year was used. A. Overall reach condition. B. Canopy density. C. Pool quality. D. Pool depth. E. Pool shelter. F. Cobble embeddedness.

MRC Road Hazard Map

MRC classified the roads in their ownership into three erosion hazard classes (Figure 116). MRC aimed to identify current problems, consider reconstruction, and prioritize maintenance through this process. Below is a brief summary of erosion hazard classes:

- High Road Erosion Hazard Class - Highest amount of recent deliverable surface erosion to watercourses and a high potential for future deliverable erosion;
- Moderate Road Erosion Hazard Class - Moderate amounts of recent deliverable surface erosion to watercourses and low potential for future deliverable erosion;
- Low Road Erosion Hazard Class - Low amounts of recent deliverable surface erosion to watercourses and low potential for future deliverable erosion.

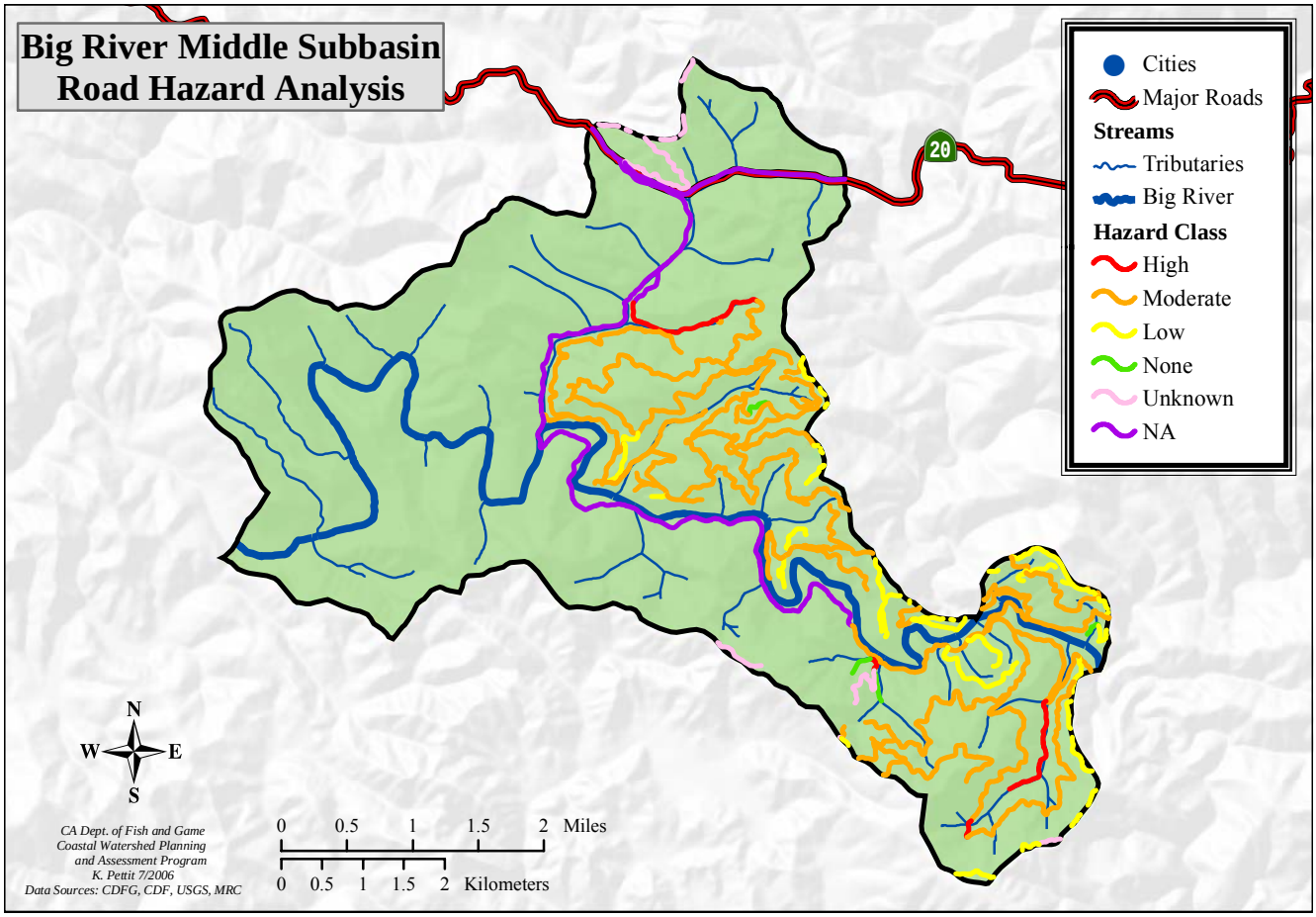


Figure 116. MRC roads erosion hazard classes in the Middle Subbasin.

Analysis of Tributary Recommendations

CDFG inventoried 9.5 miles on five tributaries and the mainstem Big River in the Middle Subbasin. A CDFG biologist selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard CDFG habitat inventories (Table 166). More details about the tributary recommendation process are given in the Big River Synthesis Section of the Watershed Profile.

Table 166. Ranked tributary recommendations summary in the Middle Subbasin based on CDFG Stream Inventories.

Stream	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
Kidwell Gulch	0.9		3			1	2		4		
Two Log Creek	3.0	2	3				1				
Sauerkraut Creek	0.1		1								
Ayn Creek	0.3										
Big River Tramway Gulch to North Fork Big River	4.7			2	1		3				
Hatch Gulch	0.5	3	4			1		5	2		

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

In order to further examine Middle Subbasin issues through the tributary recommendations given in CDFG stream surveys, the top three ranking recommendations for each tributary were collapsed into five different recommendation categories: Erosion/Sediment, Riparian/Water Temp, Instream Habitat, Gravel/Substrate, and Other (Table 167). When examining recommendation categories by number of tributaries, the most important recommendation categories in the Middle Subbasin are Erosion/Sediment and Instream Habitat.

Table 167. Top Three ranking recommendation categories by number of tributaries in the Middle Subbasin.

Target Issue	Related Table Categories	Count
Erosion/Sediment	Bank/Roads	5
Riparian/Water Temp	Canopy/Temp	2
Instream Habitat	Pool/Cover	5
Gravel/Substrate	Spawning Gravel/LDA	1
Other	Livestock/Barrier	0

However, comparing recommendation categories in the Middle Subbasin by number of tributaries could be confounded by the differences in the number stream miles surveyed on each tributary. Therefore, the number of stream miles in each subbasin assigned to the various recommendation categories was calculated (Figure 117). When examining recommendation categories by number of stream miles, the most important recommendation categories in the Middle Subbasin are Instream Habitat, Riparian/Water Temperature, and Erosion/Sediment. These comprise the top tier of recommended improvement activity focus areas.

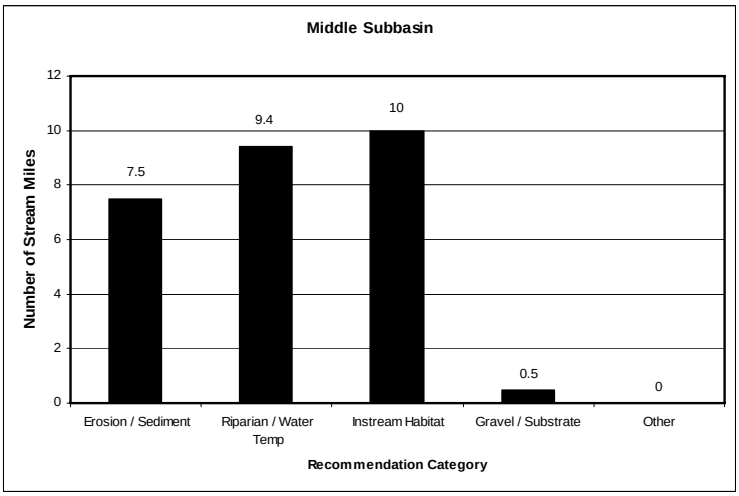


Figure 117. Recommendation categories by stream miles in the Middle Subbasin.

The high number of Instream Habitat, Riparian/Water Temp, and Erosion/Sediment recommendations across the Middle Subbasin indicates that high priority should be given to restoration projects emphasizing pools, cover, riparian replanting, and sediment reduction.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Middle Subbasin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by the NCWAPs EMDS at the stream reach scale.

The most complete data available in the Middle Subbasin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the NCWAP team.

Salmonid habitat conditions in the Middle Subbasin on surveyed streams are generally rated as medium potential refugia. Additionally, the mainstem Big River serves as a critical contributing area. The following refugia area rating table summarizes subbasin salmonid refugia conditions.

Table 168. Tributary Salmonid Refugia Area Ratings in the Middle Subbasin.

Stream	Refugia Categories*:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Big River		X				X	X
Peterson Gulch				X			X
Kidwell Gulch				X			X
Blind Gulch				X			X
Two Log Creek		X					X
Saurkraut Creek			X				X
Ayn Creek		X					X
Beaver Pond Gulch			X				X
Tramway Gulch		X					X
Hatch Gulch		X					X
Dietz Gulch				X			X
Subbasin Rating			X				X

*Ratings in this table are done on a sliding scale from best to worst. See page 45 in Program Introduction and Overview for a discussion of refugia criteria.

Responses to Assessment Questions

What are the history and trends of the sizes, range, and relative health and diversity of salmonid populations within the Middle Subbasin?

Findings and Conclusions:

- Both historic and current data are limited. Little data are available on population trends, relative health, or diversity. According to NOAA Fisheries listing investigations, the populations of salmonids have likely decreased in the Big River Basin as they have elsewhere along California and the Pacific Coast;
- Based on limited CDFG, USFWS, MRC, and HTC presence surveys and surveys documented by NMFS since the 1960s, the distributions of coho salmon and steelhead trout do not appear to have changed;
- Two tributaries and the mainstem Big River had records of coho salmon and steelhead trout since 1990. Two additional tributaries also recorded only steelhead trout.

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

Findings and Conclusions:

Erosion/Sediment

- McNeil samples in Two Log Creek indicated excessive amounts of fine material in this stream. This could indicate unsuitable conditions for salmonids.

Riparian/Water Temperature

- All of the water temperature monitoring sites on the mainstem Big River had MWATs that varied from moderately to fully unsuitable (67-70°F) with maximum daily temperatures (73-77°F) in excess of the lethal limit for salmonids. High diurnal fluctuations were also recorded (7.5-12.8°F), suggesting poor canopy and/or low flows;
- Data from lower Two Log Creek indicated water temperatures were between fully suitable, with a minimum observed MWAT of 58 F, and undetermined with a maximum observed MWAT of 64 F. However, large diurnal temperature fluctuations (6.7-12.0°F) were recorded at both lower Two Log Creek sites, which may indicate poor canopy and/or low flows;
- The only monitored tributary to Two Log Creek, Beaver Pond Gulch, had fully suitable water temperatures, but based on the thermograph, the monitoring device may have been placed in a thermally stratified pool or a site with a significant groundwater component;
- Hatch Gulch had fully suitable water temperatures with minimal diurnal fluctuations. It is likely that Hatch Gulch provides some cooling effect to the mainstem Big River;

- It is also probable that Two Log Creek has a cooling effect on the mainstem Big River. However, the magnitude of that effect is unknown as it is dependant on the temperature differentials and flows;
- Canopy cover was suitable for salmonids on all surveyed tributary reaches within this subbasin, but unsuitable on surveyed reaches of the mainstem Big River as expected on a larger order stream.

Instream Habitat

- A high incidence of shallow pools, and a lack of cover and large woody debris have contributed to a simplification of instream salmonid habitat in surveyed reaches of Kidwell Gulch, Two Log Creek, and the mainstem Big River between Tramway Gulch and the North Fork Big River;
- Areas of dry channel in Kidwell and Hatch gulches found during CDFG stream surveys may indicate fish passage problems.

Gravel Substrate

- Cobble embeddedness values in Hatch Gulch, and Saurkraut and Ayn creeks were unsuitable for salmonid spawning success. In addition, the MRC characterized spawning gravels as fair quality on all seven segments they surveyed;
- Permeability sampling in the Big River below the North Fork Big River indicated low to moderate amounts of fine material. This could indicate suitable to somewhat unsuitable conditions for salmonids.

Refugia Areas

- Salmonid habitat conditions in this subbasin on surveyed streams are generally rated as medium potential refugia;
- Two Log Creek provides the best salmonid refugia in this subbasin;
- The mainstem Big River serves as critical contributing area.

Other

- There are no water chemistry data for this subbasin.

What are the impacts of geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions in this subbasin?

Findings and Conclusions:

- Many of the tributaries in this subbasin are intermittent in their upper reaches and usually have summer and fall flows less than 1 cfs;
- This subbasin is underlain by Franciscan Coastal Belt geology and has a high percentage of area in lower slope classes;
- About 12% of the slides found across the Big River Basin and 10% of sediment delivered in the basin were in this subbasin;
- Redwood and Douglas fir forest has historically and continues to dominate this subbasin. Additional vegetation includes tan oak, madrone, alder, and blueblossom. Pre-European forests consisted of mostly large old-growth trees. Today, trees averaging 12-24 inches dbh cover 70% of the subbasin and trees averaging >24-inch dbh cover 27%.

How has land use affected these natural processes?

Findings and Conclusions:

- Two splash dams on Two Log Creek and numerous splash dams upstream of this subbasin likely greatly accelerated erosion and widened the width of the channels in Two Log Creek and the mainstem Big River in this subbasin;
- Early splash damming and barrier removal projects starting in the 1950s cleared Two Log Creek and Tramway Gulch of timber-related woody debris. The lack of instream complexity seen today likely results from these past practices;

- Construction of near stream roads throughout this subbasin and railroads along Two Log Creek constricted stream channels and destabilized streambanks;
- Roads and timber harvesting are listed in the Total Maximum Daily Loads as major sources of human-related sediment into the fluvial system. Many of the effects from these activities are spatially and temporally removed from their upland sources;
- Historic timber harvest activities reduced riparian canopy; however, canopy is currently suitable along surveyed tributary reaches in this subbasin;
- As a result of timber harvest, the current landscape is comprised of smaller diameter forest stands than in pre-European times (71% of trees in watercourse buffer zones have dbh less than 24 inches). The small diameter of near stream trees across this subbasin limits the recruitment potential of large woody debris to streams and contributes to the lack of instream habitat complexity;
- A lack of LWD also allows sediment to move more quickly through the stream system and move downstream in greater quantities than pre-disturbance.

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

- Based on the information available for this subbasin, it appears that salmonid populations are currently being limited by reduced habitat complexity, high water temperatures in the mainstem Big River, and embedded spawning gravels.

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

Recommendations:

Flow and Water Quality Improvement Activities

- Protect instream flows in Two Log Creek and Hatch Gulch for thermal refugia from the warmer mainstem Big River in the summer.

Erosion and Sediment Delivery Reduction Activities

- Continue efforts such as road improvements, and decommissioning throughout this subbasin to reduce sediment delivery to Big River and its tributaries. CDFG stream surveys indicated Kidwell Gulch, Two Log Creek, and Saurkraut Creek have road sediment inventory and control as a top tier tributary improvement recommendation.

Riparian and Instream Habitat Improvement Activities

- Where feasible, add LWD to develop habitat diversity in the mainstem channel and to increase shelter complexity for salmonids. CDFG stream surveys indicated Kidwell Gulch, Two Log Creek, and Big River from Tramway Gulch to North Fork Big River have increase escape cover as a top tier tributary recommendation;
- Ensure that this high quality habitat is protected from degradation. The highest stream reach conditions as evaluated by the stream reach EMDS and refugia analysis were found in the mainstem Big River, Two Log Creek, Ayn Creek, and Tramway and Hatch gulches.

Education, Research, and Monitoring Activities

- Continue water temperature monitoring at current locations where high temperatures have been detected on the mainstem Big River;
- In lower Two Log Creek, both MRC and HTC have temperature monitoring sites in nearly the same location. It may be more effective if one company monitored the site and shared the information with the other while the second monitoring device is deployed at another location.

Subbasin Conclusions

The Middle Subbasin represents a transition zone between the Coastal and Inland subbasins - moving from a heavily marine influenced climate and gentler slopes to larger temperature fluctuations throughout the year and

steeper slopes. Although this subbasin is small, just under 10% of the land mass of the Big River Basin, it contains Two Log Creek, an important fish-bearing tributary. Salmon and steelhead habitat conditions in the Middle Subbasin are generally degraded, but support some salmonid production.

This subbasin appears to be impacted by reduced habitat complexity, high water temperatures in the mainstem Big River, and embedded spawning gravels. In addition, this subbasin has a comparatively dense network of roads that provide potential sources of fine sediment input to streams. Historical accounts indicate that stream conditions were favorable for salmonids in the past and certain habitat factors remain favorable in some of the tributaries. Accordingly, there are opportunities for stream improvements and a need to restore areas of stream refugia. Examples of habitat improvement activities include increasing channel complexity, monitoring stream temperatures, road improvements and erosion proofing, and mitigation of stream bank erosion. The natural variability of stability and erodability of the geologic terrains should be considered before project implementation and appropriate best management practices should be followed to minimize erosion and sediment delivery to streams. Current landowners and managers interested and motivated to eliminate impacts related to land use and accelerate a return to the stable, beneficial conditions for salmonids are encouraged to do so, enlisting the aid and support of agency technology, experience, and funding opportunities.