Inland Subbasin

Upper South Fork Big River Watershed, Photo by Bill Lydgate in KRIS. May 2001

The Inland Subbasin includes the entire watershed area of the North Fork Big River, South Fork Big River, and the entire watershed area of the Big River above the confluence with the South Fork Big River (Figure 118). Stream elevations range from 200 feet at the confluence of the mainstem Big River with North Fork Big River to approximately 1300 feet in the headwaters of the tributaries. The highest point in the subbasin is Irene Peak at 2,836 feet. The subbasin encompasses 130.8 square miles, occupying 72.2% of the total basin area. Most of the subbasin is owned by MRC, Strategic Timber Trust, and JDSF and is managed for timber production. There are also a large number of smaller privately owned parcels near the western border and the small hamlet of Orr Springs lies near the headwaters of the South Fork Big River.

Climate

The Inland Subbasin has average annual rainfalls ranging from 45 inches in lower elevations to 65 inches at higher elevations and towards the northeastern border. The wettest part of the subbasin is the North Fork drainage. Temperatures are typically cooler in the winters and warmer in the summers than in coastal areas. Temperatures range from below freezing to over 90°F seasonally and average 40-51°F.

Hydrology

The Inland Subbasin is made up of 12 CalWater Units (Figure 118). There are 144.4 perennial stream miles in 58 perennial tributaries in this subbasin (Table 169). There are an additional 15.7 miles of the mainstem Big River. North Fork Big River, Chamberlain Creek, South Fork Big River, Daugherty Creek, and the mainstem Big River below the confluence with South Fork Big River are third order streams using the Strahler (1964) classification. The other tributaries and the mainstem Big River above the confluence with South Fork Big River are first and second order streams. Drainage areas range from less than one square mile to over 50 square miles for the South Fork Big River (Figure 119).

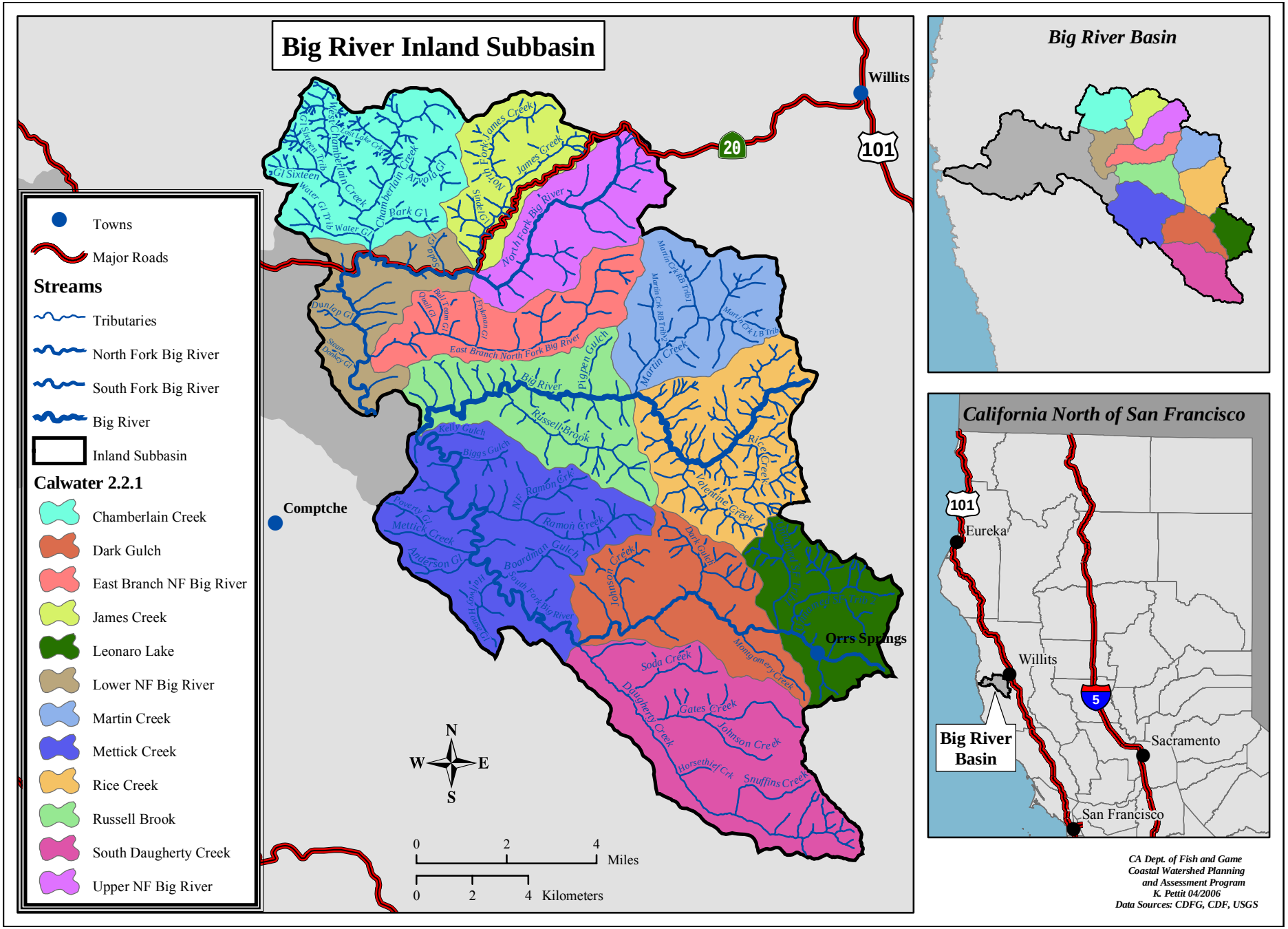


Figure 118. Inland Subbasin and CalWater 2.2a planning watersheds.

Table 169. Tributaries to the Big River in the Inland 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
	30.9	L	North Fork Big River	17.2	0.6	3
East Branch North Fork			East Branch North Fork Big River	7.4	1.4	1
Chamberlain Creek			Chamberlain Creek	6.0		3
			Water Gulch	1.2	1.2	1
			Water Gulch Tributary		1.0	Intermittent
			Park Gulch	0.8	0.6	1
			West Chamberlain Creek	4.0	0.1	2
			Gulch Sixteen	1.8	1.0	1
			Gulch Sixteen Tributary	2.4	0.1	1
			Arvola Gulch	1.2	0.9	1
			Unnamed Tributary to Chamberlain Creek/Lost Lake Creek	0.3	1.0	1
Lower North Fork Big River			Unnamed Tributary to North Fork Big River/Soda Gulch	1.1		1
James Creek			James Creek	2.8	2.8	2
			Sindel Gulch	0.8	0.3	1
			North Fork James Creek		3.6	Intermittent
	32.4	R	South Fork Big River	23.6	2.0	3
Mettick Creek			Kelly Gulch	1.2		1
			Biggs Gulch	0.1	1.2	1
			Ramon Creek	4.8		2
			North Fork Ramon Creek	2.1	0.3	2
			Bowman Gulch		1.1	Intermittent
			Mettick Creek	2.4		1
			Poverty Gulch	1.1	0.3	1
			Anderson Gulch	1.8	0.2	1
			Boardman Gulch	2.5	0.2	1
			Halfway House Gulch	1.5	0.6	1
South Daugherty Creek			Daugherty Creek	7.7	2.3	3
			Soda Creek	1.0	1.9	1
			Gates Creek	3.1	1.7	2
			Johnson Creek	1.9	0.3	1
			Horse thief Creek		1.0	Intermittent
			Snuffins Creek	2.0	0.9	1
Dark Gulch			Johnson Creek	2.4	0.3	1
			Dark Gulch	0.5	2.1	1
			Montgomery Creek	2.1	0.6	1
Leonaro Lake			Unnamed Tributary South Fork Big River #1		3.3	Intermittent
			Unnamed Tributary South Fork Big River #2		3.3	Intermittent
Russell Brook	33.4	L	Unnamed Tributary		0.7	Intermittent
	33.4	L	Unnamed Tributary	1.0	0.3	1
	34.0	L	Unnamed Tributary	1.2	0.2	1
	35.1	L	Unnamed Tributary	1.1		1
	35.6	L	Unnamed Tributary	0.6	0.2	1
	35.7	L	Unnamed Tributary	0.5	0.1	1
	36.0	R	Russell Brook	4.8	0.2	2
	36.3	L	Unnamed Tributary	0.4		1
	36.9	L	Unnamed Tributary	0.6		1
	37.3	L	Unnamed Tributary	0.6		1
	37.3	R	Unnamed Tributary		0.6	Intermittent
	37.7	L	Unnamed Tributary		0.7	Intermittent
	38.0	R	Unnamed Tributary		0.4	Intermittent
	38.5	R	Unnamed Tributary		0.4	Intermittent
	38.9	L	Pigpen Gulch	1.0	0.9	1
	39.0	R	Unnamed Tributary		1.0	Intermittent
	39.7	L	Unnamed Tributary		0.5	Intermittent
	39.8	R	Unnamed Tributary		0.7	Intermittent
Martin Creek	40.1	L	Martin Creek	5.2	0.2	1
			Martin Creek Right Bank Tributary #2	0.4	1.4	1
			Martin Creek Right Bank Tributary #1	3.2		1
			Martin Creek Left Bank Tributary		1.6	Intermittent
	40.7	L	Unnamed Tributary		0.6	Intermittent

CalWater Planning Watershed	R.M.	Bank (L,R)	Stream	Perennial (Miles)	Intermittent (Miles)	Stream Order
	40.9	L	Unnamed Tributary	1.2	0.3	1
	41.0	R	Unnamed Tributary		0.5	Intermittent
	41.4	L	Unnamed Tributary		1.1	Intermittent
	41.7	L	Unnamed Tributary	0.6	0.1	1
	42.1	R	Unnamed Tributary		0.7	Intermittent
	42.4	R	Unnamed Tributary		0.6	Intermittent
	42.6	L	Unnamed Tributary	0.5	0.2	1
	42.8	R	Unnamed Tributary		0.3	Intermittent
	42.9	L	Unnamed Tributary		1.1	Intermittent
Rice Creek	43.0	R	Valentine Creek	4.5	0.3	1
	43.3	L	Unnamed Tributary		0.6	Intermittent
	43.5	R	Unnamed Tributary		0.4	Intermittent
	43.9	R	Unnamed Tributary	0.6	0.2	1
	44.1	R	Unnamed Tributary	0.4	0.1	1
	44.2	L	Unnamed Tributary	0.5	0.1	1
	44.6	R	Rice Creek	2.8	0.3	1
	44.6	L	Unnamed Tributary		0.4	Intermittent
	44.7	L	Unnamed Tributary		0.4	Intermittent
	44.8	L	Unnamed Tributary	1.1	0.4	1
	45.5	R	Unnamed Tributary	0.4	0.1	1
	45.6	L	Unnamed Tributary		0.5	Intermittent
	45.7	L	Unnamed Tributary		0.5	Intermittent
	46.0	L	Unnamed Tributary		0.4	Intermittent
	46.2	R	Unnamed Tributary	0.6	0.1	1
	46.4	R	Unnamed Tributary	0.9	0.3	1
	46.8	L	Unnamed Tributary	0.4	0.3	1
	47.0	L	Unnamed Tributary		0.3	Intermittent
	47.2	L	Unnamed Tributary		0.2	Intermittent
	47.6	L	Unnamed Tributary	0.3	0.2	1

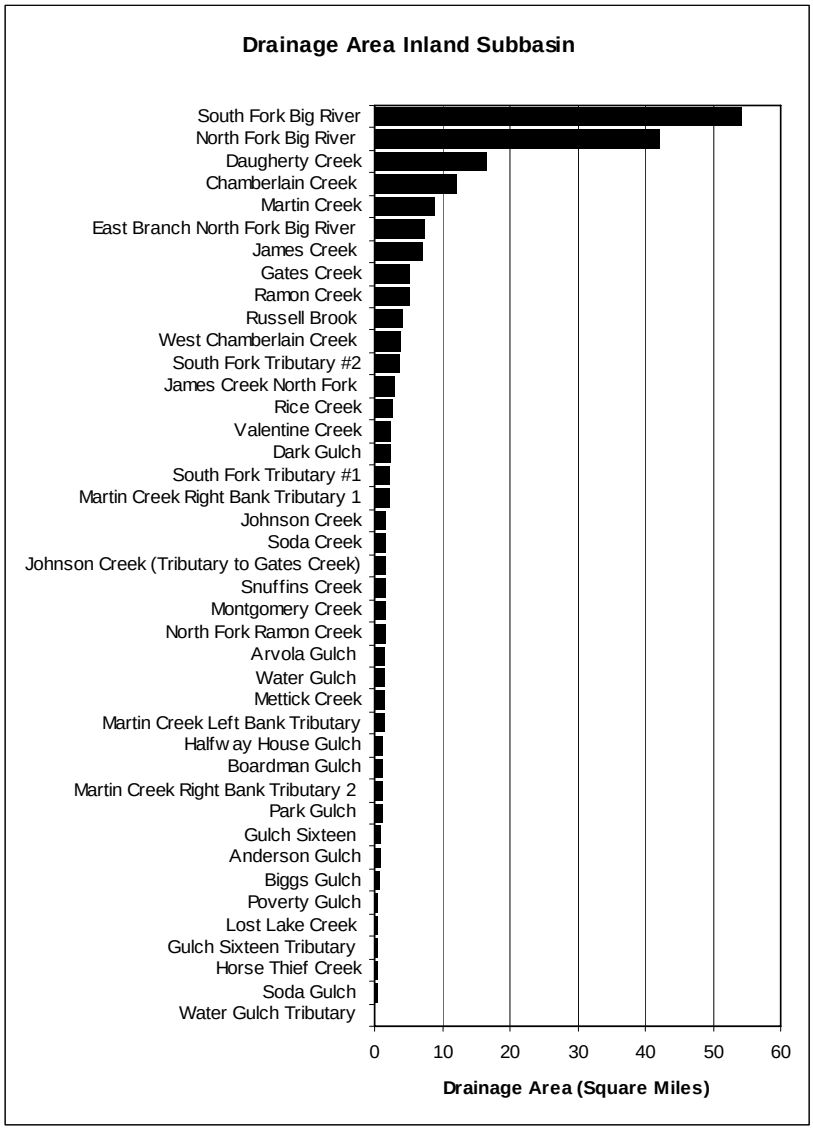


Figure 119. Drainage area of streams surveyed by CDFG in the Inland Subbasin.

Geology

The Inland Subbasin has a high percentage of area in higher slope classes. The Upper Mainstem Big PW has noticeably steeper slopes than the other PWs, with 49.1% of its slopes exceeding 50%, and 17.5% exceeding 70%. The Chamberlain Creek, Upper North Fork Big, Martin Creek, Daugherty Creek, and Middle South Fork PWs all have 36-40% of their slopes in excess of 50% (GMA 2001a).

The subbasin is underlain by rocks of the Coastal Belt Franciscan in the western part and Central Belt Franciscan in the eastern edge with a section of Tertiary age sandstone in the Greenough Ridge – Montgomery Woods State Park area.

Landsliding

A GMA (2001) analysis of landslides by time period found that about 81% of the number of slides across the entire basin were in the Inland Subbasin. The high percentage is due to the fact that this subbasin has over half of the area of the basin. The South Daugherty Creek PW had the highest number of slides in the subbasin, with the Rice Creek and Mettick Creek PWs second and third highest, respectively. The entire South Fork drainage was a high producer of landslides, producing 36% of all slides mapped in the entire Big River Basin. The period from 1937 to 1952 had the highest number of landslides.

Table 170. Inland Subbasin number of delivering slides by study period and PW.

Planning Watershed	1937-1952		1953-1965		1966-1978		1979-1988		1989-2000		Total All Periods	
	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)
Upper North Fork Big River	31	4.3	16	2.7	9	4.6	16	7.4	9	4.3	81	4.2
James Creek	28	3.9	45	7.5	13	6.6	15	6.9	8	3.8	109	5.6
Chamberlain Creek	70	9.8	59	9.8	17	8.6	10	4.6	12	5.7	168	8.7
East Branch North Fork Big	39	5.4	20	3.3	10	5.1	9	4.2	17	8.1	95	4.9
Lower North Fork Big River	51	7.1	33	5.5	3	1.5	6	2.8	7	3.3	100	5.2
Leonaro Lake	52	7.3	24	4.0	9	4.6	9	4.2	7	3.3	101	5.2
Dark Gulch	48	6.7	91	1.5	25	12.7	18	8.3	20	9.5	202	10.4
South Daugherty Creek	90	12.6	119	19.8	33	16.8	58	26.9	36	17.1	336	17.3
Mettick Creek	86	12.0	61	10.1	24	12.2	15	6.9	44	21.0	230	11.8
Rice Creek	128	17.9	90	15.0	26	13.2	34	15.7	11	5.2	289	14.9
Martin Creek	41	5.7	25	4.2	16	8.1	14	6.5	16	7.6	112	5.8
Russell Brook	52	7.3	19	3.2	12	6.1	12	5.6	23	11.0	118	6.1
Inland Subbasin	**716**	**36.9**	**602**	**31.0**	**197**	**10.1**	**216**	**11.1**	**210**	**10.8**	**1941**	**100**

GMA 2001a

Landslide volume estimates from the same time periods showed that 82.7% of sediment delivered to streams across the Big River Basin occurred in the Inland Subbasin (GMA 2001a) (Table 171). The highest volumes of sediment in this subbasin were delivered in the Chamberlain Creek PW.

Table 171. Volume of delivering slides by study period by PW in the Inland Subbasin.

Subbasin	1937-1952		1953-1965		1966-1978		1979-1988		1989-2000		Total	
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	(%f or Entire Watershed For Entire Period)
Upper North Fork Big River	37,093	1.1	29,175	1.6	10,906	3.9	39,165	8.9	8,164	2.4	124,503	1.6
James Creek	144,596	4.3	116,547	6.4	20,580	7.4	53,885	12.2	2,535	0.7	338,143	4.5
Chamberlain Creek	804,189	23.7	222,892	12.3	28,398	10.2	9,666	2.2	12,200	3.6	1,077,345	14.2
East Branch North Fork Big	137,107	4.0	70,162	3.9	17,748	6.4	44,179	10.0	24,765	7.3	293,961	3.9
Lower North Fork Big River	120,861	3.6	73,891	4.1	2,424	0.9	8,881	2.0	6,900	2.0	212,957	2.8
Leonaro Lake	828,480	24.4	69,078	3.8	14,494	5.2	40,489	9.2	16,365	4.8	968,906	12.8
Dark Gulch	95,223	2.8	288,421	15.9	31,898	11.4	18,120	4.1	17,304	5.1	450,966	6.0
South Daugherty Creek	359,000	10.6	320,909	17.7	19,781	7.1	90,227	20.4	40,900	12.0	830,817	11.0
Mettick Creek	207,219	6.1	124,382	6.9	45,865	16.4	20,331	4.6	56,836	16.7	454,633	6.0
Rice Creek	403,490	11.9	271,868	15.0	34,857	12.5	54,666	12.4	65,068	19.1	829,949	11.0
Martin Creek	123,057	3.6	188,716	10.4	42,901	15.4	32,005	7.2	47,655	14.0	434,334	5.7
Russell Brook	134,826	4.0	37,411	2.1	9,352	3.3	30,082	6.8	42,558	12.5	254,229	3.4
Total	**3,395,141**	**54.1**	**1,813,452**	**28.9**	**279,204**	**4.5**	**441,696**	**7.0**	**341,250**	**5.4**	**6,270,743**	**82.7**

GMA 2001a

The CGS (2005) landslide potential map classified 62% of the Inland Subbasin in the high and very high potential categories (Table 172).

Table 172. Landslide Potential in the Inland Subbasin.

Landslide Potential Category	Area (square miles)	% of Subbasin
Very Low	3.8	3
Low	20.9	16
Moderate	24.4	19
High	60.7	46
Very High	21.1	16

MRC Ownership

During MRC's Watershed Analysis, a total of 1,290 landslides were identified in the MRC ownership of the Inland Subbasin. Of that total, 884 were shallow-seated landslides (debris slides, torrents, or flows) and 406 were deep-seated landslides (rockslides) (Table 173). The Mettick Creek PW had the most shallow-seated landslides and most of these occurred in the 1970s. Over the whole MRC ownership in the subbasin, most landslides in the study period occurred in the 1990s.

Table 173. Shallow-seated landslide summary for lands under MRC ownership in the Inland Subbasin.

PW	Number of Landslides			
	1970s	1980s	1990s	Total
East Branch North Fork Big River	13	22	31	66
Rice Creek	6	1	6	13
Lower North Fork Big River	17	24	18	59
Mettick Creek	159	117	137	413
Dark Gulch	6	1	1	8
Russell Brook	27	45	83	155
South Daugherty	36	35	99	170
Total	**264**	**245**	**375**	**884**

MRC 2003

The majority of landslides in the MRC ownership are debris slides and rockslides. Only about 6% of shallow landslides observed were debris flows and debris torrents while none were earth flows (Table 174).

Table 174. Percent of landslides by type and PW for lands under MRC ownership in the Inland Subbasin.

PW	Debris Slides	Debris Torrents	Debris Flows	Rockslides	Earth Flows
East Branch North Fork Big River	47%	2%	4%	47%	0%
Rice Creek	7%	0%	0%	24%	0%
Lower North Fork Big River	73%	0%	1%	25%	0%
Mettick Creek	64%	3%	3%	30%	0%
Dark Gulch	54%	0%	8%	38%	0%
Russell Brook	57%	3%	7%	33%	0%
South Daugherty	67%	3%	2%	29%	0%
Total	**62%**	**2%**	**4%**	**31%**	**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 87% of the shallow-seated landslides within their ownership in the Inland Subbasin delivered sediment to a watercourse. A total of 628,226 tons of mass wasting sediment delivery was estimated for the study period, or 394 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. Within their ownership in the Inland Subbasin, the highest sediment delivery rate was in the Mettick Creek PW.

Fluvial Geomorphology

The North Fork of the Big River was the least impacted of the major channels studied in photo years 1984 and 2000. Only 8.3% (1984) and 7.6% (2000) of the blue-line stream length was impacted in the two photo years.

The South Fork of the Big River improved between photo years. In 1984, nearly 19% of the blue-line stream length was impacted; in photo year 2000, less than 12% of the length of blue line stream was impacted.

Daugherty Creek, a tributary to the South Fork of the Big River, showed the greatest improvement in channel conditions between photo years 1984 and 2000. A higher proportion of this stream contains steeper channel gradients than the other major channels described above. Daugherty Creek's blue-line stream length is about 8.7 miles. The gradient of lower Daugherty Creek ranges from 0.1% up to 2%; middle Daugherty Creek ranges from 1% to 4% in gradient; and upper Daugherty Creek is steeper than 4% and the headwaters are steeper than 10%.

In 1984, nearly 24% of the length of Daugherty Creek was impacted by stream disturbance features, including parts of the headwaters channel, with a gradient above 10%. This suggests recent disturbance, probably in 1983. In photo year 2000 less than 6% of the blue-line channel was impacted, mostly in the lower half of the tributary in reaches having gradients below 4%.

Out of 73 stream reaches surveyed by CDFG in the Inland Subbasin, the most common Rosgen channel types was F4 (Table 175) There were 17 different channel types present.

Table 175. Channel types in surveyed streams of the Inland Subbasin.

Stream	Reach	Survey Length (Miles)	Channel Type
North Fork Big River	1	7.1	F4
	2	3.5	F4
	3	1.4	F4
East Branch North Fork Big River	1	6.6	B4
	2	0.8	A4
Chamberlain Creek	1	1.5	F4
	2	3.6	F4
Water Gulch	1	1.0	B4
	1	0.9	E4
Water Gulch Tributary	1	0.4	B4
Park Gulch	1	1.0	F4
West Chamberlain Creek	1	3.3	F4
	1	0.2	A4
Gulch Sixteen	1	0.8	F4
	2	0.1	F4
Gulch Sixteen Tributary	1	0.4	F4
Arvola Gulch	1	0.9	F4
Lost Lake Creek	1	0.9	G4
Soda Gulch	1	0.7	G3
James Creek	1	2.8	F3
	2	1.6	F3
James Creek North Fork	1	2.4	F4
South Fork Big River Part 1	1	6.3	F3
	2	5.4	F3
South Fork Big River Part 2	1	3.5	C3
	2	3.3	F3
	3	1.2	B1
	4	0.8	C2
Biggs Gulch	1	0.5	F4
Ramon Creek	1	1.6	B4
	2	1.4	F3
	3	0.9	B3
North Fork Ramon Creek	1	1.5	F4
Mettick Creek	1	1.0	B4
Poverty Gulch	1	0.1	E3
Anderson Gulch	1	0.5	F3
Boardman Gulch	1	1.2	B4
	2	<0.1	B3
Halfway House Gulch	1	0.2	F4
Daugherty Creek	1	0.8	B4
	2	2.7	F4
	3	2.5	F3
	4	2.0	F2
	5	0.8	A3
Soda Creek	1	0.6	B4
	2	0.1	F4
	3	0.6	B4
	4	0.4	G4
Gates Creek	1	0.2	F4
	2	2.2	B4
	3	0.3	A4
Johnson Creek (Tributary to Gates Creek)	1	0.4	B4
	2	0.1	F4
	3	0.7	G4
Horse Thief Creek	1	0.1	F4
Snuffins Creek	1	1.3	G4
Johnson Creek	1	0.9	F4
Dark Gulch	1	1.4	B3
Montgomery Creek	1	0.2	F2
	2	0.1	B2
	3	0.4	F6
Unnamed Tributary 1 to South Fork Big River	1	0.7	F3
	2	0.1	B2
	3	0.3	B4
Unnamed Tributary 2 to South Fork Big River	1	0.6	C4
Russell Brook	2	4.1	B3
Martin Creek	1	3.5	B2
	1	0.2	F2
Martin Creek Left Bank Tributary	1	0.6	B3
Martin Creek Right Bank 1 Tributary	1	1.5	B3
Martin Creek Right Bank 2 Tributary	1	0.6	B4
Valentine Creek	1	1.8	B3
Rice Creek	1	1.8	F4

Of the 37 stream segments surveyed by MRC in this subbasin, the most common Rosgen channel type was F4 (Table 176). There were nine 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. MRC also established five long term monitoring stations where thalweg profiles, cross sections, and particle size distribution will be studied over time. These sites are on the mainstem Big River, East Branch North Fork Big River, Ramon Creek, Daugherty Creek, and South Fork Big River.

Table 176. Channel types in streams surveyed by the MRC on their ownership in the Inland Subbasin.

Stream	Segment ID	Survey Length (Miles)	Channel Type
East Branch North Fork Big River	BE1	0.2	F4
	BE2	0.1	F4
Bull Team Gulch	BE8	0.0	G4
Frykman Gulch	BE14	0.0	B4
Big River in Rice Creek PW	BI1	0.2	F4
North Fork Big River	BL1	0.2	F4
	BL3	0.2	F4
Steam Donkey Gulch	BL7	0.0	A1
Dunlap Gulch	BL12	0.1	A3
South Fork Big River	BM1	0.2	F4
	BM3	0.2	F4
	BM5	0.2	F4
Ramon Creek	BM25	0.1	F4
	BM26	0.1	F4
	BM27	0.1	F4
North Fork Ramon Creek	BM31	0.1	F4
	BM32	0.1	G4,B4
Mettick Creek	BM54	0.1	G1
	BM55	0.1	
Boardman Gulch	BM59	0.0	A3,A1,G4
Halfway House Gulch	BM64	0.1	A1,A4,G4
South Fork Big River Tributary	BM76	0.0	F4,G4
Big River in Russell Brook PW	MR1	0.2	F4
	BR2	0.2	F4
	BR4	0.2	F4
Russell Brook	BR5	0.1	B4,G4
	BR6	0.1	F4,G4
	BR7	0.1	G4,F4
Wildhorse Gulch	BR9	0.1	
Pig Pen Gulch	BR29	0.0	G4
Daugherty Creek	BS1	0.2	F4
	BS3	0.1	G3,B3
	BS5	0.1	B4,G4
Soda Creek	BS15	0.1	G4
Gates Creek	BS23	0.1	G3,B3
Johnson Creek	BS24	0.1	B4,G4
Snuffins Creek	BS49	0.1	G4

MRC 2003

Vegetation

Redwood-Douglas-fir forests cover 68% of the Inland Subbasin, with the remainder made up mostly of Douglas-fir, grass, oak, bay laurel, tan oak, madrone, and alder (Table 177). The North Fork drainage has the most acres of Redwood-Douglas-fir forest and the upper drainage has the most Douglas-fir forest. Oak, bay laurel, and grasslands are concentrated in the South Fork and upper drainages. Sixty-five percent of tree stands are composed of small trees (Table 178) and just under half of the subbasin is covered by trees with 90% crown canopy density (Table 179). Seven percent of the basin has no canopy cover. The North Fork drainage has more tree stands composed of medium/large trees and less areas with no canopy cover than the other two drainages within the subbasin. The upper drainage has the least amount of area covered by 90% canopy density.

Table 177. Acreage and proportion of area of vegetation classes in the Inland Subbasin.

Class	North Fork		South Fork		Upper		Inland	
	Acres	%	Acres	%	Acres	%	Acres	%
Redwood - Douglas-fir	23,971	86	21,684	63	11,238	54	56,893	68
Douglas-Fir	1,855	7	4,952	14	4,184	20	10,991	13
Tan Oak, Madrone, Alder	1,359	5	1,661	5	1,501	7	4,521	5
White, Black or Live Oak & Bay Laurel	253	1	2,881	8	2,122	10	5,256	6
Blueblossom Ceanothus			50	0	12	0	62	0
Manzanita, Chamise, Scrub Oak	98	0	516	1	557	3	1,171	1
Bishop Pine, Pygmy Cypress, Willow								
Grass	304	1	3,105	9	1,340	6	4,749	6
Wet Meadows								
Water								
Barren / Rock			10	0	30	0	40	0
Urban/Developed								
Totals	**27,840**	**100%**	**34,859**	**100%**	**20,984**	**100%**	**83,683**	**100%**

Table 178. Vegetation size classes in the Inland Subbasin by planning watershed.

PW	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	%
Chamberlain Creek		0	52	0.7	3,687	47	4,003	51	107	1.4
East Branch North Fork Big River	6	0.1	201	4	3,669	72.7	1,173	23.2		0
James Creek		0	95	2.1	3,083	69.2	1,273	28.6	3	0.1
Lower North Fork Big River		0	104	2.1	2,489	50.4	2,222	45	128	2.6
Upper North Fork Big River		0	266	5.2	3,543	68.9	1,309	25.5	22	0.4
Dark Gulch	50	0.8	480	7.8	3,543	57.3	1,720	27.8	391	6.3
Leonaro Lake	34	1	389	11.2	1,946	55.8	1,015	29.1	102	2.9
Mettick Creek	9	0.1	497	4.3	8,634	74.5	2,445	21.1		0
South Daugherty Creek	57	0.6	1,094	11	7,266	73.2	1,486	15	24	0.2
Martin Creek	55	1	766	14.4	3,400	64	1,065	20.1	25	0.5
Rice Creek	218	3.1	716	10.2	4,687	67	1,362	19.5	9	0.1
Russell Brook	47	0.7	311	4.6	4,816	71.4	1,566	23.2	1	0
Total Inland	**476**	**1**	**4971**	**6**	**50763**	**65**	**20639**	**27**	**812**	**1**

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

Table 179. Density of vegetation in the Inland Subbasin by planning watershed.

PW	Percent Crown Canopy Density										Total Acres
	0%		10-69%		70%		80%		90%		
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
Chamberlain Creek	12	0	57	1	1,851	24	1,105	14	4,836	62	7,863
East Branch North Fork	107	2	371	7	958	19	1,169	23	2,552	49	5,156
James Creek	1	0	144	3	760	17	1,423	32	2,128	48	4,456
Lower North Fork	7	0	146	3	905	18	923	19	2,969	60	4,950
Upper North Fork	275	5	711	13	840	16	1,479	27	2,112	39	5,416
Dark Gulch	966	14	638	9	822	11	931	13	3,793	53	7,151
Leonaro Lake	1,840	35	1,276	24	490	9	722	14	998	19	5,325
Mettick Creek	139	1	716	6	1,577	13	2,001	17	7,292	62	11,724
South Daugherty Creek	733	7	952	9	1,469	14	1,860	17	5,645	53	10,659
Martin Creek	629	11	1,264	21	681	11	1,311	22	2,056	35	5,940
Rice Creek	1,041	13	1,026	13	1,323	16	1,688	21	2,953	37	8,033
Russell Brook	270	4	460	7	1,304	19	1,397	20	3,579	51	7,011
Total Inland	**6,020**	**7**	**7,761**	**9**	**12,980**	**16**	**16,009**	**19**	**40,913**	**49**	**83,684**

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 Inland Subbasin, with larger bands of very high fuel rank along the border of the North Fork and upper drainages, through the middle of the upper drainage, and along the southern border of the subbasin. The 1931 Comptche fire burned 4,234 acres in the southern part of the subbasin and the 1950 Irene Peak fire burned 6,929 acres in the eastern part. A 1951 fire burned 322 acres in the JDSF and a smaller 2003 fire burned 10 acres near the northern border.

Land Use

The Inland Subbasin is composed mostly of large sized parcels owned by JDSF, MRC, Strategic Timber Trust, and Weger Timber Company. Smaller parcels cluster around the western boundary near town of Willits and the hamlet of Orr Springs.

Montgomery Woodlands State Reserve makes up an additional 3% of the subbasin. The reserve started with a nine-acre donation by Robert Orr in 1945, and has since been enlarged to 1,142 acres by purchases and donations from the Save-The-Redwoods League. The reserve includes 700 acres of redwood trees and many trails. It has excellent groves of both a magnificent old-growth coastal redwood grove and a fern forest. A recent land acquisition by the Save the Redwoods League will double the size of the park, adding 1,240 acres (Geneilla 2006).

The Pacific Forest Trust holds a conservation easement on 4,000 acres along the western border of the Big River Basin called the Leonard Lake Preserve. The preserve straddles four to five miles of the watershed boundary and about 33% of it lies within the Big River Basin. The conservation easement allows for a limited amount of timber harvest, maintenance of existing roads, and some horse grazing. The land cannot be further developed, however.

Cattle and sheep grazing were historically common in the grassland areas within the subbasin and still occur in some areas.

Forest Management

May 6, 1885 Alfred R. Johnston granted a land patent for 160 acres of timberland on Daugherty Creek. (In his 20 years on the upper South Fork, he was to establish 7 known logging camps, and built or operated 7 logging dams).

Timber harvesting has played an important role in the history of the Inland Subbasin for the past 250 years. Harvests increased dramatically in the post World War II years and have increased again since 1973 (Table 180). Timber harvest in the upper drainage has been especially high recently, with 50.4% of the drainage harvested from 1993 to 2001. MRC, Strategic Timber Trust, and Weger currently own 62% of the subbasin.

Table 180. Timber harvest in the Inland Subbasin.

Time Period	North Fork		South Fork		Upper		Inland Subbasin	
	Acres Harvested	Percent of Subbasin Harvested	Acres Harvested	Percent of Subbasin Harvested	Acres Harvested	Percent of Subbasin Harvested	Acres Harvested	Percent of Subbasin Harvested
1852-1944	5,884	21.1	6,760	19.4	1,912	9.1	14,556	17.4
1945-1964	12,418	44.6	7,389	21.2	10,060	47.9	29,867	35.7
1965-1974	8,917	32.0	2,410	6.9	2,765	13.2	14,092	16.8
1975-1984	13,434	48.3	4,422	12.7	3,736	17.8	21,592	25.8
1985-1992	5,427	19.5	5,054	14.5	6,057	28.9	16,538	19.8
1993-2001	6,041	21.7	7,323	21.0	10,567	50.4	23,931	28.6
Total	**49,122**		**33,359**		**35,097**		**117,578**	

Early timber harvest activities across the subbasin consisted of clear cuts and fire, while most recent harvests are single or group tree selections, shelterwood removal, seed tree removal, commercial thinning, and alternative prescription (Figure 120). Many acres of the subbasin underwent conversion from 1945 to 1964. Use of fire for harvesting was largely concentrated in the South Fork drainage prior to 1944 and the upper drainage from 1945-1964. Seed tree seed cut harvest was used more often in the North Fork drainage from 1945 to 1975 than the other drainages.

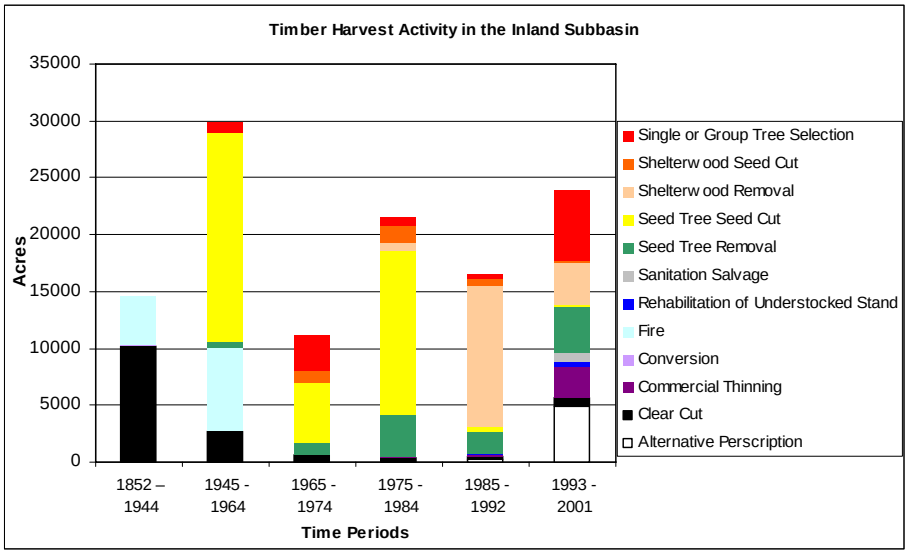


Figure 120. Acres of timber harvest activities in the Inland Subbasin.

Yarding methods have also changed over time, from predominantly cable ground and fire before World War II to tractor yarding in the post war years, and increasing cable suspended and helicopter since 1975 (Figure 121). Helicopter yarding has been concentrated in the South Fork and upper drainages.

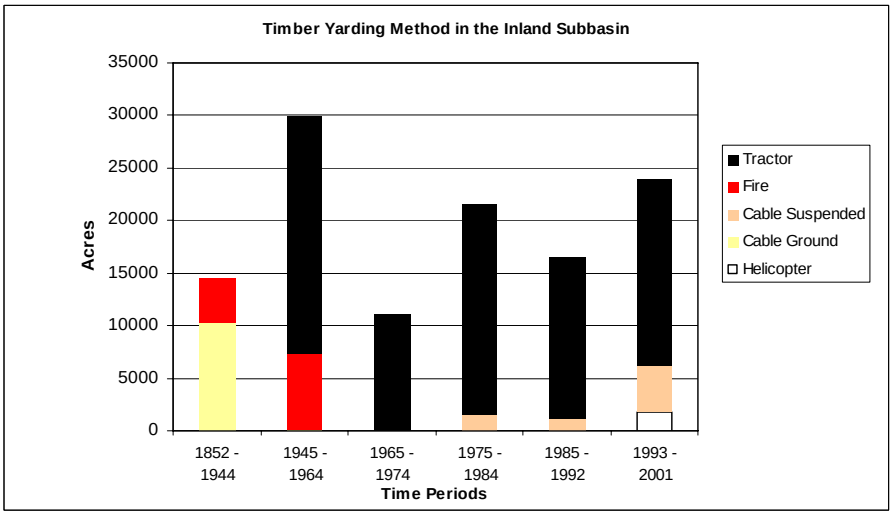


Figure 121. Acres of timber harvest yarding methods in the Inland Subbasin.

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 harvest density was 34 acre/acre for 1989 to 2000 (or 34% of the watershed). This was the most intense harvesting during any of the time periods studied. Over the entire study period, an estimated 102% of the Inland Subbasin was harvested. The percentage harvest exceeds 100% in part because some areas were harvested multiple times.

A CDF analyses of disturbance levels across this subbasin found that land use activity over the past 150 years has generally shifted from high disturbance activities to low and moderate disturbance activities (Figure 122). The rate of activities in recent years appears to have increased.

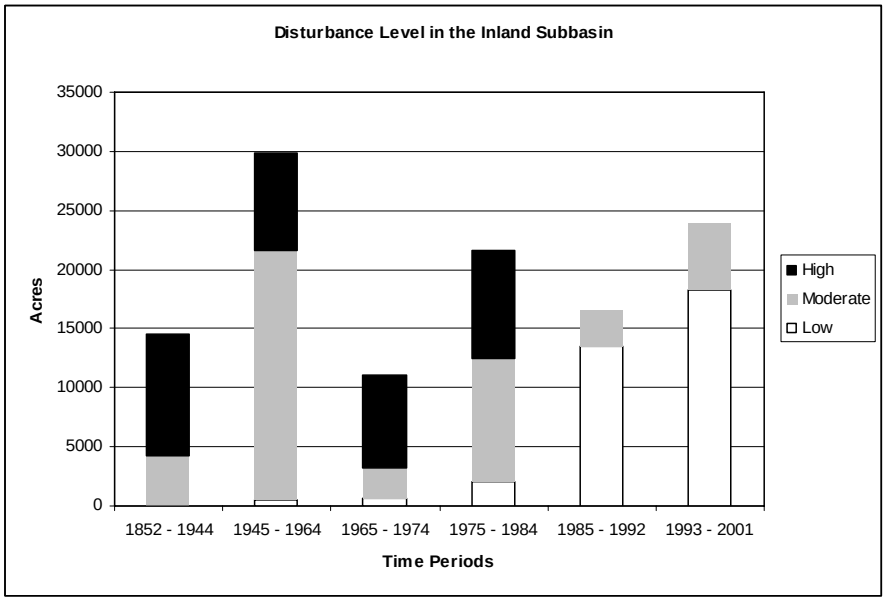


Figure 122. Acres by disturbance level in the Inland Subbasin.

Roads

The Inland Subbasin has a total of 839.2 miles of roads, the vast majority of which are made of native material (Table 181). There are very few paved roads throughout the subbasin and none at all in the upper drainage. Overall road density is 6.4 miles per square mile, the lowest of the three Big River subbasins. Road densities within the subbasin ranged from 5.8, 6.6, and 7.1 miles per square mile in the South Fork, North Fork, and upper drainages, respectively. Road construction peaked from 1937 to 1952 and decreased until 1988. Construction has increased since 1988, with increased timber harvest.

Table 181. Length of truck roads in the Inland Subbasin 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	3.9	1.4	0.1	5.4				
1937 - 1952	145.5	28	32.8	206.2	1.1	0.2	0.3	1.6
1953 - 1965	171.9		25.5	197.4	1.3		0.2	1.5
1966 - 1978	140		24.7	164.7	1.1		0.2	1.3
1979 - 1988	83		1.1	84.1	0.6			0.6
1989 - 2000	167.1		14.3	181.6	1.3		0.1	1.4
Total	711.3	29.5	98.5	839.2	5.4	0.2	0.8	6.4

Lengths are roads constructed in time period, not cumulative

Water Quality

There is a fairly complete record of water temperature information for the North Fork and South Fork drainages of the Inland Subbasin. This is due to more widespread accessibility to subbasin watercourses and broad participation by local landowners, particularly MRC and CDF at JDSF. The headwaters drainage only has water temperature data for the northern portion due to participation by the MRC and the CDF at JDSF.

Physical-chemical information is largely lacking, as noted by the presence of only four sampling events by the Dept. of Health Services (DHS) and the NCRWQCB.

Sediment records were available for bulk, permeability and by a sediment source analysis conducted by GMA. GMA and MRC were largely responsible for most of the sediment data. D50s (pebble counts) were also conducted by MRC in a number of watercourses, however, they were completed only at the head's of riffles and therefore are not comparable to more traditionally conducted pebble counts that encompass the length and width of entire riffles. A single turbidity-suspended sediment sampling event was also conducted during 2001 by GMA at the Big River Mainstem downstream from Russell Brook.

Temperature

Continuous water temperature data logging devices were deployed by MRC, JSF, and MWA at a total of 50 locations in the Inland Subbasin. However, one site on the lower North Fork (MRC 75-4) apparently had no raw data associated with it or it was not made available for this assessment. Therefore, there were a total of 49 active sites in this subbasin with summary values for one additional site. Water temperature was monitored in one or more locations in the Inland Subbasin during the years 1990 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 Inland Subbasin, all but five of the available water temperature data sets met the data quality criteria and were used for this assessment. It should be noted, however, that the MWA sites were typically positioned at the bottom of pools to assess thermal refugia. Therefore, data from these loggers may not represent average water temperature conditions in their respective thermal reaches.

Since there were so many sampling locations across the Inland Subbasin (Figure 123), results are presented by drainage: North Fork Big River, South Fork Big River, and headwaters.

North Fork Drainage

There are a total of nine monitoring sites on the North Fork of the Big River (FSP 5238, FSP 5220, JSF 527, JSF 528, JSF 529, JSF 530, JSF 531, JSF 532, and MRC 75-4). These monitoring sites are all located throughout all of the reaches in the North Fork and were recording temperatures for the following durations: two years at FSP 5238, two years at FSP 5220, one year at JSF 527, three years at JSF 528, one year at JSF 529, three years at JSF 530, one year at JSF 531, three years at JSF 532, and one year at MRC 75-4.

In the upper reaches of the North Fork (FSP 5238 and FSP 5220), the water temperature was somewhat suitable with an observed maximum MWAT of between 63 and 64°F. The North Fork then enters JDSF, and the first monitoring site (JSF 527) that is encountered is near the forest boundary. At this site (JSF 527), water temperature was moderately unsuitable with an observed maximum MWAT of 66°F. The reason for this temperature jump is unclear. However, it could be due to any one or more of the following: the influences of a small unnamed tributary between the monitoring sites, a lack of canopy or flow in the vicinity of JSF 527, or the placement of the FSP temperature probes not following the standard protocol used by JSF. Based on a 1994 Landsat vegetation map (KRIS Big River), the position in the watershed (e.g. headwaters) and the diurnal temperature fluctuations at the FSP sites, it is likely that the canopy and/or flow are poor at these sites. While the canopy appears to be good at JSF 527, the large temperature jump is likely due to a particularly exposed section of stream immediately upstream which heats the water quickly, possibly combined with a different protocol for probe placement.

After entering JDSF, the temperatures in the North Fork remain relatively high, but generally appear to decline downstream. Two probes were place on either side of the confluence with James Creek, JSF 528, and JSF 529. Water temperatures at these sites were moderately unsuitable, with a maximum observed MWAT of 66°F before the confluence with James Creek to somewhat unsuitable with an MWAT of 65°F. This, combined with temperature data from James Creek, suggests that James Creek has somewhat of a cooling effect on the North Fork. There are two monitoring sites on James Creek (JSF 534 and JSF 567) and one on the North Fork of James Creek (JSF 533). Water temperatures at the North Fork James Creek site (JSF 533) were fully suitable with a maximum observed MWAT of 59°F. Farther down on James Creek, the next monitoring site (JSF 534) had water temperatures that were moderately unsuitable, with an observed MWAT of 61°F. In the lower portion of James Creek, the next site (JSF 567) had water temperatures that were somewhat suitable, with an observed MWAT of 63°F. At these sites, diurnal fluctuations ranged from good to poor (6.2-11.5°F).

The next group of monitoring sites on the North Fork was placed on either side of the confluence with Chamberlain Creek (JSF 530 and JSF 531). Water temperatures at these sites were somewhat unsuitable to undetermined, with an observed maximum MWAT of 65°F before the confluence and an observed MWAT of 64°F after the confluence. This, combined with temperature data from Chamberlain Creek suggests that Chamberlain Creek has a somewhat cooling effect on the North Fork.

USFWS monitored one site on the North Fork Big River at the confluence with Chamberlain Creek in 1973 (Perry 1974). The monitoring site recorded water temperatures that were fully unsuitable with a MWAT of 72ºF. In addition, the maximum water temperature recorded was 83ºF, over the lethal limit for salmonids (75ºF). Comparison of 1973 data with recent monitoring at the same location (JSF 530 and JSF 531) appears to show that water temperatures have decreased significantly since 1973.

There are six monitoring sites on Chamberlain Creek (JSF 536, JSF 557, JSF 537, JSF558, JSF 538, and JSF 539) and one on West Chamberlain Creek (JSF 540). Water temperatures at the West Chamberlain Creek site (JSF 540) were fully suitable with a maximum observed MWAT of 59°F. In the headwaters of Chamberlain Creek, JSF 536 is the first monitoring site. JSF 536 had water temperatures that were fully suitable, with a maximum observed MWAT of 58°F. The next monitoring site downstream is JSF 557, which is located immediately before the confluence with Arvola Gulch. The observed water temperatures at this site, while significantly higher than JSF 536, were still fully suitable with an observed MWAT of 60°F. The monitoring site immediately downstream of the confluence with Arvola Gulch (JSF 537), exhibited water temperatures that were fully suitable to moderately suitable with a maximum observed MWAT of 61°F. Based on the observed Chamberlain Creek stream temperatures upstream and downstream of Arvola Gulch and temperature monitors in upper and lower Arvola Gulch, it appears that Arvola Gulch has little or no effect on Chamberlain Creek water temperatures. Both sites in Arvola Gulch (upper and lower) appeared to have essentially the same water temperature in the year monitored. Water temperatures in Arvola Gulch were moderately suitable with observed MWATs of 61°F at both sites.

Immediately downstream of the paired monitoring sites on Chamberlain Creek around the confluence with Arvola Gulch, is JSF 558. Water temperatures at this site were moderately suitable with an observed MWAT of 61°F, which is essentially the same as that seen in JSF 536 (immediately upstream). The next monitoring site on Chamberlain Creek (JSF 538) is placed immediately after the confluence with West Chamberlain Creek. Water temperatures at this site were moderately suitable with an observed MWAT of 61°F. It is uncertain what effect West Chamberlain Creek has on Chamberlain Creek, but it appears as though West Chamberlain Creek has little effect or possibly a slight cooling effect.

Water Gulch, a tributary to Chamberlain Creek, converges with Chamberlain Creek between West Chamberlain Creek and the confluence with the North Fork. The monitoring site located in Water Gulch (JSF 560) exhibited water temperatures that were fully suitable, with a maximum observed MWAT of 58°F. The thermograph from this site suggests that that the monitoring location may have a significant groundwater component and/or possibly a thermally stratified pool, especially in August and September. This is indicated by the atypical “flat” fluctuations. While the site at Water Gulch is much cooler than Chamberlain Creek, it is unknown what effect, if any, Water Gulch may have on the water temperature in Chamberlain Creek after the confluence.

The final site in lower Chamberlain Creek (JSF 539) appears to have substantially higher water temperatures than JSF 538. Water temperatures at this site were moderately suitable to somewhat suitable, with a maximum observed MWAT of 63°F. Based on a 1994 Landsat vegetation map (KRIS Big River), it may be that the elevated temperatures seen at this site are due to a large clearing in this portion of Chamberlain Creek.

After the paired monitoring sites on either side of the confluence with Chamberlain Creek, the next North Fork site is JSF 532. Water temperatures at this site were undetermined to somewhat unsuitable, with a maximum observed MWAT of 65°F. However, given the range of fluctuations in the MWAT at this site, it does not appear to be substantially different from JSF 531 (the site upstream of it).

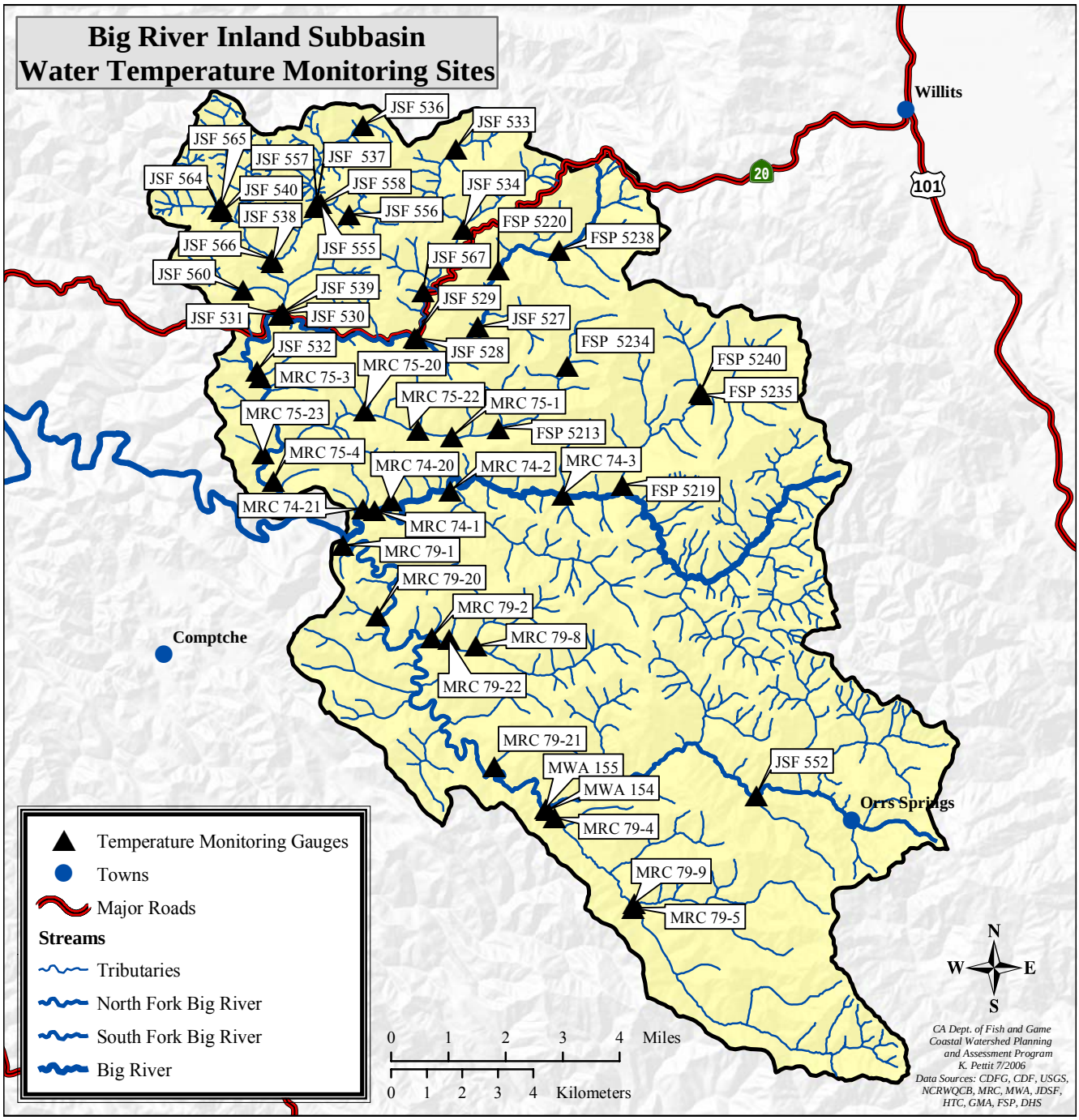


Figure 123. Water temperature monitoring sites, Inland Subbasin.

The East Branch of the North Fork, a tributary to the North Fork, has four water temperature monitoring sites (FSP 5234, FSP 5213, MRC 75-1, and MRC 75-3). These sites are spread along the length of the East Branch of the North Fork and were monitored for two years, two years, six years, and two years, respectively. The first site in upper East Branch of the North Fork (FSP 5234), had water temperatures that were fully suitable with an observed maximum MWAT of 60°F. Further downstream, located in the middle portion of the East Fork of the North Fork, are FSP 5213 and then MRC 75-1. FSP 5213 had water temperatures that were moderately suitable to somewhat suitable, with a maximum observed MWAT of 63°F. MRC 75-1 had water temperatures that were moderately suitable to somewhat unsuitable, with a maximum observed MWAT of 65°F. However, the MWATs at MRC 75-1 appear to have a downward trend.

USFWS monitored one site on the middle reach of the East Branch North Fork Big River in 1973 (Perry 1974). The monitoring site had recorded water temperatures that were fully suitable with a MWAT of 59ºF. In addition, the maximum water temperature recorded was 64ºF, well below the lethal limit for salmonids (75ºF).

Comparison of 1973 data with recent monitoring at a similar location (MRC 75-1) appears to show that water temperatures have increased since 1973.

A site in lower Frykman Gulch (MRC 75-22), a tributary to the East Branch North Fork, was monitored for one year. The confluence of this tributary is downstream of MRC 75-1. The thermograph from MRC 75-22 suggests that the monitoring probe at this site was in a stratified pool and/or a location that is significantly influenced by groundwater. This is evident by the atypical diurnal fluctuations and flat peaks. The water temperatures at this site were fully suitable with a maximum observed MWAT of 56°F. It is unclear if Frykman Gulch contributes a significant amount of flow to the East Branch of the North Fork, and thus it is not known if it provides any cooling effect.

The last site on the East Branch of the North Fork, near the confluence with the North Fork, is MRC 75-3, which was monitored for two years. Water temperatures at this site were moderately suitable to undetermined, with a maximum observed MWAT of 64°F. While there is a substantial difference in the observed MWATs at this site (-2.9°F) between 1997 and 2001, there is insufficient information to determine if there is a possible trend. This drop could be due to climatic conditions, differences in placement of the monitoring probe, or some alteration of the canopy. A review of available THP maps (KRIS Big River) did not indicate any harvesting at this location during the late 1990s.

After the confluence with the East Branch of the North Fork, the next tributary to the North Fork that was monitored is Steam Donkey Gulch (MRC 75-23). This site was monitored for one year. Inspection of the thermograph for this site suggests that the probe was placed either in a stratified pool or in a location with a significant groundwater influence, particularly in the middle to late summer. Water temperatures at this site are fully suitable, with an observed MWAT of 56°F. It is unclear what, if any, contribution of cooler water Steam Donkey Gulch makes to the North Fork. However, based on the thermograph, it is suspected that flows are minimal, particularly in the middle to late summer.

The final site on the North Fork, downstream of the confluence with Steam Donkey Gulch, is MRC 75-4. This site was monitored for one year. Water temperatures at this site are moderately unsuitable, with an observed MWAT of 67°F. However, the maximum diurnal temperature fluctuations are low (5.4°F). Unlike the North Fork sites in the JDSF, water temperatures at this site did not follow a downward trend, and in fact MRC 75-4 had the highest recorded MWAT in the North Fork subbasin. However, it should be noted that this site was only monitored in 1992, while the other upstream sites were monitored during different years. Therefore, it is possible that 1992 was an abnormally hot year.

Nevertheless, a 1994 Landsat vegetation map (KRIS Big River) indicates a substantially younger forest on the North Fork downstream of the JSF boundary. With the low diurnal fluctuations recorded at MRC 75-4, it is suspected that there is a significant amount of flow to give the water some thermal buffering capacity. The predominance of small trees in the reaches upstream of MRC 75-4 would also suggest significant solar exposure. It is unknown if the vegetation shown in the 1994 Landsat map was essentially the same in 1992. However, presuming it was, this may be the reason for the relatively high MWAT observed at MRC 75-4. In any case, further monitoring is necessary to conclusively make any connections.

As shown in Figure 124, water temperatures in the North Fork are apparently dropping as the water moves downstream. However, this only seems to apply to sites within the JDSF. Of the portions of the North Fork outside of JDSF, the limited amount of water temperature data appears to show upward spikes in water temperature. In general, the 1994 Landsat vegetation map (KRIS Big River), indicates younger forests outside of the JDSF boundaries, with a preponderance of tree sizes in the sapling through small/medium tree size. There also appears to be more areas without trees. Available THP maps (KRIS Big River) also indicate that a large portion of the land outside of JSF has been harvested in some manner in the 1990's. While more years' of data are needed to confirm this pattern, the limited amount of data from a large number of monitoring sites suggest that the North Fork is significantly heated on the private lands surrounding JDSF.

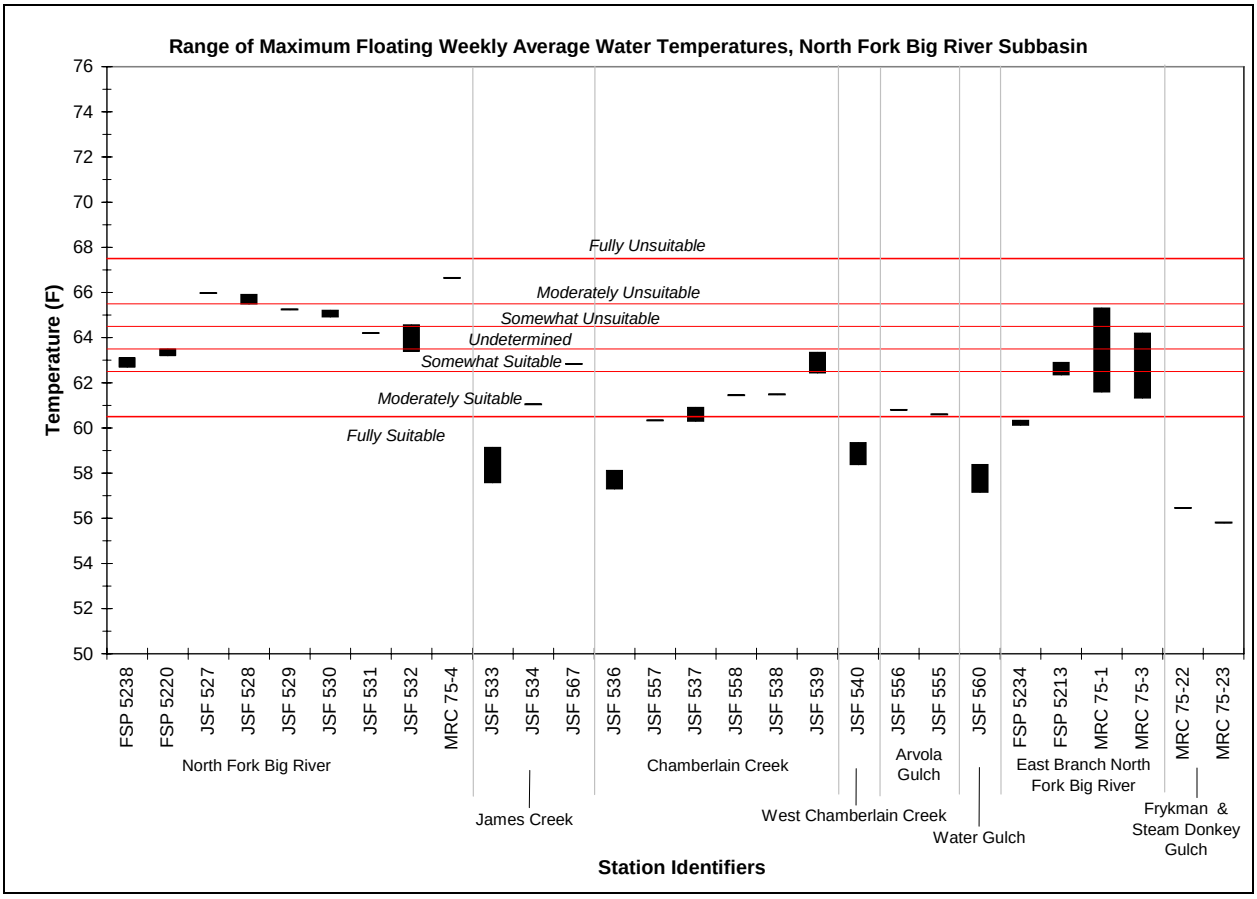


Figure 124. Range of MWATs in the North Fork drainage.

South Fork Drainage

The most extensively monitored locations in the Inland Subbasin were the South Fork Big River above the confluence with the Big River (MRC 79-1) and lower Daugherty Creek (MRC 79-4 and MWA 154). These sites were monitored for five, six, and three years, respectively. Three other sites, including Montgomery Creek (JSF 552), Lower Ramon Creek (MRC 79-2), and the South Fork Big River below Daugherty Creek (MWA 155) were monitored for three years each. The remaining sites were monitored for one year, with the exception of Lower Gates Creek (MRC 79-9), which was monitored for two years.

There are a total of three monitoring sites on Daugherty Creek (MRC 79-4, MRC 79-5, and MWA 154). Lower Daugherty Creek was monitored at two locations: one site (MRC 79-4) was monitored for six years, and the other nearby site (MWA 154) was monitored for three years. Based on data from these Lower Daugherty Creek sites, the water temperature varies between moderately suitable with a minimum observed MWAT of 62ºF, to moderately unsuitable with a maximum observed MWAT of 67ºF. In general the water temperatures at MRC 79-4 are higher than those observed at MWA 154, as seen in Figure 125. This is probably due to the fact that MWA typically deploys their temperature monitors in areas of thermal refugia, such as the bottom of a pool. However, even with the data logger deployed to capture thermal refugia, water temperature exceeded the fully supportive range.

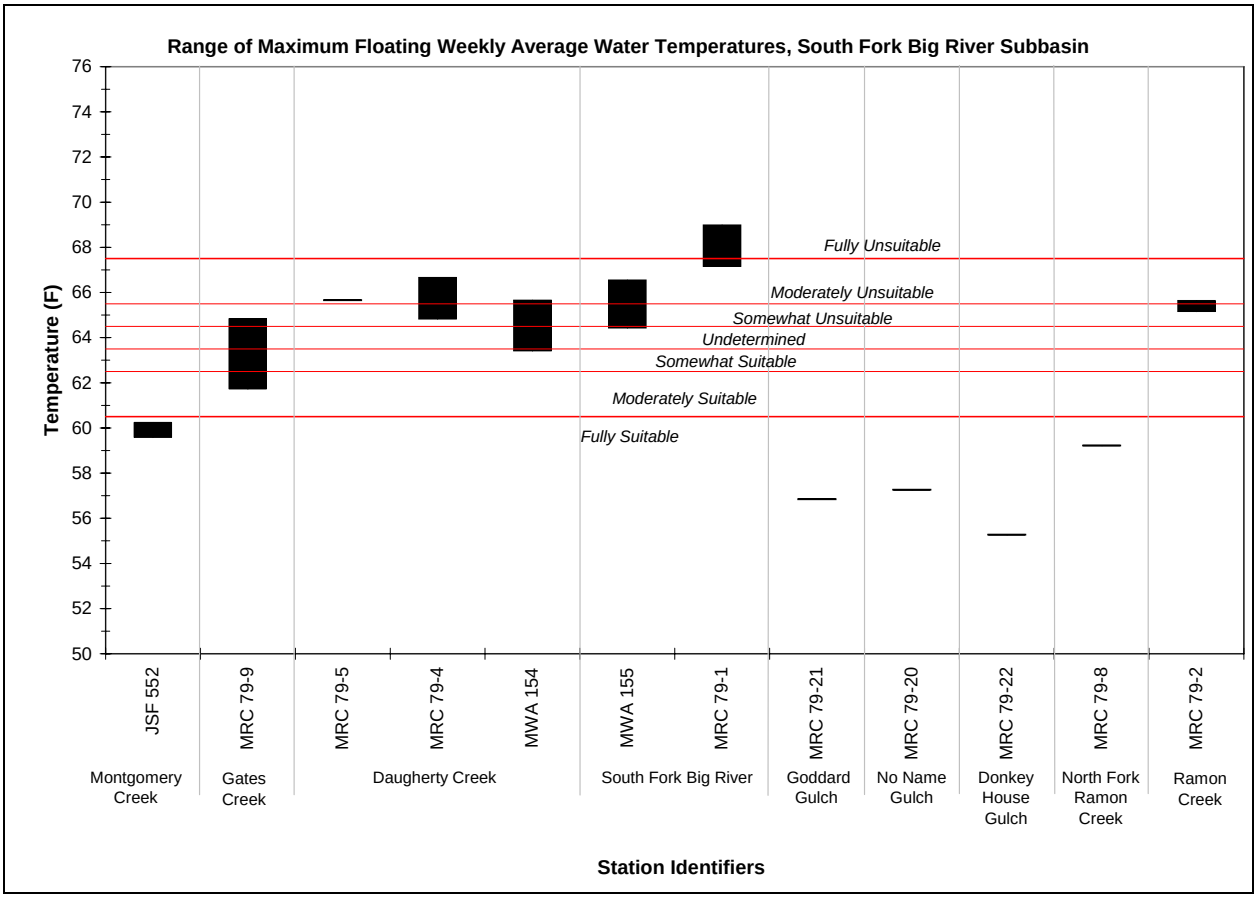


Figure 125. Range of MWATs in the South Fork drainage.

The one site in Upper Daugherty Creek (MRC 79-5) was only monitored during one year. The data from this site suggest that the MWATs are similar to those observed in Lower Daugherty Creek, as MRC 79-5 was within the range of MWATs observed in Lower Daugherty Creek. However, further monitoring is necessary to confirm this relationship. In any case, during the one year monitored, the water temperature was moderately unsuitable with an observed MWAT of 66ºF.

On the whole, both upper and lower Daugherty Creek exhibited relatively large diurnal temperature fluctuations (7.6-11.3ºF), indicating possible low flow and/or poor canopy conditions. Based on 1994 Landsat vegetation images (KRIS Big River), it appears as though much of Daugherty Creek has small trees within the riparian corridors, which may contribute to increased solar exposure and the large diurnal temperature fluctuations observed.

Gates Creek, a tributary to Daugherty Creek, was also monitored at one location (MRC 79-9) in the lower portion of the stream for two years. During the two years monitored, the water temperature varied between moderately suitable with a minimum observed MWAT of 62ºF, to somewhat unsuitable with a maximum observed MWAT of 65ºF. By comparing the range of MWATs in Lower Gates Creek against the single year of monitoring in Upper Daugherty Creek (MRC 79-5), it appears that Gates Creek may have a cooling effect on Daugherty Creek. However, more data must be collected in both sites to confirm this relationship. In addition, as with the sites on Daugherty Creek, the site at Lower Gates Creek experienced large diurnal fluctuations (9.6-9.9ºF) suggesting low flow and/or poor canopy conditions. Based on 1994 Landsat vegetation images (KRIS Big River), it appears as though much of Gates Creek has small trees within the riparian corridors, which may contribute to increased solar exposure and the large diurnal temperature fluctuations observed.

There are a total of two monitoring sites on South Fork Big River (MRC 79-1 and MWA 155). One site is located below the confluence with the mainstem Big River (MRC 79-1) and was monitored for five years. The other site is located below the confluence with Daugherty Creek (MWA 155) and was monitored for three years.

The monitoring site above the confluence with the mainstem of the Big River (MRC 79-1) recorded water temperatures between moderately unsuitable with a minimum observed MWAT of 67ºF, to fully unsuitable with

a maximum observed MWAT of 69ºF. In addition, the maximum water temperature recorded was over 74ºF, close to the lethal limit for salmonids (75ºF). The diurnal fluctuations (7-11ºF) at this site also suggest moderate to poor cover and/or low flows.

The monitoring site on the South Fork Big River below Daugherty Creek (MWA 155) recorded water temperatures between undetermined with a minimum observed MWAT of 64ºF, to moderately unsuitable with a maximum observed MWAT of 67ºF. While, in general, the diurnal fluctuations were slightly lower at this site than MRC 79-1, it still averaged around 8ºF suggesting moderate canopy and/or flow conditions. By comparing MWATs at this MWA 155 against MRC 79-1 (see Figure 125), it is apparent that MWA 155 is cooler, with no overlap in the MWAT ranges. However, this could be due to one of several factors: MWA 155 was placed in an area of thermal refugia and would be expected to be lower than the average temperature in that thermal reach; MRC 79-1 is significantly lower in the watershed than MWA 155, increasing the possibility of solar heating.

USFWS monitored one site on the South Fork Big River at the confluence with Daugherty Creek in 1973 (Perry 1974). The monitoring site recorded water temperatures that were undetermined with a MWAT of 64ºF. In addition, the maximum water temperature recorded was 71ºF. Comparison of 1973 data with recent monitoring at the same location (MWA 155) appears to show that water temperatures have remained similar since 1973.

Montgomery Creek (JSF 552), Lower Goddard Gulch (MRC 79-21), and Lower No Name Gulch (MRC 79-20) are all tributaries to the South Fork Big River. Montgomery Creek and Lower Ramon Creek were monitored for three years each, and the other streams were monitored for one year. During the years monitored, the Montgomery Creek (JSF 552) site recorded water temperatures that were entirely within the fully suitable range with a maximum observed MWAT of 60ºF. This suggests good stream flow and/or good stream shading.

Lower No Name Gulch (MRC 79-20) and Lower Goddard Gulch (MRC 79-21), tributaries to the South Fork of the Big River, both exhibited stream temperatures well within the fully suitable range for salmonids in the one year monitored. These sites had observed MWATs of 57ºF and 57ºF, respectively. However, the thermographs for Lower Goddard Gulch suggest that the data loggers were placed in an area dominated by groundwater, and/or the monitors were placed in a thermally stratified pool. By contrast, based on the thermographs for Lower No Name Gulch, it appears though the stream was flowing until early August, at which time it may have become isolated and dominated by groundwater. This is evident by diurnal temperature fluctuations that gradually become essentially flat.

Both Lower Donkey House Gulch (MRC 79-22) and Lower North Fork Ramon Creek (MRC 79-8), tributaries to Ramon Creek, exhibited stream temperatures within the fully suitable range for salmonids in the one year monitored. These sites had observed MWATs of 55ºF and 59ºF, respectively. The site on the North Fork Ramon Creek (MRC 79-8) appeared to have moderate diurnal fluctuations (8ºF), which would suggest moderate shading and/or stream flow along the thermal reach. By inspection of the thermograph, it appears as though this stream continued to flow during the year monitored and probably had some cooling effect on Ramon Creek. However, Lower Donkey House Gulch (MRC 79-22) appeared to have little to no flow for a large part of the summer in what appears to be a groundwater dominated flow regime. The temperature monitor may have been placed in a relatively deep pool which may thermally insulate it from the normal diurnal temperature fluctuations. Conversely, water temperatures observed in Lower Ramon Creek (MRC 79-2) were somewhat unsuitable with a minimum observed MWAT of 65ºF, to moderately unsuitable with a maximum observed MWAT of 66ºF. The large diurnal temperature fluctuations (8-14ºF) in this site in Lower Ramon Creek indicate moderate to poor shading or low stream flows.

Headwaters Drainage

There are a total of two monitoring sites on Martin Creek (FSP 5235 and FSP 5219). These monitoring sites are all located in the upper and lower reaches of Martin Creek. FSP 5235 was monitored for one year, and FSP 5219 was monitored for two years. Based on data from the upper Martin Creek (FSP 5235) site, the water temperature was somewhat suitable with a maximum observed MWAT of 63ºF. Based on data collected at the lower Martin Creek site (FSP 5219), the water temperature was somewhat unsuitable maximum observed MWAT of 65ºF. The only tributary to Martin Creek that was monitored was an un-named tributary (FSP 5240) in upper Martin Creek, which was monitored for two years. Based on this data, the water temperatures at this site varied between somewhat suitable with a minimum MWAT of 63ºF and undetermined with a maximum MWAT of 64°F.

There are a total of two monitoring sites on mainstem Big River (MRC 74-3 and MRC 74-1). One site is located on the mainstem between Martin Creek and Russell Brook (MRC 74-3) and was monitored for four years. The second mainstem site is located between Russell Brook and the South Fork Big River (MRC 74-1) and was monitored for four years.

The monitoring site between Martin Creek and Russell Brook (MRC 74-3) recorded water temperatures that were undetermined to moderately unsuitable with a maximum observed MWAT of 66ºF. In addition, the maximum water temperature recorded was 73ºF, slightly below the lethal limit for salmonids (75ºF). The diurnal fluctuations (9.2-14.8ºF) at this site also suggest poor cover and/or low flows.

USFWS monitored one site on the mainstem Big River at the confluence with Pig Pen Gulch in 1973 (Perry 1974). The monitoring site recorded water temperatures that were fully unsuitable with a MWAT of 69ºF. In addition, the maximum water temperature recorded was 79ºF, above the lethal limit for salmonids (75ºF). Comparison of 1973 data with recent monitoring at the same location (MRC 74-3) appears to show that water temperatures have decreased since 1973.

The monitoring site between Russell Brook and the South Fork Big River (MRC 74-1) recorded water temperatures that were moderately unsuitable to fully unsuitable with a maximum observed MWAT of 68ºF. In addition, the maximum water temperature recorded was 75ºF, which is the lethal limit for salmonids (75ºF). The diurnal fluctuations (10.8-12.9ºF) at this site also suggest poor cover and/or low flows.

Water temperatures at several tributaries that feed into the mainstem Big River below Martin Creek were also monitored. These include Russell Brook (MRC 74-2), Johnston Gulch (MRC 74-20), and Wildhorse Gulch (MRC 74-21). These sites were monitored for four years, one year, and one year, respectively. The monitoring site on Russell Brook (MRC 74-2) recorded water temperatures that were fully suitable to moderately suitable, with a maximum observed MWAT of 62ºF. The diurnal fluctuations (6.7-8.4ºF) at this site suggest moderate to poor cover and/or low flows. The monitoring site on Johnston Gulch (MRC 74-20) recorded water temperatures that were fully suitable, with a maximum observed MWAT of 58ºF. The monitoring site on Wildhorse Gulch (MRC 74-21) recorded water temperatures that were fully suitable, with a maximum observed MWAT of 58ºF. The diurnal fluctuations at each of these sites are minimal.

As would be expected, there appears to be an upward trend in water temperatures as the water moves lower in the both the mainstem Big River and Martin Creek (Figure 126). While there is insufficient information to determine if the un-named tributary to Martin Creek has an effect on the water temperatures in Martin Creek, it appears as though Russell Brook does provide some cooling effect to the mainstem Big River. The two other tributaries that were monitored were significantly cooler than the mainstem Big River. However, they were only monitored for one year and the thermographs from these sites indicate that they may have been in stratified pools or possibly a groundwater dominant regime. In either case, it is unknown how much flow they contribute to the mainstem Big River and thus if they provide any cooling effect.

Available THP maps (KRIS Big River) indicate that harvesting occurred in large portions of the Martin Creek watershed from 1989-1999. A 1994 Landsat map (KRIS Big River) shows many open areas and small trees near many of the monitoring sites, which may be contributing to the large diurnal fluctuations and generally higher water temperatures.

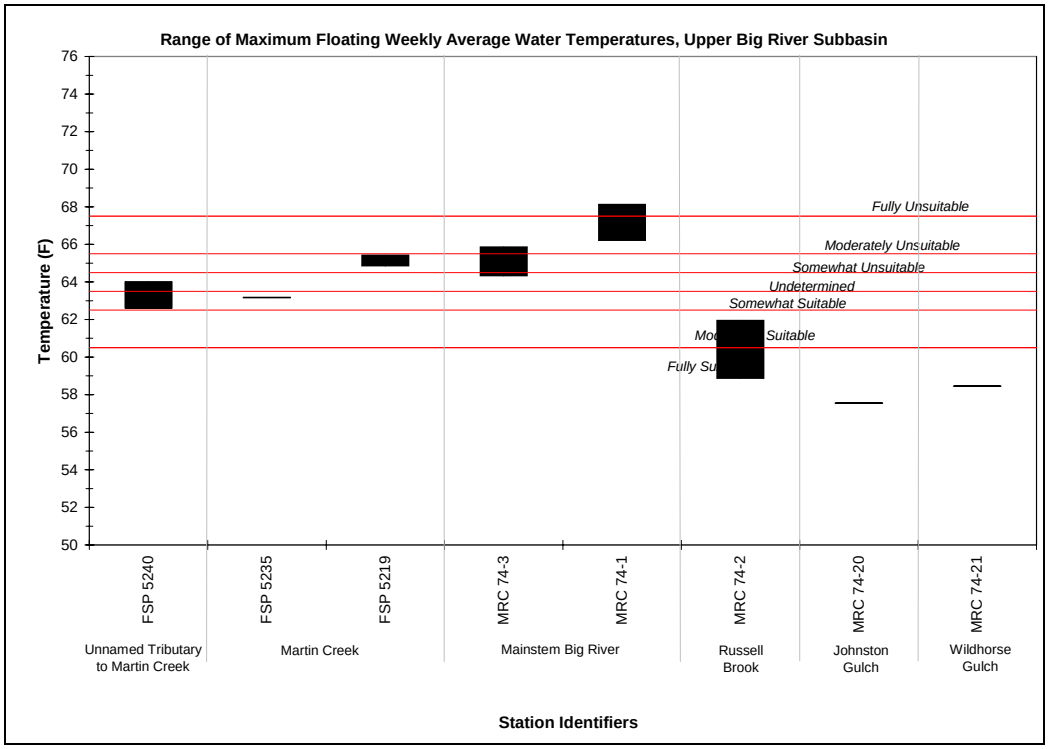


Figure 126. Range of MWATs in the headwaters drainage.

Summary

In summary, out of 47 sample sites in the Inland Subbasin, 27 had suitable water temperatures and 17 had unsuitable water temperatures (Table 182). Many of the unsuitable water temperatures recorded were on larger streams such as the North and South forks of Big River, Daugherty Creek, and mainstem Big River.

Table 182. Water temperature summary, Inland Subbasin.

Stream	Site ID	Maximum MWAT	MWAT Trend	Range of maximum diurnal fluctuations		Seasonal Maximum	Years of Data
Fully Suitable (50-60ºF)							
Donkey House Gulch	MRC 79-22	55	NA	3.5	3.5	55	1
Frykeman Gulch	MRC 75-22	56	NA	3.5	3.5	57	1
Steam Donkey Gulch	MRC 75-23	56	NA	3.5	3.5	58	1
Goddard Gulch	MRC 79-21	57	NA	2.1	2.1	58	1
No Name Gulch	MRC 79-20	57	NA	7.7	7.7	61	1
Chamberlain Creek	JSF 536	58	-0.8	3.6	4.5	60	3
Water Gulch	JSF 560	58	-1.2	3.4	3.9	61	2
Johnson Gulch	MRC 74-20	58	NA	2.8	2.8	59	1
Mainstem Big River	MRC 74-21	58	NA	4.1	4.1	60	1
James Creek	JSF 533	59	1.0	6.2	8.2	63	4
West Chamberlain Creek	JSF 540	59	-0.1	5.0	5.9	62	3
North Fork Ramon Creek	MRC 79-8	59	NA	7.5	7.5	63	1
East Branch North Fork Big River	FSP 5234	60	0.2	4.8	5.6	63	2
Chamberlain Creek	JSF 557	60	NA	6.1	6.1	64	1
Montgomery Creek	JSF 552	60	0.4	4.5	4.6	63	3
Moderately Suitable (61-62ºF)							
James Creek	JSF 534	61	NA	8.3	8.3	66	1
Chamberlain Creek	JSF 537	61	-0.6	6.5	7.4	65	2
Chamberlain Creek	JSF 538	61	NA	7.9	7.9	65	1
Arvola Gulch	JSF 555	61	NA	7.0	7.0	64	1
Arvola Gulch	JSF 556	61	NA	9.2	9.2	67	1
Chamberlain Creek	JSF 558	61	NA	9.8	9.8	69	1
Russell Brook	MRC 74-2	62	-0.6	6.7	8.4	66	4[1]
Somewhat Suitable (63ºF)							
James Creek	FSP 5213	63	-0.6	9.0	10.3	69	2
North Fork Big River	FSP 5238	63	0.4	9.1	11.1	70	2
Chamberlain Creek	JSF 539	63	-0.9	7.4	8.5	69	3

Stream	Site ID	Maximum MWAT	MWAT Trend	Range of maximum diurnal fluctuations		Seasonal Maximum	Years of Data
James Creek	JSF 567	63	NA	11.5	11.5	69	1
Martin Creek	FSP 5235	63	NA	12.4	12.4	72	1
Undetermined (64ºF)							
North Fork Big River	FSP 5220	64	0.3	8.3	11.0	71	2
North Fork Big River	JSF 531	64	NA	8.0	8.0	70	1
James Creek	MRC 75-3	64	-2.9	9.3	11.8	69	2
Unnamed tributary to Martin Creek	FSP 5240	64	1.4	11.0	15.0	75	2
Somewhat Unsuitable (65ºF)							
North Fork Big River	JSF 529	65	NA	9.7	9.7	71	1
North Fork Big River	JSF 530	65	-0.3	8.0	8.4	71	3
North Fork Big River	JSF 532	65	0.6	5.8	6.9	68	4
James Creek	MRC 75-1	65	-2.9	8.7	13.7	72	6
Gates Creek	MRC 79-9	65	-3.1	9.6	9.9	71	2
Martin Creek	FSP 5219	65	-0.6	11.7	12.4	72	2
Moderately Unsuitable (66-67ºF)							
North Fork Big River	JSF 527	66	NA	11.2	11.2	74	1
North Fork Big River	JSF 528	66	-0.4	9.5	10.2	71	3
Ramon Creek	MRC 79-2	66	0.0	8.3	13.6	73	3
Daugherty Creek	MRC 79-5	66	NA	10.0	10.0	70	1
Daugherty Creek	MWA 154	66	-1.1	7.6	8.6	70	3
Mainstem Big River	MRC 74-3	66	1.5	9.2	14.8	73	4
North Fork Big River	MRC 75-4	67	NA	5.4	5.4	70	1
South Fork Big River	MWA 155	67	-0.4	7.5	8.3	71	3
Daugherty Creek	MRC 79-4	67	-0.6	9.0	11.3	73	6
Fully Unsuitable (68ºF)							
Mainstem Big River	MRC 74-1	68	1.6	10.8	12.9	75	4[2]
South Fork Big River	MRC 79-1	69	-1.8	6.8	10.6	74	5

[1] Only 3 years of diurnal
[2] Only 2 years of diurnal

Sediment

Turbidity and Suspended Sediment

Turbidity that is significantly elevated above background levels can impede the ability of salmonids to feed and can be an indicator of potential problems with suspended sediment. This in turn may point to potential problems with heavy sediment loads. While the information collected in the Inland Subbasin is useful preliminary data, consistent long-term sampling is needed to determine the condition of these sites with respect to suspended sediment concentrations.

There were ten turbidity/suspended sediment sites established by GMA in the Inland Subbasin in 2000 and 2001 in support of the US EPA TMDL. Additional turbidity samples were collected at the Chamberlain Creek Conservation Camp under the DHS community water supply testing program and on the North Fork Big River immediately below the confluence with Chamberlain Creek under the SWAMP program at the Regional Water Board. Turbidity samples were also collected by the Regional Water Board under the SWAMP program at one location in 2001.

Ten stations were sampled by GMA for sediment and turbidity (Figure 127). In general, these sites were designed to be located closely to MRC sediment sampling sites. At the suspended sediment/turbidity locations, background conditions cannot be established due to the lack of data. Of the data that does exist, all of the samples were collected during the winter. Overall, turbidity was reported between 1.6 and 811 NTU. Each of these sites has limited data associated with them and the sample times at the various sites do not necessarily correspond. However, of the data reported, James Creek above the North Fork Big River site had the lowest average turbidity levels and the South Fork Big River below Daugherty Creek had the highest average turbidity levels (Table 183). Of all of the turbidity monitoring sites, the South Fork below Daugherty Creek (GMA 14) also had the highest spikes in turbidity.

Table 183. Turbidity samples in the Inland Subbasin.

Site	Site #	# of Samples	Dates Sampled	Range of Turbidity Values (NTU)		Average Turbidity (NTU)
				Low	High	
Chamberlain Creek above North Fork Big River	GMA1	13	February 2000 January 2001 February 2001 March 2001	5.2	114.0	38.7
North Fork Big River above Chamberlain Creek	GMA2	17	January 2000 February 2000 January 2001 February 2001 March 2001	1.6	214.0	52.1
James Creek above North Fork Big River	GMA3	4	February 2000 January 2001 February 2001	17.6	37.3	25.0
East Branch North Fork Big River above North Fork Big River	GMA4	7	February 2000 January 2001 February 2001 March 2001	5.4	65.9	32.3
North Fork Big River above Big River	GMA5	9	February 2000 January 2001 February 2001 March 2001	4.7	72.8	31.2
South Fork Big River above Big River	GMA7	7	January 2001 February 2001 March 2001	2.33	381.7	94.5
South Fork Big River above Daugherty Creek	GMA8	9	February 2001 March 2001	13.7	811.0	170.8
South Fork Big River below Daugherty Creek	GMA14	8	February 2001 March 2001	12.6	777.0	177.7
Daugherty Creek above South Fork Big River	GMA9	9	February 2001 March 2001	13.1	158.0	51.7
Big River above South Fork Big River	GMA6	7	January 2001 February 2001 March 2001	3.8	240.0	58.0

Suspended sediment and turbidity appear to be closely related at each of these sites. With the small sample set available for this site, the coefficient of determination (r^2) value is between 0.83 and 0.99. This indicates that there is probably very good correlation between turbidity and suspended sediment at all of these sites. While turbidity and suspended sediment concentrations did not correlate well with flow, it was found that the suspended sediment load did correlate well with flow at these sites (GMA, 2001).

As stated previously, DHS, NCRWQCB, and SWAMP also collected turbidity data. The turbidity sample taken at the sample sites did not exhibit significant levels of turbidity (Table 184). However, each measurement only represented one sample.

Table 184. Turbidity summary, Chamberlain Creek, North Fork Big River, and South Fork Big River (DHS and SWAMP).

Parameter	Count All	Count DetectS	Min.	Date Min[1]	Max.	Date Max
Chamberlain Creek Site (DHS)						
LAB TURBIDITY (NTU)	1	1	6.6	2/14/96	6.6	2/14/96
North Fork Big River Site (SWAMP BIGH20)						
Turbidity (NTU)	1	1	0.34	06/28/01	0.34	06/28/01
Site Name, Location: SWAMP SFBIGD, South Fork Big River Below Daugherty Creek						
Turbidity (NTU)	1	1	0.23	06/28/01	0.23	06/28/01

[1] Date on which the minimum value occurred is the first date that the value occurred. For example, if there were several "non-detects", represented here as a zero, the date given is the first instance of non-detect (chronologically).Bulk Sediment.

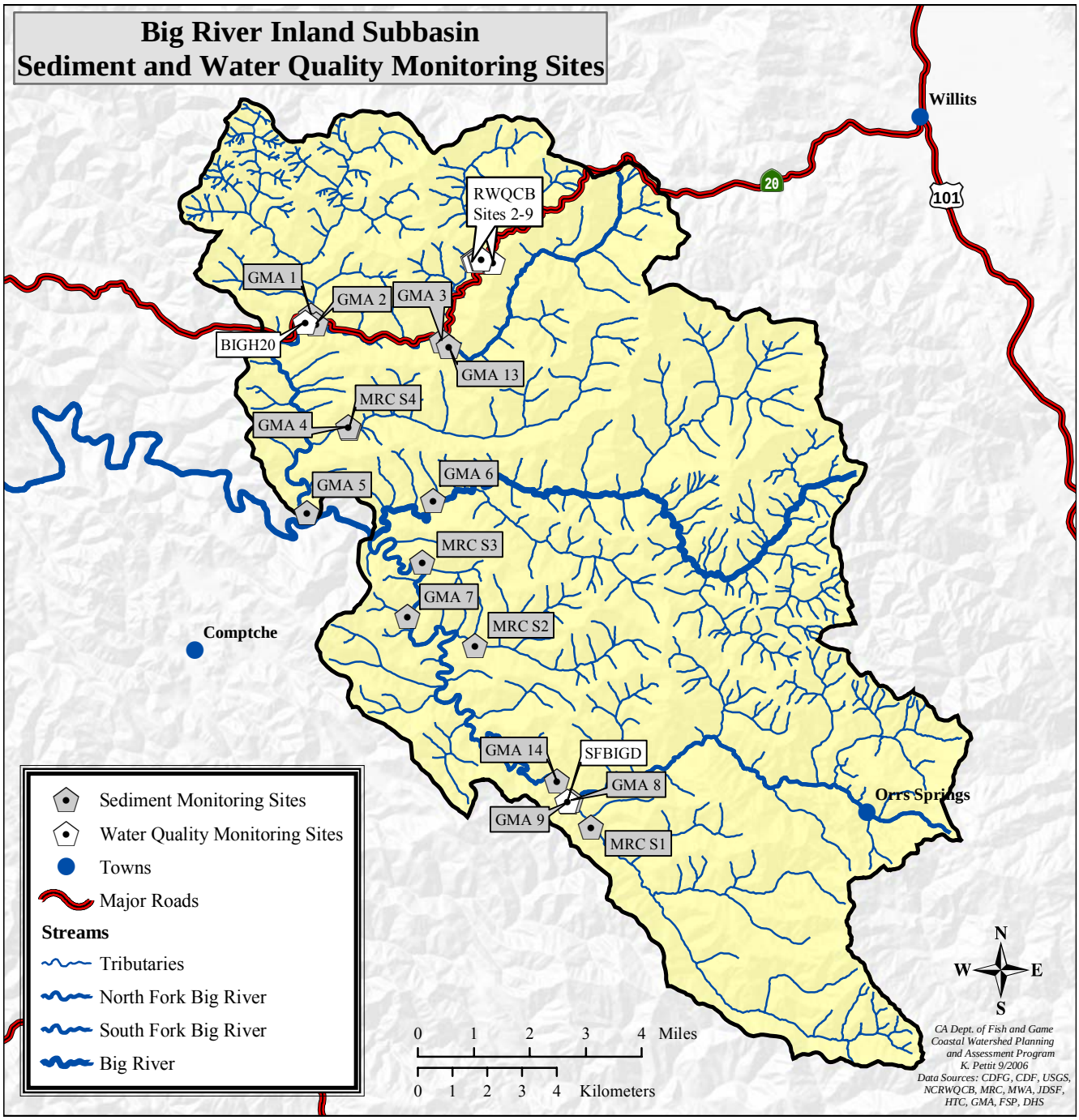


Figure 127. In-stream sediment and water quality monitoring sites, North Fork Big River Subbasin.

Bulk Sediment

MRC collected McNeil core samples in four locations in 2000 (MRC S4), including permeability measurements, thalweg profiles, and stream cross-sections. GMA also collected McNeil core samples in 2001 at most of the turbidity/suspended sediment sampling sites sampled for turbidity. No McNeil sample was collected at the James Creek site above the North Fork (GMA 3) or South Fork Big River below Daugherty Creek (GMA 14). However, additional sample sites included North Fork above James Creek, South Fork Big River above the Big River (GMA 7), South Fork Big River above Daugherty Creek (GMA 8), and Daugherty Creek above the South Fork Big River (GMA 9). When possible, GMA locations also coincided with MRC McNeil sampling sites. 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. These data are only comparable to other data collected using the gravimetric method.

The subsurface streambed material in the North Fork Big River shows large increases in the amount of fine sediment between James Creek and Chamberlain Creek (GMA 13 to GMA 2). Lower Chamberlain Creek (GMA 1) and the lower East Branch North Fork Big River (GMA 4) appear to contribute moderate amounts of fine sediment in the sub 5.6 mm and 0.85 mm size classes to the North Fork Big River. However, based on limited sampling, both tributaries appear to have less fine sediment in these size classes than found in the North Fork Big River immediately above the confluence with Chamberlain Creek. At the lower end of the subbasin, the North Fork Big River site (GMA 5) shows a decrease in fine sediment in all size classes compared to any of the measured tributaries and mainstem North Fork samples, except the one sample collected upstream of James Creek (GMA 13).

The observed changes in fine sediment may be due to fine sediment coming from James Creek into the North Fork Big River. At the bottom of the North Fork Big River (GMA 5), it appears as though sub 5.6 mm sediment is significantly lower than observed in any of the sediment sampling locations except for the single site on the North Fork Big River upstream of James Creek (GMA 13). This may be due to a lag in the downstream transport of fine sediment or to higher flows in this area more effectively transporting fine sediment out of this reach of the North Fork. At all of the sediment sampling sites, the observed differences may also be due in part to normal sample variability.

In 2000, MRC also collected McNeil core samples at one site in the North Fork Subbasin (MRC S4). The MRC site is located in the lower portion of the East Branch North Fork Big River. Like the GMA samples, these sediment samples were collected using the gravimetric method and are therefore not directly comparable to the Big River TMDL target for fine sediment. However, they are unfortunately also not comparable to the GMA samples because the GMA samples do not include surface particles.

There is substantially less fine sediment in nearly all of the size classes at the Daugherty Creek site (GMA 9) than at the other two South Fork Big River sites (GMA 7 and GMA 8). By looking at the GMA data, it appears there is a significant amount of fine sediment in all sub 5.6 mm size classes in the South Fork Big River above the confluence with Daugherty Creek. By the bottom of the subbasin, the one GMA sample in the South Fork Big River suggests that the fine sediment moving through this area is somewhat less than found upstream of Daugherty Creek. However, inspection of the MRC data collected the previous year (2000) at nearby sites indicate that the MRC Daugherty Creek site (MRC S1) contained more fine sediment than either the South Fork site (MRC S3) or the Ramon Creek site (MRC S2). As a group the MRC samples do not necessarily support the pattern seen with the GMA samples only one year later.

Permeability

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 each of 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 East Branch North Fork Big River site (MRC S4) had generally low to moderate median permeability values. Using the empirical formula (McBain and Trush 2000), this stream segment was expected to have roughly 10-35% 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.

The Daugherty Creek (MRC S1) and Ramon Creek (MRC S2) stream segments each had very low median permeability values. Using the empirical formula (McBain and Trush 2000), these stream segments were expected to have roughly 12-17% and 0-2% survival to emergence, respectively. The South Fork Big River (MRC S3) stream segment was expected to have roughly 22-47% survival to emergence. Based on this one year of data (2000), the South Fork Big River stream segment (MRC S3) had significantly better streambed gravel permeability than either the Daugherty Creek (MRC S1) or Ramon Creek (MRC S2) stream segments. Both MRC S1 and MRC S2 had substantial amounts of fine sediment in the streambed gravel interstitial spaces, and it is likely that spawning success in these stream segments was relatively poor. Conversely, MRC S3 appeared have less fine material plugging the interstitial spaces and was more likely to support successful spawning. To some degree, particularly in the sub-0.85 mm size class, the MRC bulk sediment samples appear to support this conclusion.

Water Chemistry

The Inland Subbasin contained three water quality sampling sites. One water quality sampling site was a community water system at the CDF Chamberlain Creek Conservation Camp under DHS purview. The intake to the drinking water system (the sampling point) is on lower Chamberlain Creek, immediately above the confluence with the North Fork Big River.

SWAMP sampled water quality on the North Fork Big River below the confluence with Chamberlain Creek and the South Fork Big River below the confluence with Daugherty Creek (SWAMP SFBIGD). A creek diversion (surface water) system is operated by CDF at the Chamberlain Creek Conservation Camp that has been typically sampled two to three times a year from 1991 through 2000 (last available data). The source water was not sampled in 1992, 1994, 1995, and 1998. Both SWAMP sampling sites were sampled on two occasions in 2001.

No water column chemistry data were found in the headwaters drainage.

The analysis of water column chemistry is divided into parameters with numeric water quality objectives in the Basin Plan, parameters with narrative water quality objectives in the Basin Plan (which can be quantified using numeric criteria found in the literature), and other important parameters that may have applicable narrative water quality objectives, but no available numeric criteria.

Basic water chemistry data, including dissolved oxygen, specific conductance, total dissolved solids, and hydrogen ion concentration (pH) were compared to numeric water quality objectives in the Basin Plan. Dissolved oxygen and total dissolved solids were not sampled at the Chamberlain Creek site. The summary data for basic water quality at the Inland Subbasin sites are shown in Table 185.

Table 185. Basic physical water parameters, Inland Subbasin.

Parameter	Count All	Count DetectS	Min.	Date Min*	Max.	Date Max	Avg.	W.Q. Objectives	
								MIN	MAX
Site Name, Location: CDF Chamberlain (DHS), lower Chamberlain Creek									
pH, Lab (pH units)	1	1	7.9	2/14/96	7.9	2/14/96	NA	6.5	8.5
Specific Conductance (µS/cm)	1	1	134	2/14/96	134	2/14/96	NA	NA	300[3] / 195[4]
Site Name, Location: SWAMP BIGH20, North Fork Big River									
Dissolved Oxygen, Field (mg/L)	2	2	9.86	06/28/01	10.33	05/10/01	NA	7.0 / 7.5[1] / 10.0[2]	NA
pH, Lab (pH units)	2	2	8.3	05/10/01	8.46	06/28/01	NA	6.5	8.5
pH, Field (pH units)	2	2	8.22	05/10/01	8.38	06/28/01	NA	6.5	8.5
Specific Conductance (µS/cm)	1	1	220	06/28/01	220	06/28/01	NA	NA	300[3] / 195[4]
Specific Conductance, Field (µS/cm)	2	2	209	05/10/01	226	06/28/01	NA	NA	300[3] / 195[4]
Total Dissolved Solids (mg/L)	2	2	140	05/10/01	150	06/28/01	NA	NA	190[3] / 130[4]
Site Name, Location: SWAMP SFBIGD, South Fork Big River below Daugherty Creek									
Dissolved Oxygen, Field (mg/L)	2	2	9.34	06/28/01	10.82	05/09/01	NA	7.0 / 7.5[1] / 10.0[2]	NA
pH (pH units)	2	2	8.3	06/28/01	8.36	05/09/01	NA	6.5	8.5
pH, Field (pH units)	2	2	8.14	06/28/01	8.3	05/09/01	NA	6.5	8.5
Specific Conductance (µS/cm)	1	1	300	06/28/01	300	06/28/01	NA	NA	300[3] / 195[4]
Specific Conductance, Field (µS/cm)	2	2	263	05/09/01	297	06/28/01	NA	NA	300[3] / 195[4]
Total Dissolved Solids (mg/L)	2	2	160	05/09/01	170	06/28/01	NA	NA	190[3] / 130[4]

Date on which the minimum value occurred is the first date that the value occurred. For example, if there were several "non-detects", represented here as a zero, the date given is the first instance of non-detect (chronologically).

[1] Value represents the 90th percentile lower limit. 90% of the values in a calendar year must be equal to or greater than the 90% lower limit.

[2] Value represents the 50th percentile (median) lower limit. 50% of the monthly means in a calendar year must be equal to or greater than the 50% lower limit.

[3] Value represents the 90th percentile upper limit. 90% of the values in a calendar year must be equal to or less than the 90% upper limit.

[4] Value represents the 50th percentile (median) upper limit. 50% of the monthly means in a calendar year must be equal to or less than the 50% upper limit.

The pH of the water at the Chamberlain Creek site (CDF Chamberlain) was reported at 7.9, which is within the Basin Plan water quality objective. Specific conductance appeared to be within or slightly below the acceptable range in the one sample collected. However, in all cases, the amount of data available for this site, combined with unknown data quality, limit the data to screening purposes only.

At the North Fork Big River site (SWAMP BIGH20), water samples for pH, total dissolved solids, and specific conductance were collected for laboratory analysis. Additional measurements of dissolved oxygen, pH, and specific conductance were taken in the field. Each of these constituents appeared to be within the acceptable range in both samples.

Keeping in mind the limited data that are available, specific conductance and total dissolved solids measurements were relatively high in the South Fork Big River sample site compared to Basin Plan water quality objectives.

Narrative water quality objectives in the Basin Plan apply to a variety of metals and other constituents that were detected during the sampling events. This includes alkalinity, aluminum, ammonia, barium, boron, chloride, copper, iron, sodium, sulfate, and zinc. Unlike the constituents shown in Table 185, the numeric criteria for these parameters are derived from the literature to support the narrative water quality objectives. The constituents and the most conservative applicable criteria are shown in Table 186.

Table 186. General water column chemistry, Inland Subbasin.

Parameter	Count All	Count Detects	Min.	Max.	Avg.	Criteria	Criteria exceeded?	Comments on Criteria[1]
Site Name, Location: CDF Chamberlain (DHS), lower Chamberlain Creek								
Alkalinity, Total (mg/L as $CaCO_3$)	1	1	54	54	NA	≥ 20 mg/L	No	Protection of freshwater aquatic life
Aluminum (µg/l)	3	2	0	1300	NA	≤ 87 µg/L	Yes	Protection of freshwater aquatic life
Barium (µg/l)	3	1	0	21	NA	≤ 1000 µg/L	No	Primary California MCL for drinking water
Chloride (mg/l)	1	1	14	14	NA	≤ 106 mg/L	No	Protection of agricultural water uses
Copper (µg/l)	1	1	190	190	NA	≤ 4.0 µg/L	Yes	Protection of freshwater aquatic life with a hardness of 39 mg/L[2]
Iron (µg/l)	1	1	140	140	NA	≤ 300 µg/L	No	Secondary California MCL for drinking water
Sodium (mg/l)	1	1	9.7	9.7	NA	≤ 2 mg/L	Yes	SNARL for drinking water toxicity other than cancer risk, US EPA[3]
Sulfate (mg/l)	1	1	4.1	4.1	NA	≤ 250 mg/L	No	Secondary California MCL for drinking water
Zinc (µg/l)	1	1	88	88	NA	≤ 53 µg/L	Yes	Protection of freshwater aquatic life with a hardness of 39 mg/L[2]
Site Name, Location: SWAMP BIGH20, North Fork Big River								
Alkalinity, Total (mg/L)	2	2	90	98	NA	≥ 20 mg/L	No	Protection of freshwater aquatic life
Boron (µg/L)	2	2	240	300	NA	≤ 630 µg/L	No	IRIS reference dose for drinking water, US EPA
Chloride (mg/L)	1	1	8.1	8.1	NA	≤ 106 mg/L	No	Protection of agricultural water uses
Copper (µg/L)	2	0	0	0	NA	≤ 7.6 µg/L	No	Protection of freshwater aquatic life with a hardness of 83 mg/L[2]
Iron (µg/L)	2	0	0	0	NA	≤ 300 µg/L	No	Secondary California MCL for drinking water
Sodium (mg/L)	2	2	12	13	NA	≤ 2 mg/L	Yes	SNARL for drinking water toxicity other than cancer risk, US EPA[3]
Sulfate as SO_4 (mg/L)	1	1	6.3	6.3	NA	≤ 250 mg/L	No	Secondary California MCL for drinking water
Zinc (µg/L)	2	0	0	0	NA	≤ 101 µg/L	No	Protection of freshwater aquatic life with a hardness of 83 mg/L[2]
Site Name, Location: SWAMP SFBIGD, South Fork Big River below Daugherty Creek								
Ammonia as N (mg/L)	2	1	0	0.24	NA	≤ 1.39 mg/L	No	Ambient water quality for ammonia, US EPA[2]
Boron (µg/L)	2	2	1000	2400	NA	≤ 630 µg/L	Yes	IRIS reference dose for drinking water, US EPA
Chloride (mg/L)	1	1	9.9	9.9	NA	≤ 106 mg/L	No	Protection of agricultural water uses
Sodium (mg/L)	2	2	16	19	NA	≤ 2 mg/L	Yes	SNARL for drinking water toxicity other than cancer risk, US EPA[3]
Sulfate as SO_4 (mg/L)	1	1	9.7	9.7	NA	≤ 250 mg/L	No	Secondary California MCL for Drinking Water
Total Alkalinity (mg/L)	2	2	110	130	NA	≥ 20 mg/L	No	Protection of freshwater aquatic life
Zinc (µg/L)	2	1	0	21	NA	≤ 123 µg/L	No	Protection of freshwater aquatic life with a hardness of 105 mg/L[2]

[1] See the Water Column Chemistry section for description of criteria.
[2] See text below for details on derivation of criteria.
[3] Assumes a relative source contribution of 10% from drinking water and 90% from other dietary sources.

As can be seen in Table 186, several constituents, including aluminum, copper, sodium, and zinc exceeded their numeric criteria at the Chamberlain Creek site (CDF Chamberlain). At the North Fork Big River site (SWAMP BIGH20), neither copper nor zinc was detected at or above the detection limits for the analytical method used, which were 10 µg/L and 20 µg/L, respectively. However, sodium was detected at similar concentrations at both sites; all of which were above the water quality criteria. The aluminum concentration at the lower Chamberlain Creek site (CDF Chamberlain) exceed all of the applicable primary and secondary MCLs, including the US EPA MCL (20-200 µg/l), the California primary MCL (1,000 µg/l), and the California secondary MCL (200 µg/l). No other criteria were found in Marshack (2000) relating to sodium, copper, or zinc.

At the Chamberlain Creek site (CDF Chamberlain), it is not clear if the water samples were filtered or not-filtered, and how they were collected and analyzed. Each of these factors could affect the extent to which the sample results are representative of the true concentrations. It is unclear if the metals in the water are naturally occurring or anthropogenic pollution from the CDF camp. While samples collected for DHS are generally located at the system intake, it is also possible that the sample is from some other point in the water system. In addition, with only one to three samples, these results are only a beginning of the sample set that is needed to characterize the surface water in Chamberlain Creek and the North Fork Big River. Therefore, these values are useful as screening values only and additional sampling should occur to adequately characterize the water quality.

Boron and sodium exceeded their numeric criteria at the South Fork Big River site (SWAMP SFBIGD). In the case of boron, both samples also equaled or exceeded the DHS action level (1,000 µg/l) and agricultural use criteria (700-750 µg/l). However, with only one to two samples, these results are only a beginning of the sample set that is needed to characterize the surface water in South Fork Big River. Therefore, additional sampling should occur to adequately characterize the water quality and determine the source(s) of constituents that exceed their criteria.

It should also be noted that at the North Fork Big River and South Fork Big River sites, alkalinity was speciated into carbonate, bicarbonate, and hydroxide alkalinity. At these sites, the alkalinity was almost entirely bicarbonate alkalinity, with small amounts of other alkalinity at levels below the detection limits. Samples for total hardness as calcium carbonate ($CaCO_3$) were also collected on one occasion at the Chamberlain Creek site, two times at the North Fork Big River site, and at the South Fork Big River site. The sample collected at the Chamberlain Creek site (CDF Chamberlain) on February 14, 1996 was reported to be 39 mg/L. The samples collected at the North Fork Big River site (SWAMP BIGH20) on May 10, 2001 and June 28, 2001 was 82 and 85 mg/L, respectively. The samples collected for hardness on May 9, 2001 and June 28, 2001 were 100 and 110 mg/L, respectively. These values were used to determine the water quality criteria for the metals such as copper and zinc, whose toxicity depends on the hardness of the water.

Water samples were also collected for ammonia at the North Fork Big River and South Fork Big River sites. Of the two samples collected from the North Fork Big River, one of the samples, collected on June 28, 2001 contained 0.12 mg/L of ammonia nitrogen. Ammonia in the other water sample was not detected at or above the analytical detection limit of 0.05 mg/L. Of the two samples collected on the South Fork Big River, one sample collected on May 9, 2001 contained 0.24 mg/L of ammonia nitrogen. Ammonia in the other water sample was not detected at or above the analytical detection limit of 0.05 mg/L.

The toxicity of ammonia to freshwater organisms depends on several factors, including the water temperature and pH. During sample collection, the pH was measured at 8.3 and 8.38 and the water temperature was measured at 61.2 and 61.0°F. Based on these values, the water quality criteria for ammonia is approximately 1.17 mg/L at North Fork Big River and 1.39 mg/L at South Fork Big River (US EPA 1999). This criterion is for a 30-day average concentration with fish in the early life stages present. Therefore, ammonia was detected but did not exceed the numeric criteria. Nitrate/Nitrite nitrogen was also sampled for, but was not detected at or above the analytical detection limit of 0.05 mg/L.

Turbidity, phosphorus, and chlorophyll-a were also reported, but none have specific numeric criteria at this time. However, they are broken out separately because they are significant constituents of water quality. Turbidity, for the purposes of this assessment, is considered a sediment related parameter and is discussed in the Turbidity and Suspended Sediment section.

Phosphorus can enter surface water bodies through fertilizer run-off or from the natural weathering of rocks in some watersheds. Phosphorus is as a biostimulantory substance for algae, and excessive amounts can lead to algae blooms which can impact other aquatic life by negatively affecting dissolved oxygen concentrations. The summary data for phosphorus samples collected at the North Fork Big River and South Fork Big River sites are shown in Table 187. No samples for phosphorus were collected at the Chamberlain Creek site (CDF Chamberlain).

Table 187. Phosphorus summary, Inland Subbasin.

Parameter	Count All	Count DetectS	Min.	Date Min	Max.	Date Max	Avg.
Site Name, Location: SWAMP BIGH20, North Fork Big River							
Phosphorus (mg/L)	2	0	0	NA	0	NA	NA
Orthophosphate as P (mg/L)	2	1	0	06/28/01	0.058	05/10/01	NA
Site Name, Location: SWAMP SFBIGD, South Fork Big River below Daugherty Creek							
Phosphorus (mg/L)	2	0	0	NA	0	NA	NA
Orthophosphate as P (mg/L)	2	0	0	NA	0	NA	NA

There are not sufficient data to make more than broad statements about phosphorus. However, there was not an apparent problem with elevated phosphorus levels in the samples. However, orthophosphate was detected on one occasion in the North Fork Big River. Orthophosphate, one of several species that together make up total phosphorus, is believed to be the more bio-available variety to plants such as algae. However, there is no water quality criteria for this constituent and therefore it is used primarily to screen for other potential water quality problems.

Chlorophyll-a was also sampled once at the North Fork Big River and South Fork Big River sites and was detected with a concentration of 0.00078 mg/L in the North Fork Big River. Chlorophyll-a is a measurement of the chlorophyll in the suspended algae in the water column. High chlorophyll-a content, which directly relates to high algal concentrations in freshwater, can be an indicator of nutrient contamination of the surface water (such as in fertilizer run-off). However, there are no water quality criteria for this constituent and therefore it is used primarily to screen for other potential water quality problems.

On February 27, 2001, a tanker truck containing approximately 7,000 gallons of used motor oil and diesel overturned on Highway 20 at mile marker 21.76 (measured from the Highway 1/Highway 20 intersection at Fort Bragg). While some of the liquid remained on the roadway and adjacent unpaved shoulders, a portion of it ultimately discharged to a tributary to James Creek. In an attempt to stop continued discharge of pollutants to James Creek, a dam was constructed on the tributary. However, testing at various locations along the un-named tributary and James Creek itself (RWQCB 2-RWQCB 10) indicated that some of the constituents discharged to James Creek. This included 1,2,4-trimethylbenzene, toluene, xylene, tetrachlorethene, methyl tert-butyl ether (MtBE), petroleum hydrocarbons in the diesel and motor oil ranges, and others. Many of these compounds exceeded their numeric water quality criteria, but the event was episodic and has been in active cleanup. Because of the active cleanup and frequent verification monitoring, this spill is unlikely to have a sustained impact on wildlife.

Discussion

Collectively, temperature data show that monitored sites in the Inland Subbasin are mostly unsuitable for MWATs but, conversely, are suitable when seasonal maximum temperature thresholds are considered.

The North Fork mainstem was unsuitable for MWATs but suitable when maximum temperature thresholds are considered. Most of the tributaries to the North Fork Big River had a majority of stations with suitable MWATs and, like the mainstem, all of the seasonal maximum temperatures were within the fully suitable range. In the South Fork drainage, the majority of unsuitable MWATs were located in the South Fork Big River and Daugherty Creek mainstems while tributary reaches were suitable for seven of twelve records analyzed. The mainstem Big River was unsuitable for salmonids when MWATs were considered but suitable when peak seasonal maximum temperature thresholds were considered. Four of seven tributaries in the headwaters drainage had seasonal MWAT records that were suitable for salmonids. In the eleven headwaters drainage tributaries monitored, all of the peak maximum temperatures were suitable for salmonids.

The predominance of suitable maximum seasonal temperatures in the Inland Subbasin follows similar patterns present in the other Big River Subbasins. Perhaps this is due, in part, to the proximity of most of the Big River Basin to the Pacific Ocean and the moderating influence of associated coastal marine weather, dominated during most of the mid- to late summer season by foggy, overcast conditions. Water temperatures also reflect overall habitat and geological conditions documented by the CDFG and, whose results generally show more sheltered streams located in narrow valleys and canyons, respectively, that provide a greater degree of solar protection to subbasin streams.

Bulk sediment sampling records had mixed results, with the smaller fraction threshold of ≤0.85mm found to be largely suitable for salmonid egg incubation, while gravel ≤6.4 mm were shown to be marginally suitable to unsuitable for the survival to emergence of salmonids from their redds in those stream reaches sampled. Gravel permeability sampling largely agrees with the bulk sampling data, particularly in Lower Ramon Creek, when extrapolated as a surrogate for fine sediment (matrix) particles lodged between larger (framework) gravel.

The data results from the 1996 physical-chemical sampling did show criteria/threshold exceedences for aluminum, copper, and zinc during 1996 DHS investigations at Chamberlain Creek, and also sodium during the DHS 1996 and SWAMP 2001 sampling events. The SWAMP site that was in the North Fork Big River, just downstream from the confluence of Chamberlain Creek, did not have elevated levels of metals in analyzed samples. In all likelihood sodium is naturally occurring in specific watershed tributaries. A single elevated analyses for a particular metal may be naturally occurring in local streams, but when all three metals exceed established criteria in the water sampled, anthropogenic sources become suspect. Further sampling and site characterization would be necessary to determine if the three metals present in DHS water sampling at Chamberlain Creek are related to past and/or present activities at the CDF Chamberlain Creek Conservation Camp. The data results from the two days of physical-chemical sampling in South Fork Big River during 2001, even though boron and sodium exceeded specific thresholds, are insufficient to fully characterize historical and/or future trends of chemical water quality conditions in the South Fork Big River.

Riparian Conditions

There are 8,202 acres in the Inland Subbasin in stream buffers, which includes the areas between the water and gravel bars in the lower reaches (Table 188). Across the subbasin, the area around the watercourses is well vegetated, as indicated by the 70 to 100% density class which accounts for 93% of the area (Table 189). Also 77% of the buffer area is in 80% canopy density or better, and 55% of the area is in the 90-100% canopy closure class. The PW with the lowest percent of its stream buffers covered by greater than 70% canopy density was Leonaro Lake. These numbers are substantiated by high canopy densities found along stream reaches surveyed by CDFG and discussed in *Fish Habitat Relationships*.

Table 188. Density of riparian vegetation in the North Fork 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%	
Chamberlain Creek	4		7	2	3			223	125	621	984
East Branch North Fork				14				68	159	219	459
James Creek	1			12				50	144	203	409
Lower North Fork	2			2	1	4	1	131	120	281	542
Upper North Fork	3	4		9	7	1	1	62	129	259	476
Dark Gulch	25	2		7	9	3	1	112	114	375	649
Leonaro Lake	75	27	3	21	36	16	17	64	101	135	495
Mettick Creek	7	6	2	26	1	12	3	187	295	775	1,314
South Daugherty Creek	15	1	1	10	6	4	5	84	204	501	830
Martin Creek	9	13	1	36	5	16	7	61	113	274	535
Rice Creek	15	4		22	6	1	7	121	187	451	814
Russell Brook	5	9		5	6	9	2	103	138	419	695
Total Inland	**161**	**66**	**14**	**166**	**80**	**66**	**44**	**1,266**	**1,829**	**4,513**	**8,202**

Table 189. Percentage of stream buffer area in higher canopy closure classes in the North Fork Subbasin.

Planning Watersheds	Percent of Buffer Area by Crown Canopy Density				
	70%	80%	90%	70%+	80%+
Chamberlain Creek	23	13	63	98	76
East Branch North Fork	15	35	48	97	82
James Creek	12	35	50	97	85
Lower North Fork	24	22	52	98	74
Upper North Fork	13	27	54	95	82
Dark Gulch	17	18	58	93	75
Leonaro Lake	13	20	27	61	48
Mettick Creek	14	22	59	96	81
South Daugherty Creek	10	25	60	95	85
Martin Creek	11	21	51	84	72
Rice Creek	15	23	55	93	78
Russell Brook	15	20	60	95	80
Total Inland	**15**	**22**	**55**	**93**	**77**

As shown in Table 190, the majority of the trees in the watercourse buffer zone are small to medium/large, which are 12 to 40 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 subbasin is in these size classes. The percentage area in these three size classes is highest in the North Fork drainage and lowest in the headwaters and South Fork drainages. At the PW level, the percentage varies from 76% in the Leonaro Lake PW to 99% in the Chamberlain Creek and James Creek PWs.

Table 190. Acres by vegetation size class in watercourse buffer zone in the Inland 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	%
Chamberlain Creek	0	0	8	1	429	44	511	52	33	3
East Branch North Fork Big River	0	0	13	3	314	68	132	29		0
James Creek	0	0	4	1	261	64	144	35		0
Lower North Fork Big River	0	0	11	2	233	43	248	46	48	9
Upper North Fork Big River	0	0	36	8	287	60	146	31	3	1
Total North Fork	**0**	**0**	**71**	**2**	**1,524**	**53**	**1,181**	**41**	**85**	**3**
Dark Gulch	4	1	21	3	314	48	212	33	73	11
Leonaro Lake	3	1	42	8	257	52	97	20	22	4
Mettick Creek	0	0	45	3	905	69	357	27	0	0
South Daugherty Creek	0	0	50	6	543	65	220	27	1	0
Total South Fork	**6**	**0**	**159**	**5**	**2,019**	**61**	**886**	**27**	**97**	**3**
Martin Creek	6	1	73	14	324	61	121	23	1	0
Rice Creek	7	1	52	6	551	68	189	23	0	0
Russell Brook	1	0	20	3	475	68	194	28	0	0
Total Headwaters	**15**	**1**	**144**	**7**	**1,350**	**66**	**504**	**25**	**1**	**0**
Total Inland	**21**	**0**	**375**	**5**	**4893**	**61**	**2571**	**32**	**181**	**2**

MRC examined LWD recruitment potential on their ownership in the Inland Subbasin. They found that LWD recruitment potential is quite poor in their ownership (Figure 128). An exception is the East Branch of the North Fork Big River 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.

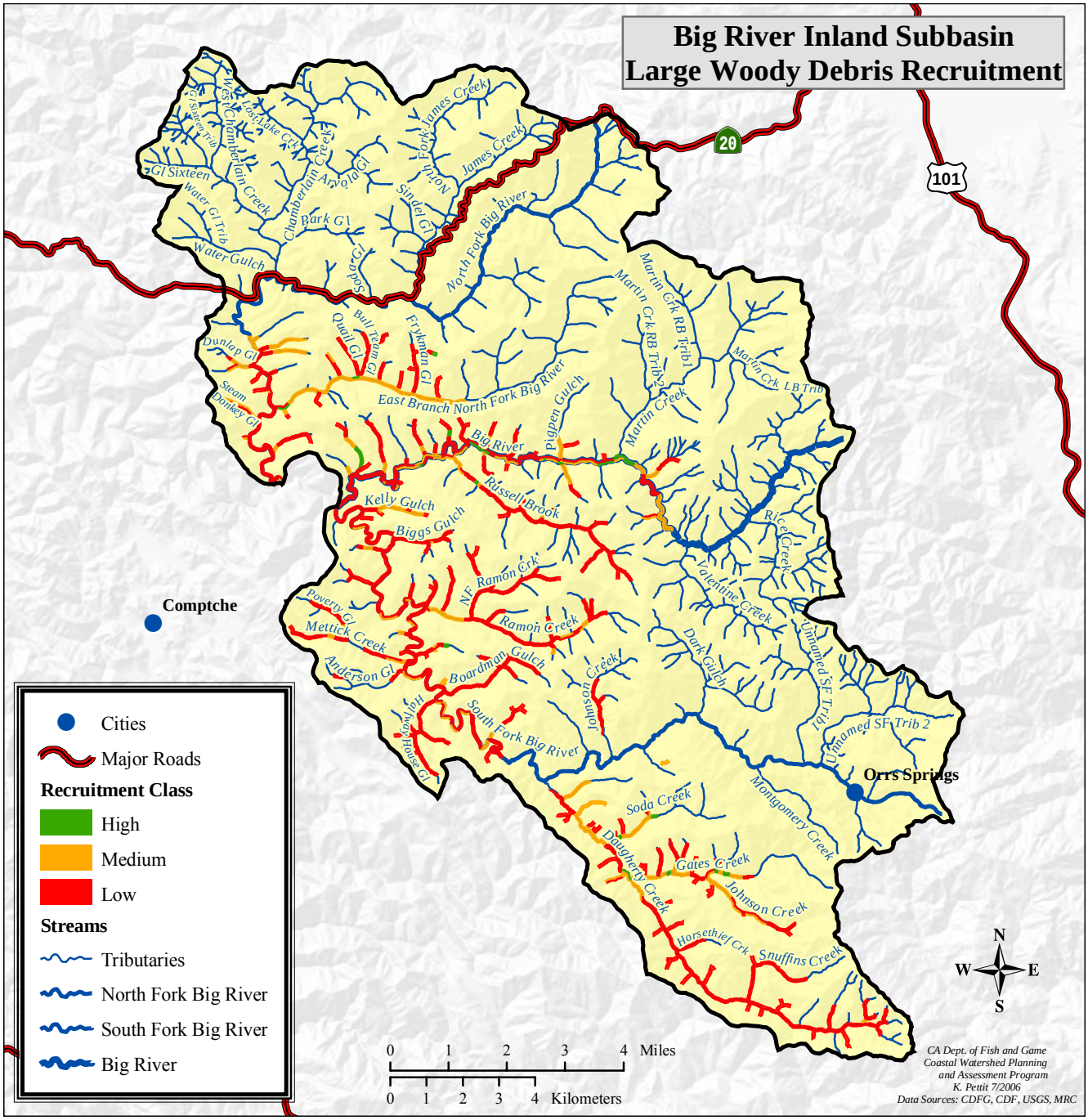


Figure 128. Map of LWD recruitment potential classes on MRC ownership in the Inland Subbasin (MRC 2003).

Fish Habitat Relationship

Past Habitat Conditions

CDFG stream surveys were conducted for 26 tributaries in the Inland Subbasin from 1950 to 1979. One stream survey was also conducted by the Center for Education and Manpower Resources in 1979. 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 mostly describe a range of spawning habitat, pools, and cover from poor to excellent (Table 191). Spawning gravel in most streams was described as excellent to fair. However, spawning gravel in James Creek, Snuffins Creek, Pig Pen Gulch, and the two unnamed tributaries to South Fork Big River was reported as scarce

or poor. Pool development was described as excellent in South Fork Big River. Pools in most streams were described as common, but not deep. Shelter in most streams was described as good to excellent though shelter in Rice Creek and East Branch Rice Creek was reported as poor.

Many debris jams were described on most surveyed streams. A 1958 CDFG flyover survey of 25 tributaries and the mainstem Big River found possible fish passage barriers on South Fork Big River, Mettick Creek, Anderson Gulch, Daugherty Creek, Montgomery Creek, South Fork Big River Tributary #1, mainstem Big River, and Martin Creek. The flyover also reported extensive damage caused by logging in Chamberlain Creek, James Creek, Johnson Creek, Dark Gulch, Montgomery Creek, and South Fork Big River tributaries #1 and #2.

Table 191. Habitat comments from surveys conducted in the North Fork Subbasin from 1958-1979.

Tributary	Date Surveyed	Habitat Comments	Barrier Comments
North Fork Big River	10/16/1958 (flyover)	Appears to have considerable fisheries value as a spawning and nursery area for anadromous fishes	Eight log jams noted in the six miles between the mouth of James Creek and the headwaters
	10/16/1958	Substrate predominantly gravel and small rubble throughout; very good to excellent spawning areas; very good pool development, some pools average 10 feet deep; very good shelter, mainly in the form of undercut banks, rock, and streamside vegetation	Two log jams may develop into barriers; 1. approximately 200 feet below TS-3 road bridge crossing- four cut logs jammed in narrow gorge section, serious barrier to fish life could result; 2. approximately ¼ mile above North Fork Camp- small amount of debris piled up against large log lying across the channel (10 feet above the streambed level), no barrier at present, potential barrier
	8/4/1959	Substrate gravel, sand, rubble, and bedrock; good spawning areas above tributary #6; good pool development, range from 2 - 4 feet deep; good shelter provided by undercut banks, boulders, and heavy tree shade; water temperatures 57-60°F	Many log jams and barriers; 10 complete barriers
East Branch North Fork Big River	10/16/1958 (flyover)	The entire stream could not be observed due to dense conifer canopy	One large log jam was observed approximately three miles above the mouth
	11/3/1958	Substrate gravel and rubble; excellent spawning areas throughout 1 mile lower section; medium sized pools scattered throughout the one mile section; good shelter provided by under cut banks and rock	One barrier observed 50 feet above the mouth of the stream; not a barrier at present, but may become a barrier in the future
	7/30/1959	Excellent spawning in the middle and upper sections; good pool development, average 6 feet wide, 10 feet long, 2 feet deep; excellent shelter provided by heavy tree shade, rocks, and undercut banks	Many log jams and partial barriers
	8/29/1966	Section 1: Few spawning areas, very little gravel, mainly boulders; pools frequently excellent, average 1 foot deep; good shelter , provided by logs, roots, boulders, and undercut banks; Section 2: spawning areas plentiful, gravels very good, silt is a problem; pools frequently good, average size 1 foot deep; good shelter, provided by logs, roots, boulders, and undercut banks; Section 3: spawning gravels present, could be good if winter flow is high enough to remove silt; pools frequently poor, average size 0.5 foot deep; shelter poorer than sections 1 and 2, provided by logs, roots, boulders, and undercut banks; water temperature 55°F	7 log jams, all major barriers to fish passage
	3/26/1979 (Center for Education and Manpower Resources)	Excellent quality gravel for spawning in the first 1 mile upstream, then increasing quantities of silt; 80% pools, some up to 4 feet deep, often more than 2 feet deep; numerous logs, pools, and boulders provide shelter; water temperature 49-50°F	8 main log jams; 1 impassable, and several with limited passage
Chamberlain Creek	10/16/1958 (flyover)	The majority of the 8 miles of stream surveyed has been removed from fisheries production through needlessly poor logging practices	
Water Gulch	10/16/1958 (flyover)	Unimportant to fish life	
	10/1959	At present, of no use to fish life; possibly could be of importance to fish life after stream clearance	
James Creek	10/16/1958 (flyover)	Practically the entire 8 miles of previously good salmon and steelhead stream has been lost to the fishery due to extensive logging damage and erosion through CDF road building activities	

Tributary	Date Surveyed	Habitat Comments	Barrier Comments
	11/30/1958	Poor spawning areas due to siltation and logging debris, spawning areas present are probably inaccessible due to existing barriers; pools common to scarce, range from 1 to 4 feet deep, average 2 feet deep; mostly excellent shelter	Filled with log-debris jams; not a 100 feet section of streambed that is free of logs; trees and slash actually fill the streambed for a considerable distance
North Fork James Creek	12/9/1958	Substrate mostly gravel-rubble and rubble-gravel, some silt in the lower section of the creek and some mud in the bottom near the headwaters; comparatively large areas of medium to good spawning gravels in the upper reaches; pools common throughout, averaging 1-2 feet deep; good to excellent shelter provided by undercut bank, riparian growth, and fallen trees	Many log jams throughout; most appear to be partial barriers, but could become permanent barriers in the future; all jams are natural windfalls
South Fork Big River	8/8/1957 10/16/1958 11/8/1958	Substrate predominantly gravel, rubble, with some bedrock; generally good to excellent spawning areas; excellent pool development, large and frequent pools; very good shelter provided by logs, brush, and undercut banks	Seven logjams that are complete or partial barriers
	10/16/1958 (flyover)		The nine miles of stream above the mouth are completely free of all obstructions to fish life; the remaining eight miles of stream contain 7 log jams or other barriers to fish life
	8/25/1966	Section 1: Good spawning gravels; excellent pool frequency, very large pools; good shelter. Section 2: abundant spawning areas; excellent pool frequency, fairly large pools; good shelter. Section 3: poor spawning area due to heavy silt, and a great deal of rubble; good pool frequency, smaller pools; good shelter. Section 4: poor spawning area due to a great deal of bedrock and silt; poor pool frequency, small pools; poor shelter. Water temperature 74°F at Orr Springs	No logjams that could be considered barriers
Kelly Gulch	circa 1950	Poor and short sections for fisheries	
	10/16/1958 (flyover)	Appeared unimportant to fish life	
Biggs Gulch	circa 1950	Poor and short sections for fisheries	
	10/16/1958 (flyover)	Appeared unimportant to fish life	
Ramon Creek	10/16/1958 (flyover)		The entire four miles of stream appears clear of obstructions to fish life
	8/11/1959	Substrate primarily gravel with some bedrock, sand, and organic debris; about 75% of the stream is extremely good for spawning fish; good pool development, up to 3 feet deep; fair to good shelter provided by overhanging trees, log jams, undercut banks, and some large boulders; average water temperature 64°F	Logjams
Mettick Creek	circa 1950	Poor and short sections for fisheries	
	10/16/1958 (flyover)		Full of old logging debris
Anderson Gulch	circa 1950	Poor and short sections for fisheries	
	10/16/1958 (flyover)		Full of old logging debris
Boardman Gulch	circa 1950	Poor and short sections for fisheries	
	10/16/1958 (flyover)		Appeared unimportant to fish life

Tributary	Date Surveyed	Habitat Comments	Barrier Comments
Daugherty Creek	10/16/1958 (flyover)	Appeared to have potential as an excellent salmon and steelhead spawning and nursery stream	The entire streambed was not visible due to heavy canopy cover; three log-debris jams noted in the lower and mid-sections of the stream and extensive logging debris in the stream bottom in the headwaters section
	8/10/1959 (downstream)	Substrate gravel and rubble, with occasional areas of bedrock; good to fair spawning areas; pools averaged 8 inches deep and were well developed; good to fair shelter provided by pools, undercut banks, and large rubble; water temperatures ranged from 58-62°F	Many log jams and barriers resulting from logging.
	8/10/1959 (upstream)	Substrate silt, gravel, boulder, rubble, bedrock and sand, heavily silted in upper areas; no-existent spawning areas in valley and upper forks, fair spawning areas in north tributary and remainder of stream; pools common in gorge and canyon and uncommon in valley, averaged 8 inches deep; good shelter provided by stream side growth; average water temperature 62°F	Many log jams and barriers.
Soda Creek	8/11/1959	Substrate gravel, bedrock, rubble, and silt in the upper area and behind barrier; good spawning areas throughout middle and upper areas, upper area only has a few scattered spots of gravel due to siltation; abundant pools averaging 1 foot deep; good shelter provided by overhanging streamside growth and trees; average water temperature 58°F	Many jams and barriers; natural rock falls barrier 75 yards upstream from the mouth.
Gates Creek	10/16/1958 (flyover)	Appeared to have excellent potential as a salmon and steelhead spawning and nursery stream	
Johnson Creek (tributary to Gates Creek)	10/16/1958 (flyover)	Appeared to be a good spawning and nursery stream for anadromous fish	
	8/7/1959	Substrate gravel with rubble, sand, boulder and bedrock; good spawning areas throughout except for a few poor areas; good pool development, average 1 foot deep; good shelter throughout provided by stream side trees and overhanging limbs and roots; average water temperature 57°F	Several logjams and barriers
	8/9/1966	Average bottom very little fine and coarse rubble, very little bedrock, moderate amount of coarse gravel, great deal of fine gravel; pool: riffle ratio 1:3, pools shallow; most pools open and devoid of hiding places, shelter not very good; water temperature 59°F	No barriers present; some logjams present in upper headwater areas.
Snuffins Creek	8/10/1959	Substrate gravel, silt, sand and small amounts of rubble, heavy concentration of silt found in the upper area; fair to poor spawning areas throughout, lower section has fine gravel, middle section has gravel to silt, upper section has some gravel and heavy silting; pools uncommon and poor, average 4 inches deep; fair to good shelter; average water temperature 59°F	Many logjams
	6/9/1966	Since the gravel in the stream bed is fairly loose, and this years fry is present in the stream, it appears that spawning areas are not a problem in the stream; the gravel particle size necessary for steelhead spawning is present in most all riffle areas, and the tail of pools; pools are not too common (1/ 100 feet approximately); pools appear to be in fair shape; average pool 7 inches deep; few pools were observed that were two feet deep; frequency of pools was 25% or less; poor shelter provided by log jams, single logs, and tree roots from large redwood stumps; water temperature 62°F	At least five log jams from the stream mouth to the first total barrier to upstream migration; first total barrier 0.1 mile above the mouth of the stream; first 5 or so jams are not barriers at present, but they will probably silt in during next winters rain; another total barrier located at the second bridge crossing; similar barrier 100 feet above the bridge; 8 log jams were removed in 1966 which improved two miles of stream
Johnson Creek	10/16/1958 (flyover)	Appeared to have been extensively logged	

Tributary	Date Surveyed	Habitat Comments	Barrier Comments
	7/8/1959	Spawning areas fair throughout; good pool development of medium sized pools throughout, becoming uncommon in the extreme upper section; excellent shelter provided by undercut banks, rocks, streamside vegetation, and fallen rocks; average water temperature 57°F	Several logjams and barriers
Dark Gulch	10/16/1958 (flyover)	The entire stream completely lost to the fishery from poor logging practices	
Montgomery Creek	10/16/1958 (flyover)	The entire stream removed from fisheries production through poor logging practice	Stream choked with old logging debris
Unnamed Tributary to the South Fork Big River #1	10/16/1958 (flyover)	Fisheries value considerably reduced through poor logging practices	Partial barriers in the form of log debris exist throughout the entire stream
	11/8/1958	Generally fair to poor spawning areas scattered throughout the entire stream, best in the lower ¾ mile; pools fair in the lower mile, and poor above; shelter provided by logging debris and undercut banks.	Considerable logging debris constituting some partial barriers
Unnamed Tributary to the South Fork Big River #2	10/16/1958 (flyover)	Fisheries value considerably reduced through logging; of minor importance to fish life	
	11/8/1958	Substrate mostly silt, some scattered gravel sections throughout; fair spawning areas present, but generally scarce; pools small and infrequent; shelter adequate and fair.	Three log barriers and other small debris.
Big River	10/16/1958 (flyover)		A large wooden dam located approximately one mile above the mouth of Valentine Creek appeared to block off approximately five miles of the Big River headwaters to anadromous fish
Russell Brook	10/16/1958 (flyover)	Appeared to be a good spawning and nursery stream	The entire four miles of stream surveyed were free from log jams and debris
	8/5/1959	Substrate gravel, rubble, and sand with some amounts of bedrock; fair to good spawning areas; good pool development, average 2 feet deep; excellent shelter provided by overhanging tree limbs and foliage; average water temperature 58°F	Log jams, but no barriers to fish
Pig Pen Gulch	10/16/1958 (flyover)	Not visible due to heavy canopy cover	
	5/29/1959	Spawning areas poor throughout, no desirable spawning areas in upper headwaters, and fair to poor spawning areas in middle and lower sections; good pool development, abundant pools, average 1 foot deep; abundant shelter provided by riparian growth, heavy horsetail and undercut banks	Logging debris and two barriers
Martin Creek	10/16/1958 (flyover)	Appeared to have considerable fisheries value	Three large log jams noted in the lower section of the stream, with a considerable amount of debris above
	8/3/1959	Gravel, rubble, sand, and silt bedrock substrate; fair to good spawning areas, none to poor in the upper and headwater sections, fair in the middle section, good in the lower section; abundant pools throughout, 6 inches to 7 feet deep; excellent shelter provided by riparian growth, undercut banks, and log jams; average water temperature 59°F	Many jams and barriers
Martin Creek Left Bank Tributary	8/3/1959	The east fork has only occasional spawning areas throughout ranging from fair to poor; the north fork of the east fork was fair to poor spawning gravel in the lower half with occasional fair to poor areas in the upper half; in the East Fork pools were common throughout, average 6 inches deep; in the north fork, pools were common in the upper half to uncommon in the lower half; shelter is good on the East Branch except for a few areas where logging operations have opened up the cover; shelter in the north fork is excellent; water temperatures ranged from 56-65°F	Many log jams and barriers

Tributary	Date Surveyed	Habitat Comments	Barrier Comments
Valentine Creek	10/16/1958 (flyover)	Appeared to be a good spawning and nursery stream	Lower mile free from obstruction and upper mile not visible due to heavy conifer canopy cover
	7/29/1959	Poor to fair spawning areas throughout most of the stream; abundant pools, 5-8 inches deep; good to excellent shelter provided by boulders, undercut banks, tree roots, and riparian growth; water temperatures ranged from 60-70°F	1 log jam; 1 fallen in flush dam
Rice Creek	10/16/1958 (flyover)	Full of old logging debris, fisheries value appeared negligible	
	Approx. 1959	Fair spawning areas in lower section, poor to non existent spawning areas in the upper section; poor pool development in the lower section, average 1 foot deep; lower section open with no shelter, middle and upper sections covered with riparian growth and logging debris; average water temperature 71°F	4 log jams and barriers
East Branch Rice Creek	7/28/1959	Extremely small gravel present, considered poor spawning; poor pool development, average 2 feet by 3 feet by 6 inches; poor to fair shelter in the form of riparian growth, undercut banks, logging debris, and rocks, many areas open due to poor past logging practices; average water temperature 62°F	Many log jams and barriers

Current Conditions

Habitat Inventory Surveys

CDFG stream inventories were conducted for 106.0 miles on 73 reaches of 41 tributaries in the Inland Subbasin since 1993 (Table 192, Figure 129). Additionally, the North Fork Big River was surveyed in 1996 as well as 1997, and Daugherty Creek, Gates Creek, Soda Creek, Johnson Creek (tributary to Gates Creek), and Snuffins Creek were surveyed in 1993 as well as 2002. Stream attributes that were collected during stream inventories included canopy cover, embeddedness, percent pools, pool depth, and pool shelter.

Table 192. Surveyed streams in the Inland Subbasin.

Stream	Survey Date	Reach	Survey Length (Miles)
North Fork Big River	August/September 1997	1	7.1
	August	2	3.5
	August	3	1.4
East Branch North Fork Big River	June 1998	1	6.6
	June 1998	2	0.8
Chamberlain Creek	July 1997	1	1.5
	July 1997	2	3.6
Water Gulch	July 1997	1	1.0
	July 1997	1	0.9
Water Gulch Tributary	July/August 1997	1	0.4
Park Gulch	June 1997	1	1.0
West Chamberlain Creek	June 1997	1	3.3
	June 1997	1	0.2
Gulch Sixteen	July 1997	1	0.8
	July 1997	2	0.1
Gulch Sixteen Tributary	July 1997	1	0.4
Arvola Gulch	July 1997	1	0.9
Lost Lake Creek	July 1997	1	0.9
Soda Gulch	September 1997	1	0.7
James Creek	October 1996	1	2.8
	October 1996	2	1.6
James Creek North Fork	July/August 1997	1	2.4
South Fork Big River Part 1	June 2002	1	6.3
	June 2002	2	5.4
South Fork Big River Part 2	August/September 2002	1	3.5
	September 2002	2	3.3
	September 2002	3	1.2
	September 2002	4	0.8
Biggs Gulch	June 2002	1	0.5
Ramon Creek	June 2002	1	1.6
	June 2002	2	1.4
	June 2002	3	0.9
North Fork Ramon Creek	June 2002	1	1.5
Mettick Creek	June/July 2002	1	1.0
Poverty Gulch	July 2002	1	0.1
Anderson Gulch	August 2002	1	0.5
Boardman Gulch	June 2002	1	1.2
	June 2002	2	<0.1
Halfway House Gulch	June 2002	1	0.2
Daugherty Creek	July 2002	1	0.8
	July 2002	2	2.7
	July 2002	3	2.5
	July 2002	4	2.0
	July 2002	5	0.8
Soda Creek	May 2002	1	0.6
	May 2002	2	0.1
	May 2002	3	0.6
	May 2002	4	0.4
Gates Creek	May/June 2002	1	0.2
	May/June 2002	2	2.2
	May/June 2002	3	0.3

Stream	Survey Date	Reach	Survey Length (Miles)
Johnson Creek (Tributary to Gates Creek)	May 2002	1	0.4
	May 2002	2	0.1
	May 2002	3	0.7
Horse Thief Creek	June 2002	1	0.1
Snuffins Creek	July/August 2002	1	1.3
Johnson Creek	July/August 2002	1	0.9
Dark Gulch	August 2002	1	1.4
Montgomery Creek	July 2002	1	0.2
	July 2002	2	0.1
	July 2002	3	0.4
Unnamed Tributary 1 to South Fork Big River	July 2002	1	0.7
	July 2002	2	0.1
	July 2002	3	0.3
Unnamed Tributary 2 to South Fork Big River	July 2002	1	0.6
Russell Brook	July 2002	2	4.1
Martin Creek	July 2002	1	3.5
	July 2002	1	0.2
Martin Creek Left Bank Tributary	July 2002	1	0.6
Martin Creek Right Bank 1 Tributary	July 2002	1	1.5
Martin Creek Right Bank 2 Tributary	July 2002	1	0.6
Valentine Creek	July/August 2002	1	1.8
Rice Creek	August 2002	1	1.8

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 Inland Subbasin ranged in drainage area from 0.4 to 54.3 square miles (Figure 142).

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 temperature to support anadromous salmonid production (Figure 130). Water Gulch tributary, Gulch Sixteen tributary, and Park Gulch had the highest canopy cover values of Inland Subbasin. Streams with canopy densities under 70% by length were Poverty Gulch, South Fork Tributary #1, James Creek, and North Fork Big River. North Fork Big River is a third order stream, however, and therefore not expected to have high canopy density.

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. Twenty-seven of the surveyed tributaries of the Inland Subbasin show percent canopy levels that meet target values for maintaining water temperature.

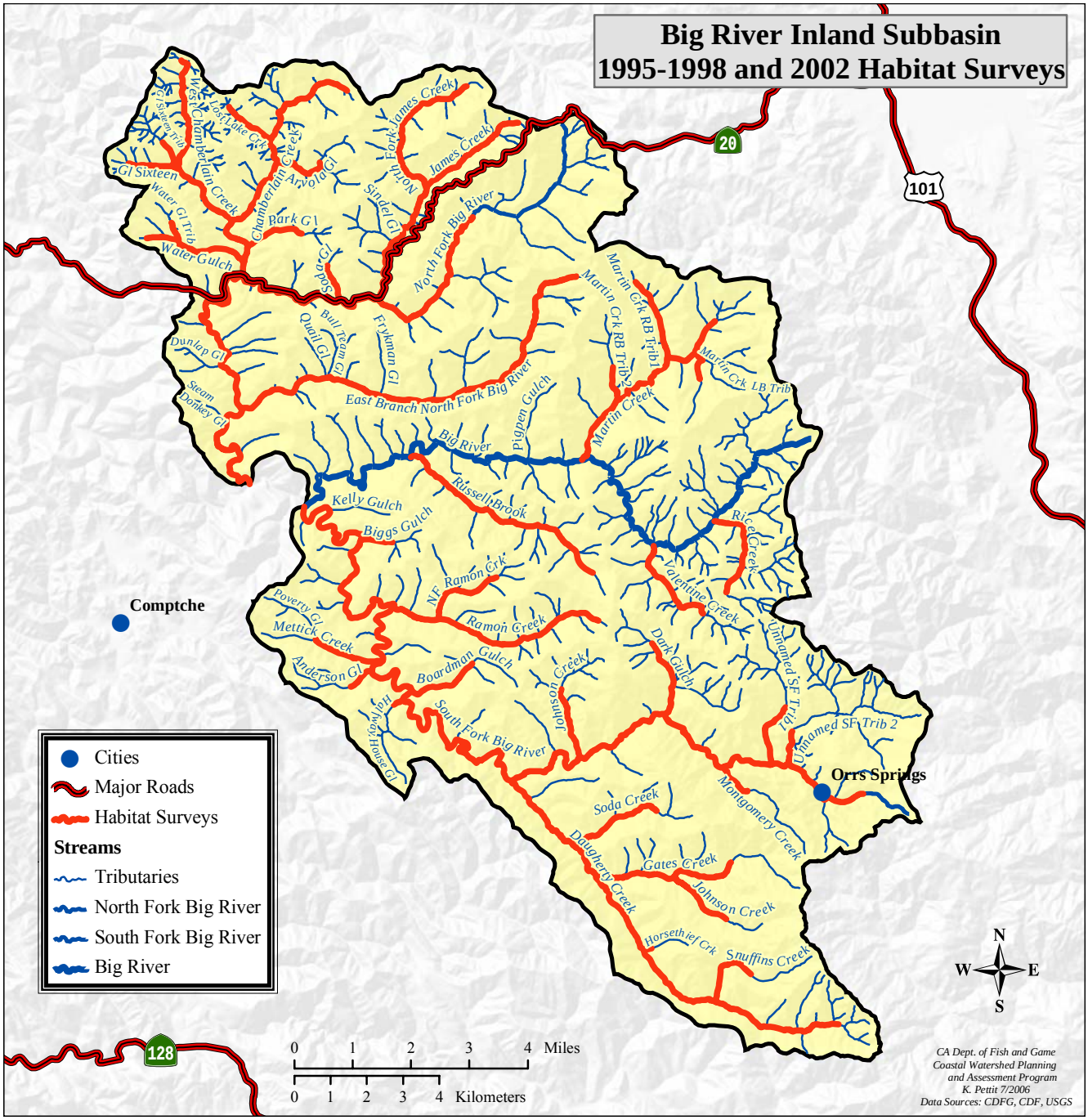


Figure 129. CDFG surveyed streams in the Inland Subbasin.

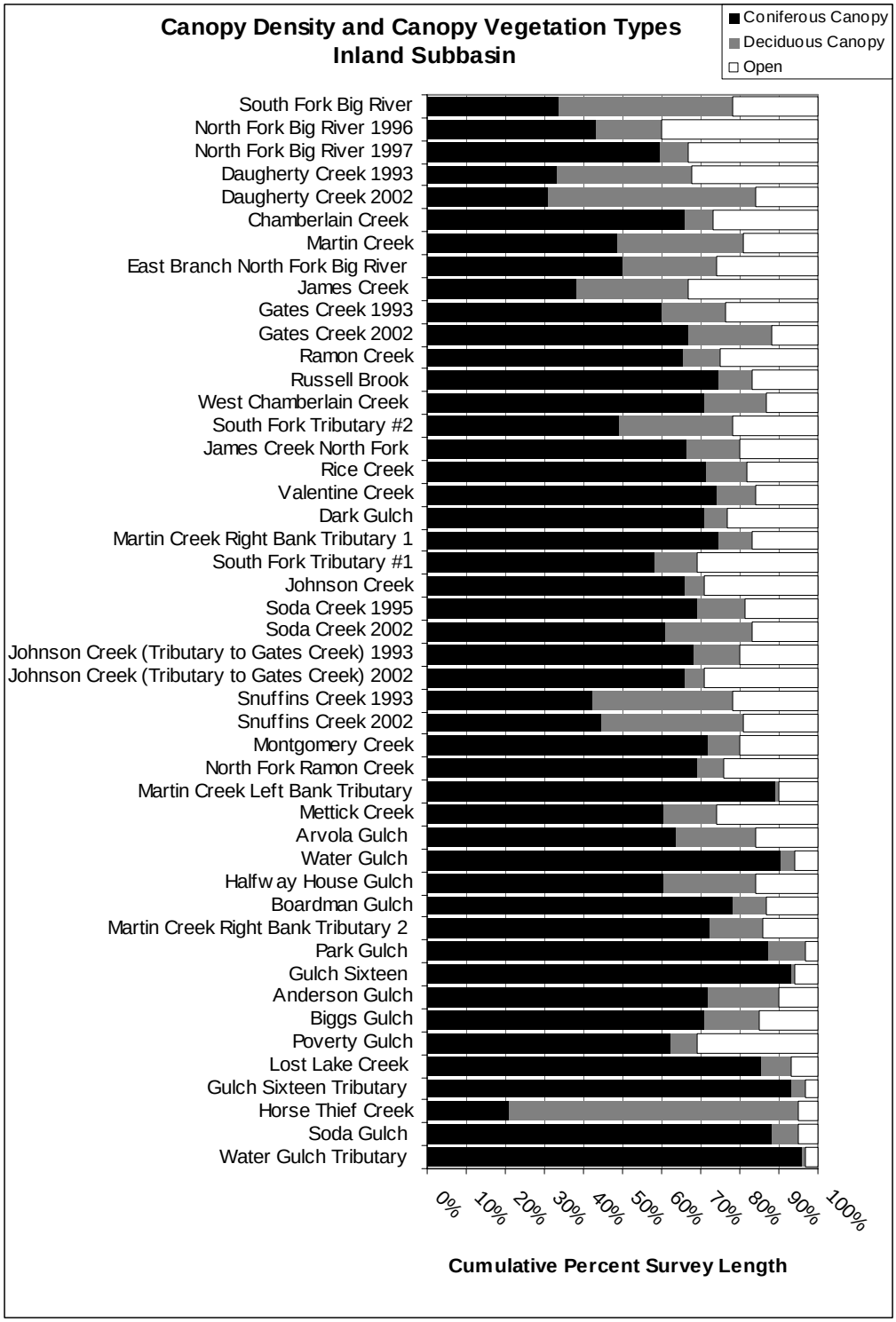


Figure 130. The relative percentage of coniferous, deciduous, and open canopy covering surveyed streams in the Inland Subbasin.

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 Inland Subbasin generally do not meet target values for successful salmonid egg and embryo development. The percent of pool tail-outs with category 1 cobble embeddedness only exceeded 50% in Halfway House Gulch and Soda Creek. The percent of pool tail-outs with category 1 or 2 cobble embeddedness exceeded 50% in 21 tributaries. Martin Creek had no pool tail-outs with category 1 or 2 embeddedness ratings and Boardman Gulch only had 8% of its pool tail-outs with category 1 or 2 cobble embeddedness. Figure 131

illustrates how stream reaches rated as unsuitable overall may actually have some suitable spawning gravel sites distributed through the stream reach.

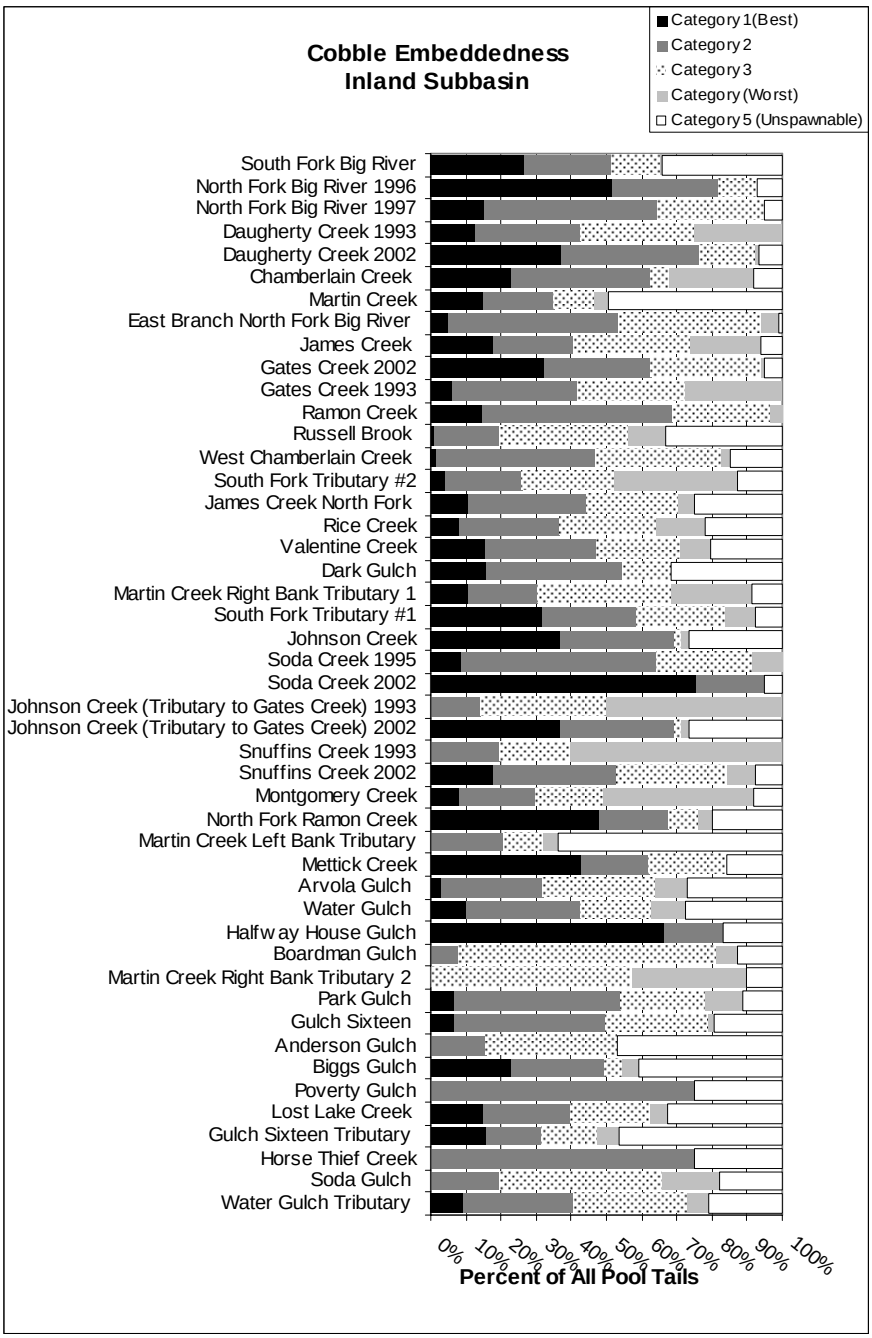


Figure 131. Cobble embeddedness categories as measured at every pool tail crest in surveyed streams in the Inland Subbasin.

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 are desirable. Eight of the surveyed Inland Subbasin streams have greater than 30% pool habitat by length (Figure 132). Only Gates Creek and North Fork Big River had 40% pool habitat by length. Horse Thief Creek had the least pool habitat by length with only 6%. Dry units measured obviously indicate poor conditions for fish and are discussed further in the Fish Passage Barriers section.

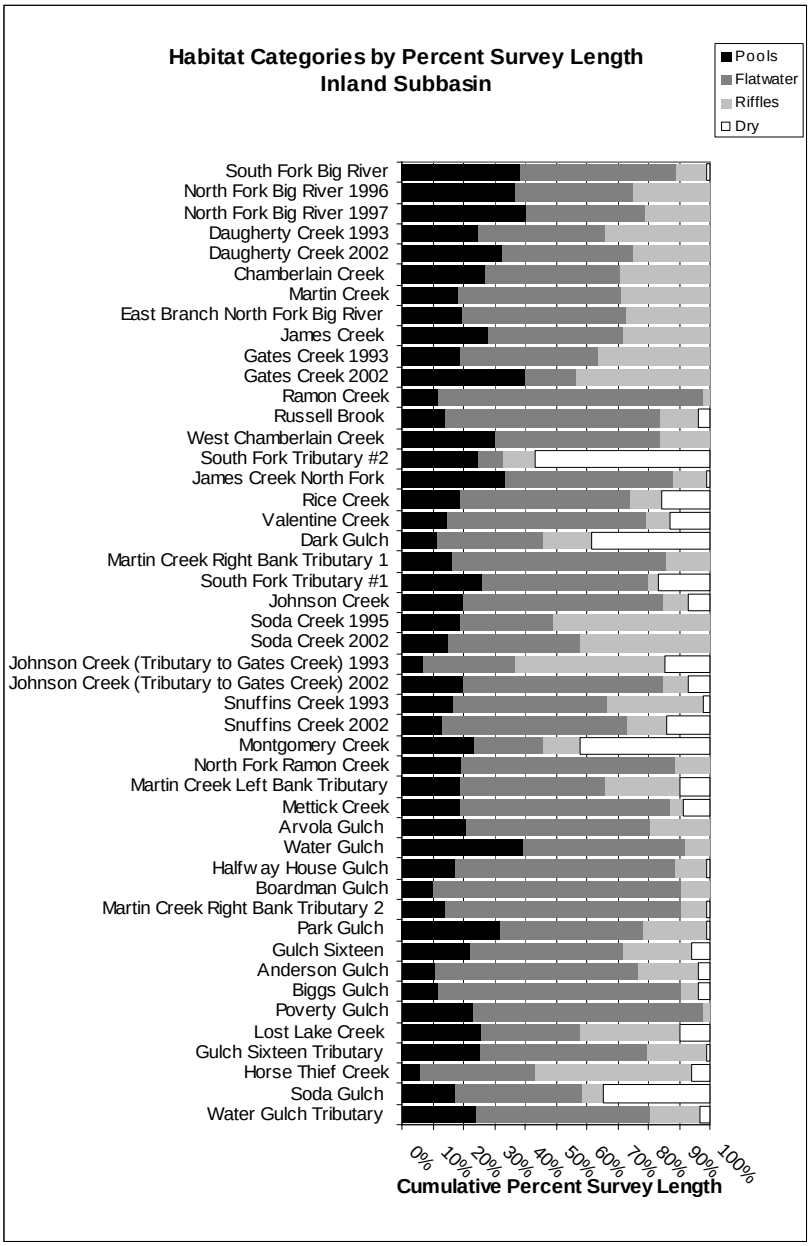


Figure 132. The percentage of pool habitat, flatwater habitat, riffle habitat, dewatered channel, and culverts by survey length in the Inland Subbasin.

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 40% 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 less suitable pool depth conditions relative to other streams of that subbasin.

Only North Fork and South Forks Big River have greater than 30% of their surveyed lengths in pools greater than two feet deep (Table 193) In addition, Daugherty Creek has greater than 20% of its surveyed lengths in pools greater than two feet deep. All other surveyed tributaries have less than 20% of their survey length in pools greater than 2 feet deep. Five surveyed tributaries had less than 2% pool habitat with maximum depth greater than two feet by length: Johnson Creek (tributary to Gates Creek), Snuffins Creek, Poverty Gulch, Horse Thief Creek, and Soda Gulch.

Table 193. Percent length of a survey composed of pools in the Inland Subbasin.

Stream	Drainage Area (Square 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
South Fork Big River	54.3	3	37.6	33.4	29.4	24	13.2
North Fork Big River 1996	42.1	3	37.3	25.4	18.7	12	5.3
North Fork Big River 1997	42.1	3	40.7	37.7	30.1	22.2	7.1
Daugherty Creek 1993	16.6	3	48.8	17	11.3	5.9	1.8
Daugherty Creek 2002	16.6	3	32.6	24.6	15.4	11.5	3.6
Chamberlain Creek	12.0	3	25.4	16.4	9.3	4.4	1.1
Martin Creek	9.0	1	18.7	14.8	10.7	6.4	2.5
East Branch North Fork Big River	7.3	1	18.8	15.6	9.1	5.3	0
James Creek	7.1	2	27.9	14.9	9.5	5.7	2.3
Gates Creek 1993	5.3	2	18.7	11.7	6.2	2.3	0.2
Gates Creek 2002	5.3	2	40.1	19.8	11.3	7	2.1
Ramon Creek	5.3	2	11.8	5.6	2.2	0.7	0.1
Russell Brook	4.1	1	14.1	5.4	2.1	0.8	0.2
West Chamberlain Creek	4.0	2	29.6	9.8	3.1	0.8	0.1
South Fork Tributary # 2	3.6	1	24.7	5.3	0.9	0.9	0
North Fork James Creek	3.0	1	29.3	11.3	7	4.1	0.7
Rice Creek	2.6	1	18.4	5	3.3	1.8	0.5
Valentine Creek	2.5	1	14.9	3.9	2	1.2	0
Dark Gulch	2.4	1	11.3	3.4	1.5	0.7	0.1
South Fork Tributary # 1	2.2	1	25.6	16.7	6.6	3.4	2.5
Martin Creek Right Bank 1 Tributary	2.2	1	15.9	3.3	2.1	0.9	0
Johnson Creek	1.8	1	14.8	5.2	1.4	0.3	0
Soda Creek 1995	1.8	1	19.3	5.2	1.9	0.8	0
Soda Creek 2002	1.8	1	15.1	5.8	2.9	1.8	0
Johnson Creek (Tributary to Gates Creek) 1993	1.7	1	6.6	0.3	0	0	0
Johnson Creek (Tributary to Gates Creek) 2002	1.7	1	14	5	2.3	0.2	0
Snuffins Creek 1997	1.7	1	16.5	6.9	3.4	2.3	1.1
Snuffins Creek 2002	1.7	1	14.2	1.8	0.5	0.3	0
Montgomery Creek	1.6	1	22.7	18.5	12.2	11.7	0
North Fork Ramon Creek	1.6	2	19.3	3.4	1.8	0	0
Arvola Gulch	1.5	1	20.5	2.9	1.7	0.3	0
Water Gulch	1.5	1	39.3	18.6	13.4	9.2	0
Mettick Creek	1.5	1	18.8	8.6	4.9	4.9	0
Martin Creek Left Bank Tributary	1.5	1	19.1	6.1	1.7	1.7	0
Halfway House Gulch	1.3	1	17.2	12.9	10.4	3.2	0
Boardman Gulch	1.2	1	10.3	3.7	0.9	0.4	0
Martin Creek Right Bank 2 Tributary	1.2	1	14	6.7	6.3	0	0
Park Gulch	1.1	1	31.8	5.5	1.5	0.4	0
Gulch Sixteen	1.0	1	22.1	2.9	0.6	0	0
Anderson Creek	0.9	1	10.7	6.4	2.1	1	0
Biggs Gulch	0.6	1	12.3	3.6	1.1	0	0
Poverty Gulch	0.6	1	23.2	0	0	0	0
Lost Lake Creek	0.4	1	10.8	2.2	1.3	0.5	0.3
Gulch Sixteen Tributary	0.4	1	22.5	5.4	2.1	0	1
Horse Thief Creek	0.4	1	6.4	0	0	0	0
Soda Gulch	0.4	1	16.8	1	0.4	0	0
Water Gulch Tributary	0.4	1	24.1	14.2	0	0	0

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

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 Inland Subbasin did not meet target values in (Figure 133). The highest pool shelter ratings were in East Branch North Fork Big River, Daugherty Creek, and Gates Creek. The lowest pool shelter ratings was in Soda Gulch.

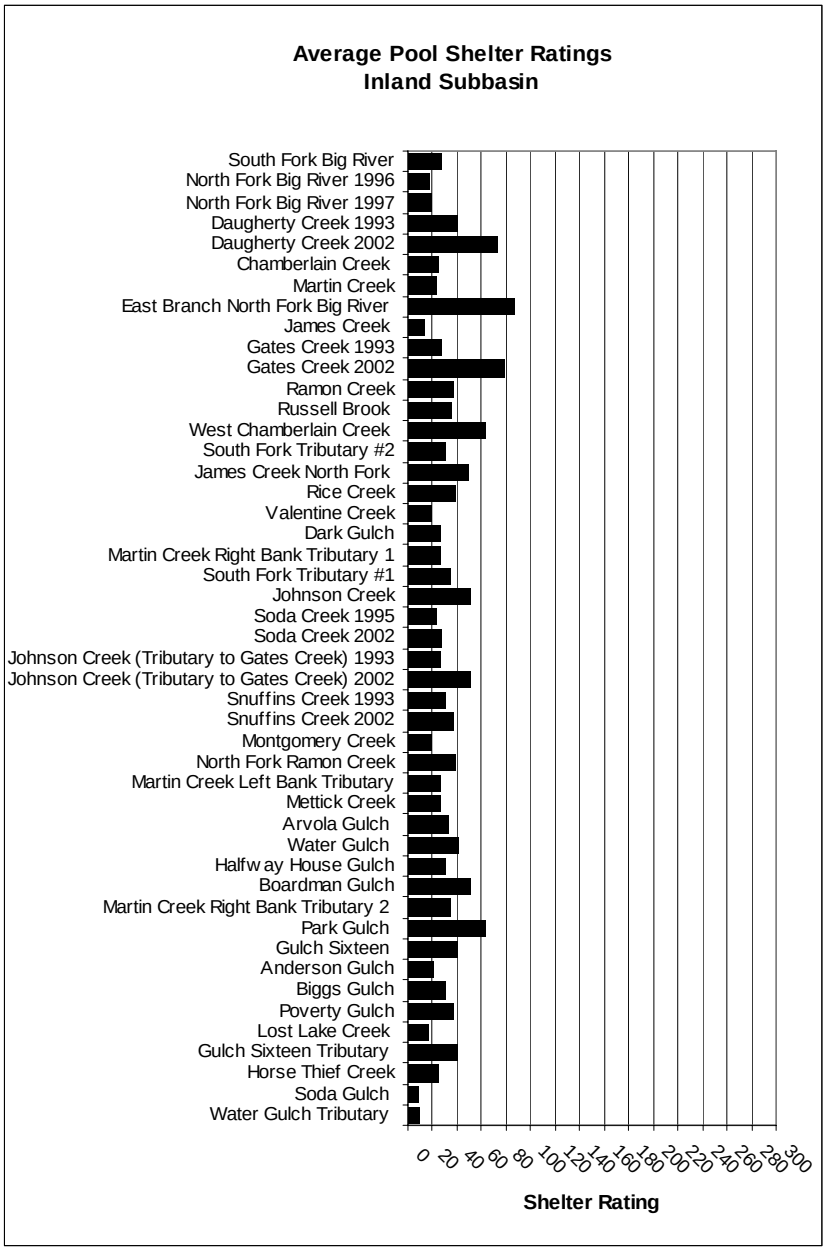


Figure 133. Average pool shelter ratings from CDFG stream surveys in the Inland Subbasin.

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

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 Inland Subbasin tributaries were undercut banks, woody debris, and boulders (Table 194).

Table 194. Mean percent of shelter cover types in pools for surveyed tributaries in the Inland Subbasin.

Stream	Undercut Banks	Small Woody Debris	Large Woody Debris	Root Mass	Terrestrial Vegetation	Aquatic Vegetation	Whitewater	Boulders	Bedrock Ledges
South Fork Big River	5.5	10.7	6.8	5.3	7.8	9.4	0.3	29.9	24.3
North Fork Big River 1997	8.9	9.1	13	14.8	11.4	0	0.5	23.2	19.3
North Fork Big River 1996	10	3.6	14.3	23.6	0.4	0	0.4	38.6	9.3
Daugherty Creek 1993	8	11	15	15	14	4	0	12	21
Daugherty Creek 2002	15.4	11.4	32.9	9.4	12	5.5	0.2	9.8	2.2
Chamberlain Creek	17.6	15.9	20.3	5.6	10.9	0	3.3	7.2	19
Martin Creek	8	7	15	4	2.8	0.6	0.7	31	31
East Branch North Fork Big River	22	9	26	19	2	1	3	8	10
James Creek	13	10	13	10	1	0	5	45	4
Gates Creek 1993	14	16	12	4	5	0	0	28	21
Gates Creek 2002	13.5	15.3	23.5	16.8	3.8	6.2	5.3	11.5	1.8
Ramon Creek	11.5	21.2	29.7	7.2	4.8	0.1	0.2	8.1	16.1
Russell Brook	8	16	34	11	4.7	0.7	1.3	16	9
West Chamberlain Creek	20.7	13.1	28.8	4.4	4.6	2.6	4.9	9	11.9
South Fork Tributary #2	25	10.5	9.3	34.8	8	1	0	0.5	11
James Creek North Fork	12.5	26.4	13	6.8	13	0.4	3.2	23.9	0.7
Rice Creek	13	22	34	5	9.9	3.2	1.4	10	3
Valentine Creek	7	16	4	4	4.6	0	0.6	46	17
Dark Gulch	10.9	10.9	29.3	1.3	3.4	7.1	0	27.3	9.9
Martin Creek Right Bank Tributary 1	10	19	14	7	0.9	0	4.1	35	9
South Fork Tributary #1	20.9	7.4	7.8	16.8	0	0.3	0	33.6	13.4
Johnson Creek	15.1	30.4	31.1	2.2	4.7	2.5	1.2	5.5	3.2
Soda Creek 1993	8.1	26.3	17.2	16.2	5.1	0	14.1	4	9.1
Soda Creek 2002	34.2	12.3	34.4	5.3	0	0	7	2.5	4.3
Johnson Creek (Tributary to Gates Creek) 1993	10	9	13	7	1	1	0	58	1
Johnson Creek (Tributary to Gates Creek) 2002	15.1	30.4	31.1	2.2	4.7	2.5	1.2	5.5	3.2
Snuffins Creek 1993	19	13	23	16	5	0	0	14	10
Snuffins Creek 2002	16.4	20.9	26.5	7.3	4.5	1	0	22.2	1.4
Montgomery Creek	22.2	15.9	9.7	7.8	0	2.5	1.9	35.6	4.4
North Fork Ramon Creek	9.4	21.5	28.6	14	5.4	1.3	7.3	8.1	4.4
Arvola Gulch	31.7	3.3	43.3	0.8	8.3	0	0.8	10	1.7
Martin Creek Left Bank Tributary	13	8	15	7	0.7	0.2	0.2	44	11
Mettick Creek	13.9	21.3	8.3	9.4	4.2	4.3	6.4	7.9	18.8
Water Gulch	18.3	8.3	23.3	10.6	5.8	0.6	0	31.1	0
Halfway House Gulch	6.7	17.5	42.5	3.3	0	0	9.2	5.8	15
Boardman Gulch	14.1	22.7	20.8	14.2	10.1	0.3	3.5	3.4	10.8
Martin Creek Right Bank Tributary 2	8	17	53	1	0	0	1.9	17	2
Park Gulch	26	11.3	38.2	1.8	4.7	2.7	6.1	7.1	0.5
Gulch Sixteen	29.3	47.1	23.6	0	0	0	0	0	0
Anderson Gulch	10.3	7.8	6.7	6.9	0	0	0.8	11.1	56.4
Biggs Gulch	10.3	13.8	45.6	5.9	3.2	0	4.1	4.7	12.4
Poverty Gulch	32.5	11.3	30	17.5	0	0	2.5	2.5	3.8
Lost Lake Creek	2	0	6	2	8	2	12	68	0
Gulch Sixteen Tributary	15.6	18.9	25.6	8.9	11.1	4.4	3.3	12.2	0
Horse Thief Creek	32.5	27.5	35	0	0	0	5	0	0
Soda Gulch	8.3	21.7	35	0	0	0	0	35	0
Water Gulch Tributary	42.2	25.6	22.2	0	10	0	0	0	0

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

MRC Habitat Surveys

MRC surveyed habitat conditions across their ownership in the Big River Basin in 2000 (Table 195).

Table 195. Surveyed stream segments on MRC ownership in the Inland Subbasin (MRC 2003).

Stream Segment	Segment ID	Survey Length (feet)
East Branch North Fork Big River	BE1	929
East Branch North Fork Big River	BE2	546
Bull Team Gulch	BE8	218
Frykman Gulch	BE14	234
Big River in Rice Creek PW	BI1	810
North Fork Big River	BL1	889
North Fork Big River	BL3	916
Steam Donkey Gulch	BL7	159
Dunlap Gulch	BL12	329
South Fork Big River	BM1	934
South Fork Big River	BM3	972
South Fork Big River	BM5	932
Ramon Creek	BM25	337
Ramon Creek	BM26	511
Ramon Creek	BM27	408
North Fork Ramon Creek	BM31	495
North Fork Ramon Creek	BM32	306
Mettick Creek	BM54	371
Mettick Creek	BM55	438
Boardman Gulch	BM59	201
Halfway House Gulch	BM64	418
South Fork Big River Tributary	BM76	177
Big River in Russell Brook PW	BR1	1,105
Big River in Russell Brook PW	BR2	1,117
Big River in Russell Brook PW	BR4	806
Russell Brook	BR5	565
Russell Brook	BR6	460
Russell Brook	BR7	312
Wildhorse Gulch	BR9	400
Pig Pen Gulch	BR29	197
Daugherty Creek	BS1	874
Daugherty Creek	BS3	627
Daugherty Creek	BS5	310
Soda Creek	BS15	389
Gates Creek	BS23	542
Johnson Creek	BS24	519
Snuffins Creek	BS49	331

Canopy Closure

Canopy closure measured on stream segments across the MRC's ownership in the Inland Subbasin ranged from less than 50% on the South Fork Big River and Ramon Creek to greater than 90% on 14 surveyed stream segments (Figure 134). Low canopy density is expected on higher order streams such as the North and South forks Big River and Daugherty Creek. Canopy density on Ramon Creek appears to be very low.

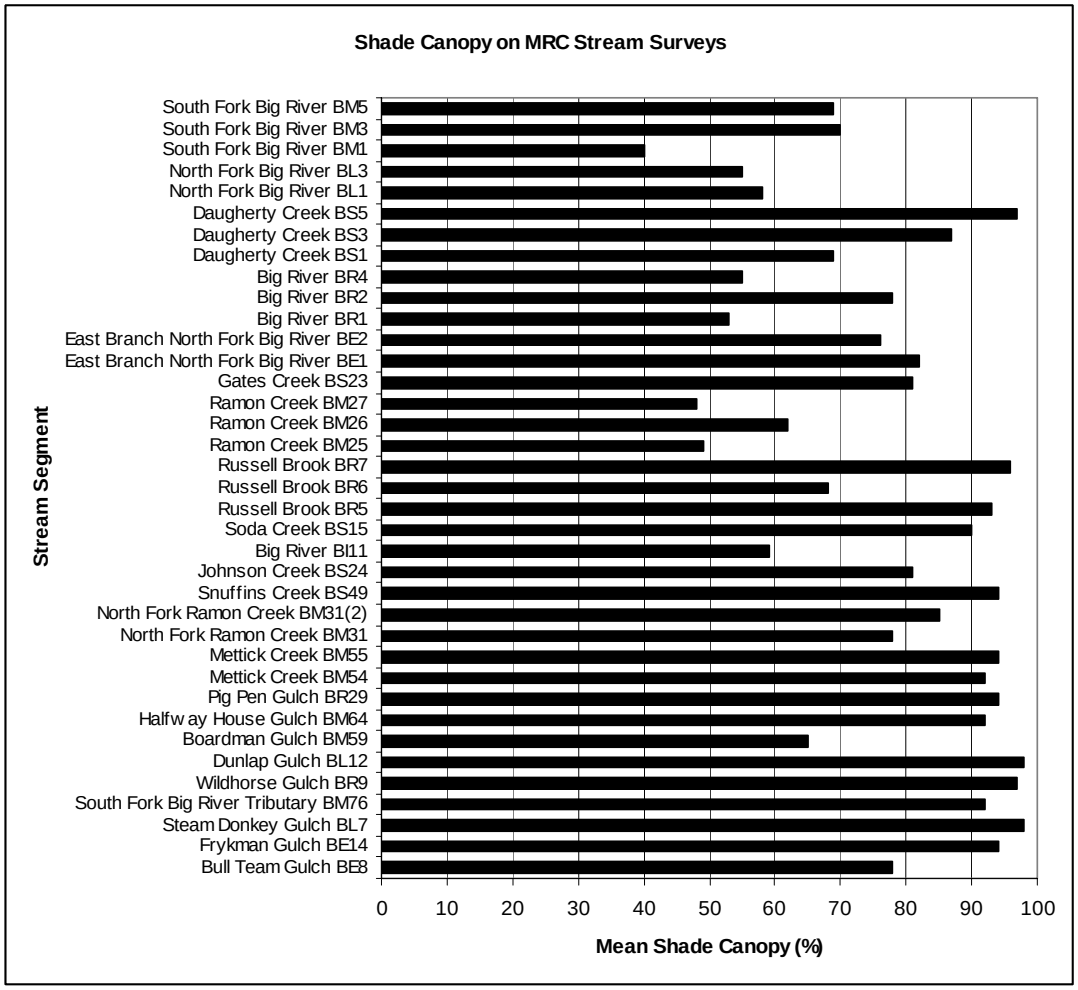


Figure 134. Stream canopy closure on stream segments in the MRC ownership of the Inland Subbasin (MRC 2003).

Pools

The number of pools measured on stream segments across the MRC's ownership in the Inland Subbasin ranged from none to 11 (Table 196). The percentage of pools with mean residual pool depths greater than 3 feet was 50% or greater in only four surveyed segments. Most pools were bank forced.

Table 196. Pool characteristics measured on stream segments in the MRC ownership of the Inland Subbasin (MRC 2003).

Stream	Segment	% Pool:Riffle: Flatwater by stream length	Total # of pools	Pool Spacing reach length/bankfull/#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	NA	NA	NA
North Fork Big River	BL1	60:10:30	3	6.3	57	2.7	33	0	0	1	0	2
North Fork Big River	BL3	68:11:21	3	6.4	72	4.3	67	0	1	0	0	2
Steam Donkey Gulch	BL7	44:56:0	4	4.9	43	1.4	0	2.1	2	0	0	2
East Branch North Fork Big River	BE1	54:46:0	9	3.3	62	NA	7	0	1	2	3	3
East Branch North Fork Big River	BE2	56:44:0	4	6.7	83	1.4	0	2.4	0	1	0	3
Bull Team Gulch	BE8	37:63:0	6	5.4	56	0.8	0	4.5	0	4	0	2
Frykman Gulch	BE14	64:36:0	7	4.1	43	NA	0	2.8	0	1	0	6
Dunlap Gulch	BL12	40:60:0	5	6	122	0.9	0	16.9	0	3	1	1
South Fork Big River	BM1	58:32:10	4	3.7	78	2.8	20	0	2	0	0	2
South Fork Big River	BM3	78:13:9	4	4.7	64	4.0	50	0	0	0	0	4
South Fork Big River	BM5	81:19:0	4	5.1	93	2.9	50	0	0	0	0	4
Ramon Creek	BM25	55:45:0	4	2.2	63	1.4	0	1.9	0	2	0	2
Ramon Creek	BM26	50:50:0	7	3.3	58	1.6	14	2.6	0	2	1	4
Ramon Creek	BM27	61:39:0	3	8.3	59	0.9	0	0.8	0	1	0	2
North Fork Ramon Creek	BM31	44:56:0	8	4.7	71	2.1	25	0	1	0	0	7
North Fork Ramon Creek	BM32	43:39:18	3	10.1	93	1.1	0	3.2	0	2	0	1
Mettick Creek	BM54	63:37:0	6	4.3	79	1.3	0	0	1	0	0	5
Mettick Creek	BM55	40:60:0	4	7.8	48	0.9	0	0.7	1	0	0	3
Boardman Gulch	BM59	61:39:0	0	0	36	0.9	0	0	0	0	0	0
Halfway House Gulch	BM65	53:47:0	5	9.3	101	1.7	14	3.9	0	2	0	3
Unnamed 20 Mile tributary to South Fork	BM76	44:56:0	3	7.4	43	0.5	0	0	0	1	0	2

Stream	Segment	% Pool:Riffle: Flatwater by stream length	Total # of pools	Pool Spacing reach length/bankfull/#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
Big River												
Daugherty Creek	BS1	56:44:0	5	4.8	70	2.6	20	0.4	1	0	0	4
Daugherty Creek	BS3	52:36:12	4	6.1	70	2.3	25	2.6	1	0	1	2
Daugherty Creek	BS5	53:47:0	6	3.6	63	1.8	0	6.3	0	4	0	2
Soda Creek	BS15	61:39:0	7	2.7	69	1.2	17	5.9	1	3	0	3
Gates Creek	BS23	45:40:15	5	3.4	67	1.3	0	2.4	0	0	0	5
Johnson Creek (tributary to Gates Creek)	BS24	59:41:0	11	2.7	68	1.1	0	5.7	2	6	0	3
Snuffins Creek	BS49	46:54:0	7	4.4	94	1.6	14	9.9	1	4	1	1
Big River	BI1	48:44:8	5	3.3	51	1.8	20	0	1	0	0	4
Big River	BR1	80:10:10	4	5.8	29	3.1	33	0.9	0	0	0	4
Big River	BR2	63:37:0	6	3.6	74	3.0	50	0.3	0	1	0	5
Big River	BR4	82:18	5	3.2	69	2.7	60	0	1	0	0	4
Russell Brook	BR5	61:23:16	8	2.6	53	1.2	0	0.6	1	0	6	1
Russell Brook	BR6	58:42:0	8	5.4	78	1.1	0	5	1	4	0	3
Russell Brook	BR7	44:56:0	8	3.7	83	1.1	0	10.5	0	2	3	3
Pigpen Gulch	BR29	52:48:0	6	3.1	43	0.9	0	3.3	1	1	2	2

Spawning Gravel

The amount of spawning gravel measured on stream segments across the MRC's ownership in the Inland Subbasin ranged from 1.5 to greater than 3% (Table 197); the target of greater than three percent was reached on 18 stream segments. MRC characterized spawning gravels as fair quality on 32 segments surveyed and good quality on four.

Table 197. Spawning gravel characteristics measured on stream segments in the MRC ownership of the Inland Subbasin (MRC 2003).

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
North Fork Big River	BL3	>3	25-50	Fair	Good	0
Steam Donkey Gulch	BL7	1.5-3	>50	Poor	Fair	62
East Branch North Fork Big River	BE1	>3	>50	Fair	Fair	50
East Branch North Fork Big River	BE2	>3	25-50	Fair	Fair	0
East Branch North Fork Big River	BL1	>3	25-50	Fair	Good	16
Bull Team Gulch	BE8	1.5-3	>50	Fair	Fair	0
Frykman Gulch	BE14	>3	>50	Fair	Fair	20
Dunlap Gulch	BL12	1.5-3	>50	Poor	Fair	66
South Fork Big River	BM1	>3	25-50	Fair	Fair	0
South Fork Big River	BM3	>3	<25	Fair	Good	0
South Fork Big River	BM5	>3	25-50	Fair	Fair	11
Ramon Creek	BM25	1.5-3	>50	Fair	Fair	0
Ramon Creek	BM26	>3	>50	Poor	Fair	0
Ramon Creek	BM27	1.5-3	>50	Fair	Fair	0
North Fork Ramon Creek	BM31	1.5-3	>50	Fair	Fair	0
North Fork Ramon Creek	BM32	1.5-3	>50	Fair	Fair	0
Mettick Creek	BM54	1.5-3	25-50	Fair	Fair	18
Mettick Creek	BM55	>3	25-50	Fair	Fair	0
Boardman Gulch	BM59	1.5-3	>50	Fair	Fair	0
Halfway House Gulch?	BM65	1.5-3	25-50	Fair	Fair	38
Unnamed 20 Mile tributary to South Fork Big River	BM76	1.5-3	>50	Fair	Fair	0
Daugherty Creek	BS1	>3	>50	Fair	Fair	50
Daugherty Creek	BS3	>3	25-50	Fair	Fair	44
Daugherty Creek	BS5	>3	>50	Fair	Fair	0
Soda Creek	BS15	1.5-3	>50	Fair	Fair	50
Gates Creek	BS23	>3	25-50	Fair	Fair	50
Johnson Creek (tributary to Gates Creek)	BS24	>3	>50	Fair	Fair	0
Snuffins Creek	BS49	1.5-3	>50	Poor	Fair	0
Big River	BI1	1.5-3	25-50	Fair	Fair	0
Big River	BR1	>3	25-50	Fair	Fair	10
Big River	BR2	>3	25-50	Fair	Good	67
Big River	BR4	>3	25-50	Fair	Fair	33
Russell Brook	BR5	1.5-3	>50	Fair	Fair	50
Russell Brook	BR7	1.5-3	>50	Fair	Fair	0
Pigpen Gulch	BR29	1.5-3	>50	Fair	Fair	11
Russell Brook	BR6	1.5-3	>50	Fair	Fair	13

Large Woody Debris

MRC (2003) examined LWD loading and demand in 37 stream segments across their ownership in the Inland Subbasin (Table 198). Only seven segments on Bull Team Gulch, Dunlap Gulch, Halfway House Gulch, Russell Brook, Soda Creek, Johnson Creek, and Snuffins Creek 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 198. MRC LWD survey results in the Inland 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
East Branch North Fork Big River	2	45	6-12.4	39.1	7.7-9.3	4	0	0
Bull Team Gulch	1	35	52.7	22.9	34.4	6	43	8
Frykman Gulch	1	15	21.0	15.8	22.2	2	0	0
Big River in Rice Creek PW	1	7	2.8	3.3	1.3	0	0	0
North Fork Big River	2	19	21-4.8	17.7	2.2-4.2	0	0	0
Steam Donkey Gulch	1	11	22.7	4.8	9.9	1	0	0
Dunlap Gulch	1	81	80.8	142.4	141.9	27	40	68
South Fork Big River	3	22	1.4-3.4	11.5	0.4-2.0	0	0	0
Ramon Creek	3	54	6.8-19.3	37.8	8.3-10.6	10	0-52	0-50
North Fork Ramon Creek	2	49	8.6-38.6	26.6	2.3-24.9	5	0-42	0-51
Mettick Creek	2	24	6.2-12.7	7.9	1.1-5.1	1	0	0
Boardman Gulch	1	10	16.3	1.3	2.1	0	0	0
Halfway House Gulch	1	33	25.9	42.5	33.3	9	42	29
South Fork Big River Tributary	1	7	13.0	0.7	1.2	0	0	0
Big River in Russell Brook PW	3	61	2.8-10.0	134.2	1.6-24.0	6	0-47	0-80
Russell Brook	3	166	26.1-58.9	119.9	13.6-55.7	18	0	0
Wildhorse Gulch	1	21	17.2	10.2	8.4	1	0	0
Pig Pen Gulch	1	20	33.3	5.9	9.8	2	0	0
Daugherty Creek	3	40	4.9-16.9	30.2	3.6-13.6	12	0	0
Soda Creek	1	17	14.3	12.8	10.8	7	0	0
Gates Creek	1	19	11.5	10.3	6.2	4	0	0
Johnson Creek	1	43	27.2	29.2	18.4	9	0	0
Snuffins Creek	1	48	47.6	31.1	30.8	10	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, likely because it 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, except for a blow-down in Johnson Creek. Low recruitment in recent years could be a result of timber harvest practices.

MRC gave surveyed stream segments in the Inland Subbasin low quality LWD ratings (Figure 135, Table 199). Only Russell Brook, East Branch North Fork Big River, Ramon Creek, Halfway House Gulch, Daugherty Creek, Soda Creek, Gates Creek, and Snuffins Creek were 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, South Fork Big River, North Fork Big River, and East Branch North Fork Big River are especially in need of LWD.

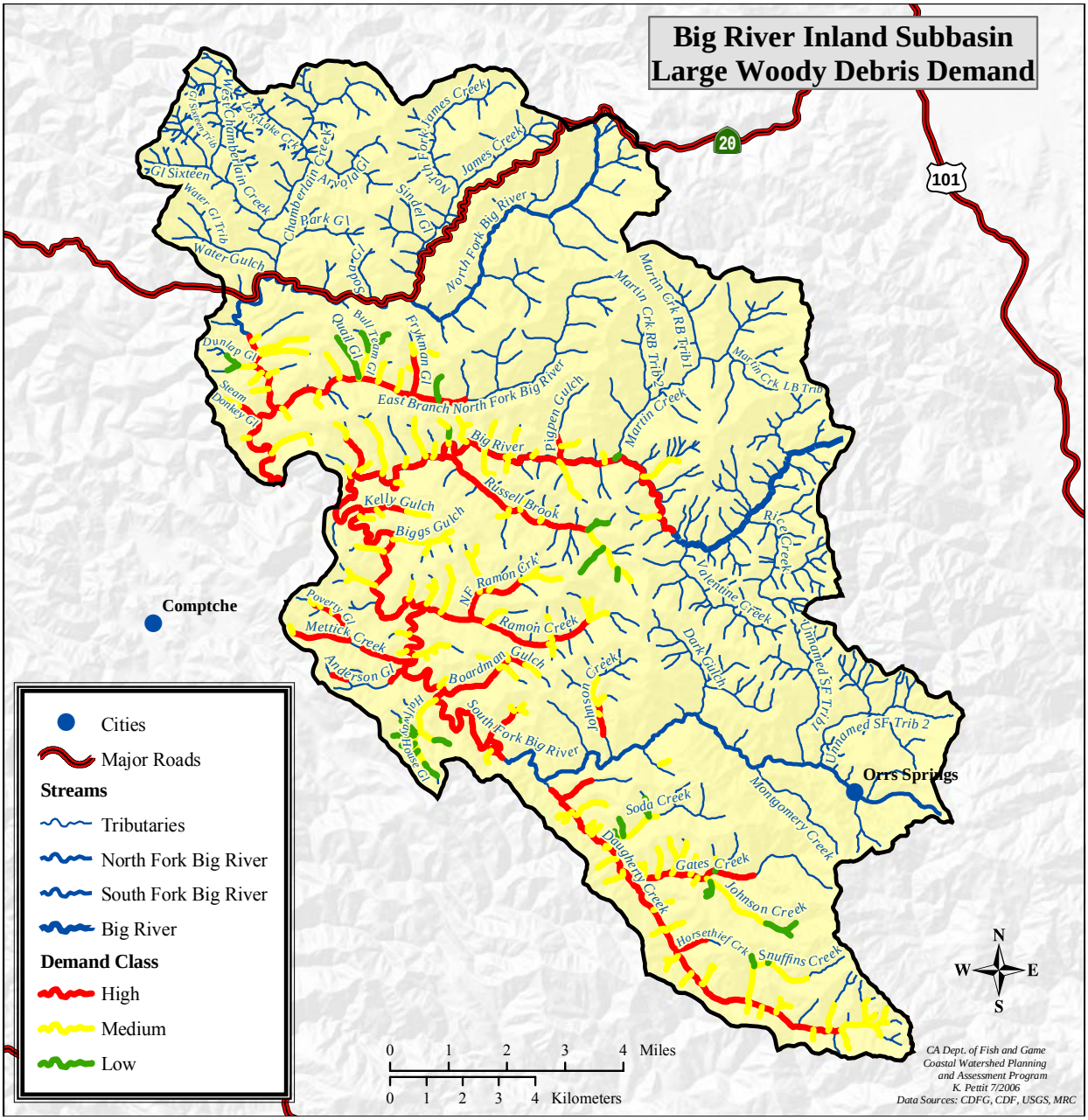


Figure 135. Map of instream LWD demand in MRC ownership in the Inland Subbasin (MRC 2003).

Table 199. Instream LWD quality ratings for major streams and sections of streams in MRC ownership in the Inland Subbasin.

Stream	Instream LWD Quality Rating
Big River in Russell Brook PW	Deficient
Big River in Rice Creek PW	Deficient
Russell Brook	Marginal
North Fork Big River in Lower North Fork Big River PW	Deficient
East Branch North Fork Big River	Marginal
South Fork Big River in Mettick Creek PW	Deficient
Ramon Creek	Marginal
Mettick Creek	Deficient
Anderson Gulch	Deficient
Boardman Gulch	Deficient
Halfway House Gulch	Marginal
Daugherty Creek	Marginal
Soda Creek	Marginal
Gates Creek	Marginal
Snuffins Creek	Marginal

MRC 2003

Fish Passage Barriers

Stream Crossings

Three stream crossings were surveyed in the Inland Subbasin as a part of the coastal Mendocino County culvert inventory and fish passage evaluation conducted by Ross Taylor and Associates (2001). Orr Springs Road has culverts on Dark Gulch, Johnson Creek, and an unnamed tributary to the South Fork of the Big River. All three culverts were found to be total salmonid barriers (Table 200). The culverts on Johnson Creek and Dark Gulch were also mentioned in surveys documented in NMFS (Jones 2000). Priority ranking of 24 culverts in coastal Mendocino County for treatment to provide unimpeded salmonid passage to spawning and rearing habitat placed the culvert on Johnson Creek at rank 5, the culvert on Dark Gulch at rank 7, and the culvert on the unnamed tributary to the South Fork of the Big River at rank 10. Criteria for priority ranking included salmonid species diversity, extent of barrier present, culvert risk of failure, current culvert condition, salmonid habitat quantity, salmonid habitat quality, and a total salmonid habitat score. The culvert on Johnson Creek and was replaced by an open bottom arch culvert in 2004, and the culvert on an unnamed tributary to South Fork Big River was modified to improve fish passage in 2003.

Table 200. Culverts surveyed for barrier status in the Inland Subbasin (Taylor 2001).

Stream Name	Road Name	Priority Rank	Barrier Status	Upstream Habitat	Treatment
Dark Gulch	Orr Springs Road	7	Total barrier. A barrier for adult coho salmon and steelhead trout and all age classes of juveniles due to excessive velocities over steep slope, lack of depth at lower migration flows, and the leap required to enter the culvert.	Approximately 1.7 miles of fair salmonid habitat.	
Johnson Creek	Orr Springs Road	5	Total barrier. A barrier for adult coho salmon and steelhead trout and all age classes of juveniles due to excessive velocities over steep slope, lack of depth at lower migration flows, and the leap required to enter the culvert.	Approximately 1.7 miles of good salmonid habitat.	Improved in 2004
Unnamed tributary to the South Fork of the Big River	Orr Springs Road	10	Total barrier. A barrier for adult coho salmon and steelhead trout and all age classes of juveniles due to excessive velocities and a lack of depth at lower migration flows within the culvert.	Approximately 0.5 miles of good salmonid habitat.	Improved in 2003

CDFG stream surveys noted culverts on four tributaries: North Fork James Creek, Gulch Sixteen Tributary, Water Gulch Tributary, and Soda Gulch (Table 201). The stream tributary report for Gulch Sixteen Tributary in 1997 recommends removal of the culvert at the confluence with Gulch Sixteen to provide fish passage. The tributary enters Gulch Sixteen through a metal pipe, three feet in diameter. Some loss of flow occurs due to holes throughout the culvert. The culvert contains no baffles and is impassible to fish.

The stream tributary report for Soda Gulch in 1997 also recommends that fish passage through the State Route 20 culvert located 114 feet from the confluence with the North Fork Big River needs to be improved. Alternatives need to be explored with the assistance of CDFG. The culvert has a five foot drop onto boulders. The culvert is 6 feet in diameter and has no baffles.

The MRC Big River Watershed Analysis identified culverts on a tributary to Ramon Creek (Donkeyhouse Gulch), Bull Team Gulch, Frykman Gulch, and Boardman Gulch. In addition, NMFS (Jones 2000) documented fish passage barriers found on surveys of Chamberlain Creek in the mid 1990s and James Creek in 1996. A pinched bedrock area under a road crossing was found to be a barrier to coho during low flow years in Chamberlain Creek. In James Creek, a barrier to coho salmon was found to occur in low flow years, such as 1996.

A complete barrier to downstream migration of salmonids was identified by CDFG in the North Fork Big River in August 1996 (Emig). It was recommended that this site be modified. The 1997 stream survey of the North Fork Big River does not mention a barrier at that location. An additional problematic stream crossing was identified on Martin Creek right bank tributary #1 where a rusty bottomed culvert created a high jump from below for salmonids (Harris, personal communication, 2006).

Table 201. Culverts described on streams inventoried by CDFG and in the MRC Watershed Analysis (2003) in the Inland Subbasin.

Stream Name	Number of Culverts	Feet of Culvert	Barrier Status*	Upstream Habitat
Ramon Creek Tributary/Donkeyhouse Gulch	2	NA	Complete barrier. Complete barrier to upstream salmonid migration.	0.5 miles coho salmon 1 mile steelhead trout
Boardman Gulch	1	NA	Partial barrier. Passable under 16% of potential flows by adult steelhead trout and completely impassable to juvenile steelhead trout.	2 miles steelhead trout
Bull Team Gulch	1	NA	Complete barrier. Complete upstream migration barrier to salmonids.	0.3 miles coho salmon 0.6 miles steelhead trout
Frykman Gulch	1	NA	Partial barrier. Barrier to upstream adult steelhead migration under 55% of the range of stream discharges, and an upstream barrier to juvenile salmonids.	0.3 miles coho salmon 0.6 miles steelhead trout
Water Gulch Tributary	1	42	NA	
Gulch Sixteen Tributary	1	60	NA	
Soda Gulch	1	95	NA	
North Fork James Creek	2	86	NA	

* NA - not assessed.

Dry Channel

A main component of CDFG Stream Inventory Surveys was 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 Inland Subbasin is 2.9% of the total length of streams surveyed. This dry channel was found in 31 streams (Table 202 and Figure 136). Dry habitat units occurred near the mouth of nine tributaries, in the middle reaches of 20 tributaries, and at the upper limit of anadromy in 19 tributaries. Dry channel at the mouth of a tributary disconnects that tributary from the mainstem Big River, which can disrupt the ability of juvenile salmonids to access tributary thermal refugia in the summer. 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.

Table 202. Dry channel recorded in CDFG stream surveys in the Inland Subbasin.

Stream	Survey Period	# of Dry Units	Dry Unit Length (ft)	% of Survey Dry Channel
North Fork Big River	August - September 1997	0	0	0.0
East Branch of the North Fork Big River	June 1998	2	119	0.3
Chamberlain Creek	July 1997	1	21	0.1
Water Gulch	July 1997	1	19	0.2
Water Gulch Tributary	July - August 1997	3	59	2.9
Park Gulch	June 1997	2	29	0.5
West Chamberlain Creek	June 1997	2	11	0.1
Gulch Sixteen	July 1997	7	94	2.0
Gulch Sixteen Tributary	July 1997	2	21	0.9
Arvola Gulch	July 1997	0	0	0.0
Lost Lake Creek	July 1997	3	489	10.0
Soda Gulch	September 1997	33	1,204	33.8
James Creek	October 1996	2	15	0.1
North Fork James Creek	July - August 1997	1	52	0.4
South Fork Big River (First Half)	June 2002	0	0	0.0
South Fork Big River (Second Half)	August - September 2002	8	997	2.1
Biggs Gulch	June 2002	2	116	4.1
Ramon Creek	June 2002	1	13	0.1
North Fork Ramon Creek	June 2002	0	0	0.0
Mettick Creek	June - July 2002	2	482	9.0

Stream	Survey Period	# of Dry Units	Dry Unit Length (ft)	% of Survey Dry Channel
Poverty Gulch	July 2002	0	0	0.0
Anderson Gulch	August 2002	4	98	3.9
Boardman Gulch	June 2002	0	0	0.0
Halfway House Gulch	June 2002	1	14	1.4
Daugherty Creek	July 2002	3	41	0.1
Soda Creek	May 2002	0	0	0.0
Gates Creek	May - June 2002	0	0	0.0
Johnson Creek (Gates Creek Tributary)	May 2002	0	0	0.0
Horse Thief Creek	June 2002	0	0	0.0
Snuffins Creek (2002)	July - August 2002	13	431	6.6
Johnson Creek	July - August 2002	10	338	6.8
Dark Gulch	August 2002	27	2,853	38.0
Montgomery Creek	July 2002	6	1,394	42.2
South Fork Big River Tributary #1	July 2003	16	1,037	17.7
South Fork Big River Tributary #2	July 2002	12	1,844	57.0
Russell Brook	July 2002	7	814	3.8
Martin Creek	July 2002	0	0	0.0
Martin Creek Left Bank Tributary	July 2002	3	300	10.2
Martin Creek Right Bank Tributary #1	July 2002	1	20	0.3
Martin Creek Right Bank Tributary #2	July 2002	3	31	1.0
Valentine Creek	July - August 2002	9	1,206	12.6
Rice Creek	August 2002	23	1,451	15.7

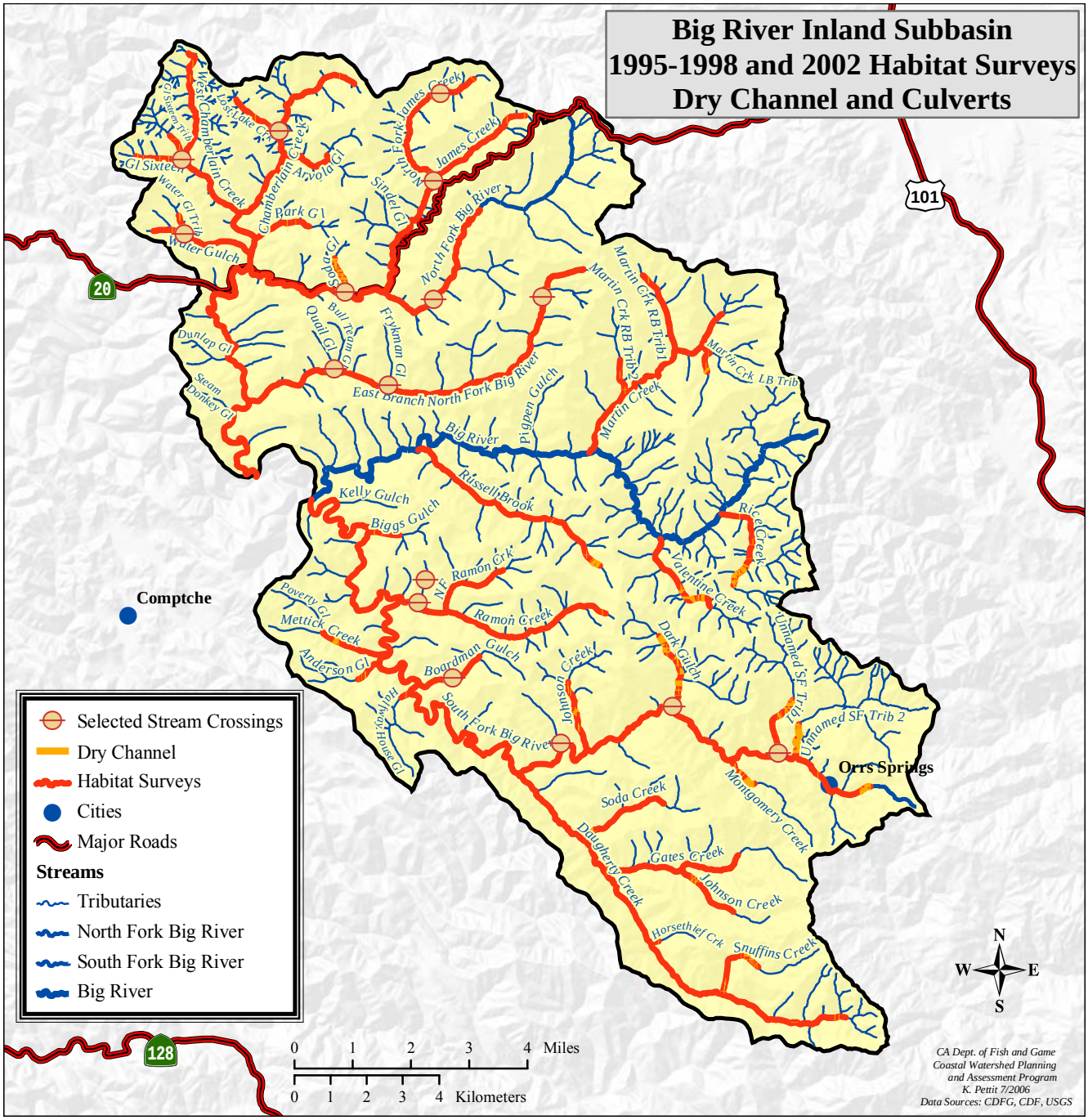


Figure 136. Dry and wetted channel and culverts reported during CDFG stream surveys, and culverts.

Reported by Ross Taylor (2001) and MRC (2004) in the Inland Subbasin

Restoration Programs

The CDFG Fisheries Restoration Grants Program has funded various projects in the Inland Subbasin (Table 203). Projects include research, education, bank stabilization, riparian planting, and fish passage barrier removal.

Restoration opportunities were identified in Mettick and Ramon creeks in 1996 under a cooperative agreement between USFWS, L-P, and the Center for Manpower Resources. Restoration work was completed in 1999 and 2000 under a cooperative agreement between USFWS, MRC, and the E Center. Additional restoration work was completed in an unnamed tributary to South Fork Big River and upper Mettick Creek in 2002.

Table 203. Restoration projects in the Inland Subbasin.

Name	Years	Project Leader	Project
North Fork Big River downstream from Steam Donkey Gulch	1986-1987	Center for Education and Manpower Resources	Stream bank stabilized, log jam removed
North Fork Big River Restoration Project	1986-1989	Center for Education and Manpower Resources	Stream bank stabilized, log jam removed
Frykman Gulch Migration Barrier Elimination and Erosion Control Project	2004	Mendocino Redwood Company, LLC	Stream bank stabilized, Rock weir installed (not below culvert), fish barrier removed, culvert replaced with bridge, culvert or other stream crossing removed and not replaced, grass planted, stream bank stabilized: riprap
South Fork Big River/Russell Brook Watershed Assessment Project	2001-2003	Trout Unlimited - California Council	Survey, study, research, watershed assessment and planning
Ramon Creek Barrier Removal	1987-1990	Northcoast Salmon Habitat Restoration Group	Pool created, fish barrier removed, large wood placement, stream bank stabilized: log revetment installed, log jam removed
Mettick Creek Barrier Removal	1987-1990	Northcoast Salmon Habitat Restoration Group	Fish barrier removed, stream bank stabilized: log revetment installed, log jam removed
Mettick Creek Stream Restoration	1996	Center for Education and Manpower Resources	Fish barrier removed, log jam removed
Anderson Gulch Barrier Removal	1987-1990	Northcoast Salmon Habitat Restoration Group	Fish barrier removed
Halfway House Gulch Barrier Removal	1987-1990	Northcoast Salmon Habitat Restoration Group	Pool created, fish barrier removed, large wood placement
Daugherty Creek Log Jam Barrier Modification	1986-1990	New Growth Forestry	Fish barrier removed, log jam removed
Daugherty Creek Enhancement	1994-1996	California Conservation Corps	Large wood placement, pool created using scour structure
Daugherty Creek Bank Stabilization	1995	Louisiana Pacific Corporation	Stream bank stabilized, stream bank stabilized: riprap (rock revetment) installed, willows planted (simple planting, not bioengineering)
Daugherty Creek Stream Enhancement Project	1997-1998	California Conservation Corps	Large wood placement, pool created using scour structure
Soda Creek Enhancement	1994-1996	California Conservation Corps	Rock weir installed (not below culvert), fish barrier removed, weir installed below culvert outlet Large wood placement, pool created using scour structure
Gates Creek Fish Passage Project	1984-1985	New Growth Forestry	Log jam removed
Johnson Creek (tributary to Gates Creek) Enhancement	1995	California Conservation Corps	Large wood placement, pool created using scour structure
Johnson Creek Log Barrier Modifications	1989-1990	Mendocino County Resource Conservation District	Fish barrier removed, large wood placement, log jam removed
Johnson Creek Jump Pool	1992-1994	Center for Education and Manpower Resources	Fish barrier removed, pool created using scour structure, culvert/bridge upgraded
Johnson Creek Instream Fish Barrier Culvert Removal	2004	Mendocino County Department of Transportation	Fish barrier removed, culvert replaced with open-bottom arch culvert
Dark Gulch Barrier Modification	1990	Center for Education and Manpower Resources	Fish barrier removed, large wood placement, pool created using scour structure
Dark Gulch: Creation of Jump Pool	1989-1991	Center for Education and Manpower Resources	Weir installed below culvert outlet
Dark Gulch Restoration Project	1993-1995	Center for Education and Manpower Resources	Fish barrier removed, culvert/bridge upgraded
Instream Barrier Removal Project on Tributary to South Fork Big River at Orr Springs Road	2003	Mendocino County Department of Transportation	Boulders placed in stream, rock weir installed (not below culvert), fish barrier removed, weir installed below culvert outlet
Russell Brook Barrier Removal	1987-1990	Northcoast Salmon Habitat Restoration Group	Fish barrier removed
Russell Brook Restoration Project	1993-1995	Center for Education and Manpower Resources	Pool created, boulders placed in stream, fish barrier removed, large wood placement
Valentine Creek Restoration Project	1986-1989	Center for Education and Manpower Resources	Stream bank stabilized, log jam removed
Rice Creek Fish Passage Project	1984-1985	New Growth Forestry	Log jam removed
Rice Creek Log Jam Barrier Modification	1986-1990	New Growth Forestry	Fish barrier removed, log jam removed

Two log cribwalls were constructed along the left bank of Mettick Creek by a bank slide that was determined to be a barrier to fish migration in 1999. In addition, the slide face was terraced and planted, and some minor small woody debris was removed to improve fish passage. Additional restoration work in upper Mettick Creek in 2002 included removal of seven culverts, streambank re-contouring, and installation of a grade control structure.

Three sites along Ramon Creek were restored in 1999. In order to close a bottleneck caused by a bank slide at one site, a log cribwall was constructed and a large woody debris accumulation was modified. Large wood was

re-positioned to direct flows away from a slide at another site and the slide was planted with conifers and willows. At the third site, a large bank slide was terraced and planted, a log cribwall was constructed, and the flow corridor width was increased.

A metal culvert at the mouth of a small unnamed tributary to South Fork Big River was replaced in 2002 to prevent the old culvert from failing.

Restoration sites will be monitored annually until 2013 and thus far restoration structures on Mettick and Ramon creeks have been stable.

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.

Where habitat data was available from both older stream surveys and recent stream inventories it appeared that spawning habitat decreased in seven streams and remained similar elsewhere (Table 204). Pool habitat decreased in 12 streams and remained similar elsewhere. Shelter decreased in 13 streams and remained similar elsewhere.

Table 204. Comparison between historic habitat conditions with current habitat inventory surveys in the North Fork 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	
North Fork Big River	ND*	Suitable	Very good to excellent	Unsuitable	Very good	Unsuitable	Very Good	Unsuitable	Spawning habitat, pool habitat, and shelter decreased
East Branch North Fork Big River	ND	Suitable	Excellent throughout lower first mile	Unsuitable	Medium sized throughout lower first mile	Unsuitable	Good	Suitable	Spawning habitat decreased
Chamberlain Creek	ND	Suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Fully unsuitable	ND
Water Gulch	ND	Fully Suitable	ND	Unsuitable	ND	Unsuitable	ND	Unsuitable	ND
Water Gulch Tributary	ND	Fully Suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Fully unsuitable	ND
Park Gulch	ND	Fully Suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Unsuitable	ND
West Chamberlain Creek	ND	Fully Suitable	ND	Unsuitable	ND	Fully Unsuitable	ND	Suitable	ND
Gulch Sixteen	ND	Fully Suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Unsuitable	ND
Gulch Sixteen Tributary	ND	Fully Suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Unsuitable	ND
Arvola Gulch	ND	Suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Unsuitable	ND
Lost Lake Creek	ND	Fully Suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Fully unsuitable	ND
Soda Gulch	ND	Fully Suitable	ND	Fully unsuitable	ND	Fully unsuitable	ND	Fully unsuitable	ND
James Creek	ND	Unsuitable	Poor	Unsuitable	Common to scarce	Fully unsuitable	Excellent	Fully unsuitable	Shelter decreased
North Fork James Creek	ND	Suitable	Medium to good	Unsuitable	Common, average one - two feet deep	Fully unsuitable	Excellent	Unsuitable	Spawning habitat, pool habitat, and shelter decreased
South Fork Big River	ND*	Suitable	Good to excellent	Suitable	Excellent - large and frequent pools	Suitable	Very good	Unsuitable	Shelter decreased
Biggs Gulch	ND	Fully suitable	ND	Suitable	ND	Fully unsuitable	ND	Fully unsuitable	ND
Ramon Creek	ND	Suitable	Extremely good	Unsuitable	Good	Fully unsuitable	Fair to good	Unsuitable	Spawning habitat, pool habitat, and shelter decreased
North Fork Ramon Creek	ND	Suitable	ND	Suitable	ND	Fully unsuitable	ND	Unsuitable	ND
Mettick Creek	ND	Suitable	ND	Suitable	ND	Fully unsuitable	ND	Fully unsuitable	ND
Poverty Gulch	ND	Suitable	ND	Insufficient data	ND	Fully unsuitable	ND	Unsuitable	ND
Anderson Gulch	ND	Fully suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Fully unsuitable	ND
Boardman Gulch	ND	Fully suitable	ND	Fully unsuitable	ND	Fully unsuitable	ND	Unsuitable	ND
Halfway House Gulch	ND	Suitable	ND	Fully suitable	ND	Fully unsuitable	ND	Fully unsuitable	ND
Daugherty Creek	ND	Suitable	Good to fair	Suitable	Well developed	Unsuitable	Good to fair	Suitable	Pool habitat decreased
Soda Creek	ND	Suitable	Good throughout	Suitable	Abundant	Fully unsuitable	Good	Unsuitable	Pool habitat and shelter

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	
			middle and upper areas						decreased
Gates Creek	ND	Fully suitable	ND	Suitable	ND	Unsuitable	ND	Suitable	ND
Johnson Creek (tributary to Gates Creek)	ND	Fully suitable	Good	Unsuitable	Good	Fully unsuitable	Good	Unsuitable	Spawning habitat, pool habitat, and shelter decreased
Horse thief Creek	ND	Fully suitable	ND	Insufficient data	ND	Fully unsuitable	ND	Fully unsuitable	ND
Snuffins Creek	ND	Suitable	Fair to poor	Unsuitable	Uncommon and poor	Fully unsuitable	Fair to good	Unsuitable	Shelter decreased
Johnson Creek	ND	Suitable	Fair	Suitable	Good	Fully unsuitable	Excellent	Unsuitable	Pool habitat and shelter decreased
Dark Gulch	ND	Suitable	ND	Suitable	ND	Fully unsuitable	ND	Fully unsuitable	ND
Montgomery Creek	ND	Suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Fully unsuitable	ND
Unnamed Tributary to the South Fork Big River #1	ND	Suitable	Fair to poor	Unsuitable	Fair and poor	Fully unsuitable	Provided by logging debris and undercut banks	Unsuitable	Habitat similar between years
Unnamed Tributary to the South Fork Big River #2	ND	Suitable	Scarce, some fair	Unsuitable	Small and infrequent	Fully unsuitable	Adequate and fair	Unsuitable	Habitat similar between years
Russell Brook	ND*	Suitable	Fair to good	Unsuitable	Good	Fully Unsuitable	Excellent	Unsuitable	Spawning habitat, pool habitat, and shelter decreased
Pig Pen Gulch	ND	ND	Poor to fair	ND	Good	ND	Abundant	ND	ND
Martin Creek	ND	Suitable	Fair to good	Unsuitable	Abundant	Fully Unsuitable	Excellent	Fully Unsuitable	Spawning habitat, pool habitat, and shelter decreased
Martin Creek Left Bank Tributary	ND	Fully Suitable	Fair to poor	Unsuitable	Common	Fully Unsuitable	Good to excellent	Fully Unsuitable	Pool habitat and shelter decreased
Martin Creek Right Bank Tributary #1	ND	Suitable	ND	Unsuitable	ND	Fully Unsuitable	ND	Fully Unsuitable	ND
Martin Creek Right Bank Tributary #2	ND	Fully Suitable	ND	Fully Unsuitable	ND	Fully Unsuitable	ND	Unsuitable	ND
Valentine Creek	ND	Suitable	Poor to fair	Unsuitable	Abundant	Fully Unsuitable	Good to excellent	Fully Unsuitable	Pool habitat and shelter decreased
Rice Creek	ND	Suitable	Fair to poor	Unsuitable	Poor	Fully Unsuitable	Poor to none	Unsuitable	Habitat similar between years
East Branch Rice Creek	ND	ND	Poor	ND	Poor	ND	Poor to fair	ND	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 Inland Subbasin supported runs of Chinook salmon, coho salmon, and steelhead trout (Table 205). CDFG biological stream surveys were conducted for 26 tributaries in this subbasin from 1959 to 1966. The USFWS electrofished four transects in the North Fork Big River, four transects in the mainstem Big River, East Branch North Fork Big River, South Fork Big River, and Martin Creek in 1973 (Perry 1974). East Branch North Fork Big River was also surveyed by the Center for Education and Manpower Resources in 1979.

Out of the 27 streams surveyed in the 1950s, steelhead trout were found in 13 and unidentified salmonids were found in North Fork Big River, East Branch North Fork Big River, James Creek, North Fork James Creek, and Soda Creek. Coho salmon were found in the East Branch North Fork Big River, South Fork Big River, Daugherty Creek, and possibly Russell Brook. Steelhead trout success was described as satisfactory to good in most surveyed tributaries. James Creek and Water Gulch were considered to have little value to fish life after being altered from their natural states.

East Branch North Fork Big River was also surveyed in 1966 and 1979, and steelhead trout were reported in 1966 and unidentified salmonids were reported in both years. South Fork Big River, Johnson Creek (tributary to Gates Creek), and Snuffins Creek were also surveyed in 1966. Steelhead trout were observed in all three, though coho salmon were only observed in South Fork Big River.

North Fork James Creek was electrofished in October of 1966 as part of a study of salmonid carrying capacity in Northern California coastal streams (Burns 1971). No coho salmon were detected, though steelhead trout were found. North Fork Big River was electrofished a second time in 1966 in another survey and coho salmon and steelhead trout were found.

North Fork Big River, Russell Brook, Pig Pen Gulch, Martin Creek, and Rice Creek were surveyed in 1967. Coho salmon were found in North Fork Big River while steelhead trout were found in all streams except for Martin Creek.

Coho salmon eggs and fingerlings were stocked in Chamberlain Creek, South Fork Big River, and mainstem Big River at various times from 1950 to 1980. More details are provided in the Basin Profile Fish History and Status section.

CDFG, CDF, the Salmon Trollers Stream Restoration Project, and MRC studies have continued to document the presence of coho salmon and steelhead trout in the Inland Subbasin.

Surveys of six streams in 1980 and 1981 were documented in NMFS (Jones 2000). Steelhead trout and coho salmon were found in Chamberlain Creek, Arvola Gulch, Lost Lake Creek, and James Creek while unidentified salmonids were found in Water Gulch. No fish were observed in Park Gulch.

CDFG conducted electrofishing surveys in several tributaries in 1983, 1993, 1995, 1996, and 1997. In 1983, coho salmon were detected in Chamberlain Creek and steelhead trout were detected in Upper North Fork Big River, Chamberlain Creek, West Chamberlain Creek, Water Gulch, Park Gulch, Arvola Gulch, and James Creek. Steelhead trout were also detected in James Creek in 1993 and 1995, Upper North Fork Big River in 1995 and 1996, and North Fork Big River above Chamberlain Creek in 1996. CDF detected steelhead trout during a 1994 electrofishing survey of North Fork Big River near the confluence with Chamberlain Creek.

A 1987 carcass survey conducted by CDFG in Gates Creek detected 1 redd and two live coho salmon. CDFG electrofishing in Daugherty Creek in 1988 detected both steelhead trout and coho salmon. Salmon Trollers Stream Restoration Project carcass surveys of six streams in 1990 found redds in South Fork Big River and Ramon Creek. A 1995 CDFG carcass survey in Daugherty Creek found 16 redds.

CDFG stream inventory surveys across the subbasin also detected coho salmon and steelhead trout from 1993 through 1998. Coho salmon were detected in 13 of 41 surveyed tributaries: North Fork Big River, Water Gulch, Arvola Gulch, Daugherty Creek, Soda Creek, Snuffins Creek, Dark Gulch, two unnamed tributaries to South Fork Big River, Russell Brook, Martin Creek, Martin Creek Right Bank Tributary #1, and Valentine Creek. Steelhead trout were detected in 27 surveyed tributaries.

Table 205. Summary of all electrofishing, snorkel survey, and bank observation surveys conducted in the Inland Subbasin.

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)

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified Salmonids
North Fork Big River	1958	CDFG	Visual Observation			Present
	1959	CDFG	Visual Observation		Present	
	1966	NMFS	Electrofishing	Present	Present	
	1967	NMFS	Visual Observation	Present	Present	
	1973	USFWS	Electrofishing	Present	Present	
	1985	CDFG	Carcass Survey			
	1994	MRC	Snorkel Survey		Present	
		CDF	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
		NMFS	Electrofishing	Present	Present	
	1996	MRC	Snorkel Survey	Present	Present	
		CDFG	Electrofishing	Present	Present	
		NMFS	Electrofishing	Present	Present	
	1997	CDFG	Electrofishing		Present	
		NMFS	Electrofishing	Present	Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Snorkel Survey	Present	Present	
		CDFG	Coho Inventory	Present		
	2002	MRC	Snorkel Survey	Present	Present	
Steam Donkey Gulch	1996	MRC	Electrofishing			
	2000	MRC	Snorkel Survey			
	2001	MRC	Electrofishing			
North Fork Big River-Middle	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey	Present	Present	
	2000	MRC	Snorkel Survey		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Dunlap Gulch	1996	MRC	Electrofishing			
	2000	MRC	Snorkel Survey			
	2001	MRC	Electrofishing			
	2002	MRC	Electrofishing			
North Fork Big River-Upper	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey	Present	Present	
	2000	MRC	Snorkel Survey		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Upper North Fork Big River	1983	CDFG	Electrofishing		Present	
	1995	CDFG	Electrofishing		Present	
	1996	CDFG	Electrofishing		Present	
East Branch North Fork Big River	1958	CDFG	Visual Observation			Present
	1959	CDFG	Visual Observation	Present	Present	
	1966	CDFG	Visual Observation	Present	Present	
	1973	USFWS	Electrofishing	Present	Present	
	1979	CEMR	Visual Observation			Present
	1995	NMFS	Electrofishing		Present	
	1996	NMFS	Electrofishing	Present	Present	
	1996	NMFS	Electrofishing		Present	
	1997	NMFS	Electrofishing		Present	
	1998	CDFG	Electrofishing		Present	
	2001	CDFG	Coho Inventory	Present		
East Branch North Fork Big River-Lower	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Snorkel Survey		Present	
	2001	MRC	Electrofishing	Present	Present	

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified Salmonids
	2002	MRC	Snorkel Survey	Present	Present	
East Branch North Fork Big River-Middle	1994	MRC	Electrofishing		Present	
Quail Gulch	1996	MRC	Electrofishing			
Bull Team Gulch	1996	NMFS	Electrofishing	Present	Present	
	1996	MRC	Electrofishing	Present	Present	
	2000	MRC	Electrofishing			
	2001	MRC	Electrofishing			
	2002	MRC	Electrofishing	Present	Present	
East Branch North Fork Big River-Upper	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Electrofishing	Present	Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Electrofishing	Present	Present	
East Branch North Fork Big River-Upper 2	1994	MRC	Electrofishing		Present	
	1995	MRC	Electrofishing		Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Frykman Gulch	2000	MRC	Electrofishing			
	2001	MRC	Electrofishing			
	2002	MRC	Electrofishing		Present	
Chamberlain Creek	1979	CDFG	NA	Present	Present	
	1980	NMFS	Visual Observation	Present	Present	
	1983	CDFG	Electrofishing	Present	Present	
	1995	NMFS	Electrofishing	Present	Present	
	1996	NMFS	Electrofishing	Present	Present	
	1997	NMFS	Electrofishing	Present	Present	
		CDFG	Electrofishing		Present	
	2001	SONAR	Carcass Surveys			
Water Gulch	1959	CDFG	Visual Observation			
	1981	NMFS	Visual Observation			Present
	1983	CDFG	Electrofishing		Present	
	1995	NMFS	Electrofishing	Present	Present	
	1996	NMFS	Electrofishing	Present	Present	
	1997	NMFS	Electrofishing	Present	Present	
		CDFG	Electrofishing	Present	Present	
Water Gulch Tributary	1995	CDFG	Electrofishing		Present	
Park Gulch	1981	NMFS	Visual Observation			
	1983	CDFG	Electrofishing		Present	
	1995	NMFS	Electrofishing		Present	
	1996	NMFS	Electrofishing			
	1997	NMFS	Electrofishing		Present	
		CDFG	Electrofishing		Present	
West Chamberlain Creek	1981	NMFS	Visual Observation			
	1983	CDFG	Electrofishing		Present	
	1995	NMFS	Electrofishing	Present	Present	
	1996	NMFS	Electrofishing	Present	Present	
	1997	NMFS	Electrofishing	Present	Present	
		CDFG	Electrofishing		Present	
	2001	SONAR	Carcass Survey			
Gulch Sixteen	1995	NMFS	Electrofishing		Present	
	1996	NMFS	Electrofishing		Present	
	1997	NMFS	Electrofishing		Present	
		CDFG	Electrofishing		Present	
Gulch Sixteen Tributary	1997	CDFG	Electrofishing			
Arvola Gulch	1979	CDFG	NA	Present	Present	
	1980	NMFS	Visual Observation	Present	Present	
	1983	CDFG	Electrofishing		Present	
	1995	NMFS	Electrofishing	Present	Present	
	1996	NMFS	Electrofishing	Present	Present	
	1997	NMFS	Electrofishing	Present	Present	

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified Salmonids
		CDFG	Electrofishing	Present	Present	
Lost Lake Creek	1980	NMFS	Visual Observation		Present	
	1995	NMFS	Electrofishing		Present	
	1996	NMFS	Electrofishing		Present	
	1997	NMFS	Electrofishing		Present	
	1997	CDFG	Electrofishing		Present	
Soda Gulch	1997	CDFG	Electrofishing			
James Creek	1958	CDFG	Visual Observation			Present
	1980	NMFS	Visual Observation	Present	Present	
	1983	CDFG	Electrofishing		Present	
	1993	CDFG	Electrofishing		Present	
	1995	CDFG	Electrofishing		Present	
		NMFS	Electrofishing		Present	
	1996	CDFG	Electrofishing		Present	
		NMFS	Electrofishing	Present	Present	
	1997	NMFS	Electrofishing		Present	
North Fork James Creek	1958	CDFG	Visual Observation			Present
	1966	Burns 1971	Electrofishing		Present	
	1995	CDFG	Electrofishing		Present	
		NMFS	Electrofishing		Present	
	1996	NMFS	Electrofishing		Present	
	1997	NMFS	Electrofishing		Present	
South Fork Big River	1957/1958	CDFG	Visual Observation	Present	Present	
	1966	CDFG	Visual Observation	Present	Present	
	1973	USFWS	Electrofishing		Present	
	1983	CDFG	Electrofishing		Present	
	1990	Nielsen et al.	Carcass Survey	Present		
	1995	NMFS	Electrofishing		Present	
	1996	NMFS	Electrofishing	Present	Present	
		NMFS	Electrofishing	Present		
	2001	CDFG	Coho Inventory			
	2002	CDFG	Visual Observation	Present	Present	
South Fork Big River-Lower	1994	MRC	Snorkel Survey		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey	Present	Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Snorkel Survey		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Kelly Gulch	circa 1950	CDFG	Visual Observation			
Biggs Gulch	circa 1950	CDFG	Visual Observation			
	2002	CDFG	Visual Observation			
No Name Gulch	1995	MRC	Electrofishing			
	1996	MRC	Electrofishing			
	2000	MRC	Electrofishing			
	2001	MRC	Electrofishing			
Ramon Creek	1959	CDFG	Visual Observation		Present	
	1990	Nielsen et al.	Carcass Survey	Present		
	1995	NMFS	Electrofishing	Present	Present	
	2001	CDFG	Coho Inventory			
	2002	CDFG	Visual Observation	Present	Present	
	2003	SC	Visual Observation			
Ramon Creek-Lower	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified Salmonids
Ramon Creek-Middle	1994	MRC	Electrofishing		Present	
	1995	MRC	Electrofishing	Present	Present	
	1996	MRC	Electrofishing	Present	Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
North Fork Ramon Creek	1995	NFS	Electrofishing	Present	Present	
North Fork Ramon-Lower	1994	MRC	Electrofishing		Present	
	1995	MRC	Electrofishing	Present	Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey		Present	
North Fork Ramon-Middle	2002	MRC	Snorkel Survey		Present	
North Fork Ramon-Upper	1994	MRC	Electrofishing			
	1995	MRC	Electrofishing		Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
Ramon Creek-Upper	1994	MRC	Electrofishing		Present	
	1995	MRC	Electrofishing		Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
Ramon Creek-Upper2	1995	MRC	Electrofishing		Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Mettick Creek	circa 1950	CDFG	Visual Observation			
	1990	Nielsen et al.	Carcass Survey			
	1994	NMFS	Electrofishing		Present	
	1995	NMFS	Electrofishing		Present	
	1996	NMFS	Electrofishing		Present	
	2002	CDFG	Visual Observation			
	2003	SC	Visual Observation			
Mettick Creek-Lower	1994	MRC	Snorkel Survey		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Snorkel Survey		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey		Present	
Mettick Creek-Upper	1994	MRC	Visual Observation		Present	
	1995	MRC	Electrofishing		Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
Poverty Gulch	2002	CDFG				
South Fork Big River-Middle	1994	MRC	Snorkel Survey		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Snorkel Survey		Present	
	2001	MRC	Electrofishing		Present	
Anderson Gulch	circa 1950	CDFG	Visual Observation			
	1990	Nielsen et al.	Carcass Survey			
	1994	NMFS	Electrofishing		Present	
	1995	NMFS	Electrofishing		Present	
	1996	NMFS	Electrofishing		Present	
	2002	CDFG	Visual Observation			
Anderson Gulch-Lower	1994	MRC	Visual Observation		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Snorkel Survey			
	2001	MRC	Electrofishing			

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified Salmonids
	2002	MRC	Snorkel Survey			
Boardman Gulch	circa 1950	CDFG	Visual Observation			
Boardman Gulch - Lower	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Electrofishing		Present	
Boardman Gulch - Upper	1996	MRC	Electrofishing			
	2000	MRC	Electrofishing			
	2001	MRC	Electrofishing		Present	
	2002	MRC	Electrofishing			
Halfway House Gulch	1996	NMFS	Electrofishing		Present	
		MRC	Visual Observation		Present	
	2000	MRC	Electrofishing			
	2001	MRC	Electrofishing			
	2002	MRC	Electrofishing		Present	
South Fork Big River-Upper	1994	MRC	Snorkel Survey		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Snorkel Survey		Present	
	2002	MRC	Electrofishing	Present	Present	
Daugherty Creek	1959	CDFG	Visual Observation	Present	Present	
	1988	CDFG	Electrofishing	Present	Present	
	1988	LPP	Carcass Survey	Present	Present	
	1990	Nielsen et al.	Carcass Survey			
	1993	CDFG	Electrofishing		Present	
	1995	CDFG	Carcass Survey		Present	
	1996	NMFS	Electrofishing	Present	Present	
	2001	CDFG	Coho Inventory			
	2002	CDFG	Snorkel Survey	Present	Present	
Daugherty Creek-Lower	1994	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Daugherty Creek-Middle	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey	Present	Present	
	2000	MRC	Electrofishing		Present	
Soda Creek	1959	CDFG	Visual Observation	??	??	
	1988	CDFG	Electrofishing	Present	Present	
	1993	CDFG	Electrofishing	Present	Present	
	1995	NMFS	Electrofishing		Present	
	1996	NMFS	Electrofishing		Present	
	1997	NMFS	Electrofishing		Present	
		NMFS	Electrofishing			
	2002	CDFG	Electrofishing	Present	Present	
Soda Creek-Lower	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey		Present	
Soda Creek-Upper	1994	MRC	Electrofishing		Present	
	1995	MRC	Electrofishing		Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing			
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey		Present	
Gates Creek	1979	CDFG	NA		Present	
	1987	CDFG	Carcass Survey	Present	Present	
		CDFG	Electrofishing		Present	
	1988	CDFG	Electrofishing	Present	Present	
	1990	Nielsen et al.	Carcass Survey			
	1993	CDFG	Electrofishing		Present	
	1996	CDFG	Electrofishing	Present	Present	
		NMFS	Electrofishing		Present	
	2002	CDFG	Electrofishing	Present	Present	

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified Salmonids
Gates Creek-Lower	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Gates Creek-Middle2?	2002	MRC	Snorkel Survey	Present	Present	
Gates Creek-Middle	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Snorkel Survey		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey		Present	
Gates Creek-Upper	1994	MRC	Electrofishing		Present	
	1995	MRC	Electrofishing		Present	
	1996	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey		Present	
Tributary to Gates Creek	2000	MRC	Electrofishing		Present	
Gates Creek-Upper2	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey			
Johnson Creek (tributary to Gates Creek)	1959	CDFG	Visual Observation		Present	
	1966	CDFG	Visual Observation		Present	
	1993	CDFG	Electrofishing		Present	
	1996	NMFS	Electrofishing		Present	
	2002	CDFG	Electrofishing		Present	
Johnson Creek (Tributary to Gates Creek)-Lower	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey		Present	
Johnson Creek (Tributary to Gates Creek)-Upper	1994	MRC	Electrofishing			
	1995	MRC	Electrofishing			
	1996	MRC	Electrofishing			
	2000	MRC	Electrofishing			
	2001	MRC	Electrofishing			
Horse thief Creek	2002	CDFG	Electrofishing			
Daugherty Creek-Upper	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey	Present	Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Snuffins Creek	1959	CDFG	Visual Observation			
	1966	CDFG	Visual Observation		Present	
	1993	CDFG	Electrofishing		Present	
	1996	NMFS	Electrofishing		Present	
	2002	CDFG	Snorkel Survey	Present	Present	
Snuffins Creek-Lower	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Electrofishing	Present	Present	
Snuffins Creek-Upper	1994	MRC	Electrofishing			
	1995	MRC	Electrofishing			
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Electrofishing			
Daugherty Creek	2002	MRC	Electrofishing	Present	Present	
Daugherty Creek	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Electrofishing		Present	

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified Salmonids
	2000	MRC	Electrofishing		Present	
Daugherty Creek	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Electrofishing		Present	
Johnson Creek	1959	CDFG	Visual Observation		Present	
	2000	NMFS	Visual Observation			
	2001	CDFG	Coho Inventory			
	2002	CDFG	Electrofishing		Present	
Dark Gulch	1958	NMFS	Visual Observation			
	1999	NMFS	Visual Observation			
	2002	CDFG	Electrofishing	Present	Present	
Dark Gulch Tributary	2002	CDFG	Electrofishing		Present	
Montgomery Creek	2000	NMFS	Visual Observation			
	2002	CDFG	Visual Observation			
Unnamed Tributary to the South Fork Big River #1	1958	CDFG	Visual Observation		Present	
	2002	CDFG	Electrofishing	Present	Present	
Unnamed Tributary to the South Fork Big River #2	1958	CDFG	Visual Observation		Present	
	2002	CDFG	Electrofishing	Present	Present	
Mainstem Big River (confluence with South Fork Big River to Duffy Flat)	1990	Salmon trollers stream restoration project	Carcass Survey			
Big River at South Fork Camp	1973	USFWS	Electrofishing	Present		
Big River Main-Lower	1994	MRC	Snorkel Survey		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Snorkel Survey		Present	
	2001	MRC	Snorkel Survey	Present	Present	
Big River at Wildhorse Opening	1973	USFWS	Electrofishing	Present	Present	
Russell Brook	1959	CDFG	Visual Observation	Present	Present	
	1967	NMFS	Visual Observation		Present	
	1996	NMFS	Electrofishing		Present	
	2002	CDFG	Visual Observation	Present	Present	
	2003	SC	Visual Observation			
Russell Brook-Lower	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Snorkel Survey		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Russell Brook -Middle	1994	MRC	Electrofishing		Present	
	1995	MRC	Electrofishing		Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Snorkel Survey		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Electrofishing	Present	Present	
Russell Brook -Upper	1994	MRC	Electrofishing		Present	
	1995	MRC	Electrofishing		Present	
	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2002	MRC	Electrofishing	Present	Present	
Russell Brook -Upper 2	1996	MRC	Electrofishing		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Electrofishing		Present	
Big River-Main-Midreach	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	2000	MRC	Snorkel Survey		Present	

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified Salmonids
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Big River upstream from dam site	1973	USFWS	Electrofishing	Present	Present	
Pig Pen Gulch	1959	CDFG	Visual Observation		Present	
	1967	NMFS	Visual Observation		Present	
	1994	MRC	Electrofishing		Present	
		NMFS	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
		NMFS	Electrofishing		Present	
	1996	MRC	Electrofishing		Present	
		NMFS	Electrofishing		Present	
	2000	MRC	Electrofishing			
	2001	MRC	Electrofishing			
	2002	MRC	Electrofishing			
Big River-Above Pig Pen	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Snorkel Survey		Present	
	2002	MRC	Snorkel Survey		Present	
Martin Creek	1959	CDFG	Visual Observation		Present	
	1967	NMFS	Visual Observation			
	1973	USFWS	Electrofishing		Present	
	1994	NMFS	Electrofishing		Present	
	1995	CDFG	Electrofishing		Present	
		NMFS	Electrofishing		Present	
	1996	CDFG	Electrofishing		Present	
		NMFS	Electrofishing		Present	
	2002	CDFG	Visual Observation	Present	Present	
Martin Creek-LP Prop L	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey			
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Martin Creek Left Bank Tributary	1959	CDFG	Visual Observation		Present	
	2002	CDFG	Visual Observation		Present	
Martin Creek Right Bank Tributary #1	2002	CDFG	Visual Observation	Present	Present	
Martin Creek Right Bank Tributary #2	2002	CDFG	Visual Observation			
Big River-Upper/Site#1	1994	MRC	Electrofishing		Present	
	1995	MRC	Snorkel Survey		Present	
	1996	MRC	Snorkel Survey		Present	
	2000	MRC	Electrofishing		Present	
	2001	MRC	Electrofishing		Present	
	2002	MRC	Snorkel Survey	Present	Present	
Valentine Creek	1959	CDFG	Visual Observation		Present	
	2002	CDFG	Visual Observation	Present	Present	
Rice Creek	circa 1959	CDFG	Visual Observation			
	1967	NMFS	Visual Observation		Present	
	2002	CDFG	Visual Observation		Present	
East Branch Rice Creek	1959	CDFG	Visual Observation			

Electrofishing in 25 streams in 1994 through 1997 was documented in NMFS (Jones 2000). Steelhead trout were found in all 25 streams, and coho salmon were found in North Fork Big River, East Branch North Fork Big River, Bull Team Gulch, Chamberlain Creek, Water Gulch, West Chamberlain Creek, Arvola Gulch, Lost Lake Creek, James Creek, South Fork Big River, Ramon Creek, and Daugherty Creek. Electrofishing in Dark Gulch in 1999 and Johnson Creek in 2000 found no fish.

The 2001 CDFG Coho Inventory detected coho salmon in North Fork Big River and East Branch North Fork Big River. The Inventory did not detect coho salmon in South Fork Big River, Ramon Creek, Daugherty Creek, or Johnson Creek.

The School of Natural Resources at Mendocino High School conducted carcass surveys in Chamberlain Creek and West Chamberlain creeks in 2001. No fish or redds were observed.

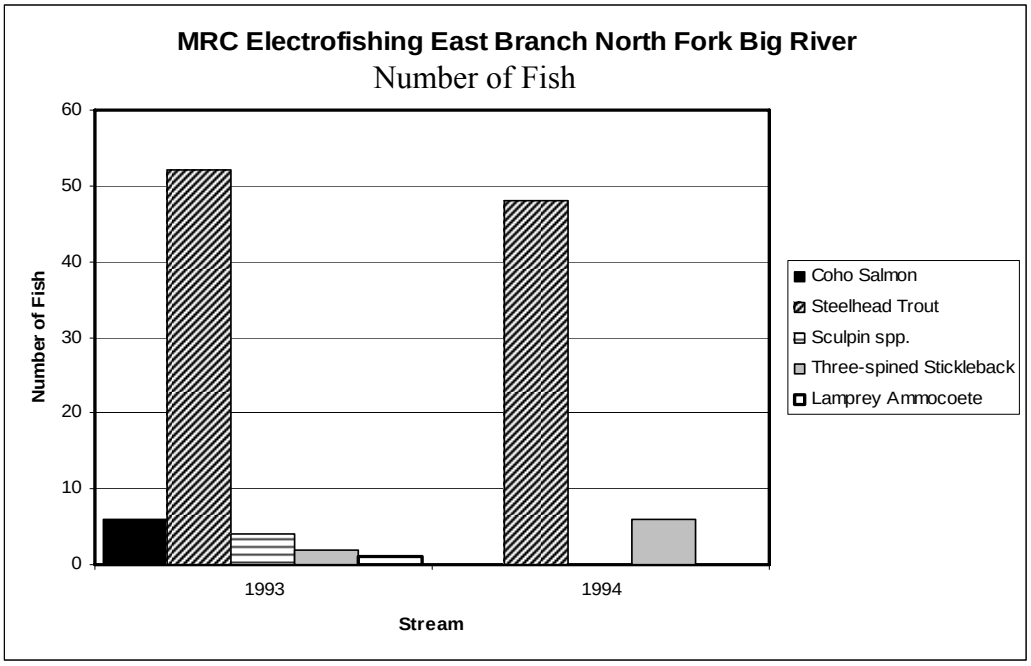
MRC has collected both quantitative and non-quantitative electrofishing data in the Inland Subbasin. Quantitative data were collected for a site in the East Branch North Fork Big River in 1993 and 1994, two sites on Gates Creek from 1990 to 1994, and a site in the mainstem Big River at Wild Horse Opening in 1993 and 1994 (Figure 137, Figure 138, Figure 139). These data can be used to investigate fish density, biomass, or changes in abundance. Coho salmon were only found in East Branch North Fork Big River in 1993. Steelhead trout were found at all four sites at all sample times. Steelhead were found at similar abundance levels in both 1993 and 1994 in East Branch North Fork Big River. Steelhead trout were more abundant in Lower Gates Creek than other sample sites.

MRC also conducted single-pass electrofishing or snorkel surveys in 56 sites across the Inland 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 salmon or other species.

Coho salmon were found in the mainstem Big River and 11 tributaries: North Fork Big River, East Branch North Fork Big River, Bull Team Gulch, South Fork Big River, Ramon Creek, North Fork Ramon Creek, Daugherty Creek, Gates Creek, Snuffins Creek, Russell Brook, and Martin Creek in 2002 (

Steelhead trout were found in the mainstem Big River and 20 tributaries: North Fork Big River, East Branch North Fork Big River, Bull Team Gulch, Frykeman Gulch, South Fork Big River, Ramon Creek, North Fork Ramon Creek, Mettick Creek, Anderson Gulch, Boardman Gulch, Halfway House Gulch, Daugherty Creek, Soda Creek, Gates Creek, tributary to Gates Creek, Johnson Creek (tributary to Gates Creek), Snuffins Creek, Russell Brook, Pig Pen Gulch, and Martin Creek.

No salmonids were detected in Steam Donkey, Dunlap, Quail, and No Name gulches. More detailed summaries of stream surveys and fisheries studies in the Inland Subbasin are provided in the CDFG appendix.



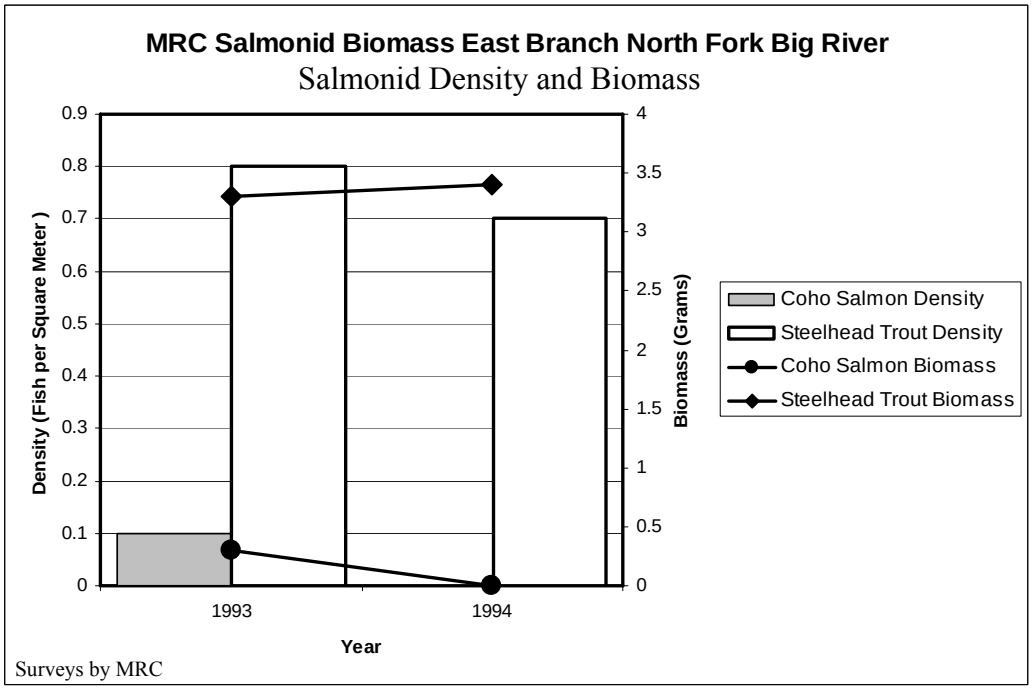
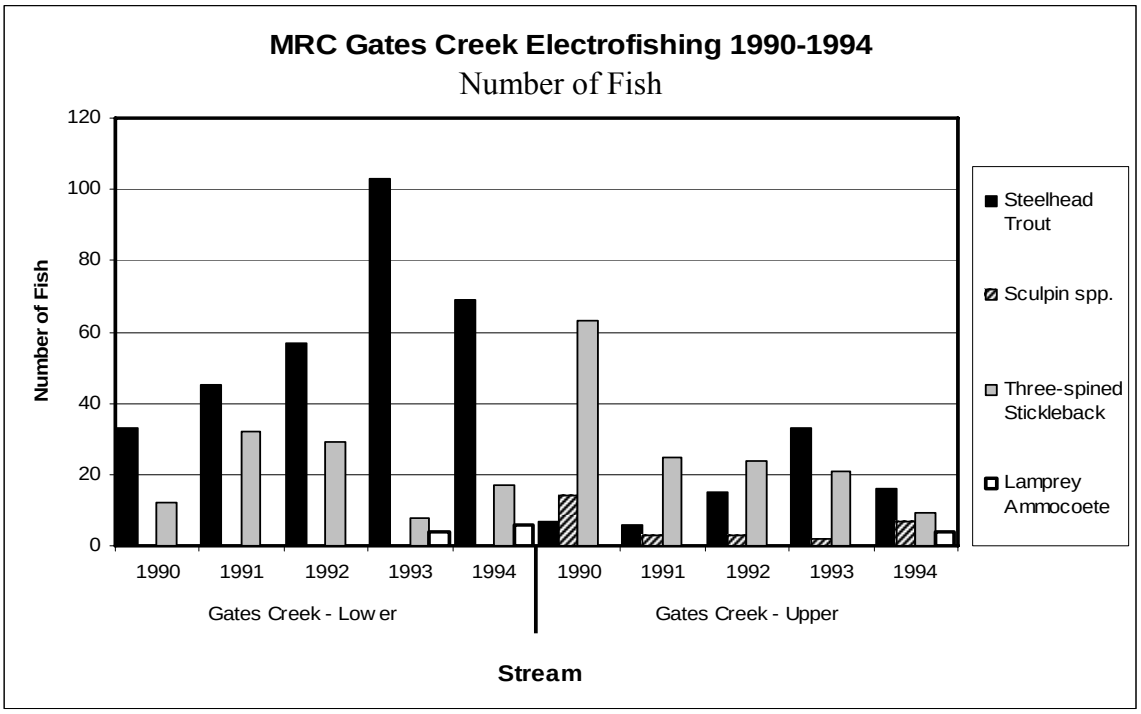


Figure 137. Electrofishing results from 1993 and 1994 for East Branch North Fork Big River.



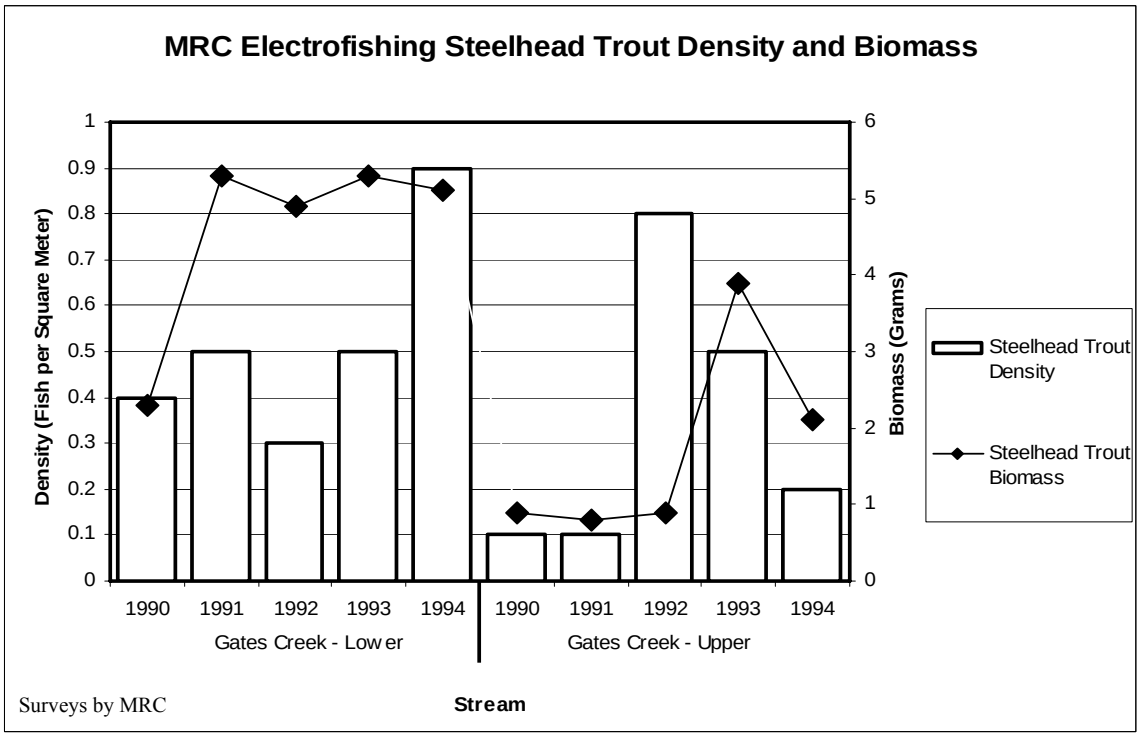
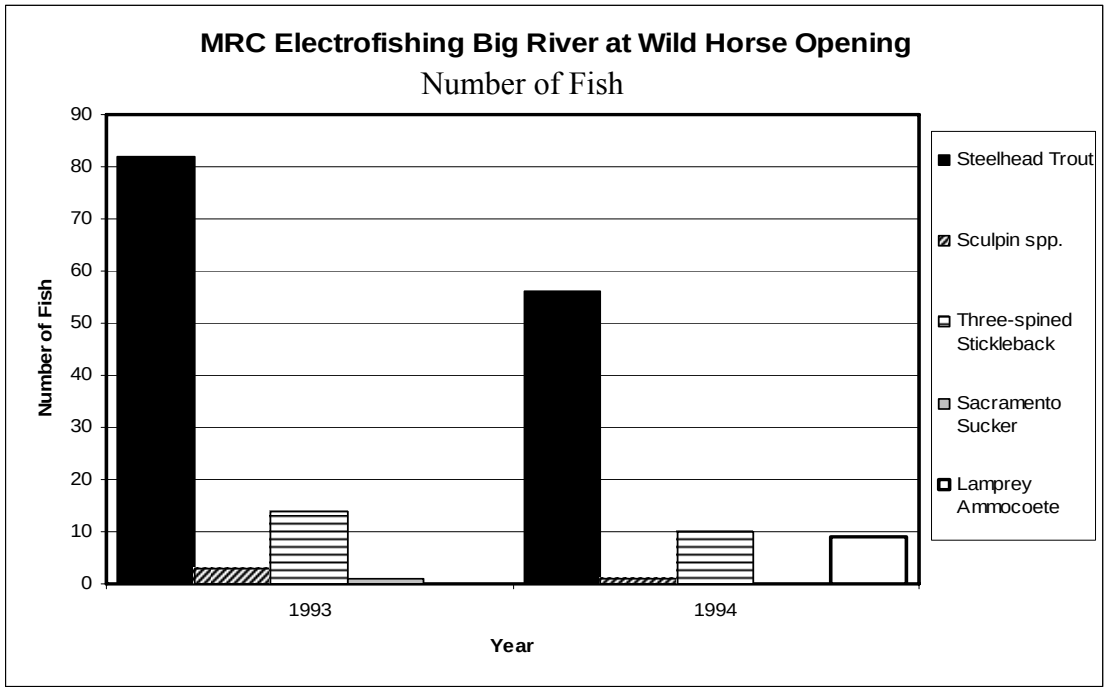


Figure 138. Electrofishing results from 1993 and 1994 for Gates Creek.



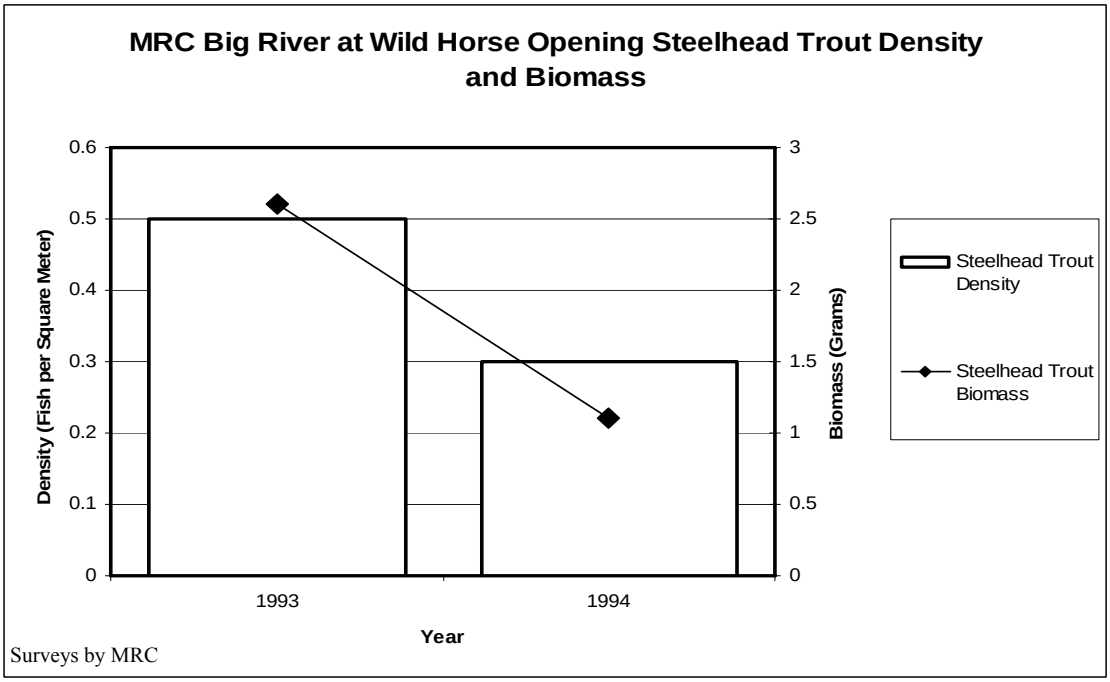


Figure 139. Electrofishing results from 1993 and 1994 for mainstem Big River at Wild Horse Opening.

Inland Subbasin Issues

From the various disciplines' assessments and constituent input, the following issues were developed for the Inland Subbasin. These must be considered in context of the Big River Basin's Franciscan mélange geology.

- Water temperatures are thought to be unsuitable for salmonids in the mainstem Big River and larger tributaries;
- There is concern that road related failures are contributing large amounts of sediments to stream channels during major storms;
- A significant amount of fine sediment may be entering the North Fork Big River either from James Creek, or between James Creek and Chamberlain Creek based on McNeil samples collected by GMA and MRC;
- High levels of fine material in streams are a concern.

Inland Subbasin Integrated Analysis

The following section provides a dynamic, spatial picture of watershed conditions for the freshwater lifestages of 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 218 tons/square mile/year for 1989-2000. In the Inland Subbasin, it was reported that 20.2% of the landslides occurred in grassland areas, none occurred in unmanaged forest, and the remaining 79.8% occurred in timber harvest areas or was related to roads (Figure 140 and Table 196). Of the delivering landslides from harvest related activities and roads, it was estimated that 23% were related to roads and 57% were related to timber harvesting (including skid trails). Results over the entire study period (1937-2000) showed that 34% of the delivering landslides were road related, 55% were related to timber harvesting (including skid trails), 11% were related to grassland areas, and the remaining <1% occurred in unmanaged forest areas.

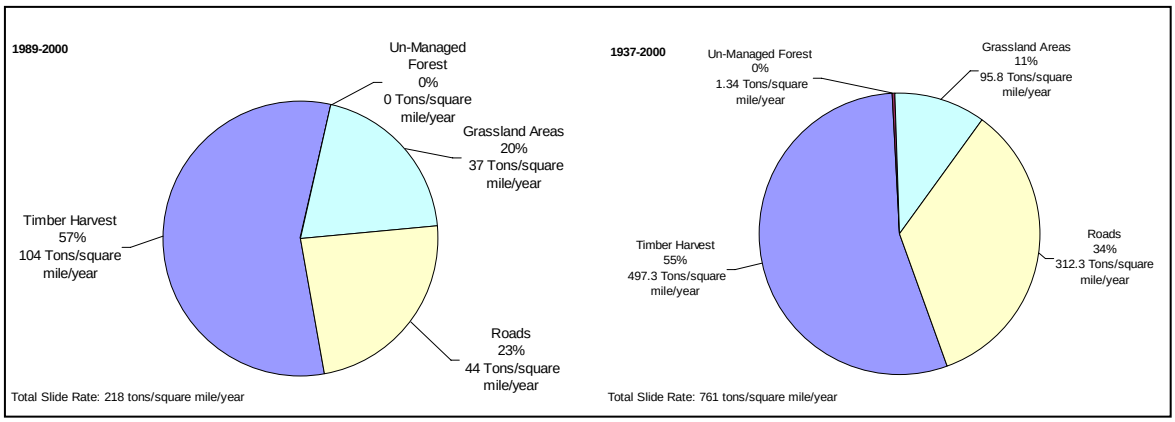


Figure 140. Delivering landslides by category, Inland Subbasin (GMA 2001a).

Thus, when comparing the 1989-2000 time period to that of the entire study period, the percentage of delivering landslides due to roads decreased while those due to timber harvesting remained similar. Timber harvest activities appear to contribute to the majority of the delivering landslides in the Inland Subbasin for the whole study period. While the relative percentages of volume from landsliding related to various land uses have stayed similar, it is important to note that the total estimated slide rate decreased from 761 to 218 tons per square mile per year, a substantial drop in sediment input by landslides.

When examining the differences throughout the Inland Subbasin, sediment volume related to roads in the North Fork drainage was much more than twice as high as the South Fork and upper headwaters drainages (Table 206). This appears to be largely due to a significant amount of road-related landslides in the Chamberlain Creek PW, which by itself contributes 30.1% of the total volume from all road-related activities. Harvest related sediment was highest in the South Fork drainage. Brush and grassland related sediment were highest in the South Fork drainage as well. Skid trail related sediment was highest in the South Fork and North Fork drainages.

The percentage of sediment volumes delivered by landslides associated with various land uses varied significantly between different PWs. Harvest related volumes varied from 23.0% to 79.96%, with the highest relative volumes in the Mettick Creek and Leonaro Lake PWs. Road-related sediment volumes ranged from 1.1% in the Leonaro Lake PW to 77.0% in the James Creek PW. Overall sediment volume delivered by landslides was highest in the Chamberlain Creek PW and lowest in the Upper North Fork Big River PW. Skid trail related landsliding was locally significant in the Dark Gulch PW at 21.3%.

Table 206. Volumes of delivering slides by land use by PW for entire study period.

PW	Forest	Brush & Grassland	Harvest-Related					Road-Related	Total
			Partial Or Clear Cut	Harvest (<20 Yrs)	Harvest (>20 Yrs)	Skid Trails	Total		
Upper North Fork Big River		4,390 3.9%		14,559 13.0%	24,395 21.8%	5,636 5.0%	44,590 39.9%	62,826 56.2%	111,806
James Creek				15,544 4.8%	13,887 4.3%	45,279 14.0%	74,710 23.0%	249,619 77.0%	324,329
Chamberlain Creek	2,650 0.2%			116,599 10.8%	286,863 26.6%	62,520 5.8%	465,982 43.3%	608,713 56.5%	1,077,345
East Branch North Fork Big		4,961 1.7%		79,331 27.2%	70,991 24.3%	2,659 0.9%	152,981 52.4%	133, 730 45.8%	291,672
Lower North Fork Big River	3,744 1.6%		48 <0.1%	38,668 16.5%	62,751 26.8%	20,773 8.9%	122,240 52.3%	107,746 46.1%	233,731
Leonaro Lake		235,897 24.7%		172,240 18.1%	535, 082 56.1%		707,322 74.1%	10,841 1.1%	954,060
Dark Gulch		118,862 27.6%	33,117 7.7%	58,189 13.5%	70,904 16.5%	91,651 21.3%	253,861 58.9%	58,114 13.5%	430,837
South Daugherty Creek	3,680 0.5%	270,130 33.0%		121,504 14.9%	88,911 10.9%	34,775 4.3%	245,190 30.0%	298,546 36.5%	817,546
Mettick Creek	996 0.2%	22,385 5.2%	853 0.2%	108,571 25.0%	226,911 52.3%	10,255 2.4%	346,590 79.9%	63,541 14.7%	433,512
Rice Creek		60,726 7.6%	18,198 2.3%	288,784 36.0%	196,445 24.5%	36,555 4.6%	539,982 67.2%	202,290 25.2%	802,998
Martin Creek		60,530 13.9%	440 0.1%	178,865 41.2%	46,630 10.7%	33,470 7.7%	259,405 59.7%	114,399 26.3%	434,334
Russell Brook		10,823 4.3%		35,665 14.0%	90,088 35.4%	3,506 1.4%	129,259 50.8%	114,147 44.9%	254,230
Inland Subbasin	11,070 0.2%	788,704 12.8%	52,656 0.9%	1,228,518 19.9%	1,713,858 27.8%	347,079 5.6%	3,342,111 54.2%	2,024,512 32.8%	6,166,397

Figures are in tons and percent of subbasin total (GMA 2001a)

Most PWs across the Inland Subbasin had a peak in sediment production in 1952, though two PWs had peaks in 1965 and one in 1988 (Table 207). The highest peak sediment production was 828, 336 tons in 1952 in the Leonaro Lake PW. Harvest-related landslides provided more volume in the peak year for the seven PWs in the South Fork and Upper drainages, while road-related sediment was greater for the other five PWs in the North Fork drainage.

In the 2000 study period, sediment production from landslides ranged from 2,535 tons in the James Creek PW to 65,068 tons in the Upper Mainstem Big PW. Harvest related landslides provided more volume in seven PWs, roads in two, and grasslands in three. All thee PWs with the most sediment related to grasslands were in the South Fork drainage.

Sediment production related to landsliding showed varying trends in different PWs from 1937 to 2000. From 1952 to 1965, most PWs showed a decrease in sediment as most PWs had shown a peak in sediment production in 1952. Half of the PWs had harvest-related landslides providing the most sediment, while four had more road-related and two had more grasslands and brush-related.

All PWs showed a decrease in sediment production from 1965 to 1978, though eight PWs showed an increase from 1978 to 1988. More landslide sediment was related to harvest in most PWs during the 1978 study period, but there was more variation between PWs in the 1988 study period. In the last study period (1988 to 2000) there was the most variation between PWs with five showing increased sediment and seven showing decreased sediment. All three PWs in the headwaters drainage showed an increase in sediment production in this time period. Eight PWs had most of the landslide sediment production related to timber harvest, while two each had more sediment production related to roads and grassland and brush.

Table 207. Volume of delivering slides by land use, PW, and year (in tons).

Year	PW	Forest	Brush & Grassland	Harvest-Related					Road-Related	Study Period Total
				Partial Or Clear Cut	Harvest (< 20 Years)	Harvest (> 20 Years)	Skid Trail	Total		
1952	Upper North Fork Big		3,249		2,590	16,298	2,427	21,314	12,530	37,093
1965			1,141		2,776	6,953		9,729	5,610	16,480
1978					67		3,160	3,227	7,679	10,906
1988					4,570	1,016	50	5,635	33,530	39,165
2000					4,557	128		4,685	3,478	8,164
TOTAL			**4,390**	**0**	**14,559**	**24,395**	**5,636**	**44,591**	**62,826**	**111,807**
1952	Lower North Fork Big	3,223			18,495	37,738		56,232	61,406	120,861
1965		522			19,384	19,654	20,773	59,812	34,331	94,664
1978						340		340	2,085	2,424
1988						432		432	8,450	8,881
2000				48	789	4,588		5,425	1,475	6,900
TOTAL		**3,744**	**0**	**48**	**38,668**	**62,751**	**20,773**	**122,240**	**107,746**	**233,731**
1952	James Creek				9,113	940		10,053	120,729	130,782
1965					3,519	6,958	13,450	23,926	92,620	116,547
1978					2,296	4,534	5,674	12,504	8,076	20,580
1988						212	25,986	26,199	27,686	53,885
2000					616	1,243	168	2,028	507	2,535
TOTAL			**0**	**0**	**15,544**	**13,887**	**45,279**	**74,709**	**249,619**	**324,328**
1952	East Branch North Fork Big		4,787		43,313	13,783	643	57,740	72,292	134,819
1965			174		15,798	35,858	996	52,652	17,336	70,162
1978					145	652	1,020	1,817	15,932	17,748
1988					1,210	16,202		17,412	26,767	44,179
2000					18,865	4,496		23,361	1,404	24,765
TOTAL			**4,961**	**0**	**79,331**	**70,991**	**2,659**	**152,981**	**133,730**	**291,673**
1952	Chamberlain Creek	2,650			99,668	236,546	2,683	338,897	462,642	804,189
1965					12,621	38,721	44,079	95,421	127,471	222,892
1978						3,111	14,404	17,515	10,883	28,398
1988						3,614	1,353	4,967	4,699	9,666
2000					4,310	4,872		9,182	3,018	12,200
TOTAL		**2,650**	**0**	**0**	**116,599**	**286,863**	**62,520**	**465,982**	**608,713**	**1,077,345**
1952	Leonaro Lake		173,112		168,393	475,990		644,384	10,841	828,336
1965			11,826		3,846	38,703		42,549		54,375
1978			8,339			6,155		6,155		14,494
1988			27,841			12,647		12,647		40,489
2000			14,779			1,587		1,587		16,365
TOTAL			**235,897**	**0**	**172,240**	**535,082**	**0**	**707,322**	**10,841**	**954,059**
1952	Dark Gulch		46,780		16,385	26,007		42,392	5,502	94,674
1965			53,929	33,003	34,487	36,085	83,639	187,213	41,785	282,927
1978			14,642	46	2,535	3,144	7,653	13,378	3,329	31,349
1988			2,215	68	4,669	1,031	205	5,973	4,438	12,626
2000			1,296		113	4,637	155	4,904	3,061	9,261
TOTAL		**0**	**118,862**	**33,117**	**58,189**	**70,904**	**91,651**	**253,861**	**58,114**	**430,836**
1952	South Daugherty Creek	3,680	144,143		104,158	22,591	4,077	130,826	80,350	359,000
1965			99,498		4,731	33,590	14,749	53,069	166,610	319,177
1978			6,988		935	2,767	1,239	4,940	7,853	19,781
1988			5,184		11,424	20,202	12,847	44,473	37,020	86,676
2000			14,317		257	9,761	1,863	11,881	6,712	32,910
TOTAL		**3,680**	**270,130**	**0**	**121,504**	**88,911**	**34,775**	**245,189**	**298,546**	**817,544**
1952	Mettick Creek	996	15,292	853	52,964	127,588		181,404	9,526	207,219
1965			7,093		16,688	55,214		71,902	24,267	103,262
1978					9,717	4,339	8,259	22,316	23,550	45,865
1988					9,965	5,819	1,996	17,780	2,551	20,331
2000					19,237	33,951		53,188	3,647	56,836
TOTAL		**996**	**22,385**	**853**	**108,571**	**226,911**	**10,255**	**346,590**	**63,541**	**433,513**
1952	Rice Creek		38,617	2,245	216,612	99,986		318,842	43,429	400,888
1965			18,283	15,953	52,680	64,780	15,575	148,988	89,330	256,601
1978					10,590	14,231	3,159	27,980	6,051	34,031
1988			3,716		8,903	13,263	5,161	27,328	15,367	46,410
2000			110			4,184	12,660	16,845	48,113	65,068
TOTAL			**60,726**	**18,198**	**288,784**	**196,445**	**36,555**	**539,982**	**202,290**	**802,998**
1952	Martin Creek		5,007	440	66,521	5,600		72,561	45,490	123,057
1965			7,165		99,517	25,168		124,685	56,867	188,716
1978			2,057		6,872	178	29,234	36,284	4,559	42,901
1988			21,867		3,980	611	4,236	8,827	1,311	32,005
2000			24,433		1,975	15,072		17,048	6,173	47,655
TOTAL			**60,530**	**440**	**178,865**	**46,630**	**33,470**	**259,405**	**114,399**	**434,334**
1952	Russell Brook		4,443		22,849	69,153		92,003	38,381	134,826
1965			3,677		3,556	14,891		18,447	15,288	37,411
1978						2,801	2,587	5,388	3,964	9,352
1988						966	919	1,885	28,197	30,082
2000			2,703		9,260	2,276		11,536	28,318	42,558
TOTAL			**10,823**	**0**	**35,665**	**90,088**	**3,506**	**129,259**	**114,147**	**254,230**

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 141). 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 218 tons/square mile/year. This would indicate that background landslides may have contributed roughly 47% 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 141 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, timber harvesting, and grassland areas needs to be addressed to meet the TMDL load allocation goals.

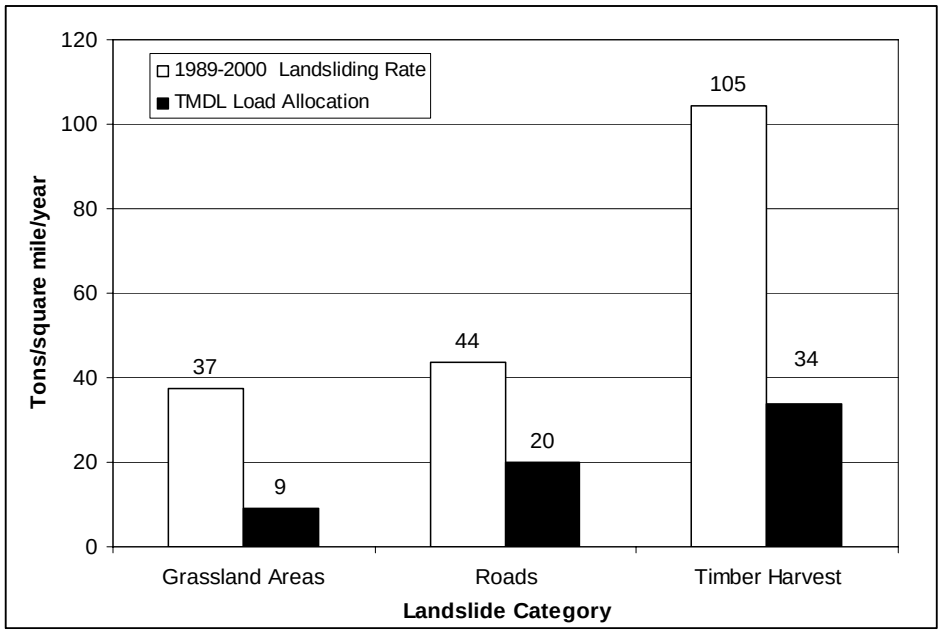


Figure 141. Landslide rate vs. TMDL load allocations, Inland Subbasin (GMA 2001a).

The MRC Watershed Analysis found that of the 884 shallow-seated landslides observed in the MRC ownership of the Inland Subbasin, 535, or 61%, were road-associated (Table 208).

Table 208. Percent of road-associated landslides by PW for lands under MRC ownership.

PW	Road Associated
East Branch North Fork Big River	31%
Rice Creek	29%
Lower North Fork Big River	29%
Mettick Creek	44%
Dark Gulch	31%
Russell Brook	47%
South Daugherty	40%
Total	61%

MRC 2003

Road associated mass wasting was found to have contributed about 408,000 tons (256 tons/square mile/year) in the study period. This is 65% of the total mass wasting sediment inputs for the MRC ownership in the Inland Subbasin. Road associated mass wasting was a major sediment source in the Mettick Creek, Russell Brook, and South Daugherty PWs (Figure 142).

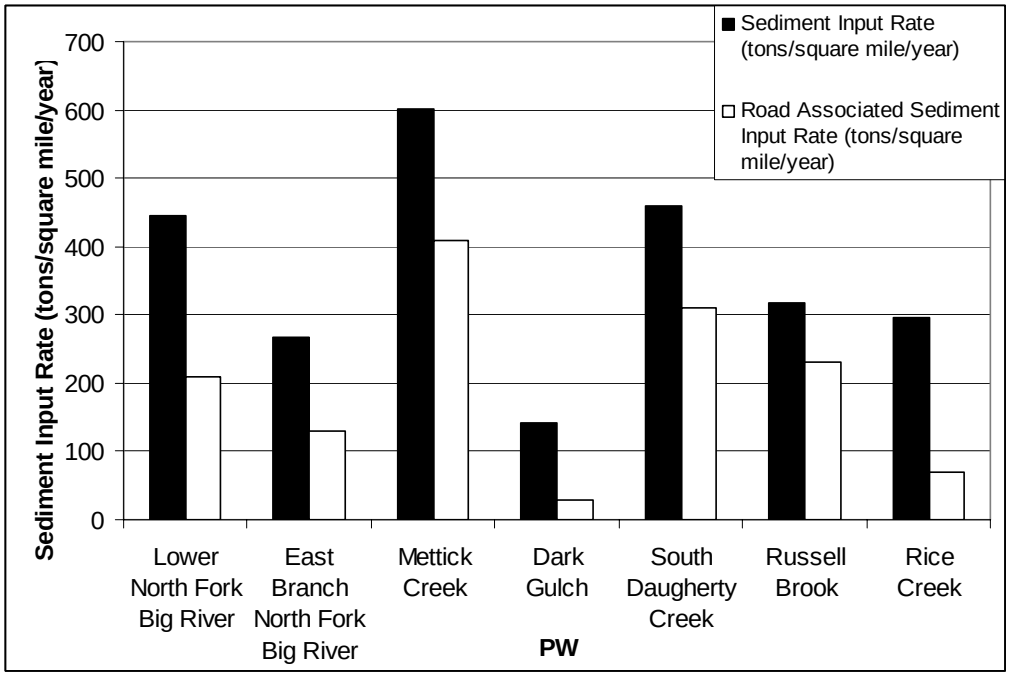


Figure 142. Sediment input rate from all shallow-seated landslides and road-associated shallow-seated landslides for the MRC ownership from 1970 to 2000.

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 209). 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 210). The proportion of roads in each location is similar across PWs (Table 211).

Table 209. Length of truck roads by side slope and road surface in the Inland Subbasin.

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	71	5	7	83	0.5	0.0	0.1	0.6	8.5	0.6	0.8	9.9
16 - 30	182	12	25	218	1.4	0.1	0.2	1.7	21.7	1.4	3.0	26.0
31 - 50	290	10	43	342	2.2	0.1	0.3	2.6	34.5	1.2	5.1	40.7
51 - 65	110	2	15	126	0.8	0.0	0.1	1.0	13.1	0.2	1.8	15.0
Greater than 65	62	1	9	71	0.5	0.0	0.1	0.5	7.4	0.1	1.1	8.5
Total	**713**	**29**	**99**	**840**	**5.5**	**0.2**	**0.8**	**6.4**	**84.9**	**3.5**	**11.8**	**100.0**

Table 210. Inland Subbasin roads by location and surface type.

	Paved	Rocked	Un-surfaced
Ridgetop			
Miles	2.7	8.2	150.3
% Total Basin Miles	<0.1	1.0	17.9
Mid-slope			
Miles	14.7	57.3	392.3
% Total Basin Miles	1.8	6.8	46.7
Riparian			
Miles	10.3	34.8	168.7
% Total Basin Miles	1.2	4.1	20.2

Total subbasin roads = 839.2 miles, 6.4 miles/square mile

Blue categories have the lowest potential for road surface erosion (2.9%). Orange categories have medium potential for surface erosion (25.9%). Magenta categories have the highest potential for surface erosion (71.0%). Road surface erosion is a source of fine sediment that can be delivered to streams, which is deleterious to fish habitat.

Table 211. Existing miles of road in different road positions by types and PW.

PW	Riparian			Mid-Slope			Ridge			Total By PW		
	Paved	Rocked	Native	Paved	Rocked	Native	Paved	Rocked	Native	Riparian	Mid-Slope	Ridge
Upper North Fork Big River		3.1	10.3	0.5	8.6	29.1	0.1	1.4	6.8	13.4	38.2	8.3
James Creek	0.7		12.7	4.7	1.1	22.6	0.4	0.6	8.8	13.4	28.4	9.8
Chamberlain Creek		1.4	25.6		0.3	24.1		0.1	12.6	26.9	24.4	12.6
East Branch North Fork Big		5.5	7.0		5.9	25.4		0.4	9.1	12.5	31.3	9.6
Lower North Fork Big River	2.5	3.0	10.7	1.4	4.7	28.5	0.0	0.1	9.4	16.2	34.6	9.6
Leonaro Lake	1.4		6.8	2.1		16.4	0.4		7.2	8.3	18.5	7.5
Dark Gulch	5.3	0.1	13.9	0.5	0.1	26.5		0.4	11.1	19.2	27.0	11.5
South Daugherty Creek	0.3	6.3	16.2	5.5	8.8	48.2	0.7	1.0	22.0	22.8	62.4	23.7
Mettick Creek	0.1	7.7	20.6		13.6	54.0	1.2	0.8	17.7	28.4	67.6	19.7
Rice Creek		0.9	19.3		1.3	42.9		0.0	20.3	20.2	44.3	20.4
Martin Creek		5.3	7.8		9.3	28.4		3.0	13.0	13.1	37.7	15.9
Russell Brook		1.6	17.9		3.6	46.3		0.5	12.4	19.6	49.9	12.8

GMA 2001a

The MRC Watershed Analysis found that about 87% of field observed shallow landslides inventoried on MRC land in the Inland Subbasin were initiated on slopes greater than or equal to 60% gradient. Almost 65% 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%, only four were not 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 just under 50% of the shallow-seated landslides; 21% inner gorge and 29% steep streamside slopes. Headwall swells accounted for 12%, 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 55% of all the contributing road area (Table 212). The East Branch North Fork Big River PW has the highest percentage of low slope roads, and the Russell Brook PW has the lowest. Low slope class roads delivered 7,150 tons/year, compared to 6,030 tons/year for middle slope class roads and 1,350 tons/year on high slope class roads. This indicates the importance of monitoring low and mid-sloped roads.

Table 212. Contributing road area, proportion estimates, and surface and point source erosion estimates by slope class and PWs for MRC ownership in the Inland 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)
East Branch North Fork	6.2	75%	930	2.0	25%	480	0.0	0%	170
Lower North Fork	4.1	48%	360	4.2	50%	540	0.1	2%	30
Mettick Creek	10.4	54%	1580	7.8	38%	1290	0.6	3%	270
Rice Creek	1.7	65%	250	0.9	35%	180	0.0	0%	10
Russell Brook	5.2	45%	1320	5.6	49%	2250	0.7	6%	480
South Daugherty	9.4	52%	2710	8.1	45%	1290	0.6	3%	390
Total	37.0	55%	7150	28.6	42%	6030	2.0	3%	1350

No data for MRC ownership in Dark Gulch. MRC 2004.

Road Interactions

GMA (2001) estimated that road surface erosion across the Inland Subbasin increased significantly from 1937 to 2000, coinciding with an increased amount of roads, (Table 213). Roads in 2000 were estimated to produce 89.3 tons of sediment per square mile per year across the subbasin, an increase over 1952 rates. Existing road surface erosion in 2000 was highest in the Lower North Fork Big River PW and lowest in the Leonaro Lake PW.

Table 213. Computed road surface erosion by study period by PW.

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)	
Upper North Fork Big River	167.0	481.9	646.4	691.0	911.8	35,191.3	5.3	66.0	107.8
James Creek	101.9	419.0	487.6	578.7	732.3	27,989.5	4.2	63.8	105.2
Chamberlain Creek	531.6	907.3	1,201.1	1,231.4	1,240.6	63,132.9	9.5	81.6	101.0
East Branch North Fork Big	92.8	133.8	532.2	586.9	688.3	24,271.8	3.7	47.8	85.4
Lower North Fork Big River	360.2	524.9	707.1	769.7	834.6	39,539.6	6.0	81.2	108.0
Leonaro Lake	172.0	335.5	351.7	362.5	445.7	20,658.4	3.1	39.4	53.6
Dark Gulch	294.3	642.1	731.9	754.4	905.5	40,981.0	6.2	58.2	81.1
South Daugherty Creek	336.8	700.7	951.7	1024.0	1286.2	52,543.7	7.9	50.1	77.2
Mettick Creek	86.8	397.6	1060.5	1203.3	1535.3	50,805.3	7.7	44.0	83.8
Rice Creek	196.9	666.8	737.8	904.8	1173.3	44,536.9	6.7	56.3	93.5
Martin Creek	134.6	326.0	420.9	492.5	745.5	25,735.5	3.9	44.0	80.3
Russell Brook	106.4	353.1	597.1	928.4	1177.1	37,463.9	5.7	54.3	107.5
Inland Subbasin	2,581.3 (22.1%)	5,888.5 (50.4%)	8,426.1 (72.2%)	9,527.6 (81.6%)	11,676.2 (100.0%)	462,849.8	69.8	56.2	89.3

GMA 2001a

GMA (2001) estimated that sediment production from skid roads across the subbasin was small (Table 214). The analysis suggested a peak in surface erosion at the time of high harvest rates using high-density tractor logging methods from 1953-1978. Surface erosion from 1989 to 2000 was highest in the South Daugherty Creek PW and lowest in the Chamberlain Creek PW.

Table 214. Summary of surface erosion estimates from harvest areas by study period in the Inland Subbasin.

PW	1937-1952 TOTAL (Tons)	1953-1965 TOTAL (Tons)	1966-1978 TOTAL (Tons)	1979-1988 TOTAL (Tons)	1989-2000 TOTAL (Tons)	1937-2000 TOTAL BY PW OR SW (Tons)
Inland Subbasin	**20,816.0**	**39,005.9**	**72,641.3**	**17,742.8**	**9,243.9**	**159,449.0**
Upper North Fork Big River	2,291.4	3,464.3	4,110.3	476.3	1,034.3	11,376.6
James Creek	944.5	10,795.0	5,084.7	765.9	296.3	17,886.5
Chamberlain Creek	872.2	5,393.8	17,528.7	58.9	1.0	23,854.5
East Branch North Fork Big	1,978.0	259.7	12,594.2	387.5	1,112.8	16,332.3
Lower North Fork Big River	2,306.0	1,862.5	6,874.8	1.3	453.0	11,497.6
Leonaro Lake	230.8	402.9	0.0	45.0	125.8	804.4
Dark Gulch	3,486.2	3,857.0	210.4	158.1	560.4	8,272.2
South Daugherty Creek	2,094.0	3,812.6	3,887.6	868.8	1,527.6	12,190.5
Mettick Creek	2,196.3	3,072.7	9,461.2	5,522.9	376.4	20,629.40
Rice Creek	1,213.1	2,486.0	641.7	603.6	1,396.3	6,340.7
Martin Creek	1,413.8	681.5	4,967.9	753.0	1,450.8	9,267.0
Russell Brook	1,789.5	2,917.9	7,279.8	8,101.7	909.2	20,998.1

GMA 2001a

As can be seen in Figure 143, estimates of surface erosion from roads and timber harvest areas (including skid trails) indicate that both exceed the TMDL load allocation for surface erosion. Surface erosion related to roads, in particular, 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.

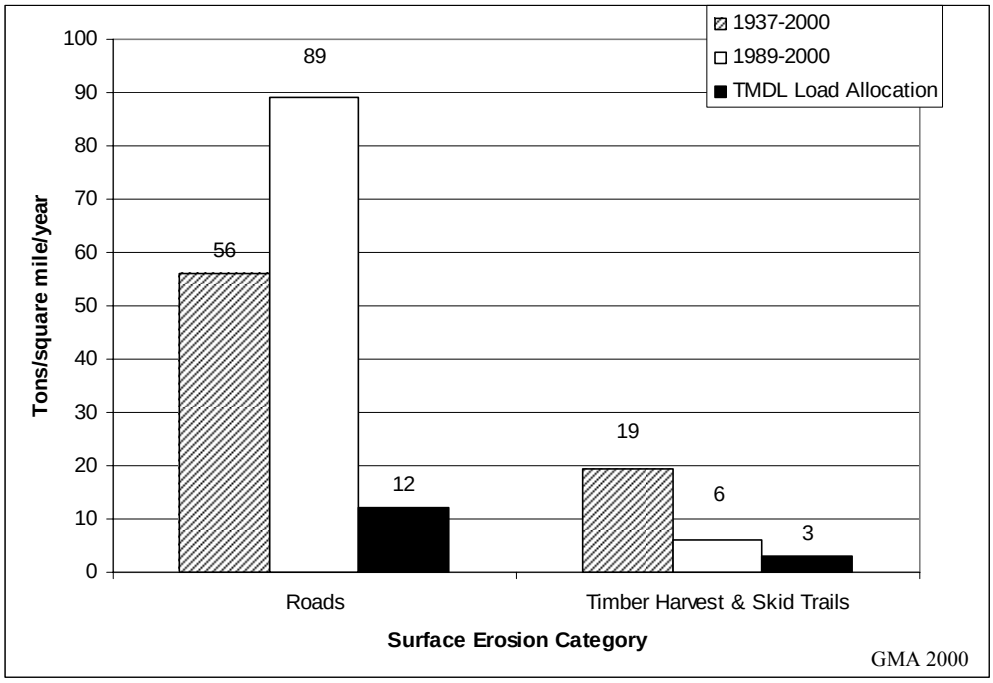


Figure 143. Surface erosion rate vs. TMDL load allocations.

Roads within MRC's ownership in the Inland Subbasin were estimated to generate 310 tons/square mile/year of sediment from road associated surface and point erosion (MRC 2003) (Table 215). The highest amounts of sediment generated are in the South Daugherty and Mettick Creek PWs. The highest sediment erosion rates are in the Russell Brook, East Branch North Fork Big River, and South Daugherty PWs. These PWs have higher road densities and a smaller amount of MRC owned land. Point source erosion was also high in these three PWs. The surface erosion rate was higher than the point source erosion rate in the Lower North Fork, Mettick Creek, and Rice Creek PWs.

Table 215. Road associated surface and point source erosion estimates by PW for MRC ownership.

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)
East Branch North Fork	1,580	2,527	400	165	235
Lower North Fork	930	2,170	270	235	35
Mettick Creek	6,140	10,294	200	130	70
Rice Creek	440	924	300	290	20
Russell Brook	4,050	5,926	440	170	270
South Daugherty	4,390	7,242	390	160	230
Total	**14,530**	**29,083**	**310**	**160**	**150**

No data for MRC ownership in Dark Gulch (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 216 and Figure 144). 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. There were peaks in sediment delivery rate from skid trails in the Lower North Fork and Rice Creek PWs in the 1970s, and in the East Branch North Fork Big River, Russell Brook, Mettick Creek, and South Daugherty PWs. Skid trail delivery rates diminished across the MRC ownership in the 1990s with less harvest activity and stricter regulations.

Table 216. Skid trail use in acres for MRC ownership in the Inland Subbasin (MRC 2003).

PW	1940s	1950s	1960s	1970s	1980s	1990s
Lower North Fork Big River	1,038	618	208	1,137	793	57
East Branch North Fork Big River	38	0	1,574	1,538	2,036	390
Russell Brook	94	22	1,050	2,756	3,360	317
Rice Creek	0	0	0	139	89	99
Dark Gulch	326	460	0	283	268	0
Mettick Creek	829	845	3,420	5,171	5,490	1,449
South Daugherty	991	1,500	2,120	2,203	3,968	463

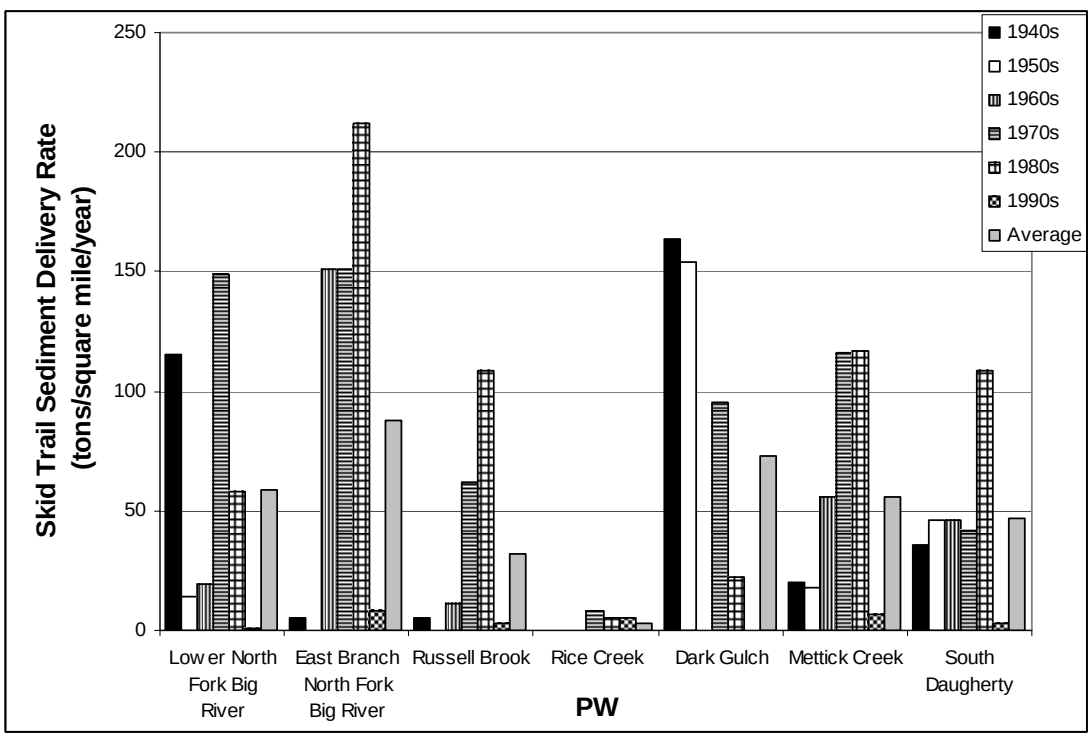


Figure 144. Skid trail sediment delivery estimates for MRC ownership in the Inland Subbasin (MRC 2003).

MRC (2003) estimated the total sediment inputs for their ownership in the Inland Subbasin. The average estimated sediment input for the past 30 years was 836 tons/square mile/year (Table 217). Road associated erosion was the dominant sediment contributing process in the MRC ownership in the Inland Subbasin, making

up 67% of the sediment input. When skid trail erosion is included in road-associated erosion totals the percentage increases to 81%.

Table 217. Estimated sediment inputs by input type for the MRC ownership averaged over 30 years, 1970-2000.

PW	Road Surface Erosion	Road Point Source Erosion	Road Associated Mass wasting	Hillslope Mass wasting	Skid Trail Erosion	Total
East Branch North Fork	165	235	100	140	150	790
Rice Creek	290	20	70	230	10	620
Lower North Fork	235	35	205	240	75	790
Mettick Creek	130	70	320	190	170	880
Dark Gulch	n/a	n/a	20	110	50	180
Russell Brook	170	270	200	90	90	820
South Daugherty	160	230	270	150	90	900
Total	**158**	**157**	**243**	**159**	**118**	**836**

MRC 2003

Road Crossings

Today there are 127 miles of roads in the watercourse buffer zone (Table 218). Seventy two percent were built before 1979 (Table 219). While the data show 98 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 more than 16 streams crossings per square mile in this subbasin (Table 220).

Table 218. Length of truck roads in near proximity to watercourse in miles by watercourse classification and road classification.

Watercourse Class	Total Length in Miles				Length in Miles per Sq Mile			
Inland Subbasin	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
w/in 150' of FPR Class I or USGS Perennial	57.3	6.8	15	79	0.4	0.1	0.1	0.6
w/in 75' of FPR Class II or USGS Intermittent	30.6	0.4	4.3	35.3	0.2	0.0	0.0	0.3
w/in 25' of FPR Class III	10.3	0.5	1.7	12.4	0.1	0.0	0.0	0.1
Total	**98.1**	**7.7**	**20.9**	**126.9**	**0.8**	**0.1**	**0.2**	**1.0**

Table 219. Length of truck roads in near proximity to watercourse in miles by period of construction and road classification.

Period	Total Length in Miles				Length in Miles per Sq Mile			
Inland Subbasin	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
1937 - 1952	9.5	6.4	3.4	19.4	0.1	0.0	0.0	0.1
1953 - 1965	35.1	1.3	8.7	45	0.3	0.0	0.1	0.3
1966 - 1978	22.6	0	4.6	27.2	0.2	0.0	0.0	0.2
1979 - 1988	13.2	0	2.8	15.8	0.1	0.0	0.0	0.1
1989 - 2000	12.7	0	1.2	13.9	0.1	0.0	0.0	0.1
Total	**64.2**	**6.1**	**13.1**	**83.6**	**0.5**	**0.0**	**0.1**	**0.6**

Table 220. Number of watercourse truck road crossings by watercourse and road classification.

Watercourse Class Inland Subbasin	Total Crossings				Crossings per Sq Mile			
	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
FPR Class I or CFF Perennial	193	10	36	239	1.5	0.1	0.3	1.8
FPR Class II or CFF Intermittent	460	16	81	557	3.5	0.1	0.6	4.3
FPR Class III	1087	52	206	1345	8.3	0.4	1.6	10.3
Total	**1740**	**78**	**323**	**2141**	**13.3**	**0.6**	**2.5**	**16.4**

Fluvial Erosion

GMA (2001a) estimates of bank erosion and small streamside mass wasting (Table 221) found little sediment from these sources.

Table 221. Bank erosion and small streamside mass wasting in the Inland Subbasin.

Planning Watershed	Bank Erosion and Small Streamside Mass Wasting		Total (Tons/Year)
	Class 1 (Tons/Year)	Class 2 (Tons/Year)	
Inland Subbasin	3,430	5,146	8,576
Upper Mainstem Big River	324	554	877
Martin Creek	168	454	623
Lower Mainstem Big River	292	445	736
Upper North Fork Big River	214	277	491
James Creek	193	273	466
Chamberlain Creek	266	785	1,051
East Branch North Fork Big	223	221	445
Lower North Fork Big River	334	184	518
Upper South Fork Big River	142	443	586
Middle South Fork Big River	277	397	674
Daugherty Creek	376	443	819
Lower South Fork Big River	620	669	1,289

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

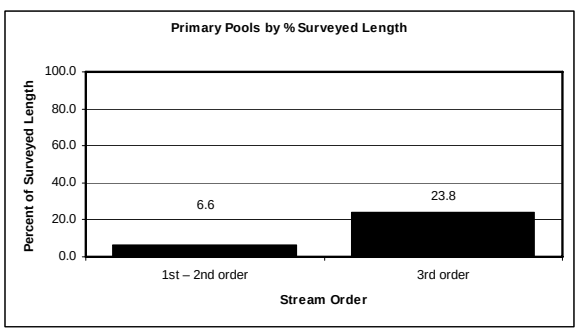


Figure 145. Primary Pools in the Inland Subbasin.

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 Inland Subbasin is generally below target values for salmonids, and appears to be less suitable in lower order streams than in higher order streams.

Spawning Gravel Quality

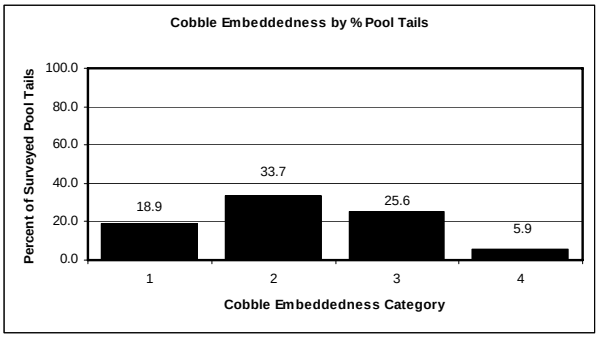


Figure 146. Cobble Embeddedness in the Inland Subbasin.

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: Just over one half of the surveyed stream lengths within the Inland Subbasin have cobble embeddedness in categories 1 and 2, which meets spawning gravel target values for salmonids.

Shade Canopy

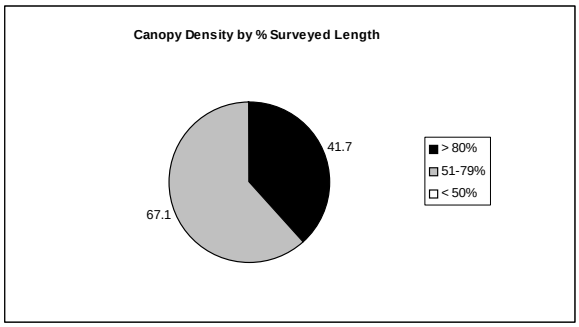


Figure 147. Canopy Density in the Inland Subbasin.

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 85% is fully suitable.

Comments: All of the surveyed stream lengths within the Inland Subbasin have canopy densities greater than 50% and over 40% of the surveyed lengths have canopy densities greater than 80%. This is above the canopy density target values for salmonids.

Fish Passage

Table 222. Salmonid habitat artificially obstructed for fish passage (N=3 Culverts).

Feature/Function		Significance	Comments
Type of Barrier	% of Estimated Historic Coho Salmon Habitat Currently Inaccessible Due to Artificial Passage Barriers	Free movement in well-connected streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity.	The Inland Subbasin had three streams crossings where fish passage was being artificially barred. All of these barriers were total passage barriers. Two of them were modified to improve fish passage and currently only 0.9% of the estimated historic coho salmon distribution is blocked.
All Barriers	0.9		
Partial and Temporary Barriers	0.0		
Total Barriers	0.9	Partial barriers exclude certain species and lifestages from portions of a watershed and temporary barriers delay salmonid movement beyond the barrier for some period of time. Total barriers exclude all species from portions of a watershed.	

1998-2000 Ross Taylor and Associates Inventories and Fish Passage Evaluations of Culverts within the Humboldt County and the Coastal Mendocino County Road Systems

Table 223. Juvenile salmonid passage in the Inland Subbasin (1993-2002 CDFG Stream Surveys, CDFG Appendix).

Feature/Function		Significance	Comments
Juvenile Summer Passage	**Juvenile Winter Refugia**	Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems.	Dry channel recorded in the Inland Subbasin during stream surveys has the potential to disrupt the ability of juvenile salmonids to forage and escape predation in 12 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.
3.0 Miles of Surveyed Dry Channel	No Data		
2.8% of Surveyed Dry Channel			

Pool Shelter

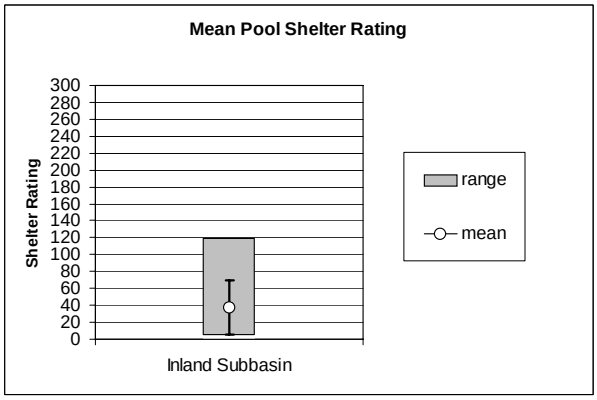


Figure 148. Pool shelter in the Inland Subbasin.

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 Inland Subbasin is 37.5. This is below the shelter target value for salmonids.

Large Woody Debris

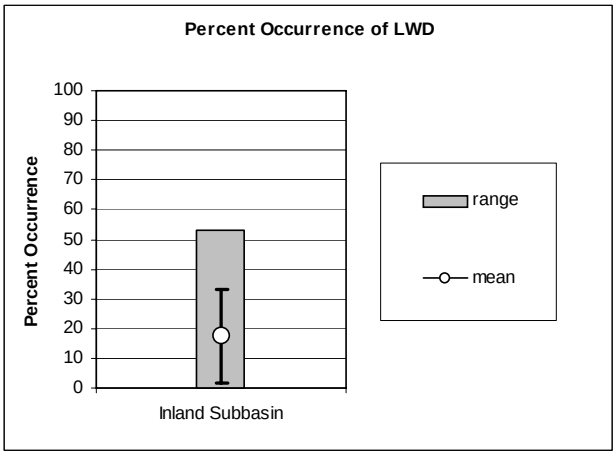


Figure 149. Large Woody Debris (LWD) in the Inland Subbasin.

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: This subbasin has the lowest average percent occurrence of large woody debris in surveyed streams of the Big River Subbasins. The dominant shelter type recorded in almost 32% of the stream reaches surveyed was boulders. LWD was the dominant shelter recorded in 19% of stream reaches surveyed.

Although instream habitat conditions for salmonids varied across the Inland Subbasin, several generalities can be made. Instream habitat conditions were generally good within this subbasin at the time of CDFG surveys. Canopy density levels were above 50% and cobble embeddedness was suitable for salmonids in over one-half of the surveyed stream lengths in the subbasin. 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 3.1 miles of surveyed stream (2.9% of the surveyed stream length) and the Inland Subbasin had the highest percentage of estimated historic coho habitat blocked by artificial barriers in the Big River Basin.

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 Inland Subbasin. Weighted average reach conditions on surveyed streams in the Inland Subbasin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 224, Figure 150). Suitable conditions exist for canopy across the subbasin except for James Creek; and for pool shelter in East Branch North Fork Big River, West Chamberlain Creek, Daugherty Creek, and Gates Creek. Suitable conditions exist for pool depth for North and South forks of Big River; and for embeddedness in ten creeks in the South Fork drainage. Unsuitable conditions exist for pool quality in all tributaries evaluated.

Six tributaries, North Fork Big River, Daugherty, Soda, Gates, Johnson (tributary to Gates Creek), and Snuffins creeks, had two years of data, 1993, 1995, or 1996 and 1997 or 2002. A comparison of the two years data shows an increase in the suitability of canopy and pool quality and a decline in the suitability of pool depth in North Fork Big River. The other five tributaries showed an increase in the suitability of pool quality, pool shelter, and cobble embeddedness. Suitability of canopy increased in Daugherty, Gates, and Johnson (tributary to Gates) creeks. Suitability of pool depth increased in Daugherty and Gates creeks.

Table 224. EMDS Anadromous Reach Condition Model results for the Inland Subbasin.

Stream		Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Inland Subbasin		-	U	++	U	-	--	--	--	-
North Fork Big River	1996	-	U	-	U	-	-	+	--	-
	1997	-	U	+	U	-	--	--	--	-
East Branch of the North Fork Big River		-	U	+	U	-	-	---	++	--
Chamberlain Creek		-	U	+	U	-	---	---	---	-
Water Gulch		-	U	+++	U	-	--	--	-	-
Water Gulch Tributary		-	U	+++	U	-	---	---	---	-
Park Gulch		-	U	+++	U	-	--	---	-	-
West Chamberlain Creek		-	U	+++	U	-	-	---	+	--
Gulch Sixteen		-	U	+++	U	-	--	---	--	-
Gulch Sixteen Tributary		-	U	+++	U	-	--	---	--	-
Arvola Gulch		-	U	++	U	-	--	---	--	--
Lost Lake Creek		-	U	+++	U	-	---	---	---	-
Soda Gulch		-	U	+++	U	-	---	---	---	---
James Creek		-	U	-	U	-	---	---	---	-
North Fork James Creek		-	U	++	U	-	--	---	-	-
South Fork Big River		-	U	++	U	-	-	+	--	+
Biggs Gulch		-	U	+++	U	-	---	---	---	+
Ramon Creek		-	U	+	U	-	--	---	--	-
North Fork Ramon Creek		-	U	+	U	-	--	---	--	++
Mettick Creek		-	U	+	U	-	---	---	---	+
Poverty Gulch		-	U	+	U	-	--	---	--	U
Anderson Gulch		-	U	+++	U	-	---	---	---	--
Boardman Gulch		-	U	+++	U	-	--	---	--	---
Halfway House Gulch		-	U	++	U	-	---	---	---	+++
Daugherty Creek	1993	-	U	-	U	-	--	---	--	--
	2002	-	U	++	U	-	-	--	+	+
Soda Creek	1995	-	U	++	U	-	---	---	---	-
	2002	-	U	++	U	-	--	---	--	++
Gates Creek	1993	-	U	++	U	-	---	---	---	--
	2002	-	U	+++	U	-	-	--	++	+
Johnson Creek (Gates Creek Tributary)	1993	-	U	++	U	-	---	---	---	---
	2002	-	U	+++	U	-	--	---	--	-
Horse Thief Creek		-	U	+++	U	-	---	---	---	U

Stream		Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Snuffins Creek (2002)	1993	-	U	++	U	-	---	---	---	---
	2002	-	U	++	U	-	--	---	--	-
Johnson Creek		-	U	+	U	-	--	---	-	++
Dark Gulch		-	U	++	U	-	---	---	---	+
Montgomery Creek		-	U	++	U	-	---	---	---	--
South Fork Big River Tributary #1		-	U	+	U	-	--	---	--	-
South Fork Big River Tributary #2		-	U	++	U	-	--	---	--	--
Russell Brook		-	U	++	U	-	--	---	--	--
Martin Creek		-	U	++	U	-	---	---	---	-
Martin Creek Left Bank Tributary		-	U	+++	U	-	---	---	---	--
Martin Creek Right Bank Tributary #1		-	U	++	U	-	---	---	---	--
Martin Creek Right Bank Tributary #2		-	U	+++	U	-	--	---	--	---
Valentine Creek		-	U	++	U	-	---	---	---	-
Rice Creek		-	U	++	U	-	--	---	--	--

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

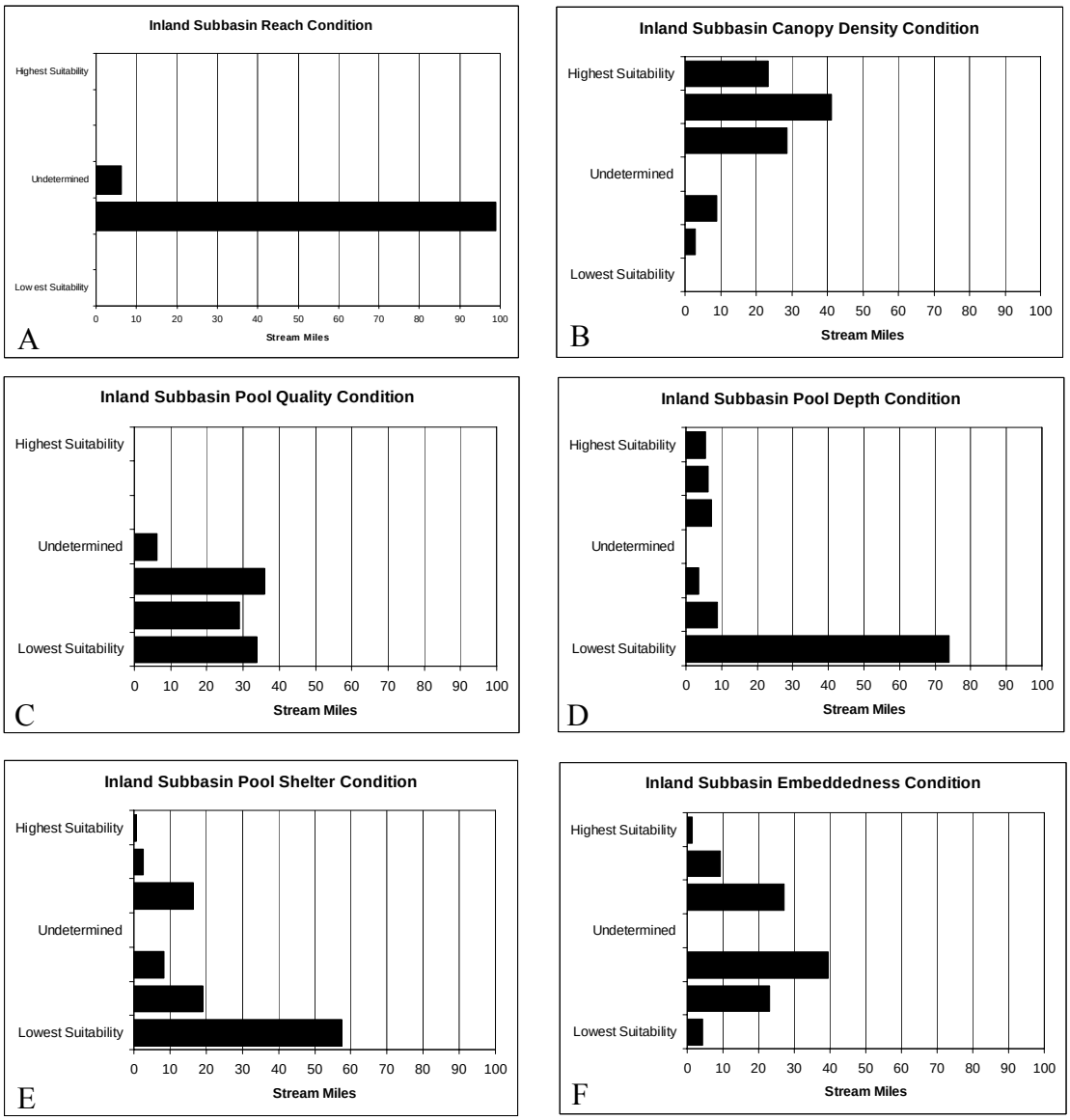


Figure 150. EMDS Reach Condition model results for the Inland Subbasin by surveyed stream miles.
In streams with multiples years of data, the most current year was used.
A. Overall reach condition. B. Canopy density. C. Pool quality. D. Pool depth. E. Pool shelter. F. Cobble embeddedness.

Analysis of Tributary Recommendations

CDFG inventoried 105.1 miles on 41 tributaries in the Inland Subbasin. A CDFG biologist selected and ranked recommendations for each of the inventoried streams (except for Poverty Gulch) based upon the results of these standard CDFG habitat inventories (Table 225). More details about the tributary recommendation process are given in the Big River Synthesis Section of the Basin Profile.

Table 225. Ranked tributary recommendations summary in the Inland Subbasin based on CDFG stream inventories.

Stream	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
North Fork Big River	12.0			2			1				
East Branch North Fork Big River	7.4	4	5	6	1	2	3				
Chamberlain Creek	5.1			2			1				
Water Gulch	1.9		2				1				
Water Gulch Tributary	0.4		2				1				
Park Gulch	1.0		2				1				
West Chamberlain Creek	3.5	3	4			1	2				
Gulch Sixteen	0.9		3			1	2				
Gulch Sixteen Tributary	0.4		3				2				1
Arvola Gulch	0.9	4	3		1		2		5		
Lost Lake Creek	0.9	3	4			1	2				
Soda Gulch	0.7		3				2		4		1
James Creek	4.4		2	4		3	1				
James Creek North Fork	2.4		3		1	4	2				
South Fork Big River Part 1	11.7	4	5	2	1	6	3		7		
South Fork Big River Part 2	8.8	2	3				4				1
Biggs Gulch	0.5	5				2		3	4		1
Ramon Creek	3.0	2		4		1			5		3
North Fork Ramon Creek	1.5	1	2			3			4		
Mettick Creek	1.0	1	2			3	4				
Anderson Gulch	0.5	1	2			3	4		5		
Boardman Gulch	1.3	1	2			3	4		5		6
Daugherty Creek	8.8			3		1	2				4
Soda Creek	1.7					1	2				
Gates Creek	2.7		1								
Johnson Creek (Gates Creek Tributary)	1.2	3				1	2				
Horse Thief Creek	0.1								1		
Snuffins Creek	1.3		3			1	2		4		
Johnson Creek	0.9	1		3	2	4	5		6		7
Dark Gulch	1.4		2	1	6	4			3		5
Montgomery Creek	0.7	1	2			3	4				5
South Fork Big River Tributary #1	1.1	2		1		3	4				5
South Fork Big River Tributary #2	0.6	2	3		1	4	5				
Russell Brook	4.1	1	2			4	6		3	5	
Martin Creek	3.7	1	2			4	5		3	6	7
Martin Creek Left Bank Tributary	0.6	1	2			3	4		5		
Martin Creek Right Bank Tributary #1	1.5	1				2	3		4		5
Martin Creek Right Bank Tributary #2	0.6	1				2	3		4		5
Valentine Creek	1.8	2	3		1	4	5		6		7
Rice Creek	1.8	2	3		1	4	5		6		7

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 Inland 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 226). When examining recommendation categories by number of tributaries, the most important recommendation category in the Inland Subbasin is Erosion/Sediment.

Table 226. Top three ranking recommendation categories by number of tributaries in the Inland Subbasin.

Target Issue	Related Table Categories	Count
Erosion / Sediment	Bank / Roads	44
Riparian / Water Temp	Canopy / Temp	15
Instream Habitat	Pool / Cover	41
Gravel / Substrate	Spawning Gravel / LDA	5
Other	Livestock / Barrier	5

However, comparing recommendation categories in the North Fork Subbasin by number of tributaries could be confounded by the differences in the number of stream miles surveyed on each tributary. Therefore, the number of stream miles in each subbasin assigned to the various recommendation categories was calculated (Figure 151). When examining recommendation categories by number of stream miles, the most important recommendation categories in the Inland Subbasin shift to Instream Habitat, Erosion/Sediment, and Riparian/Water Temp. These comprise the top tier of recommended improvement activity focus areas.

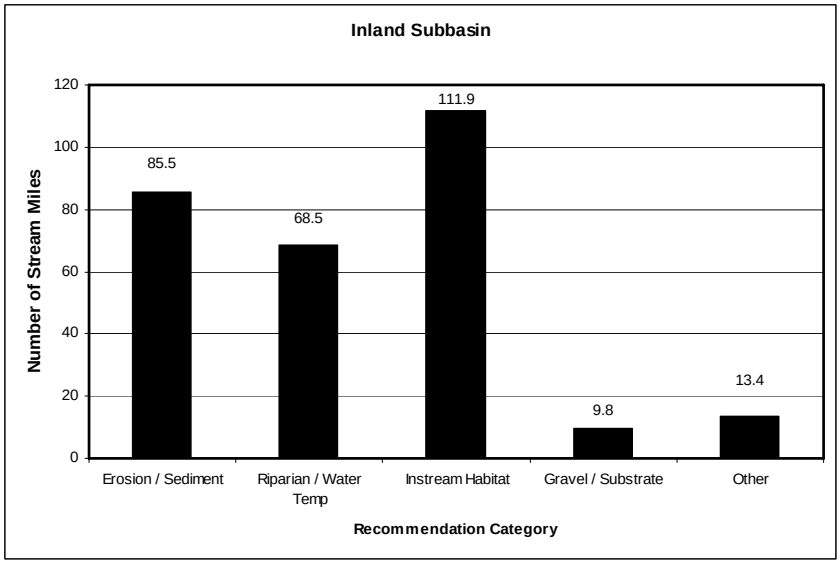


Figure 151. Recommendation categories by stream miles in the Inland Subbasin.

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

MRC Road Hazard Map

MRC classified the roads in their ownership into three erosion hazard classes (Figure 152). MRC aimed to identity current problems, consider reconstruction, and prioritize maintenance through this process. A brief summary of the erosion hazard classes is:

- 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.

MRC identified 23 high treatment immediacy point source erosion sites in their ownership in the Inland Subbasin (Table 227).

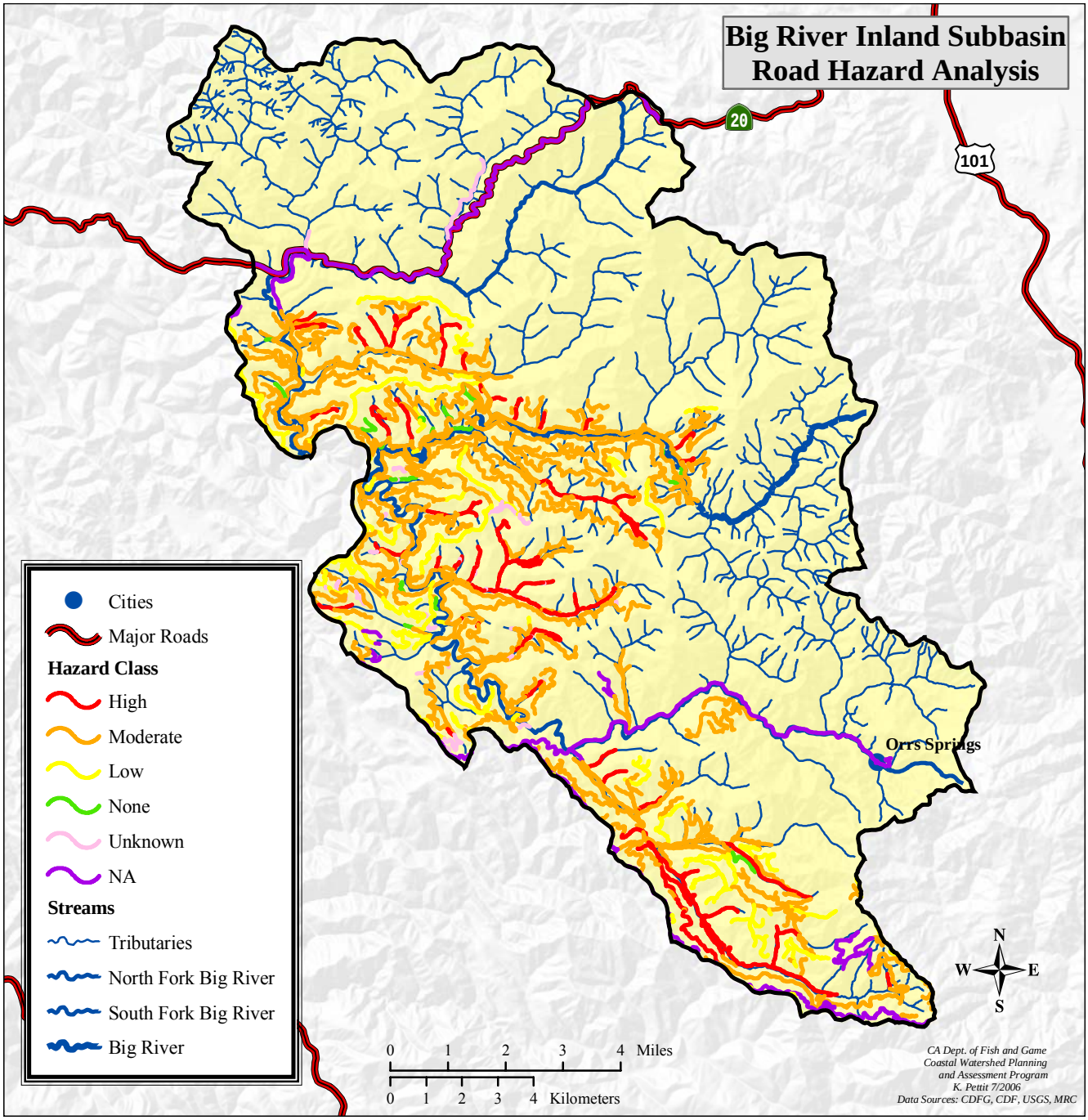


Figure 152. MRC roads erosion hazard classes in the Inland Subbasin.

Table 227. Select high treatment immediacy road sites within MRC ownership.

Site #	PW	Controllable Erosion (square yards)	Description
BL-1	Lower North Fork Big River	5	Plugged culvert
BE-1	East Branch North Fork Big River	40	Gully erosion
BE-2	East Branch North Fork Big River	21	Gully erosion
BE-3	East Branch North Fork Big River	4	Damaged culvert
BE-4	East Branch North Fork Big River	600	Diverted watercourse crossing
BE-5	East Branch North Fork Big River	28	Gully erosion
BE-6	East Branch North Fork Big River	100	Culvert failing
BE-7	East Branch North Fork Big River	138	Gully erosion
BR-1	Russell Brook	6	Gully erosion
BR-2	Russell Brook	5	Watercourse erosion
BM-1	Mettick Creek	1100	Fish barrier, failing culvert
BM-2	Mettick Creek	28	Road slide

Site #	PW	Controllable Erosion (square yards)	Description
BM-3	Mettick Creek	6	Gully erosion
BM-4	Mettick Creek	85	Plugged culvert
BM-5	Mettick Creek	18	Bridge crossing erosion
BM-6	Mettick Creek	26	Road slide
BM-7	Mettick Creek	27	Gully erosion
BM-8	Mettick Creek	32	Gully erosion
BS-1	South Daugherty	710	Road slide
BS-2	South Daugherty	65	Watercourse wash-out
BS-3	South Daugherty	85	Watercourse wash-out
BS-4	South Daugherty	105	Plugged culvert
BS-5	South Daugherty	58	Culvert starting to plug

MRC 2003

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Inland Subbasin (Table 228) 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 Inland 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 Inland Subbasin on surveyed streams are generally rated as medium potential refugia. North Fork Big River, East Branch North Fork Big River, Chamberlain Creek, Water Gulch, West Chamberlain Creek, Arvola Gulch, South Fork Big River, Daugherty Creek, and Gates Creek provide the best salmonid habitat in this subbasin. Stream Donkey, Quail, Soda, and Poverty gulches provide low quality refugia. Additionally, the North Fork and South Forks Big River and Daugherty Creek serve as critical contributing areas. The following refugia area rating table summarizes subbasin salmonid refugia conditions.

Table 228. Tributary Salmonid Refugia Area Ratings in the North Fork Subbasin.

Stream	Refugia Categories*:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
North Fork Big River		X				X	X
Stream Donkey Gulch				X			X
Dunlap Gulch			X				X
East Branch North Fork Big River		X					X
Quail Gulch				X			X
Bull Team Gulch		X					X
Frykman Gulch			X				X
Chamberlain Creek		X					X
Water Gulch		X					X
Water Gulch Tributary			X				X
Park Gulch				X			X
West Chamberlain Creek		X					X
Gulch Sixteen			X				X
Gulch Sixteen Tributary			X				X
Arvola Gulch		X					X
Lost Lake Creek			X				X
Soda Gulch				X			X
James Creek		X					X
James Creek North Fork			X				X
South Fork Big River		X				X	X
Biggs Gulch			X				X
Ramon Creek		X					X
North Fork Ramon Creek		X					X
Mettick Creek			X				X

Stream	Refugia Categories*:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Poverty Gulch				X			X
Anderson Gulch				X			X
Boardman Gulch			X				X
Halfway House Gulch			X				X
Daugherty Creek		X				X	X
Soda Creek		X					X
Gates Creek		X					X
Johnson Creek (Gates Creek Tributary)			X				X
Horse Thief Creek			X				X
Snuffins Creek		X					X
Johnson Creek			X				X
Dark Gulch		X					X
Montgomery Creek				X			X
South Fork Big River Tributary #1		X					X
South Fork Big River Tributary #2		X					X
Big River mainstem		X					X
Russell Brook		X					X
Pig Pen Gulch			X				X
Martin Creek		X					X
Martin Creek Left Bank Tributary			X				X
Martin Creek Right Bank Tributary #1		X					X
Martin Creek Right Bank Tributary #2			X				X
Valentine Creek		X					X
Rice Creek			X				X
Subbasin Rating			X				X

*Ratings in this table are done on a sliding scale from best to worst. See page 45 in the 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 Inland 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, and MRC presence surveys and surveys documented by NMFS since the 1960s, the distributions of coho salmon and steelhead trout do not appear to have changed;
- More reaches surveyed by CDFG and MRC since 1990 had steelhead trout that coho salmon, and reaches with coho always had steelhead as well;
- Twenty-two tributaries and the mainstem Big River had records of coho salmon and steelhead trout since 1990. Seventeen 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 indicated that a significant amount of fine sediment may be entering the North Fork Big River either from James Creek, or between James Creek and Chamberlain Creek. This could indicate unsuitable conditions for salmonids;
- Turbidity and suspended sediment samples in ten locations across the basin showed values ranging from 1.6 NTU in James Creek to 811 NTU in South Fork Big River below the confluence with Daugherty Creek.

Riparian/Water Temperature

- Water temperatures at sites on Donkey House, Frykman, Steam Donkey, Goddard, No Name, Water, Johnston, Wildhorse, and Arvola gulches; Chamberlain, James, West Chamberlain, North Fork Ramon, Montgomery, and Martin creeks; Russell Brook; and East Branch North Fork, and North Fork Big River are suitable for salmonids;
- Water temperatures at sites on the mainstem Big River, North and South Forks Big River, James, Gates, Martin, Ramon, and Daugherty creeks are unsuitable for salmonids;
- Sites that appear to have strong groundwater influences based on their thermographs include Goddard, Donkey House, No Name, Water, Frykman, Steam Donkey, Goddard Wildhorse, and Johnston gulches;
- Relatively large diurnal fluctuations in virtually all of the monitored sites throughout the South Fork drainage indicate that there is poor canopy and/or low flows. The only exceptions to this are the monitoring sites at Montgomery Woods Reserve, and the sites located in gulches that are apparently dominated by groundwater;
- Montgomery Creek was within the fully suitable range at approximately 60°F during all three years monitored. The maximum diurnal fluctuations varied between 4-5°F. This site is in an undisturbed location in the Montgomery Woods Reserve and is probably a good example of what can be achieved with adequate canopy in the warmer interior portion of the Big River Basin. It should be noted that much of the interior watershed is naturally grasslands, and could not reasonably be expected to achieve these water temperatures;
- It appears as though James Creek has a cooling effect on the North Fork Big River, Gates Creek provides some cooling effect to Daugherty Creek, Russell Brook contributes cooler water to the mainstem Big River, and Water Gulch and West Chamberlain Creek contribute some amount of cooling to Chamberlain Creek;
- Canopy cover was suitable for salmonids on all surveyed tributary reaches within this subbasin except for James Creek.

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 21 out of 41 surveyed tributaries;
- Areas of dry channel found in 31 surveyed tributaries during CDFG surveys may indicate fish passage problems.

Gravel Substrate

- Cobble embeddedness values in 36 out of 41 CDFG surveyed tributaries were unsuitable for salmonid spawning success. In addition, the MRC characterized spawning gravels as fair quality on 32 segments surveyed and good quality on four;
- Permeability sampling indicated low to moderate amounts of fine material at East Branch North Fork Big River, and significant fine material at Daugherty and Ramon creeks. This could indicate unsuitable conditions for salmonids in Daugherty and Ramon creeks.

Refugia Area

- Salmonid habitat conditions in this subbasin on surveyed streams are generally rated as medium potential refugia;
- North Fork Big River, East Branch North Fork Big River, Chamberlain Creek, Water Gulch, West Chamberlain Creek, Arvola Gulch, South Fork Big River, Daugherty Creek and Gates Creek provide the best salmonid refugia in this subbasin;
- The North Fork and South Forks Big River and Daugherty Creek serve as critical contributing areas.

Other

- Fish passage barriers exist on Dark Gulch, Johnson Creek, an Unnamed tributary to the South Fork of the Big River, Gulch Sixteen Tributary, and Soda Gulch;
- On February 27, 2001 a tanker truck containing approximately 7,000 gallons of used motor oil and diesel overturned on highway 20 and discharged numerous petroleum compounds into James Creek. However, this event was episodic and is in active cleanup. Because of the active cleanup and frequent verification monitoring, this spill is unlikely to have a sustained impact on fish and wildlife;
- A water quality sampling site on the South Fork Big River below the confluence with Daugherty Creek had specific conductance and total dissolved solids measurements that were relatively high compared to Basin Plan water quality objectives;
- Limited water quality data from Chamberlain Creek indicated that specific conductance was at or slightly below Basin Plan standards. Several other water quality parameters, including aluminum, copper, sodium, and zinc exceeded their respective criteria. Given the limited nature of this sampling effort and uncertainties about the method and exact location of sampling, it is suspected that this does not represent actual in-stream water quality but possibly water quality at some point in the drinking water system;
- Sodium was detected at concentrations above the water quality criteria at the North Fork Big River;
- Ammonia samples collected in the North Fork and South Forks Big River indicated that ammonia did not exceed the numeric criteria in either site;
- The two samples of boron and sodium in the South Fork Big River exceeded their numeric criteria. In the case of boron, both samples also equaled or exceeded the DHS action level (1,000 µg/l) and agricultural use criteria (700-750 µg/l).

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 mostly underlain by Franciscan Coastal Belt geology. This portion of the Franciscan complex is relatively stable compared to the mélange terrane of the Central Belt, which is found only in the upper parts of this subbasin. A small portion of Tertiary age sandstone is found in the Greenough Ridge - Montgomery Woods State Reserve area;
- This subbasin has a high percentage of area in higher slope classes;
- About 77% of the slides found across the Big River Basin and 80% of sediment delivered in the basin were in this subbasin. The South Daugherty Creek PW had the highest number of slides while the Chamberlain Creek PW had the highest volumes of sediment delivered;
- Redwood and Douglas fir forest has historically and continues to dominate this subbasin. Additional vegetation includes grass, oak, bay laurel, tan oak, madrone, and alder. Pre-European forests consisted of mostly large old-growth trees. Today, trees averaging 12-24 inches dbh cover 65% of the subbasin and trees averaging greater than 24-inch dbh cover 28%;
- The North Fork Big River was the studied major channel least impacted by stream disturbance features between 1984 and 2000. Only 8.3% of the blue-line stream length was impacted in 1984 and 7.6% in 2000;

- The South Fork Big River improved from nearly 19% of the blue-line stream length impacted in 1984 to less than 12% in 2000;
- Daugherty Creek showed the greatest improvement in channel conditions between 1984 and 2000. In 1984, nearly 24% of the length of Daugherty Creek was impacted, including parts of the headwaters channel with a gradient above 10%. This suggests recent disturbance, probably in 1983. In 2000 less than 6% of the blue-line channel was impacted, mostly in the lower half of the tributary in reaches having gradients below 4%.

How has land use affected these natural processes?

Findings and Conclusions:

- Twenty-four splash dams throughout the subbasin likely greatly accelerated erosion and widened the width of the channels in stream channels in this subbasin. Post-splash damming channels are deeply entrenched, cut down to bedrock in many places, lacking functional floodplains, and depleted of LWD. South Fork Big River is still heavily incised from flushing logs;
- Early splash damming and barrier removal projects in the JDSF starting in the 1950s cleared many stream channels of timber-related woody debris. The lack of instream complexity seen today likely results from these past practices;
- Appropriative water right permits exist for a total of about 8.5 acre-feet per year of water from the South Fork Big River or an unnamed tributary to the South Fork;
- Construction of near stream roads throughout this subbasin and railroads along the North Fork Big River 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;
- County culverts located on Dark Gulch, Johnson Creek, and an unnamed tributary to the South Fork of the Big River have been identified as total salmonid passage barriers by a Mendocino County roads study;
- Historic timber harvest activities reduced riparian canopy; however, canopy is currently suitable along most surveyed tributary reaches in this subbasin. Streams with canopy densities under 70% by length were Poverty Gulch, South Fork Tributary #1, James Creek, and North Fork Big River;
- As a result of timber harvest, the current landscape is comprised of smaller diameter forest stands than in pre-European times (66% 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, low summer stream flows, embedded spawning gravels, and artificial passage barriers.

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 James Creek, Chamberlain Creek, East Branch North Fork Big River, Montgomery Creek, and Russell Brook for thermal refugia from the warmer North and South Forks and mainstem Big River in the summer;

- Ensure that adequate streamside protection measures are used to provide shade canopy and reduce heat inputs to the North and South Forks Big River, mainstem Big River, and Daugherty Creek.

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 Water Gulch, Water Gulch tributary, Park Gulch, Gulch Sixteen, Gulch Sixteen Tributary, Arvola Gulch, Soda Gulch, James Creek, North Fork James Creek, South Fork Big River, North Fork Ramon Creek, Mettick Creek, Anderson Gulch, Boardman Gulch, Gates Creek, Snuffins Creek, Dark Gulch, Montgomery Creek, South Fork Big River Tributary #2, Russell Brook, Martin Creek, Martin Creek Left Bank Tributary, Valentine Creek, and Rice Creek have road sediment inventory and control as a top tier tributary recommendation;
- Sediment sources from eroding streambanks and adjacent hillslopes should be identified and treated to reduce sediment generation and delivery to creeks in the Chamberlain Creek PW, South Fork drainage, and the headwaters drainage.

Riparian and Instream Habitat Improvement Activities

- Consider adding pool enhancement elements (e.g. LWD) to increase the number of pools or deepen existing pools and add shelter complexity to all surveyed tributaries in the North Fork drainage, Daugherty, Soda, Johnson (tributary to Gates Creek), and Snuffins creeks, and the right bank tributaries of Martin Creek;
- Consider modifying debris accumulations in Horse thief Creek, Dark Gulch, Russell Brook, and Martin Creek to facilitate fish passage;
- 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 North Fork Big River, East Branch North Fork Big River, Chamberlain Creek, Water Gulch, West Chamberlain Creek, Arvola Gulch, South Fork Big River, Daugherty Creek and Gates Creek.

Education, Research, and Monitoring Activities

- Continue water temperature monitoring at current locations where high temperatures have been detected on the mainstem Big River, North and South Forks Big River, James, Gates, Martin, Ramon, and Daugherty creeks;
- Conduct a stream habitat survey of the mainstem Big River upstream from the confluence with North Fork Big River.

Subbasin Conclusions

The Inland Subbasin is the largest of the Big River Subbasins. Additionally, land use impacts in this subbasin occurred later in time than the other two subbasins due to its location further inland, away from easy ocean access. Much of this subbasin is owned and managed by the JDSF and large timber companies. Salmon and steelhead habitat conditions in the Inland Subbasin are generally degraded, but support some salmonid production. Salmonid populations are currently being limited by reduced habitat complexity, high water temperatures, low summer stream flows, embedded spawning gravels, and artificial passage barriers. However, historical accounts indicate that stream conditions were favorable for salmonid populations in the past.

There are many opportunities for improvements in stream conditions in this subbasin as well as a great need to restore areas of stream refugia. Surveys by landowners, water temperature monitoring, riparian canopy restoration, improvements to channel complexity such as additional LWD are examples of such opportunities. The stability and erosiveness of terrain should be considered before project implementation and appropriate BMPs should be followed to minimize erosion and sediment delivery to streams. Conditions beneficial to salmonids may be further enhanced in this subbasin through encouraging all motivated subbasin landowners to use good land stewardship practices and enlisting the aid and support of agency technology, experience, and funding opportunities.