Coastal Watershed Planning Assessment Program

Big River Basin Assessment

November 2006

State of California

Governor, Arnold Schwarzenegger

California Resources Agency

Secretary, Mike Chrisman

California Environmental Protection Agency

Secretary, Alan Lloyd

North Coast Watershed Assessment Program Participants

Contributing Agencies and Departments

Department of Fish and Game
Director, Loris "Ryan" Broddrick

State Water Resources Control Board
Chair, Art Baggett

Department of Forestry and Fire Protection
Director, Dale Gildert

North Coast Regional Water
Quality Control Board
Executive Officer, Catherine Kuhlman

Department of Water Resources
Director, Lester A. Snow

Department of Conservation
Interim Director, Debbie Sareeram

Big River Assessment Team

Assessment Manager

Scott Downie	California Department of Fish and Game

Fisheries:

Steve Cannata	California Department of Fish and Game
Beatrijs deWaard	Pacific States Marine Fisheries Commission
Cynthia LeDoux-Bloom	California Department of Fish and Game

Forestry and Land Use:

Rob Rutland	California Department of Forestry and Fire Protection

Water Quality:

Elmer Dudik	North Coast Regional Water Quality Control Board

Geology:

Karin W. Fresnel	Department of Conservation/California Geological Survey

Fluvial Geomorphology:

Dawn McGuire	Department of Conservation/California Geological Survey Currently Department of Fish and Game

Geographic Information System, Data Management, Ecological Management Decision System (EMDS)

Vikki Avara-Snider – GIS & Document Production	Pacific States Marine Fisheries Commission
Kimberly Pettit - GIS	Pacific States Marine Fisheries Commission
Steve Cannata - EMDS	California Department of Fish and Game
Chris Fischer - EMDS	California Department of Forestry and Fire Protection
Kevin Hunting - GIS	California Department of Fish and Game
Chris Keithley - EMDS	California Department of Forestry and Fire Protection
Richard Walker, Ph.D. - EMDS	California Department of Forestry and Fire Protection

Research:

John Richardson	Pacific States Marine Fisheries Commission

ACKNOWLEDGEMENTS

The Big River Assessment Team wishes to thank the following for their shared valuable data, assistance, and time: California State Parks, Mendocino Redwood Company, Hawthorne Timber Company, the California Geological Survey, Graham Matthews and Associates, Doug Albin, Scott Monday, Scott Harris, and Dave Wright. We are also very grateful to the numerous private landowners who granted team members access to collect data.

Suggested Citation:

Downie, S., B. deWaard, E. Dudik, D. McGuire, and R. Rutland. 2006. Big River Basin Assessment Report. North Coast Watershed Assessment Program. California Resources Agency, and California Environmental Protection Agency, Sacramento, California.

NCWAP Basin Assessment Products

Reports

Main products are basin level assessment reports for each subject watershed. These reports consist of an integrative synthesis report and a number of discipline-oriented appendices. A limited number of these synthesis reports and appendices were produced in printed media for program cooperators and partners, constituent groups, and agencies. Printed reports were also distributed to most major libraries. Printed documents are not currently available to the public; however, the entire synthesis report document, including appendices and maps, is available on a compact disk in PDF format or via the website www.coastalwatersheds.ca.gov. Basin assessment reports are currently available for the Gualala, Mattole, Albion, and Big River basins. CDs containing the reports, appendices, and maps may be requested from:

California Department of Fish and Game
Coastal Watershed Planning and Assessment Program
1487 Sandy Prairie Court, Ste. A
Fortuna, CA 95540
707.725.1070

Klamath Resource Information System CDs and Website

The Institute for Fisheries Resources (IFR) has produced Klamath Resource Information System (KRIS) projects for several North Coast watersheds. KRIS is a custom software program capable of managing watershed data sets, tables, charts, photos, and maps. The current KRIS products are available via the IFR website (www.krisweb.com), or on CD from:

Department of Forestry and Fire Protection
Fire and Resource Assessment Program
PO Box 944246
Sacramento, CA 94244-2460
(916) 327-3939
frap@fire.ca.gov

Maps of Landslides and Relative Landslide Potential

To date, the California Geological Survey has produced maps and GIS coverage of landslides and relative landslide potential on the Mattole, Gualala, and Big rivers, and Redwood Creek basins. To order map sets contact one of the California Geological Survey offices:

Publications Sales-Sacramento
(916) 445-6199 fax: (916)324-5644

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Data sets and GIS Products

A number of data sets and GIS products have been produced as a part of this work. Some of these products are available at www.coastalwatersheds.ca.gov

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Big River Basin Profile and Synthesis

The Big River Mill from Freundt residence, 1863.
Courtesy of the Bancroft Library, University of California, Berkeley, photographed by Carleton E. Watkins

Named for the giant redwood trees that used to line its banks, the Big River drains a 181.1 square mile watershed located in the northern California Coast Range in western Mendocino County, entering the Pacific Ocean at the town of Mendocino, about 10 miles south of Fort Bragg. The Big River Basin extends 24 miles to the east, to within three miles of Willits and Highway 101. It drains primarily from east to west, sharing ridges with the Noyo River and Caspar Creek basins to the north and the Albion and Navarro river basins to the south. Elevations within the Big River Basin range from sea level at the basin outlet to Irene Peak at 2,836 feet, five miles south-southwest of Willits in the east end of the Martin Creek Planning Watershed, Inland Subbasin.

The basin’s topography is diverse along its length, varying from flat estuarine environments and uplifted marine terraces to rugged mountains with high relief in the eastern portion. It is characterized by narrow ridgelines separated by deeply incised inner gorges of the major river channels and streams draining the watershed.

The western end of the drainage is distinguished by an eight mile long estuary laden with mudflats that become narrow floodplains further upriver and occupy a relatively narrow inner gorge. In contrast to most estuaries in the Pacific Northwest region, which are generally lagoonal or semi-enclosed and isolated by sand spits or bars; the Big River Estuary is long and narrow. A sand bar at the mouth partially restricts the connection to the sea at low flow periods. Tidal influence extends upward from the mouth three miles in the winter and as far as eight miles during the highest spring tides making the Big River Estuary one of the longest estuaries in northern California (Warrick and Wilcox 1981). Several freshwater marshes are found upriver, hidden from the estuary by the surrounding forest.

Inland areas of the basin are characterized by second growth forest, with some grasslands in the southeast margins. Logging of the basin started in the 1860s near the mouth and gradually moved eastward. Early logging included heavy use of splash dams, effects of which can still be seen today. Most of the basin is currently owned by large timber companies and managed for timber harvest, though the state owns some sections, and there are smaller ownerships as well.

The Big River is listed on the National Rivers Inventory, a list of potential wild, scenic, and recreational river areas within the United States maintained by the National Park Service. A section of river may be listed on the inventory if it is free-flowing and has one or more *outstandingly remarkable values*. The Big River was listed in 1982 with five outstandingly remarkable values: scenery, recreation, fish, wildlife, and history. Of the 209 rivers and river segments listed for California in 2004, only 15 had five or more outstandingly remarkable values (NPS 2004).

The basin supports runs of coho salmon and steelhead trout. Chinook salmon (*O. tshawytscha*) have been reported occasionally, but there is no significant run. Historical accounts indicate that salmon were plentiful and that salmon fishing was a common activity. However, agency reports starting in the 1950s indicate that salmonid populations were depleted and in decline. In recent years, efforts have been underway to recover salmonid stocks of the Big River Basin. For example, local residents and conservation groups recently organized and purchased a 7,342-acre parcel at the mouth of Big River from the Hawthorne Timber Company and gave it to DPR to be managed for conservation and recreation.

Subbasin Scale

For analysis and organization, the NCWAP divided the Big River Basin into three subbasins (Coastal, Middle, and Inland) comprised of a total of 16 CalWater 2.2.1 planning watersheds (Figure 10, Figure 11, Table 12). The subbasins were designated based on several attributes, including geography, geology, climate patterns, and land use. The Middle Subbasin is the smallest subbasin, at 11,424 acres and one planning watershed; the Inland Subbasin is the largest, with 83,682 acres and ten planning watersheds.

- The Coastal Subbasin is 32 square miles in area and contains the entire basin downstream of the confluence of Peterson Gulch. This subbasin contains the estuary, which is the longest undeveloped estuary in Northern California (Warrick and Wilcox 1981). Much of the land in this subbasin was recently acquired by DPR. The town of Mendocino lies just north of the river mouth, outside of the basin.
- The Middle Subbasin includes the area of the mainstem Big River just above its confluence with Peterson Gulch up until its confluence with the South Fork Big River, not including the North Fork Big River. The Middle Subbasin is the smallest of the three Big River Subbasins at 17.9 square miles. Most of the subbasin is owned by Hawthorne Timber Company and MRC.
- The Inland Subbasin includes the watershed area of the North Fork Big River, South Fork Big River, and the mainstem Big River above the confluence with the South Fork Big River. These drainages are referred to as the North Fork, South Fork, and headwaters drainages. This subbasin encompasses 130.8 square miles. Most of the subbasin is owned by the MRC, Strategic Timber Trust, and the Jackson State Demonstration Forest (JDSF) and is managed for timber production and recreation. 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.

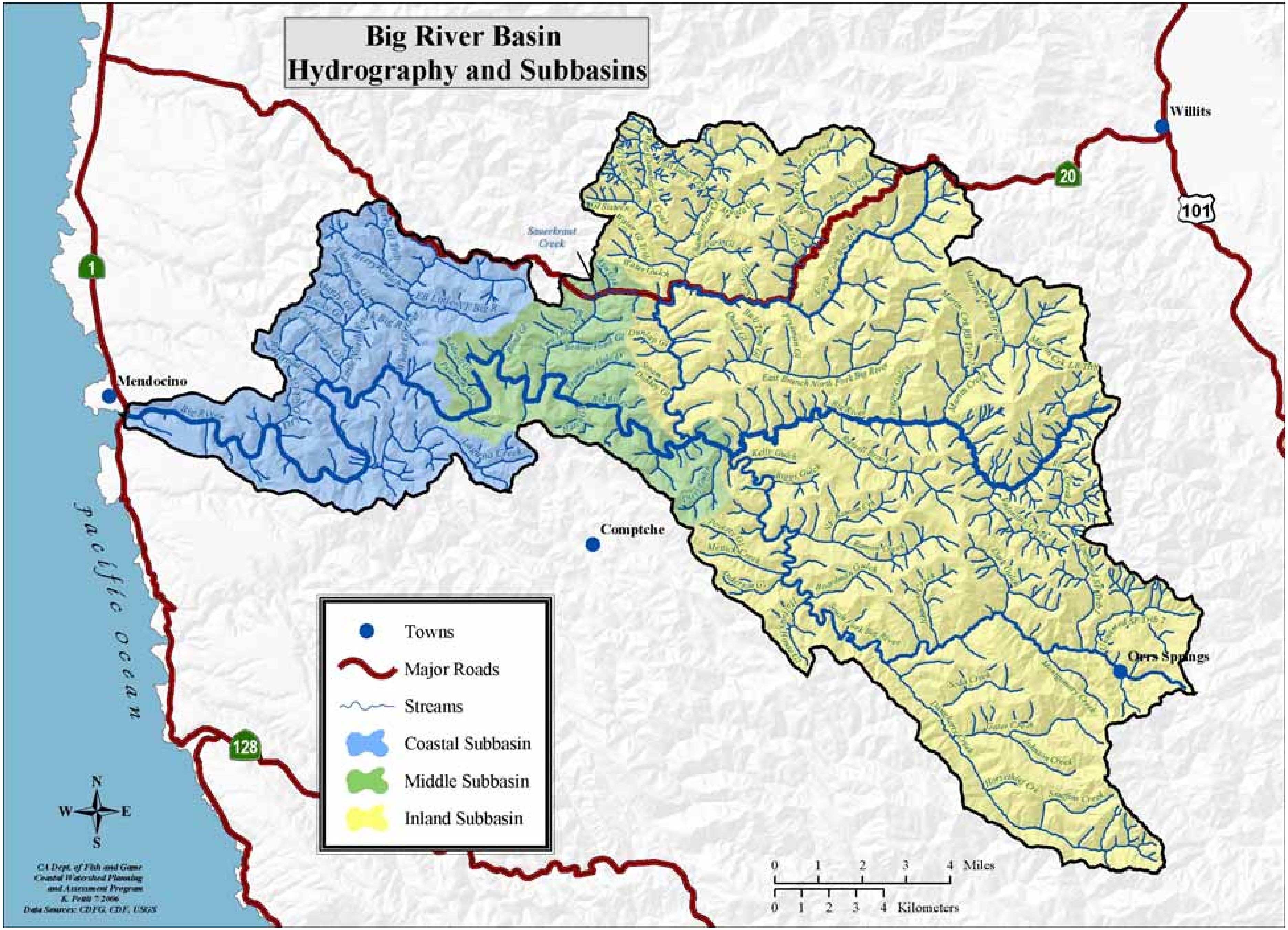


Figure 10. Big River Basin, subbasins, and streams.

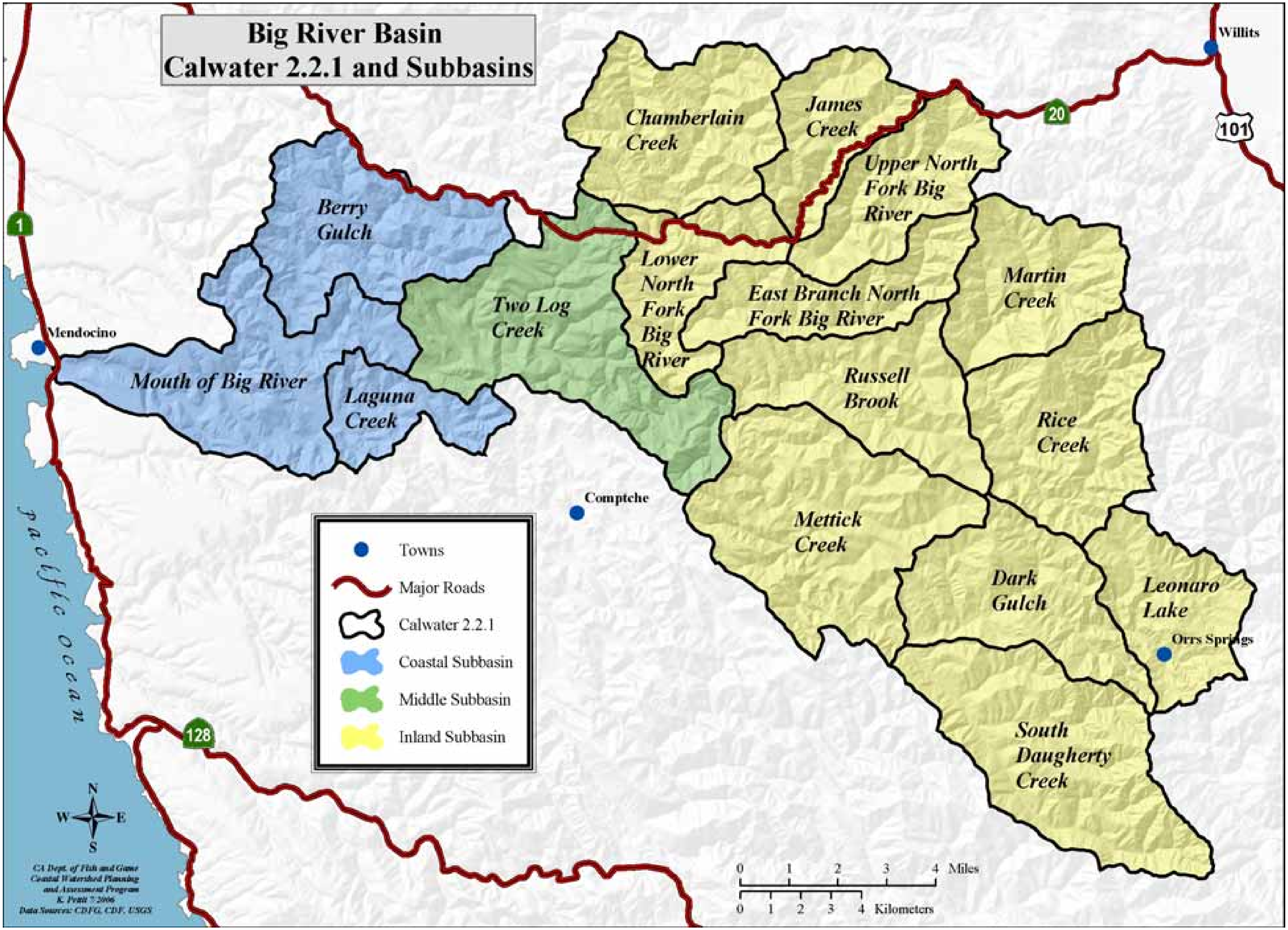


Figure 11. CalWater 2.2.1 planning watersheds, Big River Basin subbasins.

Table 12. Big River Basin and subbasin characteristics.

Attribute	Coastal	Middle	Inland	Total/Average
Square Miles	32.49	17.86	130.853	181.2
Acreage, Total	20,793	11,432	83,746	115,972
Private Land (Acres)	6,803	10,905	66,837	84,545
Public Land (Acres)	13,990	528	16,909	31,427
Low Elevation (Feet)	0	~40	~200	0
High Elevation (Feet)	1235	~1560	2836	2836
Predominant Geology	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex, small area of Tertiary Sandstone in southeast, and Central Belt rocks in central area of eastern margin	Coastal Belt Franciscan Complex
Rainfall (Inches)	~40-55	~55-65	~45-65	~40-65
Miles of Blue Line Stream	42.4	26.0	160.6	228.5
Predominant Vegetation	Redwood-Douglas-fir	Redwood-Douglas-fir	Redwood-Douglas-fir Douglas-fir White, Black, or Live Oak Bay Laurel	Redwood-Douglas-fir Douglas-fir
Principle Communities	Near Mendocino		Orr Springs	
Predominant Land Use	Public Land Recreation Timber Harvest	Timber Harvest	Timber Harvest Grazing Recreation	Timber Harvest Public Land
Fish Habitat Available	Spawning Rearing Migration Corridor	Spawning Rearing Migration Corridor	Spawning Rearing Migration Corridor	Spawning Rearing Migration Corridor
Salmonid Species	Coho salmon Steelhead trout	Coho salmon Steelhead trout	Coho salmon Steelhead trout	Coho salmon Steelhead trout

Climate

The Mediterranean climate of the Big River Basin is characterized by a pattern of low intensity rainfall in the winter and cool, dry summers with coastal fog. Temperatures range from 20 to 100°F. Mean annual precipitation for the basin is about 50 inches and varies from about 38 inches at Fort Bragg near the western margin of the basin, to over 80 inches at the northeastern edges (Figure 13). Rainfall maps for the basin indicate that although annual precipitation generally increases as one moves towards higher elevations along the north and east parts of the basin, there are areas in the Inland Subbasin that are considerably drier (GMA 2001a). The North Fork drainage is noticeably wetter than either the South Fork or headwaters drainages. Precipitation is highly seasonal, with more than 97% falling between October and May. Snowfall occurs occasionally in the higher elevations of the basin but rarely accumulates. Snow does not have any appreciable effect on the basin's hydrology.

There are no long-term precipitation stations located in the Big River Basin and relatively few nearby. There are or were six precipitation gages located near the basin (Table 13). Only two of these gages were in operation longer then twenty years: the Fort Bragg gage, located at an elevation of 80 feet and the Willits NE gage, at an elevation of 1,925 feet. An additional gage was installed at McGuire's Pond on Highway 20 in 1995 (Station MCGC1), but these data were not available for this assessment.

Table 13. Long-term precipitation gages near the Big River Basin.

Station Name	Station Number	Period of Record	Annual Precipitation					Annual 24-Hour Maximum Precipitation				
			Average (Inches)	Maximum (Inches)	Year	Minimum (Inches)	Year	Average (Inches)	Maximum (Inches)	Year	Minimum (Inches)	Year
Willits 1 NE	F60 9685 00	1942-present*	48.13	78.71	1995	20.21	1976	4.11	7.92	1955	2.10	1999
Albion 1 NE	F 80 0077 50	1981-1993	39.04	67.60	1983	23.17	1991	NA**	NA	NA	NA	NA
Fort Bragg 5 N	F 80 3161 00	1989 - present	45.10	77.31	1998	24.47	1991	2.89	3.84	1995	1.48	1992
Fort Bragg ***	F80 3161 00	1896-1988	37.98	62.11	1983	16.56	1924	2.45	4.15	1953	1.03	1977
Russian Gulch State Park	F 80 7608 18	1988-present	41.91	71.45	1998	25.00	1991	2.87	4.43	1998	1.40	1988
Willits Munson	F 60 9685 00	1974-present ****	50.58	85.89	1983	18.84	1977	3.41	6.50	1974	1.21	1977

*Gage inactive 1982-1985, 1988, and 1989 ** NA - Not available *** No record for 24-hour precipitation 1901-1909, 1914, 1917, 1936, and 1940-1947
****Gage inactive in 1995

The mean annual precipitation at the Fort Bragg gage for the 92-year record was 37.98 inches (Figure 12). The wettest year was 1983 with 62.11 inches of rainfall, though a newer gage in Fort Bragg at a different location recorded 77.31 inches of rainfall in 1998. The driest years were 1924 and 1977 with 16.56 inches of rainfall. The mean annual precipitation at the Willits 1 NE gage for the 59-year record is 48.31 inches (Figure 14). The wettest year was 1995 with 78.71 inches of rainfall and the driest year was 1976 with 20.21 inches of rainfall.

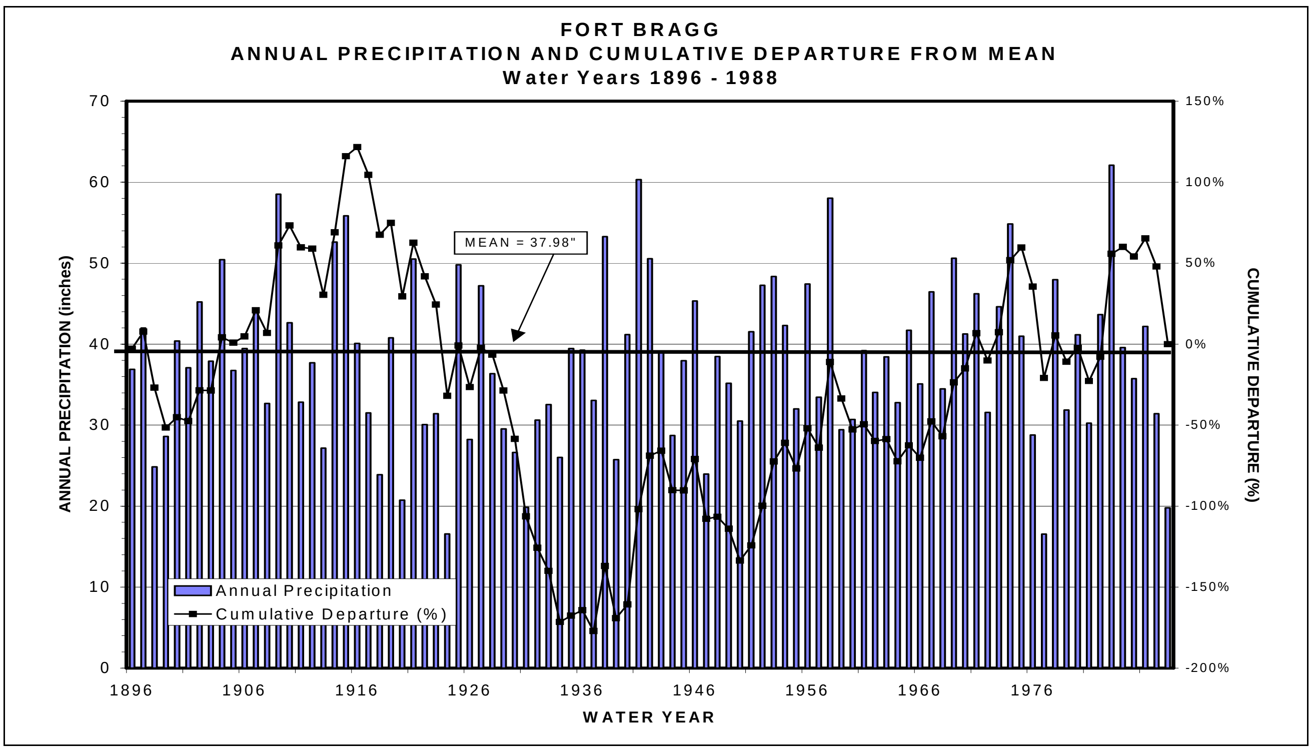


Figure 12. Annual precipitation and cumulative departure from the mean for the Fort Bragg precipitation gage, DWR Station # F80 3161 00, for the period 1886-1988.

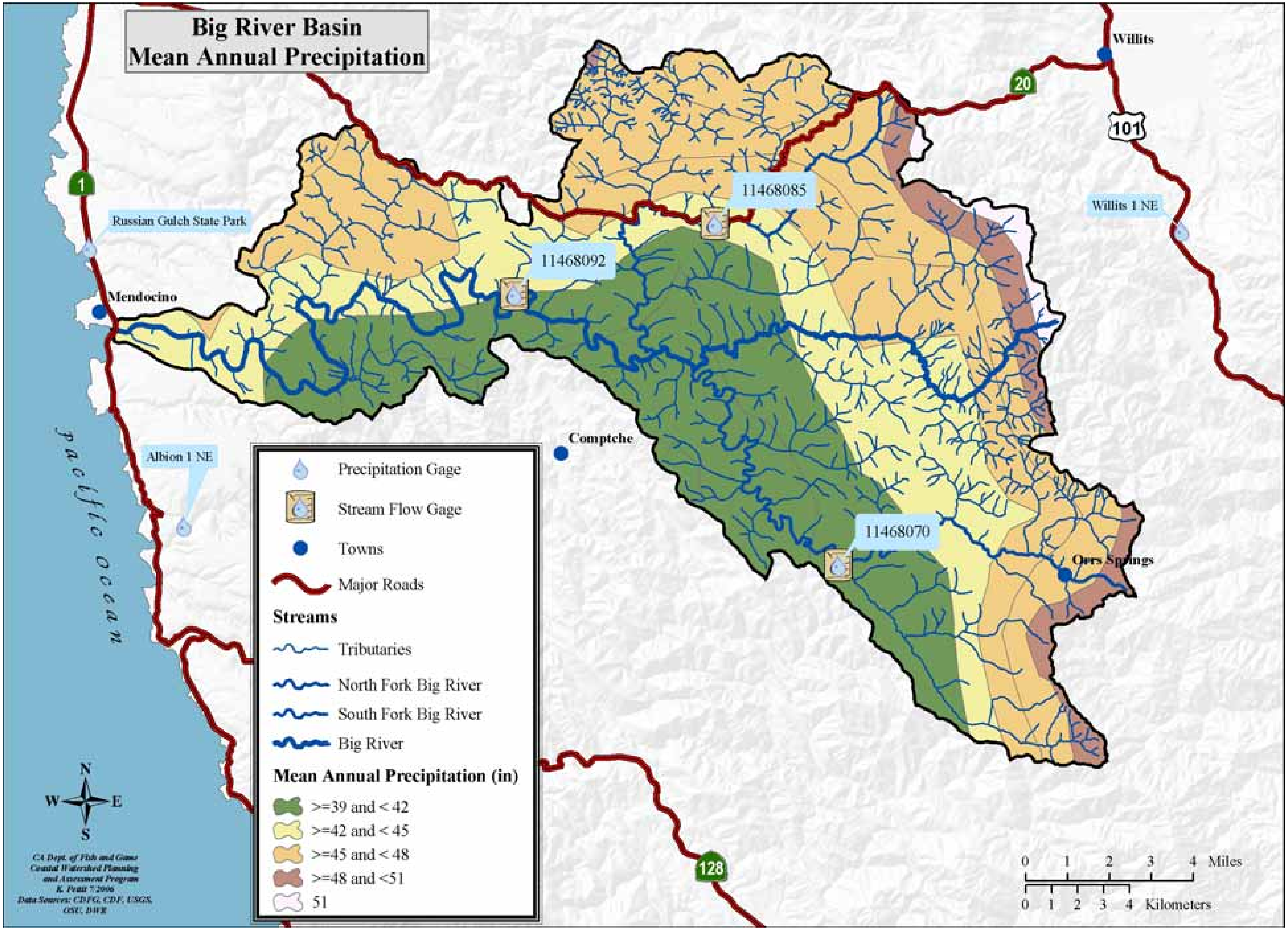


Figure 13. Big River Basin precipitation and nearby precipitation and stream flow gages.

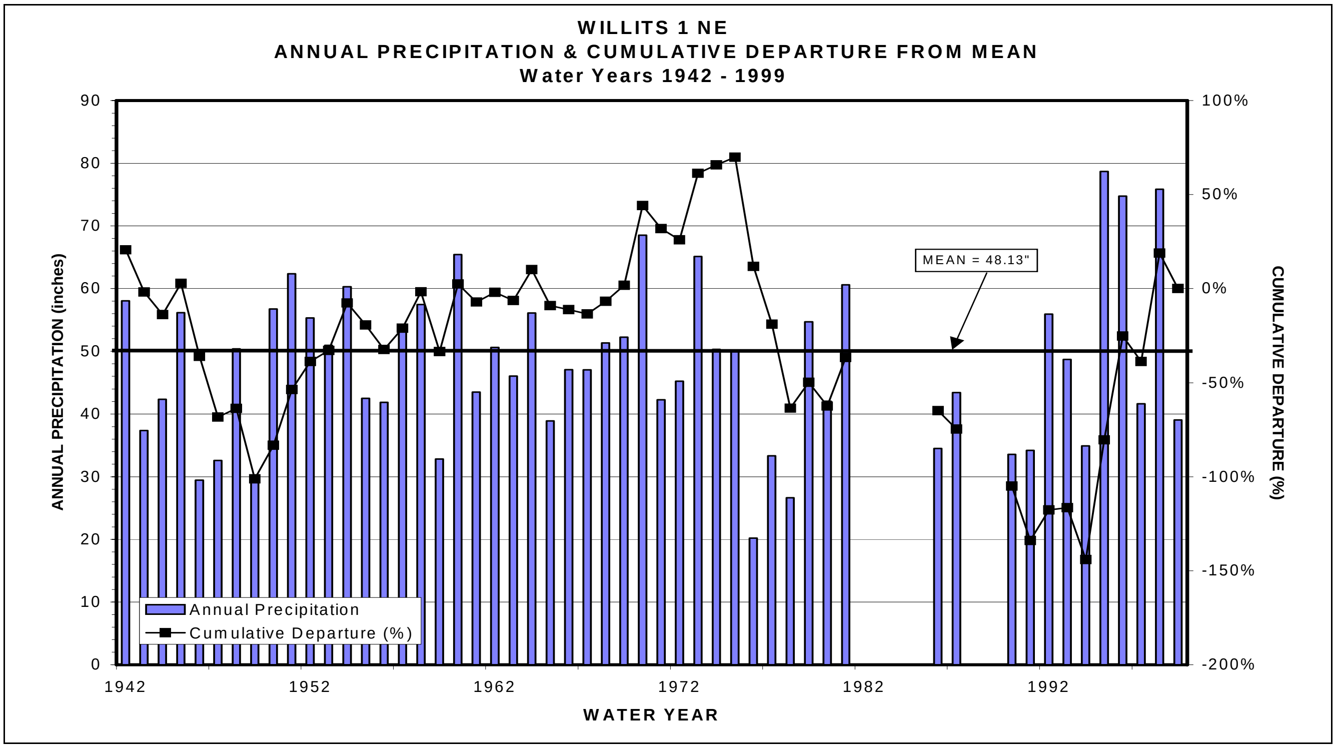


Figure 14. Annual precipitation and cumulative departure from the mean for the Willits 1 NE precipitation gage, DWR Station #F60 9685 00, for the period 1940—1999.

Hydrology

The Big River is a mid-sized coastal river with a catchment area of approximately 181.1 square miles. The mainstem becomes a fourth order stream downstream of the confluence with the North Fork Big River in the Middle Subbasin and most tributaries are intermittent or first or second order (Figure 15). North Fork Big River, South Fork Big River, and Daugherty Creek are third order streams.

The basin has many springs, most of which are cold. There is a hot spring at Orr Springs on South Fork Big River with water of 105°F (Fritz 1942).

In 1965, DWR reported that most Big River tributaries had permanent flow, though South Fork Big River usually became very low during the summer months. The mouth of the river was continuously open and had an excellent 6 mile long estuary. The mainstem Big River streambed was described as rather wide with sluggish flow throughout much of lower part of drainage. DWR estimated that flows required to maintain fishery resources were between 20 and 100 cfs, depending on the time of year (Table 14).

Table 14. DWR 1965 estimates of flow required to maintain fishery resources in the Big River.

Big River Basin Required Flows (cfs)			
Maintenance			Enhancement*
Nov 1 - April 30	May 1 - June 30	July 1 - Oct 31	Oct 1 - May 31
100	50	20	190

*Enhancement flows for June 1 to September 30 period not determined

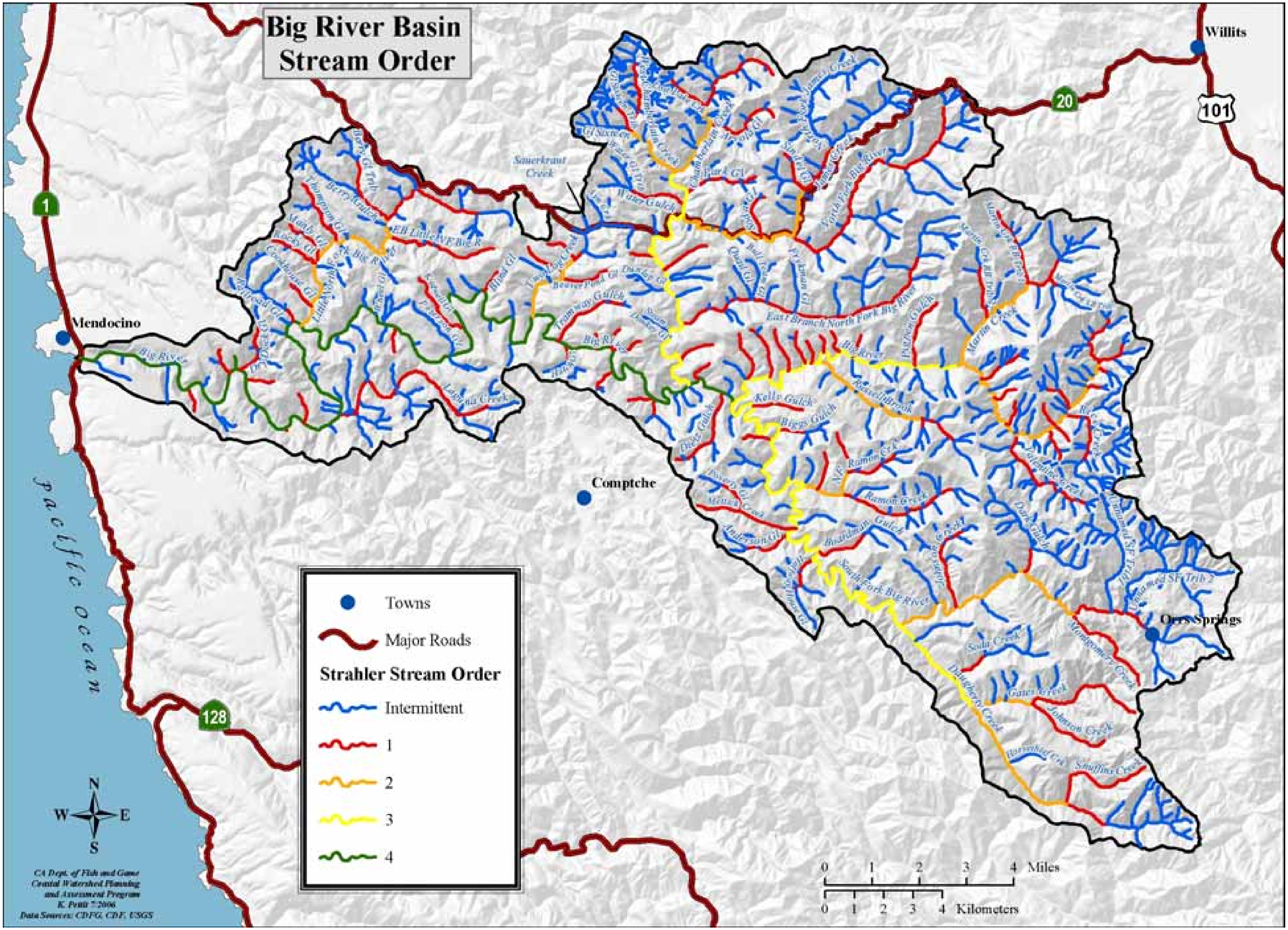


Figure 15. Stream order in the Big River Basin.

As part of a Fishery Improvement Study in 1973, USFWS (Perry 1973) measured stream flows at 20 transects in six streams and the mainstem Big River (Table 15, Figure 16). Measurements were taken bi-weekly from May 21 to July 19. In the mainstem Big River, stream flows ranged from 0.54 cfs in the headwaters in mid-July to 27.58 cfs just below the confluence with North Fork Big River in mid May. In the tributaries, stream flows ranged from 0.23 cfs in the upper reaches of North Fork Big River in mid July to 14.28 cfs in the lower reaches of North Fork Big River in mid May.

Table 15. Streamflow data collected by USFWS across the Big River Basin in 1973.

Transect	Date Measured and Flow (cfs)				
	May 21	June 5	June 19	July 5	July 19
Mainstem Big River					
Big River at Mendocino Woodlands	20.47	25.49	17.15	12.68	
Big River at Two Log Creek	21.75	19.87	--	10.44	--
Big River at South Fork Camp	27.58	22.74	16.14	12.83	9.71
Big River at Dietz Gulch	12.00	11.06	8.60	5.67	4.76
Big River at Wild Horse Opening	6.89	5.44	3.18	2.23	1.66
Big River at Upper Ranch Opening	4.72	3.32	2.67	1.64	1.37
Big River downstream from dam	2.19	1.98	1.33	1.13	0.51
Big River upstream from dam	1.04	1.33	0.83	0.57	0.54
Tributaries					
North Fork Big River downstream from East Branch North Fork Big River	14.28	9.66	8.78	5.69	--
East Branch North Fork Big River	1.16	0.93	0.90	0.67	0.46
North Fork Big River by Conservation Camp	6.73	5.22	4.16	2.95	2.41
Chamberlain Creek	--	3.18	2.26	1.50	1.12
James Creek	2.38	1.82	1.34	1.18	0.94
North Fork Big River upstream from James Creek	2.58	1.83	1.61	1.03	1.15
North Fork Big River upstream from dam	--	--	--	0.28	0.23
South Fork Big River at Biggs Gulch	10.15	6.85	--	3.37	--
South Fork Big River at Hansen School	8.63	4.14	2.55	2.31	1.45
South Fork Big River at Montgomery Creek	1.81	1.41	--	0.37	--
Martin Creek upstream from dam	2.09	1.10	1.05	0.60	0.49
Martin Creek downstream from dam	2.42	1.63	1.59	1.55	0.82

Mean Daily Discharge

Data from the Big Basin show that high flows during storms are of short duration, usually one to two days at most, and flows rapidly return to typical winter base flow within one week of peaks. Almost all significant runoff events occur between December and March (GMA 2001a).

Flow Duration

Flow duration analysis indicates that the South Fork Big River only exceeds 162 cfs 10% of the time, or 36 days per year on average, while 50% of the time flows are below 10 cfs. Flows exceed 850 cfs in the South Fork Big River only 1% of the time, or 3.6 days per year on average. It is thought that relatively little sediment transport occurs below 400 cfs, thus all of the geomorphic work accomplished by the river occurs in less than 5% of the time, with most concentrated in the top 1% of the flows (GMA 2001a).

Annual Runoff

The mean annual runoff for the 1952-1999 period was 268,700 acre-feet for the Big River downstream of Laguna Creek. Large volumes of runoff are often associated with both large flood years and years with high annual precipitation. The two largest annual runoff years were 1983 and 1974, almost 20% larger than the third largest runoff year, 1958 (Table 16). Three particularly dry periods stand out of the cumulative departure analysis, 1959-1964, 1976-1981, and 1987-1992 (GMA 2001a).

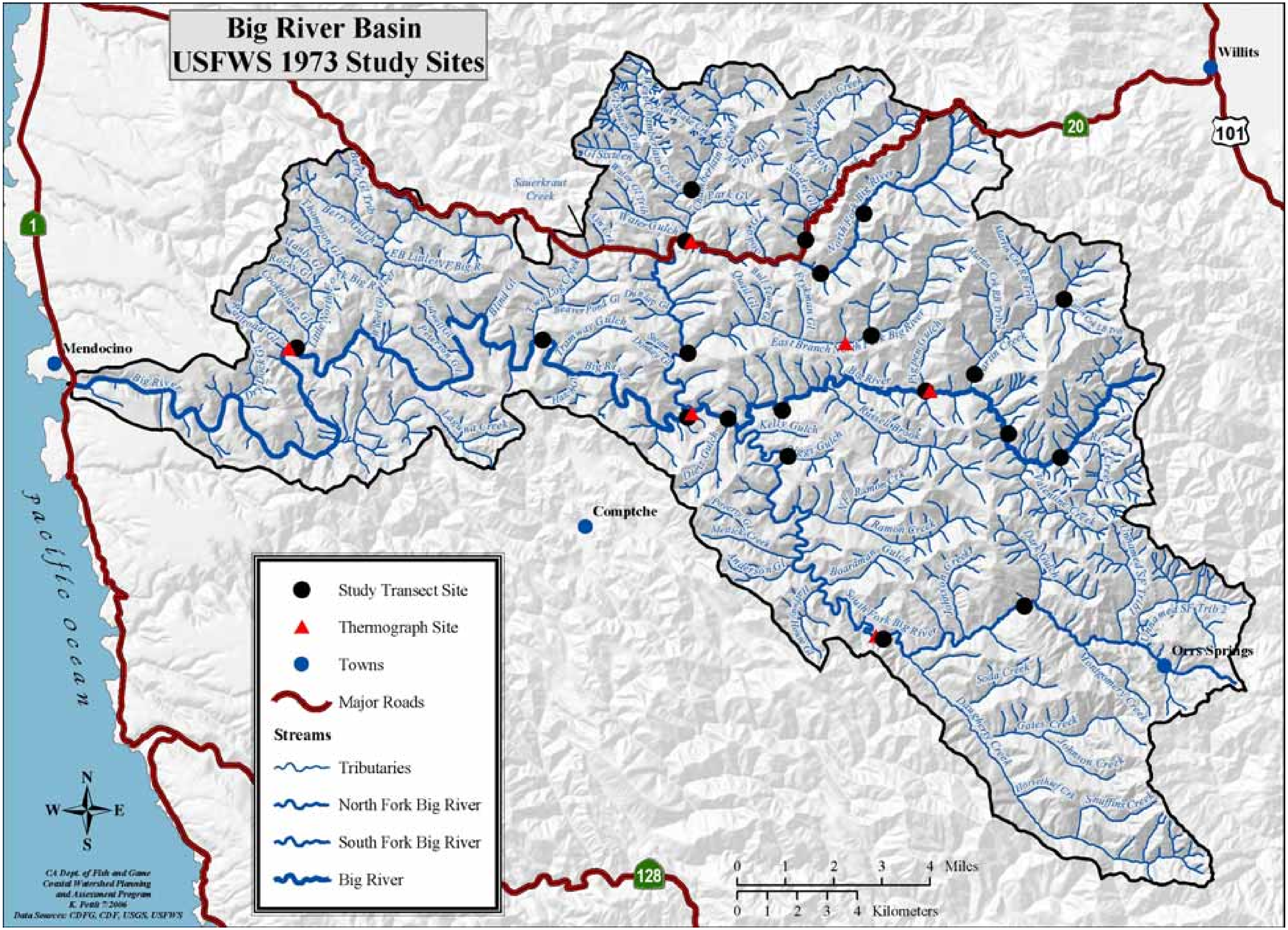


Figure 16. Map of 1973 USFWS study sites.

Table 16. Annual runoff and cumulative departure from mean Big River downstream of Laguna Creek.

Ordered Annual Runoff and Cumulative Departure Analysis			Ranked Annual Runoff		
Water Year	**Annual Runoff (acre-feet)**	**Cumulative Departure (acre-feet)**	**Rank**	**Water Year**	**Acre Feet**
1952	411,798	143,115	1	1983	605,738
1953	399,122	273,554	2	1974	604,938
1954	303,407	308,278	3	1958	496,178
1955	124,504	164,099	4	1998	490,197
1956	436,097	331,513	5	1982	441,812
1957	180,208	243,038	6	1995	438,182
1958	496,178	470,532	7	1956	436,097
1959	157,377	359,226	8	1965	415,298
1960	190,508	281,052	9	1952	411,798
1961	210,594	222,962	10	1993	401,344
1962	168,623	122,902	11	1953	399,122
1963	259,423	113,642	12	1969	367,778
1964	143,593	(11,448)	13	1986	347,194
1965	415,298	135,167	14	1996	331,960
1966	216,568	83,052	15	1997	329,279
1967	257,789	72,158	16	1971	327,536
1968	156,118	(40,407)	17	1999	327,081
1969	367,778	58,688	18	1970	325,966
1970	325,966	115,971	19	1975	322,231
1971	327,536	174,824	20	1954	303,407
1972	142,215	48,357	21	1978	298,910
1973	288,762	68,435	22	1973	288,762
1974	604,938	404,690	23	1984	277,042
1975	322,231	458,239	24	1963	259,423
1976	108,076	297,632	25	1967	257,789
1977	13,694	42,643	26	1980	256,537
1978	298,910	72,870	27	1966	216,568
1979	133,964	(61,849)	28	1989	216,206
1980	256,537	(73,995)	29	1961	210,594
1981	116,377	(226,301)	30	1960	190,508
1982	441,812	(53,173)	31	1957	180,208
1983	605,738	283,883	32	1985	173,447
1984	277,042	292,242	33	1962	168,623
1985	173,447	197,005	34	1959	157,377
1986	347,194	275,516	35	1968	156,118
1987	140,666	147,499	36	1990	145,129
1988	135,469	14,286	37	1964	143,593
1989	216,206	(38,192)	38	1972	142,215
1990	145,129	(161,745)	39	1987	140,666
1991	75,101	(355,327)	40	1988	135,469
1992	99,042	(524,967)	41	1979	133,964
1993	401,344	(392,306)	42	1955	124,504
1994	87,704	(573,286)	43	1981	116,377
1995	438,182	(403,786)	44	1976	108,076
1996	331,960	(340,509)	45	1992	99,042
1997	329,279	(279,913)	46	1994	87,704
1998	490,197	(58,399)	47	1991	75,101
1999	327,081	0	48	1977	13,694

After GMA 2001a
Mean 268,683 Maximum 605,738 Minimum 13,694
Note: Annual Runoff Data Derived from Synthetic Data

Peak Discharge

The largest recorded peak discharge for the South Fork Big River occurred in December 1964, when the river crested at 8,200 cfs (USGS). USGS peak discharge records are available for an 11-year period, 1961-1971 (Figure 17), and 1974.

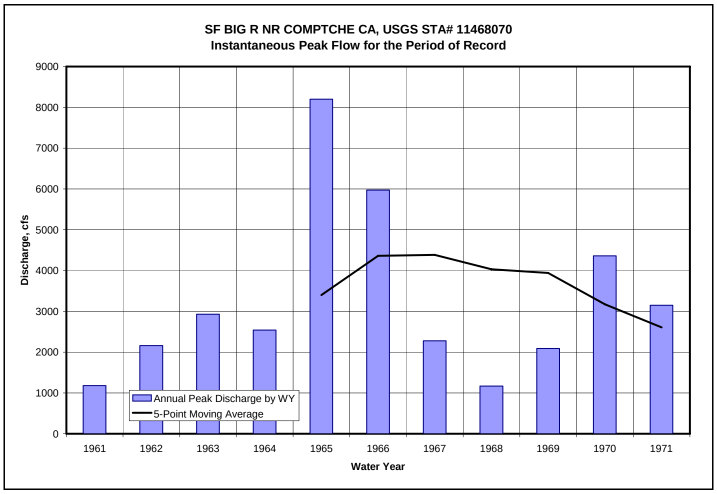


Figure 17. Annual instantaneous peak discharge and 5-year moving average for South Fork Big River near Comptche, USGS station #11468070, for Water Years 1961 – 1971.

In addition, GMA (2001) developed synthetic peak discharges for the South Fork Big River using peak correlation analysis between the Noyo River Basin and the Big River Basin in order to extend the record. Analysis showed that although the highest peak flows in the neighboring Noyo and Albion basins occurred during a January 1974 (water year 1974) storm event, this storm was not nearly as significant an event in the South Fork Big River. In fact, the correlation analysis estimated that the 1974 peak flow for the South Fork Big River should have been 68% larger than USGS data showed. No explanation for this disparity is currently available, although it indicates possible inaccuracies in available data. Precipitation intensity records for Fort Bragg are also inconsistent with the recorded magnitude of the 1974 peak discharge. A comparison of 1-day precipitation intensities with peak discharge indicates that 1-day precipitation does not appear to be the driving force behind Big River peak flows (GMA 2001a).

Significant storm flows, those in excess of 5,000 cfs, in the extended period of record occurred mostly in the months of December and January, with one event occurring in March 1986 (water year 1986). Peak discharges estimated for the entire Big River Basin based on a correlation with the Noyo record indicated that the January 1974 flood would have been the largest in the synthetic dataset, followed by December 1964 and January 1993 (Table 18) (GMA 2001a).

Flood Frequency

A flood frequency analysis by GMA (2001) for available data in the Big River Basin indicated that the January 1974 (5,250 cfs) flood would be about a 45-year event, while flows similar to December 1964 (2,540 cfs) would be about a 35-year event. The 2-year event is almost 12,000 cfs for the entire basin (Table 17).

Table 17. Mainstem Big River 3-parameter log-normal flood frequency analysis for the combined historic and synthetic 1952-2001 period of record (after GMA 2001a).

Return Period (years)	Computed Annual Maximum Peak Discharge(cfs)
2	11,900
5	22,100
10	30,100
20	38,700
50	51,000
100	61,300

A similar analysis by GMA (2001) for the South Fork Big River near Comptche site only indicated that the December 1964 flood would have been just smaller than a 50-year event, while the January 1974 flood would have been only a 10-year event.

Historic Floods

Although the Big River has a relatively short period of streamflow records, GMA (2001) was able to infer the dates of significant floods with regional data. Known large flood events in the region, many of which would also have occurred in Big River Basin, occurred in water years 1861, 1881, 1890, 1907, 1914, 1938, 1952, 1956, 1965, 1966, 1974, 1986, and 1993. The largest of these were likely to have been the 1861 and 1890 events, followed by the 1914, 1938, 1965, and 1974 events (not necessarily in that order by magnitude).

During the period of available synthetic streamflow records, 1974 stands out as a year with high peak flow and long duration of those flows (Table 19). This is similar to adjacent Noyo, Albion, and Caspar Creek basins, but considerably different from the Ten Mile basin and most coastal watersheds further north. In the Big River Basin, the January 1974 event appears to have been the most significant in the past 50, and perhaps 100, years.

Table 18. South Fork Big River USGS gage #11468070 peak discharges and annual maximums.

Rank	Water Year	Peak Discharge (cfs)	Probability	Recurrence Interval (years)
1	1965	8200	0.020	49.00
2	1993	7655	0.041	24.50
3	1956	7287	0.061	16.33
4	1966	5970	0.082	12.25
5	1952	5282	0.102	9.80
6	1974	5250	0.122	8.17
7	1986	5149	0.143	7.00
8	1970	4360	0.163	6.13
9	1953	4283	0.184	5.44
10	1995	4017	0.204	4.90
11	1960	3950	0.224	4.45
12	1954	3851	0.245	4.08
13	1983	3618	0.265	3.77
14	1997	3618	0.286	3.50
15	1982	3385	0.306	3.27
16	1971	3150	0.327	3.06
17	1963	2930	0.347	2.88
18	1996	2795	0.367	2.72
19	1958	2699	0.388	2.58
20	1980	2656	0.408	2.45
21	1964	2540	0.429	2.33
22	1975	2408	0.449	2.23
23	1967	2280	0.469	2.13
24	1962	2160	0.490	2.04
25	1969	2090	0.510	1.96
26	1998	1945	0.531	1.88
27	1973	1869	0.551	1.81
28	1990	1638	0.571	1.75
29	1985	1566	0.592	1.69
30	1978	1467	0.612	1.63
31	1959	1394	0.633	1.58
32	1989	1361	0.653	1.53
33	1984	1279	0.673	1.48
34	1972	1227	0.694	1.44
35	1957	1207	0.714	1.40
36	1955	1197	0.735	1.36
37	1961	1180	0.755	1.32
38	1968	1170	0.776	1.29
39	1988	1158	0.796	1.26
40	1976	1141	0.816	1.23
41	1981	984	0.837	1.20
42	2001	965	0.857	1.17
43	1994	800	0.878	1.14
44	1987	790	0.898	1.11
45	1979	774	0.918	1.09
46	1992	683	0.939	1.07
47	1991	510	0.959	1.04
48	1977	48	0.980	1.02

After GMA 2001a
Ranked with computed recurrence intervals based on the Weibull formula (historic and synthetic data)
Historic USGS data
GMA (2001) data
GMA (2001) synthetic data from peak correlation

Diversions, Dams, and Power Generation

There are five licensed, permitted, or pending water rights within the Big River Basin. This number does not include riparian users and other diversions that are not registered with the State Division of Water Rights. No major dams or power generating facilities are located within the basin.

Appropriative water right permits exist for a total of about 8.5 acre-feet per year of water from the Big River Basin, at a maximum diversion rate of about 16,820 gallons per day. Additionally, there is a right for one acre-foot per year for storage. The four appropriative water rights are for the South Fork Big River or an unnamed tributary to the South Fork, while the storage water right is located on a tributary to Laguna Creek in the Coastal Subbasin.

No major dams or power generating facilities are located within the Big River Basin. Four sites were considered for possible fisheries enhancement impoundments by US Bureau of Reclamation in 1973 (USBR 1973). The sites were located on the mainstem Big River, North Fork Big River, and Martin Creek.

Table 19. Big River data for assessing event magnitude. Data sources sorted and ranked with top 20 values listed.

Annual Runoff			Peak Discharge			Annual Precipitation				1-Day Precipitation Intensity				
Big River below Laguna Creek			Big River near Mendocino			Willits		Fort Bragg 5N		Willits			Fort Bragg	
Rank	Water Year	Annual Runoff (ac-ft)	Rank	Water Year	Peak Discharge (cfs)	Water Year	Annual Precipitation (inches)	Water Year	Annual Precipitation (inches)	Rank	Water Year	1-Day Precipitation (inches)	Water Year	1-Day Precipitation (inches)
1	1983	605,738	1	1974	47,900	1958	92.82	1998	77.31	1	1965	8.80	1953	4.15
2	1974	604,938	2	1965	43,200	1904	89.30	1983	62.47	2	1938	7.61	1939	4.05
3	1958	496,178	3	1993	41,600	1938	87.62	1941	60.32	3	1906	7.07	1995	3.84
4	1998	490,197	4	1956	39,600	1983	86.48	1995	58.61	4	1914	6.50	1979	3.78
5	1982	441,812	5	1966	34,600	1879	85.46	1909	58.52	5	1947	6.50	1990	3.78
6	1995	438,182	6	1952	28,800	1890	84.51	1958	58.02	6	1960	6.46	1938	3.70
7	1956	436,097	7	1986	28,100	1974	76.39	1915	55.85	7	1974	5.90	1937	3.62
8	1965	415,298	8	1970	23,900	1998	75.93	1974	54.84	8	1952	5.87	1969	3.58
9	1952	411,798	9	1953	23,400	1995	74.44	1938	53.29	9	1943	5.78	1958	3.52
10	1993	401,344	10	1995	22,000	1956	72.71	1914	52.61	10	1951	5.50	1966	3.52
11	1953	399,122	11	1960	21,600	1982	72.33	1993	51.54	11	1986	5.50	1965	3.49
12	1969	367,778	12	1954	21,100	1941	71.88	1969	50.62	12	1963	5.40	1915	3.42
13	1986	347,194	13	1983	19,800	1909	71.13	1942	50.53	13	1956	5.33	1996	3.30
14	1996	331,960	14	1997	19,800	1895	70.28	1921	50.52	14	1969	5.21	1998	3.30
15	1997	329,279	15	1982	18,500	1894	68.57	1904	50.43	15	1940	5.20	1971	3.23
16	1971	327,536	16	1969	16,700	1925	66.23	1925	49.78	16	1990	5.20	1993	3.23
17	1999	327,081	17	1971	16,300	1942	65.99	1997	49.71	17	1913	5.13	1913	3.10
18	1970	325,966	18	1996	15,300	1969	65.69	1953	48.36	18	1966	5.10	1956	3.07
19	1975	322,231	19	1958	14,800	1986	65.61	1978	47.95	19	1979	5.06	1994	3.06
20	1954	303,407	20	1980	14,600	1978	65.56	1956	47.41	20	1932	5.05	1997	3.06

After GMA 2001a
Peak Discharge was obtained by Correlation Analysis
Annual Runoff Data are Synthetic for all Years
Annual Precipitation and Intensity Data from Goodridge (1999)

Geology

The Big River Basin is mainly located on the coastal side of the Mendocino Range, which is the western-most mountain range of the northern California Coast Ranges Geomorphic Province. The topography of the basin varies from a relatively flat estuary and uplifted terraces, forming part of the Mendocino plateau (Fox 1983) on the western most portion, to the mountainous interior and eastern portion of the basin. The more subdued terrain of the western step-like marine terraces merges with the sharply dissected interior to the east. Erosional remnants of the plateau appear in the basin as scattered flat ridge tops and approximately accordant summits. Elevations range from near sea level in the western portion of the basin stepping up through a series of uplifted marine terraces to approximately 2,725 feet in the mountainous eastern portion.

The rocks of the Coast Ranges formed in deep ocean bottom and continental slope environments between about 140 and 28 million years ago (Harden 1998). Oceanic sediments and volcanic rocks were accreted to North America along the tectonic subduction zone that was present at that time (Blake and Jones 1974, 1981). The irregular folding and faulting of the rocks during this period of tectonic mixing created the resultant irregular relationship between varying rock types that is typical of the Franciscan Complex. Portions of the Franciscan Complex with similar geology are grouped into belts and further subdivided into terranes. The Coastal Terrane (broken formation) of the Cretaceous-Tertiary Coastal Belt of the Franciscan Complex forms the bedrock under most of basin with the eastern most portion composed of the more pervasively sheared and disrupted Jurassic-Tertiary Central Belt Franciscan mélange (Figure 18). Central Belt terrain generally underlies topographically subdued grassland or open forest. The Franciscan rocks are overlain by Tertiary marine sandstone in the southeastern portion of the basin.

Bedrock is locally overlain by surficial materials of marine and river terrace deposits, estuarine deposits and alluvium related to modern channel deposits, landslides, and beach and older dune sands. Several levels of alluvium and terrace deposits, present most notably in the western part of the watershed, and remnants of the Mendocino plateau in the interior indicate that much of this watershed has been uplifted relatively recently. This, coupled with the relatively flat, staircase like arrangement of terraces, incised preexisting drainages and u-shaped valleys indicate an early stage of maturity for the western portion of the watershed grading in to a fully mature topography on the eastern portion of the basin (Kilbourne 1986).

The geology and regional tectonics directly influence the nature of the slopes and the types and rates of landslides present. Landslide features are widespread in the watershed. The dominant form of mass wasting varies depending on the composition of the underlying rock. Generally, the Coastal Terrane Franciscan Complex has a greater clay component in the western part of Big River Basin than farther to the east. The degree of penetrative shearing is also more intense to the west. Finally, the cessation of watercourse incision due to sea level rise has more of an effect near the mouths of the streams than in the headwater areas. As a consequence, the slopes in the western part of the basin are less steep with more mature topography than they are to the east. Deep-seated rockslides (rotational/translational landslides) are more common in the middle and eastern portion of the basin than in the western most portions. Additionally, earthflows are more abundant in the eastern part of basin (underlain by mélange terrane) when compared with the areas to the west.

Bedrock

The entire basin is underlain by rocks of the Coastal Franciscan Complex except for a Tertiary age sandstone in the Greenough Ridge – Montgomery Woods State Park area. Within the basin, the Franciscan occurs as two distinct bedrock units: the relatively coherent (stable) Tertiary to Cretaceous age Coastal Belt terrane and the relatively incoherent (easily eroded) Tertiary to Jurassic age Central Belt terrane.

Coastal Belt Terrane

Rocks of the Franciscan Coastal Belt terrane are characterized by sandstone and interbedded siltstone and shale, with locally minor amounts of conglomerate present. Elsewhere chert, limestone, and greenstone are found. Coastal Belt rocks have been deformed by past tectonic activity. This has created a body of rock that has been broken up into coherent bedrock blocks of varying size (up to city blocks or larger) separated by shear zones and faulting; locally the bedrock is tightly folded.

Central Belt Terrane

Central Belt rocks crop out in the central area of the eastern margin of the basin. They underlie the subdued topography in portions of that area.

The Central Belt is a mélange characterized by blocks of bedrock, varying in size from fist size pieces to blocks up to city blocks or larger in size, in a highly sheared, mashed, and mangled clayey matrix. The blocks of bedrock can include sandstone, conglomerate, chert, greenstone, blueschist, limestone, eclogite, serpentine, amphibole, and ultramafic rocks. The subdued nature of the hillside topography overlying the central belt is a result of the weak nature of the sheared mélange matrix.

Tertiary Sandstone

These rocks crop out in the southeastern area of the Big River Basin. They are mapped to underlie Greenough Ridge and on to the southeast into Montgomery Woods State Park. These sandstones are well consolidated and interbedded with minor amounts of conglomerate and limestone. They are described as gently folded and thick bedded.

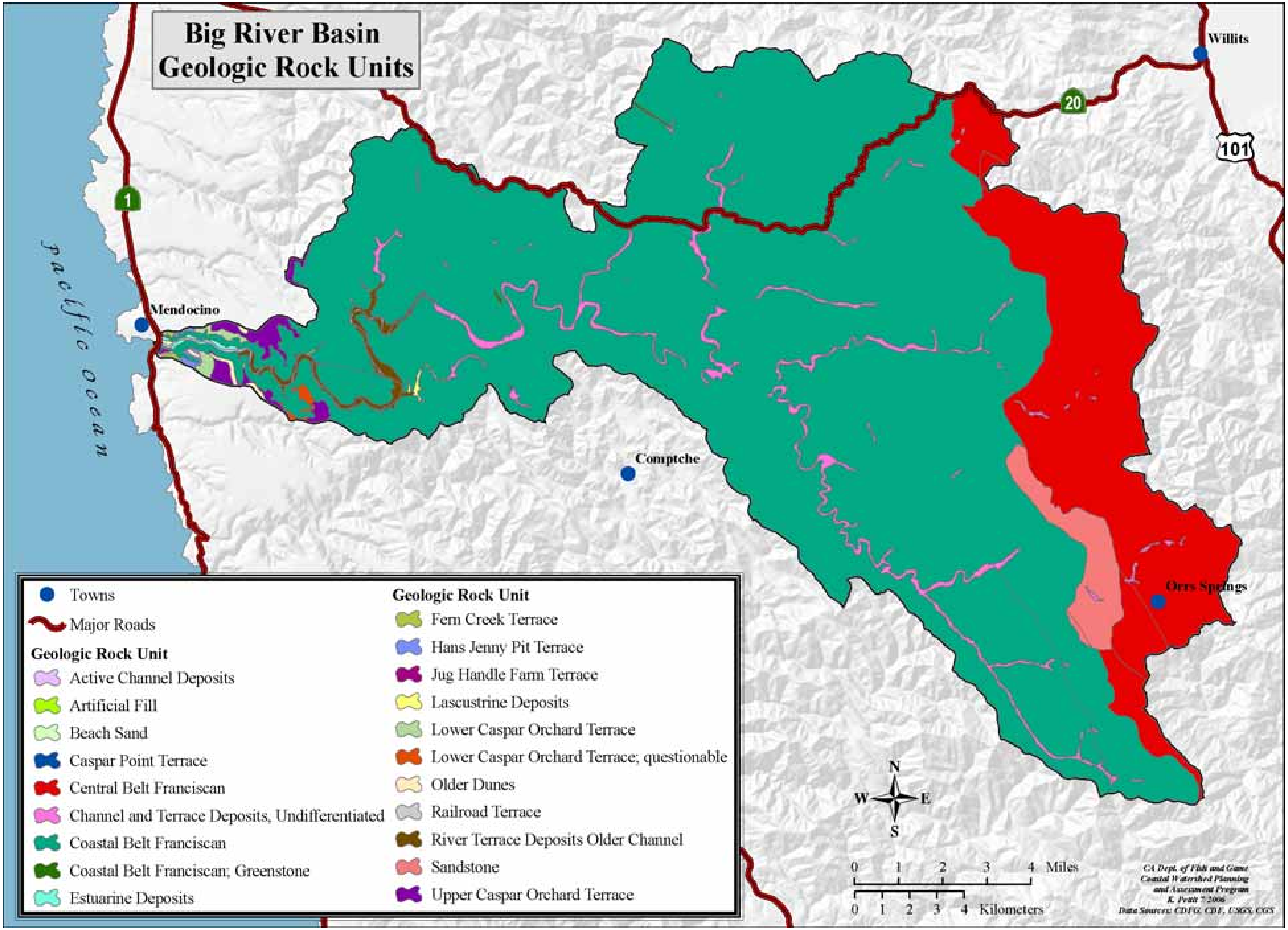


Figure 18. Geology of the Big River Basin.

Faulting, Seismicity, and Regional Uplift

The Big River Basin is located along the coastal side of the Mendocino Range, which lies along the active boundary between the Pacific and North American plates. The Pacific plate is moving northwards at a much faster pace than the North American plate, which is moving northwest. At present, most movement between the plates consists of the plates sliding past one another. The plate boundary also has a component of convergence - along which a series of northwest trending mountain ranges and active fault zones have developed. The primary active fault zone along the plate boundary is the San Andreas Fault located approximately four miles west of the mouth of Big River. This fault is a right-lateral strike slip fault and has been calculated to move 50 millimeters a year over the past three to four million years. Active uplift of the Coast Range continues at a rate of approximately 30 centimeters per 100 years in the Big River area (CGS 2004).

Slope Classes

A slope analysis of the basin was conducted by GMA (2001) using GIS data provided by the CDF. The Coastal, and to a lesser extent the Middle, subbasins contain a higher percentage of area of lower relief than the Inland Subbasin (Table 20). The Coastal and Middle subbasins have 44% and 37%, respectively, in slopes less than 31%, while the Inland Subbasin has 23% in this category. In the steeper slope classes, the Coastal and Middle subbasins have 19% and 25% with slopes exceeding 50%, respectively, and the Inland Subbasin has 34%.

Table 20. Slope classes in the Big River Basin.

Slope Class (%)	Coastal Subbasin		Middle Subbasin		Inland Subbasin		Big River Basin Total	
	Acres	%	Acres	%	Acres	%	Acres	%
0 -15	4,126	20	1,332	12	4,281	5	9,738	8
16 - 30	4,892	24	2,804	25	15,468	18	23,164	20
31 - 50	7,858	38	4,483	39	35,746	43	48,087	42
51 - 65	2,685	13	1,802	16	17,279	21	21,767	19
Over 65	1,209	6	1,001	9	10,891	13	13,101	11
Total	**20,770**	**100**	**11,422**	**100**	**83,664**	**100**	**115,856**	**100**

The low gradient valley floors and the small fragments of marine terraces in the Coastal Subbasin are seen in Figure 19, with the green colors of the lowest slope classes. Similarly, the red color for slopes exceeding 70% is visible in the headwaters areas, as well as the Lower South Fork PW, and at inner gorge locations along the narrow, incised drainages (GMA 2001a).

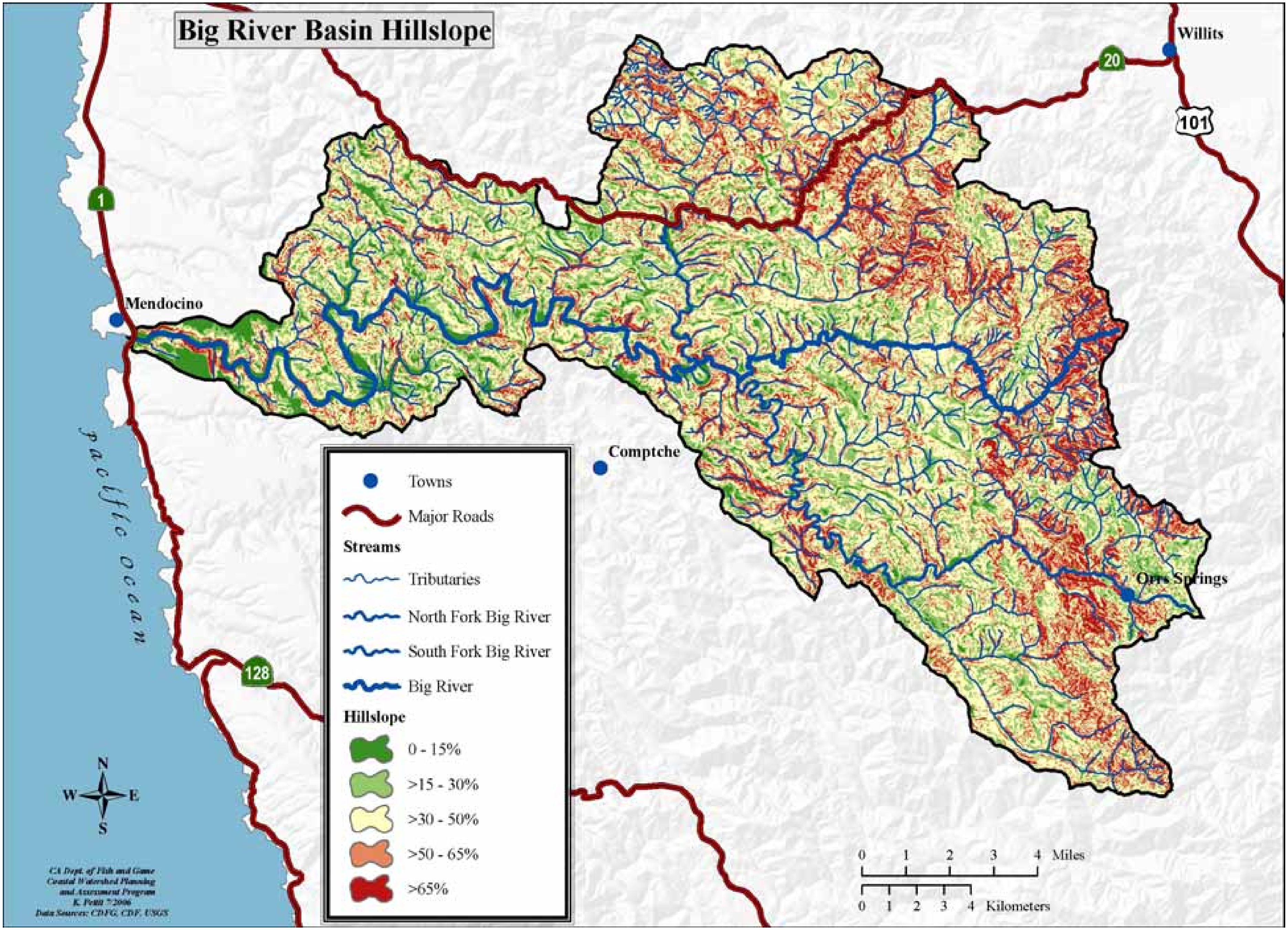


Figure 19. Slope class identification map.

Sediment Source Analysis

GMA (2001) conducted a sediment source analysis for the Big River Basin. Their sediment analysis consisted of three components:

- Evaluation of the dominant geomorphic processes that deliver sediment to stream channels;
- Measurement of parameters, such as landslide size/type/associated landuse, road length, and harvest areas from aerial photography;
- Selection of factors to complement, modify, and/or extend the photo-based measurements, thus allowing computation of results.

Sources of sediment in the basin include landsliding, surface erosion, and fluvial erosion.

Landsliding

Historic Analysis

GMA (2001) examined six sets of aerial photos from 1936, 1952, 1965, 1978, 1988, and 2000 for their landslide analysis. However, the photo set from 1936 was incomplete and is not discussed here (please see GMA 2001a for further details of 1936 data). They originally mapped 3,000 unique landsliding features across the basin and 488 features that were judged to be delivering sediment in more than one time period. GMA then eliminated questionable features and non-delivering landslides from further analysis. This resulted in a database of 2,037 unique landslide features across the basin.

Most mapped slides were debris slides. Landslides were most frequent in 1952 followed by 1965 (Table 21). Several large flood events, as measured by peak discharge, also occurred during these time periods. In addition, three of the highest 1-day precipitation intensities in the 102-year period of record occurred in the 1952 time period. Landsliding has been shown to be related to short term precipitation intensity in nearby Caspar Creek (Cafferata and Spittler 1998).

Table 21. Big River Basin number of delivering landslides by type and period.

Type	1952		1965		1978		1988		2000		Total all features	
	#	%	#	%	#	%	#	%	#	%	#	%
Debris Torrents	135	15.5	123	16.4	344	83.2	14	6.1	20	7.6	318	13.3
Earthflows	35	4.0	23	3.1	95	12.9	12	5.2	12	4.5	93	3.9
Rotational/ Translational	3	0.3	4	0.5	10	0.04		0.0		0.0	9	0.4
Slides	698	80.1	598	79.9	2220	3.6	203	88.6	232	87.9	1964	82.4
TOTALS:	**871**	**36.5**	**748**	**31.4**	**229**	**9.6**	**264**	**11.1**	**272**	**11.4**	**2384**	**100.0**

From GMA 2001a

GMA describes a trend of decreasing numbers of landslides since the peak number in 1952. Only 11.4% of all mapped slides occurred from 1989 through 2000. Higher slide frequencies appeared to coincide with periods of more intense landuse activities such as extensive timber harvest and road building following World War II. The decreased number of slides in recent years coincides with a period of reduced timber harvest and new forest management policies.

An examination of the landslide distribution amongst subbasins shows that the Inland Subbasin had the most slides in every period of study (Table 22). This is expected because of the Inland's larger area.

Table 22. Big River Basin number of delivering slides by study period and subbasin.

Subbasin	1937-1952		1953-1965		1966-1978		1979-1988		1989-2000		Total all periods	
	#	%	#	%	#	%	#	%	#	%	#	%
Coastal	106	12.2	77	10.3	10	4.4	23	8.7	32	11.8	248	10.4
Middle	49	5.6	69	9.2	22	9.6	25	9.5	30	11.0	195	8.2
Inland	716	82.2	602	80.5	197	86.0	216	81.8	210	77.2	1941	81.4
Total	**871**	**36.5**	**748**	**31.4**	**229**	**9.6**	**264**	**11.1**	**272**	**11.4**	**2,384**	**100**

GMA found that inner gorge slopes were not the most common origin for landslides across the basin. Analysts found that 22.2% (453) of the unique slides were inner gorge slides; 71.5% of these slides occurred before 1965 (Table 23). Most of the inner gorge landslides occurred in only three PWs, Lower South Fork, Middle Big

River, and the Lower North Fork PWs. This reflects the dominance of inner gorges in the main channels of the basin.

Table 23. Number and volume (in tons) of inner gorge landslides in the Big River Basin by subbasin and study period.

Subbasin	1937-1952		1953-1965		1966-1978		1979-1988		1989-2000		TOTAL	
	#	tons	#	tons	#	tons	#	tons	#	tons	#	tons
Coastal	19	70,044	19	44,827	4	4,825	3	7,056	4	7,643	49	134,396
Middle	12	41,006	33	129,430	12	23,799	10	21,874	5	3,465	72	219,574
Inland	139	417,083	102	262,451	20	35,069	25	52,848	46	49,530	332	816,980
Total	**170**	**528,134**	**154**	**436,708**	**36**	**63,692**	**38**	**81,778**	**55**	**60,639**	**453**	**1,170,951**

After GMA 2001a

Estimates of landslide volumes across the study periods showed a trend towards significantly reduced sediment volume delivered by landslides since 1989 compared to historic periods (GMA 2001a). Of the total volume of sediment delivered during the study period, 53% occurred from 1937 to 1952, 29% occurred from 1953 to 1965, and only 18% occurred after 1966. By 2000, the volume of slides was reduced to 6% of the 1937-2000 total. Most of the sediment volume was delivered in the Inland Subbasin (Table 24).

Table 24. Volume of delivering slides by study period by 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)
Coastal	474,045	11.9	130,376	5.9	28,643	8.2	50,041	9.1	114,463	23.8	797,567	10.5
Middle	114,506	2.9	271,379	12.3	40,550	11.6	58,623	10.7	25,398	5.3	510,455	6.7
Inland	3,395,141	85.2	1,813,452	81.9	279,205	80.1	441,695	80.3	341,248	70.9	6,270,742	82.7
Total	**3,983,692**	**52.6**	**2,215,207**	**29.2**	**348,398**	**4.6**	**550,359**	**7.3**	**481,109**	**6.3**	**7,578,764**	**100**

After GMA 2001a

Similar to the trend in decreasing number of landslides in the period of study, GMA (2001) found a significant decrease in the volume delivered by landslides (Table 25).

Table 25. Number, total volume, and average volume of slides by period.

Category	1937-1952		1953-1965		1966-1978		1979-1988		1989-2000		Total
	#	%	#	%	#	%	#	%	#	%	
Number of slides	871	32.6	748	28.0	229	8.6	264	9.9	272	10.2	2,384
Total Volume (tons)	3,983,692	47.4	2,215,207	26.3	348,398	4.1	550,359	6.5	481,109	5.7	7,578,764
Average Volume (tons)	4,573		2,961		1,521		2,084		1,768		3,179

GMA 2001a

GMA calculated the average annual unit area volumes of sediment production by study period (2001) (Table 26). The overall sediment delivery from landsliding for the study period was estimated to be 664 tons/square mile/year. The lowest delivery for the entire basin was from 1966 to 1978, while the highest was from 1937 to 1952. This time period is not associated with any of the five largest storms during the study period; however, three of the seven highest 1-day precipitation intensities occurred. Following the 1965 period, there has been a decline in landslide delivery.

Table 26. Rate of delivering slides by study period by subbasin (tons/square mile/year for period).

Subbasin	1937-1952	1953-1965	1966-1978	1979-1988	1989-2000	Total
Coastal	912.5	308.9	67.9	154.1	293.8	389.9
Middle	400.9	1169.5	174.7	328.4	118.6	453.4
Inland	1,623.2	1067.1	164.3	337.9	217.5	761.2
Total	**1,375.2**	**941.2**	**148.0**	**304.0**	**221.4**	**664.3**

GMA 2001a

GMA (2001) investigated the Montgomery Woods State Reserve in greater detail than the rest of the basin in order to ascertain what natural background rates of landsliding might be for this area. The Reserve is small, but relatively undisturbed. GMA's study of background landsliding rates found no signs of recent mass wasting. GMA noted that their result could be confounded by the small area of the reserve and the underlying geology, Tertiary Sandstone, which is more stable than mélange and possibly more stable than the Coastal Belt of the Franciscan Formation.

Current Mapping

CGS finished a map of active and dormant landslides across the basin in 2005 (Figure 22). Historically active landslides have moved within approximately the past 150 years. Most landslides were in the Inland Subbasin and most landslides were dormant (Figure 20).

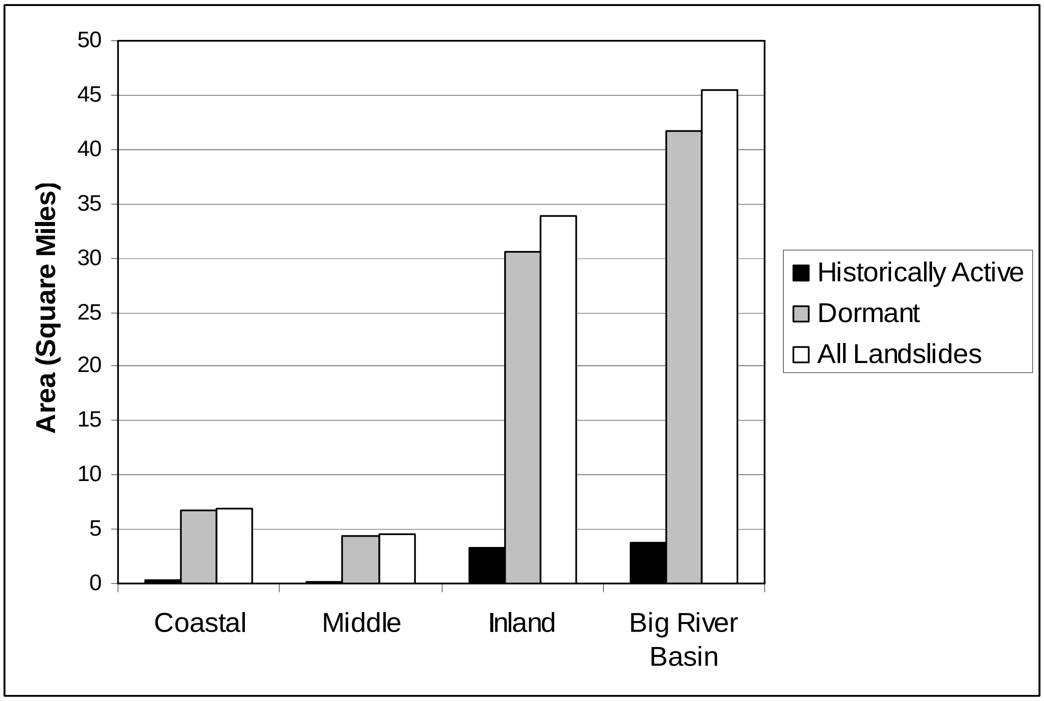


Figure 20. Map of historically active and dormant landslides across the Big River Basin (CGS 2005).

Landslide Potential

CGS completed a landslide potential map of the basin in 2005. Over 50% of the basin is in the high and very high landslide potential classes (Figure 20). The Coastal Subbasin has are higher percentage area in the very low and low landslide potential categories, while the Inland Subbasin has a higher percentage area in the higher landslide potential categories (Figure 21).

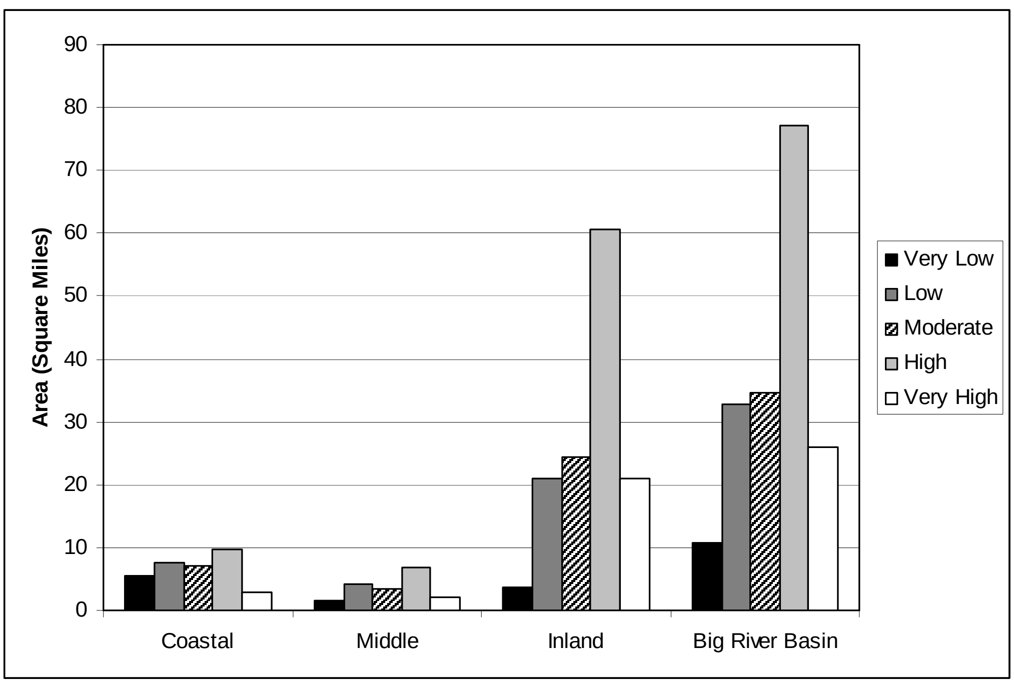


Figure 21. Area of each subbasin assigned to landslide potential categories (CGS 2005).

Fluvial Geomorphology

Channel Entrenchment

A CDF study of the Jackson Demonstration State Forest (JDSF) found that streams were often not connected to floodplains and off-channel areas (CDF 1999). Surveys by CDF showed that channels in North Fork Big River, East Branch North Fork Big River, Chamberlain Creek, and James Creek PWs are particularly affected by channel entrenchment (GMA 2001a).

CGS mapped (2005) the location and length of inner gorges throughout the basin (Figure 23). Inner gorges are geomorphic features consisting of steep slopes adjacent to channels. These inner gorges have formed along 14.6% of the blueline streams across the basin and were most common along blueline streams in the Inland Subbasin (Table 27). To look at the distribution of inner gorges across the basin, the percentage of inner gorge length along blueline streams in each subbasin was compared to the percentage of total blueline stream. Inner gorges did not appear to be evenly distributed, with less in the Coastal and Inland subbasins and more in the Middle Subbasin.

Table 27. Inner gorges in the Big River Basin.

Subbasin	Length of Inner Gorges (miles)	% of Length Along Blueline Streams	% of Total Basinwide Inner Gorge Length	% of Blueline Stream in Basin
Coastal	21.4	<1	30.2	16.9
Middle	1.5	3.3	2.1	9.2
Inland	48.8	13.6	69.0	74.0
Big River Basin	70.8	14.6	100	100

CGS 2005

Bankfull Discharge

CGS (2004) estimated bankfull discharge at a cross-section on the mainstem Big River at RM 8.7 using various methodologies. Floodplain identifiers suggested that bankfull discharge at the cross-section was 83 feet wide and 8 feet in mean depth. The estimate for bankfull discharge that CGS found most reliable was 5,600 cfs. CGS's bankfull discharge estimates are less than the bankfull discharge estimated by GMA (2001) and used in their Sediment Source Analysis. Thus, the GMA estimates of sediment discharge may be significantly overestimated. However, due to the exploratory nature of CGS's study, GMA results should not be rejected at this time. Further studies of bankfull width need to be conducted (CGS 2004).

Alluvial Sediment Storage

GMA (2001) found that fluvial-induced changes in alluvial sediment storage from 1936 to 2000 were relatively small. Non-alluvial channel boundaries in steep valleys, together with entrenched channel geometry and stable banks due to dense streamside forests reduce sediment storage opportunities across the basin. GMA found that much of the sediment that reaches entrenched channels in the basin is flushed into low gradient areas of the lower mainstem Big River over relatively short periods of time.

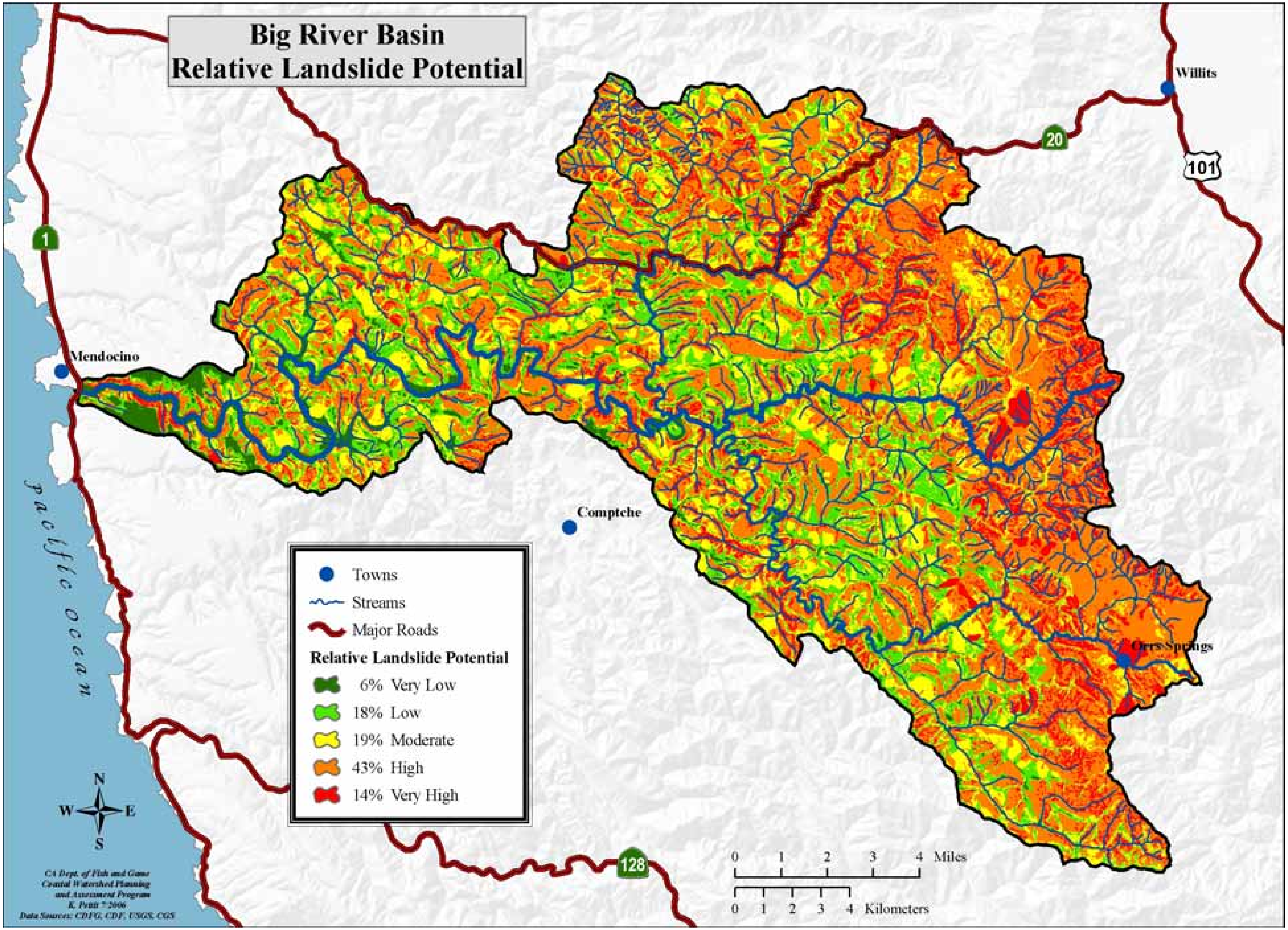


Figure 22. Landslide potential map for the Big River Basin (CGS 2005).

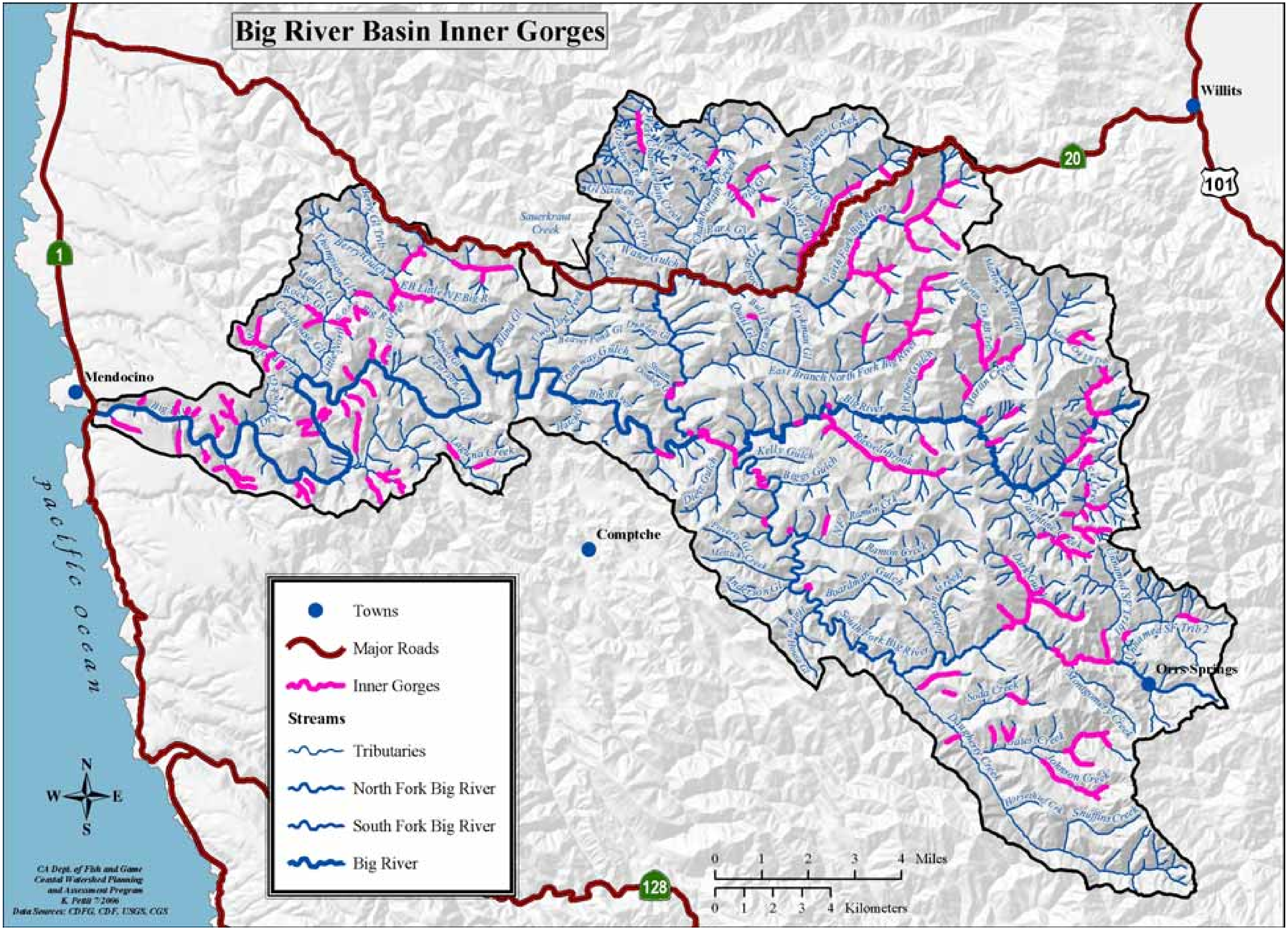


Figure 23. Inner gorges in the Big River Basin (CGS 2005).

Stream Gradient

CGS studied the distribution of stream gradients in the Big River Basin. Tributaries are steeper (>10%) than the main channels (Figure 24). The steeper gradients are source and transport reaches while the lower gradient channels are depositional reaches, which tend to accumulate and store channel sediment, including fine material trapped in interstices of gravel bars. These lower gradient reaches can become reaches of channel widening, decreased shading, and increased stream temperatures. The mainstem channel is especially low in gradient near the mouth of the Big River, <0.1%. Low-gradient reaches accumulate sediment and take longest to recover from channel disturbance.

Mappable Channel Features

CGS mapped and compiled fluvial features in several major channels within the Big River Basin from 1984 and 2000 air photos (Figure 25). General improvement between these years in the mainstem of the Big River, the North Fork, the South Fork, and Daugherty Creek were noted. Improvement was indicated by an overall net decrease in streamside erosion and accumulated bedload sediment (Figure 26). In spite of overall improvement, lower gradient reaches of the lower mainstem channel and estuary deteriorated, gaining elevated sediment. These are sites of accumulation and presumably aggradation. CGS (2004) found that deposition in estuary reaches is likely related to stream channels re-adjusting to a more natural discharge regime after the effects of splash damming (See the Coastal Subbasin for more details).

In 1984, CGS mapped 269 channel features of various lengths in major channels (Table 28). The features included both stable and unstable gravel bars, widened channels, and eroding banks. The total length of these mappable features was 26.5 miles, and 68% of the features by length indicated channel disturbance. Disturbance was represented by such things as lateral bars, mid-channel bars, eroding banks, and widened channels (about 18 miles in total length).

Between 1984 and 2000, major channel conditions generally improved as indicated by the decrease in the total number of mappable in-channel features from 269 to 221. The corresponding decrease in the total length of features was from 26.5 miles to 20.1 miles (Table 28). This represents a 24.2% reduction. Sixty-five percent (13 miles) of the mapped features in 2000 indicated channel disturbance. The net decrease in total mappable features was accompanied by, and partly accomplished by, the movement of bedload sediment to more stable in-channel features between 1984 and 2000.

Table 28. List showing number and total lengths in miles of mappable channel features in major channels, Big River Basin.

Date	Negative Sediment				All Sediment		Blue-Line Streams
	Length of Negative Sediments	% of Blue-Line Stream Network by Length	% of total Sediment Features by Length	# Negative Features	Length of All Sediments	# Total Features	Length in miles
Major Channels							
1984	17.9	3.7	67.7	219	26.5	269	485.9
2000	13.1	2.7	65.1	145	20.1	221	
North Fork							
1984	1.2	8.3	79.5	18	1.5	22	14.9
2000	1.1	7.6	62.1	13	1.8	22	
Mainstem Big River							
1984	12.0	28.2	63.5	113	18.9	155	42.6
2000	8.9	20.8	61.6	77	14.4	130	
South Fork							
1984	4.1	18.8	100.0	68	4.1	68	21.9
2000	2.5	11.6	74.6	48	3.4	63	
Daugherty Creek							
1984	2.1	23.8	95.8	25	2.2	26	8.7
2000	0.5	5.8	100.0	6	0.5	6	
Lower Mainstem							
1984	2.8	18.5	34.8	16	8.2	28	15.4
2000	5.3	34.7	66.5	24	8.0	40	

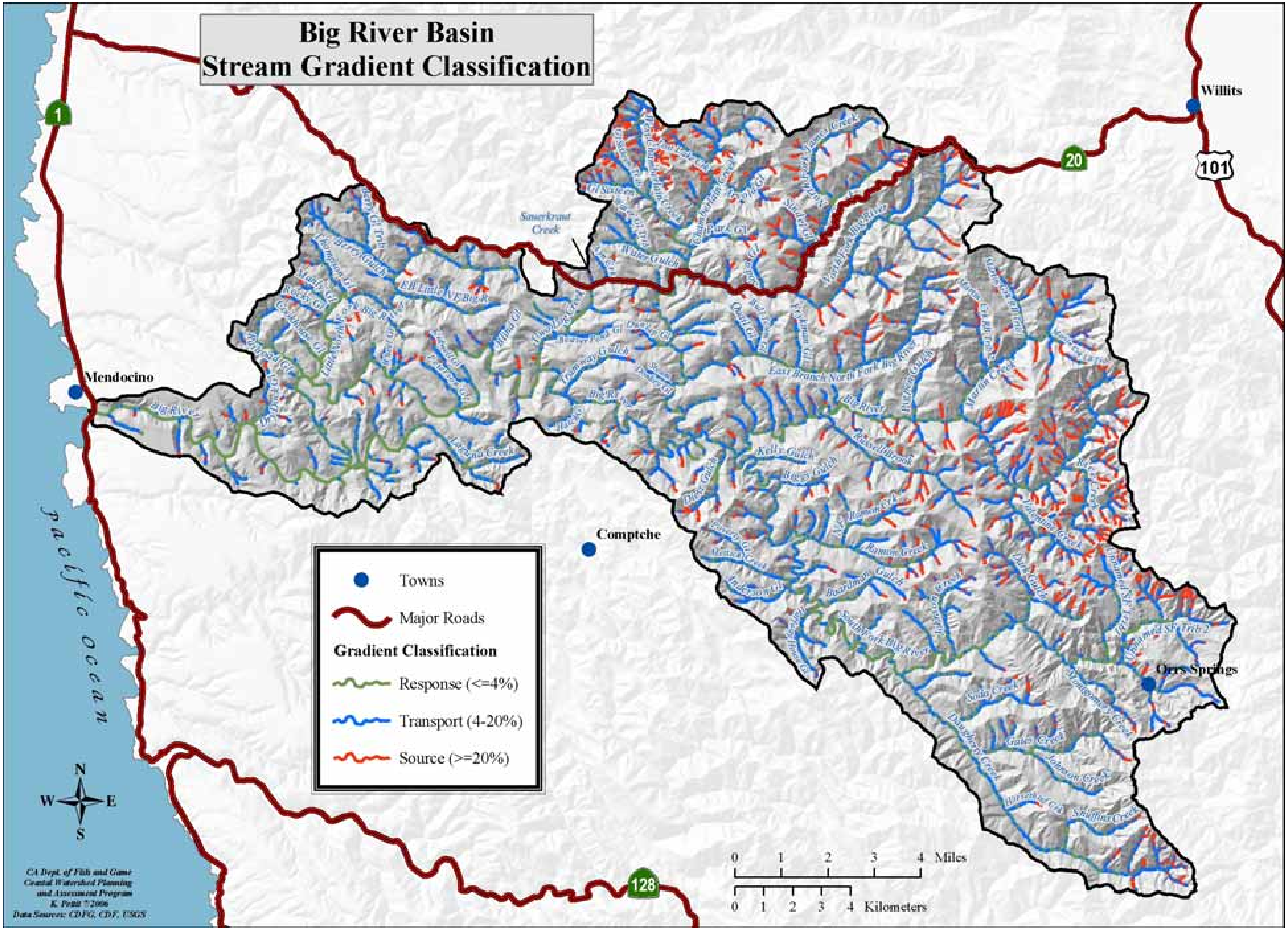


Figure 24. Stream gradients in the Big River Basin.

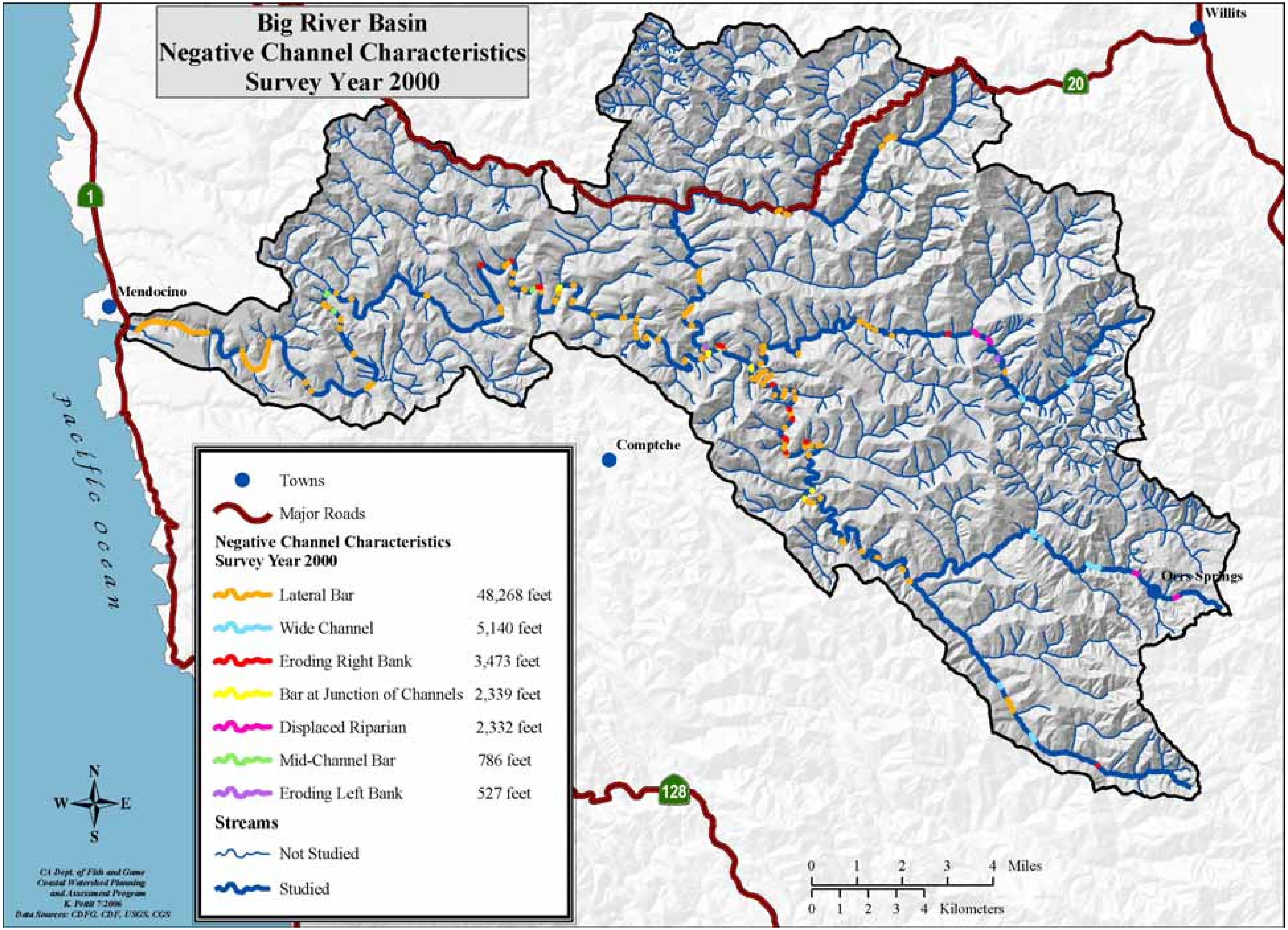


Figure 25. Mapped negative channel characteristics survey year 2000.

These characteristics may indicate excess sediment production, transport, and/or deposition in 2000 in major channels within the Big River Basin including the mainstem, North Fork, and South Fork Big River, and Daugherty Creek.

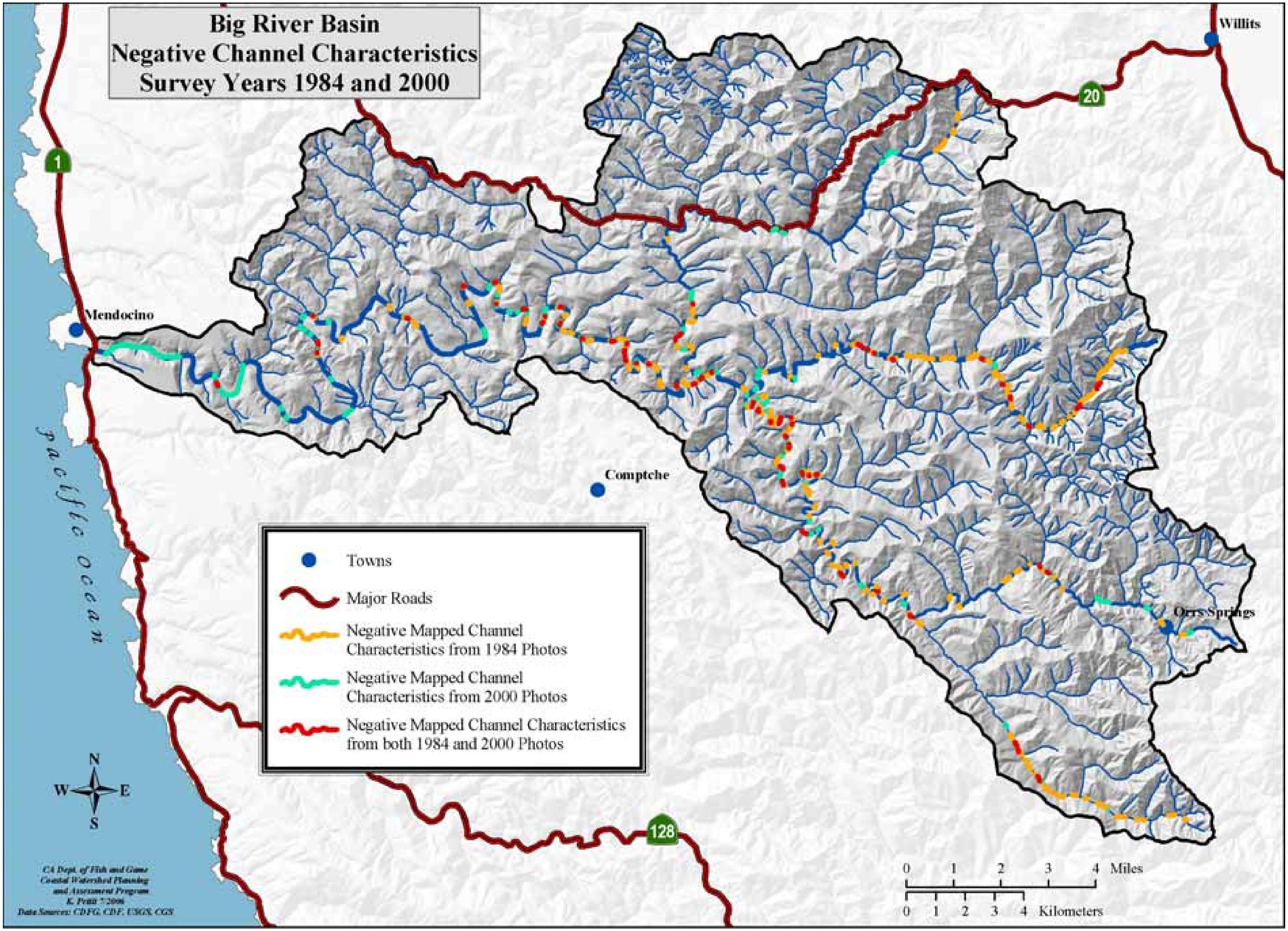


Figure 26. Mapped negative channel characteristics survey years 1984 and 2000.

These characteristics may indicate excess sediment production, transport, and/or deposition in 1984 and 2000 in major channels within the Big River Basin including the mainstem, North Fork, and South Fork Big River, and Daugherty Creek.

From 1984 to 2000, sediment accumulated preferentially in the lower 15 miles of the Big River where channel gradient is lowest. In the 1970s, a sand bar at the mouth of the Big River partially constricted water flow, and tidal water intruded into the channel 8.3 miles during the highest spring tides, making this the longest estuary in northern California at that time. CGS does not know the extent of vertical aggradation in the estuary nor does CGS know how the apparent accumulation of sediment in the estuary affected estuarine habitat between 1984 and 2000. Previous studies indicated that before 1984, the estuary was already greatly affected by accelerated deposition of sediment, which (1) created natural levees confining the channel, (2) cut off the marshes from salt water, (3) filled in sloughs, and (4) restricted the wetted area of the estuary. Previous studies suggested that the infilling of the estuary was accelerated in the late 1800s, concurrent with early timber harvest in the basin.

The mainstem channel is especially low in gradient near the mouth of the Big River. Such low-gradient reaches accumulate sediment and take longest to recover from channel disturbance. Major channel disturbances were probably caused by large storms during the 1950s through early 1980s, failures of older streamside roads, and downstream transport and accumulation of sediment stored in the mainstem and tributary channels. Areas of more unstable geology and more erodible geologic units tend to contribute more sediment to the stream network in tons per square mile. The disproportionate contribution from unstable areas is most apparent following large storms and wet years, such as 1983. Our 1984 photo mapping shows more mappable sediment stored in the channel. Further analysis of 1984 in-channel features with respect to hillslope geomorphology would show the spatial and temporal distribution of channel sediment with respect to geologic features.

Mainstem of the Big River

The mainstem channel generally improved above the estuary between 1984 and 2000. In 1984, mappable negative channel features occupied 28% of the blue-line stream length along the mainstem channel. In 2000, negative features occupied 21% (Table 28).

The lowest part of the mainstem channel accumulated sediment in the lowest gradient reach (<0.1%), within the Mouth of Big River PW (Figure 24). This area contains nearly one-third of the 43-mile total length of the mainstem channel, including about 8 miles of tidally influenced estuary.

Lower gradient stream reaches, such as the reach within the Mouth of the Big River Planning Watershed, take the longest to recover from channel disturbance. Their recovery rates are on the order of 50 years to centuries. In contrast, steeper tributary channels can take 5-10 years, or something on the order of decades, to recover from disturbance.

Vegetation

Prior to large scale timber harvest starting in the mid-1800s most of the Big River Basin supported mature coniferous forest, though original stands exist only in small areas today. Currently, redwood forests dominate the basin, but give way to Douglas-fir and oak woodlands in the upper elevations (Figure 27). Redwood in the Big River Basin typically occurs with Douglas-fir as a stand component, rather than occurring in pure stands. The Coastal Subbasin has the highest percentage of area in redwood-Douglas-fir stands (91%) and the Inland Subbasin has the least (68%), (Table 29).

Table 29. Acreage and proportion of area of vegetation classes in subbasins.

Class	Coastal		Middle		Inland		Total	
	Acres	%	Acres	%	Acres	%	Acres	%
Redwood - Douglas-fir	18,824	91	9,652	85	56,893	68	85,369	74
Douglas-Fir			219	2	10,991	13	11,210	10
Tan Oak, Madrone, Alder	363	2	1,032	9	4,521	5	5,916	5
White, Black or Live Oak & Bay Laurel			40		5,256	6	5,296	5
Blueblossom Ceanothus	645	3	150	1	62	0	857	1
Manzanita, Chamise, Scrub Oak					1,171	1	1,171	1
Bishop Pine, Pygmy Cypress, Willow	429	2			0	0	429	
Grass	283	1	180	2	4,749	6	5,212	4
Wet Meadows	31				0	0	31	
Water	176	1			0	0	176	
Barren / Rock	26		151	1	40	0	217	
Urban/Developed	2				0	0	2	
Totals	**20,779**	**100%**	**11,424**	**100%**	**83,683**	**100%**	**115,886**	**100%**

Douglas-fir does occupy some pure stands and, in an inverse ecological trend to redwood, the range is from none in the Coastal Subbasin to 13% of the area in the Inland Subbasin. In the Coastal and Middle subbasins the redwood-Douglas-fir type is predominant, but in the Inland Subbasin, redwood occupies the lower portion of the gulches and changes to drier species such as Douglas-fir and the oaks and grasslands up slope. Overall, hardwoods occupy about 20% of the basin and grasslands about 4%. Blueblossom (C*eanothus spp.*) and pampas grass are found in the Coastal and Middle subbasins and are usually a result of landscape disturbances.

Small sized trees that average 12-24 inches diameter at breast height (dbh) cover 62% of the basin (Table 30). Stands that average greater than 24-inch dbh trees cover 31.3% of the area, pole-sized trees cover 5.5%, and sapling-sized trees cover 0.9%. The Coastal Subbasin has the most acres of stands that average greater than 24-inch dbh trees, which may be a result of higher year-round precipitation. Most of the basin has a crown canopy density of over 80% (Table 31).

Table 30. Acres and percentage of vegetation in different size classes in the Big River Basin by subbasin.

Subbasins	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	%
Coastal	413	2.1	653	3.3	9,071	46.2	9,162	46.7	317	1.6
Middle	64	0.6	317	2.9	7,647	69.9	2,872	26.2	42	0.4
Inland	476	0.6	4973	6.4	50763	65.4	20640	26.6	812	1.0
Total Big River Basin	**954**	**0.9**	**5,942**	**5.5**	**67,481**	**62.4**	**32,675**	**30.2**	**1,171**	**1.1**

Table 31. Density of vegetation in the Big River Basin by subbasin.

Subbasins	Percent Crown Canopy Density										Total Acres
	0%		10-69%		70%		80%		90%		
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
Coastal	1,163	6	1,379	7	4,546	22	3,705	18	9,984	48	20,779
Middle	482	4	720	6	2,237	20	1,550	14	6,436	56	11,424
Inland	4,563	6	5,731	8	11,908	16	13,162	18	38,761	52	74,124
Total Big River Basin	**7,665**	**7**	**9,862**	**9**	**19,762**	**17**	**21,264**	**18**	**57,334**	**49**	**115,888**

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

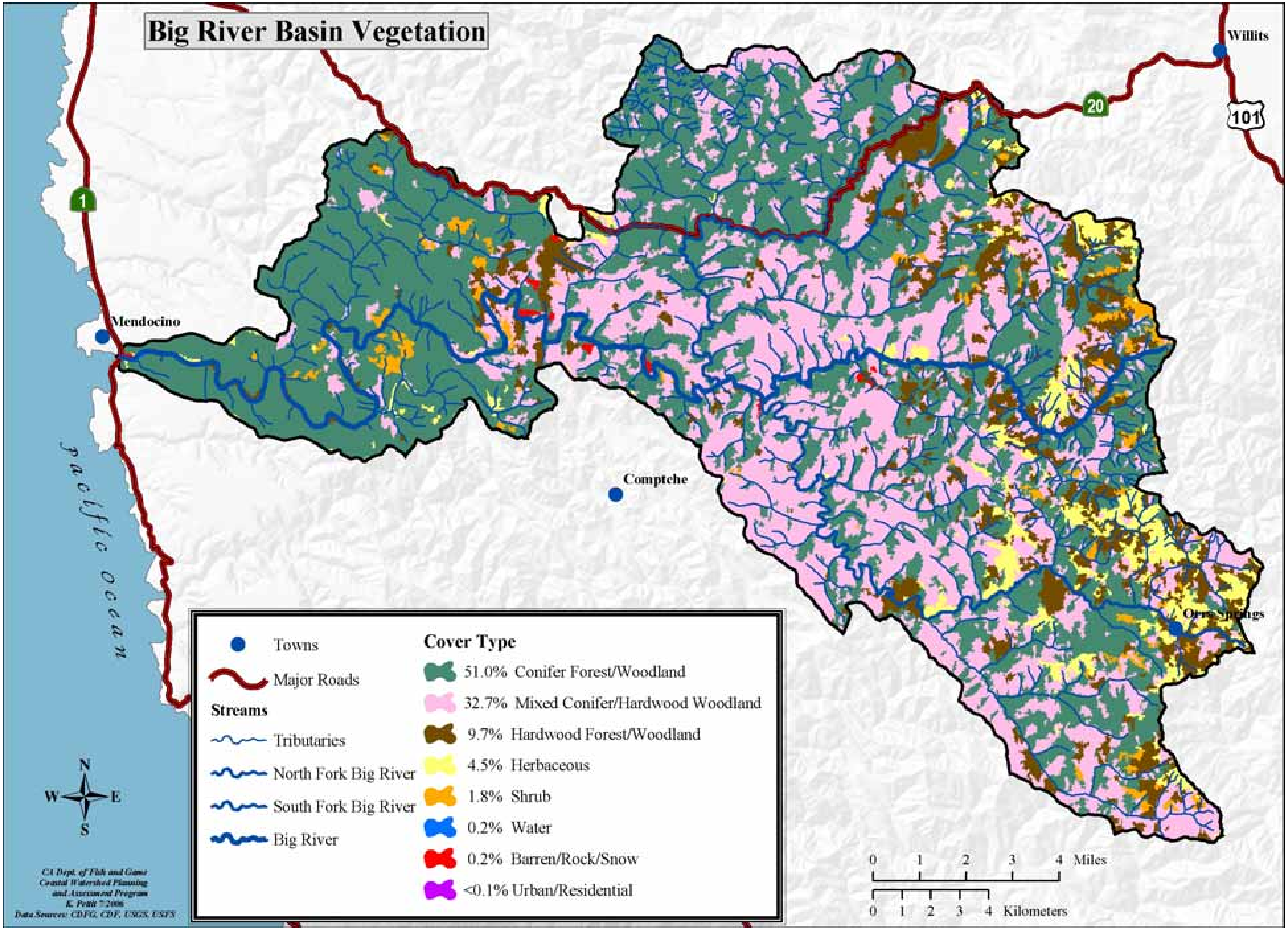


Figure 27. Big River Basin vegetation classes.

Fire History

Native Americans used fire as a land management tool. Specific practices and fire history are not known for all of the Big River Basin but information is available from research on the Jackson Demonstration State Forest (JDSF). This information indicates that redwood forests on the Mendocino Coast had a fire frequency of about 6 to 20 years during the 400 years prior to European settlement (Brown et al. 2003). Including surface fires, this burning interval is higher than previously reported in some studies, in part because of the tendency of redwood to obscure fire scarring. There was no clear trend of increasing fire frequency or intensity with increased distance inland from the coast. Most fires occurred during the late season of September through November when coastal fog generally dissipates and forest conditions are driest. These fires are thought to have been primarily started by Native Americans as a land management tool, clearing brush and providing a desirable landscape for their activities. As in the rest of the Big River Basin, JDSF wildfire activity ceased in the 1930s following the establishment of well-organized fire suppression forces.

There are five recorded wildfires in the Big River Basin in CDF records (Figure 28). The two largest were the 1931 Comptche wildfire and the 1950 Irene Peak wildfire. The Comptche fire was apparently ignited from slash piles and driven by high temperatures, low relative humidity, and strong northerly winds, the fire swept across the bordering Albion Basin and large sections of the Middle and Inland subbasins. There were actually several heads of the fire as residents frantically set back-fires to protect their property and families (Downie et al. 2003). Totaling about 29,600 acres, the fire destroyed homes and livelihoods, incinerated standing timber, the remains of the old log dams, railroad ties, trestles, and abandoned logging camps.

Current vegetation is the result of fire history in addition to timber harvesting and grazing. Interviews of nearby residents indicated that many ranchers burned the same areas every two or three years to keep the poison oak and brush down and logging slash was routinely burned after the original harvests. Management plans submitted by private landowners often state that range burning ceased in the 1960s.

Fire severity and hazard models generated by CDF indicate that fires have the ability to burn through large acreages and to severely damage both upslope and riparian areas. The fire hazard map (Figure 28) is strongly influenced by the current vegetation and proximity of residential housing.

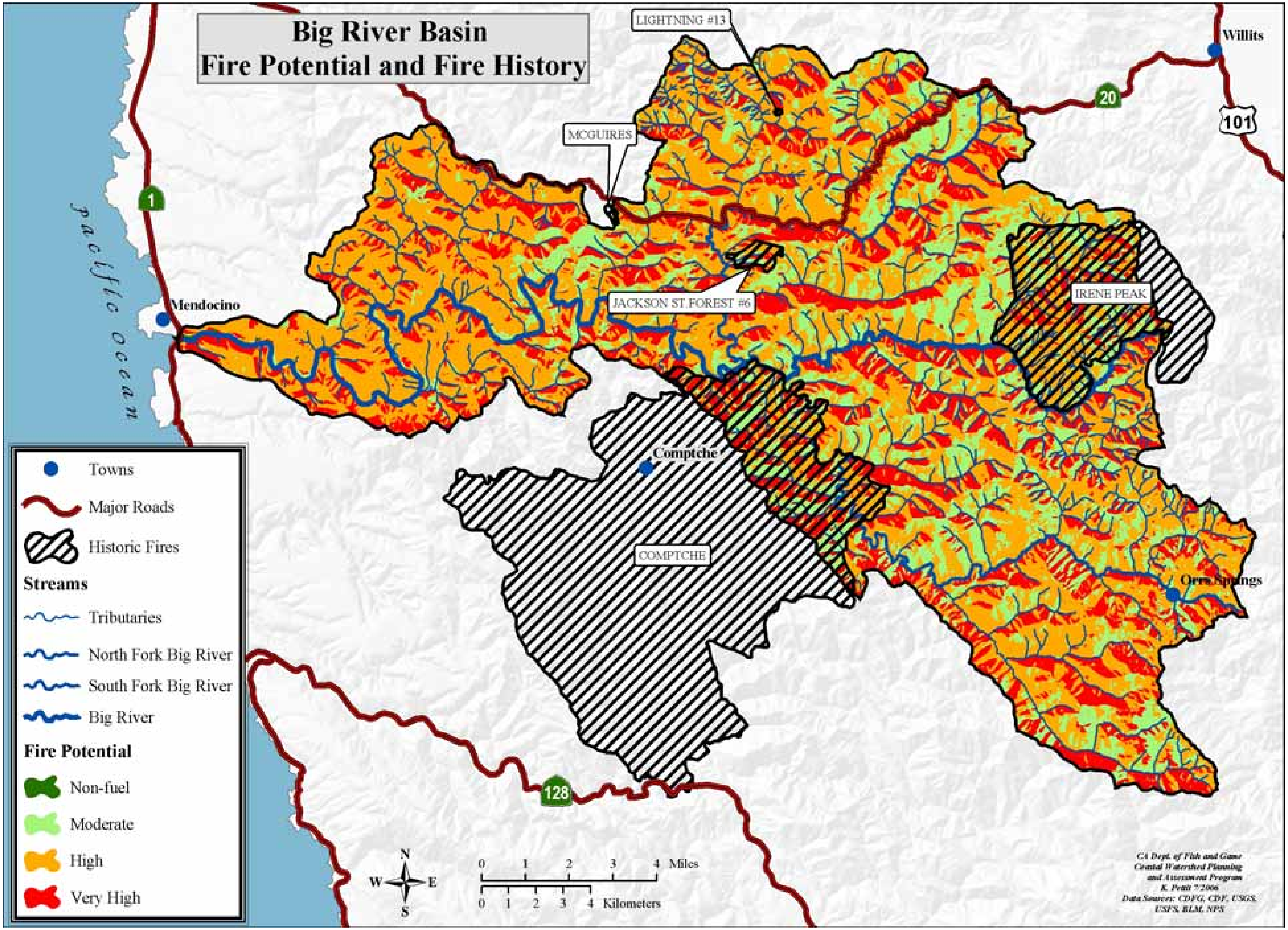


Figure 28. CDF recorded fires and fire hazard in the Big River Basin.

Population

There are no towns in the Big River Basin, though Mendocino, Little River, Comptche, and Willits are all within five miles of the watershed boundary. The total Big River Basin resident population estimated from the year 2000 census was 562 people (Table 32). Over half of the population lives in the Coastal Subbasin, which is close to the towns of Mendocino and Little River. The second most populous subbasin is the Inland, which includes Orr Springs. The town of Mendocino uses groundwater for domestic water needs. Population density across the basin is low, especially in the Inland Subbasin, which only has an estimated population of 197 across 131 square miles. The low population density and the use of groundwater mean that there is relatively little pressure throughout the basin from domestic diversion or consumption.

Table 32. Population and population density of the Big River Basin by subbasin.

Subbasin	Population	Area (Square Miles)	Population Density (Population/Square Mile)
Coastal	322	32.47	9.9
Middle	43	17.85	2.4
Inland	197	130.76	1.5
Total	**562**	**181.1**	**3.1**

Ownership

The Big River Basin is dominated by private land holdings, the largest three are owned by timber companies (MRC, Strategic Timber Trust, Hawthorne Timber Company) for a total of 29% of the basin, (Figure *29*). These companies are actively involved in managing the forest for silviculture. Weger is a family owned interest that also actively manages their forestland and is largest of the small landowners at 3% of the basin. Hawthorne Timber Company completed a land sale to the California State Parks system in 2002 creating the new 7,342-acre Big River State Park. State Park lands now comprise 7% of the basin. JDSF occupies 19% of the basin. JDSF is owned and managed by the State of California for the purpose of demonstrating forest management principles, recreation, and environmental conservation. It was acquired by the state from Caspar Lumber Company after much of the old growth had been harvested. Fifteen percent of the basin is owned privately in parcels varying from 40 to 1500 acres; 2% of the basin is in small private lots of up to 40 acres. Other than the town of Mendocino, there is relatively little human occupation in the watershed, with only scattered ranches and residences. Most of the smaller parcels are in the upper or east end of the basin and are dominated by grass or shrub lands.

Land Use

The earliest known inhabitants of the Big River were Pomo Native Americans. The Pomo village of Buldam was located near the present town of Mendocino. Little is known about this village, but the people there undoubtedly took advantage of the salmon runs in Big River, as well as the resources of the seashore and the coastal hills. The native populations along the coast were moderate in size and most of the Pomos lived in the Russian River Valley and at Clear Lake (Kroeber 1925).

Timber Harvest

Five key factors appear to have played a deciding role in how timber was harvested over time within the Big River and the North Coast in general: timber demand until the 1940s and after the mid 1940s, timber taxation, the first Forest Practices Act, the advent of the crawler tractor after World War II, and the modern Forest Practice Act in 1973.

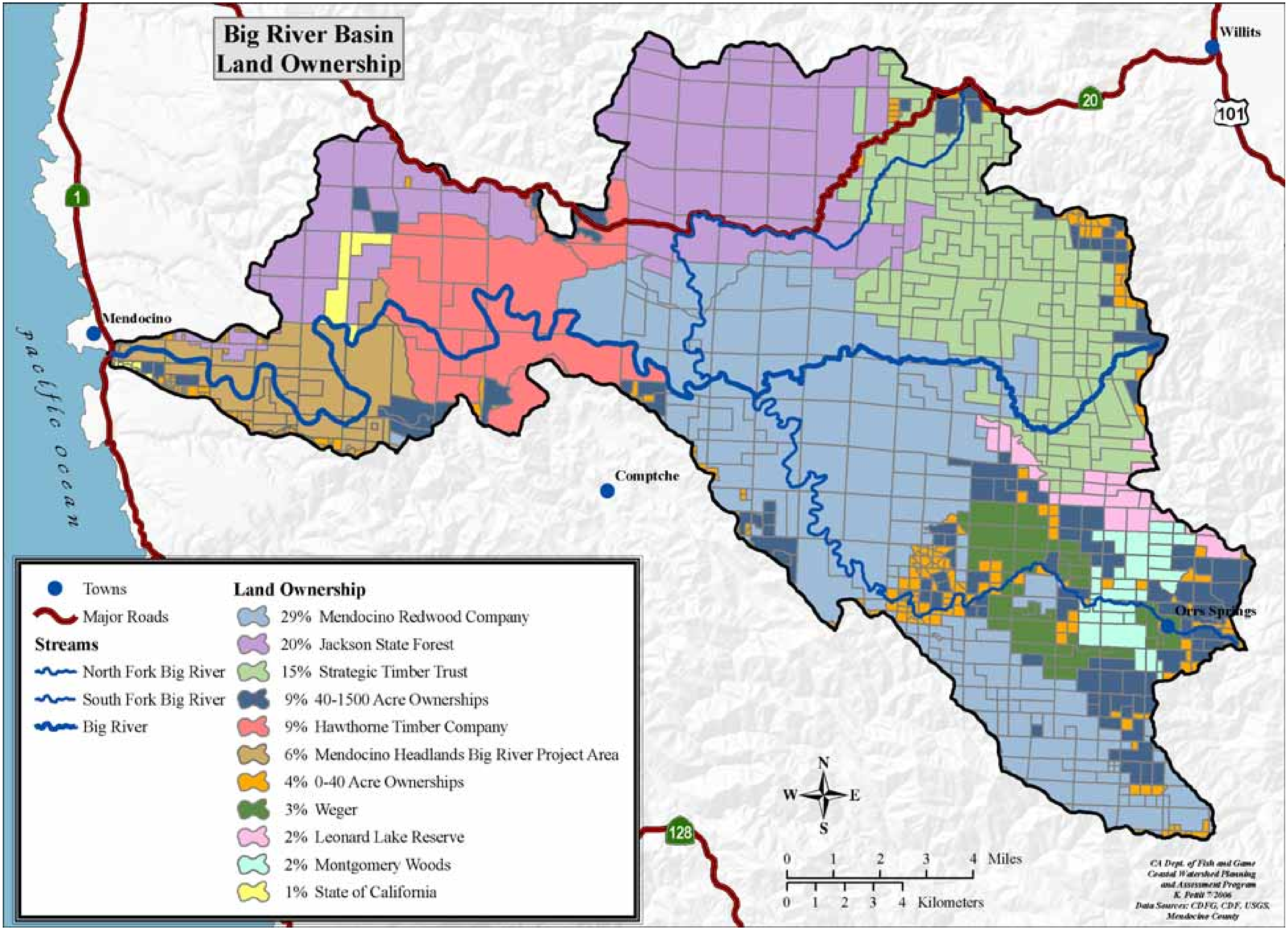


Figure 29. Big River Basin land ownership.

Following the discovery of gold in California in 1848, the demand for lumber in the state grew with the population. Logging in the Big River began in 1852 along the banks of the lower Big River around the time that the first mill was constructed in what was then known as Mendocino City. The mill was sited on the bluffs and an apron chute to load finished wood onto ships was constructed at the mill. Logs were kept in an enclosure at the mouth of the river, but this facility was continually being damaged by high river flows. In 1854, a new mill was built on the flat east of the present Highway 1.

In the early years, only those trees along the river that could be felled and then transported to the river via a rack and pinion device called a jackscrew were harvested. This pattern is evident in an aerial photograph taken in 1936, which shows a corridor of advanced second growth after the old growth had been removed along the river, trees grown back, and the old growth above the corridor was harvested in the 1920s. Loggers involved in these operations lived in large camps along wide flats on streambanks near the logging operations.

Cut-over streamside strips reforested quickly and by 1942 the basin contained some of the "finest redwood second growth in the state" (Fritz 1942). A University of California study in 1923 found 65-year old redwood second growth to contain 137,000 board-feet per acre.

Logging operations in the basin proceeded generally from the lower reaches in the early years, into the Little North Fork and Two Log Creek watersheds by the 1870s, then gradually into the headwaters over a period of 40-80 years. Logging in the South Fork began about 1888 (Jackson 1991). The early years of logging had one common theme, drag the log downhill to river, corduroy road, or track. The entire log was on the ground, thus it is called ground lead logging. Animals, primarily oxen, were used for yarding of logs until 1914 (Jackson 1991). The logs were usually dragged downhill and dumped into the river. Big River had 27 splash dams (Figure 30) that were then used to float logs downstream to the mill at the town of Mendocino.

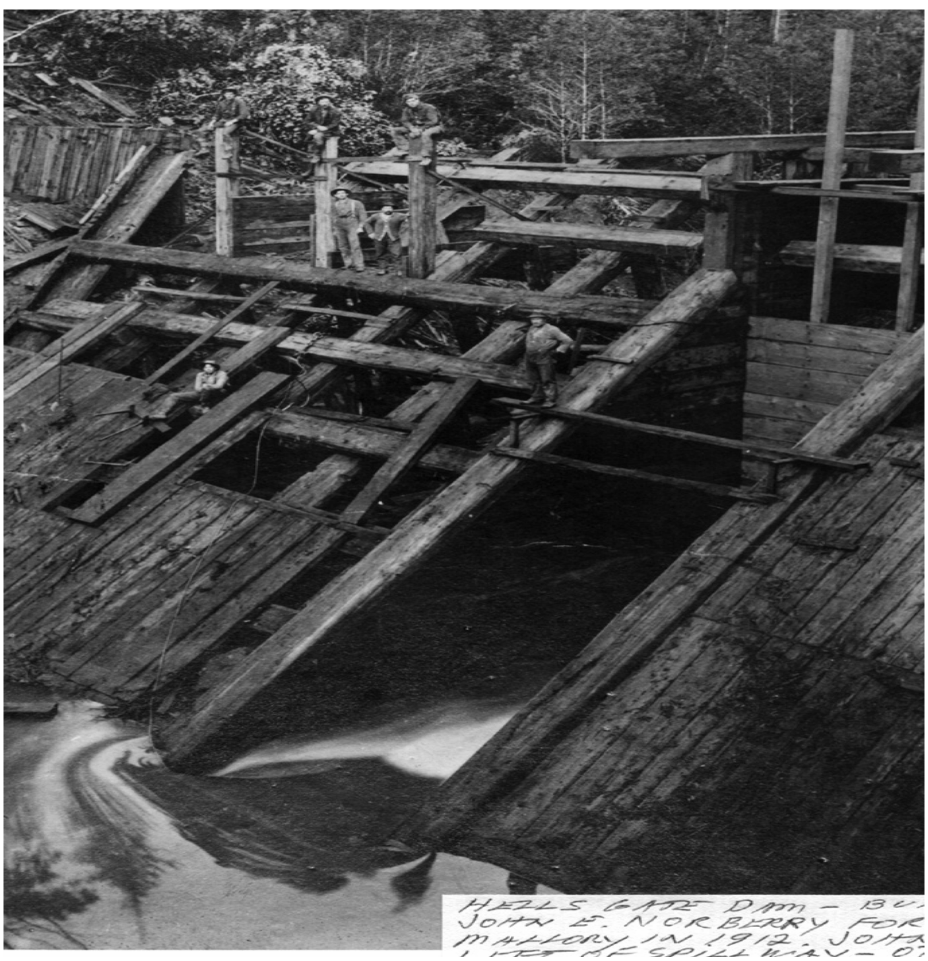


Figure 30. Hells Gate Splash Dam on the South Fork (1912).

Photo provided courtesy of the Mendocino Historical Society and the Held Poage Memorial Home and Research Library (from the Collection of Robert Lee).

Construction of splash dams began in about 1860 and continued through 1924. Some remained in use through 1937 (Jackson 1991) when the last raft of logs was floated down the North Fork Big River. The dams varied in size and construction methods, but ranged to as tall as 40 feet.

The last dam in the Big River was destroyed when it was burned by CDFG in 1972 or 1973 (Escola 2001). This was the Johnston dam on the upper mainstem Big River under Williams Peak. At the pleading of Escola, this dam had been preserved by the Resources Manager for Willits Redwood Company (present day Strategic Timber Trust) from destruction when they surveyed for a new road. Instead, WRC located the road above the dam. This dam was unique in that each joint in the construction of the dam had been ensured via mortise and tenons, or wood pins, so that the dam could later be easily disassembled and the logs transported to the mill and manufactured into lumber.

Big River was unique in that every log that went through the Mendocino Lumber Company mill came down the river, or at least through the estuary after being transported there via steam donkey and train. The last logs came through the mill in 1938 and were part of a cedar log raft that broke up in the ocean on the way down from Washington (Escola 2001). The company was the largest producer of lumber in Mendocino County until 1879.

CDFG, in conjunction with the Mendocino Lumber Company, built a fish ladder at the Hellsgate Dam on the South Fork Big River in 1927. The fish ladder was planned to allow coho salmon and steelhead trout access to spawning areas. In 1938, another fish ladder was added to the dam. The dam was later destroyed by fire in 1942 (Jackson 1991).

Steam donkeys were used beginning in the late 1800s until 1940 to move logs to the river or to a train line which ran up the lower portion of the mainstem. During the building of this track, a significant amount of hillside soil was pushed into the main channel to make room for the track bed and sidings, including one entire ridge cut back to make a wider turning radius (Jameson 2002). Other railroads were also built in the basin to aid in transporting logs (see page 92). Remnants of railroad trestles throughout the basin can still be seen today.

A log dump on RM 0.5 of the mainstem Big River operated from 1901 to 1936. Pilings were placed almost continuously between the piers and the millpond to assist in the transport of the logs to the mill and to prevent them from being swept out to sea.

From the 1880s to 1940s, entire slopes were clearcut of trees. Logs were dragged downslope to railroads and landings in stream bottoms resulting in major disturbance, including broadcast burning before yarding, massive stream filling and post-harvest debris sliding. In the 1930s and 40s there were massive attempts to convert timberland to grass for cattle grazing in the Middle and Inland subbasins.

The first tractor was used in the mainstem Big River in 1924, but tractors did not become heavily utilized until after World War II as they were big, bulky, and inefficient and could not compete with the steam donkeys. War requirements precluded further increase in use. Once the war ended, tractors became the principal means of skidding the large logs to the landings. Large skid trails were necessary due to the size of the equipment and logs. The large equipment and logs required the operator to put the blade down when going down hill to slow the tractor, resulting in more disturbance. Waterbreaks to curb erosion were rarely put in skid trails after logging.

During the initial tractor period logging arches were employed, which increased the size of these trails. The tractor-logging arch was developed on the Pacific Coast for skidding the large logs encountered there. It proved to be an effective tool for yarding logs in the redwood region. The arch was a large track or wheel mounted piece of equipment (Figure 31) pulled by a crawler tractor. In tractor arch operations, chokers were set to the log and the winch line of the tractor.

The logs were then winched up into the arch and the leading end hoisted clear of the ground. Due to the size of the tractor-arch combination there was a significant reduction in the maneuverability of the machine, resulting in an increase in the size of skid trails and landings. Each skid trail also needed a “turn around” for the tractor before it could connect to a turn of logs. These large, significant skid trails resulted in large cut banks, significant fills at low points and the increase in soil displacement. This combination of equipment, the manner of its use, and the disturbance almost certainly resulted in significant erosion and delivery of sediment to streams. Development of the integral arch eliminated the tractor arch operations, as the arch was now a part of the tractor and eliminated the need for a second piece of equipment.

Figure 31. Tractor arch operations.

Aerial photos and landscape photographs indicate that the yarding pattern during this period of logging was down the slope and drainage. Overall, ground disturbance was also increased due to the tractors' ability to construct large layouts in a relativity short amount of time. Layouts consisted of building a flat bed for the tree to fall into to cushion the blow and prevent it from breaking up upon impact. Not only was the layout made flat by moving the soil but mounds of soft soil were also pushed up along the lay to absorb the energy of the falling tree. A tractor-constructed layout was often up to 300 feet long and 20 feet wide. Once again, the harvesting practices of the day resulted in significant levels of soil disturbance.

From the 1940s to the 1970s, the predominant silvicultural method was the diameter limit cut because of the "Minimum Diameter Law" (Arvola 1977) and the "tax cut" because of the ad valorem timber tax. The Minimum Diameter Law required timber companies to leave standing timber for reforestation. This law prohibited the commercial cutting of coniferous trees of less than 18 inches in diameter unless a permit was received from the state, but was repealed in 1955. Standing timber was taxed on its assessed value on an annual basis until the time of the new timber yield tax law in 1977. The old tax law created an incentive to leave trees as the remaining timber was removed from the tax rolls once 70%of the volume had been harvested. The landowners would then move on to the next stand leaving 30%of the timber, usually the smallest. This was commonly called a "tax cut." Stands typically were entered several times as the remaining trees were harvested. Typically, they would harvest down to a 48-inch dbh in the first harvest then 24 to 36 and finally 18 to 20 inches until the original stand was harvested. Louisiana Pacific did one final cut, called the "shadow cut" of any tree over 12 inches regardless of age or vigor. Tractors were used almost exclusively without regard for watershed protections. The result was extreme damage due to roads, landings, and skid trails across very steep slopes and in virtually all skiddable watercourses accompanied by relatively high debris sliding post-harvest due to absence of erosion control and unprotected fill on steep slopes.

The post-war years and associated housing boom affected the Inland Subbasin more than the Coastal or Middle subbasins as most of the old growth already had been harvested there. The economic boom precipitated a need for Douglas-fir logs in significant amounts for the first time. Harvested lands resulted in areas that came back in vast tanoak stands, which are still evident today. Efforts at utilizing these hardwoods once they become large enough to saw have been met with some success, though landowners have been expending significant efforts and funds for years to reforest these areas with redwood and Douglas-fir.

The 1960s saw the first harvest of second growth focusing on the Coastal and Middle subbasins where the old growth had been harvested years before. Until 1973, the second growth was harvested by selection that removed half of volume, concentrating on larger trees using the same yarding systems as had been used in the old growth.

Harvesting of old growth timber was accomplished by stand replacing harvests or diameter limits cuts including seed tree cuts that removed the majority of the timber volume. These practices continued into the early 1970s. Timber harvest was occurring in the Big River Basin "practically to the bottom of small gullies, ravines, and stream courses. In some cases, ravines were completely blocked by bulldozing fill across them for passageways" (Perry 1974).

With the advent of the Forest Practice Act (1973), forestry experienced progressive improvement in road and yarding systems, but there were many landing failures from poor midslope roads in the 1970s and into 1980s. Landowners continued to selectively harvest the second growth until the 1980s, when clear cutting was instituted in the Coastal and Middle subbasins. Clear cutting constitutes 20 percent of the area harvested in the Coastal and Middle subbasins but less than 10 percent of all harvesting in the entire Big River Basin from 1980 to present.

Today a myriad of silvicultural practices are used to manage the young growth stands, resulting in more partial cutting with greater vegetation retention over the landscape and less disturbance in any one area (Figure 32). Clearcuts have been reduced in size from continuous, extensive areas to discrete units typically less than 30 acres in size. Buffers between even-aged management units were also required during this time period as part of the new rules.

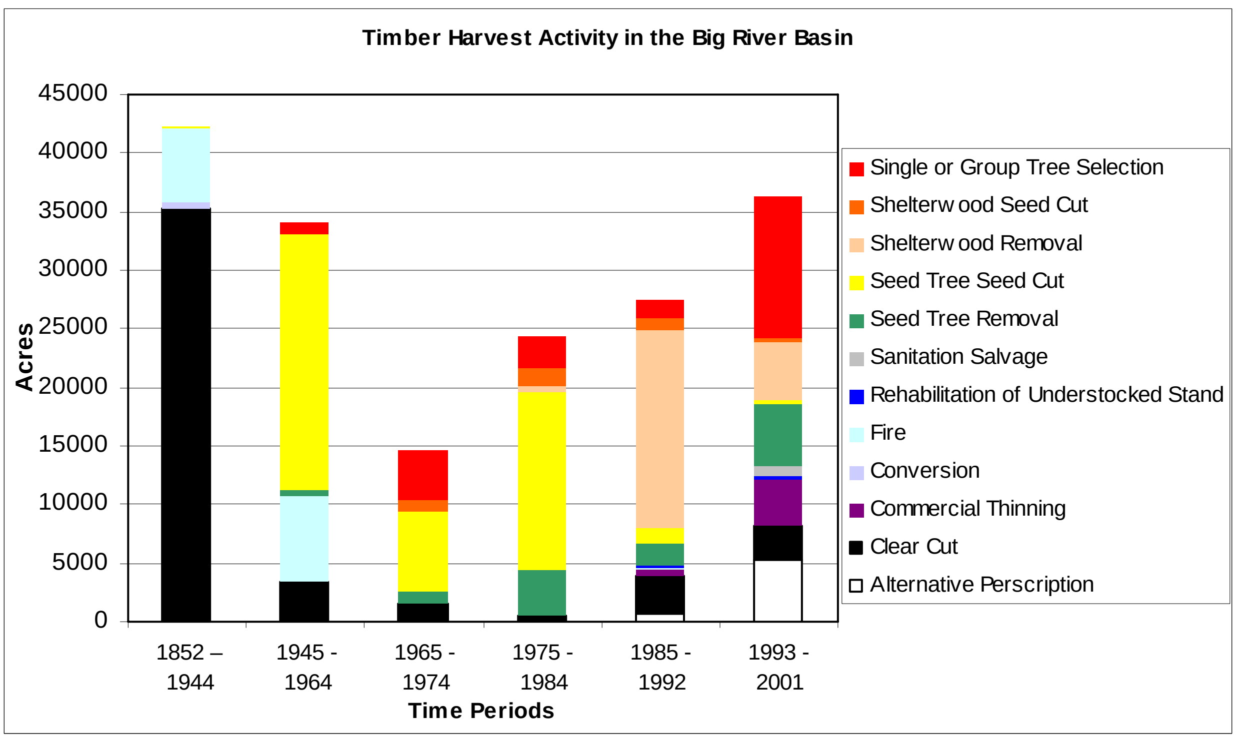


Figure 32. Acres of timber harvest activities in the Big River Basin.

Due to the gentle slopes in the Big River, tractor logging is currently the predominant method of harvest (Figure 33). Newer tractors are smaller and more nimble than those of the mid-20th century, resulting in less ground disturbance than occurred during logging of the earlier era. Modern cable yarding methods utilizing suspended cables with at least one end of the log off the ground were introduced in the 1980s.

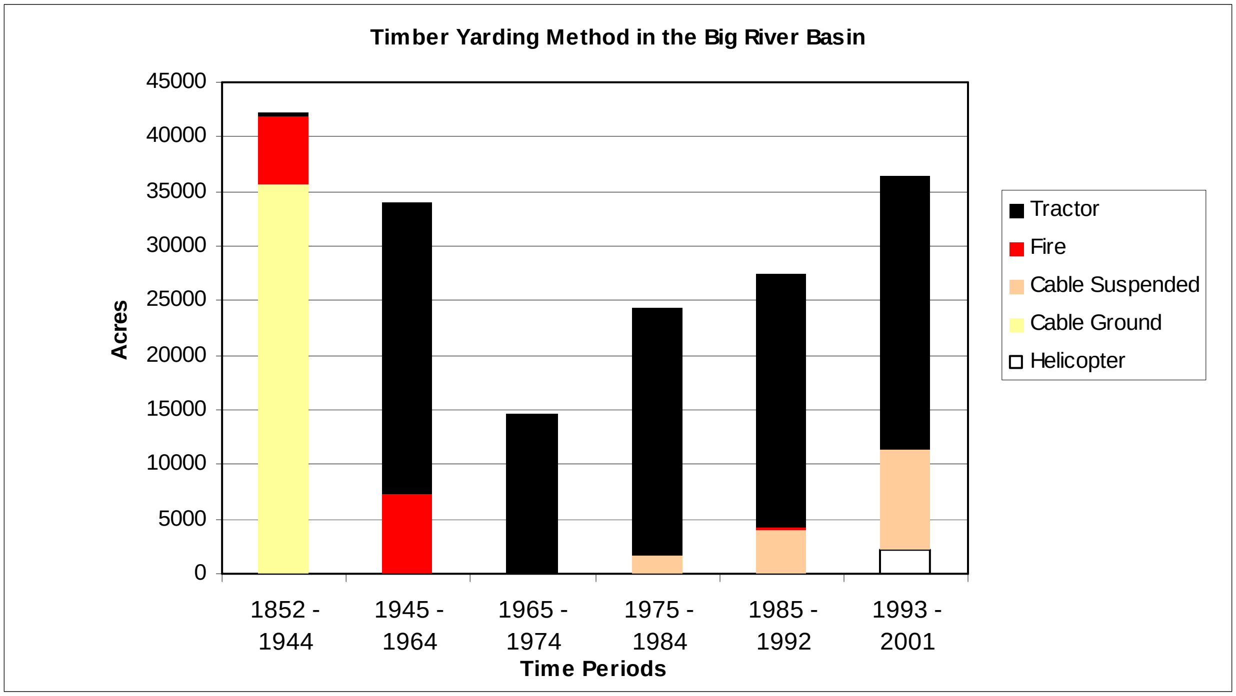


Figure 33. Acres of timber harvest yarding methods in the Big River Basin.

Along with the Forest Practices Act (1973), this technological change modified somewhat how timber was yarded within the drainage. There was an increase in the use of ridge top landings and mid-slope road construction. Whereas all logs were formerly yarded downhill to the creeks and river, it is now common to use suspended cables to log below roads and tractors above the roads. With the addition of stream protection zones in 1984 to the regulatory toolbox and refinements in 1993 these protection measures are quite visible on aerial photos.

While forest management practices have become less impactive in later years, the area harvested each year has increased. The Big River Basin is capable of growing well-stocked stands and producing high volumes of timber. As the stands cut during the original harvesting have grown back, harvesting is being repeated.

A significant number of acres have had activities more than once in the Big River Basin (Table 33). A third of the watershed area has seen activities only once since 1852; 79 percent or the acres have seen activities twice, 34 percent three times, and 8 percent have had activities four times. Fourteen percent of the area in the Big River has never had a fire, timber harvest, or been subjected to a conversion.

Table 33. Timber harvest in the Big River Basin.

Time Period	Acres Harvested	Percent of Basin Harvested
1852-1944	42,283	36.5
1945-1964	34,026	29.4
1965-1974	14,632	12.6
1975-1984	24,338	21.0
1985-1992	27,396	23.6
1993-2001	36,318	31.3
Total	**178,992**	

A CDF analyses of disturbance levels across the basin found that a total of 179,109 acres have had land use activity in the past 150 years. The first activity on 102,000 acres was in the high disturbance level category. Land use activities with high disturbance ratings were before 1985 (Figure 34). As much as ten times the timber volume per acre was removed during earlier logging of very large logs with heavy machinery and poor practices, resulting in very high impact to the watershed compared to after the Forest Practice Act. However, the more recent lower disturbance activities have been carried out over more acres per year in the basin.

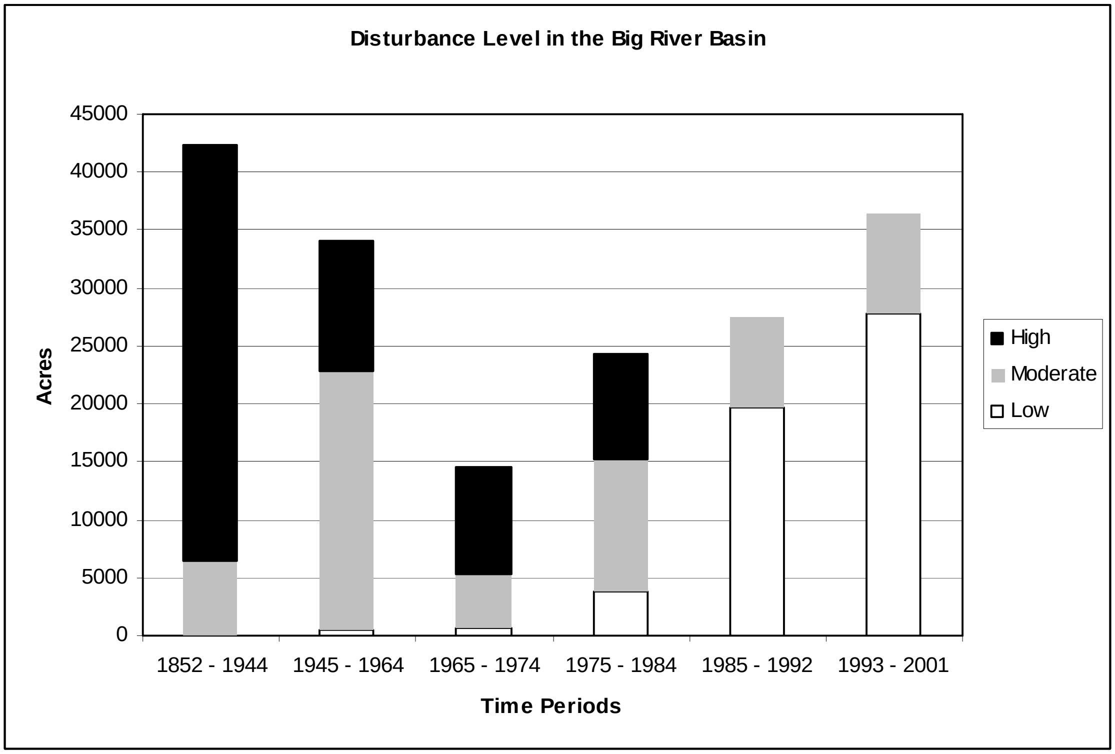


Figure 34. Disturbance level in the Big River Basin by time period and acres.

Roads

Truck roads and watercourse crossings in the basin date back to the late 1800s when the same alignment was first used by trains. Trucks were first used in the 1940s and railroad beds were converted to truck roads. Sixty four percent of roads were built before 1979, 32% are rocked surface from a local source, and 4% are paved. The paved roads are major highways or county roads. Road construction in the basin parallels timber harvest history, with an increase since 1989 as second growth timber came into maturity.

Historical roads in the basin are responsible for many legacy problems contributing sediment to watercourses today. With evolving changes in the Forest Practice Rules since the early 1970s, new harvest related road construction has to meet increasingly higher standards. These regulations cover construction activities such as operations on steep slopes, road alignment, road grades, erosion control, watercourse crossings, culvert installation, operations during the winter, and road maintenance. There are 1,242 miles of roads in the Big River Basin, which is 6.9 miles per square mile (Table 34, Figure 35).

Table 34. Truck roads in the Big River.

Period	Total Length in Miles				Length in Miles per Sq Mile			
Basin Wide	**Native**	**Paved**	**Rocked**	**Total**	**Native**	**Paved**	**Rocked**	**Total**
1852 - 1936	44.2	11.9	11.6	67.8	0.2	0.1	0.1	0.4
1937 - 1952	184.7	29.7	41.7	256.2	1.0	0.2	0.2	1.4
1953 - 1965	217.1	0.2	43.5	260.8	1.2	0.0	0.2	1.4
1966 - 1978	173.6		34.6	208.2	1.0		0.2	1.1
1979 - 1988	130.2		12.2	142.4	0.7		0.1	0.8
1989 - 2000	281.9	0.1	24.5	306.5	1.6	0.0	0.1	1.7
Total	**1,031.7**	**42.0**	**168.2**	**1,241.9**	**5.7**	**0.2**	**0.9**	**6.9**

Lengths are roads constructed in time period, not cumulative.

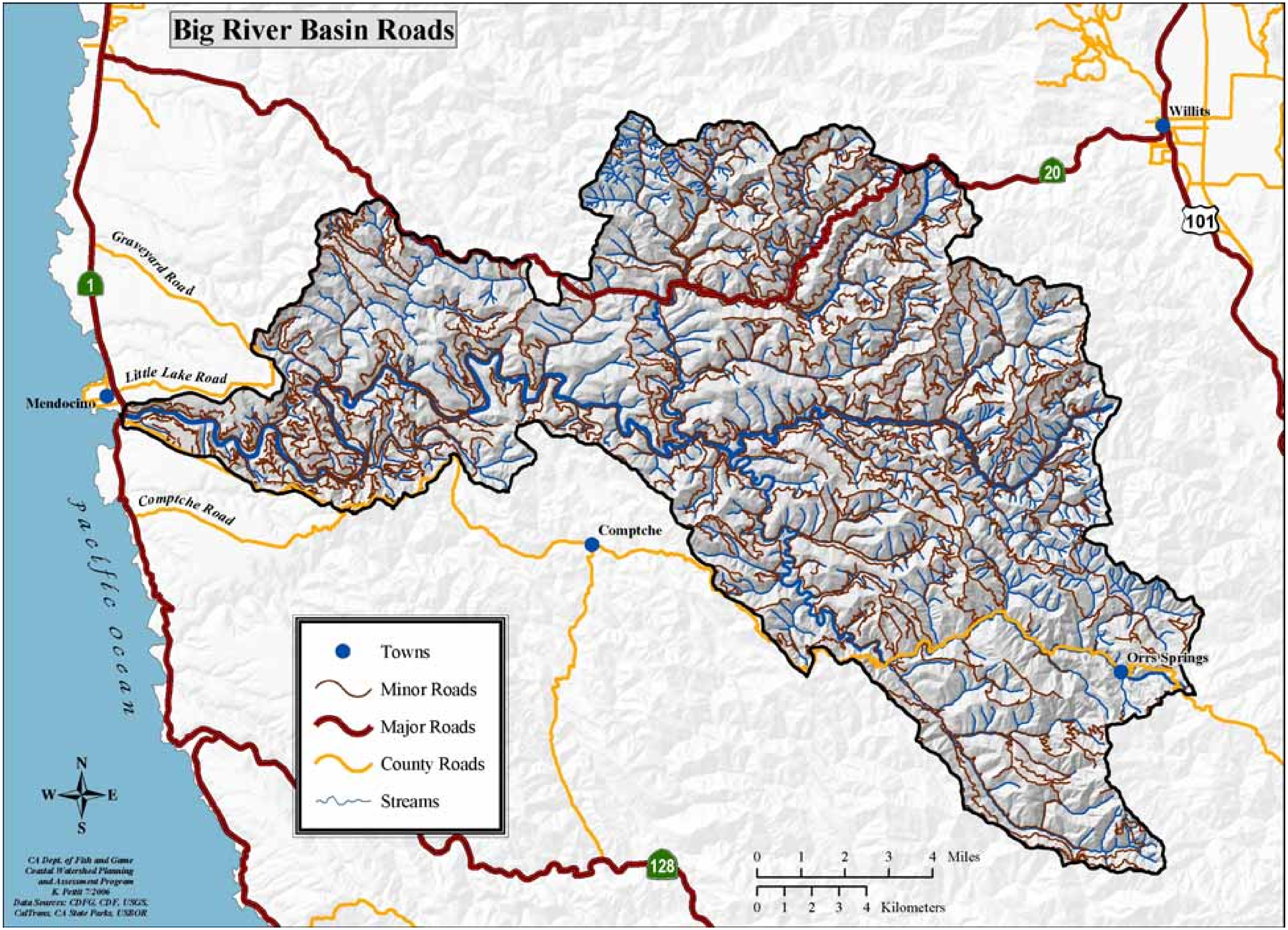


Figure 35. Roads in the Big River Basin.

Today, roads are being built to a higher standard, and larger and better watercourse crossings are being installed or upgraded. However, there is more partial stand harvesting and smaller harvest units today that will require more repeat use of existing roads. Many times historic roads were built, used for a particular harvest (typically very large units), then abandoned. On the surface leaving an area to stabilize may appear a good road practice, but the historical roads were built with no consideration for position on the slope, relation to a watercourse, minimum width or landing size, number of roads, diversion of water, or crossings that allow for water or fish passage. Construction on unstable ground was not even a serious consideration until the 1980s. Often, the easiest locations to build a road were in the creek bottoms and drag the logs down to the road. Long-term considerations were not legally required at the time, and we still experience legacy problems that continue to contribute sediment to watercourses today.

Historical roads are continually being upgraded, especially by the larger companies as they increase their level of stewardship in connection with harvesting timber. EPA noted (Geniella 1999) that the large landowners in the Eel River basin are bringing their roads up to a high standard, and the significant source of transportable sediment is due to the ranch and small landowners. This would appear to be true in the Big River as well.

Some of the techniques being used currently for abandonment of roads include the removal of watercourse crossings and re-contouring of the road prism (Figure 36, Figure 37 and Figure 39). Additionally, the number of roadside turnouts and large landings used for large old growth logging are being reclaimed (Figure 38).

Figure 36. Watercourse crossing at high risk of failing.

Figure 38. Reclaimed landing on mainline road.

Figure 37. Legacy watercourse crossing removal.

Figure 39. Abandoned road re-contoured to natural slope.

Railroads

Railroads were used in the basin for transporting harvested timber from 1885 to 1930. Locomotives were barged from the river's mouth to the middle of the estuary, where the railroad track began. The track extended upstream to the Little North Fork Big River, with branches into smaller tributaries (Figure 40). Other tracks were located in the Laguna Creek, Two Log Creek, and North Fork Big River watersheds. Some abandoned railroad grades were later converted into roads (GMA 2001a).

Public Lands

The relative remoteness, natural resources, and natural beauty of the Big River Basin have made it ideal for recreation, forestry demonstration, and conservation.

The National Park Service bought the 5,426-acre Mendocino Woodlands Recreation Demonstration Area (including 4,300 acres in the Big River Basin) in 1932 to provide a setting for activities that would introduce the public to the wonders of nature. A wood-and-stone campground facility, Camp I, was built in the Woodlands Area by the Works Progress Administration and the Civilian Conservation Corps (CCC) in 1936. Camp I was first occupied in July 1938 and gave birth to the Jack and Jill Family Camp in 1960- the first all African-American camp in the United States. The campground was one of 46 created across the country (including Camp David) during the 1930s.

In 1947, the Woodlands Area was transferred to the State of California explicitly for park, recreation, and conservation purposes. The Woodlands Area now consists of three parts: Mendocino Woodlands State Park (780 acres), a Special Treatment Area or STA in JSDF to create a buffer around the campground in the park (2,550 acres), and a part of JSDF (2,155 acres). The Woodlands Camp in the state park contains the group camping facility that is also a National Historic Landmark.

In 1942, University of California forestry professor Dr. Emmanuel Fritz suggested that California should create a state forest system to return timberlands to full productivity and thus ensure stable employment. The state Board of Forestry supported his ideas and a bill authorizing the state to purchase land for state forests was signed into law in May 1945. Fritz had proposed that the Big River Basin met the requirements for a state forest system particularly well (1942). Perceived advantages of the Big River Basin as a state forest included the high average site quality for timber, few large ownerships, large amount of second growth redwood, and high recreational opportunities. JSDF was purchased by the state in 1947 and includes 35.5 square miles of the basin.

In 1945, Robert Orr donated nine acres for the creation of a redwood reserve along Montgomery Creek in the Inland Subbasin. Since then, the Montgomery Woodlands State Reserve has grown to 1,142 acres and is reported to contain one of the world's tallest living trees. This coast redwood is 367 feet and 6 inches tall (112.0 meters) and has a diameter of 10 feet and 4 inches (3.14 meters). It is estimated to be over 1,000 years old. It was declared the tallest tree in 1996; however, a 370 foot (112.7 meters) tall tree was found in Humboldt Redwoods State Park in 2000 (Guiness World Records 2006). There is currently a proposal to expand the reserve by 1,240 acres.

In 1979, the USFWS commissioned an Environmental Assessment to help determine how a 3,000-acre parcel including the Big River Estuary could best be protected. The Big River was being considered for protection under the USFWS Unique and Nationally Significant Wildlife Ecosystem Program, which seeks to "identify, evaluate, and seek methods to assure protection and perpetuation of unique and nationally significant wildlife ecosystems." A large-scale inventory of potential sites in California identified 60 potential sites for protection. Of these, Big River was ranked as the sixth highest priority. Upcoming Timber Harvest Plans in the Big River Basin elevated the basin to the highest priority for protection in California. USFWS considered a variety of alternatives for protecting the Big River Estuary including no action, ecosystem management agreements, and USFWS acquisition. The Environmental Assessment concluded that the goals and objectives of the Unique Wildlife Ecosystem Program would be maximized with the USFWS acquisition alternative. However, this option was not realized at that time.

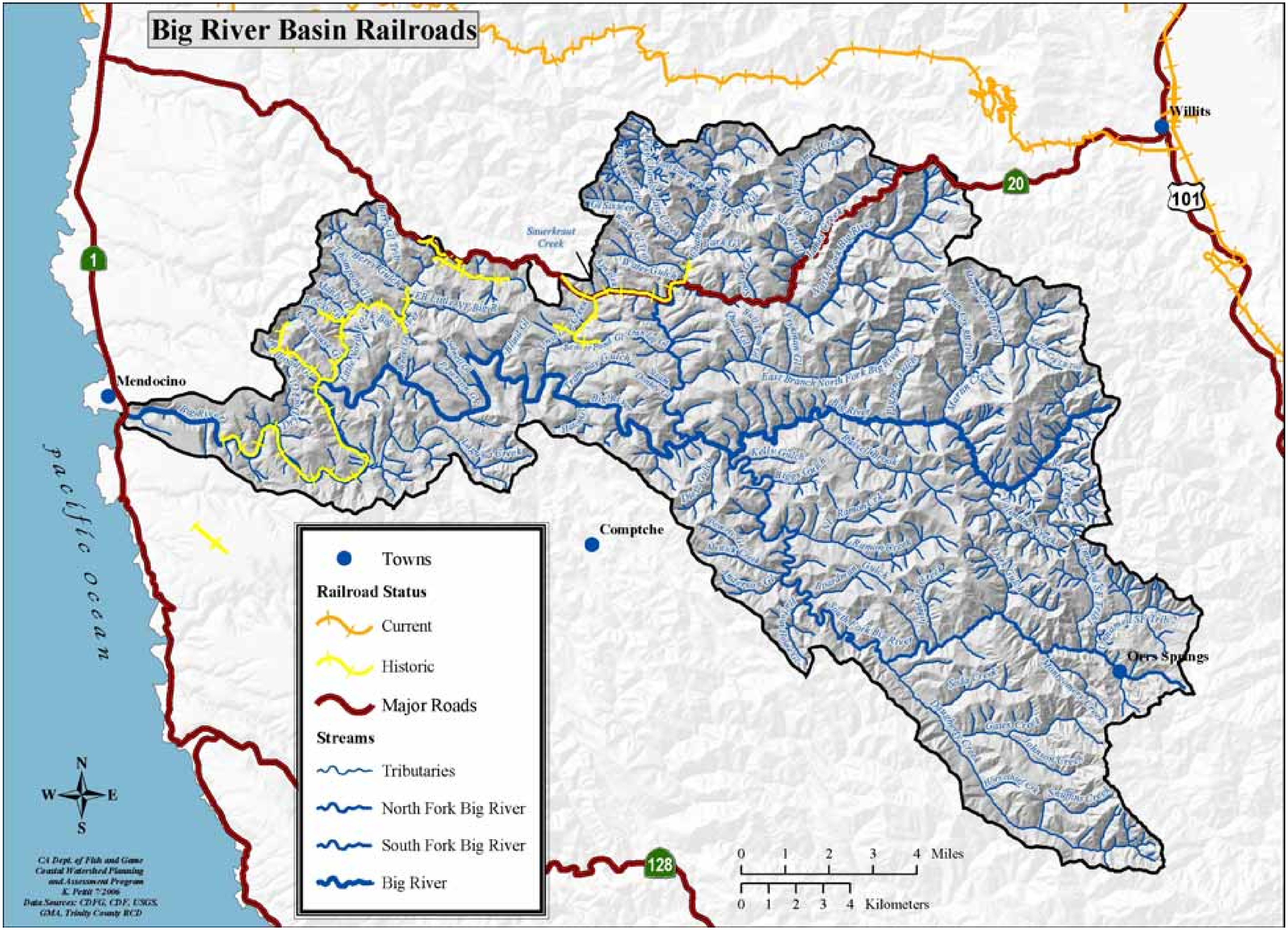


Figure 40. Big River Basin railroads.

In 1999, the Big River Estuary area was purchased by Hawthorne Timber Company. Local environmental activists and the Mendocino Land Trust protested prospective logging and Hawthorne Timber Company agreed to sell the land to the Trust for the estimated fair market value of the redwood timber on the land. The money was raised and the land was purchased by the Land Trust in 2002.

The Land Trust then deeded the land over to the California State Park system to create the Big River Unit of the Mendocino Headlands State Park. The addition of the 7,334-acre Big River Unit to the state park system created a 74,000-acre wildlife corridor linking coastal and inland habitats into the largest piece of connected public land entirely within Mendocino County. The acquisition also created 60,000 acres of contiguous public lands with more than 100 miles of joined trails.

Land Management

In 1997, the Big River Watershed Council submitted watershed guidelines for the Big River Basin to the National Marine Fisheries Service (NMFS). The purpose of the proposed guidelines was to provide NMFS with a set of guidelines to protect coho salmon and their habitat throughout the basin. The Watershed Council wrote guidelines in six categories:

- Protection of Key Watersheds:
  - No new roads should be built in roadless areas (over 5,000 acres);
  - Reduce existing road system and non-system road mileage outside road-less areas; no net increase in the amount of roads;
  - Watershed analysis is required prior to major management activities such as road building or timber harvest.
- Protection of Riparian Reserves:
  - Timber harvest is prohibited in riparian reserves;
  - Riparian reserves should not be included in calculations of timber base.
- Timber Harvest Restrictions:
  - All timber harvest is to be conducted in accordance with Institute for Sustainable Forestry Guidelines for sustainable forestry;
  - Timber harvest within a watershed or on a given ownership greater than 10 acres will be limited to 2% of inventory per year as described in the Mendocino County Forest Practices Rules;
  - Clearcutting is prohibited on all ownerships except for single-family residential purposes.
- Restriction of Use of Pesticides:
  - No pesticide spraying on wildlands or public or private roads or highways within wildlands within the Big River Basin (wildlands are all areas away from residential or business areas or the immediate area surrounding homes, businesses, or residential gardens or landscapes).
- Prohibition of Additional Water Appropriation:
  - There will be no additional drafting or allocation of water from any surface water source within the basin;
  - There will be no additional dams that will adversely affect any surface water source within the basin.
- Monitoring:
  - A specific program to monitor both the coho salmon population of Big River and the habitat at the watershed level will be developed and funded prior to authorization of further timber harvest on commercial forestlands within the basin;
  - Specific monitoring programs for site-specific monitoring of timber harvest areas to be done by qualified third parties will be designed and funded before additional timber harvest is authorized;
  - Monitoring plans will be approved by the Big River Watershed Council.

These guidelines are presented here for informational purposes and not meant to imply endorsement.

Water Quality

Water Temperature

With the exception of the Big River Estuary, continuous water temperature data were available for each subbasin, though not for every stream or year. Maps of sample locations are in the subbasin sections of this report. Water temperatures in the mainstem Big River were unsuitable in virtually every location tested, and the daily maximum temperatures measured sometimes exceeded the lethal threshold for salmonids if fish could not find thermal refuge.

Tributary samples in the Coastal Subbasin had fully suitable to moderately suitable water temperatures. It is likely that this is due, in large part, to the cooling marine influence in this subbasin. Overall, the water temperature in the Coastal Subbasin tributaries appear to be the most suitable in the Big River Basin. In addition, it is likely that the Little North Fork has some local cooling effect as it enters the mainstem Big River.

Tributaries in the Middle Subbasin had fully suitable to undetermined water temperatures. While the data in this subbasin are relatively sparse, it is likely that the marine influence in this subbasin and rapid re-growth of vegetation helps keep water temperatures relatively low. The tributaries that were monitored appear to be suitable for salmonids. It is likely that Two Log Creek has some local cooling effect as it enters the mainstem Big River.

Tributaries in the Inland Subbasin had fully suitable to fully unsuitable water temperatures. Generally, the tributaries that were monitored in the North Fork drainage appear suitable while tributaries in the South Fork and headwaters drainages appear to be unsuitable for salmonids.

The lower mainstem South Fork Big River had the highest daily water temperature (74°F) of any stream other than the mainstem Big River. It also appears that the upper mainstem Big River is one of the origins of the warm water seen downstream. Water leaves North Fork Big River with an MWAT of roughly 67°F; headwaters of Big River with an MWAT of roughly 66-68°F; and South Fork Big River with an MWAT of roughly 67-69°F.

Notable exceptions to general patterns in the Inland Subbasin are Lower Chamberlain Creek, most of the East Branch of the North Fork, the mainstem of the North Fork, one site in Montgomery Woods State Reserve, and tributaries dominated by groundwater. The mainstem North Fork is unusual in that it exhibits a rapid increase in water temperature upstream of the JDSF boundary, and then slowly declines until it leaves JDSF, and again shows a rapid increase near the confluence with the mainstem Big River. This may be due to naturally poor canopy or to commercial timber harvesting on either end of the North Fork. In any case, this should be investigated further. It also appears that the North Fork is one of the origins of the warm water seen downstream in the mainstem Big River. Conversely, the site in the Montgomery Reserve is a good example of what can be achieved with adequate canopy in the warmer interior portion of the basin.

Trends

In 1973, the USFWS (Perry 1974) recorded water temperatures at six sites in the Big River Basin as part of a Fisheries Improvement Study. Additional observations were also made of water temperatures in other sites. The study found that water temperatures in some streams exceeded 65°F almost every day from May through August with extreme high temperatures reaching the low 80s. Water temperatures in higher elevation tributaries without overstory cover along significant reaches of stream often exceeded 80°F. Researchers observed large numbers of fish grouped “in search of shade in pools.”

MWATs, MWMTs, and maximum temperatures calculated from continuous data loggers were compared to recent water temperature data at the similar locations. The site monitored in the Coastal Subbasin (mainstem Big River at the confluence with Little North Fork Big River) could not be matched exactly with a recent monitoring site. However, recent water temperatures at two nearby sites on the mainstem Big River were fully unsuitable while temperatures recorded in 1973 were moderately unsuitable.

The site monitored in the Middle Subbasin (mainstem Big River below the confluence with North Fork Big River) had moderately unsuitable water temperatures both in 1973 and during recent monitoring.

Four sites were monitored in the Inland Subbasin in 1973. Water temperatures in the North Fork Big River at the confluence with Chamberlain Creek decreased from fully unsuitable to undetermined or somewhat unsuitable while temperatures in the East Branch North Fork Big River increased from fully suitable to undetermined. One site monitored at the confluence of South Fork Big River and Daugherty Creek had moderately unsuitable water temperatures in both 1973 and during recent monitoring. The site monitored in mainstem Big River at Pig Pen Gulch showed a decrease in temperature from fully unsuitable to moderately unsuitable.

Since there were so few sample sites in 1973, no overall trends for the Big River Basin can be determined. However, increasing water temperatures in the East Branch North Fork Big River could be cause for concern while decreasing water temperatures in the North Fork Big River at Chamberlain Creek and mainstem Big River at Pig Pen Gulch may indicate recovery. Additionally, the differences could fall within the range of natural variation.

Sediment

A variety of sediment related field data have been collected in the Big River Basin, including pebble counts, V*, permeability, stream cross-sections, thalweg profiles, bulk sediment samples (McNeil), and turbidity and suspended sediment samples. Unfortunately, a large portion of these data are of limited duration or are not comparable to other data collected by others in the Big River Basin due to differing analysis techniques. Thus these data are not useful for trend analysis.

In the Coastal Subbasin, pebble counts, V*, bulk sediment samples, and turbidity samples were collected at various locations and times. Pebble count and V* measurements collected at one site in Berry Gulch during one year indicated excessive amounts of fine material in the stream. Bulk sediment samples collected in the Little North Fork indicate excessive sediment in sub-0.85 mm and sub-6.5mm size classes that generally exceed the TMDL limits for these size fractions.

A total of 88 useable turbidity samples were taken on the mainstem Big River, both upstream and downstream of the confluence with the Little North Fork Big River. Measurements indicate that 90% of all samples collected were at or below 52 NTU with a maximum recorded level of 600 NTU. The turbidity sampling conducted at these sites, combined with additional sampling, can eventually establish the range of background levels. Turbidity that is significantly elevated above background levels is not suitable for salmonids and can be an indicator of potential problems with suspended sediment.

In the Middle Subbasin, bulk sediment samples, stream cross-sections, thalweg profiles, and permeability measurements were collected at various locations and times. Bulk sediment samples collected in Two Log Creek indicate excessive sediment in sub-0.85 mm size class that generally exceeds the TMDL limits for this size fraction. Other bulk sediment data were collected by GMA and MRC. However, due to differing analysis techniques, these data are not comparable to each other or the TMDL limits. Permeability measurements on the mainstem Big River indicate low to moderate amounts of fine sediment when compared to similar sites at other locations in the Big River Basin. This is somewhat verified by the bulk sediment sample collected at the same location. Stream cross-sections and thalweg profiles were only collected during one year, so they are reported but not used in this assessment.

In the Inland Subbasin, bulk sediment, permeability, stream cross-sections, thalweg profiles, and suspended sediment and turbidity samples were collected at various locations and times. Bulk sediment samples collected at various locations in the North Fork and in Chamberlain Creek suggest 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. Bulk sediment samples collected in the South Fork drainage indicate mostly mixed results with no trends evident.

Permeability measurements on the East Branch North Fork site indicate low to moderate amounts of fine sediment when compared to similar sites at other locations in the Big River Basin. This is somewhat verified by the bulk sediment sample collected at the same location. Permeability sampling also indicated significant fine material at the Daugherty and Ramon creek sites. The South Fork Big River site appeared to have less fine material and likely better spawning success. The permeability conclusions at Daugherty Creek, Ramon Creek, and South Fork Big River are somewhat supported by bulk sediment sampling at the same locations, particularly in the sub 0.85 mm size class.

Limited turbidity measurements indicated that at the nine tributary locations, turbidity varied between 2 and 811 NTU. The South Fork below Daugherty Creek had the highest average turbidity levels and the James Creek above the North Fork Big River site had the lowest turbidity levels. Limited turbidity and suspended sediment samples were collected on the mainstem Big River during winter flows. Measurements indicated that all of the turbidity samples were below 42 NTU, except one sample with a maximum recorded level of 240 NTU. There also appeared to be a strong correlation between turbidity and suspended sediment at all of the sites sampled.

Based on the information available for this assessment, sediment in the Big River Basin may be a limiting factor for aquatic organisms in some parts of the basin. Although elevated levels of fine sediment were found at some sample locations, comprehensive sampling throughout the basin has not been conducted.

Water Chemistry

Water chemistry sampling was generally limited in duration and even non-existent in some areas, including the Big River Estuary and the Middle Subbasin. In every subbasin where it was tested, sodium exceeded the applicable water quality criteria. On other occasions, there were unusual concentrations of boron, copper, aluminum, and zinc that exceeded water quality criteria. Boron concentrations in the South Fork Big River were particularly troubling because they were collected in 2001 with known methods. However, with the other metals, it is likely that they were artifacts of the sample collection method or location.

In February 2001, a tanker truck on Highway 20 spilled roughly 7,000 gallons of waste oil. Some of this waste oil discharged into a tributary to James Creek. Subsequent sampling indicated that petroleum constituents had reached James Creek. While it is likely that this event harmed some aquatic life, this site is in active cleanup and it is unlikely that this event will have a long-term effect on the local ecology.

It is unknown which, if any, of the pesticides and herbicides make their way into the stream channels from activities such as agriculture, timber harvesting, and right-of-way maintenance on County roads. This would depend on the method of application, solubility, and the persistence of these chemicals. However, this was not studied in this assessment due to the lack of sample data. A summary of select pesticides and herbicides used in Mendocino County (although not specifically the Big River Basin) in 2000 is given in the Water Quality Appendix. Further study of pesticides and herbicides is warranted to ensure that drinking water supplies and wildlife resources are protected in the Big River (and other watersheds).

Based on the information available for this assessment, water chemistry in the Big River Basin does not appear to be a limiting factor for aquatic organisms or a health hazard to humans. However, long-term sampling should be conducted to verify that the detected metals are, in fact, not in the surface water at the detected concentrations. Sodium concentrations should be looked at more carefully to determine the source of the sodium and if it is naturally occurring. No water quality information exists for the estuary, which is unique and should be studied further. Water quality sampling for pesticides and herbicides throughout the watershed is also recommended.

Riparian Conditions

Stream buffers were established on Class I/Perennial streams at 150 feet from the bank of the watercourse on both sides and 75 feet for Class II/Intermittent streams. Data used for analysis is the USGS 1:24,000 hydrography GIS data layer, upgraded within field watercourse designation from THPs digitized by CDF Santa Rosa GIS. There are 11,762 acres in the stream buffers, which includes barren areas composed of water and gravel bars in the lower reaches (Table 35). The 0% density class is occupied primarily by gravel bars, water, willows, and grasslands and is less than 1% of the watercourse buffer zone area.

Table 35. Acres by crown canopy density in watercourse buffer zone by subbasin.

Subbasins	Acres by Percent Crown Canopy Density										Acres in Buffer
	0%	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	
Coastal	297	2	18	84	5	9	7	454	407	1,172	2,455
Middle	15	6	2	10		2	3	255	222	589	1,104
Inland	161	67	13	164	79	66	45	1,266	1,827	4,513	8,203
Total Big River Basin	**474**	**74**	**34**	**258**	**85**	**77**	**55**	**1,975**	**2,456**	**6,274**	**11,762**

Table 36 presents the percent of area with canopy in the higher percentage ranges, 70% and above, which provide significant levels of stream shading and microclimate effect. In the entire Big River Basin, the area around the watercourses are well vegetated, as indicated by the 70–100% density class which accounts for 91% of the area. Also at the basin level, 74% of the buffer area is in 80% canopy density or better, and 53% of the area is in the 90-100% canopy closure class.

Table 36. Percentage of stream buffer area in higher canopy closure classes by subbasin.

Subbasins	Percent of Buffer Area by Crown Canopy Density				
	70%	**80%**	**90%**	**70%+**	**80%+**
Coastal	18	17	48	83	65
Middle	23	20	53	96	73
Inland	17	21	53	91	74
Total Big River Basin	**17**	**21**	**53**	**91**	**74**

Looking to canopy density at the subbasin level, the Coastal Subbasin has the lowest percentage of buffer area with canopy density in the higher classes: 83% of the area has 70% canopy density or higher and 64% has a density of 80% or higher. The Middle Subbasin has the greatest percentage of buffer area in the higher canopy density classes: 97% of the area in the 70% density or higher classes and 73% in the 80% density or higher classes. The Inland Subbasin runs a close second to the Middle Subbasin. These numbers are substantiated by high canopy densities found along stream reaches surveyed by CDFG and discussed in the *Fish Habitat Relationships* section below. These buffers are consistent with the associated stream channel widths.

As shown in Table 37, the majority of the trees in the watercourse buffer zone are small to medium/large, which are 12 to 40 inch dbh trees. Gravel bars, water, and grasslands do not have a tree size associated with them and are not included.

Small, medium/large and large trees (>12 inches dbh) could be recruited to streams as large woody debris. Overall, 91% of the buffer zone area in the basin is in these size classes. At the subbasin level, the percentage area in these three size classes is 94% to 95%.

Table 37. Acres by vegetation size class in watercourse buffer zone by subbasin.

Subbasins	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**	**%**
Coastal	77	3	42	2	969	45	1,020	47	50	2
Middle	0	0	44	4	735	67	303	27	6	1
Inland	21	0	374	5	4893	61	2571	32	183	2
Total Big River Basin	**99**	**1**	**460**	**4**	**6,596**	**56**	**3,894**	**33**	**239**	**2**

Fish Habitat Relationships

The Big River Basin supports populations of coho salmon, steelhead trout, and other valuable fishery resources. Coho salmon and steelhead trout enter the Big River Basin on their spawning migration during November or December, depending on stream flow conditions. Spawning takes place from November to March. The majority of juveniles move downstream to the ocean between March and June of each year.

In order to meet the needs of the life stages of anadromous salmonids, the Big River Basin must provide appropriate diverse stream flow regimes, suitable water quality, high quality gravel substrate for spawning and incubation of eggs, suitable in-channel and riparian conditions, and adequate food supplies within the fish bearing reaches throughout the basin. High quality instream and riparian habitat is most important for coho and steelhead as they spend a year or more rearing in streams.

The advent of timber harvesting in the Big River Basin in 1850 brought changes to stream channels across the basin due to land use activities. These changes from historic stream conditions resulted in reductions of salmonid habitat quality.

Identifying salmonid life history strategies at the basin and regional scales provides clues to the range of stream conditions and environmental requirements for fish. The fish are telling us what they need by displaying a range of behavioral patterns and they are telling us about the status of their habitat by their trends of abundance. Some species or life history strategies may already be lost or rarely observed due to changes from historic stream conditions. By gaining insight into the relationships between the diverse life history strategies, fishery population dynamics and status, and assessing stream habitat condition, we can make efficient recommendations for recovery of depressed populations.

A summary of the life history strategies and historic and current status of anadromous salmonid populations of Big River is provided in the CDFG Appendix. Further information on fisheries and habitat status of Big River is provided in each subbasin section.

Historic Conditions

There are approximately 52 named streams in the Big River Basin. In 1965, CDFG estimated that these streams provided 101 miles of coho salmon habitat and 137 miles of steelhead trout habitat (Table 38).

Table 38. Anadromous habitat in the Big River Basin in 1965 (from CDFG 1965).

Species	Miles of Stream			Total Stream Miles	Accessible to Anglers	
	Summer Stream Wetted Width in Feet					
	Up to 7	8 to 20	21 to 100		Miles	%
Coho Salmon	74	22	5	101	40	40
Steelhead Trout	110	22	5	137	40	29

In 1957, 1958, 1959, 1966, and 1979 CDFG conducted stream surveys on various tributaries in the three subbasins of the Big River Basin (Table 39). Many of the stream surveys coincided with the extensive logging across the Big River Basin. The results of past stream surveys were not quantitative and cannot 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. Summary tables appear in the subbasin sections of this report.

Surveys across the Big River Basin described a range of spawning habitat, pools, and shelter from poor to excellent. Good spawning habitat was reported in most surveyed streams in the Coastal and Middle subbasins. Pools were described as small, but abundant in most surveyed streams. Abundant deep pools were reported in North Fork and South Fork Big rivers. Shelter was described as good to excellent in most streams across the Basin.

Table 39. Streams surveyed by CDFG in the Big River Basin from 1957-1966.

Year	Coastal Subbasin	Middle Subbasin	Inland Subbasin	
Undated 1950s		Tramway Gulch Dietz Gulch	Kelly Gulch Biggs Gulch Mettick Creek	Anderson Gulch Boardman Gulch
1957			South Fork Big River	
1958			North Fork Big River East Branch North Fork Big River James Creek North Fork James Creek	South Fork Big River Unnamed Tributary to South Fork Big River #1 Unnamed Tributary to South Fork Big River #2
1959	Big River Little North Fork Big River Cookhouse Gulch Rocky Gulch Manly Gulch Thompson Gulch Berry Gulch	Two Log Creek	North Fork Big River East Branch North Fork Big River Water Gulch Ramon Creek Daugherty Creek Soda Creek Johnson Creek (Tributary to Gates Creek) Snuffins Creek	Johnson Creek Russell Brook Pig Pen Gulch Martin Creek East Fork Martin Creek Valentine Creek Rice Creek East Branch Rice Creek
1966		Two Log Creek Tramway Gulch	South Fork Big River Snuffins Creek Johnson Creek	

In 1965, DWR reported that although "there was considerable logging damage to these streams (in the Big and Noyo basins) in the past… stream clearance work recently completed by CDFG has removed logging debris from stream channels and provided access throughout the drainage to anadromous fish." The report also stated that the better spawning areas in the basin were mainly upstream from the confluence with Two Log Creek.

The California Fish and Game Plan of 1965 stated that damage to the basin from logging had been severe, although a stream clearance project helped rehabilitate the drainage. The plan reports that the Big River Basin was not supporting "the maximum runs of fish" and that limiting factors for salmonids were "siltation and erosion, probably resulting from poor forest practices." The plan recommends better land use programs and post-logging rehabilitation of streamside cover to improve fish runs.

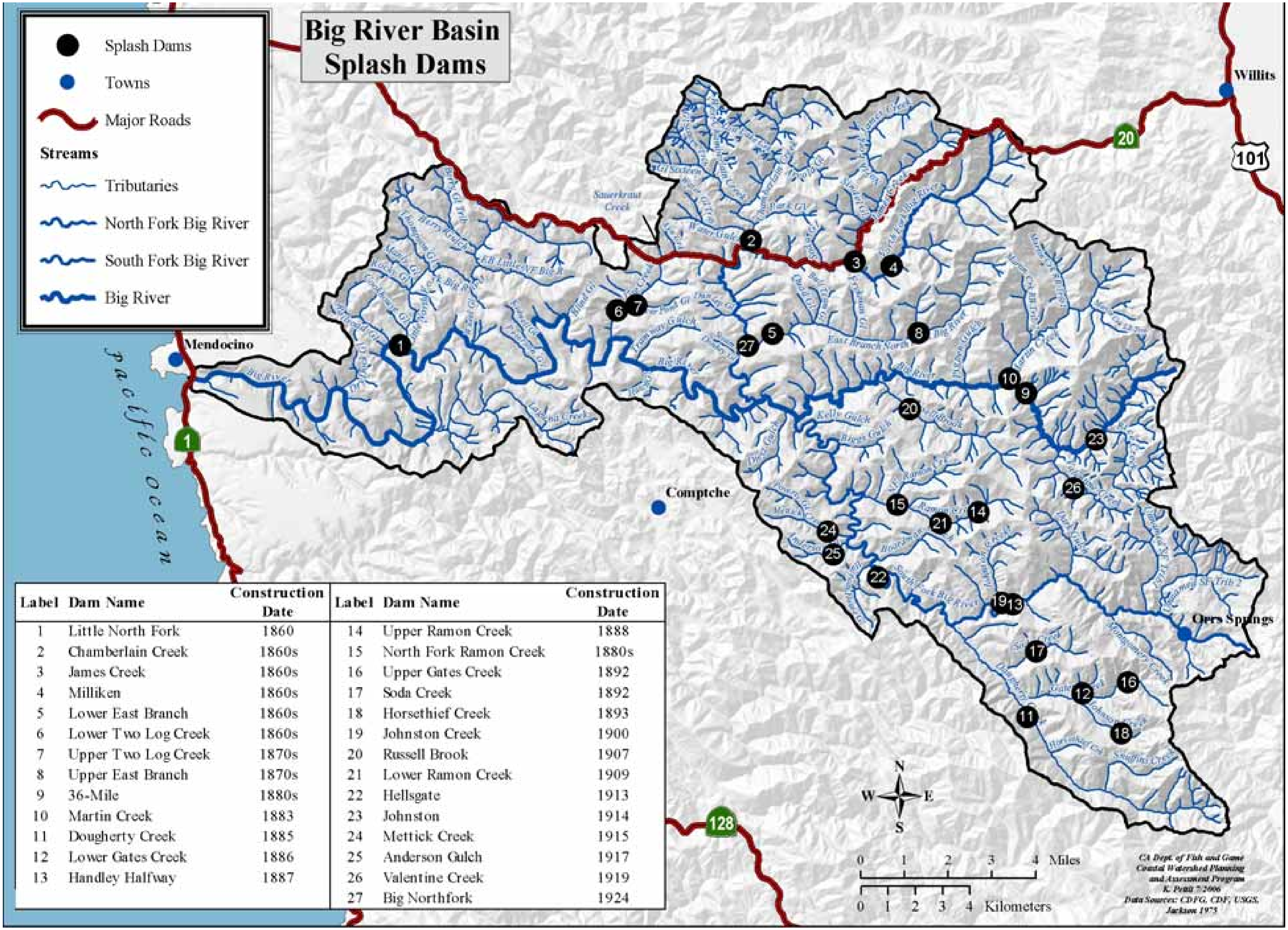
In 1973, USFWS conducted a Fishery Improvement Study in the Big River Basin (Perry 1974). USFWS found that the factors affecting fish resources in the basin in 1973 were mostly linked to timber harvesting activities:

> Cat-trails, skid roads, logging roads, and vegetation removal have contributed heavily to sediment clogging the spawning gravels. Though stream clearance projects have been undertaken, debris still presents physical barriers to migrating fish. Loss of streamside cover exposes the stream to solar radiation which increases the water temperatures to levels no longer tolerated by cold-water fishes.
>
> The stream has aggraded seriously in areas and would require reconstruction of pools and riffles. Summer flows appear adequate to support small populations of fingerlings and yearlings, provided pools, and streamside vegetation are improved.

USFWS stated that a watershed rehabilitation program would be needed to preserve and enhance existing spawning areas. Suggested rehabilitation measures included increasing summer flows in upstream rearing locations and creating additional pools. Due to Big River's potential for fishery enhancement, the basin was selected as a pilot project for a fishery improvement study. Results of this study are presented in the Water Quality and Fish History and Status sections of this report.

Effects of Historic Splash Dams

As discussed in the Land Use section of the Basin Profile, splash dam logging was used extensively throughout the Big River Basin. The basin had 27 splash dams (Figure 41).



Label	Dam Name	Construction Date	Label	Dam Name	Construction Date
1	Little North Fork	1860	14	Upper Ramon Creek	1888
2	Chamberlain Creek	1860s	15	North Fork Ramon Creek	1880s
3	James Creek	1860s	16	Upper Gates Creek	1892
4	Milliken	1860s	17	Soda Creek	1892
5	Lower East Branch	1860s	18	Horsethief Creek	1893
6	Lower Two Log Creek	1860s	19	Johnston Creek	1900
7	Upper Two Log Creek	1870s	20	Russell Brook	1907
8	Upper East Branch	1870s	21	Lower Ramon Creek	1909
9	36-Mile	1880s	22	Hellsgate	1913
10	Martin Creek	1883	23	Johnston	1914
11	Dougherty Creek	1885	24	Mettick Creek	1915
12	Lower Gates Creek	1886	25	Anderson Gulch	1917
13	Handley Halfway	1887	26	Valentine Creek	1919
			27	Big Northfork	1924

Figure 41. Splash dams on the Big River, built from 1860 to 1924, used until 1936.

When river flows were high during the winter season, dam flood gates were opened and the flood flows moved downstream and picked up logs that had been stacked in stream channels downstream. At some sites, logs were stored in the reservoir and released along with the water. Many of the dams were designed to operate in a synchronized fashion to maximize the flow of water in downstream reaches. The transport of logs downstream was called a log drive and usually occurred once per winter (GMA 2001a).

Before water was released from dams, the stream channels downstream from the dam all the way to the estuary were cleared of all obstructions and debris. Sometimes, logs moving downstream did get jammed, and one such jam on the Hellsgate reach of the South Fork Big River lasted for several years before it was cleared up. Most jams were quickly cleared, however (GMA 2001a).

These splash dam activities had a large impact upon stream channels across the Big River Basin that can still be seen today. South Fork Big River is heavily incised from flushing logs. Escola described the flushing of logs as intense snapping, popping and loud booms. In the fork where Anderson and Mettick Creeks come together, there resides a large boulder gouged by the pounding of the logs as they were flushed down the river. The Big River was "beat up the worst" (Escola 2001) of any of the coastal rivers due to the 80 years of driving logs down it.

Studies in the nearby Caspar Creek watershed of the effects of splash dams on channel geometry found post-splash damming channels to be deeply entrenched, cut down to bedrock in many places, lacking functional floodplains, and depleted of LWD. The lack of LWD is also allowing sediment to move more quickly through the stream system and thus reach the estuary in greater quantities than pre-disturbance (Napolitano 1996, 1998 as cited in GMA 2001a). Channels within the Big River Basin share these characteristics (GMA 2001a). Another common effect of splash dam logging was displacement of main-channel gravels during log drives (Sedell et al. 1991).

Large Woody Debris Removal and Reduction

LWD shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids (Murphy and Meehan 1991). A lack of LWD in stream channels contributes to reduced pool frequency, depth, and overall habitat complexity. This reduces the quality of over-summering and over-wintering habitat for anadromous fishes. Where wood is lacking, stored sediments flush out, resulting in channel lowering and entrenchment. This disconnects channels from floodplains and reduces backwater habitats, which are thought to be important refuges for fish during strong winter storms.

Across the Big River Basin, past land use practices have removed LWD from stream channels. As discussed previously, the use of splash dam logging involved both the manual removal of LWD before dam waters were released and the flushing of remaining LWD by flood waters. Other logging practices also reduced LWD in streams by removing near-stream trees that would have otherwise been recruited into stream channels.

Additionally, there was a widespread program of LWD removal from low gradient (0-4 percent) stream channels in JDSF from the 1950s to the early 1990s. Stream channels in the Big River Basin cleared under this program include:

- Tramway Gulch
- Two Log Creek
- Berry Gulch
- East Branch Little North Fork Big River
- Laguna Creek
- James Creek
- Chamberlain Creek
- Water Gulch
- East Branch North Fork Big River
- North Fork Big River (CDF 1999, as cited in GMA 2001a)

CDFG also contracted various groups to clear LWD in streams in the 1980s and 1990s. Streams affected by these programs included:

- Russell Brook
- Ramon Creek
- Daugherty Creek
- Halfway House Gulch
- Mettick Creek
- Tramway Gulch
- East Branch North Fork Big River (MRC 2003)

The idea behind LWD removal was to re-establish fish passage around large wood jams that formed after logging activities. A secondary purpose was to allow sediment to flush from upstream of logjams where good spawning gravels were buried under fine sediment (Holman and Evans 1964). The apparent assumption underlying the removal of LWD was that sediment limits fisheries and that flushing it from the system will restore stream channels to equilibrium.

This strategy did not take into account that moderating sediment movement actually benefited downstream reaches by allowing them to at least retain patches of clean gravel for spawning. Additionally, large wood provided roughness elements to sort bed load and create scour. LWD removal programs also assumed that sediment supply would decrease, but instead, additional land use activities generated more sediment.

Current Conditions

The 52 named streams in the Big River Basin currently provide approximately 148 miles of anadromous salmonid habitat. The Big River Basin includes approximately 182 miles of low gradient streams and wetland habitat that is well suited to support coho salmon.

Recent habitat inventory surveys have been conducted on a total of 55 streams and three sections of the mainstem Big River (Table 40). In 2002, CDFG conducted 79.3 miles of habitat inventory surveys on 30 streams and two sections of the mainstem Big River. These surveys were completed under the direction of this assessment. Approximately 100.2 miles of current habitat inventory data existed prior to this effort. This included five streams and the mainstem Big River inventoried by Georgia Pacific in 1996, and 28 streams inventoried by CDFG from 1993 to 1998. Of these streams, seven were re-inventoried by CDFG in 2002. Tributary data presented in this report are from the most recent tributary inventories. Data from earlier inventories are summarized in the CDFG Appendix.

Across the Big River Basin, the Flosi et al. (1998) canopy cover target value was reached on most surveyed tributary streams. Only 15 surveyed tributaries, one in the Middle Subbasin and fourteen in the Inland Subbasin did not meet canopy cover targets. Two of these, the North and South forks of the Big River, are third order streams and thus expected to have lower canopy level observations due to wider channels. Surveys on the mainstem Big River also showed low canopy density. The mainstem is a fourth order river; however, so the target values do not apply.

Embeddedness target values were only reached on three tributaries and the mainstem Big River from Wheel Gulch to Blind Gulch and from Tramway Gulch to North Fork Big River. None of the surveyed tributaries in the Middle Subbasin reached target values for cobble embeddedness.

The target values for Pool Frequency/Depth were not met on any of the streams surveyed. The target values for Pool Shelter/Cover were only met on Sauerkraut Creek and East Branch North Fork Big River.

Table 40. Summary of current (1995, 1996, 1997, 1998, and 2002) conditions.

Stream	Surveyed Length (miles).	% Canopy Density over the Surveyed Stream	% of Pool Tails with Cobble Embeddedness in Category 1	% Length of Surveyed Stream in Primary Pools	Shelter Cover Ratings
Target Values (Flosi et al 1998)		*>80%*	*>50%*	*>40%*	*>100*
Big River Basin	**154.1**				
Coastal Subbasin	**39.5**				
Big River	20.3	33	<1	36	45
Laguna Creek	1.9	87	1	30	61
Railroad Gulch	1.1	93	5	5	21
Little North Fork Big River	3.7	89	8	22	33
Rocky Gulch	0.2	100	57	2	33
Manly Gulch	0.7	92	23	1	18
Thompson Gulch	1.1	92	7	2	51
East Branch of the Little North Fork Big River	2.4	88	37	9	68
Berry Gulch	2.2	93	0	4	24
Berry Gulch Tributary	1.1	92	8	6	47
Big River (Wheel Gulch to Blind Gulch)	5.0	65	60	27	34
Middle Subbasin	**9.5**				
Kidwell Gulch	0.9	97	8	1	22
Two Log Creek	3.0	92	25	20	16
Sauerkraut Creek (Two Log Creek Tributary)	0.1	85	0	4	80
Ayn Creek (Two Log Creek Tributary)	0.3	80	0	3	58
Big River (Tramway Gulch to North Fork Big River)	4.7	56	53	35	66
Hatch Gulch	0.5	64	0	0	49
Inland Subbasin	**105.1**				
North Fork Big River	12.0	67	15	22	19
East Branch of the North Fork Big River	7.4	74	5	9	87
Chamberlain Creek	5.1	73	23	4	25
Water Gulch	1.9	94	2	13	41
Water Gulch Tributary	0.4	97	9	0	10
Park Gulch	1.0	97	6	2	64
West Chamberlain Creek	3.5	87	2	3	63
Gulch Sixteen	0.9	94	6.5	1	40
Gulch Sixteen Tributary	0.4	97	16	2	40
Arvola Gulch	0.9	84	3	2	33
Lost Lake Creek	0.9	93	15	1	17
Soda Gulch	0.7	98	0	0	8
James Creek	4.4	67	18	9	14
North Fork James Creek	2.4	80	11	7	50
South Fork Big River	20.5	78	27	24	27
Biggs Gulch	0.5	85	23	1	30
Ramon Creek	3.0	75	15	2	38
North Fork Ramon Creek	1.5	76	48	2	39
Mettick Creek	1.0	74	43	5	26
Poverty Gulch	0.1	69	0	0	38
Anderson Gulch	0.5	90	0	2	21
Boardman Gulch	1.3	87	0	1	51
Halfway House Gulch	0.2	84	67	10	30
Daugherty Creek	8.8	84	37	11	73
Soda Creek	1.7	83	74	3	27
Gates Creek	2.7	88	32	11	79
Johnson Creek (Gates Creek Tributary)	1.2	71	37	2	51
Horse Thief Creek	0.1	95	0	0	25
Snuffins Creek	1.3	81	18	1	38
Johnson Creek	0.9	71	37	1	51
Dark Gulch	1.4	77	16	2	26
Montgomery Creek	0.7	80	8	12	19
South Fork Big River Tributary #1	1.1	69	32	7	35
South Fork Big River Tributary #2	0.6	78	4	1	31
Russell Brook	4.1	83	1	2	36

Stream	Surveyed Length (miles).	% Canopy Density over the Surveyed Stream	% of Pool Tails with Cobble Embeddedness in Category 1	% Length of Surveyed Stream in Primary Pools	Shelter Cover Ratings
Martin Creek	3.7	81	15	11	24
Martin Creek Left Bank Tributary	0.6	90	11	2	26
Martin Creek Right Bank Tributary #1	1.5	83	0	2	26
Martin Creek Right Bank Tributary #2	0.6	86	0	6	34
Valentine Creek	1.8	84	15	2	19
Rice Creek	1.8	82	8	3	39

Based Upon Habitat Inventory Surveys from the Big River Basin, California. Condensed Tributary Reports are located in the CDFG Appendix.

Large Woody Debris

Large woody debris, or LWD, is an important component of stream habitats for anadromous salmonids. LWD shapes channel morphology, helps retain organic matter and provides essential cover for salmonids. MRC examined LWD in stream channels across their ownership (in the Middle and Inland Subbasins) in the Big River Basin and found a lack of LWD as well as a low recruitment potential for LWD (MRC 2003). LWD was low in major channels such as the mainstem Big River, North and South Forks Big River, and the East Branch North Fork Big River. For details, please see the Riparian Conditions and Fish Habitat Relationship sections of the Subbasin Profiles.

Fish Passage Barriers

Stream Crossings

Three stream crossings were surveyed in the Big River Basin as a part of the coastal Mendocino County culvert inventory and fish passage evaluation conducted by Ross Taylor and Associates (2001). 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. Since the culvert inventory was completed, the culverts on Johnson Creek and an unnamed tributary to South Fork Big River have been modified to improve fish passage.

Additional culverts that may pose problems for fish passage were noted by CDFG stream surveys, the CGS Geologic Report for the State Park, the MRC Watershed Analysis and in surveys documented by NMFS (Jones 2000). Please see the Subbasin Profiles for further details.

Culvert repair, upgrade, and improvement are an important part of stream restoration projects. In the Big River Basin, the CDFG North Coast Watershed Improvement Center includes culverts as a part of stream restoration and improvement efforts. They were able to supply information on recent culvert assessment and treatment contracts. Typically, following assessments like those done by Ross Taylor and Associates, the County or landowner follows up with improvement proposals to CDFG for funding support to implement recommendations. In the Big River Basin, some of the recommended treatments are currently proposed or being implemented.

Dry Channel

CDFG stream inventories found dry channels on 41 streams in the Big River Basin. 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 occur from late July through early September. Therefore, CDFG stream surveys conducted outside this period are less likely to encounter dry channel.

The amount of dry channel reported in surveyed stream reaches in the Big River Basin is 2.7% of the total length of streams surveyed. This dry channel was found in eight streams of the Coastal Subbasin, two streams of the Middle Subbasin, and 31 streams of the Inland Subbasin. Dry habitat units occurred near the mouth, in the middle reaches, and at the upper limit of anadromy of the tributaries.

Changes in Habitat Conditions from 1964 to 2001

Streams surveyed in the 1950s and 1960s and habitat inventory surveyed in the 1990s or 2002 were compared to indicate changes between past and current conditions. Data from 1960s stream surveys provided a snapshot of the conditions at the time of the survey. The results of past 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 indicate general trends.

Where habitat data were available from both older stream surveys and recent stream inventories it appeared that spawning habitat had mostly decreased across the Coastal Subbasin and remained constant across the Inland Subbasin. No general trend was seen in the Middle Subbasin.

It also appeared that pool habitat had mostly remained unchanged across the Coastal Subbasin and decreased in the Inland Subbasin. No general trend was seen in the Middle Subbasins.

Lastly, shelter appeared to have mostly remained unchanged in the Coastal Subbasin and decreased in the Inland subbasin, perhaps related to successful stream clearing projects. No general trend was seen in the Middle Subbasin.

For details, please see the Fish Habitat Relationship sections of the Subbasin Profiles and the CDFG Appendix.

Fish History and Status

Fishery resources of the Big River Basin include coho salmon and winter-run steelhead trout. Chinook salmon have been reported occasionally, but there are no current data on their distribution or population. CDFG attempted to establish a run of Chinook in the 1950s, but was not successful (DWR 1965). Other fish present in the Big River Basin include sticklebacks, lampreys, and sculpins (Table 41).

Many fish in the Big River Basin use the estuary during some part of their life history. Anadromous salmonids and Pacific lampreys pass through the estuary on migrations. Threespine stickleback, sculpins, surfperch, herring, eulachon, and topsmelt spawn or give birth within the estuary. Some steelhead trout, coho salmon, threespine stickleback, sculpin, starry flounder, Pacific halibut, and surfperch rear in the estuary (Britschgi and Marcus 1981).

Fishery resources of the Big River and its estuary were likely important food sources for the Pomo village that was once located near the town of Mendocino. The fishery resources also provided an important food supply to early European settlers of the Mendocino area.

As for most coastal streams, salmonid population data are limited for the Big River Basin. Anecdotal evidence and local opinion provide a case that salmonids were plentiful in the Big River Basin and experienced a decrease like other salmonid populations along the coast of California. Coho salmon have been documented in 31 tributaries and the mainstem Big River across the basin (Table 42). Steelhead trout have been documented in 51 tributaries and the mainstem Big River.

Table 41. Fishery resources of Big River.

Common Name	Scientific Name
Anadromous	
Coho Salmon	*Oncorhynchus kisutch*
Chinook Salmon	*Oncorhynchus tshawytscha*
Steelhead Trout	*Oncorhynchus mykiss*
Eulachon	*Thaleichthys pacificus*
Pacific Lamprey	*Lampetra tridentata*
Freshwater	
Coastrange Sculpin	*Cottus aleuticus*
Prickly Sculpin	*Cottus asper*
Sacramento Western Sucker	*Catostomus occidentalis occidentalis*
Pacific Brook Lamprey	*Lampetra pacifica*
Threespine Stickleback	*Gasterosteus aculeatus*
Marine or Estuarine Dependent	
Pacific Halibut	*Hippoglossus stenolepis*
Pacific Herring	*Clupea harengus pallasii*
Pacific Tomcod	*Microgadus proximus*
Topsmelt	*Atherinops affinis*
Bay Pipefish	*Sygnathus leptorhynchus*
Bocaccio	*Sebastes paucispinis*
Red-tail Surfperch	*Amphistichus rhodoterus*
Silver Surfperch	*Hyperprosopon ellipticum*

Common Name	Scientific Name
Striped Surfperch	*Embiotoca lateralis*
Pile Surfperch	*Damalichthys vacca*
Walleye Surfperch	*Hyperprosopon argentum*
Shiner Surfperch	*Cymatogaster aggregata*
White Surfperch	*Phanerodon furcatus*
Surf Smelt	*Hypomesus pretiosus*
Buffalo sculpin	*Enophrys bison*
Staghorn Sculpin	*Leptocottus armatus*
Starry Flounder	Platicthys stellatus
Amphibians	
Pacific Giant Salamander	*Dicamptodon tenebrosus*
Tailed Frog	*Ascaphus truei*
Red-legged Frog	*Rana aurora*
Foothill Yellow-Legged Frog	*Rana boylei*

Pers. comm. Harris and LeDoux CDFG, Wright CTM 2004, Grantham 2003, Britschgi and Marcus 1981.

Table 42. Documented salmonid presence across the Big River Basin.

Streams	Coho Salmon	Steelhead Trout	Unidentified Salmonids	Reference*
Coastal Subbasin				
Estuary channel Big River	X	X		SONAR 2001, 2002
Mainstem Big River	X	X		CDFG 1959, 2002; USFWS 1973; NMFS 1994-1996; CI 2001; HTC 1996
Laguna Creek			X	HTC 1996
Railroad Gulch	X	X		CEMR 1979; NMFS 1995-1997; HTC 1996; SONAR 2001
Little North Fork Big River	X	X		CDFG 1959, 1985, 1995; CEMR 1979; NMFS 1995-2000; SONAR 2001, 2002; HTC 1993-2002
Rocky Gulch	X			CDFG 1959, 1997
Manly Gulch			X	CDFG 1959, 1997
Thompson Gulch	X	X		CDFG 1959, 1985, 1997; CEMR 1979; NMFS1995-1997
East Branch Little North Fork Big River	X	X		NMFS 1967; CDFG 2002
Berry Gulch	X	X		CDFG 1959, 1997; NMFS 1995-1997
Berry Gulch Tributary	X	X		CDFG 1997
Middle Subbasin				
Mainstem Big River	X	X		CDFG 2002; MRC 1994-1996, 2000-2002
Kidwell Gulch		X		CDFG 2002
Two Log Creek	X	X		CDFG 1959, 1966, 1997, 1998, 2002; NMFS 1983, 1995-1997, 2000; CI 2001; MRC 1994-1996, 2000-2002; HTC 1993-2002
Saurkraut Creek				CDFG 1998
Ayn Creek		X		CDFG 1998
Beaver Pond Gulch				MRC 1995-1996, 2000-2002
Tramway Gulch	X	X		CDFG circa 1950, 1966; NMFS 1995-1996; MRC 1994-1996, 2000-2002
Hatch Gulch	X	X		CDFG 1988, HTC 1996, CDFG 1996
Dietz Gulch				CDFG circa 1950
Inland Subbasin				
North Fork Big River	X	X		CDFG 1958, 1959, 1985, 1996-1997; USFWS 1973; NMFS 1966, 1967, 1995-1997; CI 2001; MRC 1994-2002
Steam Donkey Gulch				MRC 1996, 2000-2001
East Branch North Fork Big River	X	X		CDFG 1958, 1959, 1966, 1998; CI 2001; USFWS 1973; CEMR 1979; NMFS 1995-1997; MRC 1994-1996, 2000-2002
Quail Gulch				MRC 1996
Bull Team Gulch	X	X		NMFS 1996; MRC 1996, 2000-2002
Frykman Gulch		X		MRC 2000-2002
Dunlap Gulch				MRC 1996, 2000-2002
Chamberlain Creek		X		NMFS 1980, 1995-1997; CDFG 1997; SONAR 2001
Water Gulch	X	X		CDFG 1959, 1997; NMFS 1981, 1995-1997
Water Gulch Tributary		X		CDFG 1995
Park Gulch		X		CDFG 1997; NMFS 1981, 1995-1997
West Chamberlain Creek		X		CDFG 1997; NMFS 1981, 1995-1997; SONAR 2001
Gulch Sixteen		X		CDFG 1997; NMFS 1995-1997
Gulch Sixteen Tributary				CDFG 1997
Arvola Gulch	X	X		CDFG 1997; NMFS 1980, 1995-1997
Lost Lake Creek		X		CDFG 1997; NMFS 1980, 1995-1997
Soda Gulch				CDFG 1997
James Creek		X		CDFG 1958, 1996; NMFS 1980, 1995-1997
North Fork James Creek		X		CDFG 1958, 1995; NMFS 1995-1997

Streams	Coho Salmon	Steelhead Trout	Unidentified Salmonids	Reference*
South Fork Big River	X	X		CDFG 1957/1958, 1966, 2002; USFWS 1973; NMFS 1995, 1996;CI 2001; MRC 1994-1996, 2000-2002
Kelly Gulch				CDFG circa 1950
Biggs Gulch				CDFG circa 1950, 2002
Noname Gulch				MRC 1995-1996, 2000-2001
Ramon Creek	X	X		CDFG 1959, 2002; NMFS 1995; CI 2001; MRC 1994-1996, 2000-2002; CDFG 2003
North Fork Ramon Creek	X	X		CDFG 2002; MRC 1994-1996, 2000-2002
Mettick Creek		X		CDFG circa 1950, 2002; NMFS 1994-1996; MRC 1994-1996, 2000-2002; CDFG 2003
Poverty Gulch				CDFG 2002
Anderson Gulch		X		CDFG circa 1950, 2002; NMFS 1994-1996; MRC 1994-1996, 2000-2002
Boardman Creek		X		CDFG circa 1950, 2002; MRC 1996, 2000-2002
Halfway House Creek		X		NMFS 1996; MRC 1996, 2000-2002
Daugherty Creek	X	X		CDFG 1959, 1993, 2002; NMFS 1996; CI 2001; MRC 1994-1996, 2000-2002
Soda Creek	X	X		CDFG 1959, 1988, 1993, 2002; NMFS 1995-1997; MRC 1994-1996, 2000-2002
Gates Creek	X	X		CDFG 1993, 2002; NMFS 1996; MRC 1994-1996, 2000-2002
Tributary to Gates Creek		X		MRC 2000
Johnson Creek (Tributary to Gates Creek)		X		CDFG 1959, 1993, 2002; NMFS 1996; MRC 1994-1996, 2000-2002
Horse Thief Creek				CDFG 2002
Snuffins Creek	X	X		CDFG 1959, 1966, 1993, 2002; NMFS 1996; MRC 1994-1996, 2000-2002
Johnson Creek		X		CDFG 1959, 1966, 2002; Jones 2000
Dark Gulch	X	X		NMFS 1958, 1999; CDFG 2002
Montgomery Creek				CDFG 2002
South Fork Tributary #1	X	X		CDFG 1958, 2002
South Fork Tributary #2	X	X		CDFG 1958, 2002
Mainstem Big River Headwaters	X	X		MRC 1994-1996, 2000-2002
Russell Brook	X	X		CDFG 1959, 2002; NMFS 1967, 1996; MRC 1994-1996, 2000-2002; CDFG 2003
Pigpen Gulch		X		CDFG 1959; NMFS 1967, 1994,-1996; MRC 1994-1996, 2000-2002
Martin Creek	X	X		CDFG 1959, 2002; NMFS 1967, 1994-1996; USFWS 1973; MRC 1994-1996, 2000-2002
Martin Creek Left Bank Tributary		X		CDFG 1959, 2002
Martin Creek Right Bank Tributary #1	X	X		CDFG 2002
Martin Creek Right Bank Tributary #2				CDFG 2002
Valentine Creek	X	X		CDFG 1959, 2002
Rice Creek		X		CDFG circa 1959, 2002; NMFS 1967
East Branch Rice Creek				CDFG 1959

All known surveys are listed, although salmonids may not have been detected in each survey. More details of individual surveys are available in subbasin sections and the CDFG Appendix.

* 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)

Figure 42 and Figure 43 depict the documented current and estimated historic distributions of coho salmon and steelhead trout, respectively. Current ranges are based on documented presence reports by CDFG, MRC, HTC, SONAR, and NMFS. Salmonids may be present in sites where they have not been documented due to a lack of data or imperfect sample techniques.

The limits of the estimated historic range of steelhead trout, the most athletic of the Big River salmonids, was initially defined to be a perennial stream reach of 1000 feet or more with a gradient in excess of 10%. The limits of the coho salmon range estimates were defined as perennial reaches of 1000 feet or more with a gradient in excess of 5%. These estimates were based on 30 meter digital elevation model (DEM) analyses. The preliminary range estimates were then reviewed by a team of CDFG fishery biologists.

The preliminary estimates are not a definite indication that coho salmon and/or coho salmon were historically present in the indicated reaches, rather they indicate the possibility that salmonids were present. Additionally, the estimates do not conclusively prove that salmonids were not historically present in areas above the estimated gradient barriers. Other factors that affect salmonid distributions such as flow limitations, channel shape and size, and barriers such as waterfalls could not be incorporated into this gradient-based analysis. Additionally, the 30 meter DEM may not provide enough accuracy for this analysis.

Historical accounts indicate that salmon were plentiful and that salmon fishing was a common activity (Jackson 1991). One local newspaper accounts mentioned a haul of 79 salmon seined in the river and sold for 25 cents each in 1900 (Wynn 1989).

A 1955 CDFG memo (Evans) described the coho salmon fishery as depleted, with only two salmon seen in the past year. Fisheries biologists recommended stocking coho salmon to revive their populations along with stream improvement measures.

A DWR report in 1965 described excellent populations of steelhead and coho salmon in the Big River Basin. Creel census data collected by CDFG during January 1955 indicated that about 800 angler days were expended resulting in a catch of 450 steelhead. Based on these data, DWR estimated that the Big River had runs of about 6,000 steelhead and 2,000 coho salmon annually.

The 1965 CDFG Fish and Wildlife Plan estimated spawning runs of 6,000 coho salmon and 12,000 steelhead trout in the Big River Basin. This estimate was based on comparisons to nearby streams by local fish biologists. Salmon fishing in the basin was estimated to be 1,000 angler-days per year, while steelhead trout fishing was estimated to be 1,600 angler-days per year. An angler-day is one or more fishing expeditions by an angler within one 24-hour period. The fishing yields were estimated to be 400 salmon and 500 steelhead trout per year, or 0.4 salmon and 0.3 steelhead trout per angler-day.

Salmonids have been stocked in the Big River over the past 100 years. The earliest mention of stocking was from a 1904 Mendocino Dispatch Democrat article which mentioned that juvenile steelhead trout were stocked into James Creek. Although Big River was characterized as a primarily coho salmon and steelhead trout stream, CDFG also attempted to establish a run of Chinook salmon in the basin in the late 1940s and early 1950s. A 1955 CDFG memo described the coho salmon fishery as depleted and describes department efforts to stock Chinook salmon. Many unmarked Chinook fingerlings were released in the basin from 1949 through 1952 (Table 43). In addition, over 100,000 marked Chinook salmon fingerlings were released in 1950 as part of a larger study on the survival of stocked salmonids (Hallock et al. 1952). Only 14 of these marked fish were recovered, although an increase of Chinook salmon present was observed in the year that the recheck was made. This increase was attributed to the presence of straying Sacramento River and Umpqua River fish. Coho salmon eggs were stocked in South Fork Big River in January 1956.

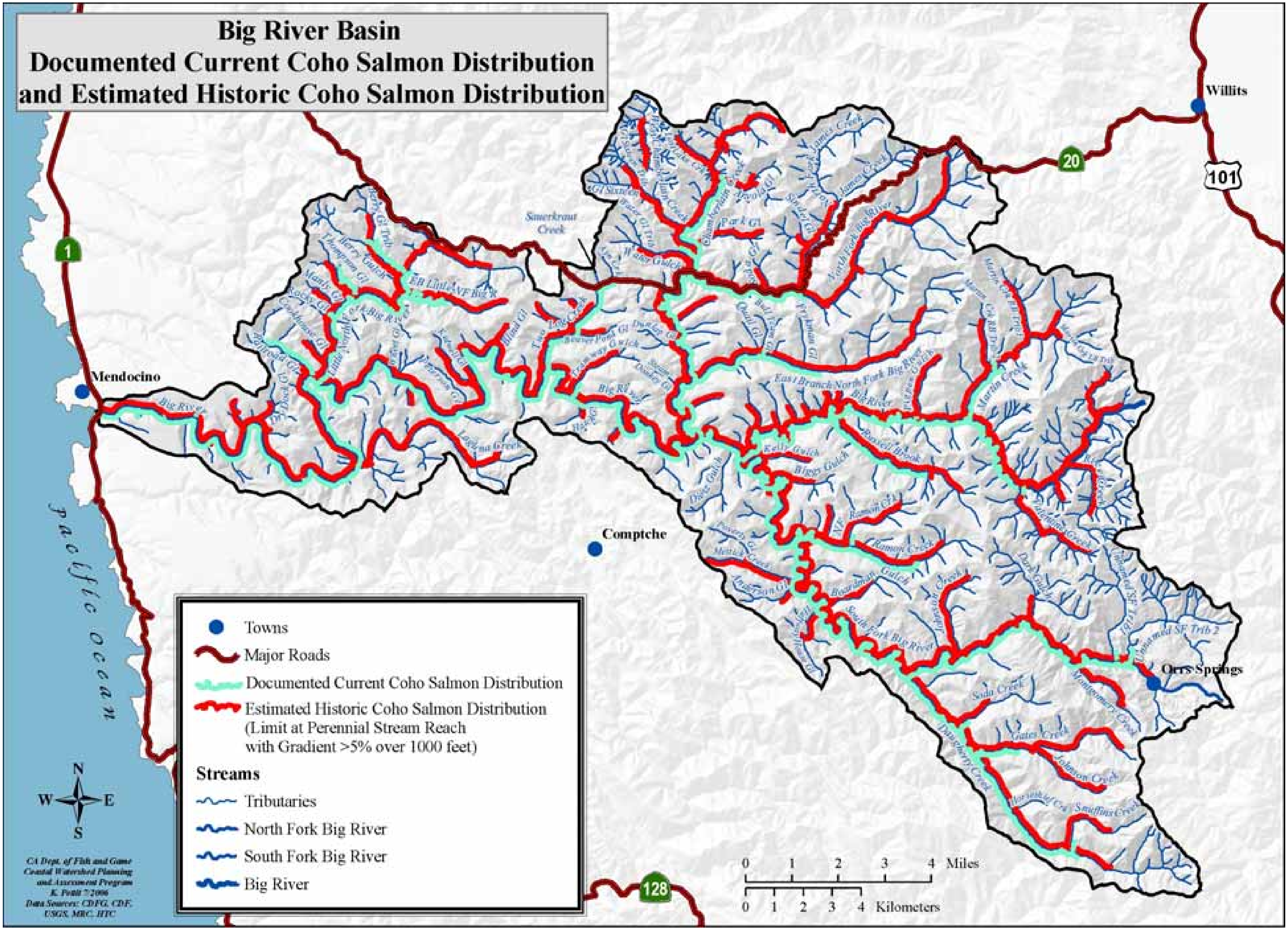


Figure 42. Coho salmon 2002 distribution based on CDFG and MRC surveys and estimated historic distribution based on a 30 meter digital elevation model in the Big River Basin.

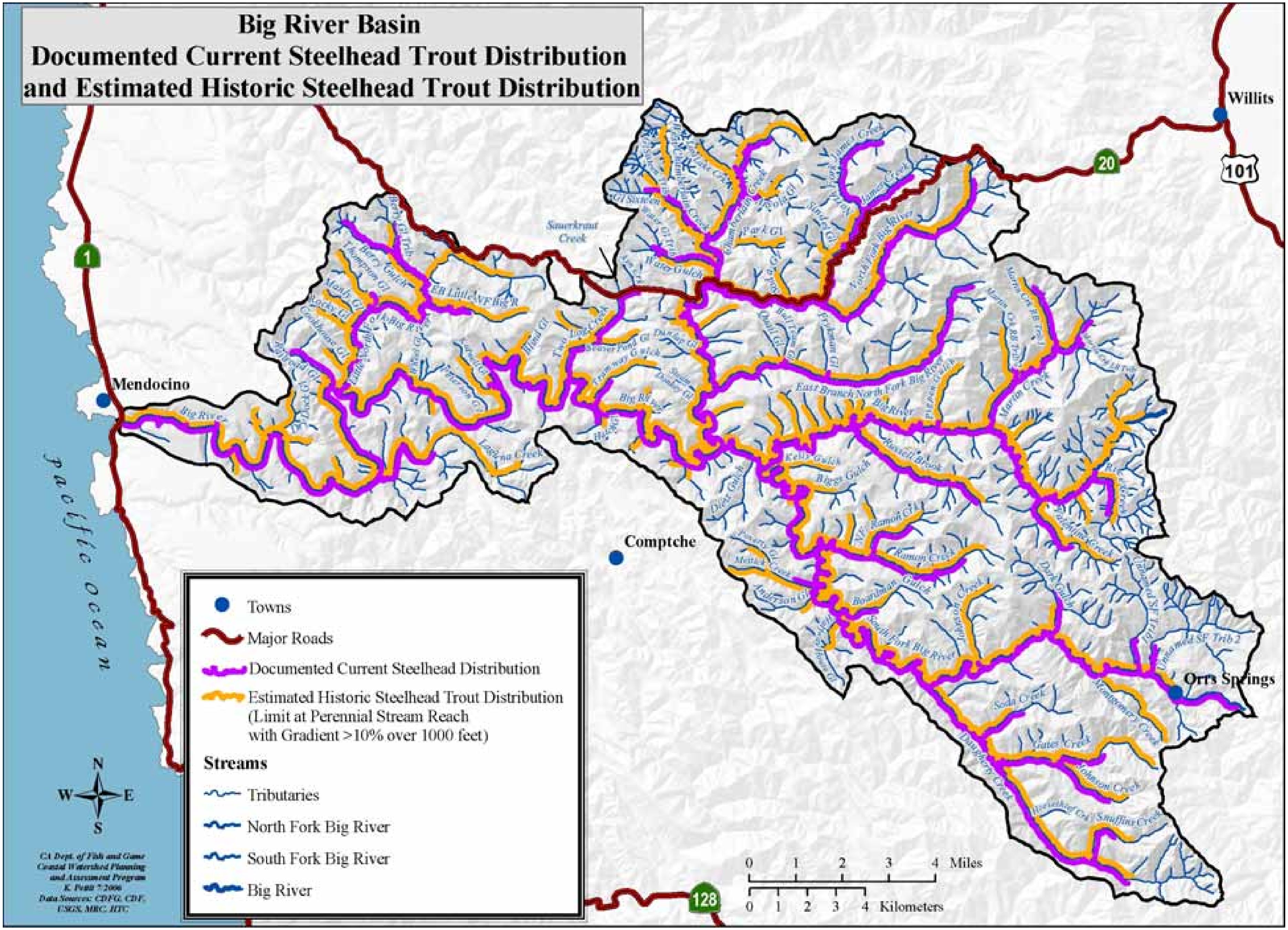


Figure 43. Steelhead trout 2002 distribution based on CDFG and MRC surveys and estimated historic distribution based on a 30 meter digital elevation model in the Big River Basin.

Table 43. Salmonid stocking in the Big River Basin.

Date	Where stocked	Number	Species	Source of Fish
1904	James Creek	Several thousand	Steelhead trout	Outlet Creek, Eel River Basin
1949-1952	Mainstem Big River	480,000	unmarked Chinook fingerlings	Mad River
1950	Mainstem Big River	132,734	marked Chinook fingerlings	Mad River
1956	South Fork Big River	200,000	Coho salmon eggs	NA
1973	Chamberlain Creek	100,000	Coho salmon	NA
1974	Mainstem Big River	100,000	Coho salmon	NA
1975	Mainstem Big River	90,000	Coho salmon	NA
1978	South Fork Big River	Many thousands	Coho salmon fingerlings	NA

CDFG conducted 40 stream surveys on 31 Big River tributaries in the 1950s and 1960s. Survey reports included drainage, stream condition, habitat suitability, stream obstruction, and fisheries descriptions. Salmonid presence and habitat characteristics were usually determined by direct stream bank observation. Survey reports concluded with recommendations for management. The Center for Education and Manpower Resources (CEMR) surveyed four streams in the Coastal and Inland subbasins in 1979 using the same protocols as CDFG. An additional 13 stream surveys and two electrofishing efforts conducted between 1958 and 1981 were documented by NMFS (Jones 2000). All surveys documented coho salmon and steelhead trout presence throughout the basin (Table 44).

Table 44. Coho salmon and steelhead trout presence reported in CDFG and CEMR stream surveys from 1950-1989.

Subbasin	Number of Streams Surveyed	Number of Streams where Coho Salmon were Reported*	Number of Streams where Steelhead Trout were Reported *
Coastal	5 (including mainstem Big River)	2	2
Middle	2	1	2
Inland	25	7	18

*These numbers do not include unidentified salmonid observations.

USFWS conducted field investigations of several streams across the Big River Basin associated with a Fisheries Improvement Study in 1973 (USBR 1974). Ten transects across the basin were electrofished to determine juvenile salmonid populations. Transects were 328 feet long (100 meters) and located in the mainstem Big River, North Fork Big River, East Branch North Fork Big River, South Fork Big River, and Martin Creek (Figure 16). Six sites were electrofished in July and all ten sites were electrofished in October. Steelhead trout were found in all transects and coho salmon were found in six transects (Table 45).

Table 45. USFWS electrofishing results from ten transects across the Big River Basin in 1973.

Subbasin	Number of Transects Surveyed	Number of Transects where Coho Salmon were Reported	Number of Transects Where Steelhead Trout Were Reported
Coastal	1	1	1
Inland	9	5	9

In 1973, the Salmon Restoration Association (SRA) started a small salmonid rearing pond on Chamberlain Creek (Maahs 1999). CDFG delivered 100,000 juvenile coho salmon and fish were fed by camp inmates at the Chamberlain Creek Conservation Camp. As air and water temperatures rose over the summer, it became clear that the pond was not large enough and stream flow into the pond was insufficient to meet dissolved oxygen needs and the project was halted.

In 1974, the SRA built a 345 feet long and 35 to 60 feet wide rearing pond along the mainstem Big River. The pond was planted with 100,000 coho salmon that year. Water temperatures over the summer were as high as 78°F and remained above 70°F for much of July and August. However, water flows were high enough to provide sufficient dissolved oxygen. Fish were flushed into the natural system with high flows on December 7. Although water temperatures in Big River were very high, another attempt at rearing coho salmon was made in the mainstem Big River pond in 1975 when 90,000 coho salmon were planted. Water temperature problems continued and the Big River rearing pond was abandoned.

In 1978, SRA estimated the spawning area available, potential for coho salmon, and runs present at that time in coastal Mendocino streams in a report describing salmonid restoration activities across the Mendocino coast (Maahs 1978). The Big River was estimated to have 75 miles of spawning area and the potential for 17,500 coho salmon. The 1978 coho salmon run was estimated to be 2,000.

CDFG conducted an extensive search of their records in 1979 and created an inventory of fish bearing streams in Mendocino County (Cherr and Griffin 1979). This inventory listed all the streams in the county and listed recorded fish species for streams where records were available. For this current assessment CDFG has utilized all of the primary sources identified by Cherr and Griffin.

From 1981-1987, SRA operated a coho salmon enhancement project on Johnson Creek in the South Fork Subbasin (Nielsen et. al 1991, Jones 2000). Fry were obtained from a hatchbox program on nearby Hollowtree Creek and the estimated capacity of the facility was 10,000 smolts per year (Sommarstrom 1984). About 2,500 coho salmon fry were reared and released in 1987 (Nielsen et. al 1991).

NMFS (Jones 2000) documented one stream survey, 32 electrofishing efforts, two carcass surveys, and one snorkel survey conducted between 1994 and 1997 across the basin. Coho salmon were found in 17 tributaries and the mainstem Big River and steelhead trout were detected in 32 tributaries and the mainstem Big River (Table 46).

Table 46. Coho salmon and steelhead trout presence documented by NMFS (Jones2000).

Subbasin	Number of Streams	# of streams with Coho Salmon Reported*	# of streams with Steelhead Trout Reported*
Coastal	5(including mainstem Big River)	5(including mainstem Big River)	5
Middle	2	1	2
Inland	26	11	25

*These numbers do not include unidentified salmonid observations.
From surveys, carcass surveys, electrofishing, and snorkel surveys between 1994 and 20007.

MRC has collected single-pass electrofishing or snorkel counts of 64 sites on 28 tributaries and the mainstem Big River in the Middle and Inland subbasins in the years 1994-1996, and 2000-2002 (MRC 2003). 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 13 tributaries and the mainstem Big River and steelhead trout were detected in 23 tributaries and the mainstem Big River (Table 47). Not all study sites were sampled for multiple years, but in 13 study sites that were sampled for four years or more, coho salmon were only found in 2002.

Table 47. Coho salmon and steelhead trout presence reported in MRC stream surveys from 1990-2002.

Subbasin	Number of Study Sites	Number of Streams	Coho Salmon Reported*		Steelhead Trout Reported *	
			Number of Sites	Number of Streams	Number of Sites	Number of Streams
Middle	8	5 (including mainstem Big River)	5	3 (including mainstem Big River)	7	4 (including mainstem Big River)
Inland	56	25 (including mainstem Big River)	26	12 (including mainstem Big River)	51	21 (including mainstem Big River)

*These numbers do not include unidentified salmonid observations.

With the publication of the *California Salmonid Stream Habitat Restoration Manual* in 1991, stream survey methodologies used by CDFG became standardized and more quantitative. Georgia-Pacific (now Hawthorne Timber Company) surveyed seven streams in the Coastal and Middle subbasins in 1996 using CDFG protocols. These surveys documented coho salmon in one stream and steelhead trout in four (Table 48). Fifty-six tributary reports were completed by CDFG on 51 Big River tributaries from 1995 to 2002. Coho salmon were detected in 21 surveyed tributaries and two reaches of the mainstem Big River and steelhead trout were detected in 35 surveyed tributaries and two reaches of the mainstem Big River (Table 49).

Table 48. Coho salmon and steelhead trout presence reported in Georgia Pacific stream surveys in 1996.

Subbasin	Number of Streams Surveyed	Number of Streams Where Coho Salmon Were Reported*	Number of Streams Where Steelhead Trout Were Reported *
Coastal	5	1	3
Middle	2	0	1

*These numbers do not include unidentified salmonid observations.

Table 49. Coho salmon and steelhead trout presence reported in CDFG stream surveys from 1990-2003.

Subbasin	Number of Streams Surveyed	Number of Streams Where Coho Salmon Were Reported*	Number of Streams Where Steelhead Trout Were Reported *
Coastal	9 (including mainstem Big River)	8 (including mainstem Big River)	7 (including mainstem Big River)
Middle	3 (including mainstem Big River)	2 (including mainstem Big River)	3 (including mainstem Big River)
Inland	39	13	27

*These numbers do not include unidentified salmonid observations.

No recent studies estimate the populations of coho salmon and steelhead trout throughout the Big River Basin.

Fishing Interests and Constituents

Historically, sport fishing for coho salmon and steelhead trout has drawn local anglers to the Big River from November through February. A 1942 report to the State Board of Forestry estimated that there were 60 miles of streams within the basin accessible to spring trout and/or fall steelhead and salmon fishing (Fritz 1942). Before the 1960s, hundreds of small boats trolled for salmon in the Big River (Mendocino Coastal Streams Subcommittee of the Advisory Committee on Salmon and Steelhead Trout 1986).

A 1965 DWR report describes a fine winter steelhead fishery. Coho salmon usually supplied most of the catch in the early part of the season with the main steelhead trout runs occurring later and providing fishing through the end of the season. Summer fishing was not permitted in order to provide protected nursery areas for young fish prior to their migration to the ocean. The majority of ocean fishing along the Mendocino coast occurred in the summer and fall. Coho salmon were taken at sea in the commercial fishery; however, relatively few fish taken in sport and commercial fisheries at sea were produced in the Big River Basin. A 1978 coastal wetland survey (Dana 1978) describes hunting and sport fishing as common uses of the wetlands in the Big River Estuary.

The threatened and endangered status of coho salmon and steelhead trout currently restricts river sport fishing on Big Basin stocks. The winter salmon and steelhead fishery of the Big River below the confluence with Two Log Creek is managed as a catch and release fishery from November 1 to March 31. Only barbless hooks may be used. For up to date fishing regulations contact Department of Fish and Game Central Coast Region in Yountville, CA 95501 (707) 944-5500 or visit the CDFG website at www.dfg.ca.gov.

Restoration Programs

The CDFG Fisheries Restoration Grants Program has funded various projects in the Big River Basin (Figure 44). Projects can be grouped into six broad categories:

- Improve Fish Passage
- Decrease Erosion/Stream Sedimentation
- Big River Estuary Biodiversity Assessment
- Road Sediment Assessment/Planning
- Improve Instream Habitat
- Increase Stream Bank Stabilization/Protection
- Increase Stream Shading

More details of the restoration projects are in the subbasin sections of this report.

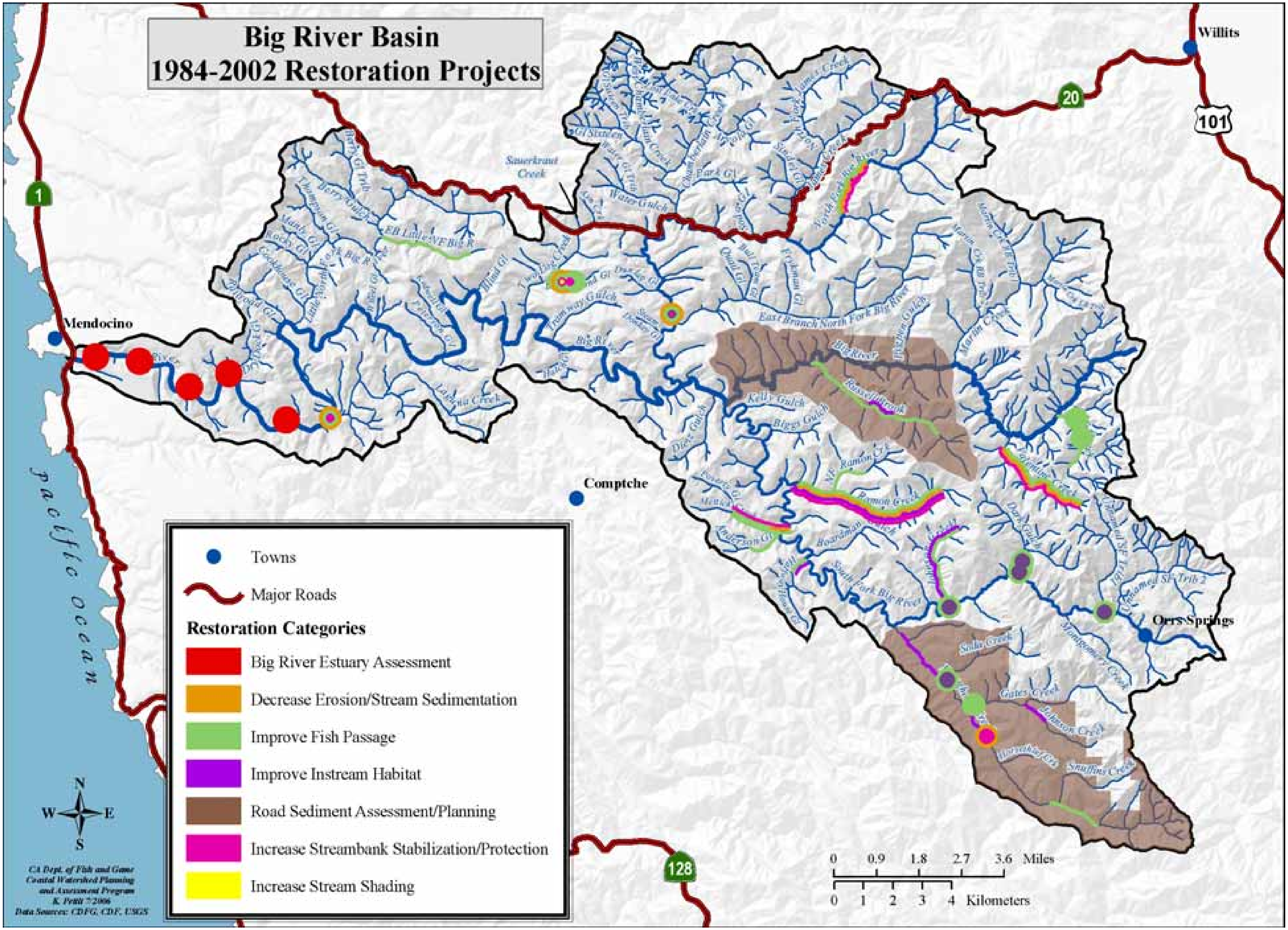


Figure 44. Restoration projects in the Big River Basin.

Special Status Species

Many plant and animal species in the Big River Basin have been found to have declining populations across their ranges and thus warrant special concern (Table 50). Species with declining populations are eligible to be listed under the federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA) for special attention. Detailed explanations of federal and state listings criteria are in the DFG Appendix. The lotus blue butterfly, Howell's spineflower, and coho salmon are listed as federally endangered, while coho salmon, marbled murrelets, American peregrine falcons, Northern Spotted Owls, Humboldt milk vetch, and Roderick's fritillary are state listed as endangered. The Big River Unit of Mendocino Headlands State Park supports an unusually high density, 0.78/square mile, of northern spotted owls. This density is among the highest recorded in California (Reid 2002).

Table 50. Special status species of the Big River Basin.

Common Name	Scientific Name	Federal Listing	State Listing
Invertebrates			
Pomo Bronze Shoulderband	*Helminthoglypta arrosa pomoensis*	Species of Concern	
Lotis Blue Butterfly	*Lycaeides argyrognomon lotis*	Endangered	
Fish			
Coho Salmon	*Oncorhynchus kisutch*	Endangered	Endangered
Steelhead Trout	*Oncorhynchus mykiss*	Threatened	
Chinook Salmon	*Oncorhynchus tshawytscha*	Threatened	
Amphibians			
Tailed Frog	*Ascaphus truei*	Species of Concern	Species of Special Concern
Foothill Yellow Legged Frog	*Rana boylii*	Species of Concern	Species of Special Concern
California Red Legged Frog	*Rana aurora draytonii*	Threatened	Species of Special Concern
Del Norte Salamander	*Plethodon elongatus*	Species of Concern	Species of Special Concern
Southern Torrent Salamander	*Rhyacotriton variegatus*	Species of Concern	Species of Special Concern
Reptiles			
Northwestern Pond Turtle	*Clemmys marmorata marmorata*	Species of Concern	Species of Special Concern
Birds			
Tricolored Blackbird	*Agelaius tricolor*	Species of Concern	Species of Special Concern
Sharp-shinned Hawk	*Accipiter striatus*		Species of Special Concern
Marbled Murrelet	*Brachyramphus marmoratus*	Threatened	Endangered
American Peregrine Falcon	*Falco peregrinus anatum*	De-listed	Endangered
Tufted Puffin	*Fratercula cirrhata*		Species of Special Concern
Osprey	*Pandion haliaetus*		Species of Special Concern
Northern Spotted Owl	*Strix occidentalis caurina*	Threatened	None
Mammals			
Red Tree Vole	*Arborimus pomo*		Species of Special Concern
Plants			
Pink Sand-Verbena	*Abronia umbellate spp beviflora*	Species of Concern	Special Plant
Blasdale's Bent Grass	*Agrostis blasdalei*	Species of Concern	Special Plant
Point Reyes Blennosperma	*Blennosperma nanum var. robustum*		Special Plant
Small Ground Cone	*Boschniakia hookeri*		Special Plant
Humboldt Milk Vetch	*Astragalus agnicidus*		Endangered
Thurber's Reed Grass	*Calamagrostis crassiglumis*		Special Plant
Coastal Bluff Morning-Glory	*Calystegia purpurata ssp. saxicola*		Special Plant
Swamp Harebell	*Campanula californica*	Species of Concern	Special Plant
California Sedge	*Carex californica*		Special Plant
Livid Sedge	*Carex livida*	Species of Concern	Special Plant
Lyngbye's Sedge	*Carex lyngbyei*		Special Plant
Deceiving Sedge	*Carex saliniformis*	Species of Concern	Special Plant
Green Sedge	*Carex viridula var. viridula*		Special Plant
Oregon Coast Indian Paintbrush	*Castilleja affinis ssp. littoralis*		Special Plant
Humboldt Bay Owl's-clover	*Castilleja ambigua ssp. humboldtiensis*		Special Plant
Mendocino Coast Indian Paintbrush	*Castilleja mendocinensis*	Species of Concern	Special Plant
Howell's Spineflower	*Chorizanthe howellii*	Endangered	Threatened
Whitney's Farewell-to-Spring	*Clarkia amoena ssp. whitneyi*		Special Plant
Round-Headed Chinese Houses	*Collinsia corymbosa*		Special Plant
Pygmy Cypress	*Cupressus goveniana ssp. pigmaea*	Species of Concern	Special Plant`
Supple Daisy	*Erigeron supplex*	Species of Concern	Special Plant
Menzies's Wallflower	*Erysimum menziesii ssp. menziesii*	Endangered	Endangered
Coast Fawn Lily	*Erythronium revolutum*		Special Plant
Roderick's Fritillary	*Fritillaria roderickii*	Species of Concern	Endangered
Pacific Gilia	*Gilia capitata ssp. pacifica*		Special Plant
Dark-eyed Gilia	*Gilia millefoliata*		Special Plant
Glandular Western Flax	*Hesperolinon adenophyllum*		Special Plant
Point Reyes Horkelia	*Horkelia marinensis*		Special Plant
Hair-Leaved Rush	*Juncus supiniformis*		Special Plant

Common Name	Scientific Name	Federal Listing	State Listing
Baker's Goldfields	*Lasthenia macrantha spp. bakeri*	Species of Concern	Special Plant
Coast Lily	*Lilium maritimum*	Species of Concern	Special Plant
Running-Pine	*Lycopodium clavatum*		Special Plant
Northern Microseris	*Microseris borealis*		Special Plant
Leafy-Stemmed Mitrewort	*Mitella caulescens*		Special Plant
Robust Monardella	*Monardella villosa ssp. globosa*		Special Plant
North Coast Phacelia	*Phacelia insularis var. continentis*		Special Plant
North Coast Semaphore Grass	*Pleuropogon hooverianus*	Species of Concern	Threatened
White Beaked-Rush	*Rhynchospora alba*		Special Plant
Great Burnet	*Sanguisorba officinalis*		Special Plant
Seacoast Ragwort	*Senecio bolanderi var. bolanderi*		Special Plant
Maple-Leaved Checkerbloom	*Sidalcea malachroides*	Species of Concern	Special Plant
Long-Beard Lichen	*Usnea longissima*		Special Plant
Marsh Violet	*Viola palustris*		Special Plant

Big River Basin General Issues

Public scoping meetings with Big River Basin residents and constituents and initial analyses of available data by watershed experts developed this working list of general issues and/or concerns:

- Water diversions have the potential to significantly reduce surface water flows of Big River and its tributaries. The potential for land development and increase in demand for water from the basin remains an issue of concern;
- Water temperatures are thought to be unsuitable for salmonids in the mainstem Big River and larger tributaries;
- There is concern that chemical and diesel spills in the basin are impairing stream conditions;
- There is concern that large amounts of sediments generated from road related failures have been and may be delivered to stream channels during major storms;
- Chronic fine sediment levels in many tributaries and the mainstem Big River are thought to be high;
- Estuary conditions are thought to be impaired by sediment;
- Fish habitat, including pool frequency, pool depth, shelter, large woody debris presence, cobble embeddedness, and fish passage are though to be unsuitable for salmonids throughout the basin;
- Timber harvest has been and continues to be the dominant land use in the Big River Basin;
- Landsliding related to roads, timber harvesting, and grassland is a concern;
- Long term effects to stream channels from splash dam logging throughout the basin are of concern;
- It is believed that there have been reductions in salmonid populations from historic levels;
- Sport and commercial fish harvests may have played a role in the reduction of numbers of Big River's salmonid populations;
- There is concern that the decline in the abundance of spawning salmon has likely caused a corresponding decrease in nutrients and organic matter available to streams;
- GMA (2001) may have over-estimated the bankfull width used in the Sediment Source Analysis (CGS 2004).

Integrated Analyses

The following section provides a picture of current 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 largely determine the quantity and quality of the freshwater habitat for salmon and steelhead.

Landsliding Interactions

As part of GMA's Sediment Source Analysis (2001), landuse was compared to landsliding activity. A landuse parameter combining occurrence in harvested areas, related to roads, and in areas of brush and grassland was used. GMA found that 33.0% of mapped debris torrents were in areas harvested more than 20 years ago and 27.0% were in areas harvested in the past 20 years (Table 51). Only 16.2% of debris torrents were road-related while 17.8% were in areas of brush or grassland. When examining all slides, GMA found that 60.0% were harvest-related, 30.3% were road-related, and 8.7% were found in brush and grassland areas. Additionally, slides related to road-fills were about five times more common than those related to road cuts.

Table 51. Occurrence of delivering debris torrents and slides by land use, 1952-2000.

A.

Land use	**Year**					**Total by land use**	**%**
Sub-type	**1952**	**1965**	**1978**	**1988**	**2000**		
Forest						0	0.0%
Harvest-related							
Clear cut		5	1			6	1.9%
Partial cut						0	0.0%
Harvested in last 20yr	48	27	2	3	5	85	27.0%
Harvest older than 20yr	49	43	6	5	1	104	33.0%
Skid trail		9	3	1		13	4.1%
Total:	***97***	***84***	***12***	***9***	***6***	***207***	***65.7%***
Road-related							
Road cut						0	0.0%
Road fill	14	15		9	13	51	16.2%
Railroad cut							
Railroad fill							
Total:	***14***	***15***	***0***	***9***	***13***	***51***	***16.2%***
Grassland	24	21	2	2	7	56	17.8%
Total by period	***135***	***120***	***14***	***20***	***26***	***315***	***100.0%***
% of total	***42.9%***	***38.1%***	***4.4%***	***6.3%***	***8.3%***	***100.0%***	

A. Debris Torrents
B. Slides

B.

Land use	**Year**					**Total by land use**	**%**
Sub-type	**1952**	**1965**	**1978**	**1988**	**2000**		
Forest	5	1				6	0.3%
Harvest-related							
Clear cut	3	9	1	5	9	27	1.4%
Partial cut	2	1				3	0.2%
Harvested in last 20yr	210	75	31	28	55	399	20.3%
Harvest older than 20yr	256	156	44	64	86	606	30.8%
Skid trail	5	59	41	31	6	142	7.2%
Total:	***476***	***300***	***117***	***128***	***156***	***1177***	***60.0%***
Road-related							
Road cut	35	26	11	23	18	113	5.7%
Road fill	114	201	63	61	42	481	24.5%
Railroad	1			1		2	0.1%
Total:	***150***	***227***	***74***	***85***	***60***	***596***	***30.3%***
Grassland	55	70	12	18	17	172	8.7%
Undetermined	7	4	2	1	1	15	0.7%
Total by period	***693***	***602***	***205***	***232***	***234***	***1966***	***100%***
% of total	***35.2%***	***30.6%***	***10.4%***	***11.8%***	***11.9%***	***100.0%***	

(GMA 2001a)

Overall, GMA (2001) found that 54.8% of sediment delivery from landsliding occurred in areas affected by timber harvest, 34.4% was related to roads, and 10.6% occurred in brush and grassland areas (Table 52 and Table 53). Most of the volume from brush and grasslands came from the Inland Subbasin, as most of the grassland in the basin occurs there.

Table 52. Volumes of delivering slides by land use by subbasin in tons.

Subbasin	Forest	Brush & Grassland	Harvest-Related					Road-Related	Total
			Partial or Clear Cut	Harvest (<20 Yrs)	Harvest (>20 Yrs)	Skid Trails	Total		
Coastal	0	54	24,622	208,728	290,705	3,881	527,937	264,967	792,958
Middle	0	25	6,759	35,973	154,730	29,439	226,900	283,213	510,139
Inland	11,070	788,704	52,656	1,228,518	1,713,858	347,079	3,342,111	2,024,512	6,166,397
Total	11,070	788,783	84,037	1,473,219	2,159,293	380,399	4,096,948	2,572,693	7,469,494
Percent of Total	0.1%	10.6%	1.1%	19.7%	28.9%	5%	54.8%	34.4%	

GMA 2001a

Table 53. Volumes of delivering slides by land use by subbasin as percentage of basin total.

Subbasin	Forest	Brush & Grassland	Harvest					Road-Related	Total
			Partial Or Clear Cut	Harvest (<20 Yrs)	Harvest (>20 Yrs)	Skid Trails	Total	Total	
Coastal	0.0%	0.0%	3.1%	26.3%	36.7%	0.5%	66.6%	33.4%	100.0%
Middle	0.0%	0.0%	1.3%	7.1%	30.3%	5.8%	44.5%	55.5%	100.0%
Inland	0.2%	12.8%	0.9%	19.9%	27.8%	5.6%	54.2%	32.8%	100.0%
Total	0.1%	10.6%	1.1%	19.7%	28.9%	5.0%	54.8%	34.4%	100.0%

GMA 2001a

In general, GMA found "a consistent pattern between road construction, harvest disturbance, and resulting sediment production from landslides" (2001). A time lag of 10-15 years seemed common between periods of intense landuse activity and sediment production. Overall, sediment production has decreased dramatically since 1965, due to a combination of less harvesting and improved timber harvest techniques following the Forest Practice Rules in 1973.

Harvest-related landsliding accounted for 54.8% of slide volumes across the Big River Basin, while road-related landsliding accounted for 34.4%. A high volume of sediment was associated with grasslands and brush in some PWs in the South Fork and headwaters drainages during some time periods. These high levels were thought to be related to landform adjustments in cleared areas and underlying Central belt or mélange terrain of the Franciscan formation.

Slope Interactions

An analysis of different timber harvest methods on slopes of varying percent showed that the highest proportion of land from 1852 to 2001 was tractor harvested on slopes from 31-50% (Table 54 and Table 55). More acres were harvested on slopes greater than 50% from 1993 to 2001 than any other study period. Most of these acres were harvested using tractor and cable suspended logging methods.

Table 54. Acreage harvested by slope of ground, period, and method.

Slope in Percent	Acres Harvested: Helicopter	Cable Ground	Cable Suspend	Tractor	Total	Proportion of Area: Helicopter	Cable Ground	Cable Suspend	Tractor	Total
1852 - 1944										
0 -15		5,331		137	5,468		14		0	15
16 - 30		7,827		375	8,202		21		1	22
31 - 50		13,894		695	14,589		37		2	39
51 - 65		5,695		316	6,012		15		1	16
Greater than 65		2,912		136	3,048		8		0	8
Total		**35,659**		**1,660**	**37,319**		**96**		**4**	**100**
1945 - 1964										
0 -15		7		1,355	1,362		0		5	5
16 - 30		19		4,718	4,737		0		19	19
31 - 50		32		11,356	11,388		0		45	45
51 - 65		12		5,169	5,181		0		20	20
Greater than 65		7		2,743	2,750		0		11	11
Total		**76**		**25,341**	**25,417**		**0**		**100**	**100**
1965 - 1974										
0 -15				876	876				6	6
16 - 30				2,947	2,947				20	20
31 - 50				6,636	6,636				45	45
51 - 65				2,777	2,777				19	19
Greater than 65				1,365	1,365				9	9
Total				**14,601**	**14,601**				**100**	**100**
1975 - 1984										
0 -15			72	1,186	1,258			0	5	5

	Acres Harvested					Proportion of Area				
Slope in Percent	Helicopter	Cable Ground	Cable Suspend	Tractor	Total	Helicopter	Cable Ground	Cable Suspend	Tractor	Total
16 - 30			173	4,654	4,826			1	19	20
31 - 50			693	10,505	11,198			3	43	46
51 - 65			430	4,250	4,681			2	17	19
Greater than 65			305	2,026	2,330			1	8	10
Total			**1,672**	**22,620**	**24,293**			**7**	**93**	**100**
1985 - 1992										
0 -15			239	2,177	2,416			1	8	9
16 - 30			615	5,811	6,426			2	21	24
31 - 50			1,620	10,117	11,736			6	37	43
51 - 65			976	3,391	4,367			4	12	16
Greater than 65			606	1,585	2,192			2	6	8
Total			**4,056**	**23,081**	**27,137**			**15**	**85**	**100**
1993 - 2001										
0 -15	83		408	2,294	2,786	0		1	6	8
16 - 30	295		1,146	5,772	7,213	1		3	16	20
31 - 50	889		3,770	10,344	15,002	2		10	29	41
51 - 65	470		2,273	4,094	6,837	1		6	11	19
Greater than 65	369		1,546	2,470	4,385	1		4	7	12
Total	**2,105**		**9,143**	**24,974**	**36,223**	**6**		**25**	**69**	**100**

Table 55. Big River Basin ground disturbance by slope and harvest type, 1852-2001.

	Helicopter	Cable Suspend	Cable Ground	Tractor
Slope: 0-15%				
Acres Harvested	83	719	5,337	8,026
% Total Harvest Acres	0.1	0.4	3.2	4.9
Slope: 16-30%				
Acres Harvested	295	1,934	7,846	24,277
% Total Harvest Acres	0.2	1.2	4.8	14.7
Slope: 31-50%				
Acres Harvested	889	6,083	13,926	49,652
% Total Harvest Acres	0.5	3.7	8.4	30.1
Slope: 51-65%				
Acres Harvested	470	3,679	5,707	19,998
% Total Harvest Acres	0.3	2.2	3.5	12.1
Slope: >65%				
Acres Harvested	369	2,457	2,918	10,325
% Total Harvest Acres	0.2	1.5	1.8	6.3
Total Harvest Acres	2,105	14,872	35,734	112,278
% total Harvest Acres	1.3	9.0	21.7	68.1

Total Big River harvest/re-harvest acres = 164,989 acres, basin area = 115,886 acres. Blue categories have the lowest watershed disturbance impacts (6.4 %). Orange categories have medium watershed disturbance impacts (31.5 %). Magenta categories have the highest potential for surface erosion (62.2 %). Watershed disturbance destabilizes and/or compacts soil, re-routes drainages, and alters runoff rates and infiltration. These impact stream flows and water quality.

GMA (2001) examined the relationship between roads on various slope positions. They classified all the roads in the basin into riparian, mid-slope, or ridge-top (Table 56). Most of the roads in the basin are mid-slope, followed by riparian, and then ridge-top (Table 57). The proportion of roads in each location was similar in each subbasin. Only 22.7% of the riparian roads across the subbasin are either rocked or paved. Native riparian roads have a high potential for sediment contribution to the channel.

Table 56. Existing miles of roads in different road positions by types and subbasin (from GMA 2001a).

Subbasin	Riparian			Mid-Slope			Ridge			Total By Subbasin		
	Paved	Rocked	Native	Paved	Rocked	Native	Paved	Rocked	Native	Riparian	Mid-Slope	Ridge
Coastal Subbasin	0.5	9.5	41.2	7.5	29.4	111.5	2.4	7.0	39.5	51.2	148.4	48.9
Middle Subbasin	1.7	10.5	19.0	0.5	10.5	84.4	0.1	2.8	24.9	31.2	95.3	27.7
Inland Subbasin	10.3	34.8	168.7	14.7	57.3	392.3	2.7	8.2	150.3	213.9	464.3	161.2

Table 57. Big River Basin roads by location and surface type.

	Paved	Rocked	Un-surfaced
Ridgetop			
Miles	5.1	18	214.7
% Total Basin Miles	0.5	1.5	17
Mid-slope			
Miles	22.6	97.2	588.2
% Total Basin Miles	2.0	7.0	47.0
Riparian			
Miles	12.4	54.9	228.9
% Total Basin Miles	1.0	4.0	18.0

Total basin roads = 1242 miles, 6.9 miles/square mile. Blue categories have the lowest potential for road surface erosion (5%). Orange categories have medium potential for surface erosion (25%). Magenta categories have the highest potential for surface erosion (70%). Road surface erosion is a chronic source of fine sediment that can be delivered to streams, which is deleterious to fish habitat.

Road Interactions

GMA (2001) estimated road surface erosion across the basin from 1921 to 2000 (Table 58). Their analysis indicates that sediment production from roads has increased significantly with the increased amount of roads over the study period. Roads in 2000 were estimated to produce 92.7 tons of sediment per square mile per year across the basin, an increase over 1952 rates. Existing road surface erosion in 2000 was highest in the Middle Subbasin and lowest in the Inland Subbasin.

Table 58. Computed road surface erosion by study period by subbasin.

Subbasin	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)	
Coastal	1176.2	1444.2	2001.8	2425.8	3200.9	127,122.5	19.2%	62.1	98.6
Middle	447.7	1068.2	1162.2	1357.8	1907.4	72,818.2	11.0%	64.7	106.9
Inland	2581.3	5888.5	8426.1	9527.6	11676.2	462,849.8	69.8%	56.2	89.3
Total	4,205.1	8,400.9	11,590.0	13,311.1	16,784.6	662,790.5	100.0%	58.1	92.7

GMA 2001a

GMA (2001) also estimated sediment production from skid roads. Overall surface erosion rates from harvest were found to be small (Table 59). The analysis suggested a peak in surface erosion at the time of high harvest rates using high-density tractor logging methods from 1953-1978. Smaller volumes of surface erosion have been produced by more extensive harvest areas since 1989 due to changing harvest techniques. Surface erosion from 1989 to 2000 was highest in the Inland Subbasin and lowest in the Middle Subbasin.

Table 59. Summary of surface erosion estimates from harvest areas by study period in tons.

Subbasin	1937-1952 Total	1953-1965 Total	1966-1978 Total	1979-1988 Total	1989-2000 Total	1921-2000 Total By Subbasin
Lower Big River	1,495	3,549	4,233	3,731	4,152	17,161
Middle Big River	783	10,180	762	2,381	1,881	15,986
Inland	20,816	39,006	72,641	17,743	9,244	159,450
Total	23,094	52,735	77,636	23,855	15,277	192,597

GMA 2001a

Road Crossings

Today there are 186 miles of roads in the watercourse buffer zone (Table 60). Seventy nine percent were built before 1979. While the data show 141 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. Additionally, landowners are building midslope and ridge roads with improved standards to replace roads in the watercourse buffer zone.

Table 60. Length of truck roads in near proximity to watercourse.

Period	Total Length in Miles				Length in Miles per Sq Mile			
Basin Wide	**Native**	**Paved**	**Rocked**	**Total**	**Native**	**Paved**	**Rocked**	**Total**
pre - 1937	15.8	1.4	3.7	21.0	0.09	0.01	0.02	0.12
1937 - 1952	26.5	7.4	10.1	44.0	0.15	0.04	0.06	0.24
1953 - 1965	40.3	0.1	11.6	52.0	0.22		0.06	0.29
1966 - 1978	22.6		6.1	28.7	0.12		0.03	0.16
1979 - 1988	10.6		1.2	11.7	0.06		0.01	0.06
1989 - 2000	25.7		2.2	27.9	0.14		0.01	0.15
Total	**141.6**	**8.9**	**34.9**	**185.4**	**0.78**	**0.05**	**0.19**	**1.02**

Lengths are roads constructed in time period, not cumulative.

Fluvial Erosion

GMA (2001) estimated bank erosion and small streamside mass wasting across the basin and found little sediment from these sources. They found that most of the stream channels were incised and moderately stable.

Table 61. Bank erosion and small streamside mass wasting.

Subbasin	Bank Erosion and Small Streamside Mass Wasting		Total
	Class 1 (Tons/Year)	Class 2 (Tons/Year)	(Tons/Year)
Coastal	955	1,193	2,148
Middle	513	535	1,047
Inland	3,430	5,146	8,576
Total	Total (Tons/Yr):		11,771
% of stream miles	Total (Tons/Mi^2/Yr):		65.0

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.

Pool Quantity and Quality

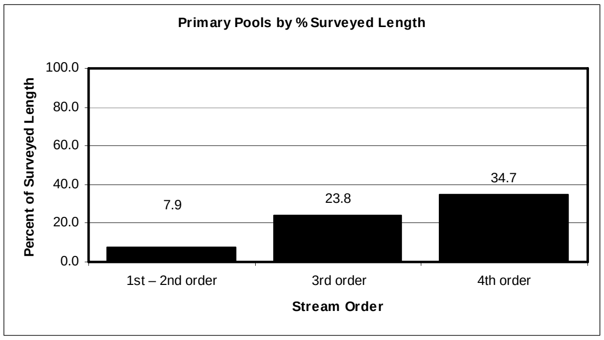


Figure 45. Primary pools in the Big River Basin.

Pools greater than 2.5 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.

Comments: The percent of primary pools by length in the Big River Basin is generally below target values for salmonids in lower order streams and appears to be suitable in fourth order streams.

Spawning Gravel Quality

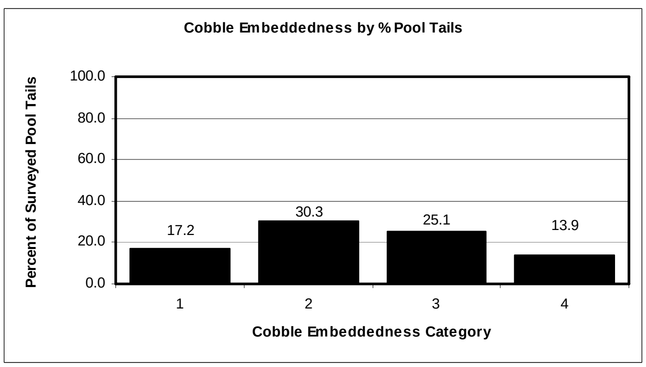


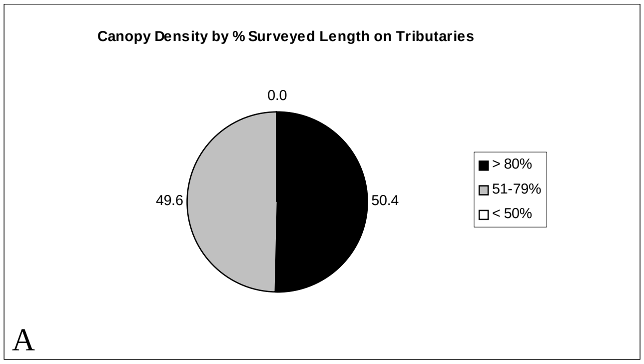
Figure 46. Cobble Embeddedness in the Big River Basin.

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

Significance: Salmonids cannot successfully reproduce when forced to spawn in streambeds with a lack of suitably such as excessive silt, clays, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is 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 fully supported range for successful use by salmonids.

Comments: Almost one half of pool tails within the Big River Basin have cobble embeddedness in categories 1 and 2, which meet spawning gravel target values for salmonids.

Shade Canopy



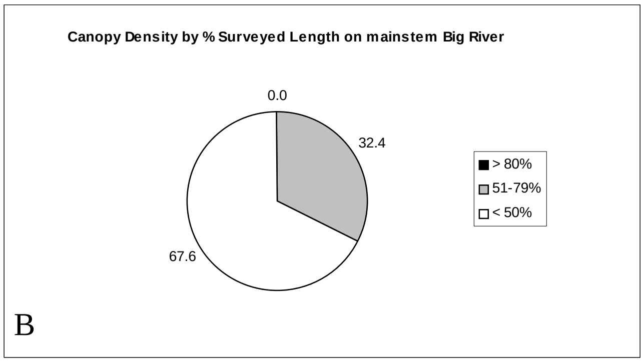


Figure 47. Canopy density in the Big River Basin. A. Tributaries. B. Mainstem Big River

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

Comments: All of the surveyed tributary lengths within the Big River Basin have canopy densities greater than 50% and just over one half of those have canopy densities greater than 80%. This is above the canopy density target values for salmonids. Canopy density is lower on the mainstem Big River, as is expected on a fourth order stream with wide channels.

Pool Shelter

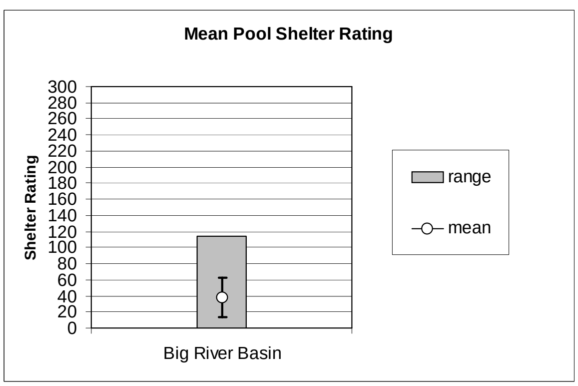


Figure 48. Pool shelter in the Big River Basin.

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 Big River Basin is 37.9. This is below the shelter target value for salmonids.

Fish Passage

Table 62. Salmonid habitat artificially obstructed for fish passage.

Feature/Function		Significance	Comments
Type of Barrier	% of estimated historic coho salmon habitat currently inaccessible due to artificial passage barriers	Free movement in 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. 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.	All of the 0.9% of estimated historic coho salmon habitat that is currently blocked by artificial barriers in the Big River Basin is blocked by a total barrier.
All Barriers	0.9		
Partial and Temporary Barriers	0.0		
Total Barriers	0.9		

N=3 Culverts in the Big River Basin
1998-2000 Ross Taylor and Associates Inventories and Fish Passage Evaluations of Culverts within the Coastal Mendocino County Road Systems

Table 63. Juvenile salmonid passage in the Big River Basin.

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 CDFG stream inventories in the Big River Basin has the potential to disconnect tributaries from the mainstem Big river and disrupt the ability of juvenile salmonids to forage and escape predation. This condition is most common in streams in the Inland Subbasin. 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.
4.2 miles of surveyed channel dry	No Data		
2.7% of surveyed channel dry			

1993-2002 CDFG Stream Surveys, CDFG Appendix

Large Woody Debris

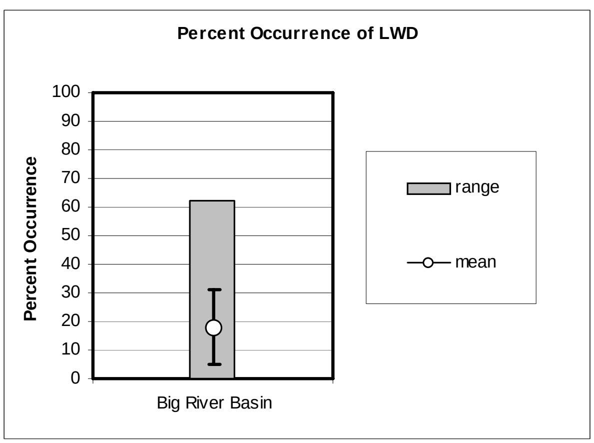


Figure 49. Large Woody Debris (LWD) in the Big River Basin.

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 percentage occurrence of LWD.

Comments: The percent occurrence of LWD in a stream as calculated by CDFG in the Big River Basin represents a measure of the amount of woody debris that was found in the wetted width of a stream channel during stream surveys that can be used by fish for cover as compared to other types of fish cover present. The average percent occurrence of LWD for the Big River Basin is 17.9%. The dominant shelter type recorded in most stream reaches was boulders, while large woody debris was the second most common dominant shelter type. This average percent occurrence of LWD is about the same as in the neighboring Albion River Basin.

Although instream habitat conditions for salmonids varied a great deal across the 181 square mile Big River Basin, several generalities can be made. Canopy density is greater than 50% across almost the entire basin, and when reaches of the mainstem Big River are not considered, half of surveyed stream length has canopy densities greater than 80%. Additionally, 4.3 miles of surveyed stream (less than 3% of surveyed stream channel) were dry and less than 4% of estimated historic coho habitat was inaccessible due to artificial passage barriers. Cobble embeddedness values are approaching target values and the percent occurrence of large woody debris is higher than that found in Redwood Creek near Orick, the Mattole River, and the Gualala River, three other North Coast California watersheds in the NCWAP assessment effort. However, across the Big River Basin the percent of primary pools by survey length in lower order streams was below target values found in CDFG's *California Salmonid Stream Habitat Restoration Manual* and calculated by the EMDS system.

Stream Reach Condition 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 came 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 subbasins and the entire Big River Basin. Weighted average reach conditions on surveyed streams in the Big River Basin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 64, Figure 50, Figure 51, Figure 52, and Figure 53). Suitable conditions exist for canopy across the Big River Basin when the mainstem Big River is not considered; for pool depth in the Coastal and Middle subbasins; and for embeddedness in the Middle Subbasin. Unsuitable conditions exist for pool quality and pool shelter across the Big River Basin.

Table 64. EMDS Anadromous Reach Condition Model results for the Big River Basin.

Subbasin	Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Coastal Subbasin (excluding the mainstem Big River) (N =9)	- (-)	U (U)	- (+++)	U (U)	- (-)	- (--)	+ (--)	- (-)	-- (--)
Middle Subbasin (excluding the mainstem Big River) (N = 5)	- (-)	U (U)	+ (++)	U (U)	- (-)	- (--)	+ (--)	- (--)	+ (-)
Inland Subbasin (N = 41)	-	U	++	U	-	--	--	--	-
Overall (excluding the mainstem Big River) (N = 55)	- (-)	U (U)	+ (++)	U (U)	- (-)	-- (--)	- (--)	-- (--)	- (-)

Key:
+ ++ +++ Highest Suitability
U Insufficient Data or Undetermined
- -- --- Lowest Suitability
Results are given first for all surveyed reaches and then for only surveyed tributary reaches excluding the mainstem Big River in parentheses.

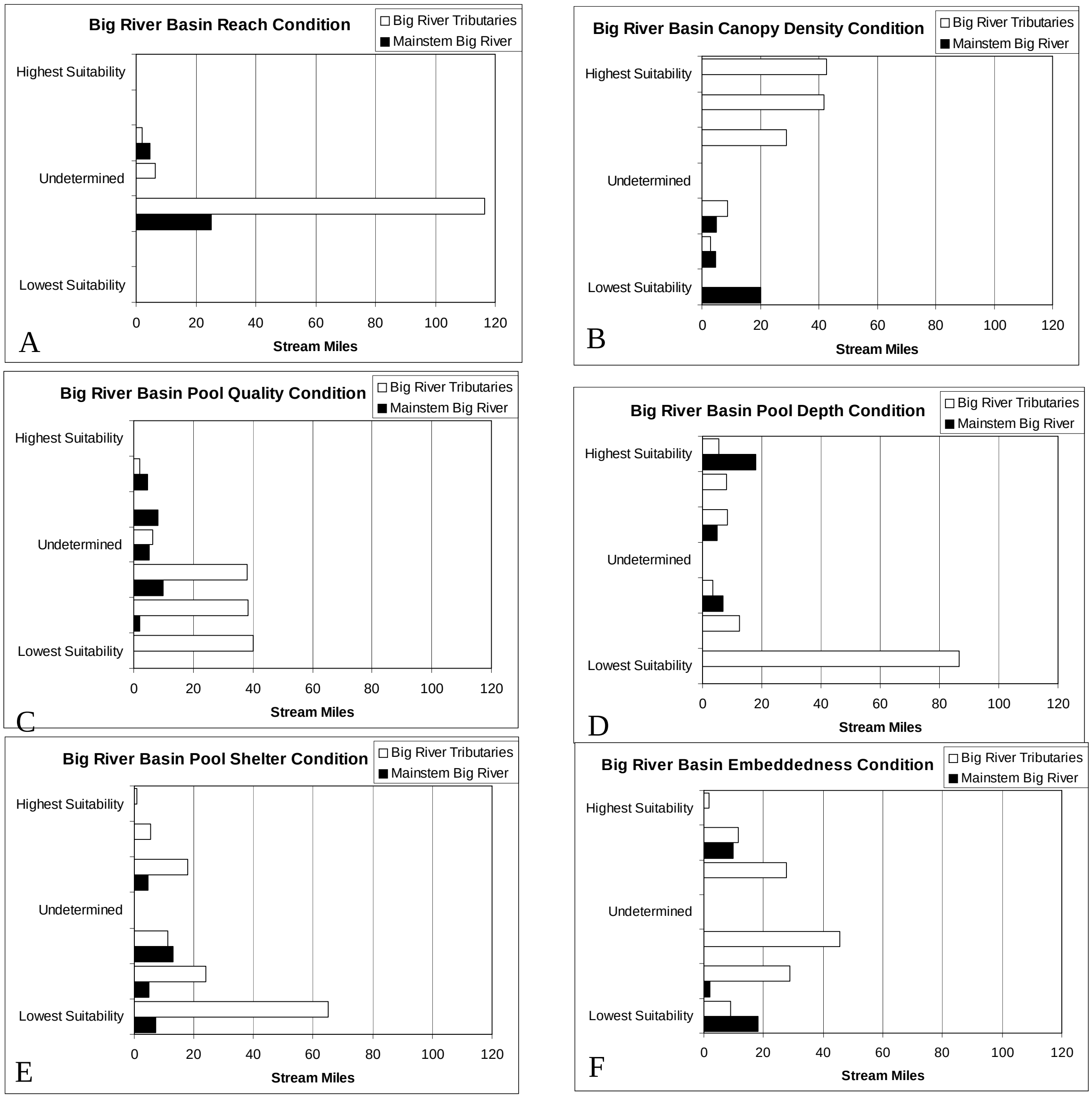


Figure 50. EMDS Reach Condition model results for the Big River Basin by surveyed stream miles.

A. Overall reach condition. B. Canopy density. C. Pool quality. D. Pool depth. E. Pool shelter. F. Cobble embeddedness.

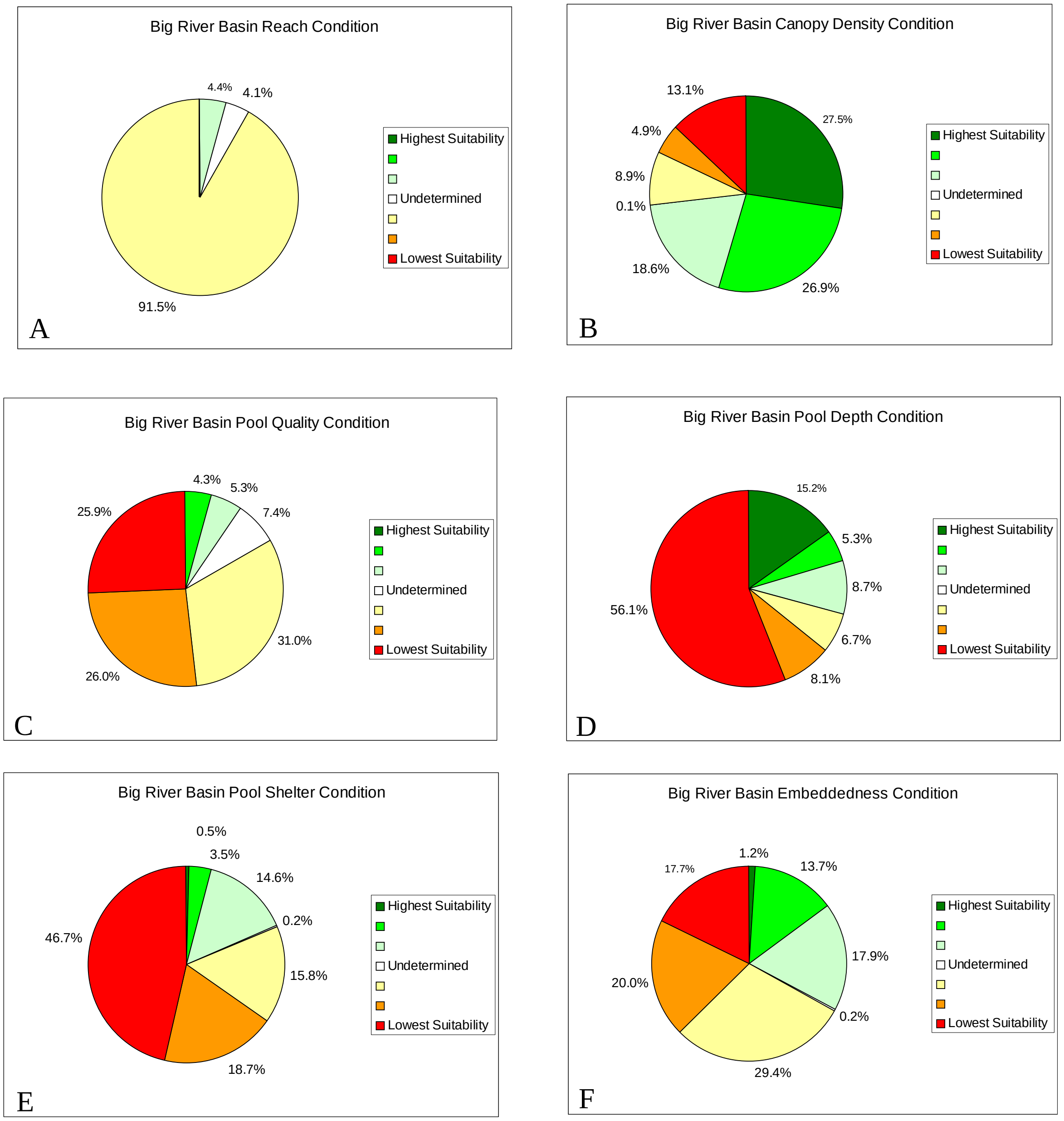


Figure 51. EMDS Reach Condition model results for the Big River Basin by percent surveyed stream miles.

A. Overall reach condition. B. Canopy density. C. Pool quality. D. Pool depth. E. Pool shelter. F. Cobble embeddedness.

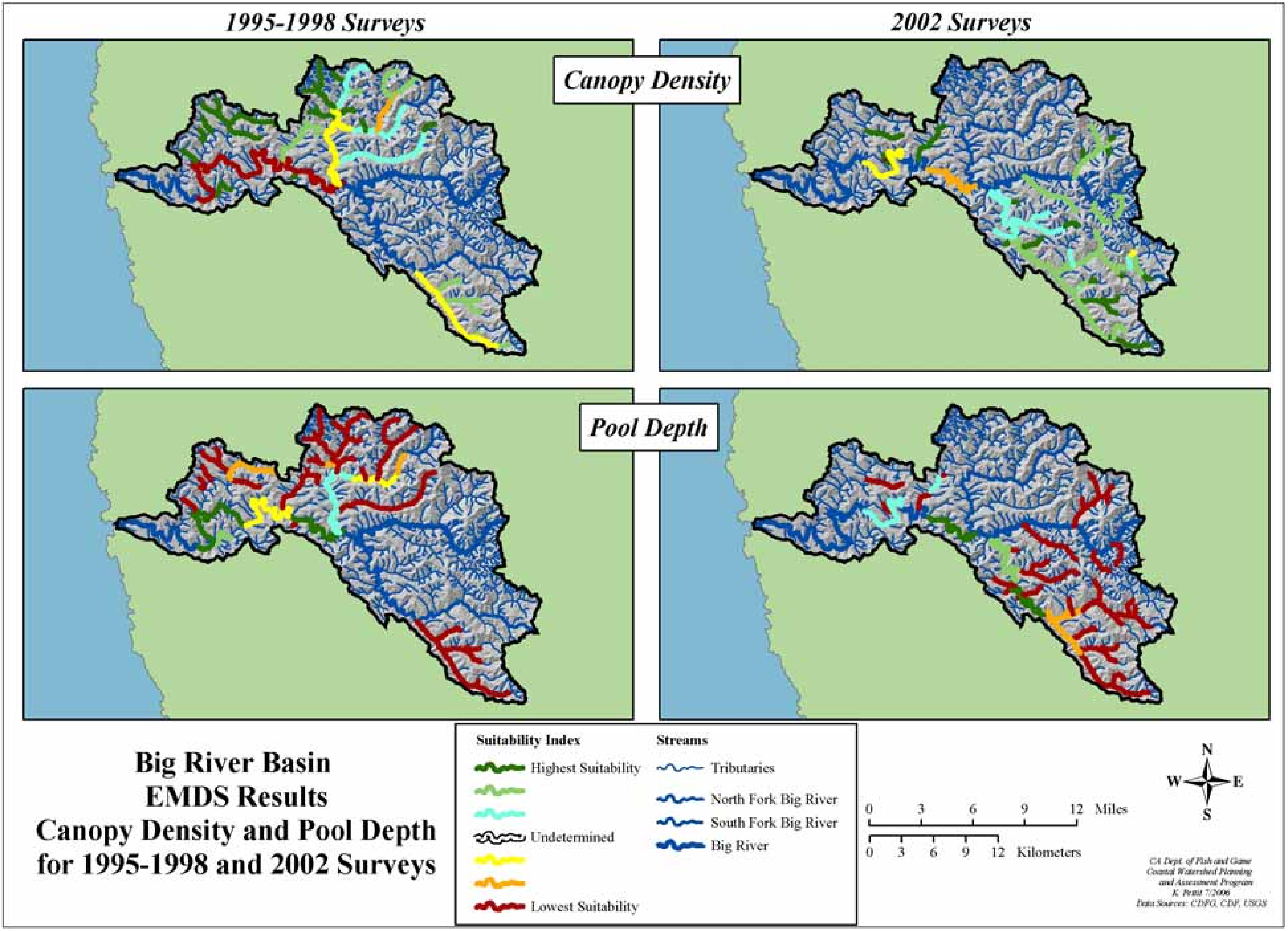


Figure 52. EMDS results for 1995-1998 and 2002 for canopy and pool depth.

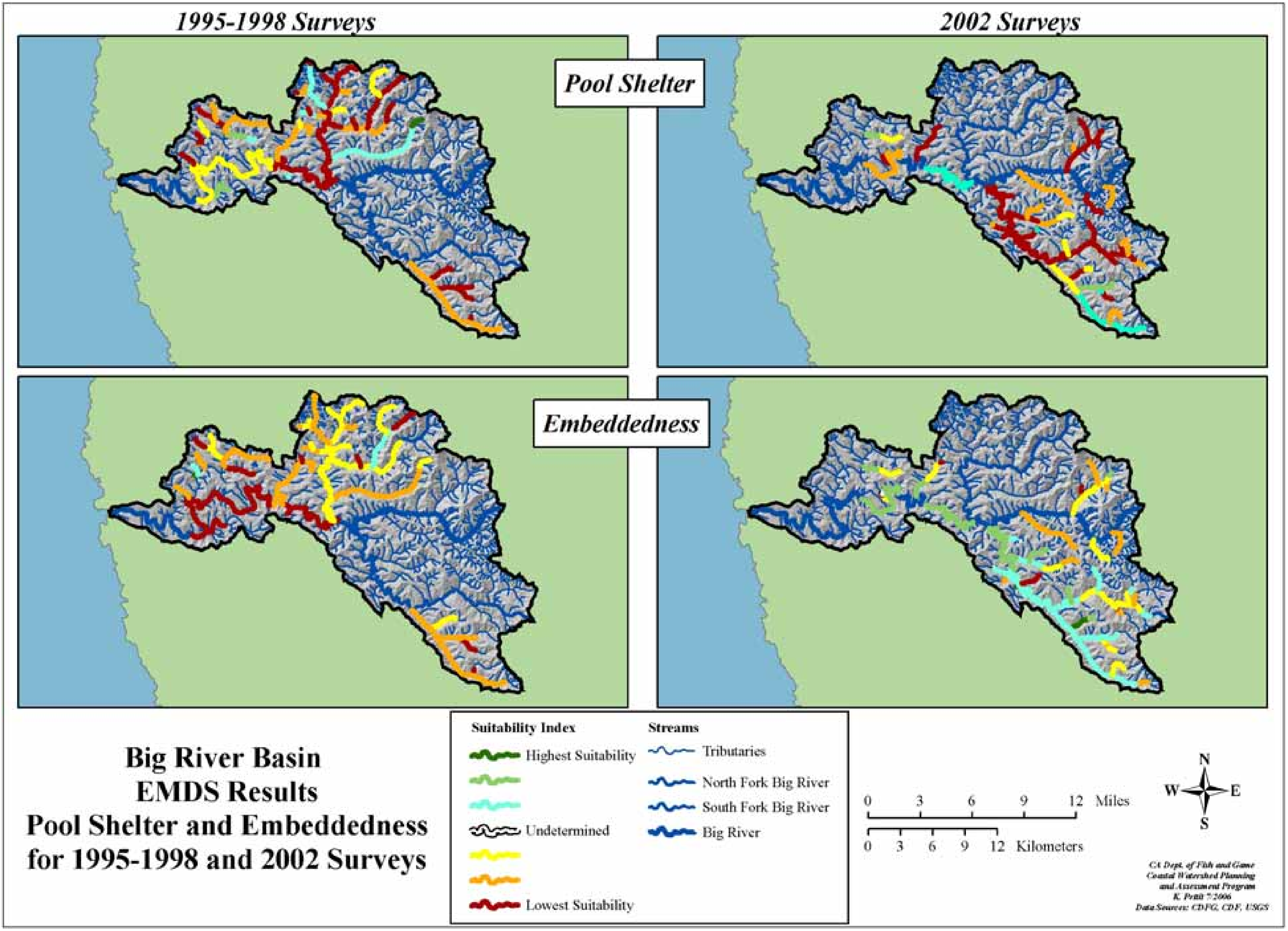


Figure 53. EMDS results for 1995-1998 and 2002 for Pool shelter and cobble embeddedness.

Analysis of Tributary Recommendations

In order to compare the occurrence of recommendations between the three subbasins in the Big River Basin, the three top ranking recommendations for each tributary were compiled. Each tributary was originally assigned anywhere from zero to ten recommendations, which were ranked in order of importance. Complete tributary recommendations for each subbasin can be found in each of the Subbasin Sections of this report.

The top three recommendations in each tributary were summed for each subbasin (Table 65). In terms of the most frequently given recommendations in each subbasin, the Coastal Subbasin had Roads and Cover recommendations for all nine tributaries and the mainstem surveyed, the Middle Subbasin had Roads and Cover recommendations for three out of five tributaries and the mainstem surveyed, and the Inland Subbasin had Roads recommendations for 24 out of 41 tributaries surveyed. Across the basin, the most frequently given recommendation was Roads.

Table 65. Occurrence of recommendations in first three ranks in surveyed streams.

Subbasin	# of Surveyed Tributaries	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Live-stock	Fish Passage
Coastal	9	39.5	4	9	0	2	5	9	0	0	0	1
Middle	5	9.5	2	3	1	1	2	3	0	1	0	0
Inland	41	105.1	20	24	7	8	20	21	1	4	0	5
Big River Basin	55	154.2	26	36	8	11	27	33	1	5	0	6

In order to further examine subbasin issues through the tributary recommendations given in CDFG stream habitat inventory 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 66). When examining recommendation categories by number of tributaries, the most important Recommendation Category in the Coastal and Middle subbasins was Instream Habitat and in the Inland Subbasin was Erosion/Sediment (Table 67).

Table 66. How improvement recommendations were collapsed into recommendation categories in the Big River Basin.

Tributary Report Recommendation	Basin Wide Recommendation Category
Bank/Roads	Erosion/Sediment
Canopy/Temp	Riparian/Water Temp
Pool/Cover	Instream Habitat
Spawning Gravel/LDA	Gravel/Substrate
Livestock/Barrier	Other

Table 67. Distribution of basin wide recommendation categories in the Big River subbasins.

Subbasin	Erosion/Sediment	Riparian/Water Temperature	Instream Habitat	Gravel/Substrate	Other
Coastal	13	2	14	0	1
Middle	5	2	5	1	0
Inland	44	15	41	5	5
Big River Basin	62	19	60	6	6

However, comparing recommendation categories between subbasins could be confounded by the differences in the number of tributaries and the number of stream miles surveyed in each subbasin. Of the 55 tributaries and the mainstem Big River surveyed in the Big River Basin, 39.5 stream miles were in the Coastal Subbasin, 9.5 in the Middle Subbasin, and 105.1 in the Inland Subbasin. Therefore, the percentage of stream miles in each subbasin assigned to the various recommendation categories was calculated for each subbasin. The percentage of the total stream length in each subbasin assigned to each subbasin recommendation category was then calculated to compare between subbasins.

Instream Habitat is the most important recommendation category in the Middle and Inland subbasins, while Erosion/Sediment is most important in the Coastal Subbasin (Figure 54). In the Big River Basin as a whole, the most important recommendation category is Instream Habitat, followed Erosion/Sediment, Riparian Water Temp, Other, and Gravel/Substrate. Therefore, the highest priority rankings changed in all of the Big River subbasins when assessed by the number of tributaries or the percentage of stream miles. Additionally, the overall rankings of recommendation categories in the Big River Basin as a whole shifted in the different analyses. The most important recommendation category in the Coastal Subbasin changed from Instream Habitat to Erosion/Sediment when assessed by percentage of stream miles rather than number of tributaries. The most important recommendation category in the Inland Subbasin changed from Erosion/Sediment to Instream Habitat.

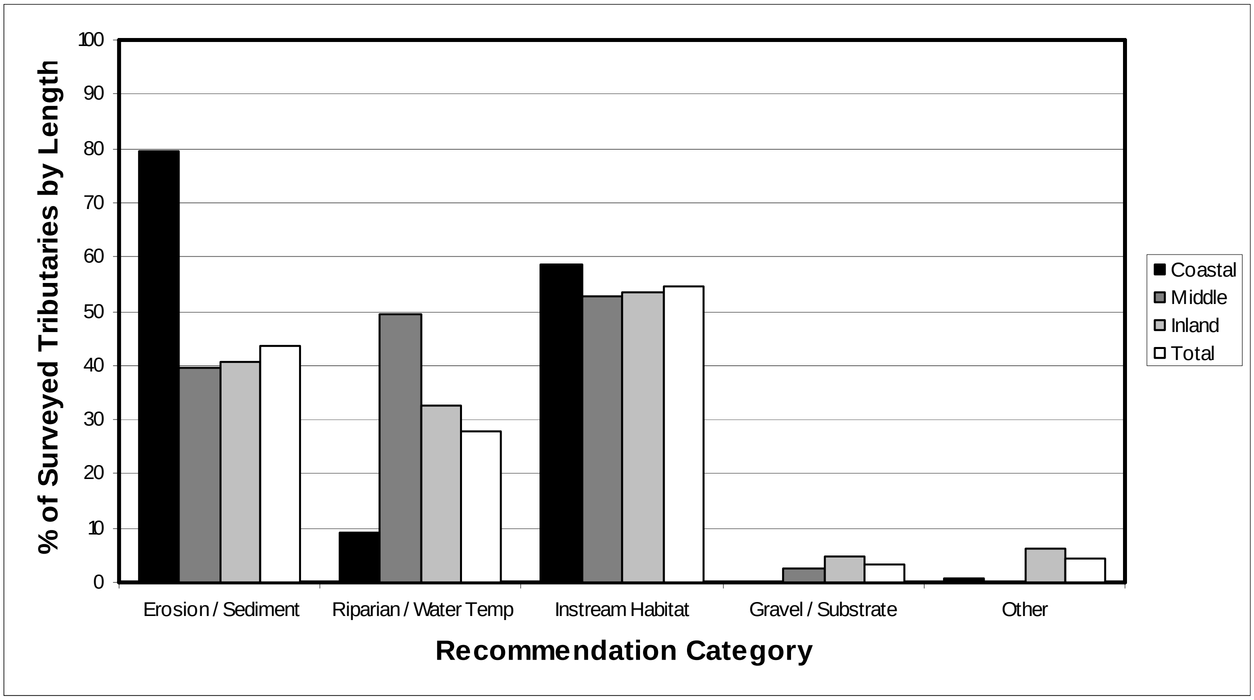


Figure 54. The percent of recommendation categories in Big River Basin surveyed streams.

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

MRC Treatment Prescriptions

The MRC (2003) included specific land management actions or recommendations for protection of aquatic resources on their ownership in the basin (Table 68). These recommendations, or prescriptions, were linked to nine specific causal mechanisms. Each causal mechanism has the following associated with it:

- Resource Sensitive Area - area or topic addressed by the prescription
- Input Variable and Process - briefly states source variable or input to a sensitive resource
- Prescriptions - specific land management actions or recommendations

Recommendations are also linked to Mass Wasting Map units, which represent general areas of similar geomorphology, landslide processes, and sediment delivery potential for shallow-seated landslides. These units are interspersed throughout MRC's ownership and do not correlate to this assessment's subbasins (see MRC 2004 for definitions and a map of the Mass Wasting Units).

Table 68. Causal mechanisms and action prescriptions for the MRC ownership in the Big River Basin (MRC 2003).

Resource Sensitive Area	Input Variable and Process	Prescriptions
Mass Wasting Map Unit #1	Coarse and fine sediment from mass wasting and bank erosion	*MWMU 1 Road construction:* • If inner gorge topography, no new road or landing construction unless field reviewed and approved by a California Registered Geologist. • If not inner gorge topography, road construction shall be minimized. • If road construction must occur, the road must utilize the highest design standards to lower risk of mass wasting sediment delivery. *MWMU 1 Existing Roads:* • Existing roads and landings shall be abandoned when no longer needed. If abandoning is not feasible, then roads or landings shall be maintained at the design standards that lower risk of mass wasting sediment delivery. *MWMU 1 Tractor Yarding:* • Equipment exclusion zones on inner gorge slopes. • Equipment exclusion zones on non-inner gorge slopes except for existing roads or where alternative yarding method creates potential for greater sediment delivery. *MWMU 1 Skid Trail Construction or Reconstruction:* • No new tractor trail construction on inner gorge slopes, no new tractor trail construction or reconstruction on non-inner gorge slopes unless field reviewed and approved by a California Registered Geologist. *MWMU 1 timber harvest:* • MWMU 1 will receive no harvest on inner gorge slopes unless approved by a California Registered Geologist. • On other areas (non-inner gorge slopes) within MWMU 1, in addition to the riparian protections set as company policy, timber harvest must retain a minimum of 50% overstory canopy dispersed evenly across the slopes. • The MWMU 1 protections will extend from the edge of the watercourse transition line up to the break in slope of the inner gorge and 25 feet of additional slope distance after the break in slope of the inner gorge. • For those areas that do not have well defined inner gorge topography in MWMU 1 timber harvest must retain 50% canopy.
Mass Wasting Map Unit #2	Coarse and fine sediment from mass wasting	*MWMU 2 Road construction:* • If inner gorge topography, no new road or landing construction unless field reviewed and approved by a California Registered Geologist. • If not inner gorge topography, road construction shall be minimized. • If road construction must occur, the road must utilize the highest design standards to lower risk of mass wasting sediment delivery. *MWMU 2 Existing Roads:* • Existing roads and landings shall be abandoned when no longer needed. If abandoning is not feasible, then roads or landings shall be maintained at the design standards that lower risk of mass wasting sediment delivery. *MWMU 2 Tractor Yarding:* • Equipment exclusion zones on inner gorge slopes. Equipment exclusion zones on non-inner gorge slopes except for existing roads or where alternative yarding method creates potential for greater sediment delivery. *MWMU 2 Skid Trail Construction or Reconstruction:* • No new tractor trail construction on inner gorge slopes, no new tractor trail construction or reconstruction on non-inner gorge slopes unless field reviewed and approved by a California Registered Geologist. *MWMU 2 Timber Harvest:* • No harvest on inner gorge slopes unless approved by a California Registered Geologist. On other areas (non-inner gorge slopes) within MWMU 2, in addition to the riparian protections set as company policy, timber harvest must retain a minimum of 50% canopy (see footnote 1, page H-2) dispersed evenly across the slopes. • The MWMU 2 protections will extend from the edge of the watercourse transition line up to the break in slope of the inner gorge and 25 feet of additional slope distance after the break in slope of the inner gorge. • For those areas that do not have well defined inner gorge topography in MWMU 2 timber harvest must retain 50% canopy.

Resource Sensitive Area	Input Variable and Process	Prescriptions
Mass Wasting Map Unit #3	Coarse and fine sediment from mass wasting	*MWMU 3 Road construction:* • No new road construction across MWMU 3 unless field reviewed and approved by a California Registered Geologist unless it is the best road alternative2. *MWMU 3 Existing Roads:* • Existing roads and landings shall be abandoned when no longer needed. If abandoning is not feasible, then roads or landings shall be maintained at the design standards that lower risk of mass wasting sediment delivery. *MWMU 3 Tractor Yarding:* • Equipment limited to existing roads or stable trails3. *MWMU 3 Skid Trail Construction or Reconstruction:* • No new tractor trail construction or reconstruction unless field reviewed and approved by a California Registered Geologist. *MWMU 3 Timber Harvest:* • Retain 50% canopy (see footnote 1, page H-2) with trees dispersed evenly across slope. Tree retention shall be emphasized in the axis of headwall swales. Deviations from this default must be field reviewed and approved by a California Registered Geologist.
Rockslides (deep seated landslides)	Coarse and fine sediment from mass wasting	No harvest or new road construction will occur on active portions of rockslides with a risk for sediment delivery unless approved by a California Registered Geologist.
High and Moderate Erosion Roads*	Coarse and fine sediment from surface and point source erosion	The roads with a high erosion hazard rating should be given special attention for maintenance or erosion control. These roads should be considered high priority roads for rock surface, improved and increased road drainage relief, design upgrades, or decommissioning. The moderate erosion hazard roads should be given similar attention, but not as high a priority as the high erosion hazard roads. The roads in close proximity to watercourses in the Big River WAU will be assessed, where possible, for decommissioning based on road network connectivity and harvesting needs. Assessment or scheduling of road decommissioning will consider operational considerations of harvest scheduling, proximity and availability of equipment, magnitude of the problem, and accessibility to the site. The following roads have been identified, to date, for decommissioning: • Road DC-023 from DC0023-05 to SC-018 • Road DC-23-07 • Road SC-037 • Road SC-016-07 • Road SC-012 • Road M-150 • Road GC-018
Known High Treatment Immediacy Sites for Roads*	Sedimentation from surface and point source erosion	The known high treatment immediacy controllable erosion sites will be the highest priority for erosion control, upgrade, or modifications to existing design. These sites will be scheduled for repair based on operational considerations of harvest scheduling, proximity and availability of equipment, magnitude of the problem, and accessibility to the site.
Fish Passage Barriers from Culverts**	Barrier to fish migration	The 5 known culverts shall be removed or replaced with a drainage facility that will pass both juvenile and adult salmonids. All of these crossings should be a high priority for fish passage improvement. Other fish migration barriers likely exist and need to be investigated over time.
Riparian Areas	LWD recruitment	The company policies for streamside stand retention are considered to be appropriate at this time for LWD recruitment. Monitoring of LWD recruitment will be done to determine if this is correct. In the interim MRC will promote attempts to place LWD in stream channels to provide habitat structure. The stream locations with high instream LWD demand should be considered the highest priority for LWD placement. The moderate instream LWD demand segments would be next.
Canopy Closure over Class I and II Watercourses	Canopy closure and stream water temperature	The company policies for promoting streamside canopy and riparian management are considered to be appropriate at this time to improve stream canopy. Monitoring of stream temperatures and canopy will be done to determine if this is correct. Areas with unnaturally low canopy in the Big River WAU will have the following considerations for canopy improvement: • Tree planting along the river for restoration of riparian vegetation should be emphasized. • Restoration harvest within the Aquatic Management Zone will not remove trees providing effective shade. • Stream temperatures will be monitored to determine if temperatures are lowering as canopy grows in over time.

* See the MRC Road Hazard maps on pages 38 of the Middle Subbasin and 93 of the Inland Subbasin for locations of road sites.
** See Fish Passage Barriers sections on pages 23 of the Middle Subbasin and 57 of the Inland Subbasin for locations of culverts.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Big River Basin 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 CCWPAP EMDS at the stream reach scale.

The most complete data available in the Big River Basin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the CCWPAP team.

Salmonid habitat conditions in the Big River Basin are generally best in the Coastal Subbasin, and mixed in the Middle and Inland subbasins. The following refugia area rating table summarizes subbasin salmonid refugia conditions.

Table 69. Subbasin salmonid refugia area ratings in the Big River Basin.

Subbasin	Refugia Categories:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Coastal Subbasin		X				X	X
Middle Subbasin			X				X
Inland Subbasin			X				X

*Ratings in this table are done on a sliding scale from best to worst. Subbasin refugia ratings are aggregated from their tributary ratings. See page 45 for a discussion of refugia criteria.

Big River Basin Tributaries by Refugia Category:

High Quality Habitat, High Quality Refugia Tributaries:

None

High Potential Refugia Tributaries:

Railroad Gulch
Little North Fork Big River
Rocky Gulch
Thompson Gulch
East Branch Little North Fork Big River
Berry Gulch
Berry Gulch Tributary
Two Log Creek
Ayn Creek
Tramway Gulch
Hatch Gulch
North Fork Big River
East Branch North Fork Big River
Bull Team Gulch
Chamberlain Creek
Water Gulch
West Chamberlain Creek
Arvola Gulch
James Creek
South Fork Big River
Ramon Creek
North Fork Ramon Creek
Daugherty Creek
Soda Creek
Gates Creek
Snuffins Creek
Dark Gulch
South Fork Big River Tributary #1
South Fork Big River Tributary #2
Russell Brook
Martin Creek
Martin Creek Right Bank Tributary #1
Valentine Creek

Medium Potential Refugia Tributaries:

Big River Estuary
Big River mainstem in the Coastal, Middle, and Inland subbasins
Laguna Creek
Manly Gulch
Saurkraut Creek
Beaver Pond Gulch
Dunlap Gulch
Frykman Gulch
Water Gulch Tributary
Gulch Sixteen
Gulch Sixteen Tributary
Lost Lake Creek
North Fork James Creek
Biggs Gulch
Mettick Creek
Boardman Gulch
Halfway House Gulch
Johnson Creek (Tributary to Gates Creek)
Horse Thief Creek
Johnson Creek
Pig Pen Gulch
Martin Creek Left Bank Tributary
Martin Creek Right Bank Tributary #2
Rice Creek

Low Quality Habitat, Low Potential Refugia Tributaries:

Dry Dock Gulch	Steam Donkey Gulch
Cookhouse Gulch	Quail Gulch
Wheel Gulch	Park Gulch
Peterson Gulch	Soda Gulch
Kidwell Gulch	Poverty Gulch
Blind Gulch	Anderson Gulch
Dietz Gulch	Montgomery Creek

Data Limited and Critical Contributing Area

Occasionally, individual streams were missing data that would have provided a more complete picture for use in the refugia analysis. In these cases, only one or two of the factors used in the rating process were missing and this did not prevent refugia determination from being estimated. Where there were not enough data to give a stream a refugia rating, the site may have been listed as a critical contributing area based on the suitability of the habitat according to available data. All streams are lacking desired data.

<u>Other Related Refugia Component Categories:</u>

Potential Future Refugia (Non-anadromous)

None

Critical Contributing Area:

Big River Estuary

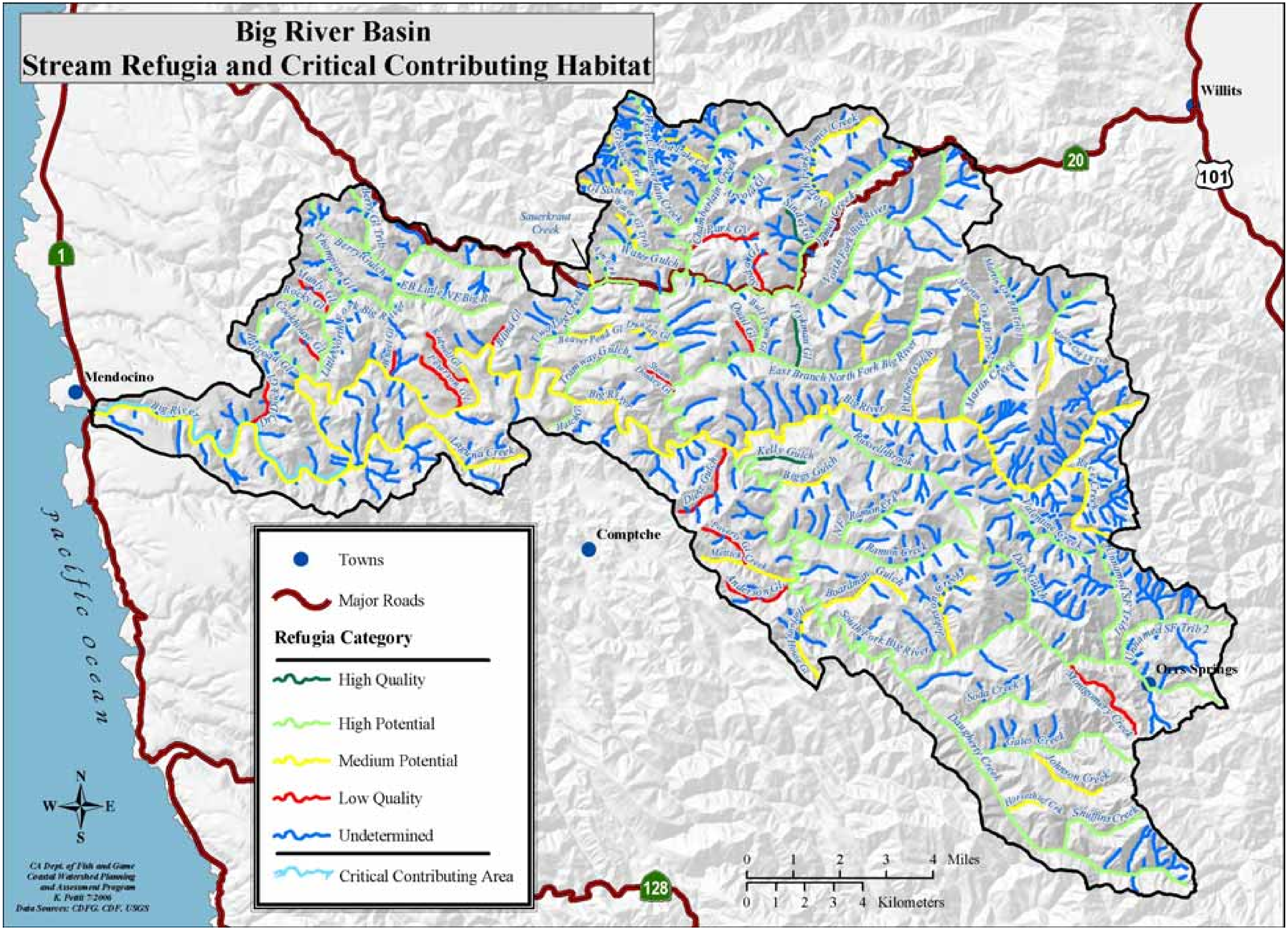


Figure 55. Stream refugia in the Big River Basin.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Big River Basin?

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 Endangered Species Act listing investigations, the populations of salmonids have likely decreased in the Big River Basin as they have elsewhere along California and the Pacific Coast. Coho salmon in Mendocino County are currently listed as endangered under the California and federal Endangered Species Acts and steelhead trout are listed as threatened under the federal Endangered Species Act;
- Based on limited CDFG, USFWS, HTC, MRC, and SONAR presence surveys and surveys documented by NMFS, the distributions of coho salmon and steelhead trout do not appear to have changed since the 1960s;
- Steelhead trout were documented in more reaches surveyed by CDFG and MRC since 1990 than coho salmon;
- Thirty tributaries, the mainstem Big River, and the estuary had records of coho salmon and steelhead trout since 1990. Twenty additional tributaries recorded only steelhead trout.

What are the current salmonid habitat conditions in the Big River Basin? How do these conditions compare to desired conditions?

Findings and Conclusions:

Flow/Water Quality

- Water temperatures at all seven monitoring sites along the mainstem of the Big River were unsuitable for salmonids;
- Water temperatures in tributaries across the basin showed that temperatures were generally suitable for salmonids in the Coastal and Middle subbasins and mixed in the Inland Subbasin. Water temperatures in the larger tributaries in the Inland Subbasin such as the North and South forks Big River were generally unsuitable for salmonids while water temperatures in the smaller tributaries were suitable;
- There have been very few water quality samples taken across the basin. Some sites show indications of exceeding NCRWQCB criteria for sodium, copper, specific conductance, total dissolved solids, aluminum, zinc, or boron. However, these findings are based on few sample sites and in some cases may be artifacts of the type of sampling procedure used.

Fish Passage

- Fish passage barriers have been identified in seven surveyed tributaries across the basin and several small tributaries along the estuary are blocked to fish passage by perched culverts;
- Areas of dry channel found during CDFG stream surveys may indicate fish passage problems in some tributaries during periods of low flow;
- Erosion/Sediment;
- Data collected in four tributaries in the basin indicated excessive amounts of fine sediment in the sub-0.85 mm and/or sub-6.5mm size classes, which would create unsuitable conditions for salmonids. However, much of the basin has not been evaluated for sediment delivery and deposition.

Riparian Condition

- Canopy cover was suitable for salmonids on all surveyed reaches within the basin except for James Creek and the mainstem Big River. The mainstem Big River has a larger, broader channel and floodplain and is expected to have relatively reduced canopy levels.

Instream Habitat

- A high incidence of shallow pools and a lack of cover and large woody debris indicate simplification of instream salmonid habitat in surveyed tributary reaches and the estuary.

Gravel/Substrate

- Cobble embeddedness values in many CDFG surveyed reaches were unsuitable for salmonid spawning success. Of surveyed pool tails, only 17.2% had cobble embeddedness less than 26%. In addition, the MRC characterized spawning gravels as fair quality on segments they surveyed;
- Permeability sampling in four locations throughout the basin indicated low to moderate amounts of fine material. This could indicate suitable to somewhat unsuitable conditions for salmonid in these sample sites.

Refugia Areas

- Salmonid habitat conditions in the Big River Basin are generally best in the Coastal Subbasin tributaries where they have generally been rated as high potential refugia. Conditions in the Middle and Inland subbasins are mixed and generally rated as medium potential refugia.

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

<u>Findings and Conclusions:</u>

- The geology of the Big River Basin is primarily comprised of Coastal Belt Franciscan Complex. 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 the watershed. A small portion of Tertiary age sandstone is found in the Greenough Ridge - Montgomery Woods State Reserve area (EPA, 2001);
- The Coastal and Middle subbasins have much lower relief and longer slopes than the Inland Subbasin, which has a high percentage of area in higher slope classes;
- Redwood and Douglas fir forests have historically and continue to dominate the basin. Additional vegetation includes tan oak, madrone, alder, bishop pine, pygmy cypress, willow, grass, oak, bay laurel, alder oak, and blueblossom. Pre-European forests consisted of mostly large old-growth trees;
- A long history of wildfire has influenced the current vegetation of the Big River Basin, although the specifics of fire practices and history are unknown. However, fire was a natural and frequent occurrence. Prior to European settlement, the Mendocino Coast experienced a fire every 6-20 years during the last 200-400 hundred years (Brown 1999). In 1931, the Comptche fire swept across the eastern part of the basin, burning 10,733 acres, 9% of the basin;
- The basin has experienced a variety of natural disturbances such as earthquakes, flooding, droughts, and decadal climate shifts. Examples include a moderate earthquake that originated about two miles south of the Albion Basin during the mid to late 1800s, another strong earthquake that originated near Fort Bragg in 1898, and the distant San Francisco earthquake in 1906. Earthquakes often trigger landsliding;
- Landsliding has occurred across the entire basin. More landslides and more volume from landslides by area are found in the Inland Subbasin than the other two subbasins;
- Many of the tributaries in the basin are intermittent in their upper reaches and usually have summer and fall flows of less than 1 cfs.

How has land use affected these natural processes?

<u>Findings and Conclusions:</u>

- Historic timber harvest activities reduced riparian canopy, 86% of the basin has experienced one or more timber harvests. However, canopy is currently suitable along most surveyed tributary reaches across the basin;
- As a result of timber harvest, the current landscape is comprised of smaller diameter forest stands than in pre-European times [61% of trees in 75-100 feet wide watercourse buffer zones have diameter at breast height (dbh) less than 24 inches]. The small diameter of near stream trees across the basin limits the

recruitment potential of large woody debris to streams and contributes to the lack of instream habitat complexity;

- Splash dam logging involving 27 splash dams across the basin before 1920 likely greatly accelerated erosion and widened stream channels across the basin. However, significant bed lowering along the lowermost reaches of Big River associated with splash dams is unlikely;
- Post splash damming channels are deeply entrenched, cut down to bedrock in many places, lacking functional floodplains, and depleted of LWD and gravel;
- Early splash dam and barrier removal projects, starting in the 1950s, cleared many streams across the basin of timber-related woody debris. The lack of instream complexity seen today likely results from these past practices;
- A lack of LWD throughout the Big River Basin also allows sediment to move more quickly through the stream system and move downstream in greater quantities than pre-disturbance;
- CGS found that channel narrowing, floodplain growth, and encroachment of forest vegetation on marshes seen since 1900 along the estuary is likely the result of a river channel reclaiming itself after the multiple decades of channel clearing, splash dam flooding, and battering by logs in transport;
- Historic sawmill complexes on the Big River flats reduced wetland habitat;
- Construction of near stream railroads in the Coastal and Middle subbasins and North Fork Big River and roads throughout the basin used fill that constricted stream channels and destabilized streambanks;
- From 1937 to 2000 the rate of landsliding across the basin was 664.3 tons/square mile/year (approximately 332 cubic yards or 33 truck loads). Rates were highest in the Inland Subbasin, followed by the Middle and Coastal subbasins, respectively;
- CGS photo mapping of stream channels in 1984 and 2000 found that negative channel features increased in the Mouth of Big River PW and decreased in the North and South forks Big River and Daugherty Creek, as expected between source and depositional reaches. The greatest reductions in negative channel features were seen in Daugherty Creek;
- There has been a significant increase in road building since 1989 across the basin, especially in the Coastal and Middle subbasins. However, new roads have been built to higher standards, on ridge-tops, and are paved; thus creating less of a sediment source;
- Roads and timber harvesting are listed in the NCRWQCB TMDL report as major sources of human-related sediment into the stream system. The effects from these activities are often spatially and temporally removed from their upland sources;
- County culverts located on three tributaries in the Inland Subbasin have been identified as total salmonid passage barriers by a Mendocino County roads study. Additionally, perched culverts have blocked fish passage to small tributaries along the estuary;
- The recent purchase of a large portion of the estuary and transfer to DPR for management as a park also will likely improve temperature and sediment conditions in the Coastal Subbasin as planned management improves roads and riparian zones.

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

<u>Findings and Conclusions:</u>

Based on the information available for this assessment, it appears that salmonid populations are currently being limited by:

- Low summer stream flows in tributaries in the Inland Subbasin;
- High water temperatures in the mainstem Big River;
- Fish passage barriers;
- Embedded spawning gravels;
- Reduced habitat complexity.

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

Flow and Water Quality Improvement Activities

- To minimize and reduce the effects of water diversions, take action to ensure compliance with state water laws to address seasonal diversion, off-stream reservoirs, bypass flows protective of coho salmon and other anadromous salmonids and the normal hydrograph, and avoidance of adverse impacts caused by water diversion;
- Discourage instream flow diversions in tributaries with cooler water temperatures for thermal refugia delivered to the warmer North and South forks and mainstem Big River in the summer;
- Land managers should work to reduce the temperature of water flowing into the Middle and Coastal subbasins. In order to do this, they should maintain and/or establish adequate streamside protection zones to increase shade and reduce heat inputs to Big River and its tributaries throughout the basin;
- Follow the procedures and guidelines outlined by NCRWQCB to protect water quality from ground applications of pesticides.

Fish Passage

- Consider modifying debris accumulations to facilitate fish passage where necessary;
- Adequately fund prioritization and upgrading of culverts to provide fish passage within the range of coho salmon and to pass 100-year flows and the expected debris loads.

Erosion and Sediment Delivery Reduction Activities

- To reduce sediment delivery to Big River, land managers should continue their efforts such as road improvements, good maintenance, and decommissioning and other erosion control practices associated with landuse activities throughout the basin. Thirty-six CDFG stream surveys had road sediment inventory and control as a top tier tributary recommendation;
- Support and encourage existing and active road management programs undertaken by landowners throughout the basin;
- Map unstable soils and use soil mapping to guide land-use decisions, road design, THPs, and other activities that can promote erosion;
- Sediment sources from eroding streambanks and adjacent hillslopes should be identified and treated to reduce sediment generation and delivery to creeks;
- Limit unauthorized and impacting winter use of unsurfaced roads and recreational trails to decrease fine sediment loads;
- Develop erosion control projects similar to the North Fork Ten Mile River erosion control plan (Mendocino Department of Transportation 2001).

Riparian and Instream Habitat Improvement Activities

- Improve instream structure for juvenile escape and ambush cover. Thirty-one CDFG stream surveys and the mainstem Big River have increase escape cover as a top tier tributary recommendation;
- Add LWD to stream channels where appropriate/feasible to develop habitat diversity and to increase shelter complexity. In addition, there is a need to leave large wood on stream banks and in estuarine channels for potential recruitment into stream channels and the estuary;
- Maintain and improve existing riparian cover where needed;
- Encourage growth and retention of nearstream conifers;
- Ensure that any land management activities include protection and preservation of stream and riparian habitats and maintain or improve ecological integrity within the basin;
- Ensure that high quality habitat is protected from degradation. Salmonid habitat conditions in the Big River Basin are generally best in the Coastal Subbasin, and mixed in the Middle and Inland subbasins;
- Consider the use of management strategies such as conservation easements to maximize potential benefits to aquatic habitats from near-stream forest protection.

Education, Research, and Monitoring Activities

- State Parks, CDFG, MRC, and HTC should continue and expand existing monitoring of anadromous salmonid populations to include some winter and spring fish sampling;
- Support stream gage installations and maintenance to establish a long term record of Big River hydrologic conditions;
- Additional investigations of the physical characteristics of Big River are needed to re-evaluate the Sediment Source Analysis. A regional curve of bankfull dimensions vs. drainage area should be developed for Mendocino County and used to validate CGS (2004) bankfull discharge estimates for Big River;
- Hillslope and in-stream monitoring proposed by the MRC in their Watershed Analysis (2003) should be carried out and additional monitoring programs throughout the basin should be planned with respect to MRC techniques;
- A study examining how sediment plugs moved downstream from historic splash dam locations over time on air photos is recommended;
- Continue water temperature monitoring at current locations and expand these efforts where appropriate;
- Further study of timberland herbicide use is recommended.