GUALALA RIVER WATERSHED

LITERATURE SEARCH AND ASSIMILATION

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Forward

The Redwood Coast Land Conservancy (RCLC) initiated this study to provide a summary of information on the Gualala River watershed and its fisheries resources. RCLC wishes to forge a cooperative working relationship with other local residents who are concerned about the river's health and want to work to reverse the decline in fisheries and water quality. This project draws together historical and recent documents from a wide variety of sources. Some references are included from studies conducted outside the Gualala watershed if the topic is germane to the limiting factors or restoration opportunities in the basin.

Assimilation of electronic data sets was beyond the scope of this current work. However, existing data sets are described so that later cooperative efforts might explore its acquisition for long-term monitoring. Maps were obtained as part of this study, such as those from the California Division of Mines and Geology, but electronic maps suitable for an electronic geographic information system (GIS) were not acquired. Photographs can provide a window back in time and project personnel were lucky to find excellent photographs of the Gualala River and its tributaries in the early days of settlement. Historical aerial photos were reviewed and their location documented so that restoration and monitoring efforts can use them for analysis. Although it was beyond the scope of this project, field visits were made to see watershed conditions first hand. Therefore, current photos from the field were taken and included in this report.

The final synthesis is an attempt to convey what is known regarding trends in watershed health and fisheries. The report was divided into sections related to trends of fish populations and fish habitat as well as key factors that are recognized as limiting fisheries and water quality. Although restoration is not well advanced on the Gualala, a section devoted to this topic documents past activities and suggests a framework for future activities. The final section is on monitoring which is necessary to gauge the success of restoration strategies and the long-term reversal of water quality problems.

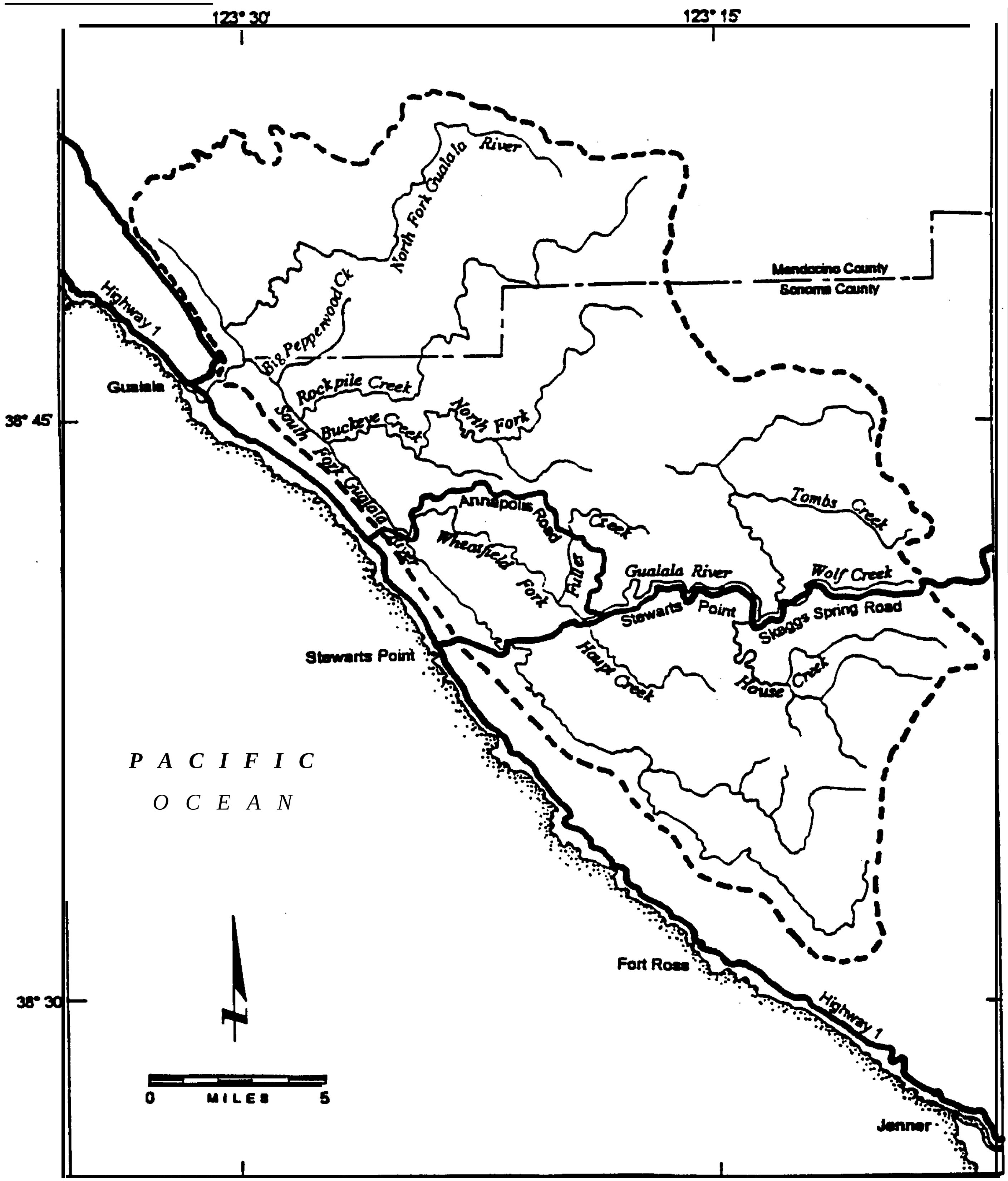
Introduction: Gualala Watershed Overview

The U.S. Bureau of Reclamation Fishery Improvement Study (1974) described the Gualala River watershed succinctly: "The Gualala River and tributaries are located in the south-westerly portion of Mendocino and the north-westerly part of Sonoma County, California. The Gualala River drains into the Pacific Ocean near the town of Gualala, approximately 114 miles north-westerly of San Francisco. The watershed encompasses about 300 square miles, has an average width of about 10 miles, and length of about 30 miles in a north-south direction. The entire river basin is mountainous and rugged, through which the river and numerous tributaries flow in gorge-like valleys with narrow bottom lands. Elevations vary from mean sea level to over 2,650 feet along the ridges and peaks. In the Gualala River drainage, there are 75 miles of silver salmon and 178 miles of steelhead habitat." Figure 1 is a watershed map from EIP Associates (1994a) but originally produced by Phillip Williams and Associates.

A California Department of Fish and Game file report (Anon., 1968) provides more background: "The five principal Gualala Tributaries in order of size are: Wheatfield Fork (34% of drainage), South Fork (16.7%), North Fork (14.7%), Buckeye Creek (14.70% and Rockpile Creek (12%). The South Forks headwaters are about 25 miles south of the river mouth and about five miles inland. This area is characterized by steep slopes forested principally with Douglas fir and redwood with madrone and tan oak present to a lesser degree. Headwaters of the Wheatfield Fork are about 15 miles inland in steeply sloped redwood, Douglas fir, madrone and tan oak forests. Open grasslands are interspersed throughout this headwater area. Major streamside vegetation consists primarily red alder, California laurel and redwood. Climate near the coast is generally mild throughout the year. Winter and summer temperatures often range from 40-600 F. Inland about five to 10 miles summer daytime temperatures often are 80-900 F and winter temperatures frequently dip below freezing. Rainfall averages 38 inches at the coast and up to 70 inches per year inland."

EIP Associates (1994a) provided these observations on land use: "The predominant historic and current land use in the Gualala River watershed is timber production. Grazing was also an important historic land use in the upper watershed, though it has become less significant today. The watershed also supports a minor amount of rural residential development and agricultural production, primarily orchards, and vineyards. Only a small number of paved roads cross through the rugged terrain of the Gualala River watershed, though a well-developed network of unpaved logging roads and skid trails is found throughout the watershed. The prevalence of logging roads and trails is particularly dense in the drainage basin of the Wheatfield Fork and the eastern portion of the Lower South Fork basin."

The Gualala River, like the Garcia River to the north, runs along the San Andreas Fault. The rapid uplift of the terrain and the regular, large seismic shaking of the San Andreas make the landscape in the Gualala watershed highly erodible. The combination of inherently unstable ground, high rainfall and intensive land use have lead to accelerated erosion (North Coast Regional Water Quality Control Board, 1996).



Gualala River watershed map. Taken **from** *EIP (1994a).* ***Originally produced*** *by Williams and* ***Associates***

Fish Population Status and Trends

The Gualala River has long been famous for its runs of salmon and steelhead. Steelhead (Oncorhynchus mykiss) still provide a viable sport fishery but coho salmon (Oncorhynchus kisutch) seem to persist only in the tributaries recently planted by the California Department of Fish and Game (CDFG). Coho salmon in the Gualala River basin and adjacent areas have been listed as threatened under Federal Endangered Species Act (Federal Register Notice, 1996) and protected status for steelhead is being considered for Gualala River stocks. Above impassable barriers, resident populations of rainbow trout exist (Cox, 1989).

Other fish species native to the river are the Gualala roach (Levenia parvipinnis), three-spined stickleback {Gasterosteus aculeatus), prickly sculpin (Cottus asper), Coast Range sculpin (Cottus aleuticus) and Pacific lamprey (Lampetra tridentata). The eulachon (Thaleichthves pacificus) or candlefish was found in the Gualala prior to 1970 but not in samples since. Similarly, Sacramento suckers (Catostomas occidentalis) may have once been abundant in the Gualala River (Spacek, 1997) but have not been noted in recent samples. The green sunfish (Lepomis cyanellus), a non-native, warm water adapted species, has recently been found during surveys (EIPa, 1994). Additional fish species found in the Gualala River estuary and lagoon are starry flounder (Platichthyes stellatus) and Pacific staghorn sculpin (Lentocottus armatus) according to Brown (1986).

Coho Salmon: Although the California Department of Fish and Game did not conduct coho salmon population surveys in the Gualala River, there are some indications that they were once numerous. In arguing for re-opening summer “trout” fishing, Bruer (1953) asserted that there were millions of steelhead and coho salmon juveniles. A Bureau of Reclamation study of northern California river basins (U.S. BOR, 1974) estimated that 75 miles of habitat was available to coho salmon in the Gualala basin and that approximately 4,000 adults returned annually. Boydstun (1974a) reported that 831 adult coho salmon were caught in the 1972-73 angling season with 244 being released. However, the high catch in 1972-73 may have been due, in part, to coho salmon planting by CDFG (Barracco and Boccione, 1977). The 1976-77 creel census reported only ten coho salmon.

Coho salmon were known to spawn and rear in many Gualala River tributaries (Cox, 1994). See Table 1. In recent years, coho salmon have been found only in Doty Creek and the Little North Fork Gualala (Dennis Halligan, personal communication), where CDFG planted fish in 1995 and 1996 (Aaesen, 1995). Numerous CDFG stream surveys from different time periods documented habitat loss in tributary sub-basins and the subsequent disappearance of coho salmon (see Habitat Trends).

North Fork Gualala River	**Wheatfield Fork Gualala River**
Little North Fork Gualala	**Haupt Creek**
Doty Creek	**House Creek**
South Fork Gualala River	**Fuller Creek**
Sproul Creek	**North Fork Fuller**
Marshall Creek	**South Fork Fuller**
Buckeye Creek	
Franchini Creek	

Table 1. Gualala *River tributaries with current or historic coho use (Cox, 1994).*

Other Salmon Species: In its pre-disturbance condition, it is quite possible that the Gualala River had chinook salmon (Oncorhynchus tshawystcha) as well as coho and steelhead. Although both the Garcia River (Moenschke, 1992) to the north and the Russian River to the south had native chinook salmon runs, information is scarce with regard to the presence of chinook in the Gualala River. Ken Spacek (1997) interviewed long-time Gualala basin resident Robert Anderson and he recalled that Henry Rang had caught a 34 pound salmon in 1919. A fish of such large size would be much too large for a coho salmon and; therefore, was likely a chinook. This does not prove conclusively that there was a run of chinook because one fish might be a stray. Mr. Anderson recalls that silver salmon were the most numerous salmon species and were known as hook bills (Spacek, 1997). He also spoke of dog salmon, which could be a reference to chum salmon (Oncorhvnchus keta) but this name could also have been a synonym for coho salmon because males of both species develop pronounced kypes and teeth as secondary sexual characteristics.

Steelhead: Catches and population levels of adult steelhead were gauged by CDFG using a combination of creel census and mark and recapture of adult steelhead. The highest catches estimated were 1700 steelhead in 1974-75, 1418 in 1975-76 and 1352 adult steelhead in 1954-55 (Table 2). In 1974-75 CDFG estimated that the adult steelhead population of the Gualala River was 7608, with a 95% confidence interval of 6126-10379 (Boydstun, 1976a). In 1975-76 the population was estimated at 6300 (Boydstun, 1976b).

YEAR	CATCH	HOURS	CATCH/HR
1954-55	570	7613	0.08
1972-73	288	12884	0.02
1973-74	1700	13218	0.13
1974-75	793	14593	0.05
1975-76	1418	27899	0.05

Table 2. Steelhead *adult catch by year with angler hours and catch per hour.*

Boydstun (1974a) noted that while angler effort in 1972-73 was 60% greater than in 1953-55, the catch in the 1970s was just 25% of the 1950's catch. He attributed the decreased catch rate to decreased adult steelhead abundance. From 1972 to 1975, CDFG supplemented Gualala River steelhead runs with Mad River Hatchery fish, which may have inflated the escapement and catch. It is also possible for external conditions to skew the catch per unit effort. Conditions in 1973-74 may have been particularly favorable for angling, while years with high flows and turbidity, such as 1972-73, may have been adversely affected.

The 1972-73 creel census found that 40% of the adult steelhead caught were over ten pounds, with one specimen weighing 21 pounds. Average length was 69 cm or 27.5 inches with a range from 22-97 cm or 10 to 38 inches (Figure 1). The large size of adult Gualala River steelhead is a result of multiple years spent in the ocean. The smaller fish included as adults may have been early returns from the 1972 Mad River Hatchery planting. In the same year, 44% of the steelhead had spawned more than once and one fish had spawned four times.

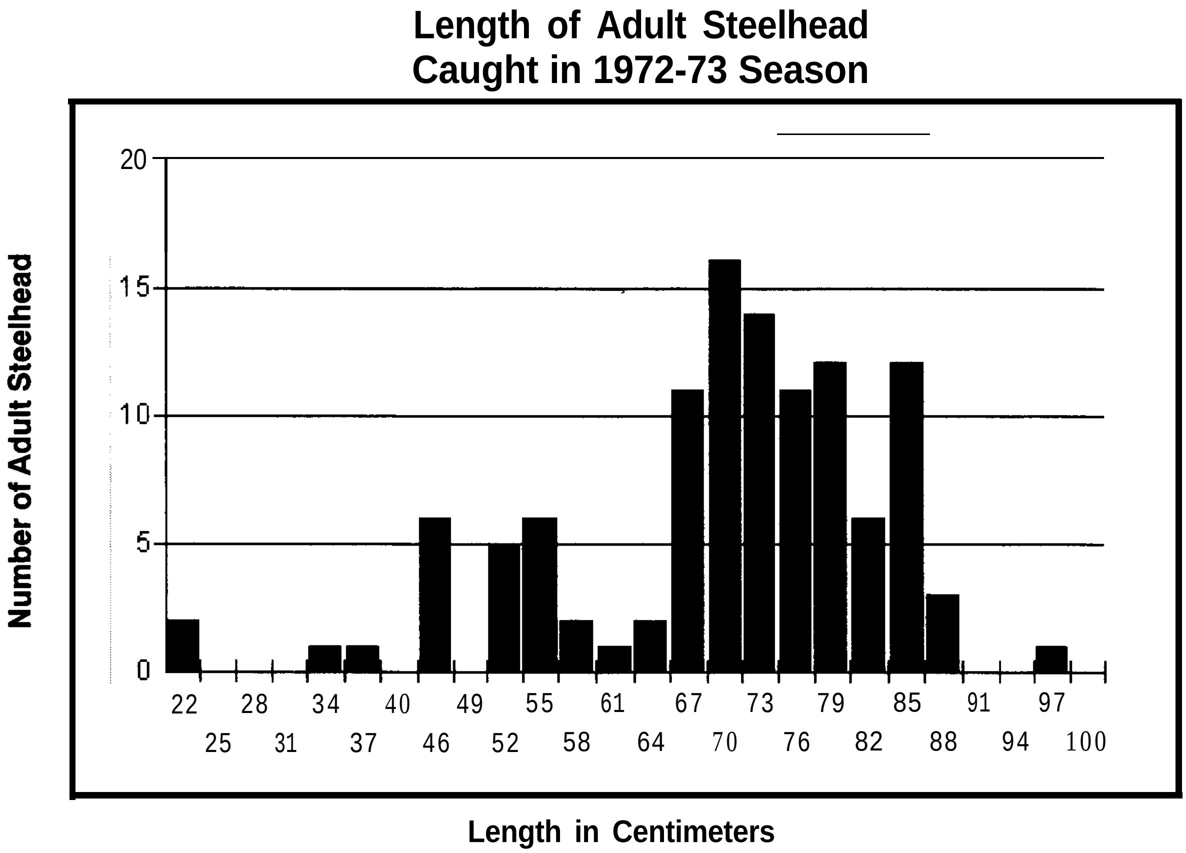


Figure 1. Length of adult steelhead measured during 1972-73 creel census.

Juvenile steelhead have been studied extensively in the lower South Fork Gualala River, below the Wheatfield Fork and in the estuary. Gualala River steelhead juveniles sampled in the spring of 1984-1986 in the lower estuary averaged 102 mm (4.0 inches), while upper estuary fish averaged only 55 mm (2.2 inches). This suggests that young-of-the-year steelhead dominated upper estuary samples in the spring. In fall of the same years juvenile steelhead had a mean length of 97 mm (3.8 inches) at all stations (Brown, 1986). California steelhead generally enter the ocean after one or two years in freshwater (Barnhardt, 1986). Young of the year often spend much of their first year in small order tributary streams. Appearance of young-of-the-year in the estuary could indicate that carrying the capacity of the tributaries is low, forcing juveniles to emigrate prematurely. Alternately, the high number of young-of-the-year steelhead may be the result of late season spawning just upstream in the mainstem or lower reaches of tributaries.

Gualala River steelhead juveniles sampled in the estuary in June 1986 by Brown (1986) had significantly shorter mean and maximum lengths than those of the Garcia River estuary sampled in June 1995 (Higgins, 1996). Figure 2 and Figure 3 show the length frequency of steelhead caught in the Gualala estuary and the Garcia estuary. A possible explanation for larger steelhead juveniles in the Garcia River estuary versus the Gualala estuary is that conditions in the Garcia River watershed allow longer residence of steelhead juveniles. Monschke (1992) noted that pools in the lower Garcia River were suitable for older age steelhead to rear throughout the summer. Lack of cover and channel complexity of the Gualala and its tributaries could also limit steelhead juvenile survival during high flow conditions. Ken Spacek (1997) has interviewed numerous long-time local residents and they recall catching many 6-10 inch steelhead juveniles while "trout" fishing prior to the 1960's. This suggests that older age steelhead juveniles may have been more abundant before habitat changes related to logging (see Habitat Trends).

Length Frequencies of Steelhead Juveniles in the Gualala River Estuary, June 1986

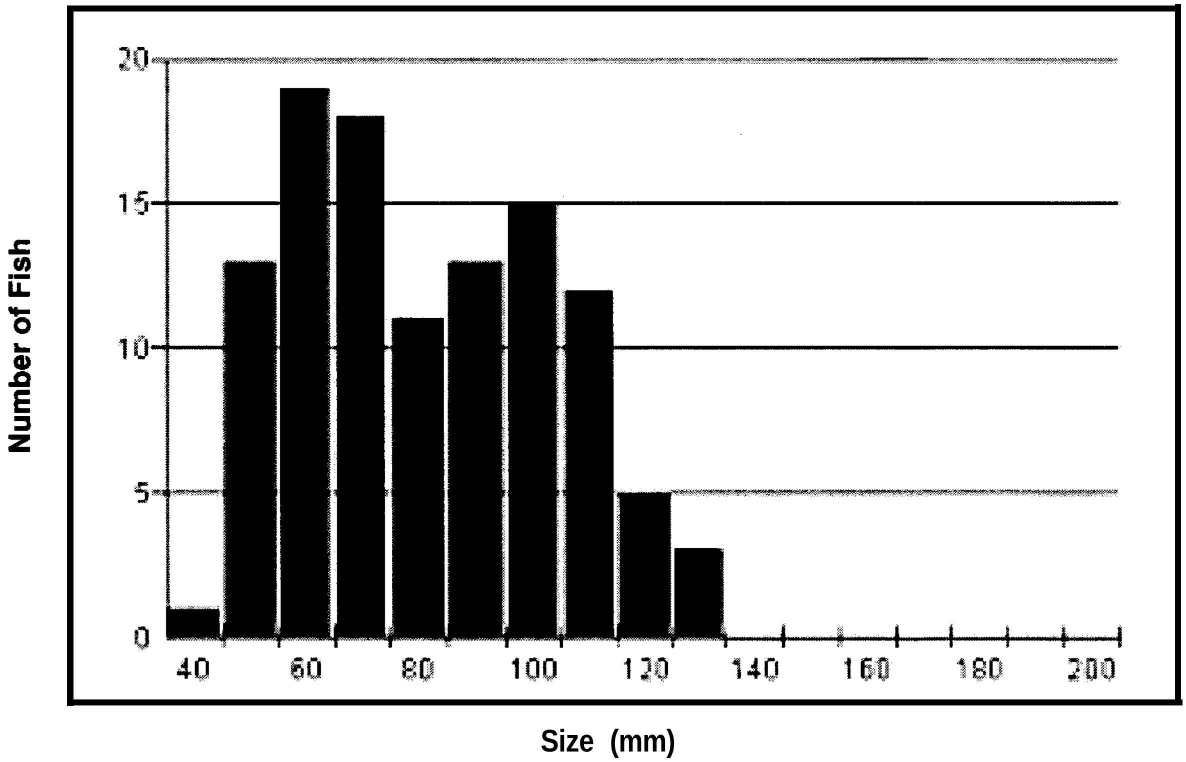


Figure 2. The number of steelhead captured in the Gualala River estuary by length. Data from Brown (1986).

Length Frequencies of Steelhead Juveniles in the Garcia River Estuary, June 1995

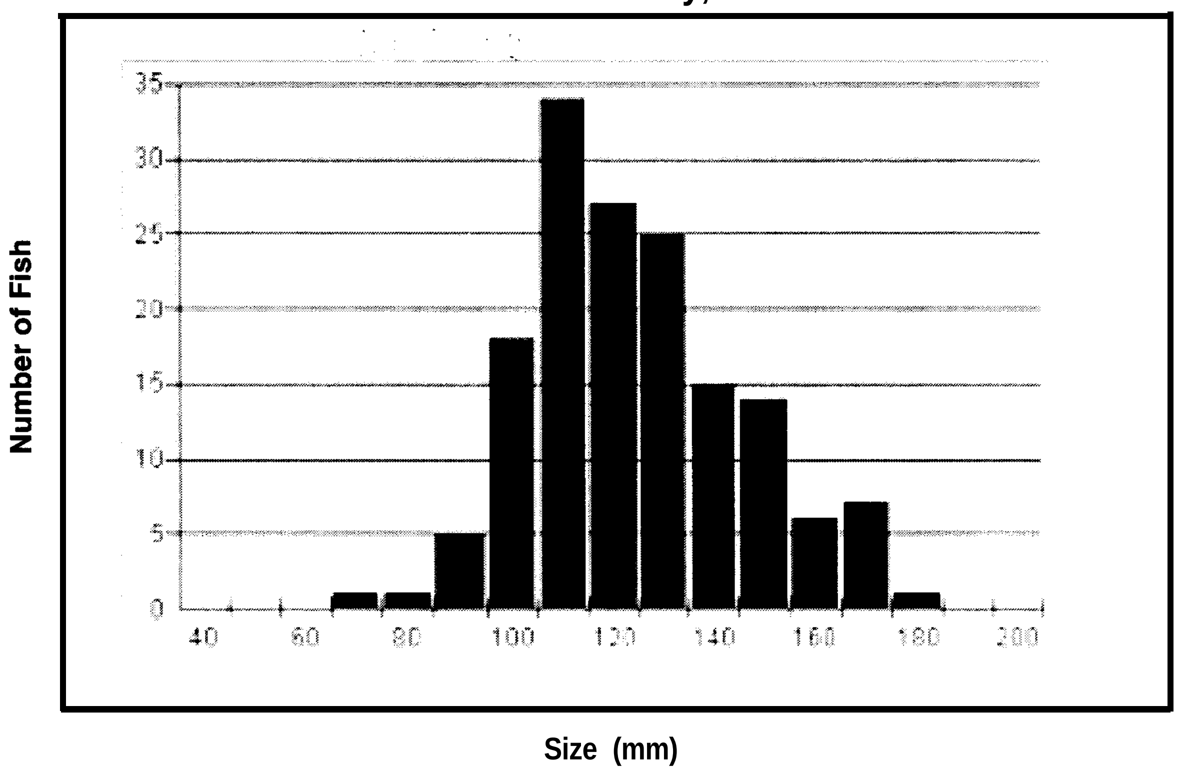


Figure 3. The number of steelhead juveniles captured by length in the Garcia River estuary in June 1995. Taken from Higgins (1996).

Gualala Roach Status and Shifts in Fish Community Structure: Brauer (1953) stated that, although Gualala roach were present throughout the river basin, they were found in only small numbers. A sample taken on the lower main Gualala River just below the North Fork by Kimsey (1952) using electrofishing showed that steelhead were the most abundant species present. (Figure 4). Dive observations in July and October 199 1 (EIP, 1994a) on the Lower South Fork below the Wheatfield Fork show a community dominated by Gualala roach and stickleback (Figures 5-6). Halligan (1997) in comments on the draft of this report, suggested that steelhead might make up a higher proportion of the community after a series of wet years. The 199 1 samples were taken after a sequence of drought years.

The 199 1 samples show that juvenile steelhead decreased from July to October, probably in response to decreased flows and increased water temperatures. The ratio of steelhead to roach also shifted from approximately 2: 1 to 3: 1. It is possible that the number of steelhead juveniles might have dropped even lower in August or early September when water temperatures would have been at their maximum. Fish in tributaries sometimes move downstream in fall into mainstem environments after temperatures cool to stage for subsequent entry into the ocean. Moyle (1976) noted that roach are a warm water adapted species and can survive in water temperatures up to 95^0 F. The increased water temperatures associated with loss of riparian vegetation and stream aggradation in the Gualala River basin have favored roach over salmonids.

One note regarding comparison of the Kimsey (1953) results with those of EIP Associates (1994) is that the former samples were collected downstream of the North Fork that contributes cold water to the mainstem Gualala River. The EIP Associates samples were taken between the North Fork and the Wheatfield Fork and may have showed slightly different results if taken below the North Fork. Halligan (1997) and Cox

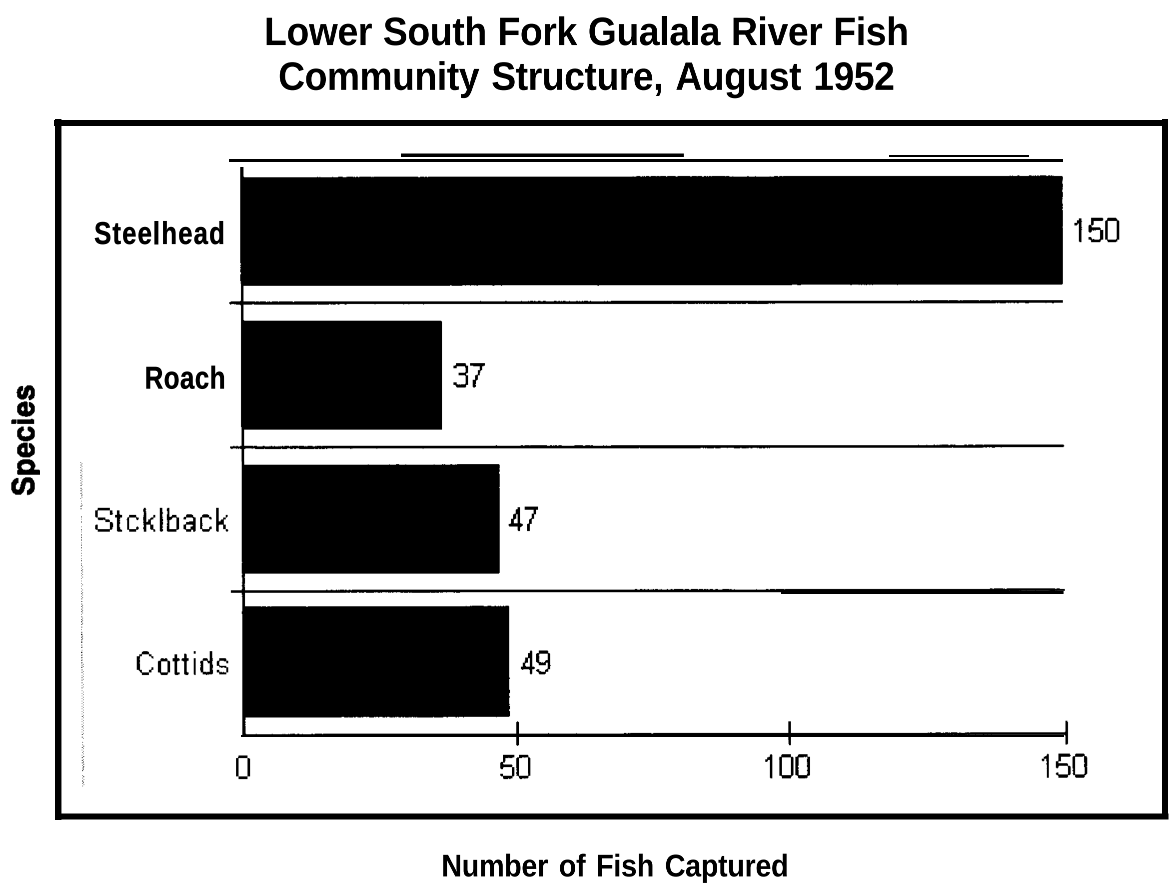


Figure 4. Gualala River fish community structure as represented by a sample collected by Kimsey (195.3) below the North For&.

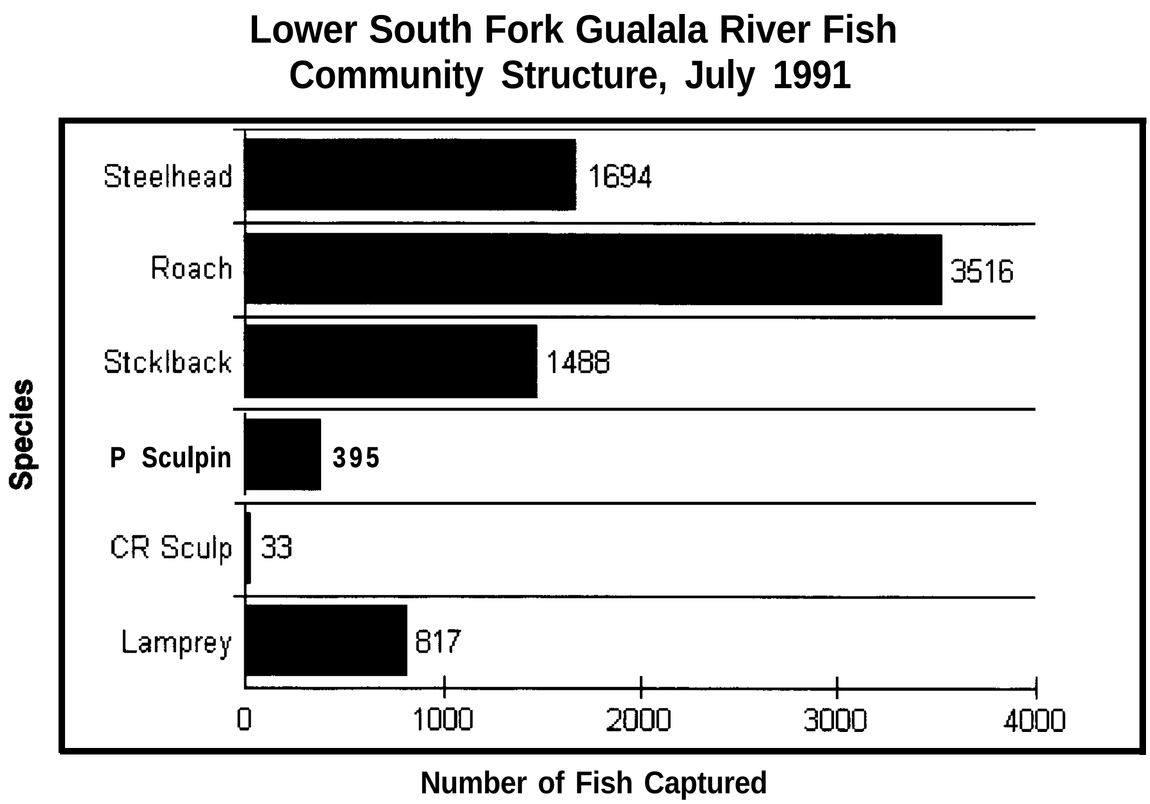


Figure 5. *Fish community structure of the Gualala River from sampler taken in July 1991 (EIPa, 1994).*

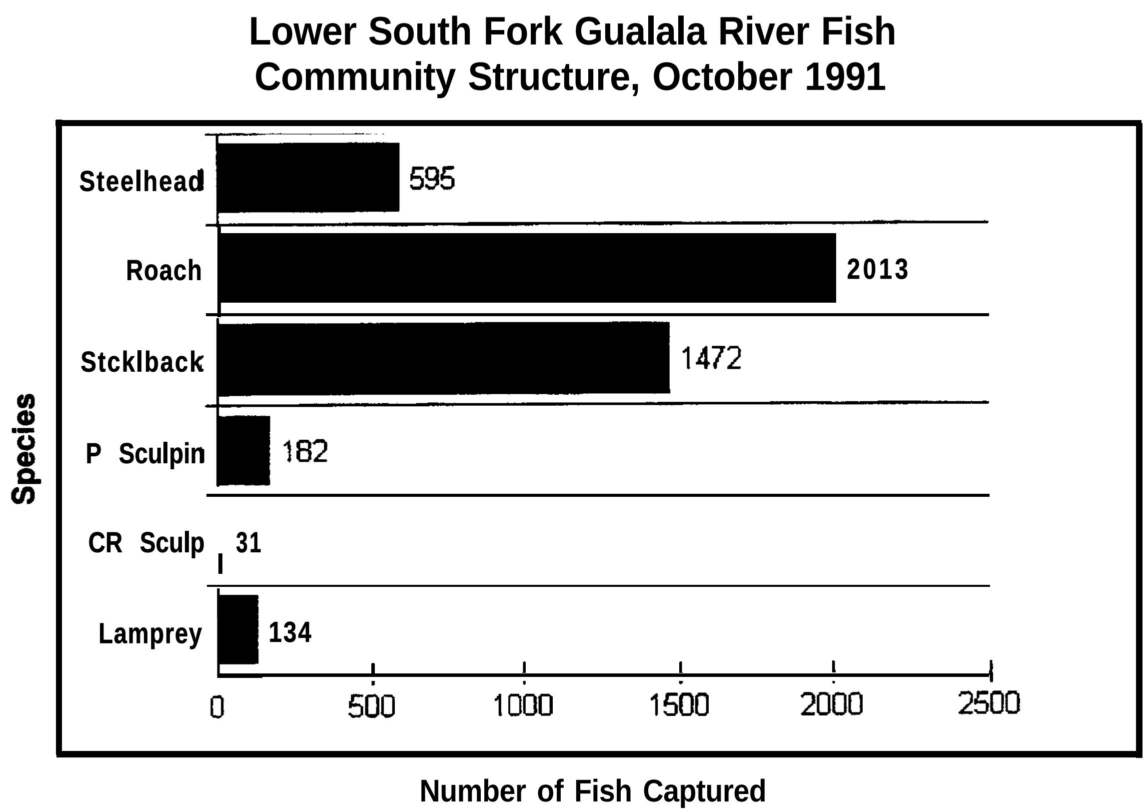


Figure 6. *Fish community structure of the Gualala River from samples taken in October 1991 (EIP, 1994a).*

(1997) suggested that similar differences might exist today if samples were taken above and below the North Fork. Biological samples should be taken above and below the North Fork Gualala in late summer in the near future to establish current community structure and discover whether salmonids predominate samples in the lower reach.

Although no population estimates have been conducted for this species, the bulk of CDFG stream surveys show that roach have increased in abundance while coho have disappeared and steelhead decreased in most tributaries of the Gualala River (see Habitat Trends). As riparian areas recover in future decades and the river cools, it is likely that the Gualala roach will decrease in abundance.

Sacramento sucker: Spacek (1997) recalled diving at the Boy Scout camp on the Wheatfield Fork Gualala River in the 1950's and spearing suckers. Klamt and Edwards (1970) also noted the presence of suckers in a survey of Buckeye Creek. The Sacramento sucker (Catostomas occidentalis) is native to the Sacramento-San Joaquin and coastal streams northward from San Francisco Bay California. Its complete absence in almost any recent Gualala River fish survey is a puzzlement.

Hatcher-v Contributions to the Gualala: CDFG planted steelhead juveniles from the Mad River Hatchery in the Gualala River from 1972 to 1975. Introduction of non-native brood stock can lead to decreased fitness in the native salmon or steelhead population (Riesenbechler and McIntyre, 1977; Chilcote et al., 1982; Ryman and Utter, 1987). A hatchery was operated by the Gualala Steelheaders in the late 1980's using native Gualala River brood fish that were caught by anglers with hook and line. Some community members still had reservations regarding the hatchery because of the potential for a long term change brought about by unintended selection related to hatchery operation (Joseph, 1990). In the early 1990's, the Gualala Steelheaders changed the emphasis of their hatchery program to rescue rearing. Because the hatchery does not select fish for breeding, there is less potential for changes in genetic diversity

CDFG planted coho salmon in the North Fork Gualala River and its tributaries in 1988 and from 1995-1997. Barracco and Boccione (1977) note that CDFG had been planting coho in the Gualala River since 1969 but no direct planting records or related memos were found during the course of this study. Coho salmon juveniles were planted in the North Fork because water temperatures were cool and fish samples showed that the species was no longer present (Jones, 1989). Poor survival of coho planted in the late 1980's was ascribed to drought conditions but the possibility of bacterial kidney disease or BKD was also raised (CDF, 1994). This disease is caused by the bacteria Renibacterium salmonarium that can be transmitted to other salmonids in the wild.

Juvenile coho were found during 1997 surveys of Doty Creek and the Little North Fork Gualala River (Dennis Halligan, personal communication) and could be the result in part of CDFG plants in 1995. Although temperatures are cool enough for coho salmon introduction, spawning gravel stability and pool volume may not be optimal for coho (see Monitoring). Riesenbechler (1988) found that the success of transplanted hatchery coho was inversely proportional to the distance from the stream of origin. Aasen (1995) pointed out that the donor stock, Noyo River Hatchery coho salmon, had genetic markers specific to Mendocino coastal stocks and were, therefore, appropriate for the Gualala River. He also noted that problems with BKD had been reduced.

Fish Harvest as a Limiting Factor: This study found no historical accounts of commercial fishing or large-scale, organized poaching that might have depleted fish populations in the Gualala River basin. The river is still well known for its steelhead fishing and until the 1970s it sustained a sport fishery for coho salmon as well. Coho salmon from the Gualala River would have experienced considerable fishing pressure from ocean trolling. Although there are no studies of ocean migration of Gualala River coho salmon specifically, California coho generally feed on the Continental shelf off the coast of northern California and Oregon (Hassler, 1986). This near shore area ranges between ten to forty miles wide and it is where commercial salmon trolling occurs.

California's first salmon trollers used sailboats as they fished waters off Monterey late in the last century (McEvoy, 1986). After motorized craft came into use, fishing began to spread north and by 1916, it extended to Eureka and

Crescent City, Snyder (193 1) studied age structure of Klamath River salmon and described a decrease in size and age of returning chinook salmon in the late 1920's that he ascribed to over-fishing in the ocean. No specific information regarding the impact of troll fishing on Gualala coho salmon is available.

Wild salmon returning to good habitat can sustain a harvest rate of up to 65% (Ricker, 1976), but those returning to impaired habitat may produce no harvestable surplus. Habitat declines in the Gualala River basin following the 1964 flood coincided with a substantial increase in fishing pressure. The number of California troll fishermen grew from 570 in 1938 to 1,100 after world War II and by the late 1970's there were nearly 5,000 vessels landing salmon in California (McEvoy, 1986). An increase in fishing pressure in conjunction with a decline in habitat can elevate the risk for stock loss (Nehlsen et al., 199 1). There has been no take of coho salmon in commercial ocean fisheries since 1994 because of endangered species concerns. Coho salmon are also protected from harvest by ocean and freshwater sport fishing in California.

The large size of adult Gualala River steelhead indicates that they spend several years in the ocean. Research shows that California coastal steelhead stocks may take very long ocean journeys to forage in waters west of British Columbia and southeast Alaska (Light et al., 1986). Long-line drift nets were used intensively in this area, both legally and illegally, in the 1980's and early 1990's (Lewis, 1990). It is possible that Gualala River steelhead were impacted by this fishery. Use of long-line drift nets was banned by a United Nations edict in 1992 and this fishery has ceased.

In-river harvest of steelhead in 1975-76 was estimated to be 15% of the adult population (Boydstun, 1976) which makes it unlikely that sport fishing for adult steelhead in the Gualala River constrains the steelhead population. However, there is concern over fishing during low water periods and closure of the steelhead season during these periods is still being considered (Sheahan, 199 1). Concern was expressed about potential impacts of juvenile salmon and steelhead harvest in the 1950's (Kimsey, 1953) and the stream was closed to summer "trout" fishing until about 1972. More recently, Reavis (1983) found that only two of the estimated 535 salmonids caught by anglers during the spring and summer of 1982 were kept. He judged summer fishing to be a minimal impact on Gualala River steelhead populations.

<u>Marine Mammals as a Limiting Factor:</u> Hunter (1990) noted that "available evidence from research on harbor seal feeding behavior indicates that their diet consists mainly of small fish not large ones. Bottom fish such as sculpin, flounder and various soles, surfperch, herring, smelt and lamprey constitute the major part of the harbor seals diet." Hunter (1990) acknowledged that harbor seals (Phoca vitulina) often haul out at the mouth of the Gualala and may sometimes dine opportunistically on steelhead adults and juveniles. Studies at the mouth of the Rogue River showed that Pacific lamprey constituted 8 1% of prey items, while steelhead 3.8% and chinook salmon 1.2% (Roffe and Mate, 1984). They estimated that harbor seals and sea lions in combination intercepted less than 1% of the summer steelhead run in the Rogue River. The highest estimated impact was on juvenile steelhead, with 5-6% of the downstream migrants lost to predation.

Graybill (198 1) suggested that public perception of a high impact on salmon and steelhead stems from the fact that seals must subdue large prey on the surface where they are highly visible. Studies of harbor seals in Coos Bay, Oregon showed that less than 1% of the harbor seal's diet consisted of salmon and steelhead (Graybill, 198 1). Studies on harbor seal diet at the mouth of the Russian River conducted by Sonoma State University may be available soon.

Fish Habitat Condition and Trends

Early photographs provide valuable clues regarding habitat conditions in the river and the types of changes caused by early logging. California Department and Fish and Game stream surveys from the 1950's to the 1980's document changes to tributary streams and mainstem Gualala River reaches. Sequential aerial photos that have been taken since World War II also provide a valuable tool for analysis of cumulative watershed effects (Grant, 1988). Environmental reports related to gravel and water extraction (EIP, 1994a) and habitat typing reports (Sotoyome, 1996) also provided additional insight into recent fish habitat conditions.

From 1890-l950 (Historical Photographs): The early days of settlement on the Gualala proved to be an irresistible subject for photographers. Luckily, the Heald Poage Library and Museum in Ukiah has served as an excellent repository for their work. The photographs offer an opportunity to see the river channel, riparian conditions and the nature of early watershed disturbance related to logging. The first photographs of the Gualala River, from the 1890's, show a wide river channel under a newly constructed bridge (Figure 7).

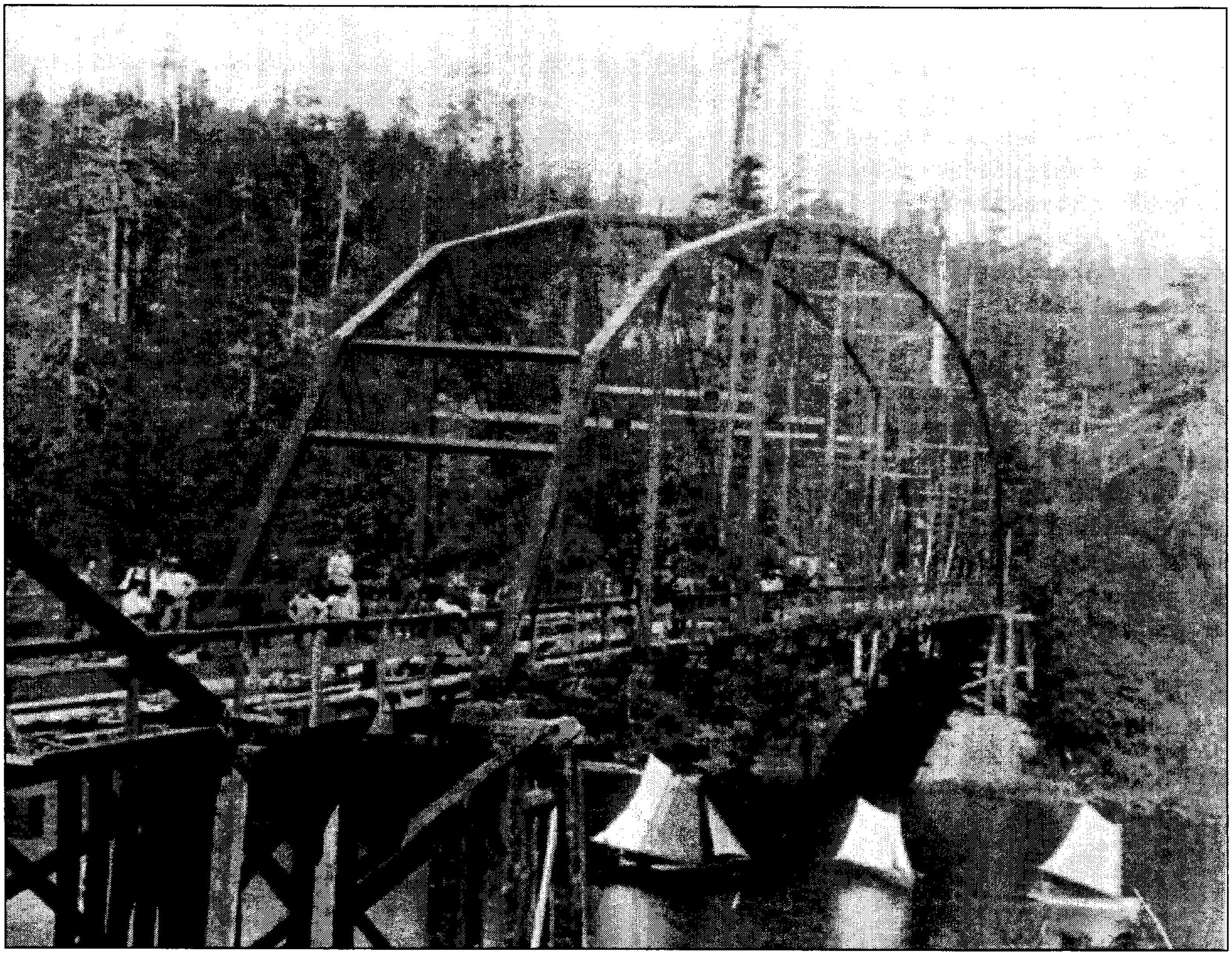


Figure **7.** ***Photograph taken in* 1898 *of the bridge over the Gualala River with sailboats underneath.*** *Courtesy* ***of Heald-Poage Museum,*** *Ukiah, CA.*

The riparian of the lower Gualala River prior to disturbance was composed of alder and an over-story of redwood. The sailboats in the photograph might be indicative of a deeper lagoon during this period.

Oxen logging could not proceed as rapidly as modern logging, but the areas disturbed using these logging methods would have had substantially increased erosion (Figure 8). Felled trees were floated down the river. These log drives may have been more destructive than the logging itself. If chinook salmon were present, they would have been particularly susceptible to habitat changes brought about by log drives since they would spawn in main river environments. Photographs also suggest that stream courses were lined with log rounds that were kept damp for skidding. This type of impact must have impaired these streams for several decades. Roger Dingman (personal communication) said that this type skid trail was known as a “corduroy road” and that he had seen sections of one in a Gualala tributary that had been exposed in recent years.

Railroad logging, which began just before the turn of the century, increased the efficiency of transporting logs to the mill and increased the extent of logging activity in the basin. Steam donkeys also increased yarding capabilities as they came into use around the turn of the century (Figure 9). Railroad lines were often constructed along the main river courses, causing a decrease in riparian trees. While the extent of watershed area reached with trains would have increased, it is likely that some sub-basins remained undisturbed. These streams would have provided a seed stock of coho salmon and steelhead to re-colonize damaged tributaries as they recovered.

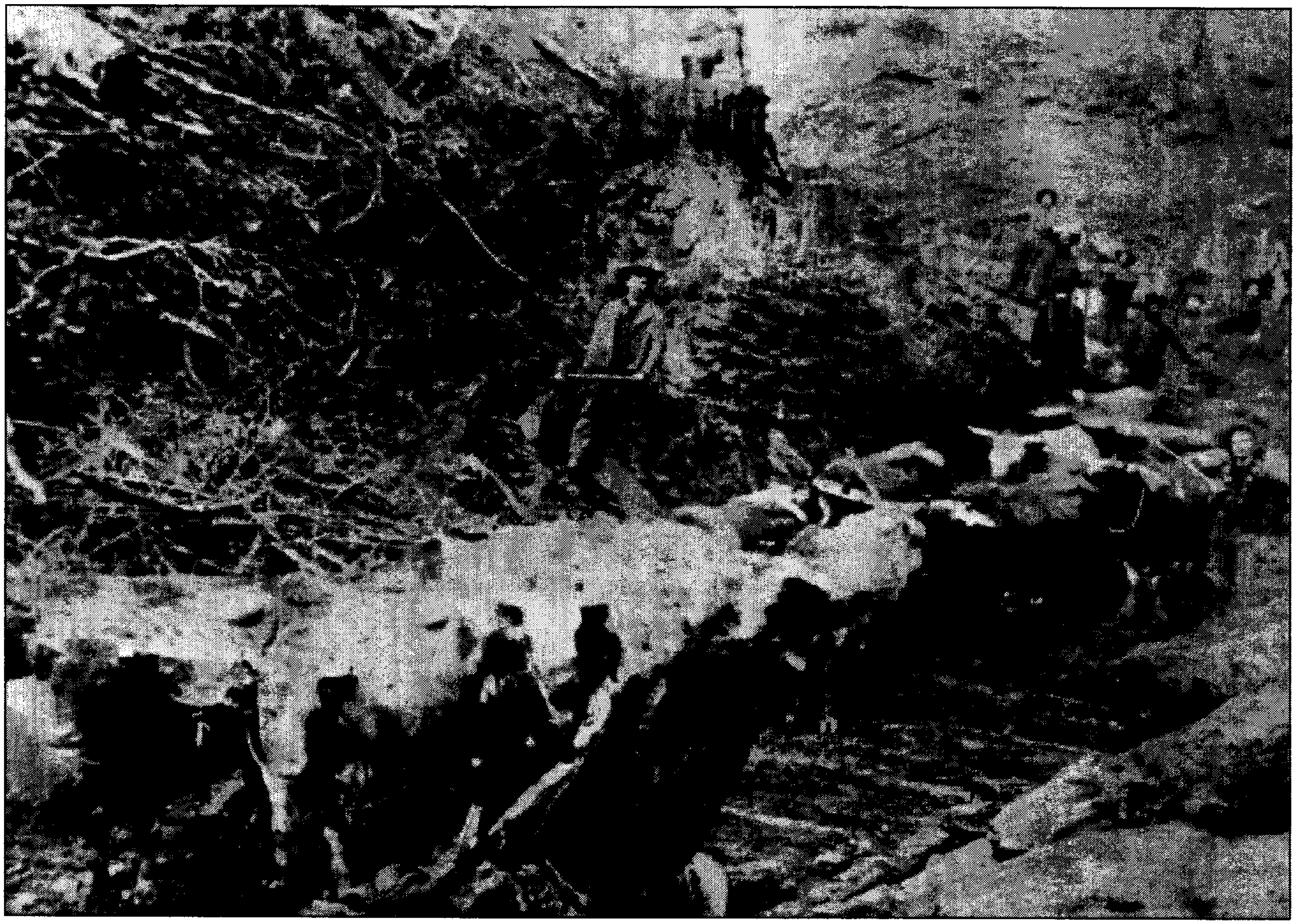


Figure 8. Oxen ***team at work in the Gualala woods, circa 1900. Courtesy of the Heaki-Poage Museum, Ukiah, CA***

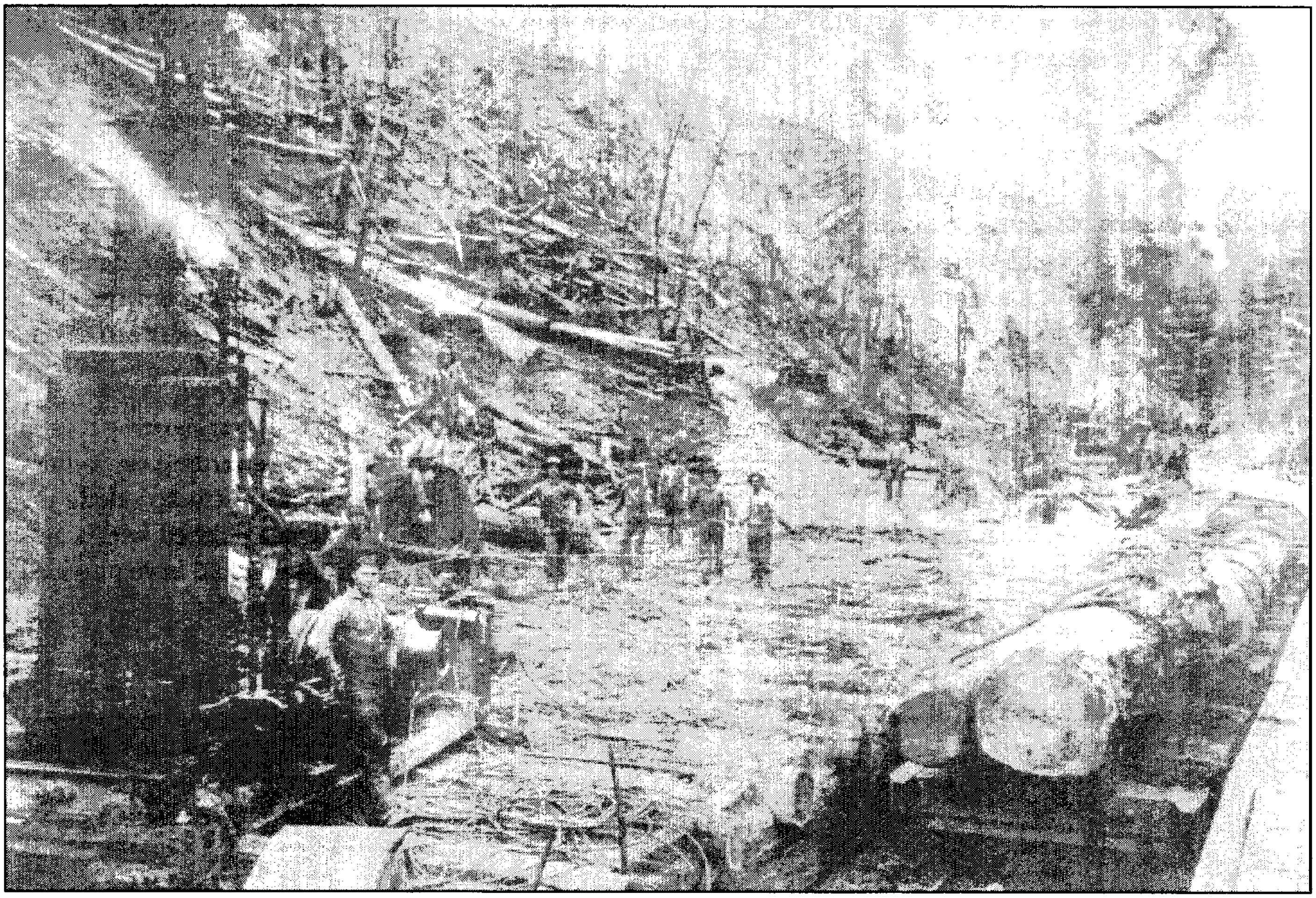


Figure 9. Typical railroad landing in the Gualala woods, 1902. Note skid road to landing in center rear paved with log rounds. Photo courtesy of the Heald-Poage Museum, Ukiah, CA.

After initial early logging there was a period of diminished activity while forest regeneration occurred. Spacek (1997), in comments on the draft of this report, noted that tractors were used for logging as early as the 1930's in the Gualala watershed. The use of logging trucks in the woods may have begun slightly earlier than in other north coast watersheds. A photograph from the Heald-Poage Historical library indicates that use of trucks began in 1941 (Figure 10), while other watersheds were entered after World War II. The first log load went from the Little North Fork Gualala to the mill in town. California Department of Fish and Game (CDFG) memos and stream survey reports provide information on the changes brought about by this second wave of logging in the Gualala River basin. Sequential aerial photographs show changes in stream channel conditions as new waves of sediment were unleashed.

<u>From 1950 to Present (CDFG Stream Surveys and Memos, Consultants Reports and Aerial Photos):</u> Post World War II logging in the Gualala River watershed heavily impacted salmon and steelhead habitat. Fisher (1955) stated that "Considerable damage has been done to Gualala River headwaters. In this respect, the stream has been damaged more than the average on the north coast, percentage-wise." Many California Department of Fish and Game stream surveys noted substantial damage to tributaries: "This tributary (of North Fork Fuller Creek) from its mouth to its headwaters is a mass of slash and debris put into the stream by old logging operations" (Rowell et al., 1964).

In addition to general habitat observations, CDFG stream surveys documented stream substrate, pool frequency, fish species present and relative densities. Klein (1997), in comments on the draft of this plan, pointed out that visual observations associated with CDFG memos are a poor substitute for more quantifiable and repeatable scientific surveys.

Figure 10. The first load of logs hauled by truck in the Gualala River watersbed, 1941. People in tbe photo are (left to right) Hobart Webster, Carl Rhoades, George Myland and Cecil Rowe. Photo courtesy of the Heald-Pogue Library and Museum, Ukiah, CA.

However, the information in surveys is consistent with expected habitat change from intensive land use and in the absence of more precise scientific data is useful as a gross indicator of habitat change. The information from these surveys is summarized below by tributary or stream reach. CDFG stream survey reports and memos are referenced by the author. If several reports were filed in a given year by the same authors, the earliest survey date was referenced by the year and the letter "a", the second "b," and so on. Additional information from other sources is added to give as complete a picture as possible

Buckeye Creek: This creek joins the South Fork Gualala River downstream of the Wheatfield Fork and upstream of Rockpile Creek. It has a 70 square mile watershed. Primbs and Fox (1964) surveyed Buckeye Creek on August 27, 1964 and found it to be in relatively healthy condition. Pools comprised of 50% habitats, which is very good for salmonid rearing. The deepest pools were about six feet deep. Stream substrate was comprised of mostly spawning gravels. Steelhead dominated the fish fauna with fish l-8 inches in length at a density of 250/ 100 feet. There were no roach present according to the survey but also no coho salmon. A stream temperature of 720 F was recorded, which could account for the absence of coho. The survey suggested replanting riparian vegetation and removing log jams to improve habitat. Primbs (1964) found that Porter Creek, a tributary of Buckeye, had sustained considerable logging damage. The stream substrate was 75% mud and the stream was clogged with slash.

Klamt and Edwards (1970) found a much altered stream substrate in their August, 1970 survey of Buckeye Creek. Pools comprised only 30% of the habitat and maximum depth was only 1 l/2 feet. Substrate had changed from predominantly gravels to 50% silt and 30% sand. Steelhead densities were down to 25/100 feet and roach and suckers numbered 70/100 feet. Buckeye Creek was resurveyed by Cox (1980), who found that the fish fauna was comprised of predominantly Gualala roach with just a few steelhead. He noted that there was a lack of shade on the stream and potential for contributions of fine sediment from Kelly Road, which paralleled the stream.

North Fork Buckeye: Successive reports on NF Buckeye suggest logging damage just prior to the Fox and Quinn (1964) survey but some degree of recovery by the time of the Ambrosius and Pomeroy survey (1982). In the earlier survey, roach comprised 99% of the fish fauna, although steelhead and coho were both present (Fox and Quinn, 1964). Pools comprised only 25% of the habitats in 1964 and were a maximum of two feet deep. They described the stream as sluggish, with substantial algae blooms. They recommended planting riparian areas and halting bad logging practices in the basin.

Ambrosius and Pomeroy (1982) found that the North Fork Buckeye Creek had high levels of fine sediment with 50% sand. However, pool frequency had increased to 40% and maximum depth to four feet. They estimated that steelhead comprised 40% of the fish fauna while Gualala roach made up the remaining 60%. They also noted that high temperatures, algae blooms and lack of cover were limiting steelhead production and recommended riparian restoration to improve habitat conditions.

Osser Creek (Buckeye): Jameson(1995) described Osser Creek as predominantly riffles heavily embedded with fine sediment. He noted that stream organisms were mostly caddisflies and snails. The heavy embeddedness is most likely linked to the loss of aquatic insect diversity as both caddis and snails are surface dwellers. Stoneflies and mayflies, which were not found, require interstitial spaces between cobble and gravel. Jameson (1995) noted that an 80% canopy had regrown on the upper reaches of Osser Creek.

Roy ***Creek (Buckeye):*** Jameso (1995) noted that the Roy Creek watershed was converted to grazing after being logged. He noted that inner gorge roads had caused extensive debris sliding. None of these were recent features, however.

Wheatfield Fork: Fox (1964) surveyed the Wheatfield Fork of the Gualala River from its headwaters to Redwood Creek and found it to be very good steelhead habitat. Substrate was 50% gravel and only 5% fine sediment. Steelhead constituted 80% of the fish present with roach comprising the other 20%. Steelhead juvenile densities were estimated as 200/100 feet. However, Fox (1964) stated that warm water temperatures during summer in the reach might have been limiting steelhead production. Lower reaches of the Wheatfield were never surveyed but Cliff Putnam recalled that this fork was 10-l ***5*** feet deep just above its convergence with the South Fork (EIP, 1995). A large blue rock rose out of the water to a height of approximately 12 feet. Today, only the tip of that rock is showing, which indicates aggradation on the order of 20-25 feet between 1950 and ***1995. Cox (1997),*** in comments on the draft of this report, noted that 25 of aggradation would change the stream gradient in this location because the elevation of the land is only 80 feet above sea level. He felt that the estimate of 25 feet was high but had no other supporting data to offer.

Fuller Creek: There is more information on Fuller Creek than any other sub-basin in the Gualala River watershed but no reports provide base line conditions before disturbance began. Rowell and Fox (1964) found lower Fuller Creek (up to NF/SF) still supporting salmon and steelhead. Pools constituted 70% of the stream's habitat with a maximum pool depth of six feet. Fine sediment comprised 20% of the stream substrate. Although coho salmon juveniles were present with steelhead, the latter up to 11 inches in length, the fish community was comprised of 75% roach, 5% stickleback and only 20% salmonids. Logging damage had altered the stream by the time it was surveyed by Parke and Klamt (1971). Pools had been reduced to 40% of the habitat and were a maximum of only four feet deep. Silt and sand components of the substrate had risen to a combined 35%. Coho salmon juveniles were still present but were few in number. Steelhead densities were 30-50/100 feet with maximum size noted as 5 inches. Loss of pool habitat probably eliminated prime rearing areas for older age steelhead juveniles (2+).

Cox (1989) noted that banks throughout most of Fuller Creek were eroding and supported little riparian vegetation. He expressed concern over the amount of fine sediment coming from roads leading to the Mendosoma subdivision. While pools and areas with shade and shelter supported steelhead, open reaches were dominated by Gualala roach and stickleback. Densities of steelhead at various electroshocking stations were as follows: lower Fuller Creek 83/100 feet, lower South Fork 53/ 100 feet and North Fork 82/100 feet. Upper South Fork Fuller Creek above a waterfall had only 18 rainbow trout per 100 feet. In a later report, Cox (1995) noted that shade on Fuller Creek was only 30% and that substrate was composed of mostly fine sediment and small angular rocks not suitable for spawning.

The Fuller Creek habitat typing report (Sotoyome, 1996) provides a recent portrait of habitat quality on the mainstem Fuller Creek as well as tributaries. It notes that the watershed is 77 square miles with 15.6 stream miles of anadromous fish habitat. The lower mainstem of Fuller Creek was comprised of **61%** riffles and flat-water habitats and 39% pools. Embeddness ratings used were those put forth by CDFG (Flosi and Reynolds, 1994) with 1 = less than 25% embedded, 2 = 25-50%, 3 = 50-75% and 4 = 75-100%. Measurements are taken in pool tail crests, which are often favored sites for spawning salmon and steelhead. Only classification 1 is considered optimal salmonid habitat. Embeddedness on Fuller Creek was: 70% rating of 4, 27% rating of 3 and only 3% with a rating of 2. The foregoing information indicates that Fuller Creek still has problems related to cumulative effects and is only in early stages of recovery. Stream temperatures also give a similar indication (see Water Quality section).

North Fork Fuller Creek; Surveys by Rowe11 et al. (1964) of the North Fork and its tributaries found the stream still supporting coho and steelhead but in rapid decline from damage related to logging. They noted that there were roach, stickleback, steelhead and coho salmon present but do not give an indication of the relative abundance. Approximately 40% of the substrate was comprised of sand and silt and pools constituted only 30% of the habitat by length. The deepest pools were three feet deep. Conifers had been logged from the riparian zone and Rowe11 et al. (1964) recommended that erosion control measures were needed to prevent further siltation of the stream. Tributaries of the North Fork such as Boyd Creek were noted to have sustained considerable logging damage and greatly diminished spawning and rearing capacity for salmonids (Primbs, 1964; Rowe11 et al., 1964).

Parke and Klan-n (197 1) found pools reduced to 25% of the habitat with a maximum depth of only two feet. Coho juveniles were still present but only in scattered schools of 5-10 fish. Steelhead juvenile density was estimated as lOO/lOO feet which is similar to Cox's electroshocking estimate in 1989 of 82/100 feet. Sotoyome (1996) found that pool frequency had increased to 36% and that maximum pool depth was three feet. This indicates that North Fork Fuller Creek is recovering from past logging damage. Canopy had regenerated substantially and was estimated as 68% with conifers comprising about 60% and deciduous trees 40%. An estimated 80% of pool tail crests had embeddedness ratings of 3 or 4, 16% had a rating of 2 and 4% the optimal rating of 1.

South Fork Fuller Creek: Rowell and Fox (1964) found h eavy sand deposits (50% of the substrate) and noted that "The entire South Fork area is heavily polluted by logging damage consisting of jams, slash and debris in great quantities." Pools had been completely filled in with a maximum depth of two feet and an average depth of six inches. Despite the damage to the stream, maximum stream temperature was still only 650 F when air temperature was 830 F. Rowe11 and Fox (1964) found only steelhead present at a density of 3/l 00 feet.

The 1964 flood must have flushed the logging debris from the lower South Fork because Parke and Klamt (1970) found both coho salmon and steelhead at lOO/lOO feet. Pools had recovered somewhat to 15-20% of habitats and a maximum depth of 2 l/2 feet. Silt and sand still comprised 50% of the substrate and a water temperature of 780 F was measured. It would seem that coho and steelhead may have been trying to recolonize this tributary after effects of logging damage had been shifted downstream. The high stream temperature would have precluded successful re-colonization by coho, particularly in drought years that followed in 1976-77.

Sotoyome (1996) found pools had increased to 35% of habitats by length and that several were four feet deep. However, only about 37% of pools were greater than two feet deep. Canopy closure had recovered to only 59% of which roughly 55% was coniferous and 45% deciduous. Cox (1989) found d ensities of steelhead juveniles at 53/ 100 feet but a 1995 survey found them at about half that density (Cox, 1995). It appears that the South Fork Fuller Creek is not as advanced in recovery as the North Fork.

Sullivan Creek (Fuller Creek): The five square mile sub-basin of Fuller Creek was habitat typed in 1995 (Sotoyome, 1996). The stream was comprised of 23% pools by length but 16% of the streambed was dry as a result of aggradation. Average depth of pools was two feet but 38% of pools measured were greater than three feet deep. Embeddedness ratings at pool tail crests were: 9% with 4, 43% with 3, 39% with 2 and 9% with the optimal rating of 1. Canopy had recovered to 89% with a 58% conifer component and the remaining 42% deciduous trees. Sullivan Creek is in mid-recovery from past logging damage.

Haupt Creek: The report of Parker and Pool (1964) on Haupt Creek provided valuable information for understanding changes in the stream that were later described by Klamt and Park (1970). In 1964, Haupt Creek had been heavily logged in its headwaters and in its lower reach but its middle reach remained intact. The middle reach was slated for logging at the time of the report. The lower reach was so aggraded from previous logging that the stream flowed underground in places. Parker and Pool (1964) noted that headwater areas were contributing fine sediment, which comprised 25% of the substrate. Pools still comprised 80% of the habitat in Haupt Creek with maximum pool depth of five feet. Coho salmon and steelhead were equally abundant but at densities of only 25/ 100 feet. Roach were much more numerous, however, with 200 found per 100 feet.

Parke and Klamt (1970) found that pools comprised only 60% of the habitat of Haupt Creek and they were a maximum of three feet deep. The loss of 20% of pool habitats and diminished maximum depth suggest that logging continued to cause accelerated erosion. Coho salmon were still present in the stream at densities of 25/ 100 feet, but only in the lowest reach. Steelhead had increased substantially from the prior survey with 500/ 100 feet in the lowest reach and lOO/lOO feet further upstream. Steelhead often compete fairly well in altered stream habitats and may increase in density as coho salmon decline (Higgins, 1995). It appears that the sediment plug in the lower reach of Haupt Creek, which had caused it to go underground in 1964, had been flushed downstream by 1970.

Upper South Fork Gualala River: Fox and Quinn (1964) surveyed 13 miles of the upper South Fork Gualala River and found the quality of salmonid habitat to be varied. They described the upper six mile reach as optimal steelhead habitat with abundant steelhead spawning gravel. The middle reach was described as sluggish with stagnant areas and some reaches underground. The reach above Marshall Creek, at the lowest extent of the survey, was dominated by bedrock and boulders. No coho salmon were found. Steelhead densities were lOO/lOO feet in the upper reach, 25/ 100 feet in the middle reach and 1 0/ 100 feet in the lowest reach where roach comprised 95% of the fish fauna. Damage to the stream was ascribed to long past logging with no recent stream damage noted. This stream also runs directly along the San Andreas Fault and some changes in stream gradient (sluggish areas) might be related to slumping or warping of the ground during large seismic events. The lowest *15* miles below Marshall Creek was not surveyed.

Marshall Creek (Upper SF): This major tributary to the upper South Fork Gualala was surveyed by Pool and Parker (1964) from its mouth to a point 13 miles upstream. Marshall Creek was found to be a productive salmonid stream with coho salmon present at about 30/100 feet and steelhead numbering lOO/lOO feet. Gravel suitable for spawning comprised 60% of the substrate. Pools comprised about 50% of the stream habitat and maximum pool depth was five feet. The maximum water temperature measured was 690 F. The report mentioned that a major forest fire occurred in the basin in 1955.

McKenzie Creek (Marshall/Upper SF): Parker and Pool (1964) surveyed this tributary of Marshall Creek and described it as optimal steelhead habitat. Fine sediment made up only 10% of the substrate and pools were approximately 60% of the habitat by length. Steelhead densities were estimated to be 50/ 100 feet and the ratio of steelhead to roach was estimated as 95:5.

Lower South Fork Gualala River: This reach of the Gualala extends from the convergence of the Wheatfield Fork and the upper South Fork downstream to the North Fork. Barracco and Boccione (1977) surveyed the lower South Fork Gualala and found pools to comprise 70% of habitats by length. However, pools were mostly shallow, with a maximum depth of six feet, and they lacked cover. Electroshocking in a 100 foot reach was used to estimate a population of 73 juvenile steelhead. Substrate was suitable for steelhead and Pacific lamprey spawning and 32 steelhead redds were counted and mapped.

EIP Associates (1994) habitat typed the lower South Fork Gualala River but it is not apparent that they used standard habitat typing techniques (McCain et al., 1990). Although pools were the predominant habitat, most were less than two feet in depth. These units might be better classified as runs or glides. Pools greater than two feet in depth comprised only about 10% of habitat between the Wheatfield Fork and Big Pepperwood Creek. The extremely low pool frequency and high occurrence of shallow flat water habitats clearly indicates major aggradation problems in the lower reaches of the Gualala River.

North Fork Gualala River: Parker and Pool (1964b) surveyed 15 miles of the North Fork by foot and by car and found it to be good salmonid habitat. Pools constituted 50% of the habitat by length and were a maximum of 10 feet deep. They divided the stream into the steeper upper reach and the mild gradient lower reach. Substrate in the upper reach was characterized as 60% boulders, 20% cobble and 20% gravel while the lower reach was 80% gravel, 10% cobble and 10% sand. Steelhead juvenile densities were 20/l 00 feet in the upper reach but 50/100 feet in the lower reach. There was at least one specimen 15 inches in length. Coho were present at 20/ 100 feet in the lower reach as were Gualala roach. Log Cabin Creek, a tributary of the North Fork, had been devastated by logging and as a consequence flowed underground in places (Parker, 1964).

Little North Fork Gualala: Parker (1964) found that pools made up 80% of the habitat by length in the Little North Fork and the maximum pool depth was five feet. Coho salmon and steelhead juveniles were estimated at 50/ 100 feet. Salmonids made up 95% of the fish fauna and Gualala roach 5%. Sand and silt made up 30% of the substrate and Parker (1964) noted that it stemmed from recent logging activity.

Lower Gualala River and Estuary: While no habitat surveys have been conducted downstream of the North Fork, there is concern that pulses of sediment may be filling the channel and the estuary (EIP, 1995). Comparison of aerial photographs taken in 1965 and 1988 suggests that the lower Gualala River has become shallower and that the active channel is now much smaller during low flow conditions. While point bars at places where the river turns are the same in 1965 and 1988, the reaches between corners seem to have substantially decreased channel widths. The photo from 1965 was taken in July while the 1988 photo was taken in May. Flow records for these two periods could not be located; therefore, the changes in channel width could also be in part a result of different flows.

Geology and Erosion Risk

The South Fork and North Fork Gualala River are relatively well studied geologically, in part because they follow the San Andreas fault (Huffman, 1972; Williams and Bedrosian, 1976) but also because of the elevated erosion risk related to land use management (CDMG, 1984; McKittrick, 1995). Maps of the southern Gualala basin were also prepared for use in Sonoma County planning (Blake et al., **1971;** Huffman and Armstrong, 1980). Despite the number of geologic studies carried out in the Gualala basin, more detailed, site-specific mapping is often needed for land use planning (Best, 1997). Soils in the northern half of the watershed are characterized by various surveys and studies carried out by the Mendocino Resource Conservation District (1987, 199 1).

The San Andreas fault forms a major divide between two distinct bedrock types. West of the fault bedrock consists of marine sedimentary sandstone, mudstone, shale and conglomerate rock that are highly interbedded (Williams and Bedrosian, 1976). On the east side lie older, more weathered rocks of the Franciscan Complex including sandstone, shale and conglomerate. Sandstones west of the San Andreas fault are generally more course grained than those to the east.

Huffman (1972) described the Franciscan assemblage:" These rocks were involved in severe large-scale deformation of the earths crust, shortly after their origin. Resultant fracturing, faulting, and crushing, together with dissociation and displacement of formerly contiguous rock bodies, has left them with characteristic physical properties." Part of the Franciscan terrain is a melange of particularly diverse rock assemblages that is extremely erodible. Vegetation on melange terrain is often grass or brush because slopes are so prone to sliding no trees can get established (Huffman, 1972).

Pacific Watershed Associates (PWA, 1996) provide a description of the geology of the Fuller Creek basin. "The Fuller Creek watershed is predominantly underlain by 65 million year old rocks of the Coastal Belt of the Franciscan Complex. The rocks exposed in sub-division road cuts are dominated by a high percentage of bedded, marine sandstones with lesser amounts of interbedded marine shales and siltstones. The rocks are generally well lithified, and have moderate to high strength, as reflected by the steepness of many natural hillslopes. However, locally the rocks are highly broken, faulted, folded and fractured as a result of mountain building processes and certain soils are especially unstable and/or erodible."

The San Andreas fault has a profound impact on slope stability. Rocks within the San Andreas shear zone, and as far as one mile west of the fault, are "highly shattered" and "natural swamps, marshes and ponds occupy depressions in the fault zone" (Williams and Bedrosian, 1976). "Offset streams and many large landslides occur along the fault trace." There are many signs of significant ground rupture from the 1906 earthquake and ground movement of up to twelve feet was measured (Huffman, 1972). Two major landslides along the Gualala River resulting from the 1906 earthquake have been recorded (Lawson et al., 1908 as taken from Huffman, 1972):

> A number of landslides blocked the wagon road and railroad track north of the Gualala River. A particularly extensive one occurred north of the junction of the branches of the Gualala, burying the tracks under many tons of rock and loose debris.
>
> East of Stewart's Point the bridge over the South Fork Gualala River was damaged by slumping of the river terrace on which its south end rests. On both sides of the sharp bend of the river east of the bridges are extensive landslides, making a clean sweep down the mountainside.
>
> The slopes east of the river (near Casey's Ranch) were similarly effected and fallen timber produced a tangle not unlike that of extensive windfalls. In at least two places the (South Fork Gualala) river was temporarily dammed up by slides from both slopes meeting in the stream-bed, but none of these dams was of noteworthy size.

It is clear that the San Andreas fault plays a dominant role in reshaping the landscape of the western Gualala River basin, including the river course itself. Maps from Williams and Bedrosian (1976) show major landslides along the San Andreas fault and different rock types on the east and west sides of the fault (Figure 11).

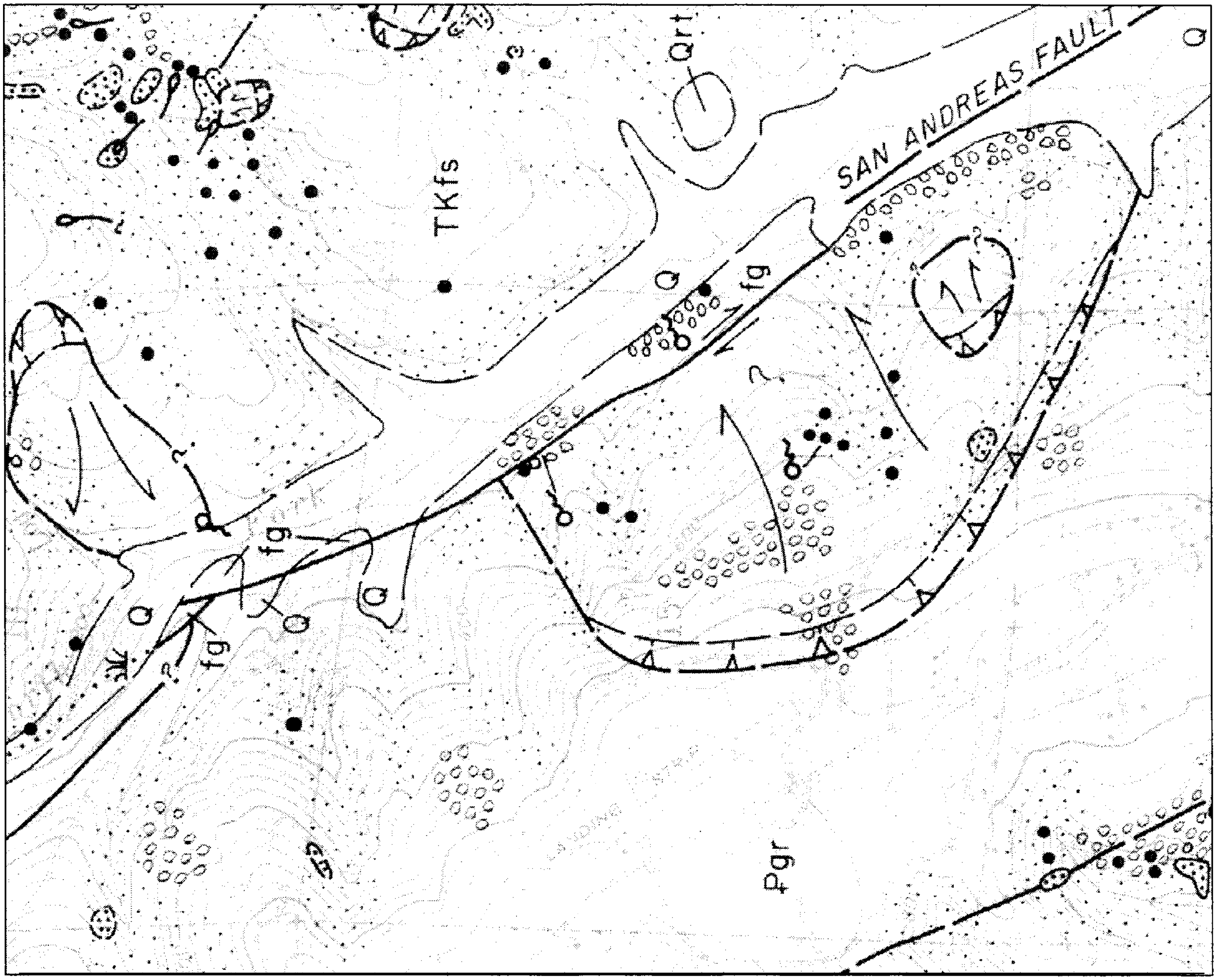


Figure 11. *San Andreas fault with inner gorge slides* **(CDMG, 1984)**

Landslides are characterized as falls, slides, flows and complex landslides which are combinations of the foregoing three types. Huffman (1972) notes that landslides result from a combination of factors: strength of rock or soil type, slope, presence of seeps and springs and whether historical landslides have occurred at a site. While slope steepness can increase slide potential, steep slopes may not be slide-prone sometimes because they are composed of resistant rock types. Huffman (1972) noted that landslides, once initiated, "influence surrounding terrain by removing support as they move downslope".

Huffman (1972) noted that stream erosion was interrelated with landslide processes in the steeper part of the Gualala watershed: "Bank slumps occur, and headward regression of these slumps may envelop an entire slope from the stream to the ridge top, as landslides. Stream transportation of landslide materials deposited at the base of the sliding slopes serves to maintain the continuum of slope erosion." Landslides and debris torrents upstream also contribute to the likelihood of stream bank failures as channel capacity is reduced and flood waters surge up slopes.

As sediment from hillslopes washes into streams, it can bury stream-beds. When the stream-bed rises in elevation because of sediment deposits, it is aggraded. Alternately, debris torrents traveling down stream channels can also scour a stream down to bedrock. Large wood and other habitat-forming elements can be blown downstream or buried. The stream course after flood damage can be much wider at locations where the stream is not confined. This widening makes the stream much more subject to warming. Steep tributaries may flush sediment resulting from flood damage within a few years but sediment in low gradient streams may persist for decades. Best (1997), in comments on the draft of this report, noted that several tributaries in the Gualala basin are actively down-cutting through old deposits.

The particle size distribution of a disturbed stream-bed can also change substantially. When sediment input is in equilibrium with sediment transport, the stream-bed will sort into a relatively stable cobble-boulder matrix with pockets of gravel. Gravel suitable for spawning would also occur upstream of large logs that spanned the stream. CDFG stream survey reports indicate several patterns of change that resulted from watershed disturbance and flood damage. Fine sediment levels increased substantially in most cases, often plugging interstitial spaces between cobble and gravel. This condition, known as embeddedness, dramatically reduces production of aquatic insects that dwell in the gravel matrix as well as reducing spawning habitat quality. Debris torrents and flood damage may also leave angular rubble that has not been worn smooth and is, therefore, poor substrate for spawning.

Nawa et al. (1990) found that disturbed streams in southwest Oregon had greatly altered bedload movement that reduced spawning success. Flat reaches of the highly aggraded streams had very small average particle size distribution. Nawa monitored areas used by spawning chinook salmon and found that the bed elevation shifted as much as plus or minus three feet during a two year storm event. Since salmon redds are generally no more than two feet in depth, this meant that eggs in the nests would have been scoured out or buried so deep that none would hatch. Since the storm recurrence interval was only two years, the likelihood of salmon survival over several generations in such a stream reach would be extremely low. The stream bed of the lower South Fork Gualala River is composed of mostly small gravels (EIP, 1994a) similar to those in streams studied in southwest Oregon.

The North Fork Gualala River has been mapped geologically to assess the potential for landslides as part of a long term California Department of Forestry (CDF) monitoring project (McKittrick, 1995). Figure 12 shows a portion of a map of landslide susceptibility (McKittrick, 1995) in the North Fork Gualala River near the San Andreas fault. Erosion hazard ratings are:

1 = Least susceptible to landsliding (along the river bottom),

2 = Moderate to highly susceptible (benches and moderate slopes),

3 = Highly susceptible (on steeper slopes or near emergent ground water) and

4 = Highly to extremely susceptible (inner gorge, headwalls, spring areas).

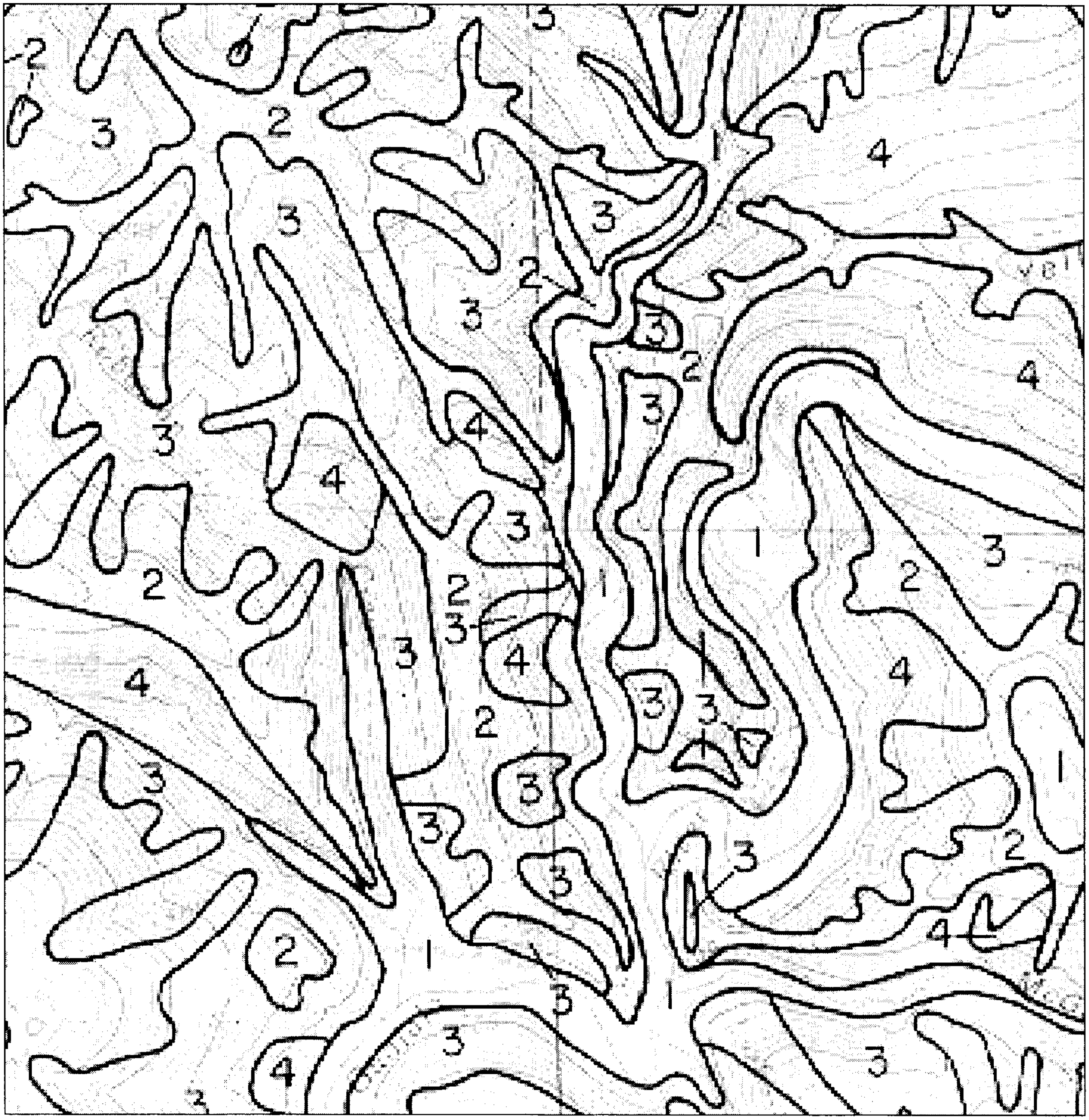


Figure 12. ***Landslide susceptibility of the N.F. Gualala River with high erosion risk shown in inner gorge. From McKittrick (1995).***

Another map from McKittrick (1995) shows geologic and geomorphic features related to landsliding (Figure 13). Several types of landslides are shown, including translational/rotational slides, earthflow/landslide complexes, debris slides, debris flow torrent tracks, debris slide slopes and small active slides. The close spacing of these features and the variety of landslides indicate how challenging erosion control is when conducting timber harvest. Best (1997), in comments on the draft of this plan, suggests that "very often simple erosion control measures can be implemented to mitigate the potential geologic hazards associated with timber harvest in these areas." CDF plans to monitor slope stability after timber harvest on various types of geologic terrain in the North Fork Gualala (see Monitoring).

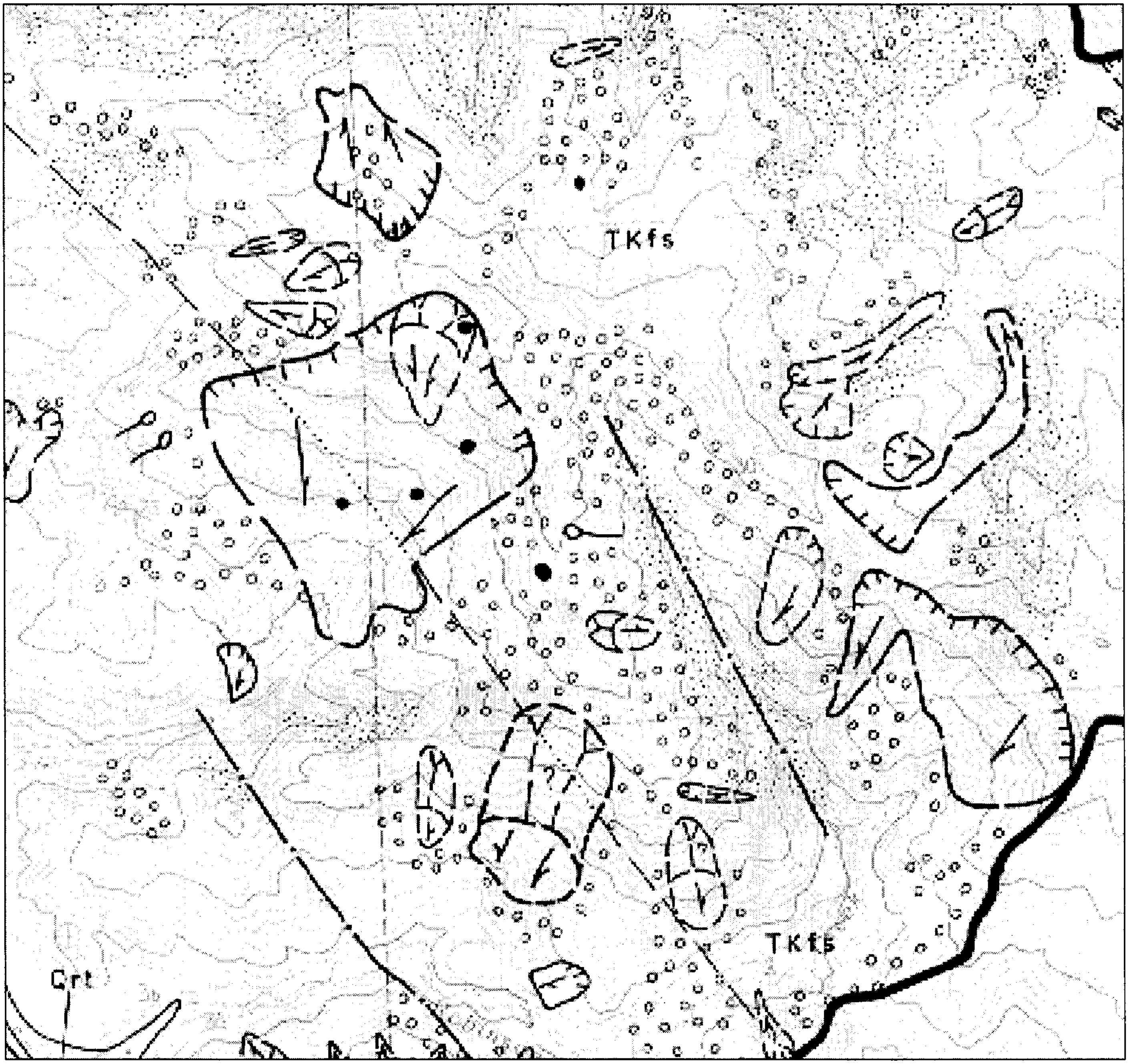


Figure 13. Landslide map of upper North Fork Gualala basin with translational/rotational slides, earthflow/landslide complexes, debris slides, debris flow torrent tracks, debris slide slopes and small active slides. (McKittrick, 1995)

“Soil types along a zone from the coast to two miles inland are predominantly Hugo, Caspar and Noyo series. Farther inland the Hugo series predominates with increasing occurrence of the Josephine and Laughlin series in the extreme eastern portion of the watershed” (Anon., 1968). The West Mendocino Soil Survev Man Unit Descriptions (MRCD, 1987) is a narrative that accompanies soil maps and describes the soil type, permeability, and basic erosion hazard information. More in-depth information related to soils relative to timber harvest can be found in the Mendocino Forest Soils Erosion Hazard Guide (MRCD, 1991). Utility of the latter document is limited with regard to analysis of site specific activities because of the large scale of the maps.

Water Quality

The Gualala River is acknowledged as an impaired water body by the State Water Resources Control Board (NCRWQCB, 1996) because of high sediment loads. The principal source of sediment is failure of road systems during major storm events (PWA, 1996a). Stream-side roads, which are common in the Gualala, can also be a chronic source of fine sediment (Cox, 1989; PWA, 1996b). Timber harvest can increase the risk of landsliding (PWA, 1996c), particularly in areas adjacent to the San Andreas fault where rocks are highly fractured (Huffman, 1972; Williams and Bedrosian, 1976). Vineyards in steep upland areas of the Gualala watershed, if poorly designed, can also contribute major quantities of sediment to water courses (Gergus, 1995, 1996, 1997). Cold water fish are recognized as a “beneficial use” of water in the Gualala River basin and other northwestern California rivers. The warm temperature of many Gualala tributaries is impairing salmonid production. In places, the river is so aggraded it runs underground.

<u>Roads</u>: Pacific Watershed Associates (1996a) made the following observation on the relative impact of roads on the sediment budget of the Gualala River: “ Prior to road construction and timber harvesting, mass movement or various types of landsliding would have been the overwhelmingly dominant erosional process occurring in the basin. This would have been followed by surface erosional processes occurring on bare soil areas, with formation of hillslope gullies playing a very minor role in the natural sediment production regime. If a sediment budget were to be constructed for the Gualala basin today, I suggest we would find that sediment production associated with the formation of hillslope gullies may be nearly as sizeable a contributor as sediment production associated with landsliding processes. The dramatic increase in hillslope gully erosion is largely caused by roads and due to how most roads, including the Kelly Road, are severely altering the natural hillslope surface hydrology.”

Kelly Road, which extends from Lake Sonoma to Annapolis, is a major source of sediment entering the Gualala River and its tributaries. The road was originally constructed for log hauling in the late 1940’s but was purchased by the Army Corp of Engineers at the time Warm Springs Dam was constructed. Pacific Watershed Associates (1996a) made the following observations on Kelly Road: “While Kelly Road has existed in its present location for nearly 50 years, it exhibits a long history of triggering widespread past erosion and man-made accelerated sediment yield to stream channels. Many stream crossings show indications of past failure and reconstruction. Long segments of inboard ditch are enlarged and eroded by gullying (Figure 14). Most of the ditch relief culverts, stream crossing culverts and berm drains have varying sized fillslope and hillslope gullies below their outlets (Figure 15). Many scars from cutbank and fillslope failures are present along the route.” The NCRWQCB recently issued a Cleanup and Abatement order to the Army Corp of Engineers regarding Kelly Road. Williams and Bedrosian (1976), in a study covering the North Fork Gualala watershed, noted that: “many erosion problems are associated with road construction, particularly within the sheared and shattered material of the San Andreas fault zone. Several deep gullies and many smaller, potentially hazardous gullies parallel to the roads have been formed by erosion as a result of improper drainage. Where the gullies have become enlarged and water has saturated underlying materials, the roads either have started to slide or have been washed out. In many places, minor cost remedial work could greatly reduce these erosion problems and deter future damage that would be much more costly to repair.”

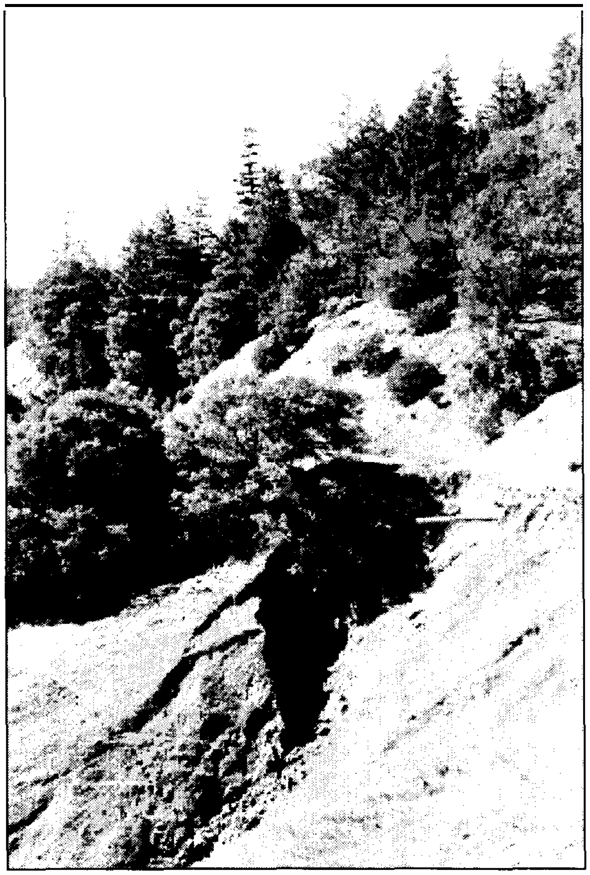


Figure 15. *Massive gully caused by improper drainage on Kelly Road.*

Figure 16. Enlarged Kelly Road ditch where small stream has been captured

Many roads in the Gualala River watershed are located immediately adjacent to stream courses. One such road along the North Fork Gualala lead to a citation of the local land owner by the North Coast Regional Water Quality Control Board memo (Neely, 1994). The problems with the road have since been corrected (Williams, 1997).

Pacific Watershed Associates (1996b) conducted an erosion control assessment of the Fuller Creek basin and found that: "Road construction through these lower strength materials has resulted in the initiation of impressive and large cutbank landslides in certain parts of the watershed. Likewise, concentrating and directing road and stream runoff on erodible soils, or sidecasting spoil materials on steep slopes during road construction, has also resulted in the formation of numerous large hillslope gullies and fillslope landslides." Cox (1989, 1995) had previously noted that streamside roads in the Fuller Creek drainage were a major chronic source of fine sediment as well. Substantial efforts are underway to reduce sediment contributions from roads in the Fuller Creek basin (see Restoration).

Vinevards: A hillside vineyard in the House Creek drainage has caused substantial erosion and has been the subject of several enforcement actions from the NCRWQCB since 1993 (Gergus, 1997). The vineyard occupies 100 acres on a steep-sided ridge. Inspections noted six foot deep gullies in uncompacted fill that were draining into headwater streams (NCRWQCB, 1994). Gergus (1996) in a letter to the owner stated: "Your vineyard appears to be steeply sloped in many areas and lacking any structures to control runoff and erosion. This area receives approximately 65 inches of rain per year. I am very concerned that your vineyard will suffer significant erosion and cause sedimentation to surrounding creeks. Your vineyard drains to House Creek and could cause significant sedimentation to this stream." Erosion from this vineyard also has caused failure of a road for which an easement exists to an adjacent property (Gergus, 1996).

Logging: It is noted in nearly all CDFG stream surveys from 1960 through the early 1970's that the streams in the Gualala River watershed were overwhelmed with sediment and debris associated with timber harvest. Incised streams, highly unstable banks, high quantities of fine sediments in spawning gravel, diminished pool volumes and lack of complex habitat were common observations from the surveyors (see Fish Habitat Trends). At one time, direct contribution of slash to Buckeye Creek was so great that Day (1962) measured dissolved oxygen levels as low as 0.6 ppm, which are well below the lethal level for salmonids (4 ppm).

The California Legislature passed the Z'berg-Negedly Forest Practice Act in 1973 which imposed restrictions on timber harvest in stream side buffers, direct contributions of slash to water courses and other logging practices that damaged aquatic resources. The California Board of Forestry (BOF) adopted Best Management Practices (BMP's) in the 1980's pursuant to compliance with section 208 of the Federal Clean Water Act. The NCRWQCB (1996) prohibited non-point source pollution in the Gualala River in 1972 and has been participating in timber harvest review since that time. Williams (1997), in comments on the draft of this report, noted that BOF continues to take "actions up to the present that . . . reduce impacts of timber harvest practices." EIP Associates (1994a) stated that: "Continued harvesting in the watershed has some effect on the sediment supply and hydrologic conditions on the Gualala River, but it may be minor compared to the effect of past logging activity."

A major indication of problems with California Forest Practice Rules is that they have never been certified by the U.S. Environmental Protection Agency (EPA) as BMP's. The last comprehensive review of the rules as BMP's was conducted in 1988 when 100 timber harvest sites with the potential to negatively impact water quality were visited. The resulting report (CSWRCB, 1988) showed that nearly 50% of the timber harvests reviewed posed threats to aquatic resources. Timber Harvest Plans (THP's) still serve in lieu of CEQA and NEPA environmental impact reports despite the lack of certification of timber harvest practices in the State as BMP's.

California Forest Practice Rules are also being questioned because of their inability to mitigate for cumulative watershed effects (Coast Action Group, 1995). While current individual timber harvests may be far less damaging than past logging, advanced technology allows disturbance of large watershed areas over a short period of time. For example, in the North Fork Gualala River Greene (1994) calculated that 4,750 acres of 6,829 acres in one planning watershed unit had been harvested from 1984-1994 (70% of the watershed area). This widespread disturbance in a short period of time may lead to changes in hydrology and sediment yield, particularly if logging disturbance occurs in an area of high erosion risk. Huffman (1972) stated that "Weak rocks and soils, particularly those of the Franciscan melange, the San Andreas fault zone, and old landslides are likely to give rise to numerous failures in cuts." The extensive road networks related to logging also greatly elevate risk (Williams and Bedrosian, 1976). Klein (1997), in comments on the draft of this report, suggested that using the amount of area harvested by decade was overly simplistic. He said that: "Issues such as silvicultural prescription, yarding methods, watercourse and lake-side protection zones (WLPZ) considerations, etc., as well as inherent climatic and geologic characteristics must also be considered." Klein (1997) recommended that integrated watershed studies be implemented to resolve the question of sediment contributions from present day timber harvest practices.

There is insufficient data at present to judge whether intensive timber harvest in areas of geologic instability, such as the North Fork Gualala River, are accelerating erosion. However, in-stream structures in tributaries to the North Fork placed by the Gualala Steelheaders were buried in sediment during the January 1997 storm. A debris torrent also occurred in a clear-cut area and crossed Annapolis Road in 1997. Spacek (1997), in comments on the draft of this report, noted that the clear-cut that triggered this slide was on a very steep slope with emergent ground water. The CDF monitoring project (McKittrick, 1995) which addresses the relationship between logging on steep, unstable ground and increased landslide risk needs to go forward and results need to be shared. Knopp (1992), in a monitoring project conducted jointly by CDF and the NCRWQCB, found very high fine sediment levels in pools in Grasshopper Creek, a tributary of Buckeye Creek using a technique known as V*. The V* score was .59, which indicates that approximately 59% of pool volume was filled with fine sediment (see Monitoring).

Clear-cut logging offers a great deal more opportunity for surface erosion and a higher likelihood of landsliding because of loss of root strength (Ziemer, **1981)** and changes in hillslope drainage. Spacek (1997) noted that slope failures in clear-cut areas may contribute a significant portion of sediment to streams during large storm events and cited a study Aerial Reconnaissance Evaluation of 1996: Storm Effects on Upland Mountainous Watersheds of Oregon and Southwest Washington (PWA, 1996c). Much of the logging currently conducted in the Gualala River basin is selective harvest that poses substantially less erosion risk (CFL, 1997). Although widespread timber harvest has taken place in the North Fork Garcia River, the use of selective harvest and road improvements have prevented additional major incursions of sediment (Hagans and Higgins, 1996).

The California Forest Practice rules allow timber harvest in riparian zones that may not be sufficient to allow recovery of coho salmon and steelhead (Spence et al, 1996). While at least 50% canopy must be maintained under the rules, only 25% of that must be conifers. In order to bring temperatures down to the range optimal for salmonids, a secondary over-story of conifers is needed (Spence et al, 1996).

Water Temperature: Although the Gualala River is not currently listed as impaired with regard to water temperature, available data suggests that temperatures are much higher than optimal for salmon and steelhead. The Oregon Department of Environmental Quality (ODEQ, 1995) states that optimal temperatures for rearing coho salmon is between 11.8-14.60 C (53-580 F). Juvenile coho salmon cease growth at 20.30 C (690 F) and their upper lethal limit is 250 C (770 F). Temperature data from Fuller Creek, Buckeye Creek, Rockpile Creek and the Wheatfield Fork of the Gualala River all exceeded optimal.

Doug Simmonds monitored both the North Fork and South Fork of Fuller Creek in 1997 (Figures 16 and 17) using automated temperature sensing devices provided by the NCRWQCB. The probes were placed in a shaded portion of the stream in flowing water, as opposed to pools which may stratify. The North Fork attained a maximum water temperature of 740 F while the South Fork water temperature reached as high as 760 F. Both creeks were over 700 F for at least some portion of the day during most of June and July. While Fuller Creek still supports steelhead trout (Cox, 1989, 1995), it is still too warm at present to be suitable for coho salmon.

Temperature data from Gualala Redwoods was available in the NCRWQCB files for Rockpile Creek at two locations and Buckeye Creek at three locations. Rockpile Creek reached a maximum of approximately 740 F in the middle reach of the stream while the maximum temperature of the lower reach was a degree cooler (730 F). Both these stream reaches exceeded stressful temperatures for salmonids for several days in June and July of 1995. Temperature sensors in Buckeye Creek showed a similar trend toward cooling in lower reaches. Maximum water temperatures in 1995 were 760 F in the upper reach, 750 F in the middle reach and 730 F in the lower reach.

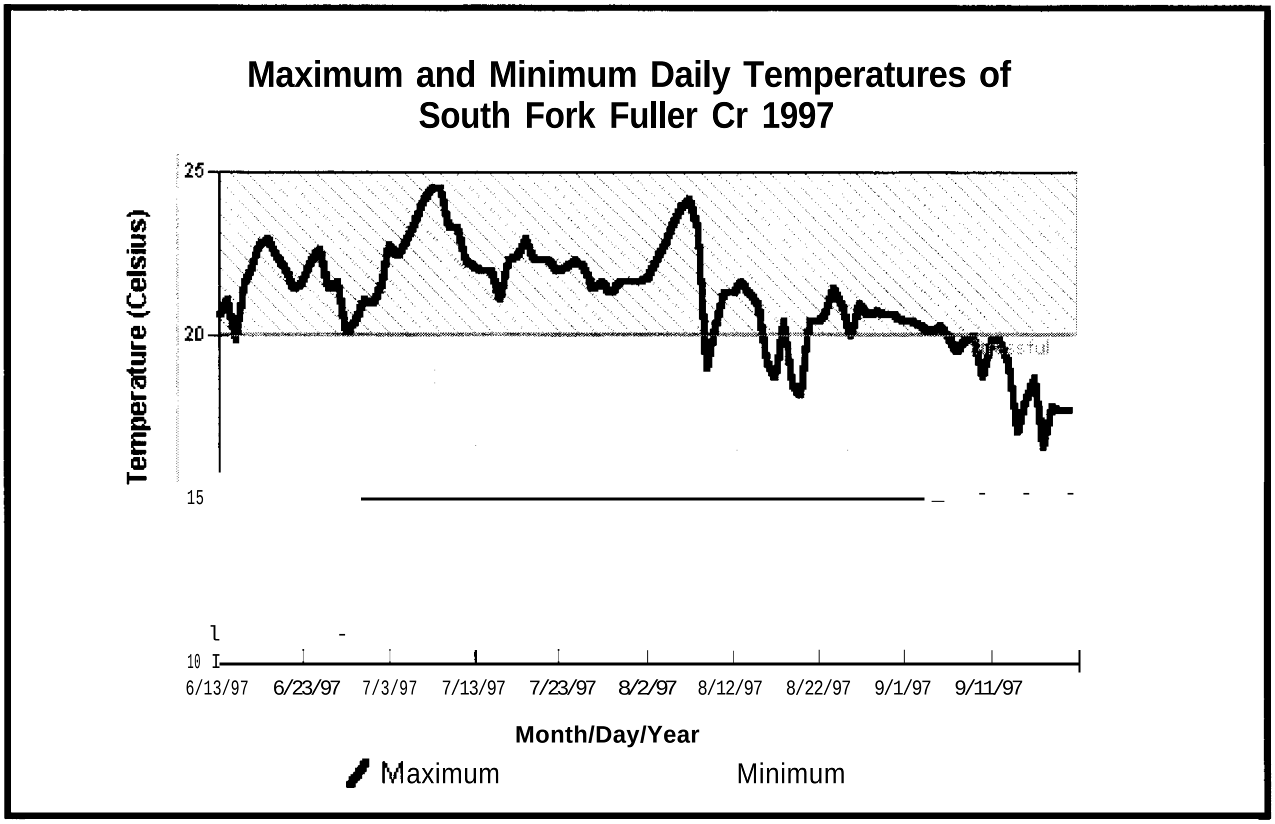


Figure 16A. Temperature graph from Hobotemp placed in S.F. Fuller From Doug Simmonds.

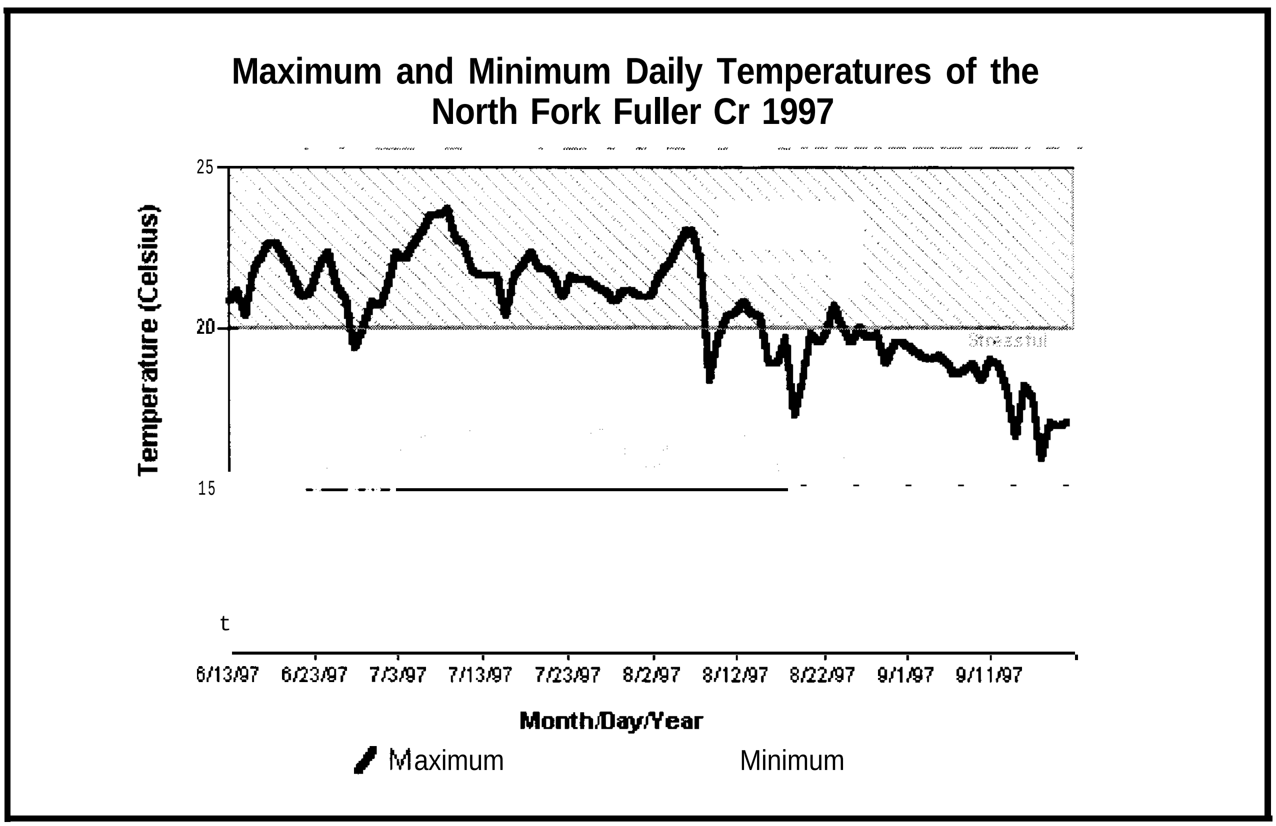


Figure 17. Water temperature from Hobotemp placed in N.F. Fuller Creek by Doug Simmonak

The highest water temperatures discovered during this project were collected by Doug Simmonds in the Wheatfield Fork of the Gualala just above Fuller Creek. The maximum water temperature recorded in 1997 was 83^0 F, which is lethal for salmonids. Water temperatures exceeded 800 F during several intervals in June, July and early August. Klein (1997), in comments on the draft of this report, noted that the Wheatfield Fork of the Gualala runs through sparsely vegetated earthflow terrain which may contribute naturally to its warming.

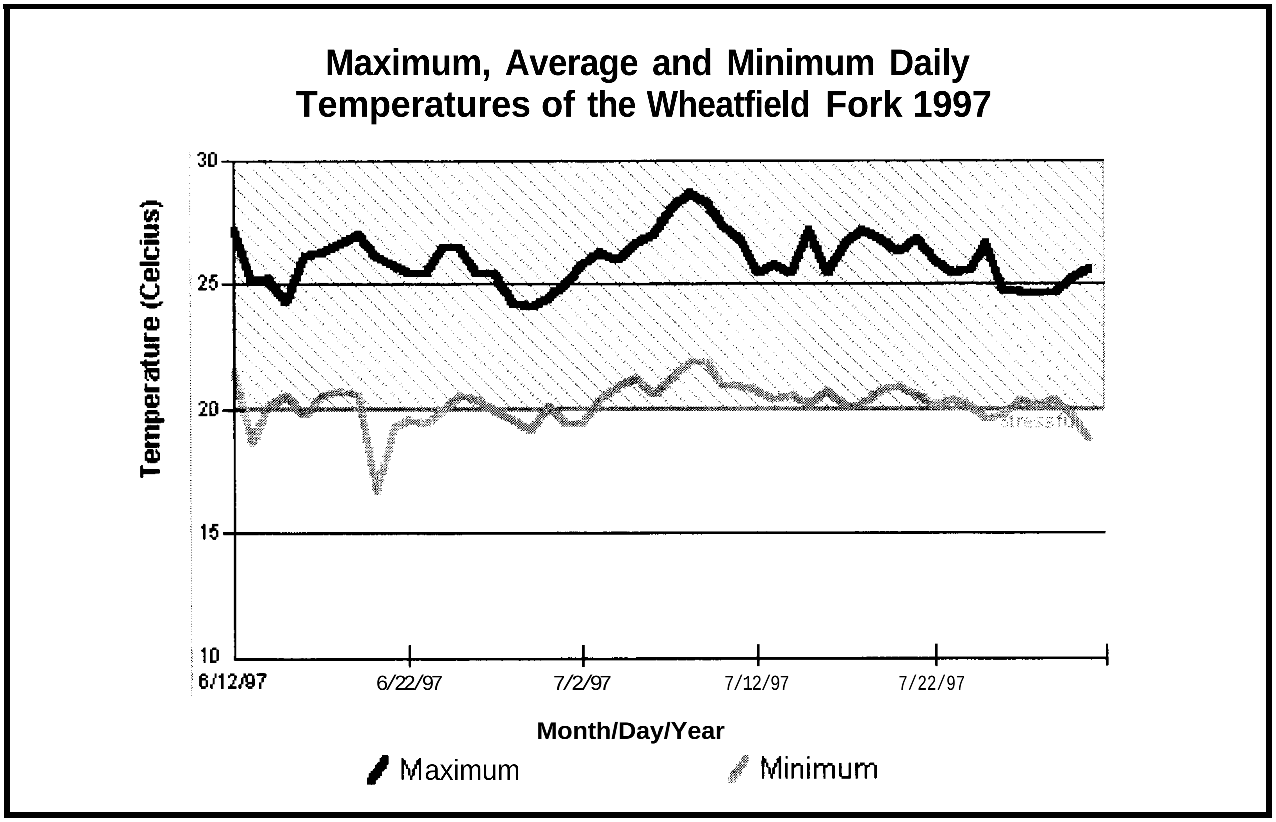


Figure 18. *Water temperature of Wheatfield Fork Gualala River as recorded by a Hobotemp placed by Doug Simmonds.*

TMDL: Water pollution has been successfully abated in the eastern United States through use of regulatory mechanism under the Clean Water Act known as Total Maximum Daily Loads (TMDL). Recently a lawsuit was brought against the U.S. Environmental Protection Agency (EPA) and the California State Water Resources Control Board for failure to enforce statutes of the Clean Water Act. Numerous northern California rivers had been recognized as impaired but no deadlines had been set to abate sources of pollution to these water bodies. The action was settled out of court when the EPA and SWRCB set a timeline for implementation of TMDL standards. The first watershed that must come into compliance is the Garcia River and a draft Garcia River Water Oualitv Attainment Stratew for Sediment (Mangelesdorf, in press). The Gualala River must have an attainment strategy by 200 1.

Sediment Supply and Gravel Extraction

The Gualala River has been delivering excess sediment since the 1950's. It is likely that a pulse of sediment also accompanied the first wave of logging that ended just after the turn of the century. It is estimated that the Wheatfield Fork of the Gualala River has aggraded approximately 25 feet in recent decades (EIP, 1996). Both the Wheatfield and upper South Fork Gualala run underground in places during late summer in dry years because of severe aggradation. This condition indicates that stored sediment in low gradient reaches of the mainstem Gualala River remain high, however, there are no studies on the rate of gravel supply from tributaries. It is likely that supply from tributaries such as Fuller Creek is decreasing as indicated by down-cutting of that stream channel (Cox, 1995). Conversely, the North Fork Gualala River may still have high contributions as indicated by aggradation around fish habitat improvement structures.

Gravel from the Gualala River has been extracted commercially since the 1960's. While gravel mining reduces sediment inputs to the lower river and estuary, it also disrupts river morphology and long-term recovery of the riparian zone (USFWS, 1994). The fd1owing excerpt about the history of Gualala River gravel extraction is taken from the Gualala Aggregates, Inc. Draft Environmental Impact Report (EIP, 1994).

> In-stream mining has occurred on a commercial scale on the Gualala River since the 1960's and, periodically, at a small scale throughout the earlier period in which the watershed was logged. In-stream mining can affect the characteristics of a river by reducing sediment supply, altering channel geometry, or changing the mix of particle sizes. Volumes of gravel extraction from the South Fork Gualala River have been recorded since 1981 and are reported in Gualala Aggregates EIR, 1994. Minor amounts of gravel extraction on the North Fork of the Gualala and its tributaries have also occurred in the past. The amount extracted is believed to have averaged less than 1,000 cubic yards per year (cy/yr). Extraction of gravel in the 1950's for use on logging roads was probably between 1,000 and 5,000 cy/yr. In the early 1960's commercial extraction began and rates rose to approximately 20,000 cy/yr. In the latter half of the 1960's construction of the roads at The Sea Ranch created an increased demand for aggregate, and rates rose to approximately 40,000 cy/yr." Sonoma County rezoned the area of operation for Gualala Aggregates Inc. in 1980 as Mineral Resources (MR).
>
> Cross section data from stations near USGS gauges is only available indirectly, as measurements of the relative elevation of various flow levels. This data shows aggradation prior to 1960, when average extraction rates were 1,000 to 5,000 cy/yr. The data also shows a fluctuating elevation in the early 1960's during a short period when extraction levels were approximately 20,000 cy/yr. In the latter part of the 1960's, however, extraction doubled to approximately 40,000 cylyr, and during this period there is a clear downward trend in the data, indicating an average drop in the channel of 1.3 feet over the seven year period. Thus we can conclude the following regarding average gravel replenishment rates in the vicinity of the confluence of the Upper South Fork and Wheatfield Forks of the Gualala during the 195 1-1993 period, (based on the qualified assumptions explicitly stated earlier in the EIR):
>
> - aggradation of the channel bed appears to have occurred at extraction rates of approximately 1,000 to 5,000 cy/yr;
> - extraction rates of approximately 40,000 cy/yr, on average, may have induced a lowering of bed elevation; and therefore,
> - the average replenishment rate of the Lower South Fork Gualala River is between approximately 5,000 and 40,000 cy/yr, with a best estimate from the available information of 16,000 cy/yr.

The Gualala Aggregates EIR (EIP 1994a) was for expansion of the area of operation from its current site at the convergence of the Wheatfield and South Fork to the entire reach down to the North Fork. Gravel extraction in the Wheatfield and in the South Fork above the convergence was also planned. The County of Sonoma approved expansion of downstream to the North Fork but not in the Wheatfield or upper South Fork.

According to Randy Sweagle (personal communication), the amount of gravel allowed for extraction annually is now based on gravel bar replenishment. Both 1995 and 1997 were high sediment delivery years as a result of high flows. In 1995, Gualala Aggregates gathered baseline stream profiles for every point bar in the lower South Fork Gualala. Every year, new measurements must be taken before and after extraction. Gravel may only be mined from the rear half of the gravel bar to protect vegetation on the front half. This helps maintain bar position from year to year. The effects of the extraction must also be monitored in areas 1000 feet upstream and downstream. Mitigation is required on-site every year and large rootwads or large wood is anchored in the channel to create local scour.

The U.S. Fish and Wildlife Service (1994) objected to the expansion of Gualala Aggregates operation on the grounds that it would be destructive to the stream channel and riparian areas and harmful to anadromous salmonids. The Gualala Aggregates EIS acknowledged that extraction could change channel morphology:

> Observations of other rivers in Sonoma County has shown that in-stream gravel bar skimming may be responsible for a change in channel cross section towards a more flattened bar form with relatively shallower pools (EIP, 1994a).

In its pre-disturbance condition, the lower South Fork and mainstem Gualala River would have been excellent rearing habitat for juvenile salmon and steelhead. Less than 10% of the lower South Fork at present is pools (EIP, 1994), the favored habitat of older age steelhead.

The Gualala Aggregates EIS (EIP, 1994a) down-played the importance of the lower South Fork Gualala River, in its present condition, as habitat for adult steelhead. EIP (1994) stated that the lower South Fork Gualala was only used by migrating fish and was not spawning habitat. Barracco and Boccione (1977) actually counted 32 steelhead redds in the reach between the Wheatfield and the North Fork. It is quite likely that steelhead will spawn in the lower South Fork again during drought conditions and might be using it to a limited extent in years with normal flow. Steelhead spawn in the mainstem Garcia River annually as late as May (Craig Bell, personal communication). Late spawn timing would be selected for if fish were using the lower South Fork because of high bedload movement during storm events (Cedarholm, 1983). Prior to watershed disturbance, it is likely that coho salmon spawned in the lower South Fork Gualala and possibly chinook as well.

Because the Gualala River and most of its tributaries are in poor ecological condition, the estuary or lagoon of the Gualala is probably the best rearing habitat at present for older age juvenile steelhead (Brown, 1986) Gravel extraction may protect the estuary from aggradation. Stopping gravel extraction could cause decreased volume in the estuary and lower Gualala River and the capacity to support steelhead juveniles.

Leopold and McBain (1995) took cross sections of the Garcia River and found that pools got deeper in the lower river after the January and March 1995 storm events, which were the storms of record in the basin. They concluded that the Garcia was no longer over-supplied with gravel. They also noted that a gravel build up on point bars would be necessary to focus the river’s energy enough to dig deeper corner pools in the lower river. They contended that gravel extraction would inhibit this build up and, therefore, substantially impede channel recovery.

Monschke (1992) found that an abundance of older steelhead juveniles inhabited corner pools in the lower Garcia. A key element in this pool formation seemed to be the recovery of riparian vegetation, which stabilized banks and allowed scour during winter storms. The stream-side trees also provided shade and cover which are key elements of good salmonid habitat. Riparian recovery is an important key to restoring fisheries in the lower Gualala River. The current permit for gravel extraction stipulates that damage to riparian vegetation is to be minimized.

While the Gualala Aggregates EIS (EIR 1994a) did not propose alternatives to gravel skimming, this practice admittedly flattens the river bed and inhibits pool formation. Randy Sweagle (personal communication) noted that trenching was tried in the 1960's because high amounts of organic material were intermixed with bedload at that time which made skimming problematic. One excavated trench was 50 feet deep and 200-300 feet long. When the river course went into the trench, a 15 foot deep pool formed for a few seasons.

Hydrology and Water Diversion

In the Gualala River region, more than 90% of the precipitation falls between October and April, with the greatest amounts falling in the month of January. Mean annual precipitation in the watershed is approximately 65 inches (EIP, 1994). Sommerstorm (1992) noted that rainfall in the North Fork Gualala River basin was greater than 70 inches per year, much higher than on the Mendocino coastal plain to the north. From 195 l-l 971, the U.S. Geological Survey measured flows on the South Fork Gualala approximately one half mile downstream of the Wheatfield Fork. Flows were measured in cubic feet per second (cfs). The average flow by month over that time period was calculated by EIP (1994a) and is presented as Table 3.

Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
1,471	1,159	626	410	117	37	13	7	10	77	245	1,026

Table 3. ***Mean monthly flows of the South Fork Gualala River below the Wheatfield Fork based on USGS flow data from I951-1971. Copied from EIP Associates, 1994.***

Peak flow events recorded at the USGS gauge were also summarized by EIP Associates (1994) and are provided in Table 4. Since the USGS flow gauge was upstream of several major tributaries, it does not represent the peak discharge for the entire basin. No flow records are available below the North Fork Gualala River. Based on USGS flow records, EIP (1994) estimated that flows of 28,000 cfs had a recurrence interval of 2.3 years, or a 43 percent chance of occurrence in a given year. Morford (1994) pointed out that 195 1- **197** 1 was a very wet period relative to 1971- 1993, however, flows during the latter period were not monitored on the Gualala River. The flow gauge on the Garcia River has remained in operation and flows in 1995 were the highest ever recorded.

Boccone and Rowser (1977) measured the flow in the lower portions of the Gualala River during the critical drought period of 1976-77. The Wheatfield Fork Gualala River flow was 2.3 cfs, while flow downstream in the South Fork was approximately 3 cfs. The North Fork contributed 4.3 cfs to the lower Gualala River that was flowing at 12.4 cfs. Pepperwood Creek, Buckeye Creek and Rockpile Creek probably added approximately 5 cfs to the flows of the lower South Fork Gualala above the North Fork.

The major water users in the Gualala River basin are The Sea Ranch and the North Gualala Water Company. Both these diversions required appropriated water rights from the State Water Resources Control Board because the water they take is distributed to parcels that are not adjacent and, in fact, are outside the basin. Under California law, riparian landowners may divert water to meet domestic and agricultural needs. Because the Gualala watershed is steep and sparsely populated, riparian water extraction is minimal (Sommerstrom, 1992). Ground water wells do not require an appropriative permit unless there is a connection between ground water and surface water. California water law and other topics relevant to planning for future water needs can be found in the conference proceedings titled: Water and the Future of the Coast (North Coast Institute, 1988).

The Sea Ranch once drew surface water from the South Fork Gualala by using a summer dam. They currently draw water from the aquifer below the lower South Fork and have augmented storage with an off-site reservoir so that extraction of water during summer low flow periods can be minimized. Although The Sea Ranch's water right allows for a maximum extraction of 3.43 cfs, its current maximum diversion is 0.56 cfs (EIP, 1994a).

WATER YEAR (OCT.-SEPT.)	PEAK DISCHARGE (CFS)
1956	55,000
1965	47,800
1962	37,700
1954	35,900
1970	35,800
1958	35,400
1951	34,100
1953	33,900
1960	33,700
1952	29,500
1969	29,100
1967	28,900
1971	27,900

Table 4. ***Largest peak flows on the South Fork Gualala River from USGS gauging data 1951-1971). Copied from (EIP, 1994).***

In 1938, the North Gulala Water Company first applied for appropriated rights to surface water in Robinson Gulch and Big Gulch (Sommerstrom, 1994). In 1958, the company received an appropriative right to divert water from Fish Rock Creek, and in 1964, the rights to the mainstem North Fork Gualala. The latter right allows for extraction of 2 cfs but calls for by-pass flows of 4 cfs. The California Department of Fish and Game measured the flow of the North Fork in 1988 and found that by-pass flows were not being met (Cox, 1988). John Bowers, manager of the North Fork Water Company, asserted that by-pass flows were indeed being met at the point of extraction (North Coast Institute, 1988). Aggradation in the lower North Fork Gualala River might cause a decrease in surface flow and explain this anomaly

In 1989, the North Gualala Water Company (NGWC) drilled a well on the terrace of the lower North Fork Gualala River and switched its intake system from surface water to ground water. The company assumed that the water it was drawing was not connected to surface waters and was, therefore, not subject to permitting from the State Water Resources Control Board. A hydro-geologic assessment was conducted for the purpose of establishing whether groundwater extracted from NGWC well was from “a source characterized as a ‘subterranean (underground) stream’ and, therefore, subject to State water rights appropriation rules and regulations or from a source classified as percolating groundwater,” and thus not subject to the above noted appropriation rules (Slade, 1992).

The Slade (1992) report concluded that “the Gualala River system and, in particular, the groundwater extracted by North Gualala Water Company Well #4 is under the controlling jurisdiction of the SWRCB and subject to permitting for appropriative rights over the use of groundwater supply within this river.” Well #4 was found by the SWRCB to be in violation of licensing and permit conditions (Kessel, 1992). NGWC subsequently applied to the SWRCB for a change in point of diversion (#14853) but several parties have protested the application (Slota, 1996), including the California Department of Fish and Game (Hunter, 1996).

Sommerstrom (1992) noted the current pattern of use by the North Gualala Water Company and projected growth of water needs for the portion of the Gualala River basin in Mendocino County. The NGWC claims a 12,000 acre service area that extends north of the town of Gualala. The number of service connections of the NGWC grew from 671 in 1985 to 847 in 1990 (Sommerstrom, 1992). The NGWC had 902 hook-ups as of 1995 and was limited to a maximum of 1034 by the California Department of Health Services unless the storage and delivery system were substantially upgraded (Coast Action Group, 1995).

Sommerstrom (1992) projected population growth in coastal Mendocino County from 1.75% to 3% but noted that some areas might experience much higher growth rates: “Gualala, for instance, could become a regional center for the south coastal area of Mendocino County and the north coastal/Sea Ranch area of Sonoma County.” Coast Action Group (1994), in comments on the Gualala Municipal Advisory Council proposed General Plan and Local Coastal Plan Amendment, expressed concern over growth and development. They noted potential conflicts with protection of fisheries and with the Mendocino County General Plan.

The Gualala River below the North Fork and the Gualala estuary are the main areas of production for juvenile steelhead, especially those older than one year which are most likely to contribute to adult returns. During the 1976-77 season, the North Fork provided about 35% of the flow in the lower Gualala River (Boccione and Rowser, 1977). The North Fork also contributes cold water that helps to buffer the lower river and estuary from warmer tributary influences. If the North Fork Gualala River flows were depleted, it would likely have a major impact on carrying capacity for steelhead juveniles.

While agricultural water use in the Gualala River watershed has been very low in the past, wineries are now being developed in some areas. These wineries may have a direct impact on tributary flow if surface water is used. If wells are drilled in upland areas, and if the aquifer is joined to headwater springs, flows in some tributaries could be affected. EIP Associates (1994a) projected that development of vacation homes or residences could result in use of up to 2.5 cfs for the entire basin.

Spacek (1997) in comments on the draft of this report, noted that fog drip in redwood forests can be a significant contributor to net moisture yield in coastal watersheds. He suggested that extensive clear-cutting might have an adverse impact on available water supply to streams in the western portion of the Gualala basin. He cited the Proceedings of the Conference on Coast Redwoods. Forest Ecolow and Management (Humboldt State University, 1996).

Restoration

Salmon and steelhead production and water quality in the Gualala River is recognized as impaired, however, no comprehensive strategy has been chosen yet for restoration. Early restoration efforts included stream clearance to improve fish passage, but now attention is focused on stabilizing hillslopes and decreasing erosion related to roads in tributary basins (PWA, 1996). Williams (1997) in comments on the draft of this report, noted that road restoration and upgrades are frequently implemented as part of mitigation for THP's. The need for riparian restoration to help abate problems with bank erosion and high water temperature has long been recognized. In the longer term riparian restoration will also provide large wood to the stream In-stream structures have been tried on a small scale in the North Fork Gualala basin. Fisheries scientists now acknowledge that in addition to actively restoring streams, that activities degrading a watershed must be abated if restoration is to succeed (Roper et al., 1997).

Numerous California Department of Fish and Game stream surveys in the 1960's and 1970's called for clearance of debris jams as well as riparian restoration. A great many stream clearance projects were carried out, while riparian recovery occurred mainly as a result of natural processes. Logjam removal was thought to benefit fish passage and continued until about 1985 (Foster and Rilla, 1985). Recent studies indicate that large wood is an extremely important element for forming pools and habitat diversity in coastal streams (Reeves et al., 1988).

Replacing large wood in streams may help to advance stream recovery but should only be done after the watershed is stabilized. Reaches of streams that have scoured down to bedrock can benefit from large logs spanning the stream and trapping spawning gravels. The Gualala Steelheaders, in cooperation with the land owner, Gualala Redwoods, have attempted to improve habitat in the North Fork Gualala River. Unfortunately, the structures installed have not functioned properly because of an over-supply of sediment in this tributary.

Riparian restoration could help accelerate stream recovery. Willows and alders have already become established on most disturbed reaches. The resurgence of these deciduous trees may have been aided by the recent cycle of drought from 1987-1992. Large-scale bank stabilization projects using living plant material (bio-engineering) have been carried out on the lower Garcia River and may have application in the Gualala River basin. Many Gualala River tributaries need a secondary over-story of coniferous trees for further reduction in stream temperatures. Where natural recovery of riparian conifers is slow, planting projects that include irrigation should be considered. Spence et al. (1996) recommend that no commercial timber harvest take place in riparian zones until stream temperatures are back within their normal range of variability.

Pacific Watershed Associates (1996) recently conducted a survey of erosion potential in about 25% of the Fuller Creek watershed. They found a potential sediment yield of 21,740 cubic yards of material. If preventative measures are not taken, this material could erode into stream courses. Major sources of sediment included 26 sites where culverts were likely to plug and 37 sites where streams could be diverted onto roads. The former contributes sediment as the fill at the stream crossing is washed away. The estimated cost of implementing all erosion prevention measures is $117,580. Erosion potential inventories were done on Louisiana Pacific holdings in Fuller Creek in 1997 and were also conducted on most of Coastal Forest Lands (Doug Simmonds, personal communication). Other Gualala River sub-basins need erosion control inventories, and timely implementation to prevent further stream damage. The North Coast Regional Water Quality Control Board recently issued a clean up and abatement order to the Army Corps of Engineers for Kelly Road. Some road upgrades and related erosion control has been carried out as part of mitigation for THP's (Williams, 1997).

Roper et al. (1997) stated that: "Restoration programs can play key roles in maintaining fish populations into the future. However, to maintain many fish populations, a shift in emphasis must occur from restoration based primarily on in-stream habitat to restoration of watershed processes." They also noted that "stream restoration in the absence of modification of upslope land management practices is likely to be futile."

Monitoring

In order to know whether restoration efforts are working, a comprehensive monitoring program must be implemented. Information gained from monitoring would allow management strategies to evolve and adapt as recovery of fisheries and water quality proceeds. It is important to directly monitor fish population trends, however, monitoring other parameters, such as water temperature, is very inexpensive and yields valuable information about the suitability for salmonids. Standard scientific monitoring techniques should be selected so that results can be compared over time and between watersheds.

Flow: The North Gualala Water District's permit for water diversion stipulates that flows of 4 cfs be maintained in the North Fork Gualala River. In order to insure compliance, a stream flow gauge should be installed just below the point of diversion on the North Fork.

Water Temperature: Low cost automated temperature sensing devices make it possible to assemble a comprehensive temperature portrait of the Gualala River. Since there is a clear link between salmonid population health and water temperature, a detailed temperature portrait would reveal whether conditions are improving over time for salmon and steelhead.

Temperature probes, such as Hobotemps, should be placed at the base of every major tributary. If more temperature sensors are available, additional probes can be placed within tributary sub-basins to determine where water temperatures are warm and where there are reaches with cool water. Cool water areas would coincide with refugia for salmonids. Temperature trends over time can be used to monitor success of riparian restoration or to assess natural recovery by reach. Frissell and Liss (1987) and Nawa et al. (1990) studied cumulative effects of forestry on several southwest Oregon streams and used water temperature as an index of recovery. These studies should be reviewed to aid in analysis of temperature results of Gualala River monitoring.

Water temperature monitoring is ideal for community involvement and is not prohibitive in expense. Data collected by volunteers can be pooled with land-owner data for a comprehensive temperature portrait of the Gualala River. This strategy is already being implemented on a pilot scale in Fuller Creek. A major temperature monitoring effort involving volunteers and local cooperators is taking place currently in the Eel River Basin through the Humboldt and Mendocino Resource Conservation Districts funded by a State Water Resources Control Board 205 (J) grant. Similar efforts are taking place in the Klamath and Trinity River basins.

Cross Sections: Changes in stream bed profiles associated with increased erosion rates and increased bed-load transport are best measured using cross sections. Gualala Aggregates is currently monitoring cross sections in the lower Gualala River at points of gravel extraction and above and below the Highway **1** bridge. Cross sections could also be used to measure bed elevation changes in highly aggraded tributaries such as the upper South Fork and North Fork Gualala. Over time, as watershed stabilization projects decrease sediment supply, cross sections will show a fall in bed elevation. Cross sections are also ideal for monitoring changes related to riparian restoration in reaches with alluvial terraces. Because collecting cross section data requires significant training, it does not lend itself as well to volunteer monitoring. The activity is also labor intensive because permanent monuments above the level of high water must be constructed.

Fine Sediment in Pools (V*): V* is an ideal tool to measure fine sediment in pools, which is a recognized limiting factor in the Gualala River basin . V* calculates the amount of fine sediment in a pool relative to the volume of fine sediment and water (Hilton and Lisle, 1993). A probe is used to monitor the depth of fine sediment covering the armor layer in pools. The technique is easy, and a trained crew can measure ten pools, which constitute a statistically significant sample, in one day. Volunteers can also help collect V* data (Higgins, 1995). V* should only be used in less steep and confined channel types (Rosgen B2 or C types). In the Gualala River basin, V* results were calculated for Fuller Creek and Grasshopper Creek, a tributary to Buckeye Creek (Knopp, 1992). While the V* value for Fuller Creek was moderate (.37 or approximately 37% of pool volume filled with fines), the results for Grasshopper Creek showed that approximately 59% of pool volume was filled with fine sediment.

McNeil Samples: McNeil samples are used to determine the amount of fines or sand in the stream bed. Too much fine sediment reduces salmonid egg and larvae survival. A bulk sample is extracted from a place likely to be used by spawning salmon or steelhead, such as a riffle crest or pool tail. The sample is usually taken to a laboratory where it is run through a series of sieves. Fine sediment of less than 0.85 mm is most harmful to salmon and steelhead. Acceptable levels for fines are 10% or less. McHenry et al.(1994) found that coho salmon and steelhead embryos did not survive when fine sediment of 0.85 mm or less reached 13% in several Olympic Peninsula (Washington) streams. Gualala Redwoods has some McNeil sample results from tributary basins where they conduct timber harvest. McNeil samples are labor intensive and usually need laboratory analysis that is costly.

Scour Chains: Stream beds with very small average particle size distribution may experience scour and fill during minor storm events (Nawa et al., 1990). Scour chains could be used where shifting bedload is thought to be limiting survival of spawning salmon or steelhead. Use of scour chains is labor intensive but results are easy to interpret.

RAPID: The riparian aerial photographic inventory of disturbance (RAPID) was devised by Grant (1988) to aid in tracking cumulative watershed effects. Historical aerial photos are compared to determine changes in riparian widths. Large debris torrents can bury riparian zones or scour stream-side areas. Initial flood damage may greatly increase stream widths in low gradient stream reaches. These mild gradient reaches were probably key salmon producers prior to disturbance. If sediment yield is diminishing, riparian zones will recover and stream widths should decrease. This technique was recently employed as part of Coastal Forest Lands sustained yield planning efforts (Hagans and Higgins, 1995).

Fish Populations: More information on steelhead population trends is needed to help evaluate the success of restoration efforts. Fisher (1957) conducted creel census surveys that demonstrated catch-per-unit-effort in 1954 and 1955. He suggested that creel census be re-initiated after logging practices were reformed and the watershed allowed to recover. While this type of creel census does not allow an adult population estimate, it does allow comparison of relative abundance over the years. Gualala Steelheaders have carried out some creel census surveys but results were not available for analysis as part of this report. If current Gualala Steelheader methods are not compatible with former survey techniques, they should be changed so that results can be compared over time.

Consistent adult steelhead counts or redd surveys are problematic because these fish often return during periods of high flow when access to streams is difficult and visibility may be limited. However, many streams in the basin do have adjacent roads that would facilitate access for such surveys. In years when conditions are appropriate, volunteers could spot-check index reaches. This could provide some indication of adult steelhead abundance, but reliable population trends could not be determined.

If population trend data is not available, fish community structure could prove a reliable index of habitat suitability. The Gualala River has changed over time from a community structure dominated by salmonids to one dominated by Gualala Roach (see Fish Population section). As the river and its tributaries recover, the community structure should shift back to one dominated by salmonids. Sampling should be done at least once every five years. Halligan (1997) suggested that steelhead might make up a greater portion of the lower Gualala River fish community in wet years than in dry years. Sampling would have to take place more frequently, including both wet and dry years, to determine the influence of water year on fish community structure.

Amphibians as Indicators of Habitat Oualitv: The amphibians and reptiles of the Gualala River basin are not well studied. CDFG stream surveys reports from the 1960's to 1970's noted only that frogs and salamanders were present. Cox (1979) specifically mentioned that the yellow-legged frog (Rana boylii) was present in Fuller Creek. Ambrosius and Pomeroy (1982) found the western pond turtle in the North Fork of Buckeye Creek.

Both yellow-legged frogs and western toads (Bufo boreas) can use edge water pools for spawning and rearing. Studies by Redwood Sciences Lab on the South Fork Trinity River showed yellow-legged frogs thrived in a river channel that had aggradation similar to the Gualala River (Amy Lind, personal communication). Consequently, it is likely that the yellow-legged frog and western toad are surviving in the aggraded conditions of the mainstem Gualala River because side pools are often present.

Bull frogs (Rana catesbiana) were found on the lower South Fork Gualala by Barracco and Boccone (1977). This species is a major predator on native frog species and is a habitat generalist. It is interesting that the Pacific giant salamander (Dicamptodon ensatus) is not mentioned in any of the literature about the basin. Pacific giants are habitat generalists in the aquatic environment, but usually become terrestrial after one year. The use of amphibians as indicator species in the Gualala needs further assessment.

Cumulative Effects of Timber Harvest: The California Department of Forestry (CDF) has been studying the Gualala watershed, particularly the management of unstable lands (McKittrick, 1995). The results of these studies should be shared with the Gualala community as well as any studies related to cumulative effects from other northwestern California watersheds. CDF should also provide all electronic map data that it has acquired for local watershed planning efforts. Klein **(1997),** in comments on the draft of this report, stated that "Some level of basin-wide monitoring by standardized, scientifically-based methods is clearly needed to settle the perennial debate on the efficacy of the Forest Practice Rules as BMP's." Williams **(1997)** noted that THP's are a resource for site specific monitoring information.

Conclusion

The historical photographs of the Gualala watershed indicate that early land use activities were far more destructive than any that occur today. The damage from early logging had largely healed by the 1940's. The new wave of sediment unleashed by post World War II logging is probably still working its way through the lower Gualala River. Some problems related to erosion may persist from current land use activities but additional monitoring is needed to judge the extent. A key to reversing the well recognized sediment problem in the Gualala is understanding sources of sediment and monitoring their long-term abatement.

Sediment routes quickly through upper watershed areas because of the steep stream gradient but moves slowly through lower river areas. Stabilizing hillslopes through decommissioning or upgrading roads will prevent further erosion. Inventories of erosion related to roads have already been conducted in the Fuller Creek basin and resources should be sought immediately to implement recommended measures. Similar erosion control surveys and erosion control projects should be carried out in all other sub-basins. Improving road network not only eliminates the largest source of sediment to streams but maintains access to rural homes and timberland. If possible, roads immediately next to streams should be put to bed or paved. If the latter course is taken, downspouts should be armored. To reduce sediment, it is also likely that land management on highly erodible areas will also have to be modified.

As tributary basins recover, prudent placement of large wood may accelerate recovery, especially where bedrock is evident in stream channel. Eroding bank may be untreatable in some cases but bioengineering should be used to help stabilize banks in appropriate places. Another key restoration activity would be to plant conifers on the terraces of tributaries and the mainstem Gualala River and let them grow to maturity. If the Gualala is to be restored as a coho salmon stream, timber harvest in riparian zones would be delayed until streams are back within their normal range of variability with regard to temperature. Selective removal of large conifers could be re-instituted using methods similar to those employed in Santa Cruz once temperature ranges drop.

The lower Gualala River is over-supplied with sediment and is likely to remain so for at least a decade, even if erosion prevention begins immediately. Gravel extraction in the lower Gualala should continue in order to avoid aggradation of the estuary. Monitoring related to gravel extraction should be used to see if local impacts are acceptable and if local improvements occur. Over the longer term, establishment of a narrower corridor of deciduous trees along the lower Gualala, similar to the lower Garcia River, would be desirable. Adaptive management should be practiced with gravel extraction to see if a strategy can be devised that allows riparian recover while still harvesting gravel. The desired future condition of the lower river riparian zone would be to develop an overstory of large redwood.

The lower Gualala River and estuary are the major summer refuge area for juvenile steelhead. The key tenet of current restoration theory is to protect those areas that are essential for species maintenance until recovery in other watershed areas can be accomplished. Adequate flows of cold water from the North Fork Gualala must be maintained to prevent the estuary and lower river from declining in health.

The recent effort to organize interests within the watershed to begin implementation of restoration is timely. Substantial financial resources are likely to become available in response to recovery efforts for coho salmon and steelhead trout. Partnerships with the Mendocino and Sonoma County Resource Conservation Districts should facilitate funding. Contributions toward restoration efforts by private land owners may be forthcoming in order to comply with both the ESA and TMDL processes. Cooperative efforts such as those underway in Fuller Creek are a model for how cooperative relationships with private landholders can be developed. In order to succeed in restoring fisheries and water quality in the Gualala River, cooperative monitoring efforts are needed. Data from such activities should be shared so that all stakeholders can clearly understand the condition of resources and their trends over time.

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GAUGE# 11467500 SOUTH FORK GUALALA RIVER NEAR ANNAPOLIS, CA LOCATION.-Lat 38‘42’18”, long 123‘25’19”, in German Grant, Sonoma County, Hydrologic Unit 18010109 DESCRIPTION: on left bank 0.5 mi downstream from Wheatfield Fork of GuaIaIa River, and 3.0 mi west of Annapolis. DRAINAGE AREA.-161 mi2. PERIOD OF RECORD.-October 1950 to September 1971, June 1991 to June 1994 (since June 1991, flows below 1,000 ft3/s only) (discontinued) GAGE.-Water-stage recorder. Elevation of gage is 70 ft above sea level, from topographic map. Prior to Aug. 30, 1962, at site 2,100 ft upstream at different datum. Aug. 3 1, 1962, to September 197 1, at site 420 ft upstream at different datum.

REMARKS.—Records poor. No regulation or diversion upstream from station. Beginning June 1991, no records computed above 1,000 ft3/s.

EXTREMES FOR PERIOD OF RECORD (1951-71).-Maximum discharge, 55,000 ft3/s, Dec. 22, 1955, gage height, 24.57 ft, site and datum then in use, from rating extended above 13,000 ft3/s on basis of slope-area measurement of peak flow; minimum, 0.4 ft3/s, Sept. 13, 195 1.

GAUGE# 114675 South Fork Gualala River Near Annapolis, CA. Records available October 1950 to September 197 1, June, 1991 to June, 1994. After June 1991 no records of flows over 1,000 cfs.

GAUGE # 11467500 South Fork Gualala River Near Annapolis, CA. Records available October 1950 to September 1965.

GAUGE#11-4475 South Fork Gualala River Near Annapolis, CA. 227 periodic observations between December 1950 through September 1968, no continuous record. Water temperature from periodic data.

GAUGE # 1167510 South Fork GuaIaIa River Near Sea Ranch. 6/1/91-12/26/91, and 05/20/1992-08/03/1993.

GAUGE# 11467560 China Gulch at GuaIaIa, CA. Peak Discharges from 10/01/1961-09/30/1973.

GAUGE# 11467300 Unnamed tributary to the Wheatfield Fork of the GuaIaIa River Near Annapolis. Peak Flow Data 10/01/1961-09/30/1973 .

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Glossary of Acronyms

BMP: Best Management Practices under the California Forest Practices Rules, pursuant to the U.S. Clean Water Act.

BOR: United States Bureau of Reclamation

CDWR: California Department of Water Resources

CDF: California Department of Forestry and Fire Protection

CDFG: California Department of Fish and Game

CDMG: California Division of Mines and Geology

CSWRCB/SWRCB: California State Water Resources Control Board

CFS: cubic feet per second (the commonly used measure for quantifying water flow)

NCRWQCB: North Coast Regional Water Quality Control Board

NRCS: U.S.D.A. Natural Resource Conservation Service

PWA: Pacific Watershed Associates

RCD: Resource Conservation District

RCLC: Redwood Coast Land Conservancy

TMDL: Total Maximum Daily Load. Refers to limits to pollution pursuant to the U.S. Clean Water Act.

USGS: U.S. Geologic Survey (Dept. of Interior)