Appendix 5: Habitat Trends and Restoration

1986-1997

Substantial habitat change in various Klamath River sub-basins has occurred since the inception of the Klamath River Restoration Program in 1986. The following discussions will focus on limiting factors and their abatement or exacerbation since 1986 and the resultant impacts on stream channels and water quality. Positive changes in some part are owing to in-stream restoration such as structural improvements, bank stabilization or riparian restoration. Several factors have also caused major declines in the quality of aquatic habitat during this period, some man-caused and others due to natural forces, and these are included in discussions below.

Kier Associates staff visited the field, consulted local experts and reviewed literature where it was available to gauge habitat change since 1986. Hundreds of photographs of site conditions were reviewed and acquired from local cooperators such as the USFS, Shasta CRMP, Scott CRMP, Salmon River Restoration Council and CDFG. A substantial number of photos were also taken during field tours of the Scott River, Shasta River, Indian Creek, Elk Creek, Beaver Creek and Dillon Creek. Most photographs were entered into the Klamath Resource Information System database (KRIS DB) and these will become part of the next CD release. Where databases were available to interpret habitat conditions quantitatively, they were also captured and summaries presented as graphs in this report.

Major fires, a prolonged drought and damaging storm events have all occurred since the inception of the Restoration Program. These natural events make it difficult to discern in some cases which negative impacts on fish habitat are natural and which are human caused. Luckily, Klamath National Forest has produced a report that explains the patterns of watershed damage and changes to stream habitat (De La Fuente, 1998). Information from the storm damage report (De La Fuente, 1998) is included in habitat change discussions where relevant. A brief synopsis of the findings of the report follows with summary descriptions of habitat change by Klamath sub-basins. Recommendations for continued actions by the Task Force are included in Chapter 3.

Lower Klamath Basin: Watersheds Downstream of the Trinity River

The primary limiting factor in the Lower Klamath Basin is high sediment yield (Earth Science Associates, 1981; Coates and Miller, 1980). Sediment problems and erosion risk has increased since 1986. Logging on private land, sometimes in combination with fire, has removed up to 90% of the cover from some watersheds. There are signs of improving cooperation between the Yurok Tribe and Simpson Timber Company that increase the prospect of future cooperation in watershed restoration. In addition, protection of Federal lands in upper Blue Creek as part of the Northwest Forest Plan (FEMAT, 1993) insures that the refugia, on which Lower Klamath salmon restoration relies, will be protected. The changes in aquatic habitat in

Lower Klamath tributaries have also lead to a change of salmonid distribution and abundance (see Chapter 2). Below is a review of habitat conditions by tributary sub-basin.

Hunter Creek: Hunter Creek has almost no mature forest in its entire watershed. The combination of wildfire in 1988 and intensive timber harvest over the last two decades has left the watershed in a very unstable condition. Steep upland areas have road networks that were built for logging but which are now poorly maintained (Figure A5-1). Several miles of the lower reaches of Hunter Creek still run underground as a result of severe aggradation (Figure A5-2). Over $100,000 has been spent on habitat improvement structures in Hunter Creek in the reach above where it flows underground. Hopelain (in press) inventoried in-stream structures in 53 northern California streams, including Hunter Creek (see In-Stream Structures in this chapter). Hunter Creek had one of the five lowest scores relative to other streams measured. No photos or data were available from this stream after the January 1997 storm but a post flood reconnaissance was conducted and results of the surveys should be available in the future (John Schwabe, personal communication).

Salt Creek, a tributary to Hunter, runs through a very low gradient reach of marshes and pastures. Sedimentation and eutrophication have combined to block access to anadromous fish in Salt Creek (Dan Gale, personal communication). Some tributaries to upper Salt Creek, such as High Prairie Creek, are in recovery from past flood damage but there is no access to this improving fish habitat for salmon and steelhead. Extensive grazing along lower reaches of Hunter Creek also impairs habitat recovery.

Fewer than 100 fall chinook salmon have returned to Hunter Creek in recent years and half of those were from the small scale rearing program operated on Hunter Creek. There is no baseline information on populations in this stream; however, Hallock (1952) marked thousands of juvenile coho in this stream. It would seem that highly disturbed watershed conditions are confounding recovery in Hunter Creek despite expenditures of the Task Force on both in-stream habitat improvement structures and artificial culture to aid in the recovery of this watershed.

Terwar Creek: This watershed has been disturbed in over 90% of its area since 1978 by green timber sales, fire and salvage logging (Figure A5-3). Coates and Miller (1980) pointed out that harvest of over 30% per decade in Terwar Creek would lead to unacceptably high sediment yield and other cumulative watershed effects. Timber harvest has continued to the present and. CDFG has tried to halt timber sales due to requirements for old growth retention in the California Forest Practice Rules but their non-concurrence was over-ridden and timber harvest continued (Bill Condon, personal communication). Terwar Creek, like Hunter Creek, runs underground as a result of severe aggradation in lower reaches during low flows in late summer. The January 1997 flood transported very large quantities of gravel through lower Terwar Creek, negatively impacting private agricultural land and threatening a community water supply (Mark Meissner, NRCS Eureka).

Figure A5-1. Upper Hunter Creek watershed with deteriorating road networks. October 1990.

Figure A5-2. Hunter Creek running underground in its lower reaches. October 1990.

Figure A5-3. Terwar Creek watershed on private industrial timberlands. October, 1990.

Figure A5-4. Lower Blue Creek inner gorge area with recent clear-cut timber harvests in the riparian zone. October 1990.

While high bed load transport would preclude lower Terwar Creek from being productive salmonid habitat, there is still some functional fish habitat in higher gradient reaches or areas with channel confinement (John Schwabe, personal communication). The flat lower reaches of Terwar Creek were formerly some of the highest quality chinook and coho salmon habitat in the Lower Klamath Basin (Rankel, 1979). It is likely that high sediment contributions will continue to depress fishery productivity in Terwar's lower reaches. Although regeneration in redwood dominated watersheds is usually vigorous because redwoods sprout from stumps, very little of the Terwar and Hunter Creek watersheds are coming back in conifers. If trees fail to establish, it may have long term implications for watershed health and fisheries productivity.

Blue Creek: Lower Blue Creek on private, industrial timber lands has been extensively logged, including in the riparian zone during the course of the Restoration Program (Figure A5-4); consequently, fish habitat has deteriorated since 1986. The channel of lower Blue Creek has widened substantially in response to an over-supply of sediment related to logging activities. USFWS (1993) has expressed concern over gravel quality and stability in lower Blue Creek with regard to survival of fall chinook salmon redds. The West Fork of Blue Creek has been heavily logged and has an extensive road network. Although a complete survey has not been conducted, weirs in the West Fork of Blue Creek were at least partially destroyed by the 1997 storm. Difficulty maintaining in-stream structures would be expected because most of the West Fork is in early seral conditions and there is an extensive un-maintained road network. Logging on private lands in inner gorge areas of lower Blue Creek was continuing during winter 1997.

While private timberlands comprise about 20% of the Blue Creek watershed, the U.S. Forest Service manages the upper 80% of the basin. The Northwest Forest Plan provides protection for most of Blue Creek as a Key Watershed with the exception of the Crescent City Fork that is in Matrix (FEMAT, 1993; ROD, 1994). While some Matrix lands are scheduled for timber management, the Crescent City Fork watershed is part of the National Recreation Area, which makes timber harvest unlikely (Jerry Boberg, personal communication). Upper Blue Creek is the last intact salmonid habitat in the Lower Klamath Basin and is, therefore, of extreme importance as a refugia. The Yurok Tribe has conducted extensive annual surveys of spawning adult fall chinook salmon in Blue Creek and counts show a resurgence in the population since 1994 over previous years, when data was collected by U.S. Fish and Wildlife Service (see Fish Population Trends). The Crescent City Fork of Blue Creek also has one of the highest concentrations of coho salmon juveniles in the Lower Klamath Basin (Voight and Gale, 1998). Habitat quality in upper Blue Creek has remained high.

Pine Creek: The Pine Creek watershed is crossed by two major faults and, therefore, is inherently highly unstable (Hoopa Fisheries Department, 1997a). The watershed is also highly disturbed as a result of timber harvest, road building and past fires. Between 1940 and 1960, 77% of Little Pine Creek was harvested (ESA, 1980). Landslides in the watershed averaged 1 per square mile in 1950 but jumped to 30 per square mile in 1965. While the 1964 flood obviously exacerbated the situation, the watersheds were more vulnerable as a result of land management activities (ESA, 1980). Pine Creek is in mixed ownership; the Hoopa Tribe owns the eastern portion of the basin but the steep, headwall areas of the creek to the west are owned by private forest companies.

Fine sediment measurements taken by the Hoopa Fisheries Department at 16 sites in Pine Creek during 1992 and 1993 showed that fine sediment levels were higher than optimal for salmon and steelhead. Using the FREDLE Index (Lotspeich and Everest, 1979), survival to emergence was calculated as averaging 61.1% for steelhead, 42.8% for coho salmon and 19.3% for chinook salmon (Figure A5-5). Cross sections in Pine Creek showed that the channel tends to migrate, which indicates bedload mobility (Hoopa Fisheries, 1997). The study was initiated after several years of drought and benchmarks for cross sections were not anchored far enough above the active flood plain. Large flows during the winter of 1992-93 destroyed survey markers. Therefore, it was not possible to determine the exact magnitude of changes in bed elevation caused by large storms in that year or subsequent years with high flow. Scour chains are lengths of chain buried in the bed of the stream to determine gravel mobility. They had been installed in Pine Creek and were lost due to a major bedload shift.

The Task Force invested in watershed restoration and erosion control activities in Pine Creek in 1990 and also funded a follow up study to see if sediment transport in the stream decreased. Pacific Watershed Associates (1993), estimated that 120,000 cubic yards (cy) of material from roads and landings could be contributed to Pine Creek if sediment prevention was not implemented. An estimated 10-15% of these sediment sources were treated as a result of erosion control activities funded by the Task Force (Hoopa Fisheries, 1997a). Because other sediment sources remain so high, it is difficult to measure the beneficial effects of these activities (Hoopa Fisheries, 1997a).

The extremely high bedload movement and channel instability in Pine Creek indicate that the watershed remains well above thresholds for cumulative effects. While Task Force investments to decrease sediment have prevented some additional supply, current changes in the channel could have resulted from remobilization of stored materials alone. Active logging also continues in Pine Creek with related disturbances, so other new sources could also have contributed. Habitat conditions within Pine Creek have continued to deteriorate since 1986, despite Task Force investments.

Other Lower Klamath Tributaries: Of the 17 streams sampled for juvenile salmonids by the Yurok Tribe, 14 run under ground in their lower reaches during summer (Voight and Gale, 1998) (Figure A5-6). Major sources of sediment, in the form of abandoned road networks, exist in all these watersheds. It is unlikely that these streams will go into recovery and regain surface flow in the near future unless hillslopes are stabilized and watersheds allowed to rest (Roper et al., 1997). Hopelain (in press) found low success rates for in-stream structures in Tarup Creek, similar to Hunter Creek (see In-Stream Structures). A post 1997 flood inventory for lower Klamath tributaries has been conducted but results were not available at the time this report went to press.

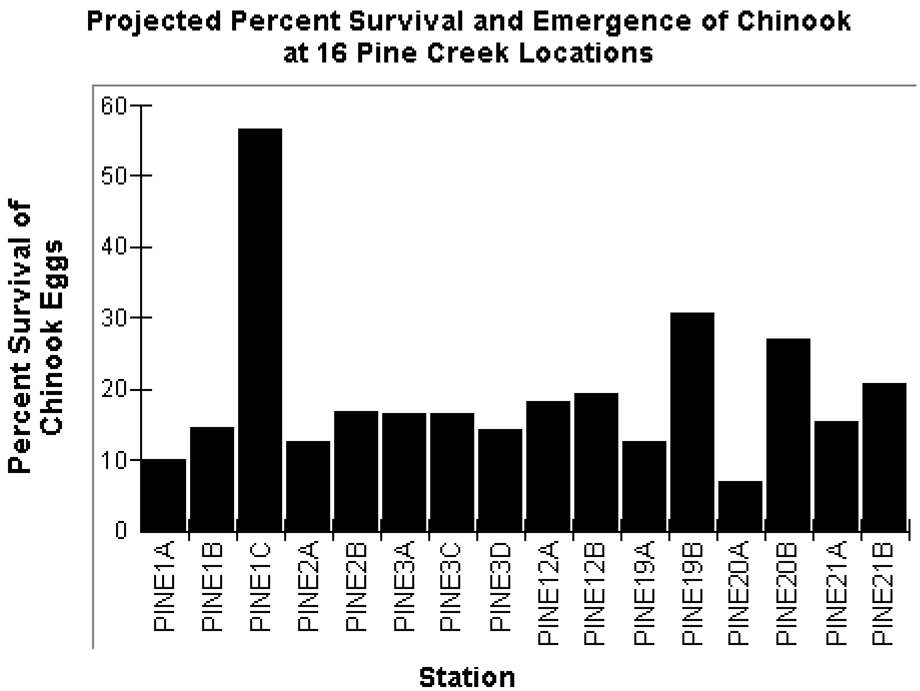

Figure A5-5. FREDLE Index estimate of chinook salmon survival to emergence based on sediment analysis. Hoopa Tribal Fisheries (1997a).

Figure A5-6. Cappell Creek represents a typical Lower Klamath Basin tributary delta. These large sediment deposits cause the streams to go under ground in late summer.

Ah Pah and McGarvey Creek suffered considerable damage from the U.S. Highway 101 by-pass in October, 1989 when construction operations were not erosion proofed prior to the storm. Ah Pah also was damaged by logging in the early 1990's, with clear cutting of old-growth redwoods taking place in the riparian zone (Ronnie Pearce, personal communication). The failure rate of in-stream structures in Ah Pah Creek was much higher than in Hunter Creek in 1997 (John Schwabe, personal communication). Cal Trans has provided funding for mitigation of the water quality infraction that is being applied in part to the McGarvey Creek watershed.

Mc Garvey Creek has been surveyed with Cal Trans funds to estimate potential sediment yield related to roads in the drainage. The Yurok Tribe has acquired funding from the U.S. Fish and Wildlife Service Jobs in the Woods program and sediment reduction activities will take place in that watershed during the summer of 1998. The projects will take place on Simpson Timber Company lands with their permission. McGarvey Creek still has coho, chinook, steelhead and cutthroat trout.

Middle Klamath Tributaries (Trinity to Iron Gate Dam)

The Middle Klamath Basin in this report is comprised of all tributaries between the Trinity River and Iron Gate Dam, excluding larger basins such as the Salmon, Shasta and Scott Rivers. Habitat changed dramatically in some Middle Klamath tributaries during the January 1997 storm. The Klamath National Forest 1997 Flood Damage Report (De La Fuente, 1998) indicates that a substantial amount of sediment was contributed by road failures and from landslides within areas that were recently clear cut (see Storm Damage). While discussions of the flood damage report follow the habitat trends section, results from the study are included in sub-basin discussions below.

Bluff, Camp and Red Cap Creeks: All three of these Six River National Forest streams have been classified as Key Watersheds under the Northwest Forest Plan (FEMAT, 1993). Timber harvest was limited in these watersheds over the past ten years and all three watersheds are in advanced recovery from the 1964 flood. Structures in all three streams were surveyed in 1997 and failure rates in Bluff Creek and Camp Creek were below 10% (Jerry Boberg, personal communication)(Figure A5-7). While structures in Red Cap Creek had a very low failure rate, many structures were isolated when the channel meandered and left structures out of the active channel (Figure A5-8). Red Cap Creek may have experienced a slightly greater impact from a rain-on-snow event as its upper watershed is at higher elevations.

Dillon Creek: While Dillon Creek experienced extensive burns in 1994 and 1996 (Figure A5-9), it still produces some of the highest quality water in the Klamath Basin. Large areas of the Dillon Creek watershed were proposed for salvage logging in 1996 but community pressure forced the USFS to confine activity to the perimeter of the watershed. Sediment yield may still increase 30 years after a fire, as root strength of burned trees is lost. No landslides occurred as a result of the 1997 storm but there were 14 road failures (De La Fuente, 1998).

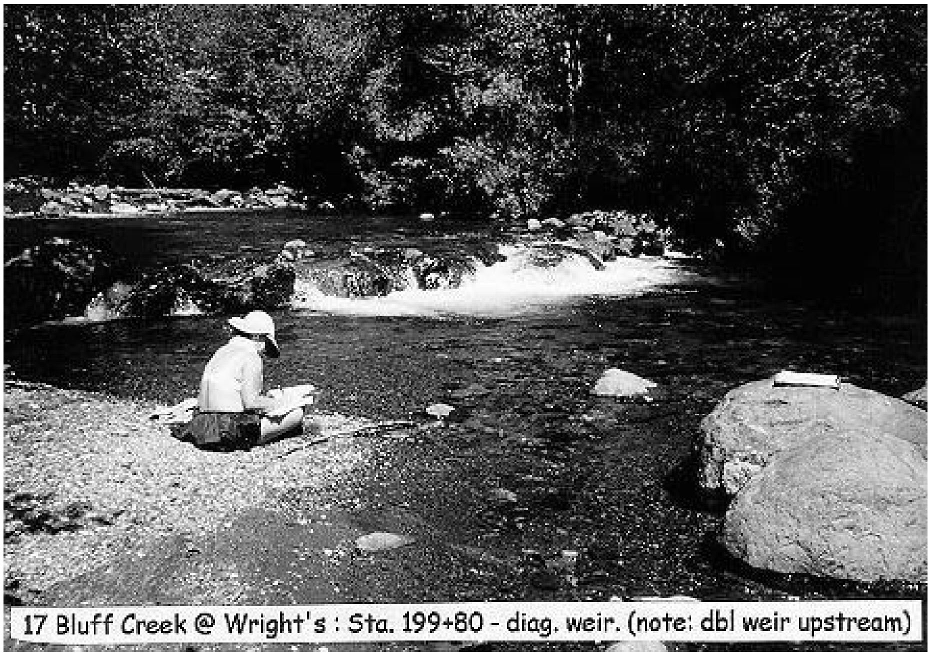

Figure A5-7. Boulder weir on Bluff Creek in September 1997. Photo courtesy of Six Rivers National Forest.

Figure A5-8. Camp Creek boulder weir with large wood above delivered by the January 1997 storm. Photo courtesy of Six Rivers National Forest.

Ukonom Creek: This Marble Mountain tributary has less than a mile of anadromous fish habitat, but is an important cold water source for the Klamath River. The entire length of the Ukonom Creek channel changed in response to the 1997 flood (De La Fuente, 1998). The large extent of the area burned in 1987 may have increased susceptibility of this watershed to the rain-on-snow event. The Ukonom watershed experienced 21 major landslides as the result of the storm but only 7 road related failures. A large delta formed at the mouth of Ukonom Creek after the January 1997 storm (Figure A5-10) and it is likely that fine sediment will increase for a few years. Most of Ukonom Creek is deeply incised and, therefore, it is unlikely that major temperature changes will occur in response to the 1997 storm event.

Independence Creek: The Klamath National Forest increased access to Independence Creek by altering the delta at its convergence with the Klamath River in 1986. While access to the creek remains open, salmonid habitat quality in Independence Creek has deteriorated. Headwater tributaries arise at high elevation (4,000-6,000 feet) and the upper watershed was extensively burned during 1987 and subsequently salvage-logged. The January 1997 storm left a delta at the mouth of the Klamath approximately 10 feet high (Figure A5-11). De La Fuente (1998) noted that the upper two-thirds of the Independence Creek channel was re-configured by the 1997 storm which triggered numerous natural debris torrents in the Marble Mountain Wilderness. Multiple stream crossing failures also occurred in the watershed and contributed to sediment problems in the lower reaches of the stream.

Clear Creek: This large Siskiyou Mountain tributary is a fairly intact watershed, although it was extensively burned in the 1987 Fires. Water quality has remained high and lower Clear Creek is an important cold water refugia. It is also designated as a Key Watershed under the Northwest Forest Plan (FEMAT, 1993), except for some of the lower drainage which is classified as Matrix. Clear Creek suffered only six landslides and eight road failures during the January 1997 flood and habitat remains in excellent condition over-all.

Elk Creek: This Key Watershed was extensively burned in 1987 and subsequently salvage logged. Elk Creek has coho salmon, winter and summer steelhead, fall chinook and occasional spring chinook. The U.S. Forest Service, with some funding from the Klamath Task Force and other sources, had installed a number of in-stream structures of many types in Elk Creek (Olsen and West, 1990). The January 1,1997 storm initiated debris torrents at the headwaters of Elk Creek and major channel changes occurred in treated reaches. De La Fuente (1998) showed over 80% of the channel of Elk Creek was scoured by debris torrents or otherwise altered by the flood. Significant quantities of big wood were entrained by floodwaters (Figure A5-12) and major bed aggradation also occurred. Consequently, the failure or impairment rate of structures was high (see In-Stream Structures). While 53 landslides occurred, over 70 road failures contributed substantially to natural watershed damage. Some tributaries from undisturbed watersheds like Granite Creek also had debris torrents (De La Fuente, 1998). Debris slides in these areas contribute large trees which subsequently add to habitat complexity in lower Elk Creek.

Figure A5-9. Dillon Creek watershed after fires in 1994 and 1996. Notice that areas near ridges burned hotter while green timber was retained in moister draws. October 1996.

Figure A5-10. Delta at the mouth of Ukonom Creek in February 1997. Note substantial flood depositions from the January storm event.

A high amount of fine sediment remained in the active channel when field visits occurred in late September 1997 (Figure A5-13). The California Department of Fish and Game measured gravel quality in Elk Creek during the summer of 1997 and found fine sediment levels less than 1 mm at 19.6% and sand size particles (<6.3 mm) at 35.2% (Jong, 1997). CDFG concluded that fine sediment levels in Elk Creek were likely to impede salmonid production. USFS temperature monitoring showed that Elk Creek had increased substantially from past years when it was almost always below 68^0 F, the threshold for stress for salmonids. Although the data is not yet available, the USFS characterized Elk Creek as having a serious water temperature problem in 1997 (De La Fuente, 1998).

Indian Creek: This stream was showing improvement until the 1997 storm, although the eastern portion of the basin had burned in 1987. Indian Creek had major shifts in bedload as a result of the January 1997 but damage was not nearly as severe as Elk Creek. Field inspections during September 1997 of Indian Creek showed that failure rates for in-stream structures were variable (see In-stream Structures section in this Chapter). Bed elevation increased by 4-6 feet (Ken Baldwin, personal communication) at some locations, and some boulder structures remained intact but were buried in place. Jong (1997) also found high levels of fine sediment in Indian Creek (<1 mm = 19.9% and <6.3 mm = 36.9%) and noted that salmon and steelhead egg survival were likely to be negatively impacted.

De La Fuente (1998) showed that there were 70 road failures in Indian Creek but only 15 non-road related slides. The most extensive channel changes were in the South Fork and upper mainstem reaches where road failures occurred. De La Fuente (1998) estimated that the storm recurrence interval at only 16 years. The substantial damage incurred in this moderate storm event is indicative of poor watershed health. The Indian Creek watershed has a large amount of its area in the high Siskiyou and is, therefore, inherently susceptible to rain-on-snow events. Potential problems with rain-on-snow induced flood events may continue to recur unless the watershed is rested and is allowed to attain a greater component of mature trees, particularly at high elevations. The USFS has extensive timber harvests planned for this watershed despite its poor watershed health

Transitory water quality problems may still be occurring in Indian Creek below the old Gray Eagle Mine. Although the entire bed of Indian Creek was turned over during the January 1997 storm, the embedded cobble on the stream bottom was dyed orange in reaches below the mine during summer 1997. Leachate from the mine tailings appears to be causing the discoloration of the rocks in Indian Creek and there may be high levels of metals associated for short periods. Dive observations in areas with discolored rocks found two age classes of steelhead, suckers and sculpin; therefore, no year round problem from this pollution was evident. Work has been done recently by the U.S. EPA and the Karuk Tribe to cap the Grey Eagle Mine tailings (Leaf Hillman, personal communication).

The U.S. Forest Service has done extensive planting in the riparian zone of Indian Creek, with a special emphasis on coniferous trees to create a secondary over-story in the future (Figure A5-14). Planting projects were in evidence throughout the lower nine miles of

Figure A5-11. The delta at the mouth of Independence Creek in February 1997 was several hundred feet wide. Sediment in alders at center left of photo is about ten feet deep.

Figure A5-12. Large wood deposit in Elk Creek after January 1997 storm. USFS biologist Bill Beamis can be seen at the bottom center of the photo. September 1997.

Indian Creek and will help advance Indian Creek's recovery over the next several decades. No flood damage to riparian plantings resulted from the 1997 storm.

Beaver Creek: This streams flows from the Siskiyou Mountains just west of Mt. Ashland. The Beaver Creek watershed suffered extensive damage in the 1955 Haystack Fire from which it has not fully recovered. Much of the burned area did not come back in conifers. A major debris torrent in decomposed granitic terrain occurred in a tributary of Beaver Creek (Grouse Cr.) during a summer thunderstorm in 1989 (Kier Associates, 1991). The USFS has acknowledged that Beaver Creek had "stream channel embeddedness greatly in excess of the accepted level for anadromous fish for survival" (Ford, 1992).

The USFS discontinued timber harvest in Beaver Creek in the late 1980's in recognition of cumulative effects problems and began an aggressive program of stream and upland rehabilitation. Subsequently in-stream structures were funded through the California Wildlife Conservation Board with extensive placement of boulder weirs in the lowest two miles of Beaver Creek. Reaches above the West Fork had dozens of boulder clusters and wood structures including digger logs, cover logs and weirs. Upland restoration was funded by the USFWS (Ecosystem Restoration Office) but there was a substantial cost share from Fruit Growers Supply Company, a large private timberland holder in Beaver Creek.

Photos of Beaver Creek in 1994 show the willows closely encroaching on the stream channel as a result of several years of consecutive drought (Figure A5-15). The January 1997 storm did not transport sufficient bedload to kill the alder and willow in the riparian zone of Beaver Creek. While the riparian zone widened somewhat, only moderate increases in stream temperature are likely to have resulted from the 1997 storm. The mobilization of the stream bed disrupted all but two of many boulder weirs in lowest two miles of Beaver Creek (Figure A5-16) and resulted in a loss of habitat complexity in this reach. Shallow riffles and runs habitats predominated after the storm. The upper reaches of Beaver Creek, above the West Fork, faired better with regard to retention of in-stream structures which reflects less channel scour (see In-Stream Structures).

The extensive areas in early seral stage, high elevations at the headwaters, erodible soil types and a road network of over 450 miles make Beaver Creek a high risk for cumulative watershed effects. There were 64 road-related failures in the watershed and only 28 landslides away from roads in January 1997. Road failures at higher elevations were a substantial contributor to channel scour in some tributaries. Approximately one third of the Beaver Creek channel changed as a result of the 1997 storm. Timber harvest on private land has accelerated in the Beaver Creek watershed and the USFS is also planning a timber sale in the watershed in the near future.

Horse Creek: This creek flows out of the Siskiyou Mountains and joins the Klamath from the north. This watershed had been identified as being over cumulative effects thresholds by the USFS (Larsen, 1976) with regard to a rain-on-snow event. Larsen (1976) suggested that increased risk of peak flows warranted a cessation of timber harvest for 11 years.

Figure A5-13. Partially buried boulder cluster on Elk Creek, September 1997. Note the lighter colored fine sediment in the active channel behind boulders.

Figure A5-14. Indian Creek flood plain with conifers planted by the U.S. Forest Service to help restore riparian over-story. September 1997.

Figure A5-15. Boulder weirs in lower Beaver Creek in fall 1994. Notice encroaching riparian. Photo courtesy Klamath National Forest.

Figure A5-16. Lower Beaver Creek in July 1997 after high flows earlier in the year had washed out boulder weirs.

Fires burned part of the watershed in 1987 and significant salvage logging followed (Fox, 1992). Fox also noted that the watershed has an extremely high number of roads and that geology in the basin was inherently unstable with both decomposed granitic and schist formations.

Horse Creek did not receive the same level of "habitat improvement" from the USFS as Beaver Creek and there were few structures installed in the drainage (Alan Tanner, personal communication). However, the Oak Knoll Ranger District did contract with USFWS (Klamath Task Force) to build a cattle exclusion fence and a fish passage at a diversion dam on a private land in-holding on lower Horse Creek. This project was specifically referenced in the Long Range Plan (Kier Assoc., 1991) and construction was completed during the summer of 1996. Unfortunately, the January 1997 flood removed over 300' of the 600' of culvert installed as part of the diversion and the entire concrete apron that anchored the project disappeared. Large portions of the riparian forest in lower Horse Creek were removed by the 1997 high water so some increase in stream temperature is expected.

Only eight landslides apart from road failures were identified by Klamath National Forest staff (De La Fuente, 1998) after the January 1997 storm in this basin but approximately 20 road failures occurred. Approximately 30% of the channel of Horse Creek was altered by the storm, with the most severe damage occurring in the lowest reaches. Such heavy flood damage in a moderate storm event is a result of human caused watershed disturbance. The large amount of this watershed in early seral conditions continues to pose significant risk of cumulative effects. Extensive road networks exist in upper Horse Creek and timber harvest is still being actively pursued by private timber companies in the basin.

Grider Creek: This stream suffered major damage from the 1997 storm event and yet it retains a substantial component of old growth trees. Extensive areas of the Grider Creek watershed burned in 1987, which may have increased susceptibility to erosion. In addition, numerous road failures occurred in the Rancheria Creek sub-basin which had been logged. The rain-on-snow event in January 1997 triggered over 63 landslides but only 15 road failures. The lowest reaches of Grider Creek widened substantially and water temperatures increased. A small number of in-stream structures in lower Grider Creek were destroyed by the storm as were two diversion screens (Ron Dotson, personal communication). The riparian vegetation along lower Grider Creek should recover within five to ten years, depending on the frequency of high scouring flows. The mouth of Grider Creek formerly produced one of the most important large, cold water refuge areas on the mainstem Klamath (Belchik, 1997), but the storm raised temperatures and reduced the benefit of this area as a refugia substantially. Mostly natural forces caused the downturn in habitat quality in Grider Creek.

Walker Creek: This tributary suffered the worst flood damage of any stream on the Klamath National Forest and its stream channel was scoured from its headwaters to the mouth. The Walker Creek drainage likely had extremely high rainfall intensity, similar to Grider Creek, but it also had a much more extensive road network. Over 45 road failures combined with 60 other active landslides in this relatively small watershed. Walker Creek also had extensive areas of its watershed burned in the 1987 fires. One reach of Walker Creek went from approximately 50 feet wide to over 200 feet wide (Figure A5-17). It will be decades before this tributary recovers. It had provided a medium sized refuge area of cold water at its convergence with the Klamath according to Belchik (1997), but stream temperatures are likely to have risen substantially as a result of flood damage.

Cottonwood Creek: Fisheries resources of this Klamath River tributary remain substantially impaired. This creek has been heavily impacted by a number of sources. The Cottonwood Creek watershed includes a substantial amount of decomposed granitic terrain that can contribute fine sediment to the stream. A major impoundment and irrigation cause the stream to go dry in some reaches during summer. Spawning gravel supplies were also depleted during the construction of Interstate Highway 5. Although boulder structures installed on lower Cottonwood Creek have withstood recent flood events, but they have failed to improve spawning habitat because there is no gravel supply.

Bogus Creek: Stream temperatures at most locations in Bogus Creek remain below stressful to salmonids. However, recent McNeil samples taken by Jong (1997) found fine sediment levels higher than optimal for survival of eggs and alevins. The fine sediment level at a station 0.3 km above the convergence with the Klamath was 19.2% less than 1.0 mm and 36% less than 6.3 mm (sand sized). Optimal salmonid habitat has less than 14% fines less than 0.85 mm and less than 30% 6.3 mm (EPA, 1998). The samples in this reach may not be representative of the whole of Bogus Creek as it is the lowest in gradient. Sources of fines might be minor areas of bank erosion. Bogus Creek is also largely spring fed and extremely high flows that would mobilize fine sediment are less common than in watersheds with higher rainfall. Bogus Creek has retained habitat quality since the Klamath Restoration Program's inception and all structures within the creek remain intact. Fall chinook salmon counts in Bogus Creek are some of the highest in the Klamath River Basin (A5-18).

Salmon River

The Salmon River remains one of the healthiest of Klamath River sub-basins but recent fires, extensive road networks and disturbance related to logging have greatly elevated potential sediment yield should a large storm occur (De La Fuente and Hassig, 1994). While fine sediment delivery may have increased somewhat related to the 1987 fires, habitat quality has not decreased substantially over the last decade.

The 1987 fires that burned over 100,000 acres of the Salmon River watershed (A5-19), including sub-basins with decomposed granitic soils (De La Fuente and Haessig, 1994). A substantial area burned by the 1977 Hog Fire re-burned in 1987 and extensive salvage logging took place after both fires. Table 1 shows the number of acres burned in 1977 and 1987 by intensity class. Some Salmon River tributaries that had high intensity burns and decomposed granitic soils, such as Crapo, Olsen and Kanaka Creeks, began to yield

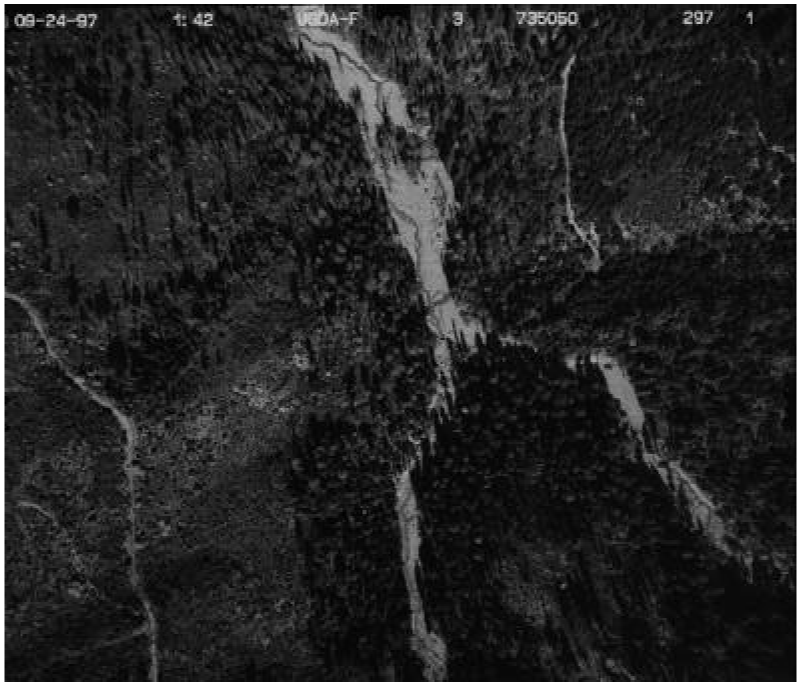

Figure A5-17. Mid-reach of Walker Creek where convergent debris torrents caused the channel to widen to 200 feet during the January 1997 storm. Photo courtesy of Klamath National Forest and Redwood Sciences Lab, Arcata.

A5-18. California Department of Fish and Game staff have help from Siskiyou County high school students in conducting salmon counts annually in Bogus Creek.

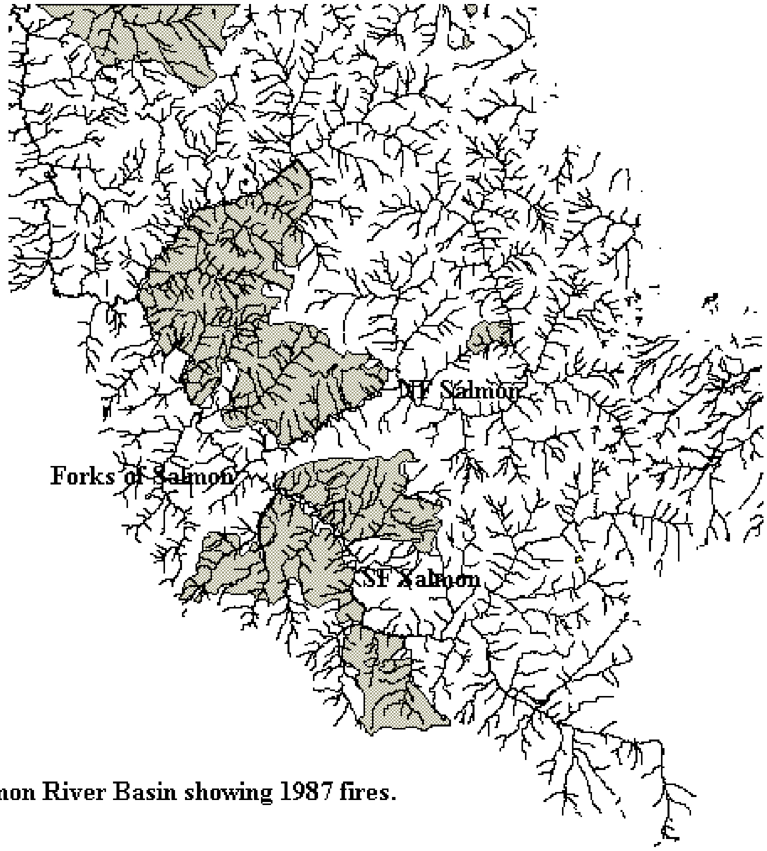

Figure A5-19 Salmon River Basin showing 1987 fires.

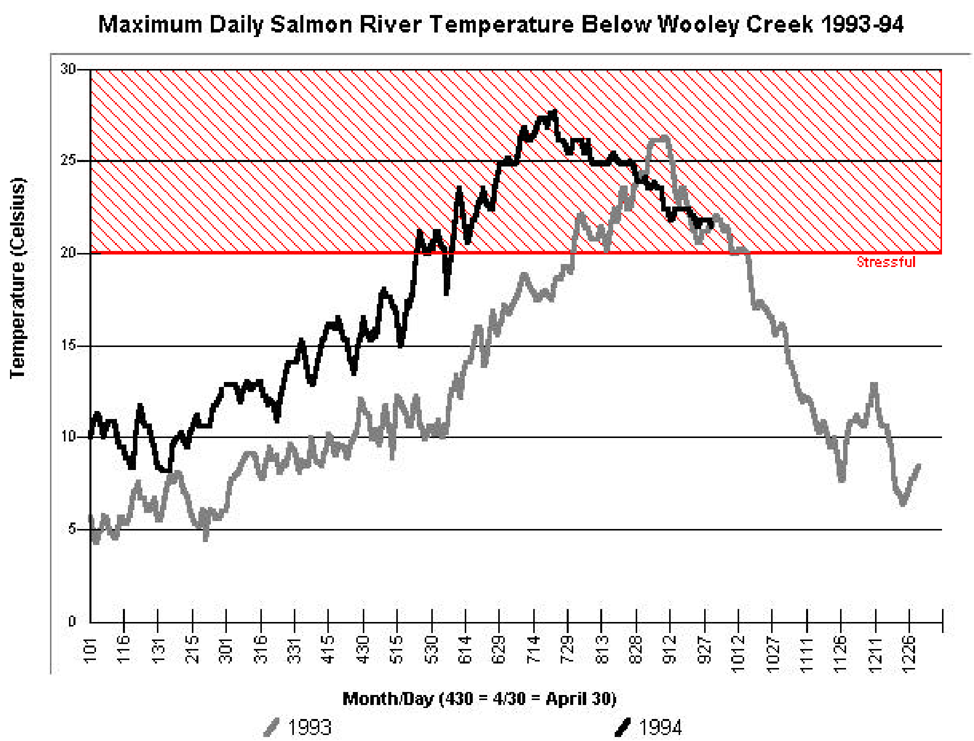

Figure A5-20. Salmon River maximum daily temperatures below Wooley Creek were cooler in 1993 than 1994.

high amounts immediately after the 1987 fires (Figure A5-21). An estimated 105,100 cubic yards of sediment entered the Salmon River immediately following the 1987 fires as a result of surface erosion, increasing from 15,800 cubic yards prior to the fire (De La Fuente and Haessig, 1994). Lisle (personal communication) noted high amounts of sand in main channel reaches in years following the fire, but flushing flows in 1992-93 reduced storage in these areas. Because rainfall was extremely low until 1992-93, much less surface erosion occurred than if intense rain had followed the 1987 fires more closely.

Fire	High	Moderate	Low	Total
1977 Hog Fire	14,106	30,341	13,042	57,489
1987 Fire	16,654	21,510	64,205	102,369

Table 1. Acres burned in the Salmon River basin in 1977 and 1987 by intensity class.

The extremely steep terrain of the upper South Fork in the Trinity Alps Wilderness has yielded high sediment levels even in moderate rainfall years. Robbie Van De Water (personal communication) found that fine sediment in pools increased substantially in the South Fork in 1992-93 and that sediment was contributed from undisturbed areas in the upper watershed.

Some slides and erosion triggered by the 1997 storms may have been delayed response from areas disturbed by the 1987 fires (Robbie Van De Water, personal communication). Slides in occurred in Hotelling Gulch and filled sediment basins that had been constructed immediately after the fire. Slides in the Methodist Creek sub-basin were also thought to be attributable to disturbances caused by the 1987 fires. Specimen Gulch on the Little North Fork Salmon River burned in 1994. U.S. Forest Service studies indicated that some aggradation did take place in the lowest reaches of the creek in 1995 (Robbie Van De Water, personal communication).

The Salmon River is potentially limited by high sediment yield and water temperatures, although the mainstem Salmon may have been naturally warm because of its orientation to the summer sun (USFS, 1997). Water temperatures stressful to salmonids occur in the lower Salmon River annually, but the extent and duration may change in different flow years (Figure A5-20). The North Fork and South Fork may also rise above stressful for salmonids.

Restoration Projects: The January 1997 storm was a 37-year recurrence interval event in the Salmon River (De La Fuente, 1998), which was larger magnitude than in some other Klamath basins that experienced greater damage. The South Fork experienced extremely high flows and did cause some restoration projects to fail. The Salmon River Restoration Council had assisted the USFS with a riparian restoration project on a high bar at Petersburg on the South Fork Salmon River. Seedlings and cuttings were surviving well with shade cards and irrigation leading to high survival; however, the high flows of January 1997 washed out the project. The long-term objective of reclaiming areas

Figure A5-21. Olsen Creek in the Salmon River Basin with decomposed granitic sand in channel after the 1987 fires and moderate rainfall. Photo courtesy Andy Collonna.

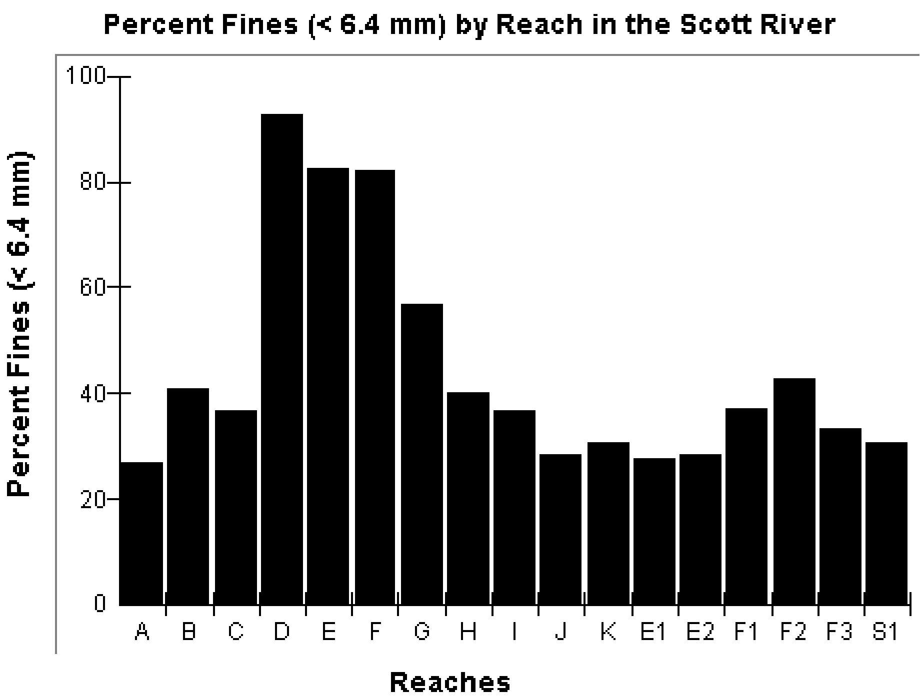

Figure A5-22. Scott River fine sediment less than 6.4 mm (sand size particles) for the mainstem Scott River reaches (A-K), Etna Creek (E1-E2), French Creek (F1-F3) and Sugar Creek (S1) from 1990. Results from Sommersrom (1990).

disturbed by hydraulic mining is still valid, but future projects may need to be further from the active channel (Petey Brucker, personal communication).

A large slide along the South Fork at Big Flat in erodible glacial till soils had been stabilized using local cottonwood cuttings. Approximately 5000 feet of stream bank had been treated but the high water in 1997 resulted in remobilization of part of this slide. Boulder weirs near Petersburg that had been extensively used by spring chinook salmon (Kier Associates, 1991) were disrupted by the flood but large woody structures near the margin of the stream were maintained (Orion Dix, personal communication). The East Fork South Fork in the same area did not experience channel change or substantial structure loss.

In order to improve riparian shade, the USFS and Salmon River Restoration Council (SRRC) planted extensive areas in burned tributaries such as Crapo, Negro, Indian Creek and Specimen Creek. Tree planting in Negro Creek was also used to stabilize numerous, small, active landslides. Rooted cuttings or small nursery starts did not survive well in Salmon River locations but buried willow starts and large cottonwood cuttings did much better. SRRC also helped stabilize mine tailings adjacent to Black Bear Creek. The SRRC has also won several Jobs in the Woods grants from USFWS to restore landscape health and to reduce fire risk in riparian zones through fuels management projects.

The Salmon River Ranger District, in cooperation with the Karuk Tribe, is currently moving to decommission the Steinacher Road in the Wooley Creek drainage. Strategic planning is also underway by the USFS to determine which roads in the upper South Fork basin are essential and which could be decommissioned (Robbie Van De Water, personal communication). Sections of the Steinacher Road decommissioned before the 1997 storm yielded little sediment to Steinacher and Wooley Creeks (De La Fuente, 1998).

The Salmon River Restoration Council (SRRC) works cooperatively with the USFS to keep road networks open, particularly those leading to private in-holdings. SRRC members and community volunteers cruise roads during storms to unplug culverts and stop storm damage before it starts. SRRC has also organized volunteer efforts to clean culverts and decrease flooding on Godfrey Road which was formerly one of the most problematic for the USFS to maintain. Low road failure rates in some portions of the Salmon River basin may have been in part owing to the active partnership between the USFS and SRRC (Petey Brucker, personal communication).

Potential for Cumulative Effects Remains High: Although the Salmon River has remained relatively intact despite some increased rainfall in 1995 and 1997, erosion risk is greatly elevated. The Salmon Sub-Basin Sediment Analysis (De La Fuente and Haessig, 1994) characterized current erosion potential as follows:

> "The large landslide producing events of the 1960's and 1970's occurred when the Salmon River watershed had less than 3% of its area disturbed by roads, harvest or recent fires. In 1989, about 18% of the watershed was in disturbed condition, due in large part to the 1977 and 1987 fires.Roaded lands were

> found to produce landslides at a rate 100 times greater sediment undisturbed land, and harvested lands produced landslides at a rate about five times greater than undisturbed land. This study estimated that if a climatic sequence such as that of 1965-1975 (excluding the 1964 flood) were to occur when the watershed were completely undisturbed (no roads, harvest or recent fire), 1.33 million cubic yards of sediment would be delivered to the river system. If the same disturbance conditions which existed in 1989, it is estimated that 2.68 million cubic yards of would be delivered."

A major storm event in the Salmon River basin, with current watershed conditions, could result in extensive scour of channels and resultant degradation of fish habitat. Despite the promising steps taken to reduce erosion, a great deal more resources are needed to accomplish sediment prevention in the Salmon River basin in a prudent time frame in order to avoid potential catastrophic sediment yield.

Scott River

While some habitat improvements have occurred in the Scott River basin since the inception of the Klamath River Fishery Restoration Program, some set backs have also taken place. Progress is being made on remediation of problems related to agricultural activities in the Scott with cattle exclusion fences, riparian re-vegetation, bank stabilization and innovative stock water systems. However, the anadromous fish production of the Scott River continues to be impaired by high sediment levels and high water temperature, which is partially related to flow depletion. There are some signs of sediment abatement through cooperative efforts in the French Creek drainage. However, sediment yield from some lower Scott River tributaries increased as a result of the 1997 flood and many reaches of the East Fork Scott, Moffett Creek and Shackleford Creek also suffered flood damage.

Sediment/Erosion Control: The Task Force funded report by Dr. Sari Sommerstrom (1990) measured fine sediment at many different locations on the mainstem Scott River and also on some tributaries. McNeil samples of fine sediment in the mainstem Scott showed sand size particles (<6.3 mm) to comprise more than 90% of the bed at some locations (Figure A5-22). Optimal levels of fine sediment of this size would be less than 20%. Sommerstrom (1990) noted that the principle source of fines was watersheds with granitic terrain and more specifically from road surfaces, road cuts and road fills.

Following the sediment study, a French Creek Watershed Advisory Group was formed to help coordinate activities in this a highly erodible Scott River sub-basin. The U.S. Forest Service, private timber landowners, ranchers, the County of Siskiyou and the Scott Valley CRMP all contributed to erosion control projects in French Creek (Figure A5-23). Studies to determine fine sediment in pools (V*) were conducted by the U.S. Forest Service in French Creek to determine the progress of restoration. The volume of fine sediment in pools decreased from approximately 30% in 1992 to nearer 10% in the following three years (Figure A5-24). It is possible that erosion control efforts in the French Creek watershed have contributed to the decrease in fine sediment. However, further work is needed with regard to sediment stored on terraces in French Creek before there is definitive proof that the net sediment yield from the basin is decreasing.

Figure A5-23. Road in French Creek drainage that has been rocked to prevent sheet erosion. Photo courtesy Scott CRMP.

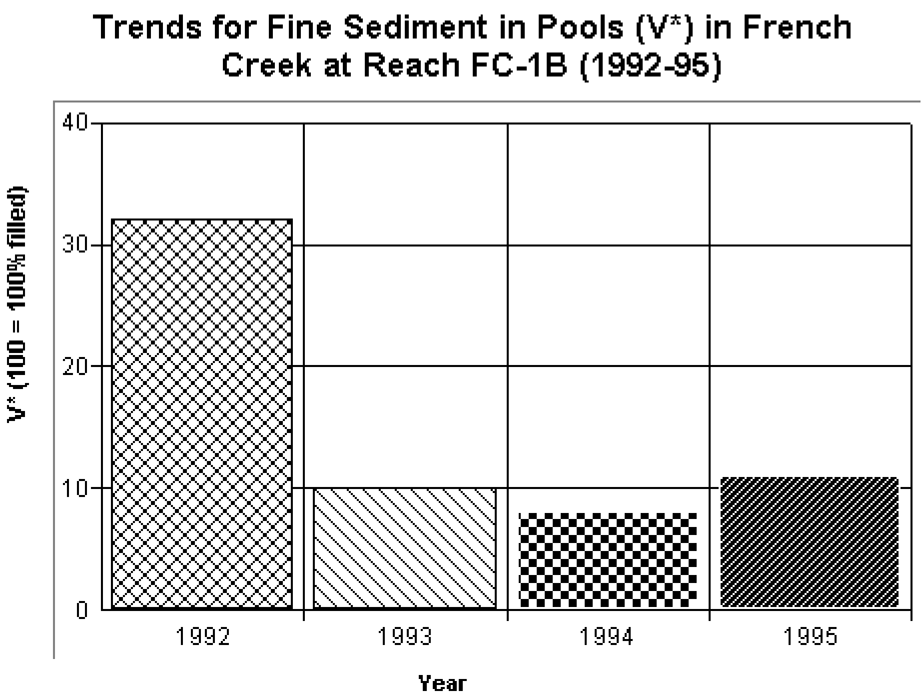

Figure A5-24. V Star results for French Creek from 1992 to 1995. The decrease in fine sediment happened at the same time as erosion control work was being implemented. Data supplied by Klamath National Forest and Redwood Sciences Lab, Arcata.

The Scott CRMP and RCD have made several attempts to fund follow up Mc Neil sampling surveys in the mainstem Scott to see if fines are also decreasing, but proposals have not been successful. The 1997 high water seemed to shift a great deal of fine sediment to reaches of the Scott River just above its convergence with the Klamath. These reaches are often the most important for spawning, particularly in drought years. However, the flows in fall of 1997 allowed fish access to reaches further upstream that had lower levels of fine sediment.

Sediment yield increased in lower Scott River tributaries on USFS lands as a result of the January 1997 storm event. Tributaries from the Marble Mountains that help provide cool water for the lower Scott River during summer include Canyon, Kelsey, Deep, Middle and Tompkins Creeks. Although Canyon Creek had 11 landslides and 19 road failures, it sustained only minor flood damage and less than 20% of its channel length experienced scour. Kelsey Creek had 17 landslides and 11 road related failures but experienced scour in 70% of its length. The channel of Kelsey Creek aggraded substantially as a result of the flood and lateral scour undermined a streamside home. Lower Kelsey Creek also was re-routed around the Kelsey Creek spawning channel (Figure A5-25). This channel was created by the USFS to enhance spawning areas for coho and chinook salmon which had difficulty accessing Kelsey Creek because of its steep gradient. It had had some spawning activity from chinook and coho salmon but in more recent years had been used predominantly by spawning steelhead (Sue Mauer, personal communication). The sediment from Kelsey Creek filled in a hole at its convergence with the Scott River, greatly decreasing the volume of a pool that typically has provided a refuge for thousands of juvenile salmonids.

Tompkins Creek, a tributary of the lower Scott River, also experienced scour in 90% of its channels and suffered 56 landslides and 34 road related failures. This tributary was second only to Walker Creek with regard to damage suffered by streams on Klamath National Forest as a result of the January 1997 flood. Deep Creek and Middle Creek were also scoured in almost their entire length and both experienced both natural landslides and road related failures. Many of the landslides in lower Scott River tributaries initiated on areas that had been recently harvested (see Storm Damage section in this Chapter).

The U.S. Forest Service acquired $27 million to repair flood damage to roads and other infrastructure by the 1997 storms. The most intensive area of activity for road repair in 1997 was in the Canyon Creek and Kelsey Creek watersheds. The Klamath National Forest improved drainage structures and stream crossings in these watersheds so that future flood damage is much less likely (see Storm Damage). Anywhere that recurrence of a debris torrent was likely, the USFS installed cement crossings (Figure A5-26).

Moffett Creek has been noted to have major erosion problems in recent years (Figure A5-27). Even during moderate flows, Moffett Creek has such high turbidity levels that it discolors the Scott River down to its convergence with the Klamath. This stream as well as the East Fork Scott and Schackleford Creek experienced bank erosion during the January 1997.

Figure A5-25. Kelsey Creek spawning channel de-watered by flood effects. Photo taken July 1997.

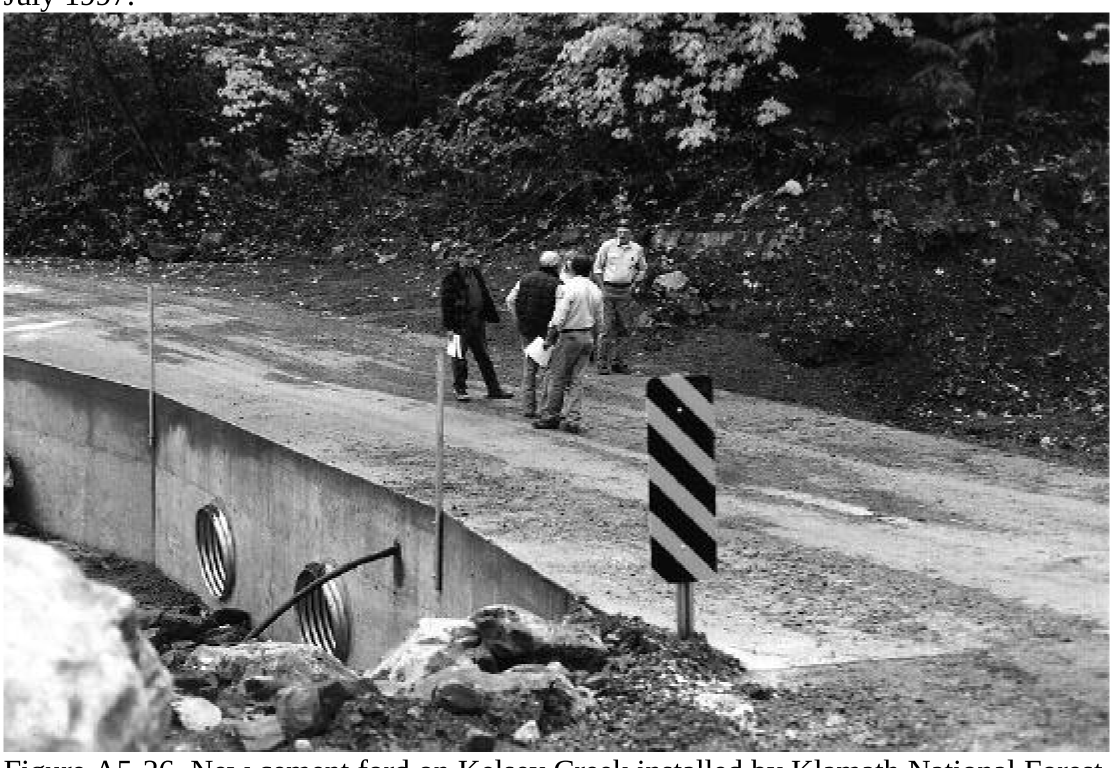

Figure A5-26. New cement ford on Kelsey Creek installed by Klamath National Forest with flood relief money. This approach should reduce long term maintenance and prevent sediment input into Kelsey Creek. October 1997.

Figure A5-27. Moffett Creek channel during summer 1997. Riparian vegetation in Moffett Creek has decreased, most likely as a result of a drop in the water table.

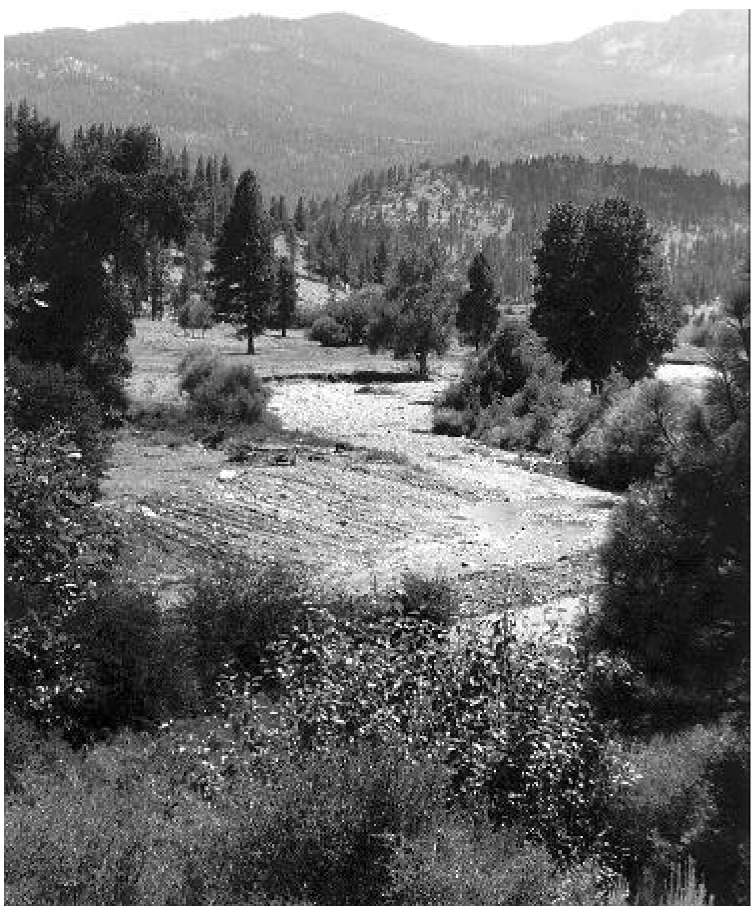

Figure A5-28. East Fork Scott River after excavation with heavy equipment under emergency flood relief. July 1997.

Subsequently, NRCS funded emergency manipulation of the channel with heavy equipment (Figure A5-28). While bulldozing bedload to form a berm increased channel capacity temporarily, this action does not promote long-term channel stability and riparian restoration. Therefore, such activities lead to chronic problems with bank erosion. Removing large wood during these activities also decreases fish habitat complexity.

Water Temperature, Flows and Water Conservation: Water temperatures in the Scott River can be limiting for salmonids, particularly in dry years. Flow depletion tends to contribute to temperature problems. Comprehensive temperature monitoring on the Scott and its tributaries has provided a greater understanding of how varying water years can effect temperature. The Task Force and SWRCB have provided assistance to the Scott River RCD and CRMP for temperature monitoring. Cooperative efforts in the Scott River watershed for temperature monitoring also include private timber companies, the USFS, Etna High School and Scott Valley High school. As a result of these efforts, nearly 50 automated temperature sensing devices have been deployed annually and a great deal has been learned about water temperatures in the basin. The substantial amount of baseline information should allow the CRMP and RCD to track success of restoration efforts, as stream temperatures decrease over time in response to riparian vegetation increases and water conservation measures are implemented.

The Scott River can exceed stressful for salmonids in low gradient valley reaches in dry years, but remains below stressful on average in wet years (Figure A5-29). The warmest reaches of the Scott mainstem in the valley are at Highway 3 and Jones Beach. The lower Scott River flows in a gorge which is completely open to the full arc of the summer sun and very subject to warming.

Cold water tributaries flowing from USFS lands in the Marble Mountains moderate mainstem Scott River temperatures in this reach and provide substantial refugia at their mouths (Figure A5-30). While Kelsey Creek attained a maximum temperature of 62^0 in 1995, widening of it's channel lead to a substantial increase in summer stream temperatures in 1997. Kier Associates measured a temperature of 68 degrees F in the field in August 1997. Channel scour in other lower Scott River tributaries may have also contributed to temperature increases. Loss of cold water contributions from these lower tributaries may have profound impact on ecosystem function in the lower Scott River.

Reaches in the lower Scott Valley at Highway 3 may go dry in drought years as well. During the sequence of drought years from 1987 to 1992, tributaries such as Kidder Creek were dry even during winter months. Shackleford Creek continues to dry up before joining the Scott during late summer annually as a result of irrigation diversions. Long-term trends show that periods of critically low flow have tended to increase since 1942, when flow records began to be monitored consistently on the Scott River. A comparison was made of the number of days

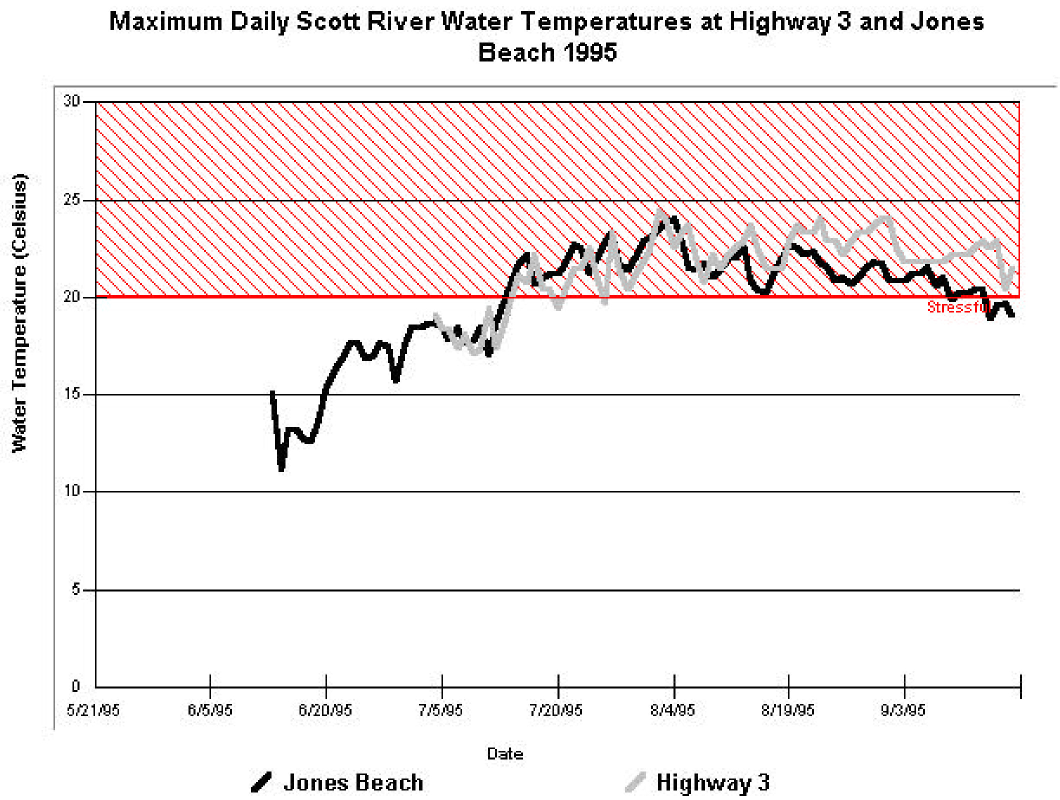

Figure A5-29. Maximum daily water temperature at Jones Beach and Highway 3 during 1995. Most other Scott River locations were below stressful for salmonids during most of the summer.

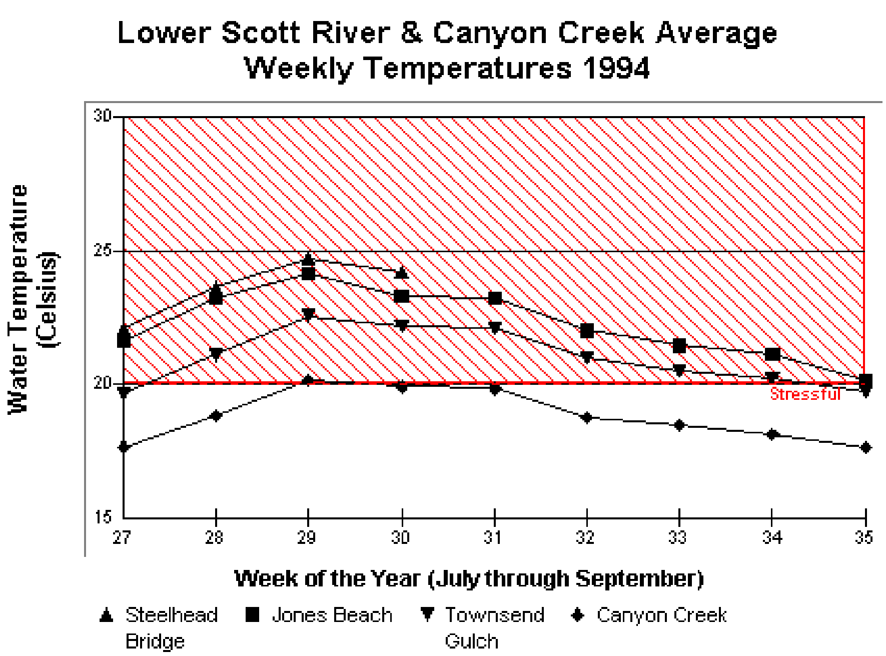

Figure A5-30. Maximum weekly temperatures for the lower Scott River and Canyon Creek during summer 1994. Canyon Creek and other Marble Mt. tributaries buffer the lower main Scott River temperature.

the Scott River has dropped below 40 cubic feet per second using U.S. Geologic Survey flow data. There appears to be a substantial increase in the number of days with extremely low flows (Figure A5-31). Moffett Creek lost perennial surface flow in the late 1950's as a result of ground water depletion (DWR, 1958). The drop in ground water has contributed to loss of riparian vegetation that in turn effects bank stability.

Stock water systems funded by the Task Force are making diversions for livestock un-necessary. These cost-effective pump and trough systems require far less maintenance than typical stock water diversion systems and are economical to run (Figure A5-32). Stock water systems also obviate the need for cattle to access the mainstem Scott River which allows riparian recovery. Experiments have also been conducted on ground water recharge using "beaver ponds" to help provide higher base flows in fall to aid chinook salmon migration. These impoundments did elevate the water table by four feet and it was calculated that 5.5 acre feet of water had percolated into ground water as a result of this activity (Gary Black, personal communication). The pool formed by the structure was 10 feet deep and was stratified so that temperatures below 4 feet deep remained under 68^0 F all summer.

Low flows are a major constraint for access to spawning areas for fall chinook salmon in drought years. In 1994, fall chinook were able to spawn only in the lowest six reaches of the Scott River (approximately 25 miles). In years with high flows, such as 1995, fall chinook can move upstream through the Scott Valley, more than 60 miles upstream. Confining fall chinook spawning to the reaches just upstream of the convergence with the Klamath poses substantial risk to egg and alevin survival in the event of a large winter storm event. A comprehensive strategy for increasing efficiency of water use and providing improved flows for fish is still needed. The Scott CRMP has addressed fall flow issues for adult passage as a planning element but not summer low flow issues.

Riparian Condition and Recovery: Many of the projects funded by the Task Force in the Scott River Basin are for riparian restoration. A complete map of the project sites funded through USFWS in the basin is shown as Figure A5-33. Extensive restoration efforts have been carried out on private lands in the Scott Valley to restore riparian zones to improve fisheries and water quality and to protect farm lands from erosion. These efforts include cattle exclusion fences, riparian planting and bank stabilization (Figure A5-34). Funding sources for these projects include the U.S. Fish and Wildlife Service on behalf of the Klamath Task Force and the Jobs in the Woods program, the California Wildlife Conservation Board, the State Water Resources Control Board and the California Department of Fish and Game. Private landowners have also contributed substantially by funding projects themselves or providing sweat equity.

Through cooperative efforts promoted by the Siskiyou RCD and the Scott Valley CRMP, farmers and ranchers have excluded cattle from thirteen miles of the Scott River from above Schackleford Creek to above Serpa Lane. This reach is all private land and all landowners cooperated willingly with some covering the entire cost of fencing. Getting livestock out of the riparian zone is an essential first step in re-establishing trees. Fences that ran perpendicular to the Scott River in areas where the Scott jumped its banks were damaged but most fences withstood flood flows.

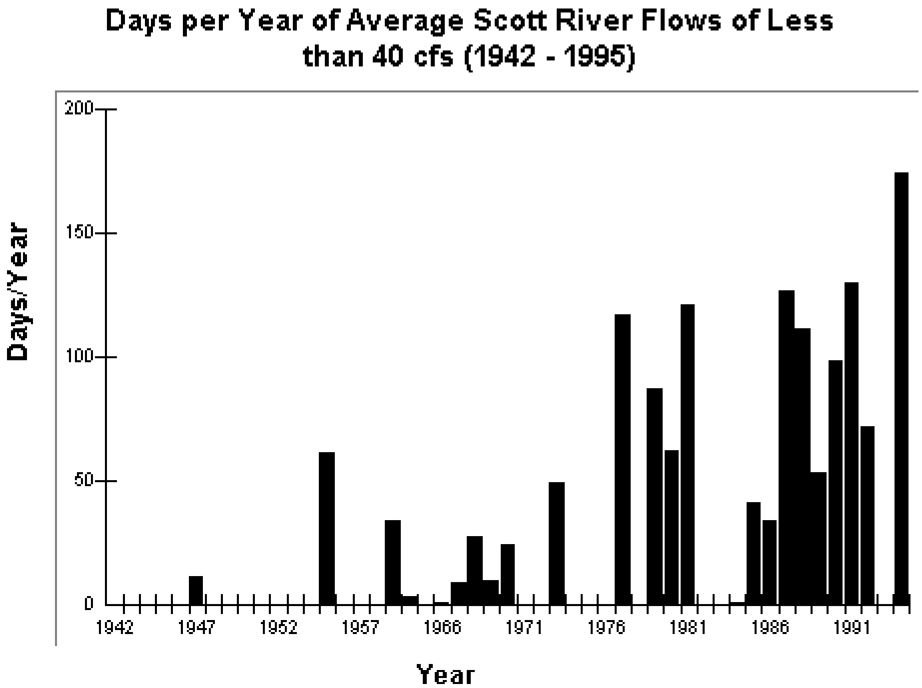

Figure A5-31. The number of days per year that Scott River average daily flow drops below 40 cubic feet per second from 1942 to 1994. Part of the increase in the latter period is a result of prolonged drought. Data from USGS flow gauge at Jones Beach.

Figure A5-32. Off-stream stock water system just outside the Scott River riparian zone. Photo taken in July 1997.

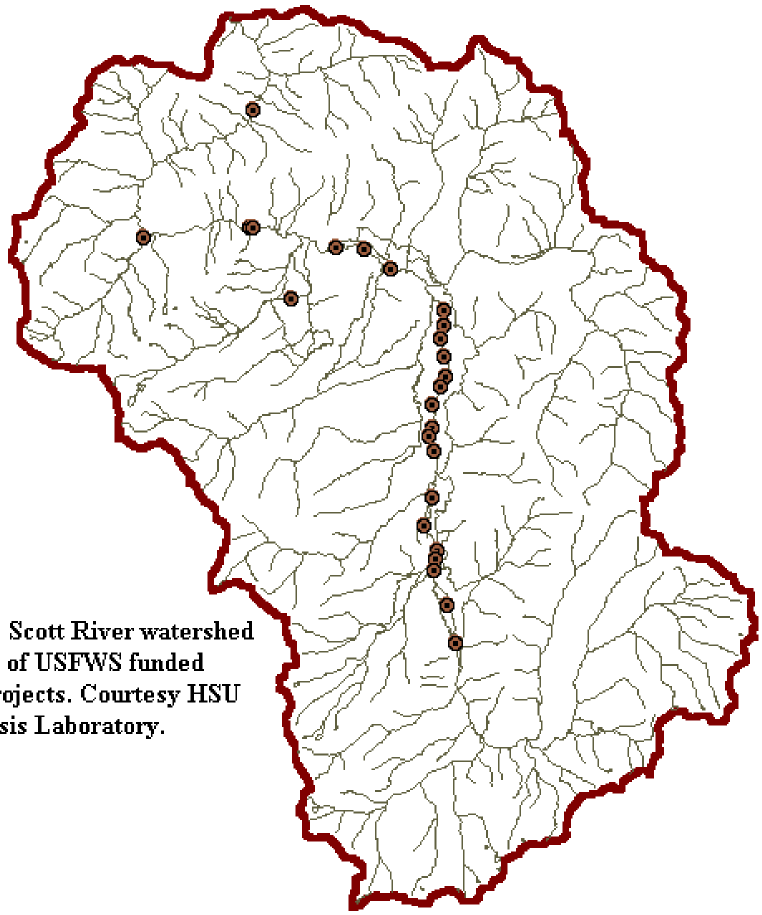

Figure A5-33. Scott River watershed with locations of USFWS funded restoration projects. Courtesy HSU Spatial Analysis Laboratory.

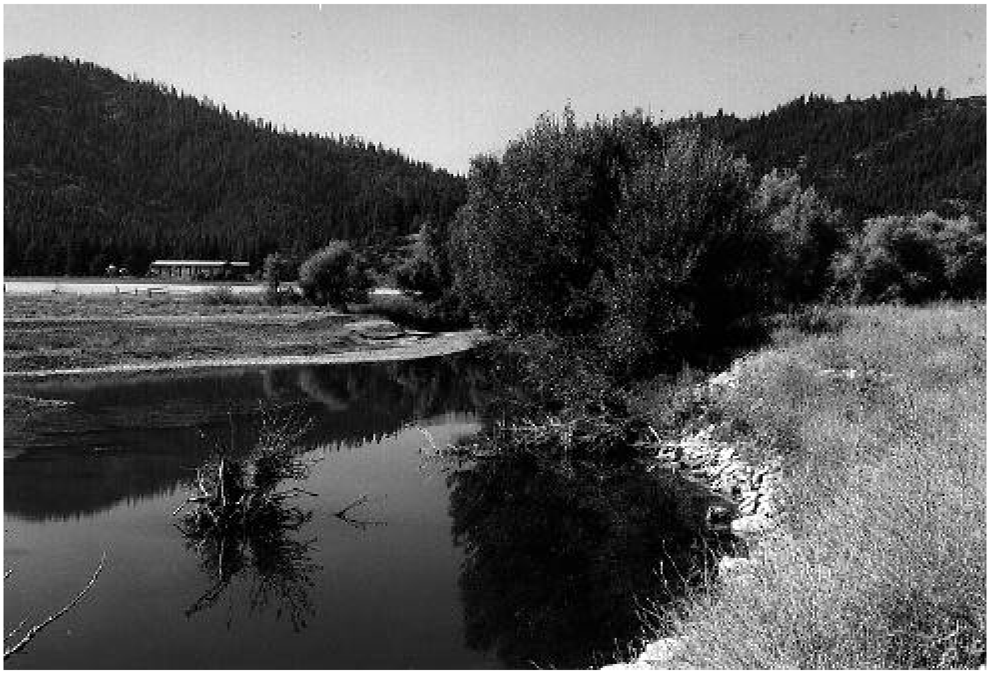

Figure A5-34. Bank stabilization project on the mainstem Scott River at Pastures of Heaven, combining rip-rap with tree planting. Photo July 1997.

Figure A5-35. Deep-planted cottonwood stakes survived high flows of 1997 at Pastures of Heaven along the Scott River. July 1997.

Willows, cottonwoods and conifers have been planted extensively in Scott River riparian areas. Grubbing away competing plants before planting improves survival of tree starts. Over 23 acres were being planted during the summer of 1997 alone (Gary Black, personal communication). Getting trees established is difficult because the Scott River runs within levees at many locations and trees planted along its banks may be well above the water table. Two methods have been used to help get riparian trees established: drip irrigation and deep planting of long stakes or poles. Success of drip irrigation was increased by allowing periods with no water so that the young trees send down taproots. Shade cards are necessary to prevent burning in some locations, such as exposed gravel bars (Gary Black, personal communication). The most successful planting method is digging a hole 6-7 feet deep and planting long, stout cuttings of willow or cottonwood (Figure A5-35).

Success of riparian plantings was monitored in 1996 and success rates ranged from 61-90% with an average of 79% success. The January 1997 high water scoured some of the trees that had been planted in the active flood plain that may have reduced the over-all success rate. Extensive experimental plantings in 1997 undertaken on extremely harsh gravel bar locations could also reduce over all success rates.

Scott River banks have been stabilized using a combination of rip rap and willow mattresses. Groins of large rock are keyed into the banks and extend out into the river and deflect the main flow of the river away from the bank. Areas immediately downstream of the structures are planted intensively with willows. The combination of riprap and vegetation provides more complex fish habitat than use of riprap alone and has been successful in preventing bank erosion. The failure rate of bank stabilization structures as a result of the January 1997 storm was approximately 15% despite the fact that companion vegetation had not become established on many recently completed projects.

Bank stabilization, fencing and riparian planting projects are showing promise in reversing habitat trends on the mainstem Scott River.

Shasta River

The Shasta River watershed experienced a prolonged period of drought in the late 1980's and early 1990's. Water quality measurements taken during the drought period indicated that the Shasta had severe water quality problems for salmonids, including high water temperatures and low dissolved oxygen (Gwynne, 1993). High fine sediment levels in Shasta River spawning gravels have also been noted as a problem (Jong, 1995). The formation of the Shasta CRMP in 1992 lead to an increase in restoration projects aimed at reversing water quality problems. Some improvement in habitat related to these projects is already in evidence. While there are some positive signs with regard to habitat trends in the Shasta, there was some has been substantial degradation to the critical habitat area in riparian zones at two locations.

Flows/Water Quality: The North Coast Regional Water Quality Control Board (NCRWQCB), CDFG and the Shasta CRMP all have collected extensive amounts of data on Shasta River water quality. The data has helped raise community awareness about the magnitude of problems and has lead to cooperative efforts to improve conditions. CDFG (1997) noted that low flows in summer were contributing to water quality problems and also directly hindering migration of salmon and steelhead in some years.

Gwynne (1993) showed that dissolved oxygen at some locations in the lower Shasta River was dropping below stressful or lethal levels for salmonids (Figure A5-36). Although algae blooms contributed to the depressed dissolved oxygen levels, high biological oxygen demand related to detritus in impounded areas above diversion dams was contributing significantly to the problem (Gwynne, 1993). CDFG and the Klamath Task Force have funded a pump and paid electricity costs to remove the Fiock diversion dam near Montague (Figure A5-37). This action should have at least partially remedied problems with low dissolved oxygen in this reach and below. Unfortunately, dissolved oxygen measurements have not been continued in recent years in the project area. Removal of the diversion dam also had the additional benefit of improving fish passage for adult and juvenile salmonids.

Water temperatures in the Shasta River can reach lethal temperatures for salmon and steelhead with highest water temperatures in the lower Shasta Valley (Gwynne, 1993; CDFG, 1997). Lack of shade canopy contributes to stream temperature problems, but warm agricultural runoff may exacerbate the problem. The Shasta CRMP has worked cooperatively with a number of riparian landowners to reduce livestock access, restore bank stability and increase shade canopy (see Riparian Condition and Recovery). A pilot project has also been initiated to recover tail-water on the Meamber Ranch (Figure A5-38) funded by the SWRCB. This project prevents heated agricultural drain water from entering the Shasta River. The reclaimed water has also induced better growth in the pasture areas where it was used. A second SWRCB funded tail-water project on the Ekstrom property does not re-use the agricultural drain water. Instead it shunts the tail-water into an old river channel which is a marsh area which strips it of nutrients and reduces temperature impacts to the Shasta River.

Yreka Creek is sustained by out flows of tertiary treated wastewater from the city of Yreka. The water is of sufficient quality to sustain juvenile steelhead year around and fall chinook used the lower creek in 1995. Recently a golf course was proposed that would have used Yreka's wastewater for irrigation. The city should fully study the use of Yreka Creek by steelhead and chinook juveniles before re-allocating waste water toward other uses.

CDFG (1997) noted that flow regimes have changed substantially in the Shasta River since the construction of Dwinell Dam. The Shasta River Biological Needs Assessment for Anadromous Salmonids (CDFG, 1997) pointed out that average daily flows in April through June was 132 cfs before dam construction but 87 cfs from 1985-1994. Similarly, July and August flows were 42 cfs before and 28 cfs in recent years and September flows

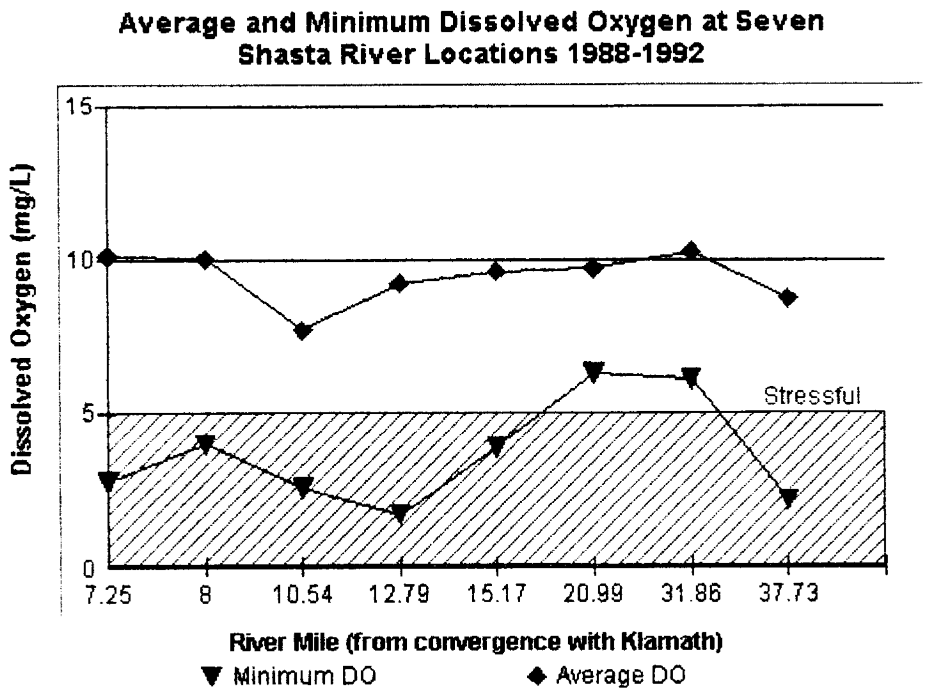

Figure A5-36. Minimum and average of all readings of dissolved oxygen in the Shasta River as measured by Gwynne (1993). Dissolved oxygen of less than 5 is stressful for salmonids. River Mile 0 is the convergence with the Klamath River.

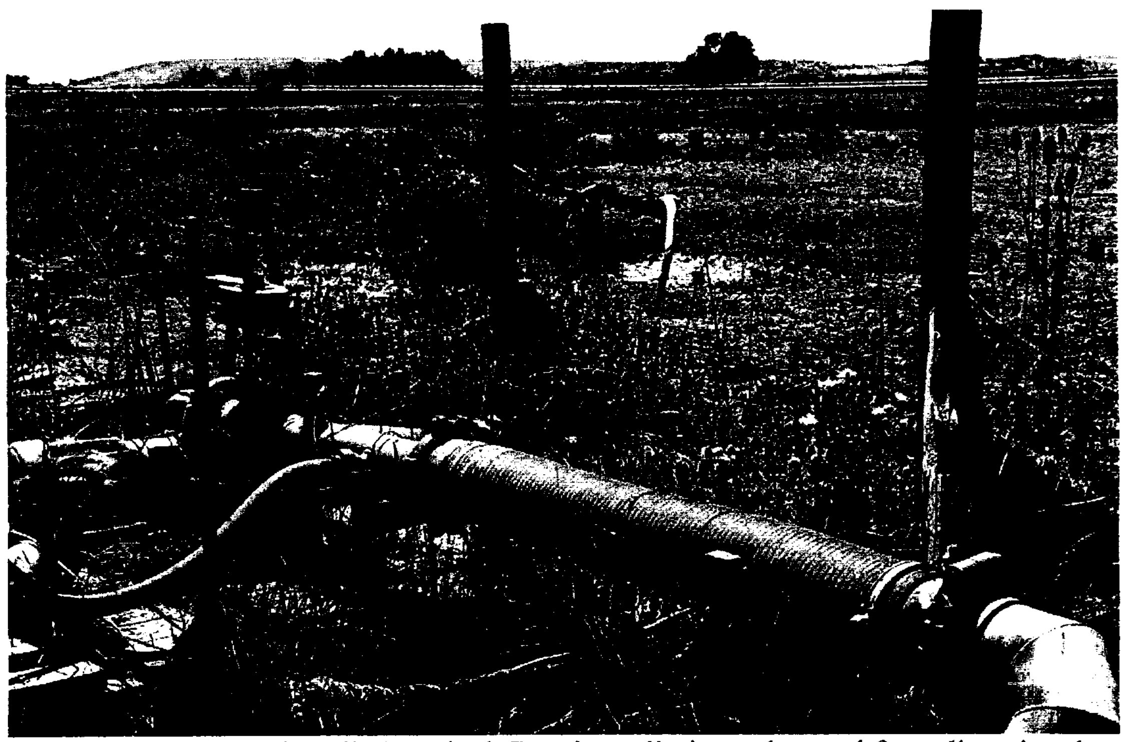

Figure A5-37. Pump installed at Fiock Ranch to eliminate the need for a diversion dam on the lower Shasta River. Dam removal should help improve dissolved oxygen conditions locally.

Figure A5-38. CRMP coordinator Dave Webb shows Jason Johnson of Kier Associates the sump pump for tailwater recovery at the Meamber Ranch on the Shasta River. July 1997.

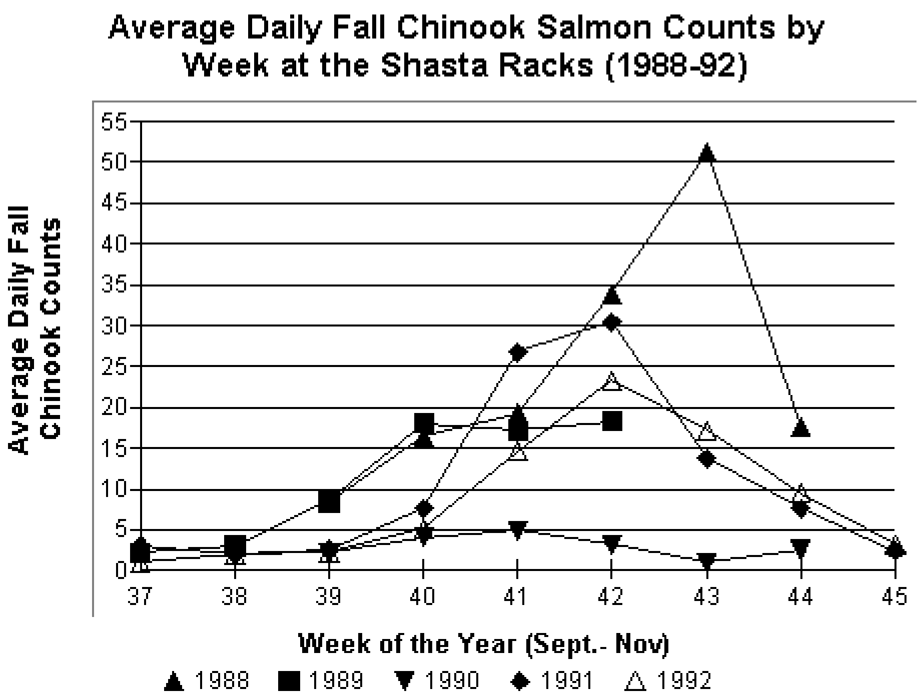

Figure A5-39. The average daily fall chinook counts by week in the Shasta River form 1988-1992 show that the majority of fish wait until October 1 to move upstream. Data courtesy of CDFG.

were 79 cfs before and 61 cfs from 1985-1994. CDFG (1997) concluded that quick drawn down of the Shasta River in 1992 resulted in a fish kill of juvenile salmonids.

Adult salmon may also delay their migration into the river and spawning from early to mid-September to early October (CDFG, 1997). Delayed spawn timing and the stress associated with holding in the warm Klamath River waters could reduce spawning success. In recent years, Shasta River fall chinook entered the river after October 1, when irrigation season ends (Figure A5-39). CDFG (1997) noted that low fall flows may also inhibit access to the Big Springs area which has been the most important spawning area for chinook salmon (CDWR, 1982).

As the farming and ranching community became aware of the extreme seasonal temperature problem for salmon and steelhead, they devised a strategy to try to induce migration out of the system prior to stream warming. "Flushing flows" were initiated in 1993 and have been carried out in three years since. Water is first spilled at Dwinell Dam and then downstream landowners with diversion impoundments pull their flashboards. The extremely robust return in 1995 may have been as a result of flushing flows increasing survival of the 1992 year-class of Shasta River chinook salmon juveniles (see Chapter 2). Increasing flows in September for returning adults has not yet been addressed.

Surface flows in the Shasta River are often strongly tied to springs and ground water (USGS, 1960). CDFG (1997) pointed out that the number of new wells in the Shasta Valley continues to increase. The flow at Big Springs was decreased from approximately 50 cfs when the Montague Irrigation District established a well for domestic water supply. Later a court order required that flows not be reduced to less than 17 cfs. In recent years, the Louie Ranch at Big Springs has been sold and the new owner appears to further decreasing surface flows in Big Springs and Little Springs Creeks because of changes in irrigation practices. Bruce Gwynne (personal communication) noted that Little Springs Creek was drying up where it crossed Louie Road and also noted juvenile salmonids in irrigation ditches on the Louie Ranch. He notified the CDFG wardens of his observations to act on at their discretion. Further habitat loss as a result of flow depletion in the Big Springs area could have substantial impact on the long-term viability of fall chinook, coho salmon and steelhead in the Shasta River.

Gravel Quality and Supply: Gravel quality studies of the Shasta River by CDFG in 1994 (Jong, 1995) demonstrate a substantial increase in fine since 1980 (Scott and Buer, 1981). Jong (1995) measured fine sediment less than 0.85 mm, which is most damaging to egg survival, at 36.3%, 34.8% and 31.9% in the middle, lower and upper reaches of the Shasta River. Fine sediment less than 0.85 mm should be less than 15% to allow for optimal survival to emergence of salmon and steelhead eggs and larvae (Hall and Lantz, 1969). The 1994 fine sediment levels were approximately 2.5 times those found in 1980 (Scott and Buer, 1981), although sieve sizes used in both studies were not directly comparable. The Parks Creek overflow is causing severe gully erosion and contributing fine sediment to the Shasta River (A5-40) and CDFG has also identified over 23,000 feet of bare banks in riparian areas in the Shasta Valley in surveys between 1991 and 1993 (CDFG, 1997).

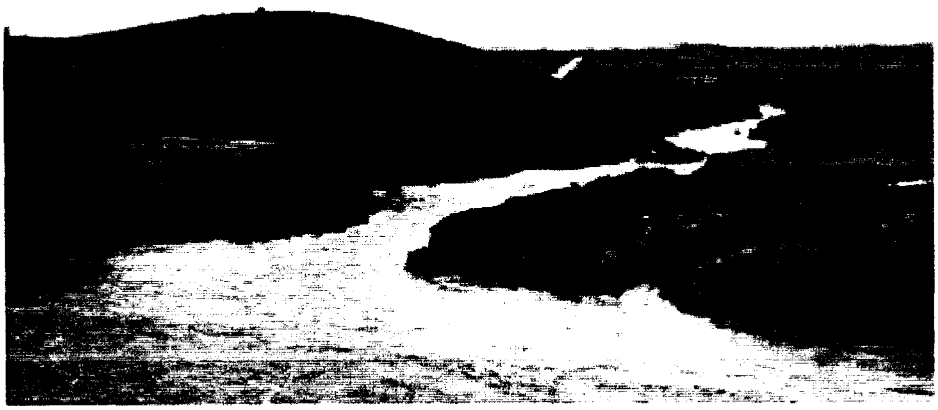

Figure A5-40. The Parks Creek overflow causes major problems with gully erosion during high water and increases the supply of fine sediment to the Shasta River.

Figure A5-41. CRMP coordinator Dave Webb next to new tree starts on the Peter's Ranch along the Shasta River just below Interstate 5. July 1997.

Riparian restoration is underway to remedy this problem (See Riparian Condition and Recovery).

A Department of Water Resources study (Scott and Buer, 1981) described the distribution of chinook salmon spawning in 1980. Most spawning took place either in the canyon in the lowest reaches of the river or in Big Springs Creek. Reduced flow at Big Springs may be decreasing critical spawning and rearing habitat for all anadromous salmonid species. Dwinell Dam stops recruitment of gravel from the upper Shasta River and peak flows from Parks Creek are diverted into Dwinell Reservoir as well. Without a change in winter flow regimes to allow increased gravel supply from Parks Creek to enter the Shasta River, long-term depletion of spawning gravels for salmon and steelhead is inevitable.

Riparian Condition and Recovery: The Shasta CRMP has facilitated implementation of riparian restoration projects on numerous farms and ranches along the Shasta River. Projects include fencing, bank stabilization, riparian replanting and stock water access. Funding has come from such diverse sources as CDFG, USFWS, State Water Resources Control Board, California Wildlife Conservation Board and Cal Trans. USFWS projects include both Klamath Restoration Program and Jobs in the Woods. Landowners have contributed both in cash and services to restoration efforts. Local high school students have volunteered in many ways to assist riparian restoration efforts in the Shasta River.

Riparian restoration projects along the Shasta River have established many new trees that will provide a substantial increase in shade over the next decade. However, getting riparian trees to grow in some reaches of the Shasta is problematic because of alkaline soils and clay pans (Dave Webb, personal communication). A Great Northern Corp. study funded by the Task Force should answer questions about what areas of the Shasta River have conditions that may confound success of tree planting. Some benefit is derived from excluding livestock from riparian zones, even if trees cannot be established, as tule beds often colonize. Tule beds can provide filter capacity for agricultural runoff, trap sediment during high flows and help prevent bank erosion.

Many of the trees planted to help restore the Shasta River riparian zone have been provided by a Yreka High School HROP program in Yreka that has operated a nursery for native trees. Trees will usually grow in soils that have some colluvium that allows drainage (Dave Webb, personal communication). Plantings by the HROP students and also Discovery High School in the Shasta gorge are doing well in some areas. Riparian conditions on Bureau of Land Management land has continued to improve with no cattle grazing allowed in recent years. Sparse soils in the riparian zone of the lower Shasta limit opportunities for establishing a complete canopy (Dave Webb, personal communication).

Sites like the Peter's ranch in the lower Shasta Valley above Interstate 5 have good soil types in the riparian zone and there has been a high success rate for establishment of trees (Figure A5-41). Areas further upstream between A-12 and Montague Grenada Road may have locally adverse conditions. Riparian conditions upstream of A-12 generally improve and the Freeman Ranch project provides a model in this reach. All tree starts in the riparian zone on the Freeman property were drip irrigated to increase the success rate of plantings. Riparian conditions along the Shasta River below Dwinell Dam are good but there is little fish habitat in this reach because of insufficient flows released from the dam.

A major volunteer effort that included angling groups, schools and the California Conservation Corp planted over 10,000 trees (mostly willow) on the A.C. Marion Ranch on the Shasta River below A-12 in 1990-91. Unfortunately, success of tree recruitment was less than 10% in the long term. Some soil conditions in the riparian were unsuitable for tree growth, beaver browse caused a surprisingly high mortality rate and fences to exclude cattle were not sufficiently maintained. Late season plantings (April) without subsequent irrigation also limited survival. The experience on the Marion Ranch, while not a success, provided a learning experience and most riparian plantings on the Shasta are now protected from beavers using cages. Figure A5-42 shows the location of all USFWS funded projects in the Shasta Basin.

Because much of the peak flow from the upper watershed of the Shasta River and Parks Creek is captured in Dwinell Reservoir, the river has less erosive force during flood events. Much of the river in agriculturally impacted reaches is also of low gradient with a wide flood terrace where flood energy can be released. Consequently, very few cattle exclusion fences on the Shasta River were seriously damaged during the January 1997 storm. Fences near the edge of the river often caught substantial amounts of debris but could simply be cleaned off and stood back up (Dave Webb, personal communication). Short sections of cross-fences that ran perpendicular to the river in the flood plain, such as at cattle crossings, were dislodged by the 1997 storm. Cattle access gates have been specially designed for the ranches on the Shasta River to allow selected drinking access of crossings for livestock. These gates can be retracted during high flows and sustained minimal flood damage in the 1997 high water.

Bank stabilization using only willow waddles is a technique employed by the CRMP with a great deal of success at a number of sites on the mainstem Shasta River (Figure A5-43 and A5-44) and in Yreka Creek as part of the Yreka Greenway Project. Bundles of live willow sticks are secured to sections of eroding banks. Scour is prevented and silt from high flows is trapped. As the willows sprout and increase their root mass, bank stability and shade cover both result. There were no failures of willow waddle projects during the 1997 storms.

There are two notable areas where riparian conditions have deteriorated in the last few years. The riparian zone adjacent to Louie Road along the upper Shasta River was bulldozed and partially filled in 1996 (Figure A5-45). Although CDFG cited the landowner, the courts dismissed the case under the condition that the landowner negotiate a 1603 permit from the Department (see Policy/Administration). The January 1997 storm also caused flood damage to a field adjacent to Highway 263 that was in the river flood plain. During the summer of 1997, the landowner at the site built a berm using substrate from the river and partially armored with chunks of asphalt supplied by the city of Yreka (Figure A5-46). No Army Corp of Engineers permit was issued on this project but a

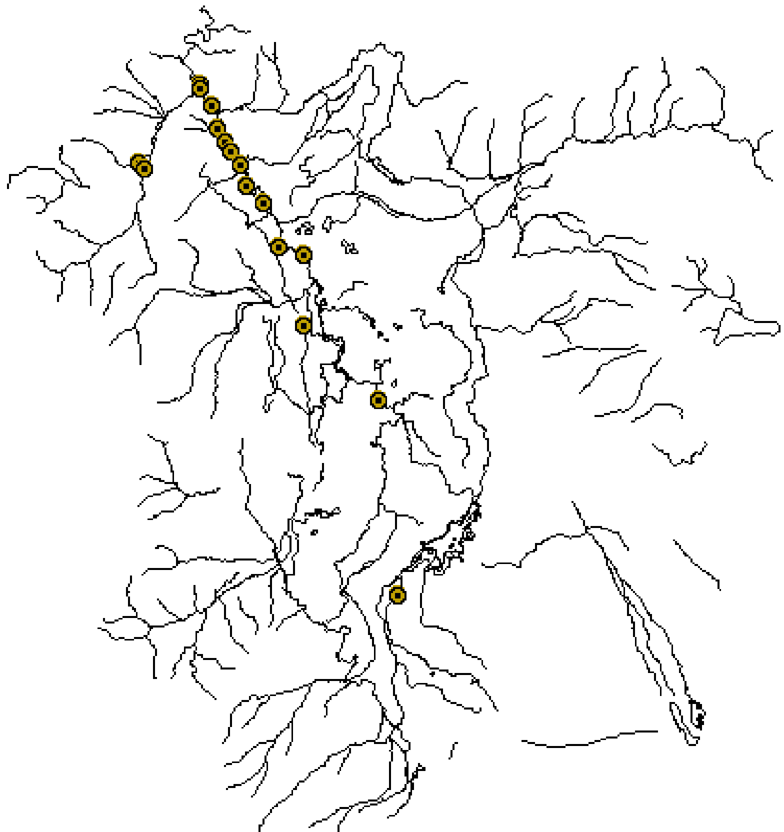

Figure A5-42. Shasta River Basin with location of USFWS funded restoration projects

Figure A5-43. Willow waddles used for bank stabilization at the Easton Ranch along the Shasta River during project construction. Photo courtesy Dave Webb.

Figure A5-44. Stabilized bank at Easton Ranch after project completion. New willow starts in the foreground are not highly visible because the photo was taken in winter. Photo courtesy Dave Webb.

Figure A5-45. Riparian zone of the Shasta River at Louie Road with heavy equipment and filled riparian wetlands.

Figure A5-46. Riparian destruction along the Shasta River at Highway 263. Berm at the center of the photo confines the Shasta River to a narrow channel against far bank. Note wetland area in foreground. Photo October 1997.

CDFG 1603 was issued. The U.S. Environmental Protection Agency (1997) has written a letter of inquiry to the landowner requesting information on whether appropriate permits were obtained.

Release of a U.C. Davis report on riparian condition of the Shasta River funded by the SWRCB should allow a quantitative assessment of riparian condition by reach. Also a study is underway regarding factors which limit the success of riparian restoration in the Shasta River conducted by Great Northern Corp. Unfortunately, results from the latter study were not available as this report went to press.

Upper Klamath

The Klamath Restoration Program has not invested in projects above Iron Gate Dam because they are not accessible to anadromous fish. None-the-less, substantial funds have been spent in recent years on restoring habitat through the U.S. Fish and Wildlife Service Klamath Ecosystem Restoration office and the Bureau of Reclamation in Klamath Falls, Oregon. Senator Mark Hatfield has also convened a committee of local citizens in the Upper Klamath to take a comprehensive approach to fisheries, water quality and water supply issues.

A major thrust of projects is restoring marsh buffer areas to filter nutrients around Upper Klamath Lake to help restore water quality. Major projects currently under way include purchase of the Wood River Ranch at the confluence of the Wood River and Upper Klamath Lake. The Bureau of Reclamation is also moving to purchase an extensive marsh area in upper Agency Lake that will also provide additional water storage. Marsh restoration is also taking place on Nature Conservancy property on the Sycan River, a tributary of the Sprague. Cumulatively, marsh restoration may help improve water supply during late summer (Gerhardt et al., 1995). Marsh restoration in the Tule Lease lands is also under study by the University of California Cooperative extension.

The USFS and SWRCB have also supported riparian restoration projects aimed at restoring Lost River and short-nosed sucker habitat in tributaries of Clear Lake in the Lost River basin (USFS, 1996). The USFWS is also becoming more involved in funding riparian restoration as part of the strategy for protecting and restoring sucker habitat.

The linkage between water quality in the Upper Klamath basin and in the Klamath River below the dams is difficult to accurately assess at this time. However, studies are currently proposed by the U.S Geologic Survey and the Klamath Compact. The former plans to apply its Total Water Quality Model to the upper Klamath River while the Klamath Compact has proposed studies related to its Klamath Basin Water Supply Initiative. The U.S. Bureau of Reclamation is also advancing a substantial funding package for flow studies that may also help to answer some of these questions (Larry Duggan, personal communication).

Mainstem Klamath River and Estuary

The mainstem Klamath River is recognized as impaired with regard to temperature and conditions that are acutely stressful or lethal to salmonids occur in many years (Figure A5-47). In August of 1997, USFWS also measured nocturnal dissolved oxygen (D.O.) levels of 3.1 ppm at Big Bar on the Klamath River below Orleans (Figure A5-48). This low D.O. is in the range of severely stressful or lethal for salmonids (EPA, 1986). Other more temperature tolerant fish species such as suckers and dace were succumbing to diseases at the time of the measurements (USFWS, 1997). Previous research and water quality monitoring had not considered the possibility that a river with the turbulence of the Klamath might be less than saturated. The USFWS findings suggest that sufficient quantities of algae must be entrained in the Klamath to cause the entire water column to fluctuate nocturnally as the algae respires. Previous samples were taken during day light hours only which would not detect nocturnal D.O. sags. NCRWQCB water quality samples have found pH values as high as 9.7 in the mainstem Klamath above the Scott River and 9.2 below the Shasta River. These high pH values could be another indicator of photosynthetic activity.

Major declines of steelhead, particularly summer steelhead, across all Klamath tributary basins (see Chapter 2: Population Trends). Because many of the sub-basins showing declining trends for summer steelhead have not suffered habitat loss, such as Wooley Creek, it suggests that life history bottlenecks could be occurring in the mainstem Klamath. Because Klamath tributary steelhead exhibit a 85-100% occurrence of half-pounder life history (Hopelain, 1998), survival problems could be owing to conditions encountered when entering the river in late summer and fall to feed when water quality is very poor. Loss of steelhead stocks at Iron Gate Hatchery may also be indicative of major problems with ecosystem function of the mainstem Klamath River (see Iron Gate Hatchery).

Belchik (1997) inventoried cold water refuge areas in the mainstem Klamath to determine their frequency, use and importance to salmonid juveniles. Between Iron Gate Dam and Seiad Valley, Belchik (1997) found 32 cold water refugia: 4 large (>1000 sq ft.), 16 medium (50-1000 sq ft.) and 11 small (<50 sq ft.). Bogus Creek was classified as an intermittent refugia because it was not always cooler than the Klamath River. Three out of four large refugia, the mouths of Beaver, Horse and Grider Creeks, suffered significant channel changes in the January 1997 storms and some significantly increased in temperature as a result (De La Fuente, 1998). Reduction in the size or quality of the limited number of refugia may have profound influence on survival of salmonid juveniles during summer in the mainstem Klamath. Cumulatively, the increase in tributary temperatures may also contribute to severe water temperature problems in the mainstem Klamath itself.

There is no quantitative measure of sediment transport in mainstem Klamath River to provide information on trends of recovery, such as increased pool depth. Sequential aerial photos of river near the location of Highway 101 today from 1941 to 1996 suggest that

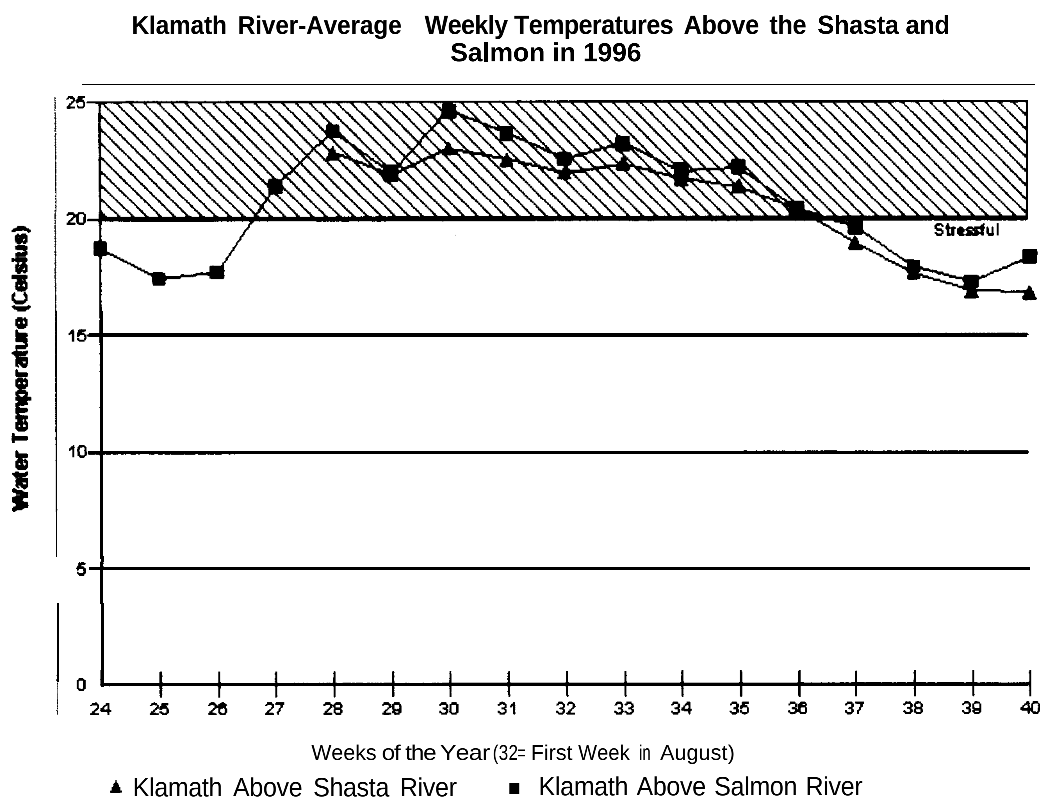

Figure A5-47. Average weekly water temperatures of the Klamath River above the Shasta and Salmon Rivers were chronically stressful for salmonids throughout the summer of 1996.

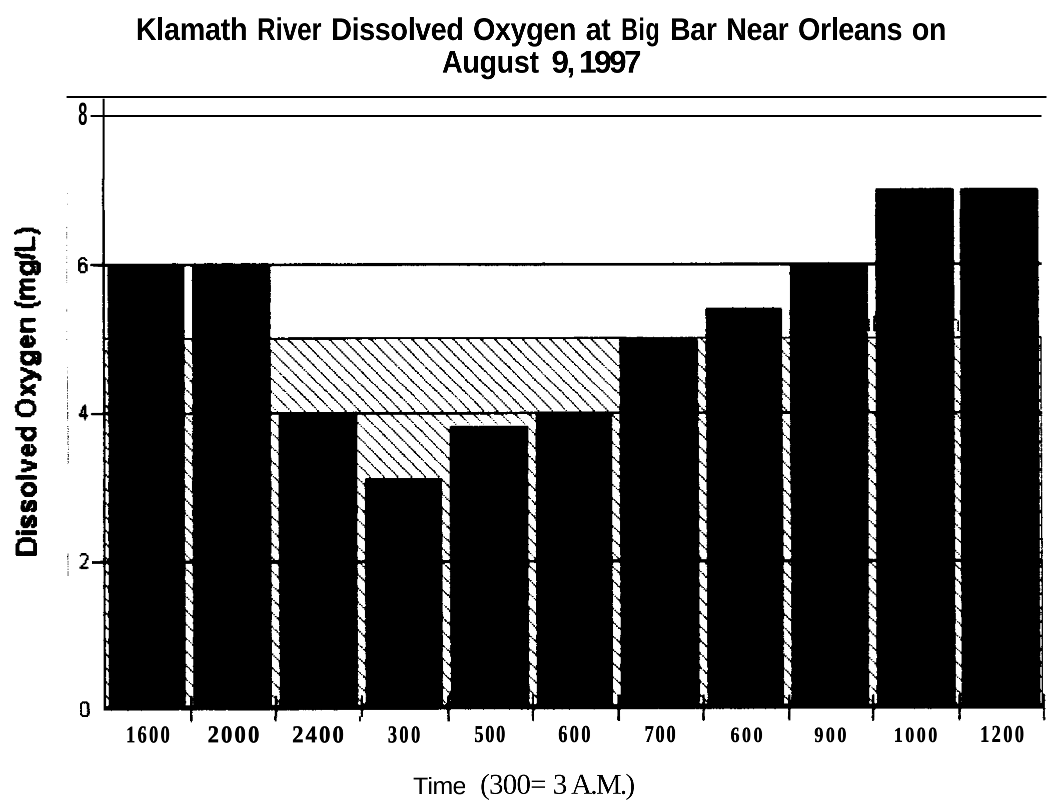

Figure A5-48. Dissolved oxygen readings taken by USFWS staff at Big Bar trap below Orleans on the Klamath River show stressful or lethal conditions for salmonids (<5ppm is stressful).

major aggradation of the lower Klamath River occurred in recent decades. This indicated by a distinct widening and shallowing from 1947-1996 (Figure A5-49 and A5-50). Note the blond colored areas within the active channel in 1996 that represent sand bars. These most recent photos do not show a marked trend toward recovery.

Mike Wallace (1998) has not found water quality problems in the Klamath estuary similar to those found by USFWS further upstream but test were conducted during summer 1997. Although some areas of the estuary filled in during recent high flows, other areas were substantially deepened. For example, the southern estuarine shore area, formerly occupied by Dad's Camp, was scoured out by recent floods and the estuary is now over 20 feet deep there. The area of the estuary just off the mouth of Hunter Creek is 30-40 feet deep and retains high numbers of juvenile salmonids throughout summer. Wallace (personal communication) has also observed a substantial number of juvenile salmonids associated with the tidal wedge of cold salt water that intrudes into the estuary. Fish seem to move back and forth in the freshwater just adjacent to the salt wedge, probably for its moderating influence on temperature.

Effectiveness of In-stream Habitat Improvement Structures

Both the Klamath and Six Rivers National Forests have had on-going efforts to inventory and maintain in-stream structures on the respective forests. The Klamath National Forest Storm Damage Assessment Report (De La Fuente, 1998) also had some findings on the pattern of failure of in-stream structures. The California Department of Fish and Game has also recently completed an evaluation study of in-stream structures and their success throughout northern California, including some Klamath tributaries (Hopelain, in press). Frissell and Nawa (1992) studied the effectiveness of structural enhancements in southwest Oregon streams. Because of the striking similarity to Lower Klamath tributaries in rainfall, geology and land use, their findings are also discussed in this section. Kier Associates gauged the effectiveness of in-stream structures in Beaver, Elk and Indian Creeks and the Scott River in summer 1997 and observations are noted below. While it was not possible to gauge the cost effectiveness of each investment in the basin, a great deal has been learned about the success of these projects overall.

Klamath National Forest

The Klamath National Forest has periodically inventoried in-stream structures throughout the Forest. Olson (1997) conducted dive observations of sites on Indian Creek and Elk Creek in order to gauge whether structural treatments were working. Dives prior to installation of in-stream structures in July 1990 usually found only young-of-the-year steelhead. After installation of boulder clusters and boulders with root wads, July 1991 dives found young-of-the-year steelhead, yearling steelhead, chinook and coho salmon juveniles. "Juvenile salmonids were associated more frequently with complex combinations of boulders and rootwads, for example, than relatively simple arrangements of boulders alone" (Olson, 1997). Observations showed that adult salmon were often used cover structures as well.

Figure 49. Lower Klamath River at the top of the estuary in 1941. Note that the channel is narrower than in the 1996 photo and that no sand bars are visible.

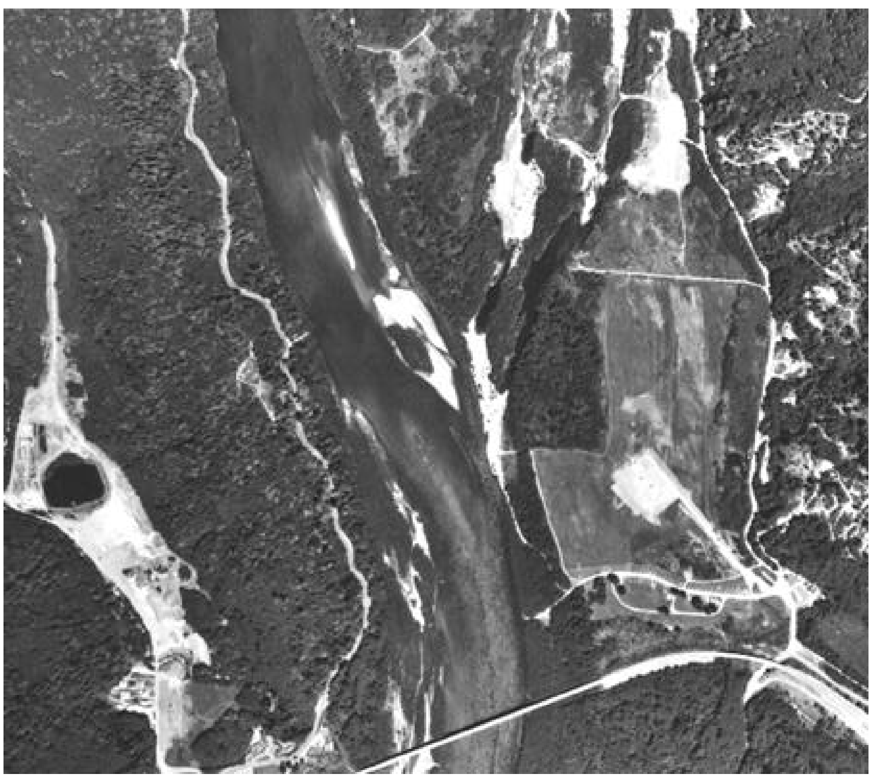

Figure 50. Aerial photo of the Klamath River at the top of the estuary in 1996 shows a wider riparian zone with sand bars both at the margins and in the main channel of the stream.

A cost-effectiveness study by Klamath National Forest, funded in part by the Restoration Program (Olson and West, 1990), rated the performance of in-stream structures and found that simple structures, such as digger logs and boulder deflectors, provided greatest cost-efficiency. They estimated the longevity of various structures at 18-57 years. Failure rates associated with the January 1997 storm, where the recurrence interval was about 10-37 years in many areas, indicate that life of structures may be lower (see Frissell and Nawa below).

Klamath National Forest staff did a reconnaissance of in-stream structures after the January 1997 storms (De La Fuente, 1998). Boulder structures had the highest durability with 70% remaining in place and retaining some function, even if re-arranged by high water. Only 50% of boulders and rootwads were still intact and working after the storm and only 30% of complex log structures survived. It is possible that large wood may have relocated to areas downstream and still providing some benefit. Boulder structures were also buried in some cases and may re-emerge as streams cut back down. De La Fuente (1998) also found that structures in the margins of streams had a higher rate of retention than in the thalweg (main current).

Six Rivers National Forest

Six Rivers National Forest has regularly inventoried in-stream structures, including taking photo-points. Summaries of field work were not available for the 1997 season but failure rates were approximately 10 % on Bluff and Camp Creeks (Jerry Boberg, personal communication). California Conservation Corp and AmeriCorps personnel assisted in the field inventories on the Forest. Red Cap Creek experienced slightly higher bedload movement that resulted in more structures being isolated by gravel bar shifts. Structures failures were noted on inventory sheets and repair work was initiated at some sites during the 1997 field season.

California Department of Fish and Game

Hopelain (in press) inventoried in-stream structures in 53 creeks and gathered statistics on 1423 structures throughout northern California, including the Klamath Basin. The purpose of the inventory was to assess partially the success of CDFG investments in in-stream restoration activities. According to the study, those investments between 1980 and 1995 totaled over $45 million. The study began in 1993 with a 25% random sampling of structures in the 53 streams selected. A sub-set of sites was revisited in 1995 after higher flows had occurred. Scores for the physical condition of the structure and for whether it was meeting its objective were: excellent =100, good = 75, fair = 50, poor = 25 and failed = 0.

Hopelain's (in press) over all assessment from 1993 found that boulder clusters had the highest condition and objective scores with an average of 81 and 75, respectively. Weirs had mean condition scores of 60 but mean objective or function scores were only 43 and log covers had almost identical performance (62/45). Log constrictors had the lowest scores with mean conditions and objectives of about 35. Hopelain (in press) noted that a major cause of failure was use of inappropriately sized materials.

The results for streams in the Klamath Basin in Hopelain (in press) include Elk Creek, Indian Creek, Tarup Creek and Hunter Creek. Cumulative scores for all structures within Klamath tributaries are summarized as Table 2.

Stream	**Condition Score**	**Objective Score**
Elk Creek	79	61
Indian Creek	95	79
Hunter Creek	64	47
Tarup Creek	70	48

Table 2. Mean condition and objective scores for in-stream structures in Klamath River tributaries from Hopelain (in press).

Failure rates were much lower in Indian Creek and Elk Creek than in the Lower Klamath tributaries Hunter Creek and Tarup Creek. The high sediment supply in the Lower Klamath tributaries and high level of watershed disturbance are consistent with these findings. A complete inventory of some Lower Klamath tributaries, such as Hunter Creek and Tarup Creek, was conducted during summer 1997 but results could not be obtained.

Overall scores for success rates for structures for all northwestern California were higher in 1993 than in 1995 after higher flows (Table 3). The years between 1986 and 1994 did not have any significant storm events, while two storms in January and March 1995 were of a larger magnitude.

Score	Condition 1993	Objective 1993	Condition 1995	Objective 1995
Excellent/Good (75-100)	80%	60%	67%	39%
Fair/Poor (25-75)	15%	31%	22%	42%
Failed (<25)	5%	9%	11%	19%

Table 3. Cumulative scores for all sites and all structure types in 1993 versus 1995 from Hopelain (in press).

Southwest Oregon Study

Frissell and Nawa (1992) compared failure rates of in-stream habitat improvement structures in eight southwest Oregon streams with those in seven southwest Washington streams. The southwest Oregon streams studied have major similarities with Lower Klamath tributaries with regard to rainfall intensity, geology and land use. Their study classified structures as failed if they were washed away, disassembled or isolated from the active channel. Impaired structures were those that remained in place but were no longer function as intended. The study was conducted after storms in 1990 that were of less than 10-year recurrence interval.

Southern Oregon sites showed a mean failure rate of 48% while those in southwest Washington failed only 6% of the time. Combined rates of failure and impairment in southwest Oregon were 67% and 46% in Washington. Frissell and Nawa (1992) noted that:

> "Failure of internal structure or materials - the dominant concern for most biologists and hydrologists who build these projects - appears to be a far less important cause of damage than are watershed-driven aspects of channel dynamics. Deposition of bedload sediments in wide, low-gradient alluvial valley segments and the erosion of stream banks and shifting of channels associated with this deposition were the most common causes of damage to structures."

In-stream structures on Siskiyou National Forest, which were among the southwest Oregon sites, were estimated to have a life span of 20-25 years. Frissell and Nawa (1992) found that the actual life expectancy, calculated from the field data, was 10 years or less in southwest Oregon and 15 years or less in southwest Washington. They calculated flow related to 10 year storm events and found that streams with a discharge of greater than 1 cubic meter per second per square kilometer posed a much greater risk to in-stream structures. Although use of this method was beyond the scope of this study, the Klamath Task Force's technical work group should consider this as a tool to gauge risk to in-stream restoration investments.

Frissell and Nawa (1992) concluded that use of in-stream structures would not work until watershed health had improved. With regard to southwest Oregon they found that: "Basins continue to suffer impacts from failing roads, high erosion rates along streams in second growth forests, continued logging on steep, highly erodible federal lands and repeated, short-rotation logging on private lands where there is little regulatory protection for unstable slopes and headwater stream channels." This suite of problems is also confounding restoration successful use of in-stream structures in many Klamath tributary basins.

Kier Associates Field Reconnaissance 1997

Kier Associates visited the field to directly gauge the benefits of in-stream restoration projects and damage to streams from the January 1997 storm. Field visits to Beaver Creek, Indian Creek, Elk Creek and Scott River are discussed below.

<u>Beaver Creek</u>: This creek experienced channel changes in its lower reaches as a result of the 1997 storm that caused failure of numerous boulder weirs (see Figures 15 & 16). Boulders with a diameter less than 3 feet were dislodged from boulder weirs and clusters.

Those with 2-2.5 foot diameters were completely mobilized and were generally not recognizably close to their original location. The two boulder weirs that did survive in this reach had a wide adjacent terrace for flood relief.

Cumulative effects damage to the Beaver Creek stream channel was significantly diminished above the West Fork. Although cables failed on wood structures in some cases, many of the wood and rock structures in the upper reaches survived intact (Figure A5-51). Some structure failures in upper Beaver Creek may have been owing to under-sized materials used in the original project (Figure A5-52). Logs were not large enough to withstand floods and some were rotting. Hopelain (in press) cited inappropriately sized materials as a prime cause of structure failure and suggested that projects for which proper materials were not available should not be implemented.

<u>Indian Creek</u>: This stream experienced substantial bedload mobility and aggradation. At river mile (RM) 6.4, where there was a wide terrace for flood relief, three boulder clusters with root wads remained intact. These structures were also in the margin of the stream. Just upstream 30 boulder clusters were pulled apart and partially buried in a short stretch more subject to aggradation. At RM 8.9 Indian Creek was confined in a narrow channel by alder groves. Several boulder clusters in this reach were completely buried with the top foot of one sticking up (Figure A5-53). The boulder structures at both locations were greater than three feet in diameter and were sufficiently large to withstand flows but shifting bedload caused loss of function.

Flood damage at locations further upstream decreased somewhat. At RM 11.7 three of six boulder weirs were still in place (Figure A5-54). The three that had partially failed had lost boulders from the middle of the span. Upstream of the bridge at this location near the convergence with Luther Creek, aggradation had completely filled the rearing pond that had formerly occupied the site. The pond had formerly been 60' X 60' and six feet deep. Structures in Indian Creek above the bridge boulder clusters were also partially buried. Aggradation can vary in a stream like Indian Creek that may have lead to bedload build up where there was back-pressure from the bridge. .

<u>Elk Creek</u>: Major channel change occurred in reaches of Elk Creek treated with in-stream structures. Channel shifts, in some cases, left structures high and dry. Wood structures suffered a high failure rate as cables broke loose from the force of the flood. Large wood was naturally mobilized by high flows, or introduced into the stream channel by debris flows, and huge logjams formed as a result. Boulder structures were pulled apart and partly buried. The amount of bedload and the magnitude of the high flows made survival of even the most well built structures problematic in Elk Creek. The complex log structure in a side channel of Elk Creek shown as Figure A5-55 was of appropriately sized materials and appeared to be excellent fish habitat. Figure A5-56 shows the result of bedload shift, leaving structures in this side channel isolated.

<u>Scott River:</u> The experimental use of partial rock armoring of banks has been widely employed by the Scott CRMP in combination with tree planting. These fall under the classification of in-

Figure A5-51. Upper Beaver Creek, shown here, did not experience the channel change that lower Beaver Creek did as a result of the 1997 storm. Note the wood and boulder structures still intact.

Figure A5-52. Klamath National Forest photo-point taken in 1994 of in-stream cover logs installed in 1992. The wood in this project was not sufficiently large to withstand high flows.

Figure A5-53. This reach of Indian Creek at RM 8.9 was treated with boulder clusters that were buried by the January 1997 storm event. Aggradation at this site must have been at least four feet.

Figure A5-54. Boulder cluster and root wad in the margin of Indian Creek (RM 11.7) that survived the January 1997 storm intact. Photo courtesy of Al Olson, Klamath National Forest.

Figure A5-55. Complex log-cover structure in side channel of Elk Creek installed by Klamath National Forest. Photo courtesy of Al Olson. Circa 1991. Note spawning gravels adjacent to structure.

Figure A5-56. Elk Creek side channel after January 1997 flood with log cover structures isolated from the main flow by shifting bedload.

stream structures and; therefore, bear mention here. These structures withstood high flows in January 1997 with only an approximate 10% failure rate (Gary Black, personal comm.). The one incidence of failure occurred where water from the flood plain of the river scoured out bank armoring. All such bank stabilization projects visited in the field seemed to be providing very good fish habitat as well as having the intended bank stabilizing effect. This far preferable to the former all riprap approach.

Learning From the January 1997 Storm

The Effects of the 1997 Floods on the Klamath National Forest (De La Fuente, 1998) provides an in depth analysis of the types and locations of landslides and road failures on the forest. The January 1997 storm caused catastrophic damage to the road system of the Klamath National Forest (KNF), with over $27 million dollars damage caused. Funding for repair of the roads and other forest infrastructure damaged by the storm is provided through the Emergency Relief for Federally Owned Roads (ERFO) (U.S. Department of Transportation, 1990). Flood damage site, known as ERFO sites, were predominantly road failures and 712 sites were funded for treatment. De La Fuente (1998) considered precipitation, flows, storm recurrence interval, elevation, geology, slope and previous management for links to flood damage. The geographic area of the study was from the Trinity Alps, in the headwaters of the South Fork Salmon River, north through the Marble Mountains and into the Indian Creek and Beaver Creek watersheds in the Siskiyou Mountains.

The storm recurrence interval varied from 14 to 37 years, which indicates that it was not a catastrophic event on the scale of the 1964 flood (100 year). De La Fuente (1998) found that the most severe damage to roads and streams did not necessarily coincide with the areas with the greatest recurrence interval. Over 446 miles of stream channels in the Klamath National Forest were altered by the January 1997 storm event, some sustaining complete scour and others only moderately rejuvenated. Many streams experienced major bedload movement, channel widening and shallowing and changes increases in bed composition, often an increase in fine sediment. Channel widening caused a loss of riparian vegetation that in turn allowed considerable warming in some streams. Shallower streams also are more subject to warming.

The most landslides occurred in the 4000-6000 foot elevation range, triggered by a rain-on-snow event. The greatest flood damage to roads occurred at the 2000-4000 foot elevation levels as debris torrents initiated at higher elevations took out road crossings at lower elevations. While the greatest number of landslides occurred on undisturbed sites (255), there were 243 landslides in recently burned areas, 215 in recently harvested areas (since 1977), 182 along roadbeds and 60 in old harvest sites. It is instructive to look at the number of slides per square mile with regard to undisturbed, burned, harvested and roaded areas (Figure A5-57). Roads had by far the highest failure rate per area of landscape with 7.34 landslides per square mile and burned and recently harvested units yielding similar landslide rates of 1.58 and 1.61, respectively.

Road failures at higher elevations some times were the initial source of the debris torrent. The failure of multiple crossings in one tributary can have catastrophic consequences as

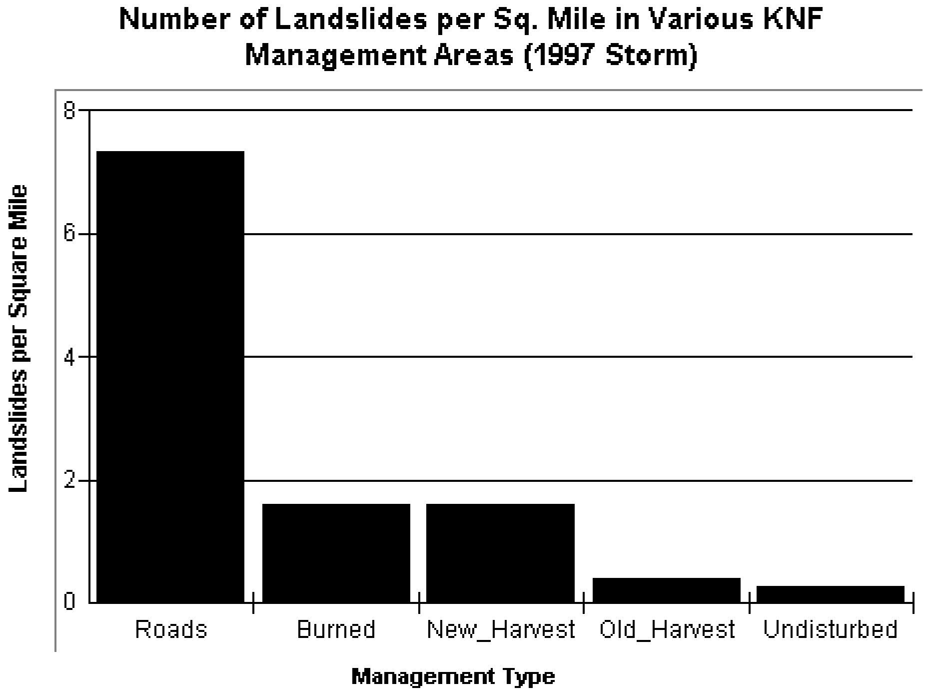

Figure A5-57. The number of landslides per square mile from various land management regimes. Data from De La Fuente (in press)

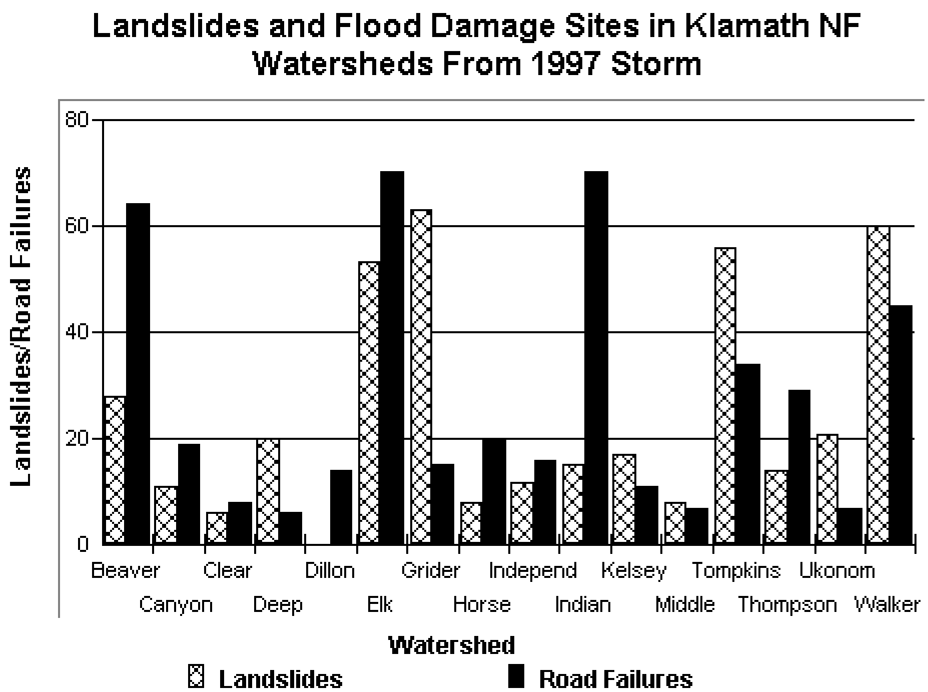

Figure A5-58. Landslides and road failures in various Klamath tributary watersheds. Data taken from De La Fuente (in press).

the fill material at each crossing is added to the debris torrent. Impacts to stream channels often continued into reaches at lower elevations. Many landslides and road failures occurred on old or active landslides or landslide deposits and in the inner gorge area adjacent to streams (De La Fuente, 1998).

De La Fuente (1998) used aerial photos and ground surveys to map landslides and road failures that occurred as a result of the January 1997 storm. Landslide and road failure raw data was not available for use in this study; therefore, estimates of the number of these features by watershed were estimated by counting points on maps. The approximate estimate of landslides and road failures is shown in Figure A5-58.

Fish Screens

While fish screens do not constitute fish habitat improvements, they certainly prevent substantial loss of salmon and steelhead juveniles and have been a major expenditure of the Klamath River Restoration Program. For the most part, the installation and maintenance of fish screens is carried out by the California Department of Fish and Game Screen Shop in Yreka. Funding for this effort has traditionally been provided by federal Sportfish Restoration funds but they have been decreasing for the last decade (Ron Dotson, personal comm.). To supplement staffing for the screen shop, the Klamath Task Force provided funds for positions for two years and, more recently, Proposition 70 funds have been used for the same purpose. The Shasta and Scott CRMP's have also begun to assist in acquisition of funding for and installation of fish screens.

Ron Dotson, supervisor of the Yreka Screen Shop, informed Kier Associates staff that 62 screens are currently installed. Each screen is custom built for the site with the installation aimed at proper sizing and orientation to reduce wear points and maintenance needs. Over 85% of the budget of the shop goes to maintenance of screens and only 15% is available for the fabrication and installation of new screens (Ron Dotson, personal comm.). After the January 1997 storm event, over 2400 hours of staff time were required for screen repairs and re-locations in some cases. On an annual basis, 10 of the 62 screens currently installed must be removed and refurbished, including sand blasting and part replacement. Because farmers and ranchers do not clean fish screens, Screen Shop employees must cover a circuit of 120 miles weekly. If screens are not maintained and cleaned, property owners sometimes remove them (Ron Dotson, personal comm.). Major damage from the January 1997 storm was sustained on fish screens on Grider Creek, Beaver Creek and upper Kidder Creek.

The listing of coho salmon under the Endangered Species Act has increased interest in the farming and ranching community for acquiring fish screens and there is a backlog of landowners that want them in the Scott Valley (Gary Black, personal comm.). The annual goal of the shop is to provide two to four new screens per year but this goal is not always met because of budget short falls (Ron Dotson, personal comm.). Actually, the number of screens in 1990 was estimated at 56 (Kier Assoc., 1991) and the number shown by CDFG is 62 in 1997. Four screens were destroyed in 1997 on Grider, Beaver and Kidder Creeks and only one has been replaced (Ron Dotson, personal comm.).

The Scott River CRMP has attempted to help meet the demand of for additional fish screens by fabricating them locally. Etna High School has been part of this effort that has been going on since 1994. The high school has fabricated screens for smaller streams such as French Creek and Sugar Creek that are of the tube type. These screens have had some problems with maintenance because they are often at remote sites and the design is not self-cleaning. Currently there are efforts to work with high school students to perform maintenance at these sites (Jennifer Davis, personal communication).

Funding for additional screens has recently provided by the U.S. Natural Resources Conservation Service (NRCS) to the Scott River CRMP. Fish screens were also funded by the Cantara Trustees as part of an extensive riparian restoration project on the Scott River below Callahan. The CRMP screens are being designed similarly to those built by CDFG. Design review through NRCS was cumbersome in initial projects but efforts are underway to streamline the process. Thirteen screens will have been completed and installed by the Scott CRMP by summer 1998. All CRMP installed fish screens include an agreement with the local landowner for maintenance (Jennifer Davis, personal communication).

Plumb Creek type fish screens were purchased with funding from the Jobs-In-the-Woods program (USFWS) for installation in the Shasta River. However, these screens have not yet been installed because site-specific problems have to be addressed (Dave Webb, personal communication). The pre-made Plumb Creek screens can work in streams like the Shasta with low current velocity but some problems with the stock design have been encountered. Some sites have water depth of less than 24 inches which is the standard height of the Plumb Creek screen and the pump cannot function with part of the system above water. A 15-inch diameter screen based on the Plumb Creek design was locally fabricated and is currently under design review by NRCS and CDFG. The Shasta CRMP also experienced considerable delays in design review from NRCS that constrained expeditious installation of screens. The CRMP has won 50% cost share funding from the U.S. Agricultural Stabilization and Conservation Service (ASCS) for future projects.