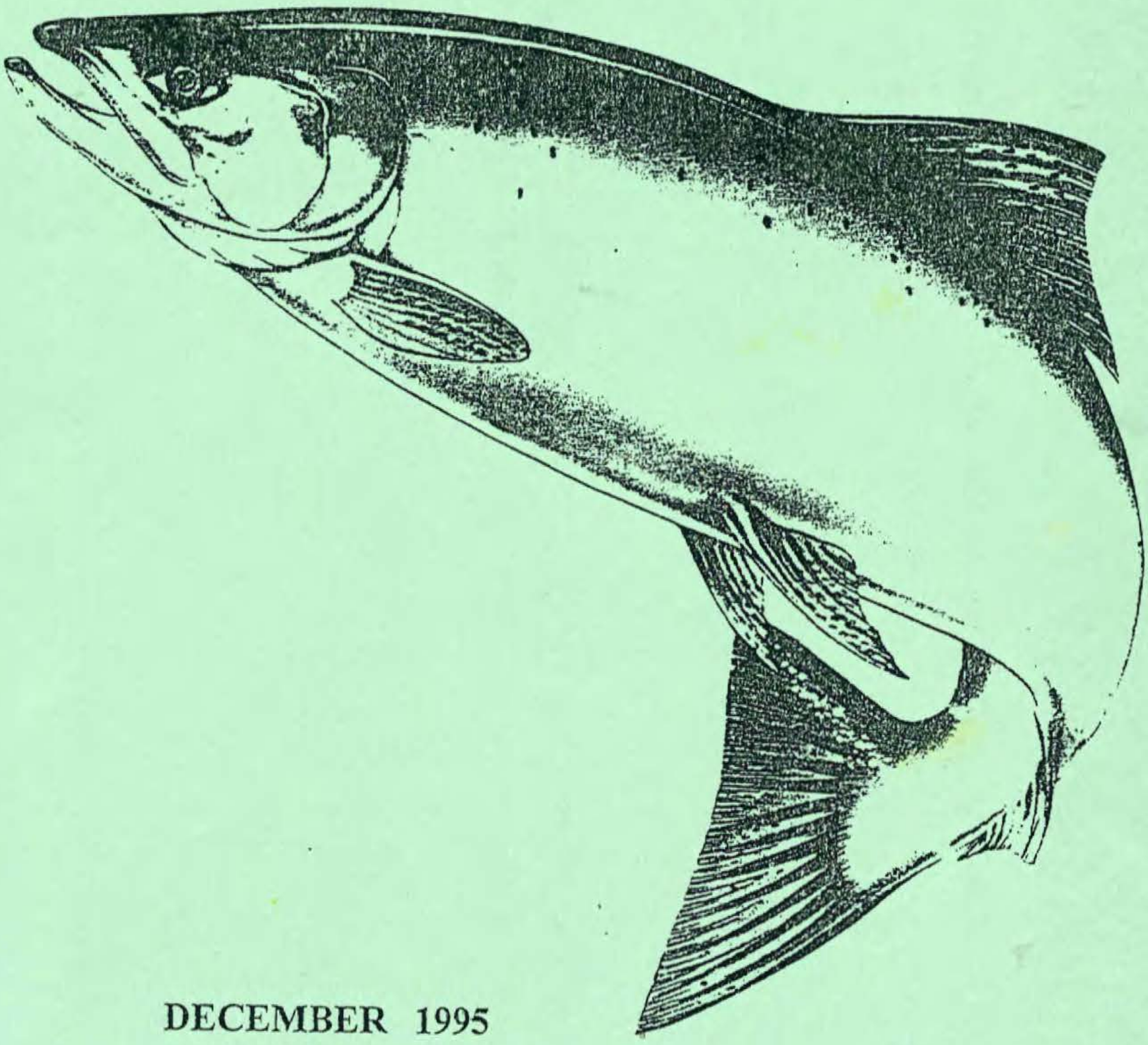
UNITED STATES DEPARTMENT OF INTERIOR
BUREAU OF LAND MANAGEMENT
REDDING RESOURCE AREA

MAINSTEM TRINITY RIVER WATERSHED ANALYSIS



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INTRODUCTION

Background

In April 1993, President Clinton commissioned an interagency scientific team to develop a set of alternatives for management of ecosystems within the range of the northern spotted owl. This effort culminated in the report by the Forest Ecosystem Management Assessment Team (FEMAT) entitled Forest Ecosystem Management: An Ecological, Economic, and Social Assessment (FEMAT) in July 1993 (Thomas, 1993). The report provides the scientific basis from which to implement ecosystem management in the Pacific Northwest. It addresses the species and habitat needs on a regional scale, providing a multi-faceted conservation strategy from which basin-scale, watershed-scale, and eventually site-level restoration planning can be placed in a regional context.

The FEMAT report was utilized as a cornerstone in the development of the Final Supplemental Environmental Impact Statement (FSEIS) for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl. The Record of Decision (ROD) for this FSEIS was signed in April, 1994 (USDA FS and USDI BLM, 1994b). The ROD formalized ecosystem management as the land management policy in the Pacific Northwest.

Aquatic Conservation Strategy

A major component of the Northwest Forest Plan (NWFP) is the Aquatic Conservation Strategy. As defined in the ROD, there are nine objectives for the Aquatic Conservation Strategy:

1. Maintain and restore the distribution, diversity, and complexity of watershed and landscape-scale features to ensure protection of the aquatic systems to which species, populations and communities are uniquely adapted.

2. Maintain and restore spatial and temporal connectivity within and between watersheds.

3. Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations.

4. Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.

5. Maintain and restore the sediment regime under which aquatic systems evolved.

6. Maintain and restore in-stream flows sufficient to create and sustain riparian, aquatic, and wetland habitats and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected.

7. Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands.

8. Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, band erosion, and channel migration and to supply amounts and distributions of coarse woody debris sufficient to sustain physical complexity and stability.

9. Maintain and restore habitat to support well-distributed populations of native plant, invertebrate, and vertebrate riparian-dependent species.

Four components of the strategy include:

1. Riparian Reserves: Lands along streams and unstable and potentially unstable areas where special standards and guidelines direct land use.

2. Key Watersheds: A system of large refugia comprising watersheds which are crucial to at-risk fish species and stocks and provide high water quality.

3. Watershed Analysis: Procedures for conducting analysis that evaluates geomorphic and ecologic processes operating in specific watersheds.

4. Watershed Restoration: A comprehensive, long-term program to restore watershed health and aquatic ecosystems, including the habitats supporting fish and other aquatic and riparian-dependent organisms.

Intent of Watershed Analysis

The intent of watershed analysis is to develop and document a scientifically based understanding of the processes and interactions occurring within a watershed. This understanding, which focuses on specific issues, values, and uses within the watershed, is essential for making sound management decisions. Protecting beneficial uses, such as those identified by the states in water quality standards and criteria under the Federal Clean Water Act, is a fundamental motivation for watershed analysis.

The ROD clearly directs federal agencies to manage ecosystems - all components and species - to protect and sustain the natural systems upon which society depends. Watershed analysis provides a vehicle to efficiently identify and balance multi-species concerns. This requires an understanding of the interactions between land use activities, the physical environment, and the biological environment.
Watershed analysis is not a decision-making process in the traditional sense. It is an analytical process as opposed to a legally-mandated, NEPA-driven (National Environmental Policy Act) legal process. Watershed analysis does not result in a formal decision document. It brings together information which can serve as a basis from which land managers and the public can develop a mutual understanding of processes at work in a watershed.

Context/Scope of Main Stem Trinity River Watershed Analysis

The focus of the watershed analysis for the Main Stem Trinity River is the program of habitat restoration along the river corridor. Habitat conditions evident on the main stem are the result of the interaction of numerous human-induced alterations to natural ecological processes, primarily sediment discharge and flow diversion. The "1994-96 Watershed Analysis Guidelines" provide direction to "support analysis of new and ongoing projects in the initial years of implementation of the President's Forest Plan". For projects proposed in areas where watershed analysis is required, such as Key Watersheds, Riparian Reserves, and Roadless Areas, this direction provides for analyses that are less detailed and are project-driven as long as they comply with specific guidance, as follows:

> The goal of the analysis is to determine whether the proposed actions are consistent with the objectives of the Standards and Guidelines contained in FEMAT.
>
> Existing information will be used to the greatest extent possible, with new information collected, to the maximum extent practicable to fill crucial data gaps.
>
> Analysis will address the entire watershed, even though some areas may be analyzed at a lower level of precision, and the analysis of issues may be prioritized.
>
> Information from the analysis will flow into the NEPA documentation for specific projects, and will be used where practicable to facilitate ESA and Clean Water Act compliance.
>
> Restoration opportunities will be identified.

Though maintaining a focus on the aquatic/riparian ecosystem, the analysis includes upland areas and issues as they relate to mainstem conditions. The analysis provides a holistic view of mainstem issues which would otherwise receive a fragmented analysis through a series of 20 to 200 square mile scale analyses of the subwatersheds of the Trinity system. These subwatershed-scale analyses are being addressed by land management agency efforts and will provide a greater level of detail for other terrestrial issues and restoration opportunities.

This analysis includes the Trinity River and its tributaries from the Lewiston Dam downstream to the confluence of, but excluding, the North Fork Trinity River. For analysis purposes, this unit was segregated from reaches farther downstream by channel substrate and landform, and by the immediacy of the effects of the dam on flows, channel morphology, gravel supply, sediment transport, and riparian conditions.

Issue Identification

To address the need for watershed analysis, the Trinity River Technical Coordinating Committee requested the organization of an interagency team. A broad group of managers and specialists met in November, 1994 to begin an issue scoping-process and to identify core team members for the analysis. At that time a broad issue list was generated and a general strategy for issue development was agreed upon. The watershed analysis team would develop an extensive issue list to insure that all concerns were explored. Using that list, the team would limit the scope to those issues affecting the Trinity River Restoration Program as it has been defined. The analysis would be consistent with the 1994-1996 Watershed Analysis Guidelines for a project-driven analysis.

The team reviewed a variety of previous Environmental Impact Statements/Reports, agency general land use plans, activity plans, the county general plan, and public scoping sessions for the Trinity River Fishery Restoration EIS/EIR (USFWS, Hoopa Valley Tribe, Trinity County) and the Klamath River Basin Assessment (Ecological Restoration Office). From this review, a focus list of six priority mainstem issues were identified for in-depth analysis. The six issues are discussed in Section 2: Issues and Key Questions.

Northwest Forest Plan Land Allocations

The Trinity River main stem from Lewiston Dam to the confluence of the North Fork Trinity includes four Northwest Forest Plan land allocations.

Congressionally Withdrawn
Approximately 7,814 acres of Shasta-Trinity National Forest land within the Salmon-Trinity Alps Primitive Area is Congressionally Reserved, an allocation which, in effect, supersedes Northwest Forest Plan land allocations.

Adaptive Management Area
Approximately 8,499 acres of Shasta-Trinity National Forest land is within the Hayfork Adaptive Management Area (AMA). AMAs are landscape units designated to encourage the development and testing of technical and social approaches to achieving desired ecological, economic, and other social objectives.

Matrix
The remaining federal lands managed by USFS (69,236 acres) and by BLM (53,873 acres) are within the Matrix allocation in the NWFP. Matrix lands are the remaining undesignated lands and comprise the area where most traditional land management activities, such as timber harvest, will occur. Some additional standards and guidelines do apply to matrix lands.

Riparian Reserve
All federally-managed lands contain lands allocated as Riparian Reserves. These reserves are portions of watersheds where riparian-dependent resources receive primary emphasis and where special standards and guidelines direct land use.

Key Watershed
Additionally, all watersheds are allocated to a system of watershed designations which overlay all other allocations. These include Tier 1 and Tier 2 Key Watersheds, and non-key watersheds. These are designed to serve as refugia for maintaining and recovering habitat for at-risk stocks of anadromous salmonids and resident fish species. The Canyon Creek watershed is the only Key Watershed. It includes 23,271 acres managed by USFS and 4,149 acres managed by BLM. Federal ownership includes 97% of the Canyon Creek watershed.

I. CHARACTERIZATION OF THE WATERSHED

The Analysis Area

The Trinity River watershed analysis area lies in the eastern half of Trinity County in northern California. It includes 39.29 miles of the river and all tributaries from the base of the Lewiston Dam to its confluence with the North Fork Trinity River, encompassing 268,299 acres. This comprises approximately 14 percent of the entire Trinity River Basin. The Trinity River flows east to west and is the largest tributary to the Klamath River, joining the Klamath 40 river miles from the ocean. The Trinity basin as a whole is among the three largest California anadromous river systems north of San Francisco, second to the Klamath and similar to the Eel River in volume and drainage area. The analysis area is displayed on the color plate entitled "Trinity River Watershed Analysis Area Land Status".

It lies within the area known as the Klamath Province, including headwater reaches of the Trinity Alps and the Trinity Mountains. The highest point in the analysis area is in the northern headwaters in the Trinity Alps on Sawtooth Mountain, elevation 8,888 feet. The lowest point at the confluence of the North Fork Trinity River is approximately 1,475 feet in elevation. Virtually the entire analysis area is mountainous, with steep V-shaped valleys formed by the tributaries. Only 5.1 percent of the whole Trinity Basin is farmland, most of which occurs in the Hayfork Valley outside the analysis area. Most ridgetop elevations range from 4,000 to 5,000 feet.

Lands within the analysis area are of mixed ownership. The Shasta-Trinity National Forest manages 86,335 acres (32 percent of analysis area) of relatively consolidated national forest lands, including approximately 60,000 acres in the Trinity Alps associated with the Canyon Creek watershed, and smaller tributaries including the forks of Weaver Creek and Rush Creek north of Weaverville. A second major block of approximately 20,000 acres lies southwest of Junction City and drains the north end of the Hayfork Divide. Public lands managed by the BLM total 53,910 acres (20 percent of the analysis area) and have a checkerboard ownership pattern interspersed with private lands. Consolidated areas of BLM land occur only in the Grass Valley Creek watershed, a recent acquisition for watershed restoration, and in the lower Canyon Creek watershed north of Junction City. Of 39.3 miles on mainstem Trinity River in the planning area, 18.5 miles occur on BLM lands, 3.6 miles occur on USFS lands, and 17.2 miles on private lands. Other federal and state lands managed by Bureau of Reclamation (BR) or State of CA comprise 786 acres. Private lands account for 127,721 acres (48 percent of the analysis area).

Natural Processes

Climate over the analysis area can be broadly described as "Mediterranean" in terms of rainfall distribution. Nearly all rainfall occurs within a period of six to eight months centered around the winter season. Winter storms originate over the Pacific Ocean, with the amount and distribution largely determined by local topographic factors. Average annual rainfall varies from 35 to 75 inches with a range of variation, dependent upon location, of 15 to over 100 inches in extreme years. Precipitation will occur as either rain or snow, depending on a variety of factors. Storms from the Pacific Ocean have a "snow level" associated with them, which generally drops as storms move east, away from any moderating effects of the ocean. This relative snow level can vary greatly from one storm to another. Only the highest elevations receive most precipitation in the form of snow, and conversely, only the lowest elevations of the downstream end of the analysis area receive most precipitation in the form of rain. The area falls into a transient-snow/rain zone (AFS Special Publication, 1991). The transient rain/snow zone geography can have a leveraging or dampening influence on the relationship between precipitation and run-off, depending on the temperature of the event and subsequent precipitation and temperature patterns. Warm storms carrying large amounts of precipitation combined with snowmelt can produce extremely high runoff events over large areas of the watershed.

Winter temperatures depend upon the origins of air masses moving across the Pacific, with lows ranging from low teens to below zero at higher elevations. Summer temperature ranges have greater predictability due to the normal summertime location of high pressure over the eastern Pacific. This weather feature effectively blocks the seasonally weaker Pacific storm fronts, leading to a continuous season of clear, cloud-free weather. Warm summer air masses of tropical origin bring occasionally humid summer weather conditions, which create convective weather phenomena, including lightning. The warm temperatures that characterize the dry summer season reflect the lessening of marine influences on the interior landscape. Humid maritime air dries and warmse as it moves easterly over the land mass. Afternoon summer temperatures routinely reach 90 to 110 degrees at lower elevations and up to 85 degrees at the highest elevations. These weather patterns combine with temperature and precipitation regimens to produce a relatively high wildfire frequency interval of 7 to 35 years.

The watershed lies within the Klamath Mountains Geomorphic Province (DWR 1980). Major rocks range from 330 to 125 million years in age (Devonian to Jurassic). Principal geologic features include Copley Greenstone, the Bragdon and Abrams formations, ultramafic rocks, the Shasta Bally batholith, the Weaverville formation, landslide deposits and river terrace deposits. These formations yield four erosive or unstable rock types which affect the watershed. The first type are the ultramafics. Where these rocks are present, serpentine rock occurs, which is readily susceptible to mass movement. The second type, the Weaverville formation, consists of mudstone, sandstone, and conglomerate with an impervious dark green clay matrix. The formation is generally unstable. The third type is the Abrams formation, which is a schist. It is considered stable, but soils which form on this material are highly erodible. The fourth type, granitic rocks of the Weaver Bally batholith, Canyon Creek pluton, Wildwood pluton and the Shasta Bally batholith, are the most erosive of the four rock types and are the major sediment-producing formations. The granitic soils are coarse- textured, easily eroded soils with a predominance of weak bedrock that is easily broken down into sands. On steep slopes the coarse-textured material is highly erodible and produces extremely high volumes of sediment. Concentrated water flowing on this highly erosive landscape results in accelerated erosion. This is most acute where road systems, skid trails, landings, etc. have altered the hydrologic processes on upland slopes. The granitic formations occur in several major tributaries in the analysis area, including Grass Valley Creek, Indian Creek, Rush Creek, Canyon Creek, Reading Creek, Weaver Creek, Browns Creek, Deadwood Creek, and Hoadley Gulch.

The Resources

The upland landscape is characterized by three major forest types. The mixed evergreen conifer forest with chinquapin, madrone, black oak and canyon live oak includes a portion of the Rush Creek drainage and upper sections of Grass Valley Creek, Indian Creek, Reading Creek, and Browns Creek. The Klamath montane mixed conifer forest includes higher elevations north of the Trinity mainstem. The Oregon white oak forest is typical throughout lower elevations along the mainstem and in all but the headwaters of the major tributaries (Kuchler 1977). Extensive south slope areas of the watershed are shrub-dominated. The northern extent of the watershed is noted for its diversity of conifer species, with the center of this richness located just north of the Trinity Alps in the Klamath Mountains. A variety of climatic influences converge in the area, having receded and encroached over geologic time, leaving disjunct populations in remnant microclimates which persist from one period to the next (Fowells 1965).

Characteristic influences include boreal, maritime, continental, and Mediterranean, with aspect and elevation determining the location and extent of these influences.

Wildlife species represent a high degree of diversity, reflecting the influences of elevation, climate, topography, and vegetation. A list of species can be found in Tables 1, 2 & 3 on pages VI-3-23 through 35. Characteristic species of forested areas of the Pacific Northwest are relatively abundant. These include black bear, black-tailed deer, northern flickers and other woodpeckers, alligator lizards, and newts. Numerous species with special status inhabit the Trinity River watershed as well. The California Department of Fish and Game database for the northern spotted owl provides information on 56 known territories for the species in the analysis area (density of one territory per 4,800 surface acres). All three North American accipiters (Cooper's hawk, sharp-shinned hawk, northern goshawk) occur in the watershed. Pacific fishers have been sighted, as have ring-tailed cats and northern flying squirrels. Black salamanders and tailed frogs have been found in the area. Riparian-associated wildlife species also exhibit a high degree of diversity and density. Bird species richness is high compared to other riparian locations in the west. The 127 species sighted during surveys (Table 1; Wilson 1991) include numerous special status species such as the willow flycatcher, yellow-breasted chat, yellow warbler, and black-capped chickadee. Rare raptors are present as well, including bald eagle, peregrine, and merlin. A variety of shorebirds and waterfowl inhabit the analysis area and include herons, egrets, sandpipers, wood ducks, and three species of merganser. The composition of the riparian bird community is likely to have changed as a result of the dam-related increases in acreages of riparian vegetation.

Riparian mammals occurring along the mainstem Trinity River (Table 3) include numerous rodent species, whose distributions are linked to the distribution of riparian vegetation. Larger, semi-aquatic species occur as well, including beavers and river otters. The native herpetofauna (Table 2) includes two candidates for a federal listing: western pond turtles and yellow-legged frogs. Introduced bullfrogs have begun to invade the analysis area, with potentially deleterious effects on native amphibians, fishes, and waterfowl.

The river supports four anadromous fish species: the chinook salmon, coho salmon, steelhead trout, and Pacific lamprey. Historic accounts of huge salmonid runs are typical of the rivers of the Pacific Northwest and are described anecdotally as having spooked horses at river crossings. Chinook salmon pre-dam run sizes or escapement estimates from four years of historic data from 1944, 1945, 1955, and 1956 ranged from 19,000 to 67,115, with a mean of 38,154. Post-dam estimates adjusted to exclude hatchery returns range from 2,551 to 54,921, with a mean of 13,465 (Fredrickson, Kamine, and Assoc. 1980). Resident fish species include rainbow trout, three-spined stickleback, speckled dace, and Klamath small-scale sucker (Moffett and Smith 1950). Eastern brook trout and brown trout have been introduced as sport fish.

Human Imprint

Archaeological research on South Fork Mountain has uncovered human occupation of Trinity County dating back some 8,000 years. The Native Americans in the watershed maintain that their ancestors originated on their homelands in the Trinity River watershed, which would date human habitation of this area back some 50,000 to 100,000 years (personal communication with David Hostler 1994). Two tribes, the Chimariko and the Wintu, most recently lived in the analysis area. It is believed that the Chimariko lived in the lower watershed up to Helena, or perhaps as far as Junction City, while the Wintu lived all along the river from above Trinity dam downstream to Junction City.

The vast reaches of unaltered land and the dynamics of the existing environment were crucial to the lifestyle and spirituality of the native people who lived in this region. The landscape was a reflection of their entire cosmology and it defined a sustainable way of life, which they maintained for millennia. Prior to European entry into this land, the native people's traditional lifestyle was intimately connected to the dynamics of the river ecology and the uplands adjacent to the river drainages. Salmon, which were abundant in the Trinity River, was their main source of meat. Acorns, which were prolific in the surrounding hills, provided their main source of plant food. These primary food sources were supplemented with many other animals and plants that inhabited this region. Once the Europeans arrived, the native population was drastically reduced and the natural environment was altered. European impacts on the native people and the environment made it very difficult for the remaining native people to live a traditional lifestyle.

European man entered the watershed in the 1820's and, in the ensuing 175 years of settlement, completely altered the landscape and the river system. These impacts were generated from mining, logging, the construction of dams, and intensive harvest of the river fishery. Gold was first discovered in 1848 at Reading Bar, near Douglas City. The news enticed a massive movement of miners and settlers into the region. Mining operations literally lined the banks of the Trinity River. The instream gravels were dredged and the river often diverted entirely out of the channel. Huge hydraulic mining operations washed immense quantities of soil from the hillsides into the river. These operations resulted in the first long-term impact to the salmonid habitats of the Trinity River.

The timber industry commenced in the mid-1850's when numerous small sawmills began operating sporadically, usually in conjunction with mining activities. The timber companies at that time used very selective harvest techniques, taking only the largest and most easily accessible trees for the supply of a very localized market associated with the settlement of Weaverville and with local mining efforts. Though logging became an important industry by the mid 1940's, significant volumes were not taken until after WWII, when modernization and improved technologies occurred. Production peaked countywide in 1959 at 439 million board feet (mmbf), but was maintained at 200-300 mmbf through the 1980's. Timber markets served during this time were national, and even international. Extensive road building and logging on steep slopes took place over large areas of the watershed, resulting in accelerated erosion and sedimentation.

In 1963, the Bureau of Reclamation completed the Trinity River Division of the Central Valley Project. The two dams forming Trinity and Lewiston reservoirs resulted in the initial diversion of 90 percent of the average annual discharge in the Trinity River at Lewiston and blocked access to 109 miles of spawning and rearing habitat to migrating salmon and steelhead. The reduced river flows, combined with massive inputs of fine sediment, caused major changes in the morphology of the Trinity River.

The Culture Today

Natural resources in this area have always been critical to the economic and social well-being of local residents. Available resources were actively developed and utilized, providing important economic benefits to the community. Losses in some areas, however, have resulted in concerns over the depletion of resources and/or habitats, which have in turn led to regulations placing limits on resource activities. This required a significant adjustment socially in the county, reducing family incomes and adding to the problems associated with high unemployment rates. The social organization and much of the economy of Trinity County still rely on natural resource utilization, but it is becoming more dependent on recreation and tourism. Two lumber mills continue to operate in the county (down from 28 mills in 1961), along with several gravel mining operations, while recreation-based activities and tourism are increasingly important to the economic health of the county. These latter activities include fishing, swimming, boating, camping, hiking, backpacking, hunting, horseback riding and mountain biking. These activities bring people into the county from other areas as well as attract local residents.

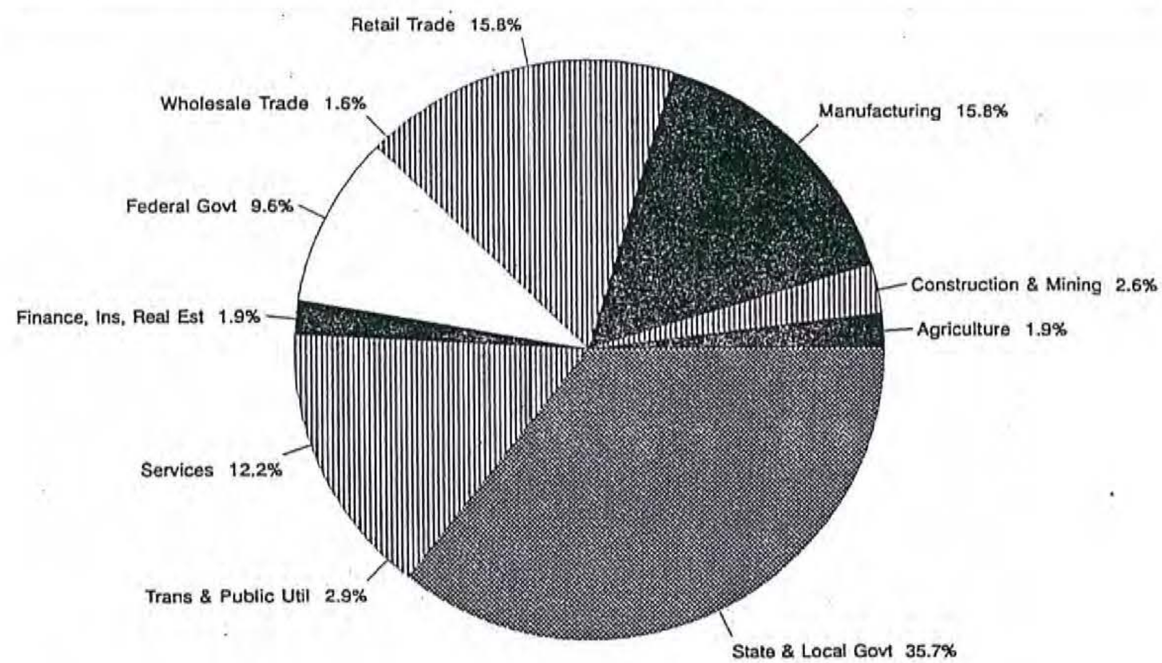
Gold mining is limited to suction dredging in the streambed and is predominately recreational, though there are over 7,000 mining claims across Trinity county (BLM). Construction and mining jobs currently comprise less than three percent of employment, but remain a major institution culturally.

The timber industry has been considered the economic engine for the county since World War II. This sector briefly provided nearly one-third of the direct employment opportunities in the county in the late 1980's, declining by 50 percent by 1994 (EDD 1995). The industry decline in employment stems from a reduction in standing volume available, automation of the industry, and increased environmental regulation. Due to lost employment in this industry, the sentiment of a large sector of the community runs strongly against the imposition of environmental safeguards.

Typical of many small counties in the Pacific Northwest, employment in the government sector at the local, state, and federal level comprises 40 to 50 percent of employment opportunities (EDD 1995). Much of this employment is provided by the US Forest Service and other federal, state and local agencies, as well as jobs related to education. The following chart is a breakdown of jobs by industry in Trinity County for 1994.

Trinity County--Jobs by Industry

1994 Annual Average



Source: Employment Development Department

The Hoopa Valley Indian Reservation, located in northwest California near the mouth of the Trinity River, was established in 1864 by the Department of the Interior pursuant to Congressional legislation (13 Stat. 39). Several court rulings in the 1970's established that an important "Indian purpose" for the creation of the reservation was to reserve to the tribes the right to take fish from the Klamath and Trinity Rivers. More significantly, the courts also established that when Federal reservations are created pursuant to Congressional authority, the federal government reserves the use of such water as may be necessary for the purpose for which the reservation was created. Generations of Hoopa and Yurok Indians have resided on the Klamath and Trinity rivers below the present Lewiston Dam site. They have depended upon the salmon and steelhead fisheries for subsistence, ceremonial, and economic purposes. The fisheries have historically provided the mainstay of the Indian economy in the area and remain of profound cultural and spiritual significance. Today many native people continue to carry on traditional gathering of plants. This must all be done within the context of modern society and is therefore constrained by such things as land use regulations, land ownership, differing cultural perspectives and priorities and the present state of the river ecology.

The Trinity River area offers a variety of recreation opportunities and, since World War II, have spawned an increasingly popular recreation-based industry. Fishing, river and reservoir watersports, hunting, hiking, backpacking, camping, and auto touring draw many visitors and have become a significant source of revenue. Tourism accounts for an estimated 50 to 75 percent of summer and 25 percent of winter business activity along the river corridor (BR 1986).

Fishing opportunities and the commercial enterprises supported by the sport are varied. In addition to the traditional anadromous fishery, the controlling of flows and the resultant habitat changes in the river have created a resident river fishery for brown trout, which has some recreational following. The establishment of reservoir fisheries also resulted from alteration of the river system. Resident rainbow trout, kokonee salmon and warm water species, such as smallmouth bass, attract a diversity of recreationists who support numerous private fishing guides, campgrounds, RV parks, motels, and markets.

The Trinity River Division of the Central Valley Project

The Trinity River Division was authorized by the Trinity River Act of 1955 (PL 84-386) to store water for regulated diversion into the Sacramento Valley for commercial uses. The act also directed the Secretary of Interior to "adopt appropriate measures to insure the preservation and propagation of fish and wildlife". Construction of the Lewiston and Trinity dams/reservoirs was completed in 1963 and fish and wildlife mitigations were addressed by providing for a minimum flow of 150 cubic feet per second (cfs). An immediate decline in the anadromous fish resource was detected, along with changes in channel morphology. Sediment inputs from tributary streams were no longer transported through the system, and extensive riparian vegetation became established over time, covering or blocking water from 95 percent of the naturally open, barren gravel bar area. Residential and commercial developments began to encroach onto the historic floodplain.

Within four years after construction, official efforts were begun to study the problems associated with the dams. A statewide Task Force was established, and their study correctly identified the suite of problems associated with reduced flows, erosion rates, and land use practices. Funding for the Task Force to implement restoration projects was provided in 1974. The Task Force was expanded to 11 and eventually 13 agencies by 1978. There are now 14 agencies, as follows: US Fish and Wildlife Service, US Forest Service, US Natural Resources Conservation Service, US Bureau of Reclamation, US Bureau of Indian Affairs, US Bureau of Land Management, National Marine Fisheries Service, Hupa Valley Tribe, CA Department of Fish and Game, CA Water Quality Control Board, CA Department of Water Resources, CA Department of Forestry and Fire Protection, Humboldt County and Trinity County.

Initial work focused on restoring spawning habitats immediately below Lewiston Dam. A $7.6 million, eight-year appropriation authorized in 1976 greatly broadened the scope of restoration activities. An EIS assessing the benefits of increasing flow releases was completed in 1980 and flows were increased in 1981 by Interior Secretarial decision to a maximum of 340,000 acre-feet per year in wet years. In 1991, a minimum flow of 340,000 acre feet was established. The decision also ordered a 12-year study to describe the effectiveness of the increased flow and the habitat restoration measures. This study commenced in 1984.

Restoration Efforts

The community reliance upon a viable ecosystem, in particular the Trinity River ecosystem, became evident as those dependent upon these resources for their livelihood recognized a decline in both the resources and the resource-based economy. There is a tendency to attribute economic declines to over-regulation and environmental activism. However, the cumulative impact on the anadromous fishery resulting from the construction of the Trinity division have been well documented. This awareness and a strong desire to restore the fishery galvanized a movement to address river restoration.

The Trinity River Restoration Act (PL-98-541) of 1984 recognized that the Trinity Division of the Central Valley Project "substantially reduced the streamflow in the Trinity River Basin thereby contributing to the damage to pools, spawning gravels, and rearing areas and to a drastic reduction in the anadromous fish populations and a decline in the scenic and recreational qualities of such river system". The Act directs the Secretary of the Interior to "formulate and implement a fish and wildlife management program for the Trinity River Basin designed to restore the fish and wildlife populations in such basin to the levels approximating those which existed immediately before the start of the construction... and to maintain such levels." Among specifics of the law, it mandates "Rehabilitation of fish habitats in the Trinity River between Lewiston Dam and Weitchpec,...". The Trinity River Task Force (TRTF), authorized under the Act and funded through a Congressional appropriation, created a ten year Trinity River Restoration Program (TRRP). The TRRP has funded a variety of activities, including upland watershed restoration, instream restoration, fish population monitoring and numerous studies, evaluations, and research aimed.

Upland restoration activities have focused on reducing the sediment entering the Trinity River. Investigations revealed that Grass Valley Creek watershed was a major source of sediment and efforts to trap sediment or prevent erosion have been focused there. BR constructed the Buckhorn Sediment Dam near the middle of the watershed and CADWR built Hamilton Sediment Ponds near the confluence with the Trinity River. TRRP purchased private industrial lands in the watershed and funded an aggressive erosion control program implemented jointly by TCRCD, NRCS and BLM. BLM now manages those lands primarily for erosion control and sediment reduction.

A pilot program of instream restoration projects was started in 1988. The pilot projects developed river side channels and removed streamside berms and riparian vegetation that had resulted from regulated flow regime. The projects were designed to restore rearing habitat for juvenile chinook salmon which was lost due to encroaching riparian vegetation and simplification of the channel morphology. Full implementation of project construction began in 1992, following completion of Buckhorn Sediment Dam. Approximately 25 project sites were developed with TRRP funding on BLM, USFS, and private property. During construction, controversy arose from public concerns for water quality and visual impacts ultimately resulting in cessation of the instream construction projects. In addition to Trinity River instream projects, several habitat improvement projects were constructed in various tributaries.

Restoration efforts on the Trinity River are complicated by a host of concurrent interests, values, and developments. Mechanical channel restoration removes riparian vegetation which is opposed by some river users. This disturbance also affects wildlife species that are dependent on niches in these riparian zones. These disruptions cause temporary turbidity increases, which in turn affect the recreational experience of whitewater boaters and fishermen, and disrupt wildlife habitat.

Residential development encroaches on the original pre-dam floodplain and constrains restoration opportunities. These developments are dependent upon regulated flows to prevent property damage to homes, roads and bridges. Riparian river vegetation which constrains the natural channel dynamics has aesthetic values to residents as well. The Trinity division generates revenue from water and power. Diverted Trinity River water helps support a multi-million dollar agricultural industry in the Central Valley and in the process generates millions of dollars in hydroelectric power.

II. ISSUES AND KEY QUESTIONS

Issues

The previous section described both the legal requirements and current setting for Watershed Analysis in the Trinity River Basin. This analysis focuses on the aquatic/riparian ecosystem, but includes upland areas and issues as they relate to the main stem ecosystem. Six issues have been identified by the Trinity River Main Stem Watershed Analysis Team.

1. **Channel morphology/fluvial processes** - This issue includes the whole realm of processes related to the managed flow regime and the effects on the channel and floodplain. Historic conditions on the main stem were very different than current conditions. The Trinity River experienced seasonal fluctuations in flow, resulting in a channel that had extensive gravel bars and little established riparian vegetation. Natural and human-induced impacts such as mining and logging affected the river system beginning in the mid-1800s. The Trinity and Lewiston Dams have had the most dramatic impact however, by severely limiting the ability of the river to transport sediment and naturally reconfigure the river channel, these dams permanently changed the channel morphology and fluvial processes of the Trinity River by altering seasonal flows. The current flow regime no longer sufficiently flushes sediment in the channel or prevents the establishment of dense, mature riparian vegetation.

2. **Anadromous fish** - Fish populations, their status and condition, and their relationship to the natural and human-induced processes affecting the main stem, comprise this issue. It is well documented that the Trinity River supported abundant anadromous fish populations (salmon and steelhead) prior to dam construction. Significant early impacts to this resource, including mining and logging, reduced yearly anadromous runs; however, the natural flow regimes allowed the river to reorganize salmonid habitat substrate and maintain a dynamic channel morphology. By regulating flows, the dam introduced long-term impacts to salmonid habitats within a few years of its construction. The ongoing alteration of natural flow regimes continues to contribute to the decline of the fisheries today. This fishery decline has not only affected the local economy but impacts commercial, recreational, and Native American economies and cultures downstream and in the Pacific Ocean.

3. **Riparian and aquatic ecosystems** - This issue addresses the conditions in the riparian corridor and the natural and human-induced processes affecting riparian vegetation and riparian-dependent wildlife. The dynamics of the Trinity River system were very different before dam construction, when very little permanent riparian vegetation existed. The aquatic environment evolved around seasonal flushing flows, which moved fine-grained sediment downstream, and frequently removed emerging riparian vegetation. The high flows created in-channel habitat diversity of pools, riffles, runs, and point bars, producing high quality salmonid and amphibian habitat. High winter and spring flows were followed by low late summer flows that served to dessicate seedling that may have developed earlier. Thus, the proliferation of riparian vegetation was effectively and naturally controlled. Salmonids began their life cycle by returning to these diverse habitats during seasonal low flows.

Current conditions depict a much different environment. Mature riparian vegetation is well established, providing extensive habitat for riparian-dependent species. In-channel habitat diversity for salmonids and other aquatic species has been greatly simplified. The mix of wildlife species reflects these habitat shifts. Attempts to restore historic habitats may affect populations of special status or game species, which have become established current habitat conditions.

4. **Upland sediment dynamics** - Vegetation, soils, geology, geomorphology, hydrology, and fire in the uplands are evaluated as they relate to the delivery of sediment to the main stem. The Trinity River Basin is on the southern boundary of a biologically complex area, the Klamath Mountain Province. It supports a wide range of flora and fauna, and is one of the most diverse river ecosystems on the west coast. It has both stable and unstable rock formations, and background sediment loads can be high. Historic basin conditions include periodic wildfires, controlled burning, flood events and seasonal erosion. Other sediment contributors include hydraulic mining and logging. Logging in highly erosive watersheds, such as Grass Valley Creek, dramatically increases fine-grain sediment amounts introduced into the Trinity main stem. This decomposed granite, if not flushed out of the river system, degrades fish habitat by filling in spawning beds and pools. It also provides a substrate for the establishment of riparian vegetation.

5. **Land use practices** - This issue addresses human occupancy and resource utilization as they relate to conditions and processes affecting the main stem. Historically, gold mining was the economic and resource base of the Trinity River basin, and the county. Large-scale hydraulic mining replaced smaller operations on gravel bars, dramatically altering the local topography and introducing enormous amounts of sediment into the river. Small lumber mills sprang up along the river to supply timber for mining infrastructure. Large-scale, intensive logging did not occur until after WWII, concurrent with equipment modernization. The national postwar housing boom spurred increased logging throughout the northwest, which became the primary industry in the river basin. Logging continues to contribute significant amounts of sediment to the river due to existing and new road systems, and certain past logging practices. The construction and completion of the Trinity Dam in 1963, though not a flood control dam, controls river flows to the point where residential encroachment into the historic floodplain has occured. This constrains potential increased flow releases from the dam for fish restoration purposes. The transportation network of roads and highways, necessary to support human occupancy, contributes to sedimentation problems.

6. **Human values** - This issue evaluates human expectations or uses, which are dependent upon or may directly affect main stem riparian and hydrologic conditions. These include recreation uses, Native American traditional uses, aesthetics, economics, and other intrinsic values.

The native people living within the watershed desire conditions that would reestablish the natural dynamics of the entire river system and eliminate some of the fragmentation of the landscape because it would enhance the fisheries and the riparian ecosystem that continue to be of primary importance in their traditional lifestyle.

Issues and concerns have shifted over time as cultural priorities evolve. Resource extraction has been based on the historic European value placed upon the landscape of the Trinity River Basin. Logging and mining have been the economic base of this area. Mining, though important culturally, is now primarily recreational, and timber harvests have peaked and have been declining. Environmental regulation, reduced standing volume and industry modernization have affected timber harvest volumes. Regulations have been established restricting land use and other resource related activities as a result of changing human values. A shift from resource extraction to river recreation and the continuation of Native American fish resource access is occurring. The diversion of Trinity River water to the Central Valley Project is very important to water and power users in agricultural and urban area in California. These factors influence restoration efforts on the Trinity River.

Key Questions

Channel Morphology and Fluvial Processes

1. What is the range of natural variability of channel morphology and fluvial processes?

   What was the natural variability for channel geometry?

   What were the dynamics of the natural floodplain?

2. How have channel morphology and fluvial processes changed over time?

3. What natural events/human activities have caused these changes?

   What effect did construction of the Trinity and Lewiston dams have on channel morphology and fluvial processes?

   How did construction of the Trinity and Lewiston dams affect flood intensity, duration, and how did that affect channel morphology and fluvial processes?

   What were the effects of the historic mining operations on channel morphology and fluvial processes and do they still affect the river today?

   What were the effects of logging and road-building on channel morphology and fluvial processes?

   Have pilot channel modifications been effective in restoring stream channel morphology, fluvial processes, and anadromous fish populations?

   How has human settlement affected channel morphology and fluvial processes?

4. What processes and conditions related to channel morphology/fluvial processes are necessary to mimic or achieve conditions which are within the natural range of variation?

   What are the key elements necessary to re-establish river floodplain function, channel dynamics and diversity?

5. What are the constraints and/or opportunities for restoring the channel morphology and fluvial processes to its natural range of variability/desired conditions?

Anadromous Fish

1. What is the range of natural variability of anadromous fish populations and their habitats?

2. How have fish populations and their habitats changed over time?

3. What natural events/human activities have caused these changes?

4. What processes and conditions related to fish populations and their habitats are necessary to mimic or achieve conditions which are within the natural range of variation?

5. What are the constraints and/or opportunities for restoring fish populations and their habitats to their natural range of variability/desired conditions?

Riparian and Aquatic Ecosystems

1. What is the range of natural variability of riparian and aquatic animal and plant species and their habitats?

   What biotic and abiotic conditions and processes lie outside the natural range of variation as a result of damming, and how have riparian and aquatic wildlife species adapted to these?

2. How have riparian and aquatic animal and plant species and their habitats changed over time?

3. What natural events/human activities have caused these changes?

4. As a consequence of the dams, what biotic and abiotic ecological conditions or processes lie outside the natural range of variability?

   What upland ecological processes must be restored to increase upland seral stage diversity?

   What upland ecological processes must be restored to increase upland seral stage diversity?

   How can a natural upland disturbance regime be reinstituted?

5. What are the constraints and/or opportunities for restoring biotic and abiotic processes and conditions for riparian and aquatic animal and plant species and their habitats?

   What are the physical constraints associated with the dams?

   What are the social constraints and regulatory constraints?

   What are the biological constraints?

   What are the available opportunities for restoring biotic and abiotic processes and conditions for riparian and aquatic animal and plant species and their habitats?

6. What are desired future conditions for riparian and aquatic animal and plant species?

7. Which threatened and endangered species occur in the riparian and aquatic ecosystem?

Upland Sediment Dynamics

1. What is the range of natural variability of tributary sediment inputs into the Trinity River?

2. How have tributary sediment inputs changed over time?

3. What natural events/human activities have caused these changes?

4. What is the desired condition for tributary sediment inputs of the Trinity River?

5. What are the constraints and/or opportunities for restoring the desired condition for sediment inputs from tributaries to their natural range of variability/desired conditions?

Land Use Practices and Human Values

1. What land use practices have occurred in the watershed?

   How have land use practices affected the physical and biological processes of the river system?

2. How have land use practices changed over time?

   How have these changes affected the physical and biological processes of the river system?

   How did Native Americans manage the landscape prior to European settlement?

   What were the primary land uses affecting the physical and biological processes of the river system during European settlement?

   What key physical and biological processes of the river system were affected by the modernization of logging following World War II?

   How were the land use impacts from mining and logging compounded by the construction of the Trinity Division?

3. What are the causes for changes in land use practices?

   What economic and social factors have been determinant for land use practices?

4. What are the human expectations for major land uses affecting the river?

   How do these expectations constrain or enhance opportunities for restoring the physical and biological processes of the river?

   What are the human expectations for resource conditions of the river system and fishery?

5. What are the constraints/opportunities for meeting land use expectations?

III. CURRENT CONDITIONS

This section describes the current conditions in the analysis area organized by issue. Under each issue, ecological elements are briefly described and the relationship to other issues, relevance to the ecosystem, and economic significance are discussed. The presentation format is intentionally brief, focusing only on relevant ecosystem connections in order to avoid redundancy with other parts of the report, which describe interdependencies and cause and effect relationships thoroughly.

Channel morphology/Fluvial processes

The current flow allocation from Lewiston Dam on the Trinity is a maximum of 340,000 acre feet/year. During the past few years flows up to 6,000 cfs have been released for several days' duration. The average annual stream flow of this watershed from 1912 to 1960 was about 1.2 million acre feet. Stream flow magnitude and seasonal distribution play a major role in determining aquatic habitat quality and quantity, channel configuration, sediment transport capacity, and riparian habitat quantity and characteristics. The stream flow distribution affects seasonal temperature variations, sediment transport, channel morphology, riparian germination and survival, and various life cycle triggers of aquatic species. The reduced flow has caused profound changes in the ecological communities mentioned above and hampers efforts to make real progress towards fishery restoration. Flow allocation decisions have widespread economic significance both to the recreation industry within the basin and to beneficiaries of water and power resulting from Trinity River water diversion through the CVP. Figure III-1 constrasts mean monthly flows before and after dam construction.

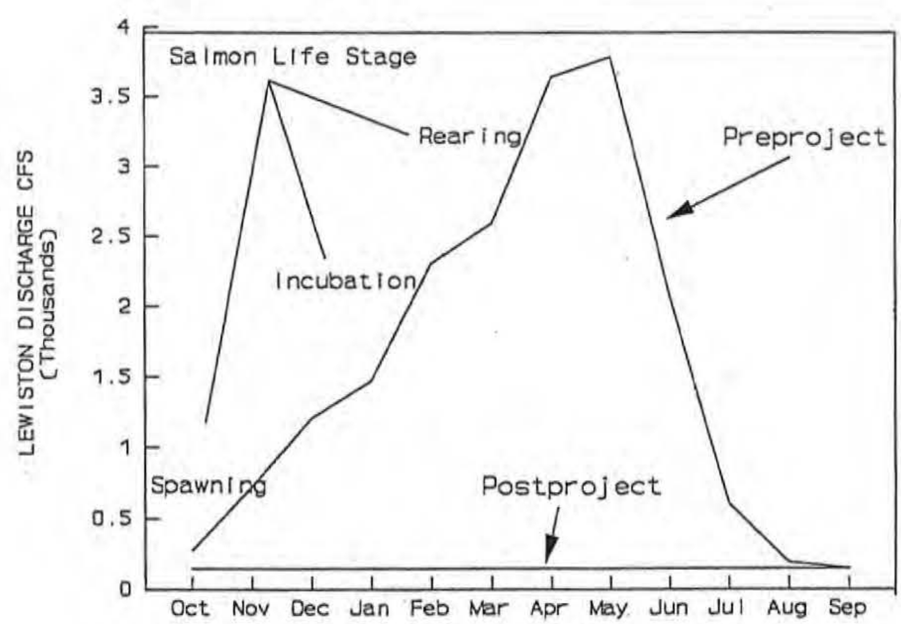


Figure III-1:. Pre and post-project mean monthly flow in the Trinity River at Lewiston. Note salmonid life history coincidence with streamflow. (from USFWS 1994).

Sediment berms covered with mature riparian vegetation line the channel for most of the 40 mile reach in the analysis area. The river is severely channelized and restricted by sediment berms, which have reduced the actual open water area by 45 percent and decreased the accessible gravel bar area by 95 percent. These changes in channel morphology and the loss of flow diversity and channel dynamics have had numerous impacts on aquatic and terrestrial habitats. Increased water velocity and depth and decreased channel width have reduced rearing and spawning habitat. The concurrent increases in riparian habitat are discussed in that issue. Recreational access is limited by the dense vegetation which lines the channel, a phenomenon which has had a positive impact on the local drift boat fishing guide industry. Figure III-2 shows the compositional change along the riparian corridor between 1960 and 1989. Sixteen color plates entitled "Trinity River Riparian Vegetation", graphically display conditions in 1960 and 1989.

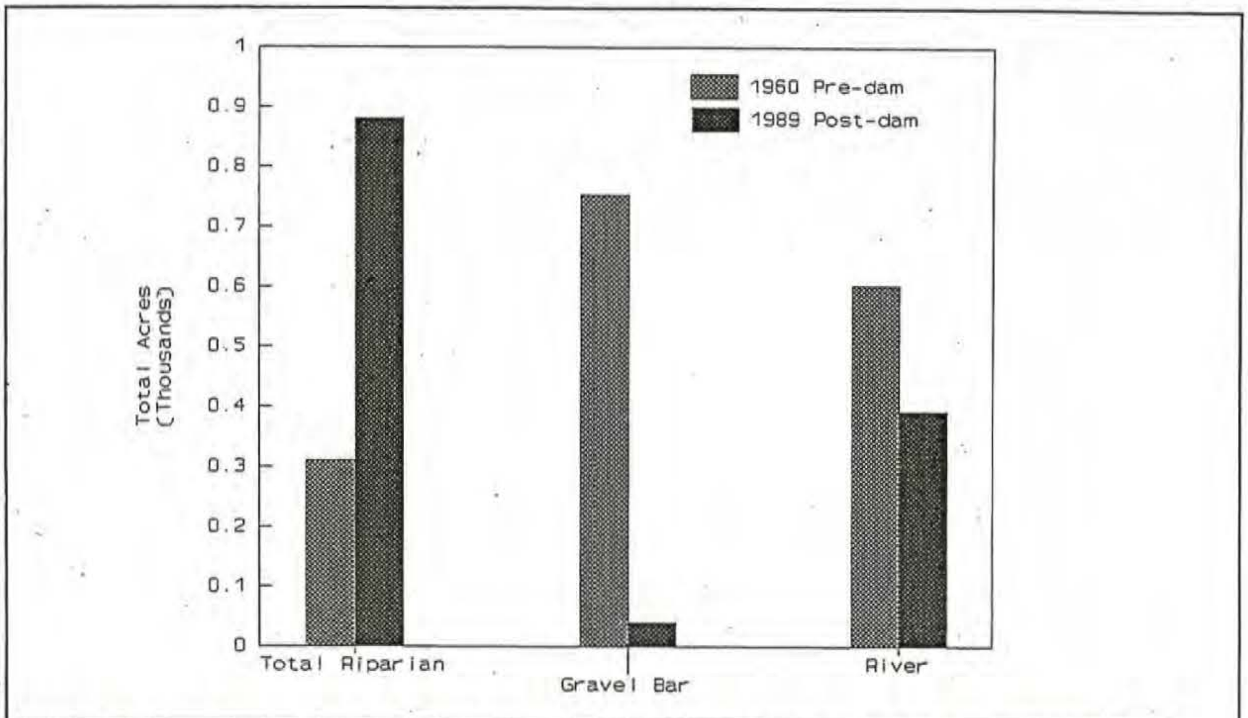


Figure III-2. Comparison of riparian vegetation, gravel bar, and open water habitat between 1960 and 1989 in the upper Trinity River (Wilson 1993).

Current water releases are of insufficient magnitude and duration to flush the sediment input from the tributaries or mobilize the streambed. Prior to dam construction, natural high flows resulting annually from storm runoff and spring snow melt flushed sediment through the main stem channel and mobilized the streambed, maintaining dynamic, high quality aquatic habitat. Figure III-3 compares sediment discharge from Grass Valley Creek versus the Trinity River at Limekiln Gulch, 12.7 miles downstream of Lewiston Dam.

The current flow regime does not mimic the natural flow regime under which the channel conditions and biologic community evolved. The seasonal variations in flow of the natural system shaped the conditions in the stream channel and influenced the timing and distribution of various life stage events of species dependent on habitat the river provides. Flow regulation, which varies considerably from the natural regime, has had negative impacts on those species and channel conditions under which those species evolved.

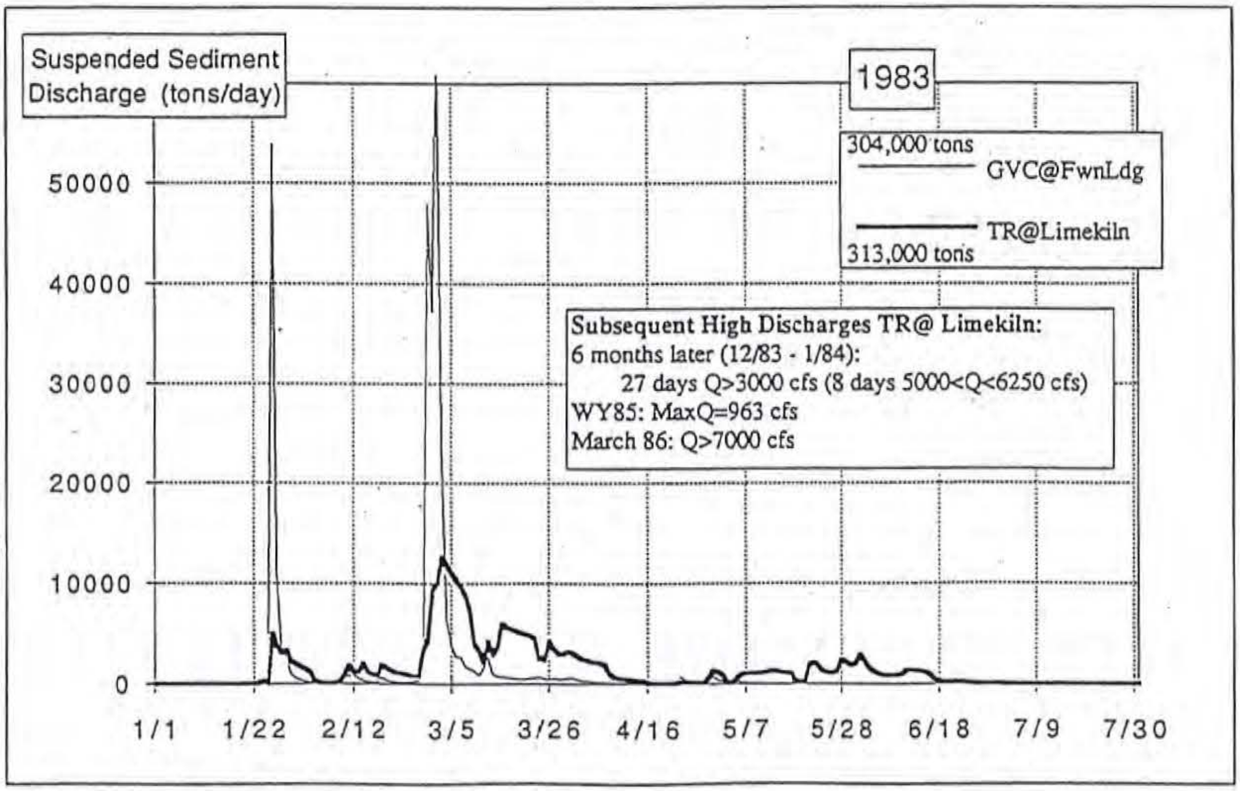


Figure III-3: Water and sediment discharge for the Trinity River and Grass Valley Creek: January-July 1983 (Wilcock, 1995)

The coarse channel substrate is embedded with sand. Under natural conditions, the channel substrate was mobilized by annual high stream flows and remained relatively free of sand, providing high quality habitat for the various life stages of anadromous salmonids and invertebrates. The currently degraded habitat and reduced source of invertebrates limits the productive capacity of the river. The recreational and commercial fishing industries have suffered economic losses due to fish population reductions resulting from habitat losses and other factors.

Urban development has encroached onto the 100 year flood plain since construction of the dams in 1960. Prior to construction this floodplain flooded at least every other year. Construction on the flood plain has created the potential for economic loss and public safety hazards during stream flows exceeding 6,000 cfs. Regulated flow has provided economic and aesthetic opportunities for a few people, but limits flow management which could benefit the fishery and a much larger segment of the public.

Anadromous Fisheries

Numbers of chinook have declined overall since construction of Trinity and Lewiston dams, although there has been extensive variation in run size during this period. Spring chinook generally begin entering the basin, as they did historically, in late spring and early summer and begin spawning in early to mid-September. The fall run of chinook salmon is presently the dominant run (numerically) in the Trinity River. This run generally enters the analysis area during late summer or early autumn (September to October). They reach sexual maturation quickly and usually begin spawning in October. Although the spring run begins spawning earlier, there is some overlap of spawning activity between the two runs.

Presently, coho salmon and steelhead occur throughout the main stem as well as in may of the tributaries. Coho enter the analysis area during fall and spawn from late fall to early winter. Steelhead enter the basin during several months of the year and most spawning in the analysis area occurs in early winter. Steelhead populations have continued to decline for several years in the Trinity basin even though they have been protected from commercial harvest for several years. The life cycle of steelhead trout, coho and chinook salmon is presented in Table III-1.

Table III-1:The Life Cycle of Trinity River Steelhead Trout, Coho and Chinook Salmon.

Fish Species or Run	Steelhead Trout (Summer Run)	Coho	Chinook Spring-Run	Chinook Fall-Run
Principal Months Adults migrate into fresh water to spawn	August through March; peak Oct-Nov (April-June)	Early September through January.	April through October.	August through December
Principal Spawning Months	February through April. (Dec-April)	November through January.	September through October.	October through January. Peaks in November.
Eggs in gravel, time related to water temperature	80 Days at 40F incubation	1-3 months	3-4 month incubation	3-4 month incubation
Alevins in Gravel	2-3 weeks	4-10 weeks	2-3 weeks	2-3 weeks
Max period in gravel	February through late July (Dec. through late Aug.)	November through mid-May.	Late September through late February.	October through late March.
Length of time fry stay in fresh water	1-2 years, majority at 2 years (1-3 years)	1 year 10-13 cm	About six months, move to estuary in October-December or first rains.	About six months, move to estuary in October-December
Smolt migrate from freshwater to the sea	end of March to early August	end of February through mid-June; peaking in April.	April - June & Oct. - Nov.	April - June & Oct. - Nov.
Length of ocean life	1-3 years (3-5 years)	1-3 years, most 2 years in the ocean (age 3 yrs)	2-4 years, today most return after 2 years	2-4 years, today most return after 2 years

Summer Steelhead trout runs have been recorded from the North Fork Trinity River, New River (tributary to the Trinity), South Fork Trinity River, and Canyon Creek.

The Trinity River hatchery was constructed in order to mitigate the loss of salmonids that were historically produced above the dam sites. Each year, the hatchery artifically spawns returning adult chinook and coho salmon and steelhead. Numbers or returning adults have varied widely with each species since the hatchery began operation. Returns of chinook salmon have ranged from 2,586 to 36,386: coho returns have ranged from 12 to 23,338, and steelhead returns have ranged from 13 to 6,941. Numbers of juveniles released from the hatchery have varied as well. Recent releases (1991-1995) for fall run chinook fingerling have ranged from 202,275 to 2,342,037; spring run fingerling releases have ranged from 828,406 to 1,498,015. For the same time period, coho and steelhead yearling releases have ranged from 384,555 to 627,739 and 323,791 to 1,158,171 respectively.

Fish habitat in the analysis area is limited by reduced flows and the physical condition of the Trinity River and its tributaries. Historical spawning beds composed of clean gravel and cobble have become embedded with fine sediment deposits. Access to shallow water rearing habitat once abundant on gravel bars is blocked or buried by sediment berms which line both sides of the river and by the loss of gravel recruitment resulting from the dams. The habitat losses resulting from the sedimentation of the river channel have reduced the reproductive carrying capacity of this portion of the Trinity River. Table III-2 displays habitat types and their importance to fish life stages.

Table III-2: Important Steelhead and Salmon Habitat that is Limited in the Trinity River Basin and the Time-frame the Habitat is Most Critical.

Habitat	Importance	Critical Time-frame
Shallow water along stream or river margins.	After salmon fry emerge from gravel they require slow water habitat in order to avoid being washed downstream and avoid being eaten by larger fish. This habitat is very important energy (food) production site. Shallow water is the most productive area in an aquatic ecosystem and it produces the insects that are the size young fish can eat.	December through August
In Tributaries - Deep (1 + m) well shaded pools. Best with large amounts of woody debris.	As fry grow bigger they soon set up individual territories in pool areas. The larger ones tend to occupy the heads of pools; the smaller ones are found further down the pools. These pools are critical holding areas for summer-run steelhead and spring-run chinook.	All year
River run habitats with large cobble substrates without excessive sedimentation.	Juvenile steelhead rely on clean large cobble substrates for cover habitat during the winter. Excessive sedimentation in the main stem Trinity River has nearly eliminated these cobble habitat areas. Chinook juveniles also require this cobble habitat because it provides water velocity shelters.	July - March
Beds of loose coarse spawning gravel at the heads of riffles or tails of pools with cover nearby for adults. With less than 25 percent fines, depths of 20-120 cm, and mean water-column velocities of 20-40 cm/sec^{-1}. Steelhead gravel range from 0.64 to 13 cm. Chinook and coho gravel range from 5 to 15 cm in diameter	Steelhead, coho, and chinook require clean, cool water over gravel for successful spawning and egg incubation. The construction of the Lewistown dam has closed 109 miles of spawning habitat and reduced flow in the main stem Trinity which limits its ability to flush sediment.	Septembe r through July

Trinity and Lewiston dams are migration barriers which block salmon and steelhead from 109 miles of suitable reproductive habitat. The loss of this habitat has contributed to the reduction of fish numbers. Spring chinook which historically "summered-over" in deep pools between Lewiston and Stuarts Fork are now limited to pools below Lewiston which have partially filled with sediment. Summer releases from Lewiston reservoir are artificially higher than historic levels in order to provide cool water for the spring chinook adults.

Introduced fish species include brown trout, brook trout, and three-spine stickleback. The effects of introduced species have not been thoroughly studied in the Trinity basin. Brown trout compete directly for food and cover with all native salmonids in the river. Brown trout become territorial and larger fish tend to dominate areas of suitable habitat. Direct mortality results from brown trout preying on juveniles of other species including salmon and steelhead.

Riparian and Aquatic Ecosystems

Mining on the main stem Trinity River produced changes in the landscape that are still visible today and influence the distribution of wildlife. Hydraulic mining in the late 1800's and early 1900's produced lasting alterations from excavation of entire hillsides. Mining tunnels currently provide cover for terrestrial species, such as bats, which roost and overwinter in the shafts. Dredge mining in the mid 1900's created terrace pools some of which harbor western pond turtles and/or migratory fowl. These ponds may also facilitate the spread of non-native bullfrogs, which inhabit lentic waters.

Acres of riparian vegetation along the main stem Trinity River increased by 282 percent between 1960 and 1989 as an indirect result of the dams. The regulated stream flow prevents the removal of young riparian plants that historically would have been removed from gravel bars by high winter flows. Also, riparian seedlings receive year-round irrigation, in contrast to natural conditions of summer desiccation. The combined result is the establishment and maintenance of willows and alder in later seral stages, with the accompanying loss of open water and gravel bar habitats. These changes in the distribution of riparian vegetation have a wide range of effects on wildlife species. Riparian-dependent birds and mammals, such as the willow flycatcher and muskrat, are likely to have increased in number. Other species that require shallow edgewater habitats, such as wading birds and yellow-legged frogs, are likely to have decreased.

The Trinity River has also changed structurally as a result of the dams. Whereas winter flooding flows used to wash woody debris and sediment downstream, they now accumulate in slow-flowing areas. Piles of woody debris provide cover for numerous species, including salmonids, western pond turtles, and beavers. However, accumulated sediment fills pools, resulting in the loss of deep, cool-water refuges for fishes and turtles. Below the confluence with Grass Valley Creek, sediment buildup is particularly acute, and the composition of aquatic invertebrate populations appears altered. Coarse sand fills the interstitial spaces of gravel and cobble substrates, which are the sites of invertebrate production. Because invertebrates form the base of the riverine food chain, such alterations can have ramifications throughout the system.

To mitigate for the dams' preclusion of annual flooding flows and elimination of fish habitat, a program of artificially high flows was instituted. The timing of these flows, to the degree that it varies from natural conditions, has impacted amphibians and reptiles. Frog egg masses deposited during the spring were washed downstream by subsequent flow boosts (Lind 1992). Artificial flows also generate lower water temperatures during the summer months than under natural conditions. Ectothermic ("cold-blooded") wildlife species respond to temperature changes. For example, juvenile steelhead and coho salmon are likely to grow more slowly, as are amphibian and aquatic reptile larvae. Cool waters might retard egg development and/or delay metamorphosis of amphibians with consequent impacts on reproductive success.

Efforts to restore the main stem Trinity River with respect to spawning salmonids have included mechanical manipulations of the channel. The side channels and feathered edges, which mimic the conditions available prior to the dams, incidently provide habitat for wildlife that utilize shallow edgewaters. These include yellow-legged frogs, which have deposited eggs in the manipulated sites, as well as hatchling western pond turtles, which occupy slow-flow habitats. The manipulations may also provide foraging areas for wading birds and semi-aquatic mammals.

Overall, conditions have become more stagnant in the main stem Trinity due to disruption of the natural processes that renew habitat. Bar migration is restricted, vegetation scour moderated, and sediment transport reduced. The long-term consequence may be lowered spatial and temporal diversity of habitats. Wildlife diversity may decline as particular habitats, such as unvegetated gravel bars, become scarce.

__Upland Sediment Dynamics__

Geology and soils interact with vegetation, climate, various land disturbances and stream channel sediment transport characteristics to produce sediment. Highly erosive granitic soils constitute 17 percent of the analysis area and are distributed over eight tributaries. Estimates indicate that these areas produce 72 percent of the sediment reaching the Trinity main stem. Figure III-4 displays the sources of sediment. Land use activities which modify drainage patterns or remove vegetative cover in these highly erosive areas can greatly accelerate erosion and sedimentation. Efforts to curb sediment production and delivery are concentrated in these geographic areas.

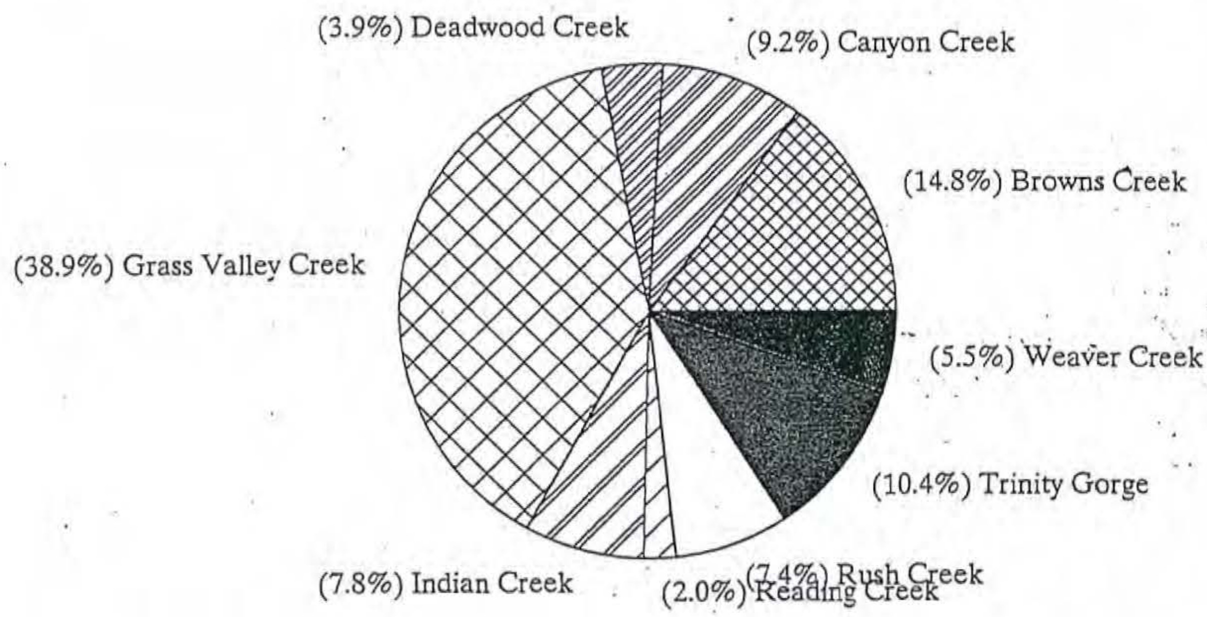


FIGURE III-4: Estimate of Sediment Contributions from Significant Sediment-Producing Tributaries.

Granitic sediment produces the size fraction which is most detrimental to the aquatic habitat in the Trinity river. Granitic soils contain a high percentage of sand, a sediment which becomes embedded in the river bed, destroying aquatic habitat. It is the major particle constituent of the sediment berms deposited on natural gravel bars along the river. Non-granitic soils dominantly have very gravelly loam and very gravelly clay loam soil textures, which produce a bimodal distribution of sediment. The fine size sediment component remains suspended and is transported down the river. The coarse size sediment component constitutes the gravel fraction which is beneficial to the aquatic ecosystem. This coarse sediment is currently in deficit, an indirect result of the Lewiston and Trinity dams.

Two tributaries, Grass Valley Creek (GVC) and Canyon Creek constitute 65 percent of the granitic areas. Land management in GVC has undergone drastic changes in the last few years. Since 1993 GVC has been dominantly publicly owned and managed for erosion and sediment control rather than timber production. Granitic soils in the Canyon Creek watershed are publicly owned, are managed as wilderness area, have few roads and consequently experience low erosion rates considering the high erosion hazard. Erosion control activities in GVC have reduced the long term sediment production capacity by about 50 percent and land management goals have changed from timber production to erosion and sediment reduction. These measures should gradually reduce erosion to the natural range of variability.

Vegetation in the analysis area consists of coniferous and hardwood forests, montane chaparral and riparian. Large, severe wildfire events destroy vegetation and leave the soil susceptible to severe erosion. Erosion following fire can produce large sediment influxes to the tributary streams which may be transported and deposited in the main stem Trinity River.

The suppression of wildfire has resulted in the buildup of fuel throughout the analysis area and has increased the potential for large scale fires, which burn with greater intensity than under "natural" conditions and generally result in greater resource damage. Large scale watershed disturbance such as wildfire can result in soil hydrophobicity, loss of vegetative cover, increased runoff and severe erosion and sediment production, which may damage aquatic habitat.

Current land use activities which constitute the greatest sedimentation hazards are logging and the transportation network. Logging disturbs the natural equilibrium by removing vegetative cover and altering the natural drainage pattern through road construction. Logging practices which minimize the impacts of these phenomena, such as helicopter yarding and retention of the maximum vegetative cover practical, can reduce erosion and sedimentation resulting from this land use. Transportation network design, location and maintenance can reduce the sediment production and delivery. The logging and wood processing industry is a major employer in the area.

Land Use Practices and Human Values

Land use in the Trinity River watershed continues to be limited by the mountainous terrain and dispersed ownership of the land. With much of the land in forests and publicly owned, logging remains an important use. Other major uses of the land in the watershed are recreation, housing, mining and road networks. Along the Trinity River, private property ownership and development has increased. All of these land uses have resulted in ecological and economic impacts within the watershed and have helped shape human values and expectations.

Logging, conducted extensively throughout the tributaries except Canyon Creek, has significantly modified natural conditions. Most of the forested areas have been cut at least once and many areas twice. Logging intensified as technologies improved and roads were constructed in unstable locations, increasing natural erosion rates. Certain logging practices such as tractor logging and poor road construction may increase erosion and sedimentation, alter runoff characteristics and destroy aquatic and terrestrial wildlife habitat. The decline in logging in recent years has negatively affected the economy of the area, as this community has been resource-dependent. Figure III-5 illustrates the declining trend of timber harvest volume in Trinity County.

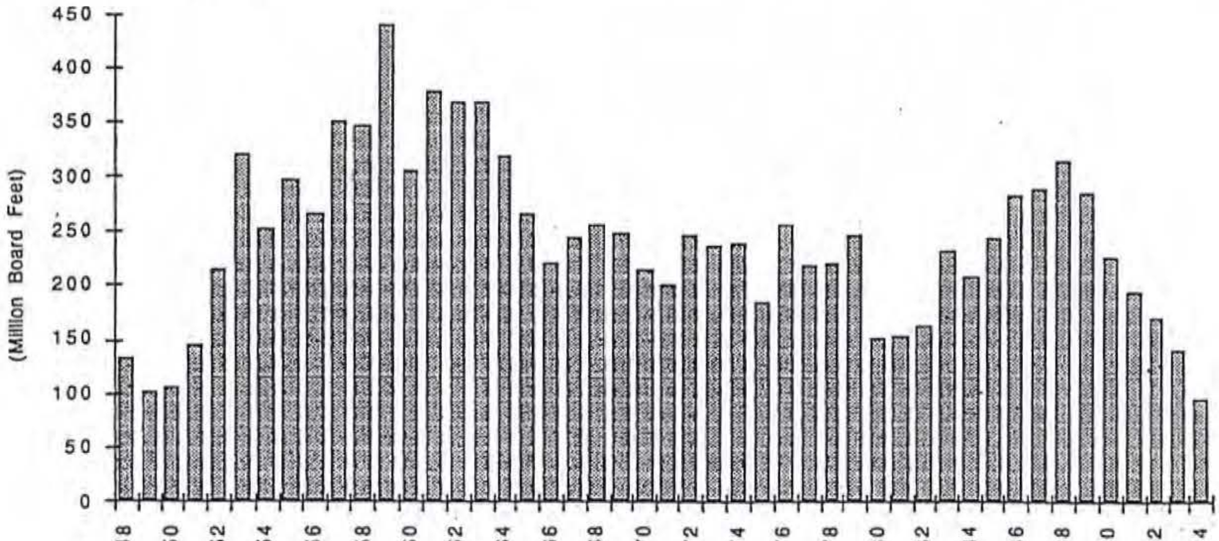


Figure III-5: Timber harvest volume in Trinity County between 1948 and 1994.

Recreational fishing is important on the main stem and many tributaries. The economic value of sport fishing is significant and provides employment to many residents and recreation for visitors, and benefits the owners of resorts, motels and restaurants. This industry is dependent on a healthy productive fishery, and the decline of the fishery has negatively affected these businesses.

Water sports, such as rafting and boating, occur on the main stem during the summer months. Water sports draw needed tourism dollars and are dependent on clean water and adequate stream flow during the summer. Attractive scenery along the stream corridor is important to these river users as well. Camping and hiking uses occur on the main stem and in tributaries and are dependent on maintenance of high visual quality. Maintained trails and camps attract visitors to this area because of the beauty, relative remoteness and uncrowded atmosphere. Recreation is economically significant in this area.

Water diversions for local consumption occur on the main stem and many tributaries. Local water diversions meet residential water needs and are dependent on clean abundant supplies. This activity has minor impacts basinwide except in Weaver Creek, where diversion greatly reduces the late summer flows between Weaverville and the Trinity River, reducing the habitat and productivity of the Weaver Creek fishery.

The Trinity Division of the CVP diverts and exports an average 800,000 to 1,000,000 acre feet/year to the Central Valley Project. Water export for agricultural consumption, urban uses and power generation supports a multimillion dollar industry and provides employment for thousands of people living in the California's Central Valley. These water diversions have initiated huge changes in the main stem ecology, resulting in detrimental effects on many habitats and enhancement of those dependent upon late seral riparian vegetation.

Mining occurs in the main stem and Canyon Creek as suction dredging and in a few tributary watersheds as placer mining. Most of the historically productive commercial mines are now idle, but have had considerable impact on the watershed in the past. Mining activities provide part- and full time employment for a few residents and recreational opportunities for tourists. Mining can have a negative impact on the fish habitat if conducted in the wrong location or at the wrong time of year.

Regulations have affected land use practices and are a result of human values as impacts of certain practices have become recognized. Mining regulations attempt to mitigate for the problems mentioned above, while regulations associated with timber harvests are attempts at protecting what is considered valuable to society, such as endangered species. The regulations currently in place are due in large part to increased awareness of environmental concerns facing society. Regulations have become more stringent over times which has resulted in reductions in resource extractions. However, the increased amount of regulations aimed at protecting resources has created conflict in a community that is so vitally resource-dependent. The impact of these regulations are felt significantly since the job market is often reduced as a result and unemployment is already very high for the area compared to the rest of the state. Figure III-6 compares the unemployment rate in Trinity County to that of California between 1983 and 1994.

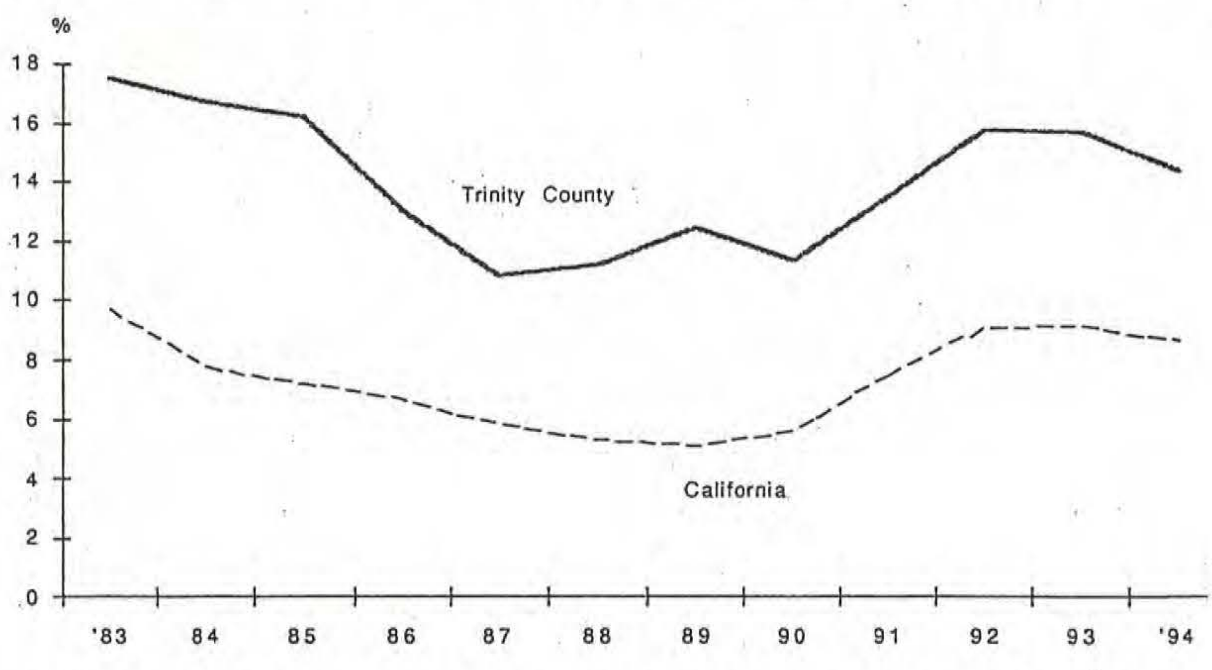


Figure III-6: Unemployment rates in California and Trinity County between 1983 and 1994.

Residential development in the floodplain of the main stem Trinity River in several small areas has occurred and benefits a small number of citizens. This encroachment limits the magnitude of beneficial stream flow releases. During stream flow releases exceeding 6,500 cfs, flooding of homes, structures, some bridges and roads occurs. This could be a limitation on the amount of increased flows allowable for fisheries enhancement. Further encroachment onto the Trinity River 100-year post-dam flood plain (8500cfs) is no longer allowed.

A transportation network of paved and unpaved roads traverses most tributaries and the main stem corridor. The transportation network which is essential to human interests creates erosion, sedimentation and stream course diversions, which negatively impact ecological conditions in the stream corridors and species dependent upon those habitats. As the population increases and new homes are constructed, road building for access tends to occur as well. People value the ability to drive to places for hunting, hiking, residential and industrial needs. These benefical uses are in conflict with the potential damage roads have on the ecosystem, due to erosion.

Traditional Native American lifestyle in the Trinity River Basin was inextricably tied to the river ecology that preceded the dam. The native land use practices and the river's yearly flooding created a healthy dynamic environment which was the source of most of their needs and was significant to their spiritual and cultural well-being. Currently, the changes that exist because of the dam, current land uses, and population densities define a totally different kind of interaction by the native people with their environment. Some native people in the watershed continue their traditional gathering of fish and plants for ceremony and subsistence though the conditions are less than ideal for such practices.

The traditional native use of fire to enhance the health of the environment has been regulated to date and has contributed to the change in the structure and age of the forest. There are less young shoots growing on the willow and filbert bushes, which are essential to native basket making. There is also less young growth in the understory of the forests and less native perennial bunch grass species. All of these changes relate to the health of the riparian ecosystem and the degree to which the native people can carry on their traditional lifestyle.

River restoration projects including feather edges and side channels have been implemented on the main stem of the Trinity River in an effort to create or improve fish habitat. Temporary high levels of turbidity in limited reaches of the river resulting from these projects caused concern among users of the river amd affected other river uses.

Recreation-based tourism is becoming increasingly important to the communities as the decline in timber production and other resource extraction continues. The economic benefit is significant to this low income community. This industry requires adequate stream flow and a healthy fishery, and high visual and aesthetic quality. At the same time, a road network for people to access these areas is necessary.

IV. CAUSES AND EFFECTS OF CHANGE IN THE ANALYSIS AREA

To place the issues in context of the history of the analysis area, the last 145 years have been divided into eras: pre-european (before 1850), mining (1850-1945), logging (1946-1960), and post-dam (1961 to present). All the issues are framed within these eras so that linkages between reference and current conditions are revealed. Each era describes the six watershed analysis issues and their relationship with each other. Issues five and six (Land Use and Human Values) have been combined due to their similarity.

PRE-EUROPEAN ERA

Channel Morphology/Fluvial Processes

Virtually nothing is known regarding channel conditions on the Trinity River before arrival of European influences in the mid-1800's. However, equations four through 11 (on page VI-1-2) may be used with the earliest existing information to produce an educated guess as to what conditions were like. The earliest anecdotal information on the river channel was an 1889 account describing a wide (600 feet at high flow), relatively shallow (could cross it on horseback at low flow) river through much of its length. The earliest aerial photos of the stream corridor (1940's vintage) yield a somewhat similar description. And the earliest streamflow data for the reach in the analysis area dates from 1912-1960, prior to construction of Trinity and Lewiston Dams.

But the air photos and early anecdotes describe a river already severely impacted by decades of intensive mining activities. And the suitability of pre-dam streamflow record for the pre-European era is subject to the uncertainties of climate fluctuations. Thus, only certain generalizations may be made, and those must be based on an assumption of a temperature and precipitation regime not greatly unlike what is occurring at present.

Prior to early mining activity, much less sediment was available for transport; thus, equation 7 (page VI-1-2) should provide the best predictor of differences between the channel prior to European influences and that which was described anecdotally from the late 1800's. From equation 7, one would expect that the pre-mining channel likely was somewhat narrower and deeper than that described for the mining era, with somewhat greater sinuosity and a slightly gentler gradient. However, the non-cohesive nature of most of the sediment load in the basin probably precluded a narrow, deep stream channel, even in the pre-European era. This would be even more likely if the climate was hotter and drier (as some suggest), because such a climate would support less vegetation and more frequent wildfires, leading to naturally higher sediment loads, especially from droughty granitic soils.

The Trinity River was still a wild river and its flow was uncontrolled. The annual hydrograph peaked during the winter months due to storm runoff and during the spring due to snowmelt. These high flows scoured the floodplain, preventing establishment of large areas of mature riparian vegetation and encouraging early seral stages at elevations below the terraces. As snowmelt runoff subsided and water levels receded, low summer flows resulted in warm water temperatures and desiccation of seedlings that had germinated in late spring and early summer. The seasonal floods of the natural flow regime mobilized the predominantly non-cohesive sediments, maintaining pools and the large alternate bars that were so inviting to the early placer mines. Thus, the pre-European channel likely resembled the anecdotal channel, but may have been slightly narrower with well-vegetated, relatively undisturbed terraces.

Anadromous Fisheries

Mainstem Fisheries

The Trinity River likely resembled other large anadromous fish rivers, with alternating point bars of cobble and gravel on the inside bend of the river. The channel was much wider and deeper during winter and spring. During low flow periods of late summer (August/September), the river was usually much narrower than it is today, with shallow riffles composed of relatively coarse gravel. Pools were deeper than at present due to the ability of the river to flush fine sediments from the channel. These deep pools afforded thermal refugia for migrating adults as well as juveniles that remained in the river during this time. The Trinity River supported anadromous populations of coho, chinook, steelhead and Pacific lamprey. Green sturgeon were also present in the lower Trinity River and were reported in the South Fork. Non-anadromous species included rainbow trout, speckled dace and suckers. Every one-and-one-half to two years, flows greater than 6,000 cfs would occur at Lewiston for several days at a time during spring every. These types of flows had major impacts on channel and floodplain morphology and ecology by maintaining the deep pools required by oversummering adult salmonids. These deep pools also benefitted juveniles that remained in the river for extended periods.

Floods and low flows generally had beneficial effects on fisheries. Floods helped maintain habitat diversity, while low flows allowed for recolonization by macroinvertebrates that are the primary food source for juveniles. Adult spawning migrations were triggered by changes in flows, along with other seasonal factors.

The temperature regime in the river was colder in the winter and warmer during the low flow periods of summer and early fall. The transition periods during the months of May and November were similar to present temperatures. Juvenile fish outmigration patterns were probably triggered by the temperature and flow changes that occurred in the river, along with other factors, such as photoperiod.

Tributary Fisheries

Historical information on the role of tributaries in fisheries is very limited, although they were undoubtedly very important for steelhead. This species usually seeks smaller streams and areas far upstream for spawning. Some of the larger tributaries would have provided spawning and rearing habitat for chinook and possibly, coho salmon.

Riparian and Aquatic Ecosystems

Assuming that pre-dam assessments of riparian vegetation are a good proxy for the conditions prior to European settlement, inferences can be made about wildlife distributions (Table IV-1). No data exists regarding the abundance and distribution of riparian wildlife habitat prior to European settlement; however, the relative abundance of most species must be inferred from knowledge of their life history requirements in relation to the changes that have occurred on the mainstem. The distribution of riparian wildlife species is associated with the distribution of riparian vegetation.

Comparison of aerial photographs from 1960 (pre-dam) and 1989 (post-dam) reveals that gravel bars used to be much more extensive and that riparian vegetation was dominated by young willows. Early seral stage vegetation was maintained by dynamic flow regime that regularly mobilized and reorganized the river substrate. Species found in association with mature riparian vegetation, such as willow flycatchers, various neotropical warblers, yellow-breasted chats, and rufous-sided towhees, were presumably less abundant. The species composition of fish-eating bird populations may have depended upon their foraging strategies. Species that forage from shaded perches or snags, such as green-backed herons and belted kingfishers, were probably more scarce, while species that utilize open gravel bars with slow-flowing water, such as great blue herons, were probably more common.

Table IV-1: Comparison of Riparian Vegetation Distributions
1960 vs. 1989
ac/% of riparian zone

Year	Open water	Gravel bar	Willow dom (early-seral)	Will/Alder (mid-seral)	Alder (late-seral))
1960	601	752/71%	239/22%	67/6%	7/1%
1989	393	41/4%	326/36%	382/41%	173/19%

Equivalent relationships between the historic distribution of riparian habitat and riparian-dependent species can be described for mammals and herpetofauna. For example, minks, shrews, and other small mammals are likely to have benefited from the increase in riparian vegetation along the riverbanks. Western toads and Pacific treefrogs, which are associated with gravel bar habitats, may have suffered.

Upland Sediment Dynamics

Sediment was produced largely as a result of natural processes. Geologic erosion produced sediment as a result of uplift, landslides, streambank scour, sheet and rill erosion of landform surfaces. Natural disturbances to the vegetative cover such as fire or insect mortality temporarily reduced the surface soil cover and increased the erosion rates. Large storm events produced runoff, erosion, and sediment transport. The sediment mobilized by these events was transported through the system by high stream flows.

Land Use Practices/Human Values

The ecology of the area evolved with native people's interactions. Though a popular myth is that the land at the time of European contact with the native people as "wild and natural", free of human manipulation, the land actually was largely affected by native land use practices. Fire, harvesting, pruning, digging and some in situ cultivating were used to encourage the species they needed for survival. These activities encourage plant foods and animal species used as food and medicine, and promoted the growth of young shoots in the willow and filbert bushes that were used in basketry. Baskets were essential in the native cultures of this area because pottery was not used. These interactions helped create what is considered a very healthy and diversified ecosystem.

MINING ERA

Channel Morphology/Fluvial Processes

With the discovery of gold on the Trinity River in 1848, mining became the predominant industry in the basin for the next 80 to 90 years. Placer mining became widespread along the mainstem Trinity River and on many of the tributary streams. Placer mines worked the sands, gravels and cobbles of the channel bars and floodplain, essentially disturbing all of the streambed that could be accessed at low-water elevations. Placer mining virtually ensured that all available sediment below flood elevation was non-cohesive and subject to transport. But the flow regime of the Trinity was still natural, and periodic flooding (such as the large floods of 1861-62 and 1888-89) essentially destroyed floodplain mine workings and rejuvenated the channel to a great extent. These floods undoubtedly transported large amounts of non-cohesive sediment that had been disturbed and made available by placer operations.

Once the gravel bars of the Trinity River and its tributaries had been traversed and prospected for placer mining, new mining efforts employed hydraulic techniques, using water under pressure from upstream diversions to wash stream terraces and even hillsides into sluicing operations on the floodplain below. These hydraulic mining operations introduced large quantities of sediment of all sizes into the active channels of the Trinity River and many of its major tributaries. The result was a tremendous increase in the amount of sediment available for transport. Again, the great majority of this sediment would have been non-cohesive in nature.

Dredging of the Trinity River's alluvium followed placer and hydraulic mining and resulted in diversions and realignment of the channel in order to mine the streambed and the deeper deposits of the floodplain and terraces. Along the mainstem Trinity River, dredging of alluvial deposits drastically altered channel morphology both during and for decades after the initial disturbance. Disturbance of alluvial deposits in the tributaries resulted in contributions of significant quantities of sediment to the mainstem for several decades following the mining era.

Water diversions associated with mining likely affected stream discharge at low and moderate flow levels. Substantial diversion of streamflow did occur; however, depletion of streamflow from mining operations was primarily limited to tributary streams where diversions supplied a source of pressure and a means of transport for hydraulic mining operations. Water diversions likely had little impact on magnitude of large floods, which partially restored historic channel morphology and the natural functions of the streams. In short, flow depletions from mining-related diversions likely had little effect on channel shape and dimensions.

The primary impact of all mining operations was an increase in sediment yield from the basin and sediment transport through the drainage network. Equation 6 (page VI-1-2) predicts direction-of-change channel adjustments expected from an increase in watershed sediment discharge. Increased sediment loads due to mining likely caused an increase in width and a decrease in depth for a given discharge. Morphological adjustments also may have favored straighter channels, with slightly steeper gradients. Channel pattern probably tended toward a braided condition, at least locally. And while the natural flood regime of the Trinity River and its tributaries provided a recovery mechanism for the stream channels and their floodplains, evidence from 1944 aerial photographs indicates a lack of vegetation on tailings piles and an overall lack of natural conditions on stream terraces not subject to periodic flooding.

Anadromous Fisheries

Mainstem Fisheries

During this era (and probably prior to European settlement), and up until the dams were constructed, almost the entire length of the Trinity River was used by anadromous fish. The earliest spring run chinook migrated past Lewiston during June and July. These fish then "summered over" in deep pools between Lewiston and Trinity Center. In addition to these early spring chinook, Moffett and Smith (1950) reported that a later run of "summer chinook" usually migrated beyond Lewiston during August and September. They also noted that fish from this summer run were "quite noticeable in the larger holes along the river between North Fork and Trinity Center." Spawning fish were seen in early October between Grass Valley Creek and the Stuart's Fork. Later in the month, spawners would be scattered from the North Fork to the East Fork, about 65 miles upstream. Migrations of adult fall chinook usually coincided with the first fall rains and subsequent increased river flows, with the fish reaching Lewiston in early October. The actual timing of migration and spawning after dam construction has remained similar to historic trends.

The spring chinook race may have comprised the largest run of chinook entering the Trinity River before gold miners arrived in 1850. Snyder (1931) cites an undated paper by R.D. Hume claiming this as a fact, which is logical given the characteristics of the river system and its potential fish habitat. Hume's paper, presumed to have been written around 1900, already declared the Trinity River spring chinook race as nearly extinct by 1892. This could very well be true, given the intensive mining that took place, beginning in the 1860's through the early part of this century. Actual numbers of fish are almost non-existent and only anecdotal information is available. Other native salmonids included steelhead, which preferred tributary habitat, and coho salmon. There were also brown trout and brook trout introduced to the Trinity Basin sometime during the late 1800's.

Undoubtedly, there were long lasting impacts to spawning, rearing and associated habitat as a result of mining activities. Millions of yards of material were moved out of the active channel; much of that material, which would have provided high quality spawning and rearing habitat, remains out of the channel today. However, the natural river dynamic was continually reestablishing itself, providing flows and temperatures that were conducive to spawning habitat.

Farms and ranches probably had temporary effects on water quantity and quality, due to streambank erosion, water diversions and cattle waste in the water, but agriculture was not a major land use below Lewiston. Direct effects of agriculture on the fisheries populations and habitat may have been significant during this time.

Tributary Fisheries

Historical information on tributary fishery populations is very limited. They were important for steelhead, as the species usually seeks smaller streams and areas far upstream for spawning. There is almost no information on tributary use by salmon between the North Fork and Lewiston prior to the dams. Mining activity in tributaries also had temporary effects on aquatic habitat through water diversions and placer mining activities.

Riparian and Aquatic Ecosystems

The mainstem Trinity River harbors a long history of mining activity with associated impacts on wildlife. Early placer mining produced widespread but temporary disruptions of gravel bar substrates, while hydraulic mining produced lasting alterations from excavation of entire hillsides. Large areas of riparian and upland habitat were removed. Short-term effects of placer mining undoubtedly included direct mortality of riparian species, including amphibian eggs and larvae associated with gravel bars. Hydraulic mining instigated severe sedimentation, that further degraded the suitability of gravel bars as rearing habitats for aquatic insects, amphibians, and fishes. Aquatic species that forage by sight, such as western pond turtles and river otters, were potentially impaired by river turbidity, and underwater cover was eliminated as crevices were filled with sediment. The overall result was simplification of habitat with loss of diversity in depth and underwater structure.

During the mining era, localized logging reduced the density of conifers adjacent to the river. Perching species, such as osprey and bald eagle, may have been impacted, as well as species that require dense forest canopies (eg. goshawks, spotted owls). Long-term declines on recruitment of large woody debris into the river may have occurred as a result of source reduction. Coarse woody debris has been shown to be important for the functioning of stream ecosystems by providing cover, contributing nutrients, and generating pooled habitat. Salmonids, western pond turtles and semi-aquatic mammals have associations with woody debris.

Thus, impacts to riparian and aquatic wildlife habitats during the mining era were dramatic and are still visible on the landscape today. However, the riparian and fluvial processes were still at work, such that sediment transport and gravel bar migration could occur. In contrast, human activities during the era that followed not only altered the landscape, but also hampered the processes that permit recovery.

Upland Sediment Dynamics

The discovery of gold and subsequent mining activities altered the natural sediment balance in the river. Mining activities such as hydraulic mining, placer mining, logging for mine, flume and shelter lumber and road construction introduced massive amounts of sediment into the tributaries and the Trinity River. Hydraulic mining operations diverted streamflow into constructed ditches, using this water to wash millions of yards of gold-bearing sedimentary deposits from terraces and hillsides into adjacent streams. This activity reduced natural streamflow at the diversion points and choked stream channels with sediment, temporarily altering aquatic habitat conditions.

The demand for lumber to support mining activities spawned localized logging operations of limited geographic extent. Photographic evidence of the hillsides adjacent to mining areas and communities document the "clearcut" nature of this timber harvest activity, which undoubtedly increased erosion and sedimentation. However, the primitive transportation system limited the total acreage impacted to a small percentage of the analysis area.

Land Use Practices/Human Values

European values emphasized resource extraction and landscape manipulation, in stark contrast with the values of the indigenous people then occupying the Trinity River basin. In their quest for gold, and the need for related infrastructure, the European settlers claimed land that the Chimariko and Wintu had traditionally held. The Native Americans were killed, enslaved or moved to reservations.

The settlers established camps and small communities centered on gold mining, including Junction City, Weaverville, Douglas City and Lewiston. Trail systems were built to transport supplies in and out of the county. Small mills were set up in conjunction with the camps to supply lumber for mine shafts and sluices, buildings, wagons and bridge crossings. Farms were established on the broad river terraces, and they supplied food and other goods to the miners.

Generally, the establishment of towns, farms, ranches and roads during this period were for the express purpose of serving the thriving mining community. The original and enduring attraction of Trinity County, in particular the Trinity River, was the promise of gold. All other enterprises were subordinate to this industry.

The Timber Culture Act of 1873 was enacted to provide the private citizen with the opportunity to purchase large tracts of land and to increase the lumber supply. Prior to this Act, it was difficult for sawmill owners and others to acquire large holdings of timberland. Through this act, an individual could receive 160 acres of land if one quarter of the acreage was planted in trees within four years.

As hydraulic mining wound down in the early 1900's, farming and ranching replaced these activities. Small scale logging continued, but harvesting was still limited to sites that were easily accessed.

Transportation routes continued to be improved, and the Trinity National Forest was created in 1905. Timber harvesting gradually replaced gold mining as the dominant industry as WWII approached, and local economies became more dependent on this resource.

LOGGING ERA

Channel Morphology/Fluvial Processes/Upland Sediment Dynamics

Following World War II, the market for lumber and the advent of tractor yarding once again drastically altered the natural environment in the study area. The market for lumber changed the timber-production economy from one of local consumption to an export market, and widespread tractor logging and road construction resulted in huge increases in the amount and distribution of land disturbance in the basin. Thousands of miles of roads and skid trails were constructed, often in close proximity to or within stream channels. Sediment production increased dramatically, especially from soils derived from decomposed granite. Whereas sediment increases from mining provided a wide range of particle sizes for transport, sediment increases from logging on predominantly granitic soils produced primarily sand-size particles for transport through the drainage network.

Logging-related increases in watershed sediment production likely influenced both mainstem and tributary channels in a manner similar to that described above for mining-related sediment increases. Streams adjusted to higher sediment loads by becoming wider and shallower and, where possible, straighter and steeper. Streams with particularly high sediment loading likely tended toward a braided condition, at least locally. The predominantly sand-size particles available for transport were more efficiently intruded into the streambed than were the coarser sizes associated with some of the mining activity. Intrusion of sand into the gravel/cobble matrix of most streams in the WA area likely produced some imbeddedness of coarser substrates and a reduction in channel roughness and resistance to flow.

Diversity of channel features (pools, riffles, etc.) may have been reduced temporarily as fine sediments (mostly sands) filled pools between major flood events; however, pool filling and imbeddedness of channel substrate likely were ephemeral because of the natural flow regime. Extremely high flows triggered by rain-on-snow events were more than adequate to initiate motion of the substrate with depth flushing of finer sediments. These peak flows were geomorphically significant because they had the effect of renewing a variety of aquatic habitats (e.g., scour holes, undercut banks, new bar deposits, woody material, etc.) and resetting conditions on the floodplain to an early seral stage. As long as the watershed experienced these natural flood events, the Trinity River had a process for adjusting channel size and shape to attain an equilibrium with the water and sediment being supplied by the watershed.

Population growth and development of timber resources since World War II has also affected the flow regimes of several Trinity River tributaries. Population growth in the analysis area has primarily affected Weaver Creek flows due to diversions for domestic, industrial, and agricultural uses in the vicinity of Weaverville. Analysis of flow-duration characteristics for Weaver and Grass Valley Creeks (discussed below) indicates similar levels of streamflow per unit area of watershed when flow levels are high; however, during low flow season, Grass Valley Creek maintains significantly higher base flows compared to Weaver Creek. The lower base flows in Weaver Creek are attributed to diversions in the basin.

Small diversions for agricultural purposes date from the era of European settlement (1850-1945), but widespread changes from logging have primarily occurred in the last 50 years. The most common impacts of forest harvest on streamflow include increased peak flow, low flow, and annual water yield. Low flow and annual water yield frequently increase after harvest because of reduced evapotranspiration from the forest canopy. Increases in peak flow are usually associated with logging roads, where drainage ditches function as extensions of the stream network, routing surface and subsurface storm runoff out of the watershed more efficiently.

Increases in low flow and annual water yield have no appreciable effect on channel morphology and fluvial processes, but increases in peak flow will alter channel dimensions considerably. Equation 8 (page VI-1-2) predicts direction-of-change channel adjustments that are expected from increased flows and sediment discharge after logging. Obviously, a stream will evolve toward a larger channel with an increase in flow and sediment load (i.e., a wider and sometimes deeper channel, depending on magnitude of sediment load increases), but other adjustments may include a decrease in sinuosity and a change in shape to a wider, shallower cross section (i.e., higher width/depth ratio). The magnitude of increase in bankfull width and depth may be estimated from the hydraulic geometry relationships presented above (CMFP Figures-1, 2, and 3 on pages VI-9, 11, and 12) if relations exist for relating peak-flow increases (at bankfull discharge) to amount of basin harvested or in a roaded condition.

However, changes in streamflow due to roading and logging usually are insignificant unless large proportions of a basin are in a clearcut or roaded condition. Generally, clearcuts must occupy at least 25 to 50 percent of a basin and roads must occupy at least five to ten percent of a basin for changes in flow to be statistically measurable. Thus, while logging-induced changes in flow regime of some smaller watersheds may have been significant, changes in flow regime of the larger tributaries and the Trinity River likely have been small.

Anadromous Fisheries

Mainstem and Tributary Fisheries

Rainbow trout were an important sport fishery in the Trinity River during this time. In 1941, an estimated 389,900 rainbow trout were harvested by anglers in the river, though some of them may have been juvenile steelhead. Unpublished Fish and Game reports indicate that rainbow trout were stocked for several years in many tributaries of the Trinity. A fish species that was probably introduced into the upper river during this era was the three-spine stickleback. Brook and brown trout stocking in the basin continued into this era, though the brook trout were limited in distribution to the upper Trinity and its tributaries. Brown trout are very territorial, compete directly with all native salmonids for food and cover and prey upon native species.

Reports of spawning chinook salmon in Rush, Reading, Brown's and Canyon Creeks, as well as the North Fork Trinity, occurred in 1965 (LaFaunce). During investigation of the Trinity Basin in the 1940's, impoundments in the upper limits of Rush Creek and Browns Creek were suggested as possible means to increase salmon spawning capacity in these streams (Moffett and Smith 1950). These impoundments would have been used to store water, then provide adequate flows to recruit salmon into these streams during the spawning season. There usually was not adequate water in these tributaries for spawners until later in the fall or winter, when rains increased the flows. There were also suggestions to remove several artificial dams and diversions in Browns and Rush Creeks that restricted fish movement during low flow periods.

Other tributaries that were suggested as potential sites for storage reservoirs were the North Fork Trinity, Canyon Creek, and Indian Creek (Wales 1950). Wales (1950) also stated that these streams were little used by salmon at the time, and would probably require special measures to initiate runs.

Coho salmon were not known to migrate far up the mainstem during Moffet and Smith's (1950) investigations. There were no definite indications that they had ever migrated upriver as far as Lewiston. Fine-scaled Klamath River suckers were reported to be widely distributed throughout the Trinity drainage, and dace were even more abundant. The speckled dace was apparently the most numerous fish in the Trinity River drainage during surveys in the 1940's and inhabited all sections of the drainage except for the headwaters of some tributaries.

Typically, steelhead would enter the larger tributaries, such as North Fork, Browns Creek and Stuarts Fork, following the first fall rain. Smaller tributaries were entered later in the year, usually by February, as streamflows increased and maintained a flow sufficient to insure adequate spawning conditions. Spawning in tributaries occurred mostly in gravel pockets between boulders; however, spawning in the few available large riffle areas was so dense that individual redds could not be discerned (Moffett and Smith 1950). Actual timing varied from year to year, depending on weather and river flow patterns.

Though chronic sources of sediment were created through intensive and widespread logging operations during this era, there is no indication that there were longterm depressive effects on chinook salmon fish populations. Pre-dam information on coho is limited. They are not known to migrate far up the mainstem during Moffett and Smith's (1950) investigations and there were no definite indications that they had ever migrated upriver as far as Lewiston. However, historic estimated spawning escapements of 5,000 coho above Lewiston were reported in a joint USFWS/CDF&G (1956) publication. Population estimates for the entire Klamath Basin ranged from 350,000 to 500,000 chinook salmon during the first 60 years of this century. This is true also of natural sediment-producing events, such as floods.

Riparian and Aquatic Ecosystems

The logging of large geographic areas and the development of an extensive network of roads and skid trails disrupted natural drainage patterns and resulted in chronic sedimentation of the mainstem Trinity. Riparian wildlife was undoubtedly affected both via direct sedimentation of aquatic habitat and indirect decreases in the aquatic insect prey base. During this era, large areas of upland and riparian wildlife habitats were disturbed, leading to fragmentation of previously continuous forests. Secretive species, such as fishers and martens, may have been affected. In addition, canopy cover was reduced, eliminating the characteristic structure of older forests that dictates suitability for amphibians, northern spotted owls, and other species. Logging of large conifers may also have reduced the availability of sites for snag-nesting and cavity-nesting birds, such as bald eagles and goshawks. Substantial logging occurred in inner gorges, exposing tributaries to solar radiation and thereby eliminating microhabitats for species with thermal sensitivities. Tailed frogs, for example, are restricted to montane streams with low water temperatures; thus, their associations with habitat variables indicative of older forests (downed wood, ferns, etc.). The impacts of logging, overall, were widespread and significant. However, they were mitigated to some degree by the natural fluvial processes of the river, which were still intact.

Land Use Practices/Human Values

The transformation from a gold mining-based economy to a timber-dependent economy was complete after WWII. In 1959, timber production peaked in Trinity County with a harvest of 439 MMBF. In the late 1950's, large blocks of land privately owned in tributaries to the Trinity were intensively logged. Production on US Forest Service-managed land was high as well. The preferred logging method was 'clearcutting', which meant that at least 70 percent of standing timber was cut. There were two primary reasons for this: Forest Service performance was based on production numbers and, on both federal and private lands, 70 percent or more of a unit cut meant the land would not be taxed for 40 years. Economic incentives combined to favor clearcutting as the dominant method of logging.

Not only did machinery and equipment improvements allow larger and more remote areas to be accessed for logging, but public transportation routes were improved as well. In the 1940's, state highway 299 was completed, and numerous county roads in the analysis area were also constructed. Population increases in the Trinity River basin, as in the rest of the county, were slow but steady (10-15 percent). The analysis area, however, experienced a sharp population increase during dam construction, resulting in a 50 percent increase countywide in one year. The river basin became increasingly popular as a sport fishery and hunting area. Recreation was a small, but increasingly important component of the local economy during this era.

POST-DAM ERA

Channel Morphology/Fluvial Processes/Upland Sediment Dynamics

Following World War II, rapid population growth and an expanding agricultural industry in California's central valleys created a need for additional water to supply the farms and towns of central California. As part of the Central Valley Project (a major water-supply development effort of the USDI-Bureau of Reclamation), Trinity and Lewiston Dams were constructed in 1960-1963 to store Trinity River water for transmountain diversion into the Sacramento Basin. The result was a drastic change in flow regime for the mainstem Trinity River below Lewiston Dam. With approximately 90 percent of annual streamflow initially diverted to the Sacramento Basin, the Trinity River underwent significant changes in channel morphology with associated changes in its riparian and aquatic environments.

Nearly fifty years (1912-1960) of streamflow record for the Trinity River at Lewiston are available for characterizing natural flow conditions for the past 100 years. Flow statistics displayed in Tables CMFP-1, CMFP-2 and Figures CMFP-2, CMFP-3 on pages VI-1-9 through 12) for this period of record summarize average and extreme conditions representing the natural range of variability. Table CMFP-1 presents statistics on monthly and annual mean flows, and Table CMFP-2 gives estimates of extreme high and low flows for the natural condition. Selected values of extreme high and low flows are plotted in Figure CMFP-2, and the annual flow-duration curve is plotted in Figure CMFP-3. The flow-duration curve represents percent of time that a given flow was equalled or exceeded over the approximately 50 years of record.

Approximately 30 years of streamflow record also exists to characterize present flow conditions in the Trinity mainstem since the two dams were closed. Tables CMFP-1 and CMFP-2 and Figures CMFP-2 and CMFP-3 also contain flow statistics for this post-dam period of record. Comparison of statistics for pre- and post-dam periods reveals augmented monthly flows for August and September and greatly reduced monthly flows for November through July as a result of reservoir operations (Table CMFP-1). Impact of the dams on extreme high and low flows is even more pronounced (Table CMFP-2 and

Figure CMFP-2). Pre-dam flood events of relatively frequent occurrence (and major floods as well) have been eliminated, as have extended periods of low flows less than 150 cfs during the summer months. Loss of these extreme flow levels has had profound effects on the channel morphology and ecology of the river. The shift in the flow-duration curve of Figure CMFP-3 portrays the overall reduction in flows in the post-dam period, but the effect is even more impressive when individual water-year hydrographs are displayed from the two periods (Figure CMFP-4).

At the same time that sediment production from tributaries disturbed by logging was increasing, transport capacity of the mainstem Trinity River was almost totally eliminated. Changes in channel morphology were swift and dramatic. The constant water level provided by a regulated year-round flow of 150 cfs fostered rapid establishment of dense riparian vegetation on the floodplain, which previously experienced both frequent scour from winter storms and spring runoff and late summer desiccation from low flows in August and September. Floodplain vegetation downstream from the dam trapped sediment from tributaries during runoff events, creating berms that had the effect of channelizing the river. Gone were the annual high flows that scoured vegetation, transported sediment, drove the constant migration of alternate bars, and maintained a clean gravel/cobble substrate. Within the berms, channel width decreased, stream depth and velocity increased, and fine sediment buried coarse gravel deposits, destroying essential spawning habitat. Wilson (1993) reported that total area of riparian vegetation increased by 282 percent between 1960 and 1989, while 95 percent of open gravel-bar areas had disappeared and open-water habitat had decreased by 45 percent. Numerous other studies also documented encroachment of vegetation on the floodplain, accumulations of sediment in the channel, and changes in channel morphology (Ritter 1968, Knott 1974, Lisle 1982).

River conditions that developed after the closing of Lewiston Dam can be illustrated by comparison of two similar and remarkable flood events. The storm of 1955 provided a peak flow of 70,000 cfs in the Trinity River at Lewiston. Enormous sediment loads contributed to the river system from intensive logging apparently did not damage aquatic habitats over the reach from Lewiston to the North Fork, according to regularly conducted habitat surveys. After closing of the dams, the storm of 1964 produced a measured peak discharge of 110,000 cfs as inflow to the reservoir, and only 150 cfs was released at the base of the dam (compared with the 100,000+ cfs that would have passed by the site naturally). The reservoir contained the entire storm event. Flooding tributaries downstream of Lewiston Dam flowed at unimpeded levels, carrying huge sediment loads that were deposited in the placid flows of the mainstem below the dam. Grass Valley Creek alone discharged an estimated 1,000,000 cubic yards of coarse granitic sand in the river. Spawning beds were completely covered, sediment berms gained feet in elevation, and large deltas formed at many tributary confluences.

A decrease in channel width and an increase in gradient (decreased sinuosity) are predicted for a decrease in streamflow by equation 5 (page VI-1-2). An increase in stream depth would not be expected for a decrease in flow; however, encroachment of riparian vegetation has been so effective at building sediment berms and constricting the channel that depth has been maintained (and possibly increased) by severe constriction of channel width. Reduction in channel width following elimination of frequent flooding also is predicted by hydraulic geometry relations (Figure CMFP-1). From Table CMFP-2, the 1.5-year flood (assumed roughly equal to bankfull flow) decreased from about 10,000 cfs prior to dam construction to about 1000 cfs following dam construction. Corresponding bankfull widths from Figure CMFP-1 are about 180 feet for pre-dam conditions and about 55 feet for post-dam conditions. Thus, significant reductions of channel width were to be expected for the flow regime originally planned for Lewiston Dam.

Recent attempts to restore lost aquatic habitat have focused on removal of the sediment berms. These projects attempt to re-create the alternate bar morphology that existed when the river had a natural flow regime. While initial attempts to restore bar habitat for juvenile salmonids looks promising, long-term success at maintenance of such features will be strongly dependent upon a new flow regime from the dams. Without periodic flood flows and control of tributary sediment loading, such efforts are doomed to failure, as the fluvial processes that created the berms are natural responses of a river system attempting to adjust to the flow and sediment supplied to it.

Anadromous Fisheries

Mainstem Fisheries

Dam closure immediately eliminated 109 miles of anadromous fish habitat. Concurrent with this loss was the 1964 flood event, which resulted in millions of tons of sediment being deposited by tributaries, with a mainstem now incapable of transporting this sediment.

Numbers of chinook have declined overall since dam closure, although there has been large variation in run size during this era. In general, both salmon and steelhead populations declined at a rapid rate after dam closure. Harvest records kept since 1978 for fall run chinook salmon show a high of 65,951 (grilse and adult) in 1986, with a low of 3,347 in 1991. The mean for this period is 17,313. A significant percentage of that number are hatchery fish, however. It has been estimated that 59 percent of in-river spawners for 1987 were of hatchery origin (Hamaker 1995). This is contrasted with a mean of 38,154 wild fish, with a range of 19,000 to 67,115, above the North Fork prior to the dam (Hamaker 1995).

Tributary Fisheries

The conspicuously white sand river bed downstream of GVC was noted after 1964 during salmon spawning surveys; it was also noted that during the late 1960's salmon shifted their emphasis to the area within two miles of the base of the dam and began to avoid the reach of river downstream of GVC (GVC WA 1995).

Spring chinook now had to "summer over" in whatever deep pools were available below Lewiston until the fall, when spawning begins. Many spring chinook now hold in the pool and section of the river close to the dam. Flows below Lewiston since dam construction have not been adequate to move sediment contributed from tributaries out of the mainstem. Pools below Lewiston may become too warm for adult salmon during low flow periods. Releases from Lewiston Reservoir are generally much lower in June and July than historical flows, but are now often held at artificially high levels during late summer in order to provide cool water for the spring chinook adults. In addition, the holding habitat for spring/summer-run steelhead has been substantially reduced. The largest portion of the steelhead runs in the Trinity now consist of fall and winter fish.

Overall, 90 percent of the historic anadromous fish runs have been lost, primarily in the last four decades. The combined effects of the Trinity Dam (1963), increased fish resource harvest (1970's and early 1980's), increased logging activities (post WWII to present), flood events (1964, 1983) and recent drought have all contributed to the decline in mainstem and tributary anadromous fisheries. As part of the Trinity Dam mitigation effort, a fish hatchery was established in Lewiston and has been augmenting wild salmonid stocks with hatchery fish stocks. Fishery programs developed and initiated since enactment of the Trinity River Restoration Program (1984) have attempted to recreate suitable habitat and pre-dam river conditions for salmonid populations. Most of these projects have only been in place for three years.

Riparian and Aquatic Ecosystems

As a result of the regulated flow of the Trinity River and its severely limited ability to flush sediment through the system, sediments accumulated, filling the previously deep pools that are utilized by salmonids, western pond turtles, and other creatures requiring cool-water refuges. Mitigation measures include the release of cool water from the dam, which lowers the river temperature overall. The decreased temperature is likely to impact amphibians and reptiles, in that their metabolic rates are closely tied to ambient temperature. The smaller body size and roughened carapaces of turtles on the mainstem Trinity River relative to those on the undammed South Fork Trinity River may constitute evidence of poorer growth. The timing of flow releases has also impacted wildlife. High flows have been timed to mimic the historical late-spring snowmelt runoff period. In 1991, the majority of yellow-legged frog egg masses were washed away by these artificial flows (Lind et al 1992). Although the flow timing resembled the historic scenario, it did not take into account the proximal cues, which change from year to year, and to which frogs respond.

Another effect of the dam was to decrease surface water along the mainstem by 45 percent, with consequent drying of side channels and shallow, edgewater habitats. The river contour overall became more trapezoidal, with a decrease in slow-flowing waters close to the margins. In addition to their value as rearing habitat for salmonids, these areas harbor hatchling western pond turtles and early life stages of yellow-legged frogs. With lowered water volume, flow conditions also became more homogeneous, with the natural alternation of riffles and pools replaced by continuous glides. This lowered diversity of aquatic habitats is likely to result in lower diversity of aquatic wildlife.

Associated with the dampening of winter flood flows, which had a scouring effect, was an expansion of riparian vegetation, which constituted only 29 percent of the riparian zone prior to the dam. Now, it had increased to 96 percent by 1988. While early-stage willow used to predominate, late-seral willow and alder assemblages are now common. These habitats favor riparian-dependent species, such as willow flycatchers and neotropical birds. Species that require open gravel bar habitat, such as yellow-legged frogs, are disfavored.

Land Use Practices/Human Values

Though single year timber production peaked in 1959, logging was the mainstay of the economy of Trinity County through the 1980's. The county's lumber production in 1990 totaled 224.2 MMBF, with a value of $59.4 million (CA State Board of Equalization 1995). Interestingly, total Trinity County timber harvest amounted to only 141.4 MMBF for 1993, but timber market value was $66,775,000 (CA State Board of Equalization 1995). Perceived lumber scarcity has kept wood product prices high.

Prior to 1970, forest practices on private lands were unregulated. The Z'berg-Negedley Act of 1973 (commonly known as the California Forest Practice Act) was enacted and applied to private timberlands. Until then, logging roads were poorly engineered, constructed and maintained and were (and continue to be) the source of substantial amounts of sediment into streams (Klamath River Basin Fisheries Resource Plan 1985). Clearcutting continued to be the dominant method of tree harvesting, on both private and public lands. By 1977, 42 percent of the Trinity River watershed had been logged, with 26 percent of that as clearcut, and 16 percent harvested with selective cut methods (DWR 1980).

Mining during this era has been largely relegated to recreational use, though a minor upsurge in claims occurred during the inflationary times of the early 1980's. Most gold mining is now done with suction dredging in the streambed, though a large high bench placer mine is in operation on Forest Service land on Canyon Creek. Evidence of past mining methods are still in evidence throughout the analysis area mainstem, including numerous large mine tailings and altered landscapes adjacent to the river.

Agricultural activities declined during this period and there are now no working ranches or farms in the analysis area.

Interest in sport fishing on the Trinity River continued to increase through the 1960's, '70's and '80's, even as fish runs were declining. At the same time, the commercial fishing industry developed more efficient methods of fish harvesting in the ocean, further increasing the pressure on this resource. Native American gill netting, coupled with intensive ocean harvesting and sport fishing and meteorological events (such as El Nino), continued to contribute to the declines in populations of anadromous fish in the river basin (VTN 1979).

Recreation-oriented businesses and services, both in the analysis area and along the shores of the newly created reservoir, continued to increase during this time. In 1984 the Trinity Alps Wilderness was created, adding to the scenic attractions of the river basin. Tourism now accounts for 50-75 percent of the summer business and about 25 percent of winter business (BR 1986).

With the change in river dynamics brought about by the dam, the riparian ecosystem changed drastically and the fisheries declined, which negatively affected the cultural, spiritual, economic and subsistence lifestyle of the native people living in the watershed.

Fire suppression efforts have increased in the analysis area as it becomes more populated. There are four volunteer fire departments, CDF and US Forest Service equipment to respond to fires. The result is that fuels have accumulated throughout the basin, increasing the risk of a catastrophic fire, as occurred in 1987. This approach is in sharp contrast to that of the pre-European era.

Because the dam now regulates the flow of the river, human encroachment onto the floodplain has occurred, and continued until 1990, when the county prohibited construction within the 100 year post-dam floodplain of the Trinity River. The existing encroachments now constrain the flow regime, thus limiting restoration possibilities.

A recreation-based economy (rafting, sport fishing, camping) has developed in the analysis area, with interest centered on high quality river water for both domestic purposes and aesthetic reasons. High summer flows necessary for some recreation can conflict with restoration efforts to mimic a natural flow regime. Native American claims to fish harvest amounts and water levels for ceremonial purposes affect both the fishery and flow management regime.

V - MANAGEMENT RECOMMENDATIONS, DATA GAPS AND MONITORING

This section builds upon the results of the analysis and the understanding of the interrelationships described in the previous sections. Restoration opportunities and management actions that would initiate an ecosystem recovery process are presented in this section. Each action is described in terms of the potential to move the system toward natural conditions. In addition, the physical, ecological and social constraints which may hinder each action are explored. Additional data necessary to prescribe treatments or understand ecosystem components or relationships is listed. Finally, a brief list of monitoring needs is included. Since many restoration efforts have already been completed the monitoring task is extensive.

A restoration program should seek to restore natural processes within current and "reasonable" constraints (reasonable means socially acceptable tradeoffs). The restoration philosophy embraced in this section can be explained as follows: if the natural processes are restored or steps are taken to re-initiate natural processes, then critical habitats and functions will follow and be self-maintaining. The success of such a restoration scenario requires a coordinated approach which includes some combination of the following:

I. Restore stream flows of sufficient magnitude and duration to initiate dynamic fluvial processes similar to those which existed prior to dam construction.

II. Remove a significant portion of the sediment berms which have accumulated in the stream channel as a result of flow regulation and water diversion. This action will greatly facilitate the effectiveness of item I.

III. Reduce the sediment supply originating from various tributary watersheds through erosion control actions and land management activities.

IV. Restore a fire regime which approximates the frequency and intensity of the natural regime.

I. Restore Stream Flows

The re-institution of flows adequate for maintenance of dynamic channel morphology and all the ecosystem benefits associated with it is identified as the highest priority restoration need. Two categories of restored flows are addressed as recommendations.

<u>Stream Flow Option 1: Restore the Natural Hydrograph</u>

This recommendation assumes a completely restored hydrograph which would require the removal of the Trinity River Division of the CVP. The natural timing and magnitude of flows would be fully restored. The stream channel morphology would respond to the natural flow dynamics, resulting in substrate movement, sediment flushing, channel migration and riparian scour. Over time, channel geometry and aquatic and terrestrial habitat would resemble the natural conditions which existed before dam construction and flow diversion. Sediment berms would gradually disappear, riparian vegetation would be reduced and riverine habitat diversity would be restored for fish and for riparian and aquatic dependent wildlife species. This restoration option carries significant social and economic constraints which may make it infeasible as a restoration scenario.

Constraints to restoring the natural hydrograph.

Physical Constraints

Lewiston Dam Outlet works: The existing outlet structures can not accommodate the high flow volumes associated with the natural hydrograph. Restoring the magnitude of natural flows implies the removal of the dam.

Floodplain encroachment: The regulation of flows since the closing of the Trinity River Division allowed the development of homesites, low bridges, and businesses within the historic floodplain. These structures occur between Lewiston and Junction City. Many of these structures would be flooded under a natural flow regime. The California Department of Water Resources is currently evaluating the potential structural damage which may occur under several flow release scenarios.

Sediment berm resistance: Theories vary regarding the establishment of berms in the floodplain and their resistance to flows. The berms are armored by extensive riparian vegetation development and resist erosion under moderate streamflow. High flows currently appear to accelerate berm aggradation (Wilcock 1995), indicating a possible need to mechanically remove berms even under a fully restored natural flow regime. It is not known whether fully restored flows would eventually overcome the resistance of the riparian vegetation and existing berms, resulting in gradual restoration of the natural channel morphology. McBain and Trush's experiments pulling mature alders adjacent to the channel indicated that 15,000 cfs approached the lower limit of flow capable of alder removal. Additional considerations revolve around the life cycle of alders in the riparian zone. Typically alders establish in relatively even-aged stands which complete their life cycles and begin to lose stand structure in approximately 30 years. Declining alder stands may provide an opportunity to initiate berm deterioration with flows only.

Ecological Constraints

Thermal refugia: A natural flow regime includes late summer flows much lower than the current releases. In the short-term, until the natural channel morphology was completely re-established, the lack of deep pools would impose a biological constraint. Deep pools provide cool water refugia for riparian and aquatic wildlife as well as salmonids. These refugia are not currently available due to accumulation of sediment in pools. Thus, artificially low summer water temperature in the whole channel is currently maintained by augmenting summer flows with releases from the dam.

Species impacts: A natural flow regime would result in short-term impacts to species which have adapted to altered conditions. Relative to current conditions, a natural hydrograph includes higher flows during the snowmelt runoff period and lower flows during the late summer months. In the short term, the disturbance created by these changes in flow could disrupt the activities of resident species. For example, western pond turtles that have colonized lentic backwater areas since construction of the dam might suddenly be displaced by the invasion of fast-flowing waters. New lentic areas would be created under a natural flow regime, but there could be a lag-time before colonization occurred. In the long-term, species that benefitted from the alterations in conditions as a result of the dam would suffer. For example, willow flycatchers, which are likely to have been scarce historically, have colonized the main stem Trinity River in response to the dam-related increase in acreage of mature riparian vegetation. Restoration of a natural flow regime would substantially diminish the acreage and potentially exclude willow flycatchers from this area.

Social Constraints

Contracts for water delivery through the CVP may limit the total amount of water which flows down the Trinity River. Power and agriculture revenues generated from the diversion of Trinity River water would diminish under this recommendation and present a formidable social barrier. Urban water users in the Sacramento Valley who consume CVP water would suffer if diversions were reduced or eliminated.

Fish and wildlife in the Sacramento Valley currently benefit as a result of Trinity River water diversion. Reduced water diversion, currently used for water quality enhancement and wetland habitat enhancement, may harm fish and wildlife in the Sacramento Valley.

Floodplain encroachment along the main stem Trinity River would only be a temporary problem, as the first unregulated flows resulting from a 10 year storm would eliminate encroachment.

Recreation opportunities that have become established on the reservoirs would be eliminated, negatively impacting the tourism industry. Summer river recreation would be altered but likely evolve and adjust to the re-establishment of the natural flow regime.

Stream Flow Option 2: Establish a Flow Regime which Mimics the Natural Hydrograph

This restoration scenario envisions a flow regime which is less than the natural hydrograph in quantity, but similar in seasonal distribution, duration and recurrence frequency. The re-introduction of "channel forming flows" that approximate the 1.5 year, one week duration recurrence interval flow, would mobilize substrate, flush sediment and initiate natural channel migration. Wilcock (1995) suggest that discharges in the range of 5000 to 6000 cfs provide the greatest efficiency for moving sand through the main stem Trinity River in the analysis area, while keeping gravel loss to a minimum. McBain and Trush (1995) suggest that flows of 8500 cfs are required for mobilization and limited migration of alternate bars and tributary delta deposits. Fogg describes the use of flow duration data presented in Table CMFP-2 on page VI-1-10 of this document to determine the flow magnitude and duration necessary to mimic natural events.

The channel morphology would respond and be controlled by these channel forming flows, the degree of response would vary depending on the magnitude, duration and frequency of flows. Fluvial processes would have the ability to maintain a channel which is smaller in scale than the natural channel but is ecologically functional. The flow regime would be compatible with the timing of life history requirements of fish, as well as with riparian and aquatic dependent species.

The flow hydrograph should contain variability based on annual and long-term climatic cycles such as drought/wet cycles. Flows within the reduced hydrograph would be calibrated based on indicators of these conditions. Such conditions may be determined by total inflow into Trinity reservoir or a variety of other potential indicators. Fogg describes the methodology for developing flow recommendations in Section VI- Channel Morphology/Fluvial Processes.

Sediment accumulation in the main stem has occurred as a result of main stem flows which are out of phase with tributary sediment inputs. High tributary flows transporting heavy sediment loads in the absence of correspondingly high main stem flows allow tributary sediment loads to be stored in the main stem Trinity River. High tributary inflow conditions must be offset with sufficient main stem flows to flush introduced sediment loads through the system. Sediment discharge functions developed in this watershed analysis (and elsewhere) should be useful for evaluating sediment-transport efficiency of the recommended flow scenarios.

Currently the riparian zone includes extensive riparian development on established sediment berms. This condition confines the natural pre-dam channel geometry from its historical configuration. In effect, a small river is attempting to reshape the channel of a much larger river. Low flows do not carry sufficient energy to reconfigure the channel and are confined by the late-seral riparian vegetation and the established sediment berms. High flows through the current channel geometry during periods of tributary sediment transport appears to accelerate berm aggradation (Wilcock 1995). It is not known whether fully restored flows would eventually overcome the resistance of the riparian vegetation and existing berms, thereby resulting in gradual restoration of the natural channel morphology.

Constraints to establishing a flow regime which mimics the natural hydrograph

Physical Constraints

Lewiston Dam outlet works: The existing outlet structures can not accommodate flow volumes high enough to mimic the entire range of the natural hydrograph. However, releases approximating the 1.5 year recurrence interval flow of approximately 6,000 cfs for seven days duration, are physically possible with the current maximum release capability of 8,400 cfs.

Floodplain encroachment: The regulation of flows since the construction of the Trinity River Division allowed the development of homesites, low bridges, and businesses within the historic floodplain. These structures which occur between Lewiston and Junction City, begin to flood at releases of about 6,500 cfs.

Ecological Constraints

Thermal diversity: A dynamic river system frequently reorganizes the substrate, establishing meanders and alternate point bars, sorting gravels, and scouring pools. These processes provide a diversity of habitats for fish and for riparian and aquatic wildlife species. Under natural conditions, shallow, quiet, and warm water areas were available during high flows, and deep, cool habitats are available during summer low flows. Reinstituting a full range of flow diversity under current conditions may result in the exceedence of biological thresholds for certain species.

A flow regime which mimics the natural hydrograph would include summer flows much lower than the current releases. Under a natural flow regime, low summer flows played a critical role retarding the annual establishment of riparian seedlings. Seed germination and seedling survival is reduced when the floodplain watertable drops below the root zone and the wetted channel perimeter recedes from high water lines. Conversely, artificially high summer flows provide constant irrigation for young plants, aiding establishment and colonization of open gravel bar habitat.

In the short-term, until a channel geometry based on lower flows has established, the lack of deep pools imposes a biological constraint. Deep pools provide cool water refugia for riparian and aquatic wildlife as well as salmonids. These refugia are not currently available due to accumulation of sediment in pools. Summer water temperature standards are currently maintained by augmenting summer flows with releases from the dam. Such flows may need to continue in order to meet water quality standards for salmonids in particular.

Species impacts: A mimicked natural flow regime could result in both short and long-term impacts to species which have adapted to altered conditions. Relative to current conditions, a natural hydrograph includes higher flows during the snowmelt runoff period and lower flows during the summer months. In the short-term, the disturbance created by these changes in flow could disrupt the activities of resident species. For example, western pond turtles that have colonized lentic backwater areas since construction of the dam might suddenly be displaced by the invasion of fast-flowing waters. New lentic areas would be created under a natural flow regime, but there could be a lag-time before colonization occurred. In the long-term, species that benefitted from the alterations in conditions as a result of the dam would suffer. For example, willow flycatchers, which are likely to have been scarce historically, have colonized the main stem Trinity in response to the dam-related increase in acreage of mature riparian vegetation. Restoration of a natural flow regime would substantially diminish the acreage and potentially exclude willow flycatchers from this area.

<u>Social Constraints</u>

The diversion of Trinity River water to the Sacramento and San Joaquin valleys provides numerous benefits to those regions. Any changes in the water diversion policies affect those diversion beneficiaries. Loss of power and agricultural revenue would result from a reduction in water diversion. Fish and wildlife habitats in the Sacramento Valley which benefit from the diversion of Trinity River might not benefit as much under a reduced water diversion scenario. Urban water uses in the Sacramento Valley may end up with less Trinity River water.

Structures and road improvements located within the floodplain along the main stem Trinity River may be damaged by stream flow releases which exceed 6,500 cfs.

Recreation opportunities would be affected by a change in the current stream flow management. Summer river recreation activities have become dependent on minimum stream flow which could drop below the current amount in the future resulting in reduced tourism income.

Reservoir levels determine the recreation usage and tourism income of the associated industry. Under modified flow management, reservoir levels may drop more and sooner than under current water management. This water level reduction could negatively affect tourism income.

II. Remove Sediment Berms

Since recent experiments (McBain and Trush 1995) indicate a flow of approximately 15,000 cfs is the minimum necessary to topple a mature alder tree, we recommend mechanical removal of the sediment berms at carefully selected sites along the river. Implementation of a program of mechanical berm removal would stimulate the river channel to seek a new geometry based on the magnitude, duration, frequency and timing of mimicked natural flows.

The erosion of berms and established riparian vegetation may not occur over extensive reaches but may occur only gradually over limited reaches and over very long periods of time. In the absence of flood events of historical magnitude which naturally "reset" channel conditions, channel morphology changes can be approximated mechanically. Mechanical removal of berms and established riparian vegetation eliminates the physical barriers currently preventing natural fluvial dynamics. Subsequent high flows might perform the functions of resetting the seral stage of riparian vegetation and reorganize the channel morphology over the affected reach. The combination of berm removal and mimicked natural flows would allow the channel to establish a meander frequency, channel complexity and configuration commensurate with reduced flows. The ability of these stream reaches to maintain themselves, resetting the seral stage and reorganizing the channel substrate, would be a function of the degree to which natural flows can be duplicated. It will also depend on project site selection for mechanical treatment and other variables.

Constraints to Mechanical Sediment Berm Removal

Physical Constraints

Approximately half the mainstem corridor is private property, the remainder is managed by federal and state agencies. Access to private property for berm removal is voluntary. Some property owners perceive these projects as government intrusion. Concerns about future access needs or a loss of the right to deny access and general distrust of government activities or motives have also been cited as reasons for access denial.

Ecological Constraints

Short-term habitat losses for some riparian and aquatic species may result from berm removal. Habitat conditions for some species will deteriorate while conditions for other species may improve. The magnitude of the changes is difficult to estimate, since the size on any one berm removal project would be small and there would be sizeable gaps between projects, suitable habitat will still be available in the vicinity.

The occurrence of any special status plant species within the riparian zone is unknown. Surveys prior to site selection could eliminate or reduce the potential negative impacts.

Social Constraints

Even though the dense riparian corridor did not exist under natural stream flow conditions, a portion of the public has grown to appreciate the scenic value. Removal of this vegetation will not be favored by some people.

Water quality is temporarily affected during berm removal. Although current knowledge indicates that these temporary turbidity increases are biologically benign, turbidity resulting from this activity is still considered a violation of the basin plan water quality standards. Recreational experience and value along the corridor is dependent on clear water. Turbidity during the recreational season reduces the quality of the recreational experience and may result in a reduction of recreational users, resulting in lost tourism revenues.

Introduced fish species have become a recreational draw and have spawned an income opportunity. The current channel conditions favor introduced resident brown trout which bring recreational income to the community. Sediment berm removal may reduce some of the preferred brown trout habitat and could negatively affect the recreational experience and tourism income. This potential loss may be offset by economic opportunities resulting from increased numbers of native salmonids.

III. Reduce Sediment Production in Tributaries

Implement a program for restoring upland sediment dynamics to a natural balance. This restoration goal should address not only the symptoms of erosion and sedimentation but also the land use practices which cause this pervasive phenomena. An aggressive program of site treatment and land use technique improvements has been underway for years in the analysis area. Additional progress can be made and the program should continue.

The sediment budget process identified potential sources of sediment by tributary and in some cases, specific areas within tributary watersheds. Substantial progress testing and implementing sediment control practices has been made in several tributaries especially in the Grass Valley Creek watershed. Inventories of sediment sources have been completed in other tributary watersheds and are listed in the bibliography.

The sediment budget indicates there may be additional significant sources which have not been identified yet. Specifically the granitic areas of small tributaries encompassed by the "Trinity Gorge" watershed appear to have significant potential which should be investigated further. Inventory and treatment procedures established in the basin should be followed to identify potential sediment sources and develop treatment scenarios. Existing inventories should be reviewed and determinations made whether to implement treatments.

Treatment activities which restore natural hydrologic processes and facilitate reestablishment of native plant communities are the preferred alternatives. Treatments include but are not limited to: road reconstruction, road decommission, culvert replacement or removal, vegetative plantings, mulching, headcut and streambank stabilization.

Land use practices, specifically road building associated with urban development and timber production activities and timber harvest methods, should be aggressively regulated in order to prevent the sediment producing disturbances which occurred historically.

Constraints to Sediment reduction.

Physical constraints

Access: Site access may be limited by the remote locations. Treatments which limit access disturbance or the potential of creating new sediment sources should be selected. Disturbance created while gaining access should be carefully weighed against the sediment savings realized from site treatment.

Ecological constraints

Riparian habitat impacts: Tributary riparian habitats may experience localized reductions during the course of upland sediment control projects. Such impacts would be short term and distributed across the landscape.

Exotic plant introductions: Restoration involving revegetation projects may provide a conduit for exotic plant introductions. Only native plant species should be considered for revegetation projects.

Social constraints

Erosion control treatment projects on private property are voluntary and some property managers or owners perceive these treatments as government intrusion. Concerns about future access or a loss of the right to deny access and general distrust of government activities or motives have also been cited as reasons for erosion control treatment denial.

Erosion control is costly, taxpayers may be unwilling to expend limited funds on "indirect" activities which may take years to pay a dividend.

Some recreationists are reluctant to relinquish the use of old road systems for hunting, touring and OHV use.

Private property rights issues become important when proposing strict enforcement of regulations which limit options on private property. Regulations on timber harvest activities or road building techniques are perceived by some as an infringement on personal rights.

IV. Restore the Natural Fire Regime

Under the natural fire regime, fires occurred frequently and generally burned at a lower intensity. This regime resulted in smaller burned areas with fewer negative impacts to the ecosystem than the fires experienced in recent years. It is generally accepted that reintroduction of frequent, low intensity fires has numerous benefits for various ecosystem components. Fire may be used as a tool to reduce the occurrence and severity of large "stand replacing" fires which often cause severe ecosystem damage and increase erosion and sedimentation.

Constraints of natural fire regime restoration

<u>Physical Constraints</u>

In some parts of the analysis area the close proximity of urban development to densely vegetated areas presents formidable barriers; however, throughout most of the area this is not a constraint.

<u>Ecological Constraints</u>

The susceptibility of controlled burns to escape from control lines and cause severe resource damage may limit the viability or time frame for implementing this restoration effort.

Temporary habitat losses occur at burn sites as a result of changes in vegetation structure. Although short-lived, these habitat losses can be severe, given the fragmented state of upland ecosystems. Species that historically could have dispersed from burn sites into adjacent suitable habitats might now be limited by migration barriers and/or the absence of suitable habitat in the vicinity.

<u>Social Constraints</u>

A segment of the population still possess "Smokey Bear Syndrome" and believe that all fire is bad and should be suppressed.

Air quality standards restrict the window of opportunity to specific time periods which may not coincide with the occurrence of fire prescriptions conditions, and/or staffing availability.

Data Gaps

- The occurrence of special status species in riparian zones proposed for mechanical manipulation.

- The evolution and dynamics of pilot fish habitat projects in the absence of annual maintenance.

- The ability of the channel geometry established under a mimicked flow regime to provide cool water refugia for fish and aquatic wildlife without summer flow augmentation.

- The severity of the sediment production hazards which exist in un-inventoried areas of granitic soils in the Browns Creek watershed and the "Trinity Gorge" basin.

- The impacts of temporary turbidity on aquatic species other than salmonids.

- The potential of using "flows only" to remove sediment berms.

- The potential of a restored upland disturbance regime to generate a suitable mosaic of habitat.

Monitoring

Monitoring is essential to determine the effectiveness of the treatments and projects which have been completed in the fishery restoration program. Evaluations of the effectiveness of these projects is an obvious need in order to recommend additional restoration activities. A variety of treatments have been installed, and are categorized for discussion into groups of fisheries enhancement projects, sediment control projects, and wildlife enhancement projects. Because of the long term function of some of these activities, and the complex interrelationship of ecosystem components influencing the outcome of treatments, obvious results may take years to observe. For instance, sediment reduction projects may take years to achieve full benefit, whereas a side channel constructed to provide additional fish habitat may be occupied by fish three months after construction.

Fisheries enhancement projects such as side channels and feathered edges should continue to be monitored to determine utilization and viability over time. Some projects have changed over time due to stream bed changes which occur during high stream flow. These changes may diminish the designed habitat values but may produce other aquatic habitat valuable to the ecosystem.

Conversely, some projects such as specific feathered edge projects were designed not only to immediately provide juvenile rearing habitat but to initiate changes in stream channel geometry when combined with moderate stream flows in order to create additional habitat naturally. These projects are designed to re-initiate the natural process of a dynamic channel substrate that is mobile over both time and space, dynamics that are currently minimized by flow regulation and the resulting channelization.

Monitoring of these specific projects designed to re-initiate channel dynamics is recognized as one of the key elements of any restoration plan. This type of project, which combines flows that mimic the natural hydrograph with excavation of historic gravel bars is considered the best opportunity to create a long term solution to the aquatic habitat deficit. Preliminary monitoring results on the Douglas City feathered edge project indicate that significant channel morphology changes have taken place. The thalweg now migrates from one stream bank to the other, evidence that a new meander sequence is forming in a formerly straight stream reach and that channel morphology complexity is increasing (Trush, personal communication).

Instream fishery projects in tributary streams such as Rush Creek, Browns Creek and Canyon Creek should be monitored to determine long term viability and utilization.

Since one of the restoration program goals is to restore the anadromous fishery, long term population monitoring of both outmigrating anadromous salmonid smolts and returning adults as they return is essential.

Sediment control projects have been installed in several tributaries but the majority of the work has been done in Grass Valley Creek, Hoadley Gulch and Indian Creek. Monitoring of the effectiveness of road removal, road reconstruction, vegetation plantings, surface mulch treatments and stream crossing removal projects currently is carried out annually. This is necessary in order to assess the effectiveness of various treatments. Many different levels of treatment and different techniques have been installed in order to learn which treatment combinations provide the best erosion reduction for the least cost.

Millions of dollars have been expended to curb sediment production, additional treatments which may be recommended should be designed with the knowledge of project performance of existing treatments. Treatment option costs vary considerably and should be closely evaluated for the cost/benefit ratio in terms of sediment saved for dollars expended. This analysis has identified additional areas which need erosion potential inventories. If significant sources of sediment are discovered then the information gathered during erosion control project monitoring will be beneficial in planning erosion treatments for these additional sediment sources.

Since erosion occurs episodically and diminishes each year following a disturbance, valuable monitoring data is collected following large storm events such as the data collected during and after the 1995 winter. Vegetation treatments require long term monitoring to accurately assess the performance of various plant materials and their interaction with native plant communities.

Wildlife habitat enhancement projects such as vegetation burning and furbearer den construction have been implemented. Monitoring of some special status species dependent on the mainstem Trinity River corridor has occurred.

The potential for habitat losses along the mainstem exist under the recommended restoration actions. Species dependent on riparian habitat should be monitored to assess the impacts of restoration actions. The recommended flow management schedule which mimics the natural hydrograph seasonal distribution may be detrimental to certain species. Those species should be monitored to determine the impacts of this flow management.

Land use activities have resulted in large scale ecosystem impacts and should not be forgotten when considering monitoring needs. Specifically, the impacts of road construction and "intensive" timber harvest methods on aquatic ecosystems should be evaluated to determine the impact of "current technology".

SECTION VI - DETAILED INVESTIGATIONS

This section briefly describes the contents of detailed reports, focused on ecosystem components, that were prepared as part of this watershed analysis. The technical reports which contain data and the findings of various investigations and studies were prepared as the basis for the discussions and recommendations presented in the previous sections. Copies of the reports are available from Steve Borchard, 355 Hemstead Dr., Redding, CA, 96002, (916) 224-2100.

A major benefit of conducting watershed analysis is the compilation of all existing knowledge about a geographic region. The materials presented here and the following bibliography accomplish that goal.

Section VI-1: Channel Morphology/Fluvial Process is a comprehensive hydrologic analysis of stream discharge data for several streams in the Trinity River basin. The report presents the data and discusses the relationships between streamflow, channel morphology and wildlife habitat. A methodology for designing stream channel restoration utilizing various streamflow scenarios is presented, methods for selecting streamflow amounts and durations in order to mimic natural flows is described. Restoration opportunities are discussed in detail.

Section VI-2: Fish Habitat and Populations reviews the historic and present conditions of the fishery in the main stem Trinity River and the major tributaries. Fishery data and the results of numerous studies were reviewed to prepare information on fish habitat, fish populations, and habitat needs of anadromous and resident fish. The life history patterns of anadromous species are described. The importance of tributary streams and historical information on each one is reviewed. The causes behind changes in fish populations and habitat are chronicled.

Section VI-3: Wildlife discusses the diversity of wildlife and composition of aquatic and terrestrial fauna present on the Trinity River. The changes over the last 100 years and the factors responsible for change are discussed. Potential causal relationships between changes and species reactions are presented. Extensive tables of species are included.

Section VI-4: Sediment Budget describes a method of estimating sediment production within a basin using streamflow and sediment discharge records. Sediment discharge rating curves were developed for suspended and bedload sediment for the Trinity River and Grass Valley Creek by plotting the log of sediment discharge against the log of the streamflow measurements. These sediment rating curves can be used to evaluate the sediment transport efficiency of various streamflow discharges currently being evaluated for the Trinity River, as was done for the present post dam flow regime (82-91) in this analysis. Sediment production from individual tributaries was estimated using sediment estimates based on the soil distribution patterns. Sediment production rate estimates for granitic soils and non-granitic soils, developed from sediment discharge rating curves, was applied throughout the basin. Estimates for each tributary were adjusted for land use patterns and erosion control treatments.

Section VI-5: Land Use and Human Values depicts the impacts humans have had over time. It discusses the diverse array of human relationships with the land from the Native American peoples' sustainable interaction with the landscape; through the European settlement era which emphasized mining; to the post World War II logging boom; up to current conditions in the area. This section also touches on the economic and demographic status of the county as it relates to land use and social issues. The culmination of these human historical, cultural, social, and economic issues affect current expectations and the needs of residents and other users of the river and its waters.

Section VI-6: Vegetation section describes the upland vegetation in terms of general categories (conifer forest, hardwood forest, montane chaparral, and grasslands). The riparian vegetation is described in terms of the current condition of the riparian corridor of the main stem Trinity River. Plant species of concern, (sensitive plants and noxious weeds) known or thought to occur along the main stem are described and their habitats characterized.

Section VI-7: Soils, Geology and Climate covers some basic resource data which was compiled for the watershed analysis.

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UNITED STATES DEPARTMENT OF INTERIOR
BUREAU OF LAND MANAGEMENT
REDDING RESOURCE AREA

MAINSTEM TRINITY RIVER WATERSHED ANALYSIS

SECTION IV

DETAILED INVESTIGATIONS

SECTION VI - DETAILED INVESTIGATIONS

In this section the complete reports focused on ecosystem components are presented. Detailed technical reports, data, and investigations are presented in their entirety. This material was prepared as the basis for the discussions and recommendations presented in the previous sections.

A major benefit of conducting watershed analysis is the compilation of all existing knowledge about a geographic region. The materials presented here and the following bibliography accomplish that goal.

Section VI-1: Channel Morphology/Fluvial Process is a comprehensive hydrologic analysis of stream discharge data for several streams in the Trinity River basin. The report presents the data and discusses the relationships between streamflow, channel morphology and wildlife habitat. A methodology for designing stream channel restoration utilizing various streamflow scenarios is presented, methods for selecting streamflow amounts and durations in order to mimic natural flows is described. Restoration opportunities are discussed in detail.

Section VI-2: Fish Habitat and Populations reviews the historic and present conditions of the fishery in the main stem Trinity River and the major tributaries. Fishery data and the results of numerous studies were reviewed to prepare information on fish habitat, fish populations, and habitat needs of anadromous and resident fish. The life history patterns of anadromous species are described. The importance of tributary streams and historical information on each one is reviewed. The causes behind changes in fish populations and habitat are chronicled.

Section VI-3: Wildlife discusses the diversity of wildlife and composition of aquatic and terrestrial fauna present on the Trinity River. The changes over the last 100 years and the factors responsible for change are discussed. Potential causal relationships between changes and species reactions are presented. Extensive tables of species are included.

Section VI-4: Sediment Budget describes a method of estimating sediment production within a basin using streamflow and sediment discharge records. Sediment discharge rating curves were developed for suspended and bedload sediment for the Trinity River and Grass Valley Creek by plotting the log of sediment discharge against the log of the streamflow measurements. These sediment rating curves can be used to evaluate the sediment transport efficiency of various streamflow discharges currently being evaluated for the Trinity River, as was done for the present post dam flow regime (82-91) in this analysis. Sediment production from individual tributaries was estimated using sediment estimates based on the soil distribution patterns. Sediment production rate estimates for granitic soils and non-granitic soils, developed from sediment discharge rating curves, was applied throughout the basin. Estimates for each tributary were adjusted for land use patterns and erosion control treatments.

Section VI-5: Land Use and Human Values depicts the impacts humans have had over time. It discusses the diverse array of human relationships with the land from the Native American peoples' sustainable interaction with the landscape; through the European settlement era which emphasized mining; to the post World War II logging boom; up to current conditions in the area. This section also touches on the economic and demographic status of the county as it relates to land use and social issues. The culmination of these human historical, cultural, social, and economic issues affect current expectations and the needs of residents and other users of the river and its waters.

Section VI-6: Vegetation section describes the upland vegetation in terms of general categories (conifer forest, hardwood forest, montane chaparral, and grasslands). The riparian vegetation is described in terms of the current condition of the riparian corridor of the main stem Trinity River. Plant species of concern, (sensitive plants and noxious weeds) known or thought to occur along the main stem are described and their habitats characterized.

Section VI-7: Soils, Geology and Climate covers some basic resource data which was compiled for the watershed analysis.

VI-1 CHANNEL MORPHOLOGY / FLUVIAL PROCESSES

Stream channels are constantly adjusting to the water and sediment supplied by the watershed. The history of channel conditions in the Trinity River and its tributaries corresponds to changes in streamflow and sediment supply in the basin, as well as human manipulation of the channels themselves. Thus, an understanding of channel adjustments in this area requires an understanding of changes in streamflow and sediment production throughout the drainage.

One of the earliest relations proposed for explaining stream channel behavior was suggested by Lane (1955), who related mean annual streamflow (Q_w) and channel slope (S) to bed-material sediment load (Q_s) and median particle size on the streambed (d_{50}):

$$(Q_w) * S \sim (Q_s) * (d_{50}) \qquad (1)$$

In this relationship bed-material load is that portion of the sediment load that interacts with and comprises part of the streambed. It may be carried in suspension or in contact with the channel bottom. Bed-material load is distinguished from wash load, i.e., the component of the sediment load that washes through the system and does not appear in appreciable quantities in the streambed.

Lane's relationship suggests that a channel will be maintained in dynamic equilibrium when changes in sediment load and bed-material size are balanced by changes in streamflow and channel gradient. For example, if the bed-material sediment load supplied to a channel is significantly increased with little or no change in streamflow, either the stream will attempt to increase its gradient (e.g., by reducing its sinuosity), or the median particle size of the bed will decrease. If the additional sediment load is associated with tributary deposits, both channel adjustments frequently will occur. Backwater upstream of the tributary delta will cause deposition of finer materials (smaller d_{50}), and stream slope will increase through the delta deposit as the river seeks to return to its original grade. If the delta includes substantial amounts of finer sediments, median particle size will also decrease downstream as these finer materials are intruded into the streambed.

Additional qualitative relations have been proposed for interpreting behavior of alluvial channels (i.e., channels with bed and banks composed of sediments being transported by the river). Schumm (1977) suggested that width (b), depth (d), and meander wavelength (L) are directly proportional, and channel gradient (S) inversely proportional to streamflow (Q_w) in an alluvial channel:

$$Q_w \sim \frac{b, d, L}{S} \qquad (2)$$

Schumm (1977) also suggested that width (b), meander wavelength (L), and channel gradient (S) are directly proportional, and depth (d) and sinuosity (P) inversely proportional to sediment discharge (Q_s) in alluvial streams:

$$Q_s \sim \frac{b, L, S}{d, P} \qquad (3)$$

Equations (2) and (3) may be re-written to predict direction of change in channel characteristics, given an increase or decrease in streamflow or sediment discharge:

$$Q_w^+ \sim b^+, d^+, L^+, S^- \quad (4)$$

$$Q_w^- \sim b^-, d^-, L^-, S^+ \quad (5)$$

$$Q_s^+ \sim b^+, d^-, L^+, S^+, P^- \quad (6)$$

$$Q_s^- \sim b^-, d^+, L^-, S^-, P^+ \quad (7)$$

Combining equations (4) through (7) yields additional predictive relationships for the situation of concurrent increases or decreases in streamflow and/or sediment discharge:

$$Q_w^+Q_s^+ \sim b^+, d^{+/-}, L^+, S^{+/-}, P^-, F^+ \quad (8)$$

$$Q_w^-Q_s^- \sim b^-, d^{+/-}, L^-, S^{+/-}, P^+, F^- \quad (9)$$

$$Q_w^+Q_s^- \sim b^{+/-}, d^+, L^{+/-}, S^-, P^+, F^- \quad (10)$$

$$Q_w^-Q_s^+ \sim b^{+/-}, d^-, L^{+/-}, S^+, P^-, F^+ \quad (11)$$

where F is the channel width/depth ratio at bankfull discharge and the other channel parameters are as defined above.

Much of the Trinity River is bedrock controlled and does not meet the definition of an alluvial channel. However, most of the reach of the Trinity in the WA area is at least somewhat adjustable, flowing through materials originally deposited by the river. Before attempting to interpret land-use history and channel adjustments in the drainage basin, it would be interesting to determine if any quantitative relations can be developed to supplement the "direction-of-change" qualitative relationships described above.

It is a remarkable characteristic of natural rivers that channel dimensions vary throughout a basin in a very systematic way. The hydraulic parameters of top width, mean depth, and mean velocity may be compared from cross section to cross section throughout a watershed (mainstem and tributaries) if flows of equal frequency of occurrence are compared for the various locations. Thus, if the mean annual discharge or the bankfull flow is compared at a number of cross sections throughout a drainage, the hydraulic parameters of top width, mean depth, and mean velocity may be systematically plotted as a function of discharge. The resulting quantitative relationships are referred to as the hydraulic geometry of the stream system (Leopold 1994).

Hydraulic geometry relationships were found in the literature for a number of drainages in northern California (including the Napa, Russian, and lower Eel Rivers); however, no such relationships were discovered for either the Trinity or lower Klamath River Basins. But a review of streamgaging records dating from the turn of the century revealed that nearly 20 streamgages, each with at least 10 years of record, have been operated in the Trinity Basin since about 1910. Determination of bankfull discharge and corresponding values of width, mean depth, and mean velocity for each of these gages would produce the information required to construct hydraulic geometries for the entire Trinity River watershed.

Bankfull discharge on the great majority of streams in the world has a recurrence interval between 1.0 and 2.5 years, with a value of 1.5 being considered a reasonable average (Leopold 1994). A frequency analysis was conducted on the record for each of the streamgages identified above, and flood magnitudes were determined for recurrence intervals of about 1.25 to 2 years. Thus, approximate bankfull discharge was determined for each of the identified gages. Records of individual discharge measurements were reviewed to determine if bankfull flow had been measured from a cableway at any time during operation of the streamgage. Where such measurements were available, the information collected by the hydrographer was used to obtain estimates of bankfull width, mean depth, and mean velocity. Where such measurements were not available, a field survey of the channel cross section was made in the vicinity of the indicated gaging station, and hydraulic parameters of width, mean depth, and mean velocity obtained from field-measured bankfull dimensions. All sites were visited to determine if the channels were at least marginally adjustable or entirely bedrock controlled.

The data gathered from the historic records and field surveys was used to construct hydraulic geometries for the Trinity River Basin (CMFP-1). Estimated bankfull discharges ranged from 340 to 43,000 cfs, with estimated bankfull widths ranging from 34 to 480 feet and estimated bankfull depths ranging from 2.0 to 11.7 feet. Equations for bankfull width, mean depth, and mean velocity are given below:

$$w = 1.4\ Q^{0.52} \qquad R^2 = .94 \quad (12)$$

$$d = 0.147\ Q^{0.42} \qquad R^2 = .91 \quad (13)$$

$$v = 4.9\ Q^{0.053} \qquad R^2 = .12 \quad (14)$$

The relationships for bankfull width and depth are strong (i.e., high R^2), but the predictive equation for bankfull velocity is weak. The velocity plot in Figure CMFP-1 reveals that nearly all bankfull velocities plotted between about 6 and 10 feet per second (fps). Generally, one might expect bankfull velocities in the upper half of this range (8 to 10 fps) where channels are steep or channel roughness is low (homogeneous gravel/cobble substrate with few bars or bends), and bankfull velocities in the lower half of this range (6 to 8 fps) where channel gradients are gentler or channel roughness is high (large boulders, bars, or bends are abundant). Bankfull width and depth may be estimated from equations 12 or 13 or graphically from Figure CMFP-1.

Streamgages located in channel reaches that were considered unadjustable (i.e., bedrock-controlled channels) were excluded from the analysis. Although a few of the sites used in the analysis were only marginally alluvial (i.e., bed and banks somewhat adjustable), exponents in the hydraulic geomtry relations for the Trinity River Basin are very close to average values cited in the literature for width (0.5), depth (0.4), and velocity (0.1). Thus, the hydraulic geometries depicted in Figure CMFP-1 present quantitative relations for assessing the magnitude of channel response to increases or decreases in bankfull discharge (about 1.5-year recurrence interval). These relations should complement equations 4 through 11 for evaluating river response to perturbations in flow regime.

Research attempts to quantify channel response to changes in sediment load are far less numerous in the literature. Most efforts have focused on quantifying change in channel shape or pattern as a function of kind of sediment load. The parameter usually chosen to represent channel shape is the width-depth ratio at bankfull flow, and channel patterns are usually categorized as straight, meandering, or braided. The meandering pattern of relatively flat alluvial streams may be expressed as a riffle-pool or step-pool morphology in steeper mountain channels. Sediment load is usually characterized as suspended versus bedload, with percent of total load as bedload being a commonly used parameter. The percent silt-clay in the channel bed and banks also is used as an indicator of importance of bed-material load.

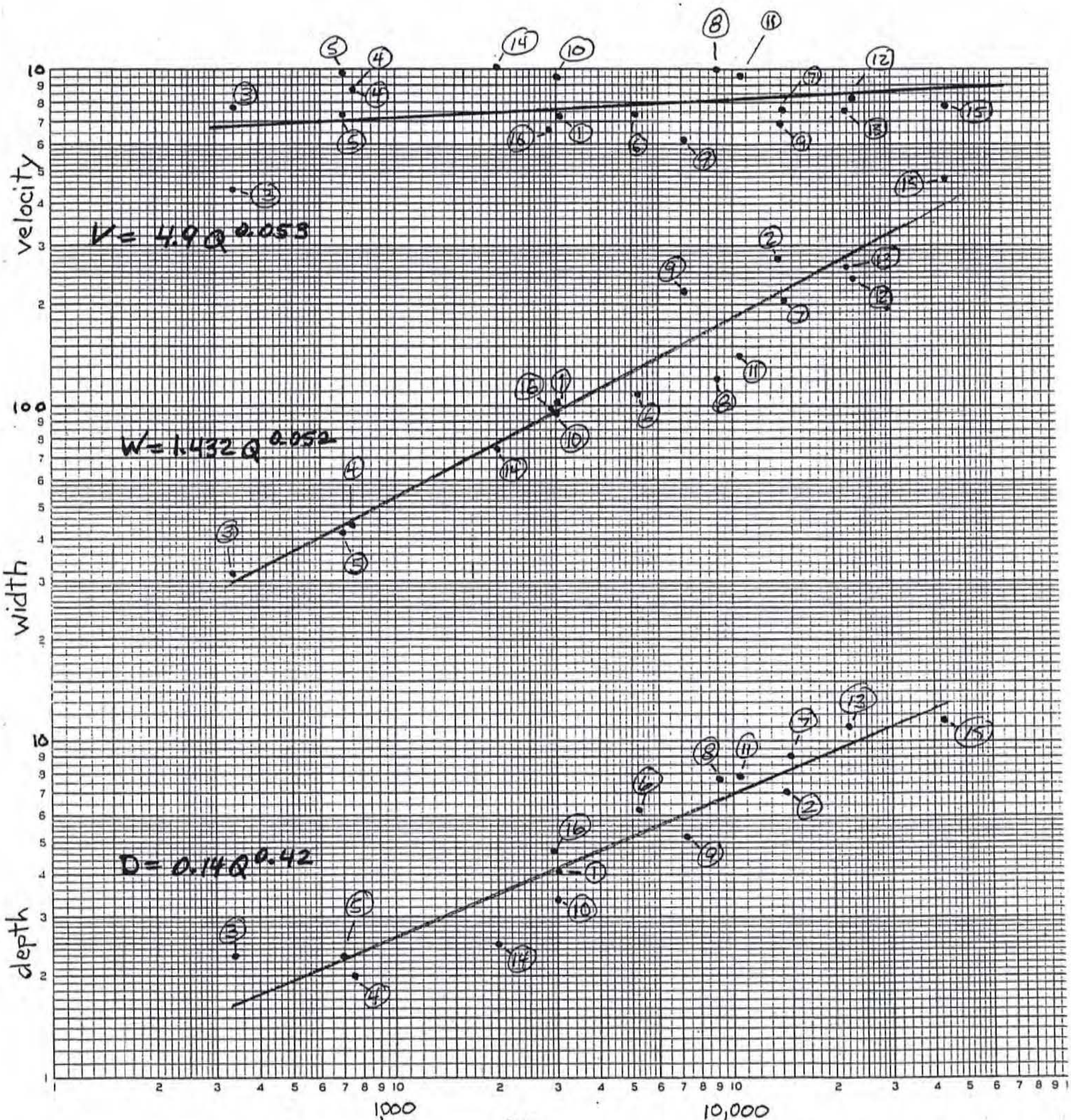


Figure CMFP-1 Hydraulic Geometries for Trinity River Basin

The nature of the sediment load as suspended or bedload has a significant influence on channel shape. Generally, channels with a high percentage of silt and clay in their bed and banks carry a predominantly suspended sediment load and usually display relatively low (<15-20) width-depth ratios at bankfull discharge. This is due, at least in part, to the cohesive nature of the sediments in transport. In contrast, channels where the bedload discharge comprises a significant portion of the total sediment load (at least 10 percent of the total load) usually display relatively high (>40) width-depth ratios at bankfull discharge. The bed and banks of these channels are usually composed of sand and coarser materials.

Relations between kind of sediment load and cross-section shape are important for understanding channel behavior on the Trinity River. Sediment load supplied to the river is a function of watershed geology, soils, and vegetation, and mechanisms of weathering, detachment, and transport that govern delivery of sediment to the channel. The particle-size distribution and transport mode of watershed-derived sediments likely will determine if the Trinity River is relatively wide at bankfull stage or relatively narrow with steep, cohesive banks.

Elsewhere in this document, sediment-producing characteristics of the watershed are described in terms of two distinct geology/soil types. Soils derived from decomposed granitic rocks generally produce high quantities of sand-size sediment, which do not undergo further weathering and thus remain non-cohesive in fluvial transport. Sediments derived from these parent materials are generally less than 8 mm in diameter and move through the stream network as bed-material load. The remaining soils in the watershed are gravelly loams and gravelly clay loams and produce bimodal distributions of sediment. The silt and clay size fractions generally are cohesive and will transport through the stream system as suspended load; however, the high degree of relief in the watershed and relatively high stream gradients render most of this load as wash load (i.e., washing through the system and not appearing in significant quantities in the bed and banks of the river). The coarser size fractions from the non-granitic sediments (gravels and cobbles) are non-cohesive material and will transport through the drainage network as bed-material load, similar to the sands from the decomposed granite.

The non-cohesive nature of the bed-material sediment load, with most silt and clay sizes passing through the river as wash load, means the Trinity River likely will possess a relatively high width-depth ratio at bankfull flow, similar to other western streams flowing through non-cohesive materials. However, the watershed likely supplies enough fine material to support well-vegetated, relatively stable banks on stream terraces that are high enough to avoid frequent scour from annual floods.

Causes and Effects of Change in the Analysis Area

The background information presented above, especially the qualitative and quantitative relations describing channel response to changes in streamflow and sediment load, will be useful for evaluating the evolution of channel conditions on the Trinity River over the past 200 years.

Pre-European Era

Virtually nothing is known regarding channel conditions on the Trinity River before arrival of European influences in the mid-1800's. However, equations 4 through 11 may be used with the earliest existing information to produce an educated guess as to what conditions were like. The earliest anecdotal information on the river channel was an 18?? account describing a wide (600 feet at high flow), relatively shallow (could cross it on horseback at low flow) river through much of its length. The earliest aerial photos of the stream corridor (1940's vintage) yield a somewhat similar description. And the earliest streamflow data for the reach in the analysis area dates from 1912-1960, prior to construction of Trinity and Lewiston Dams.

But the air photos and early anecdotes describe a river already severely impacted by decades of intensive mining activities. And the suitability of pre-dam streamflow record for the pre-European era is subject to the uncertainties of climate fluctuations. Thus, only certain generalizations may be made, and those must be based on an assumption of a temperature and precipitation regime not greatly unlike what is occurring at present.

Prior to early mining activity, much less sediment was available for transport; thus, equation 7 (above) should provide the best predictor of differences between the channel prior to European influences and that which was described anecdotally from the late 1800's. From equation 7, one would expect that the pre-mining channel likely was somewhat narrower and deeper than that described for the mining era, with somewhat greater sinuosity and a slightly gentler gradient. However, the non-cohesive nature of most of the sediment load in the basin probably precluded a narrow, deep stream channel, even in the pre-European era. This would be even more likely if the climate was hotter and drier (as some suggest), because such a climate would support less vegetation and more frequent wildfires, leading to naturally higher sediment loads, especially from droughty granitic soils.

The Trinity River was still a wild river and its flow was uncontrolled. The annual hydrograph peaked during the winter months due to storm runoff and during the spring due to snowmelt. These high flows scoured the floodplain, preventing establishment of large areas of mature riparian vegetation and encouraging early seral stages at elevations below the terraces. As snowmelt runoff subsided and water levels receded, low summer flows resulted in warm water temperatures and dessication of seedlings that had germinated in late spring and early summer. The seasonal floods of the natural flow regime mobilized the predominantly non-cohesive sediments, maintaining pools and the large alternate bars that were so inviting to the early placer mines. Thus, the pre-European channel likely resembled the anecdotal channel, but may have been slightly narrower with well-vegetated, relatively undisturbed terraces.

Mining Era

With the discovery of gold on the Trinity River in 1848, mining became the predominant industry in the basin for the next 80 to 90 years. Placer mining became widespread along the mainstem Trinity River and on many of the tributary streams. Placer mines worked the sands, gravels, and cobbles of the channel bars and floodplain, essentially disturbing all of the streambed that could be accessed at low-water elevations. Placer mining virtually ensured that all available sediment below flood elevation was non-cohesive and subject to transport. But the flow regime of the Trinity was still natural, and periodic flooding (such as the large floods of 1861-62 and 1888-89) essentially destroyed floodplain mine workings and rejuvenated the channel to a great extent. These floods undoubtedly transported large amounts of non-cohesive sediment that had been disturbed and made available by placer operations.

Once the gravel bars of the Trinity and its tributaries had been traversed and prospected for placer mining, new mining efforts employed hydraulic techniques, using water under pressure from upstream diversion to wash stream terraces and even hillsides into sluicing operations on the floodplain below. These hydraulic mining operations introduced large quantities of sediment of all sizes into the active channels of the Trinity River and many of its major tributaries. The result was a tremendous increase in the amount of sediment available for transport. Again, the great majority of this sediment would have been non-cohesive in nature.

Dredging of the Trinity River's alluvium followed placer and hydraulic mining and resulted in diversions and realignment of the channel in order to mine the streambed and the deeper deposits of the floodplain and terraces. Along the mainstem Trinity River, dredging of alluvial deposits drastically altered channel morphology both during and for decades after the initial disturbance. Disturbance of alluvial deposits in the tributaries resulted in contributions of significant quantities of sediment to the mainstem for several decades following the mining era.

Water diversions associated with mining likely affected stream discharge at low and moderate flow levels. Substantial diversion of streamflow did occur; however, depletion of streamflow from mining operations was primarily limited to tributary streams where diversions supplied a source of pressure and a means of transport for hydraulic mining operations. Water diversions likely had little impact on magnitude of large floods, which partially restored historic channel morphology and the natural functions of the streams. In short, flow depletions from mining-related diversions likely had little effect on channel shape and dimensions.

The primary impact of all mining operations was an increase in sediment yield from the basin and sediment transport through the drainage network. Equation 6 (above) predicts direction-of-change channel adjustments expected from an increase in watershed sediment discharge. Increased sediment loads due to mining likely caused an increase in width and a decrease in depth for a given discharge. Morphological adjustments also may have favored straighter channels, with slightly steeper gradients. Channel pattern probably tended toward a braided condition, at least locally. And while the natural flood regime of the Trinity River and its tributaries provided a recovery mechanism for the stream channels and their floodplains, evidence from 1944 aerial photographs indicates a lack of vegetation on tailings piles and an overall lack of natural conditions on stream terraces not subject to periodic flooding.

Logging Era

Following World War II, the market for lumber and the advent of tractor yarding once again drastically altered the natural environment in the study area. The market for lumber changed the timber-production economy from one of local consumption to an export market, and widespread tractor logging and road construction resulted in huge increases in the amount and distribution of land disturbance in the basin. Thousands of miles of roads and skid trails were constructed, often in close proximity to or within stream channels. Sediment production increased dramatically, especially from soils derived from decomposed granite. Whereas sediment increases from mining provided a wide range of particle sizes for transport, sediment increases from logging on predominantly granitic soils produced primarily sand-size particles for transport through the drainage network.

Logging-related increases in watershed sediment production likely influenced both mainstem and tributary channels in a manner similar to that described above for mining-related sediment increases. Streams adjusted to higher sediment loads by becoming wider and shallower and, where possible, straighter and steeper. Streams with particularly high sediment loading likely tended toward a braided condition, at least locally. The predominantly sand-size particles available for transport were more efficiently intruded into the streambed than were the coarser sizes associated with some of the mining activity. Intrusion of sand into the gravel/cobble matrix of most streams in the WA area likely produced some imbeddedness of coarser substrates and a reduction in channel roughness and resistance to flow.

Diversity of channel features (pools, riffles, etc.) may have been reduced temporarily as fine sediments (mostly sands) filled pools between major flood events; however, pool filling and imbeddedness of channel substrate likely were ephemeral because of the natural flow regime. Extremely high flows triggered by rain-on-snow events were more than adequate to initiate motion of the substrate with depth flushing of finer sediments. These peak flows were geomorphically significant because they had the effect of renewing a variety of aquatic habitats (e.g., scour holes, undercut banks, new bar deposits, woody material, etc.) and resetting conditions on the floodplain to an early seral stage. As long as the watershed experienced these natural flood events, the Trinity River had a process for adjusting channel size and shape to attain an equilibrium with the water and sediment being supplied by the watershed.

Population growth and development of timber resources since World War II has also affected the flow regimes of several Trinity River tributaries. Population growth in the analysis area has primarily affected Weaver Creek flows due to diversions for domestic, industrial, and agricultural uses in the vicinity of Weaverville. Analysis of flow-duration characteristics for Weaver and Grass Valley Creeks (discussed below) indicates similar levels of streamflow per unit area of watershed when flow levels are high; however, during low flow season, Grass Valley Creek maintains significantly higher base flows compared to Weaver Creek. The lower base flows in Weaver Creek are attributed to diversions in the basin.

Small diversions for agricultural purposes date from the era of European settlement (1850-1945), but widespread changes from logging have primarily occurred in the last 50 years. The most common impacts of forest harvest on streamflow include increased peak flow, low flow, and annual water yield. Low flow and annual water yield frequently increase after harvest because of reduced evapotranspiration from the forest canopy. Increases in peak flow are usually associated with logging roads, where drainage ditches function as extensions of the stream network, routing surface and subsurface storm runoff out of the watershed more efficiently.

Increases in low flow and annual water yield have no appreciable effect on channel morphology and fluvial processes, but increases in peak flow will alter channel dimensions considerably. Equation 8 (above) predicts direction-of-change channel adjustments that are expected from increased flows and sediment discharge after logging. Obviously, a stream will evolve toward a larger channel with an increase in flow and sediment load (i.e., a wider and sometimes deeper channel, depending on magnitude of sediment load increases), but other adjustments may include a decrease in sinuosity and a change in shape to a wider, shallower cross section (i.e., higher width/depth ratio). The magnitude of increase in bankfull width and depth may be estimated from the hydraulic geometry relationships presented above (Figures CMFP-1, 2, and 3) if relations exist for relating peak-flow increases (at bankfull discharge) to amount of basin harvested or in a roaded condition.

However, changes in streamflow due to roading and logging usually are insignificant unless large proportions of a basin are in a clearcut or roaded condition. Generally, clearcuts must occupy at least 25 to 50 percent of a basin and roads must occupy at least 5 to 10 percent of a basin for changes in flow to be statistically measureable. Thus, while logging-induced changes in flow regime of some smaller watersheds may have been significant, changes in flow regime of the larger tributaries and the Trinity River likely have been small.

Post-Dam Era

Following World War II, rapid population growth and an expanding agricultural industry in California's central valleys created a need for additional water to supply the farms and towns of central California. As part of the Central Valley Project (a major water-supply development effort of the USDI-Bureau of Reclamation), Trinity and Lewiston Dams were constructed in 1960-1963 to store Trinity River water for transmountain diversion into the Sacramento Basin. The result was a drastic change in flow regime for the mainstem Trinity River below Lewiston Dam. With approximately 90 percent of annual streamflow initially diverted to the Sacramento Basin, the Trinity River underwent significant changes in channel morphology with associated changes in its riparian and aquatic environments.

Nearly fifty years (1912-1960) of streamflow record for the Trinity River at Lewiston are available for characterizing natural flow conditions for the past 100 years. Flow statistics (Tables CMFP-1, CMFP-2; Figures CMFP-2, CMFP-3) for this period of record summarize average and extreme conditions representing the natural range of variability. Table CMFP-1 presents statistics on monthly and annual mean flows, and Table CMFP-2 gives estimates of extreme high and low flows for the natural condition. Selected values of extreme high and low flows are plotted in Figure CMFP-2, and the annual flow-duration curve is plotted in Figure CMFP-3. The flow-duration curve represents percent of time that a given flow was equalled or exceeded over the approximately 50 years of record.

TABLE CMFP-1. Flow statistics for the Trinity River at Lewiston, 1912-1960 and 1962-1993.

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1912 - 1960, BY WATER YEAR (WY)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	302	742	1257	1572	2544	2653	3675	3832	2131	611	201	158
MAX	2174	3055	5319	5734	11670	6116	6986	9062	6311	2579	628	423
(WY)	1951	1921	1956	1956	1958	1941	1915	1958	1915	1941	1941	1912
MIN	92.3	121	147	169	331	519	725	442	115	42.7	41.0	41.1
(WY)	1918	1930	1937	1937	1933	1924	1924	1924	1924	1924	1924	1924

SUMMARY STATISTICS	WATER YEARS 1912 - 1960	
ANNUAL MEAN	1641	
HIGHEST ANNUAL MEAN	3721	1958
LOWEST ANNUAL MEAN	367	1924
HIGHEST DAILY MEAN	38700	Dec 22 1955
LOWEST DAILY MEAN	28	Jul 30 1924
ANNUAL SEVEN-DAY MINIMUM	31	Jul 26 1924
INSTANTANEOUS PEAK FLOW	71600	Dec 22 1955
INSTANTANEOUS PEAK STAGE	27.3	Dec 22 1955
ANNUAL RUNOFF (AC-FT)	1189000	
10 PERCENT EXCEEDS	4310	
50 PERCENT EXCEEDS	732	
90 PERCENT EXCEEDS	132	

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1962 - 1993, BY WATER YEAR (WY)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	270	293	358	489	414	576	652	637	618	336	288	280
MAX	424	849	2285	4038	1782	5489	5029	3937	4668	1096	577	531
(WY)	1993	1984	1984	1974	1983	1983	1963	1963	1983	1983	1982	1982
MIN	203	220	144	145	145	149	130	149	146	142	139	150
(WY)	1966	1971	1977	1977	1977	1977	1976	1976	1976	1976	1976	1966

SUMMARY STATISTICS	WATER YEARS 1962 - 1993	
ANNUAL TOTAL		
ANNUAL MEAN	434	
HIGHEST ANNUAL MEAN	1784	1983
LOWEST ANNUAL MEAN	165	1977
HIGHEST DAILY MEAN	13800	Jan 19 1974
LOWEST DAILY MEAN	100	Apr 14 1976
ANNUAL SEVEN-DAY MINIMUM	103	Apr 12 1976
INSTANTANEOUS PEAK FLOW	14400	Jan 18 1974
INSTANTANEOUS PEAK STAGE	10.41	Jan 18 1974
ANNUAL RUNOFF (AC-FT)	314500	
10 PERCENT EXCEEDS	554	
50 PERCENT EXCEEDS	289	
90 PERCENT EXCEEDS	154	

TABLE CFMP-2. Flow Duration Data for the Trinity River at Lewiston.

Stream Name:	TRINITY RIVER AT LEWISTON					
			Recurrence Interval			
	1.25 Year	*2 Year*	*5 Year*	*10 Year*	*25 Year*	*50 Year*
Period of Record: 1912-1960, Pre-Dam						
High Flow Duration						
1 Day	8,532	13,899	21,953	27,542	34,766	40,215
3 Day	6,490	10,375	16,162	20,171	25,357	29,276
5 Day	5,529	8,517	12,858	15,821	19,621	22,476
7 Day	4,979	7,477	10,937	13,206	16,025	18,084
10 Day	4,476	6,596	9,416	11,202	13,359	14,896
15 Day	4,008	5,808	8,096	9,490	11,120	12,247
30 Day	3,352	4,779	6,507	7,514	8,649	9,409
Low Flow Duration						
1 Day	153	110	73	57	43	35
7 Day	158	114	77	61	47	29
30 Day	174	127	86	68	52	43
Period of Record: 1964-1992 Post-Dam						
High Flow Duration						
1 Day	527	1,361	3,714	6,418	11,701	17,411
3 Day	500	1,303	3,604	6,281	11,569	17,340
5 Day	476	1,241	3,448	6,033	11,172	16,824
7 Day	457	1,183	3,269	5,709	10,560	15,889
10 Day	436	1,109	3,017	5,235	9,627	14,440
15 Day	413	1,008	2,637	4,485	8,072	11,943
30 Day	360	784	1,839	2,961	5,039	7,197
Low Flow Duration						
1 Day	236	177	137	121	107	99
7 Day	255	190	145	126	109	100
30 Day	271	202	153	133	115	105

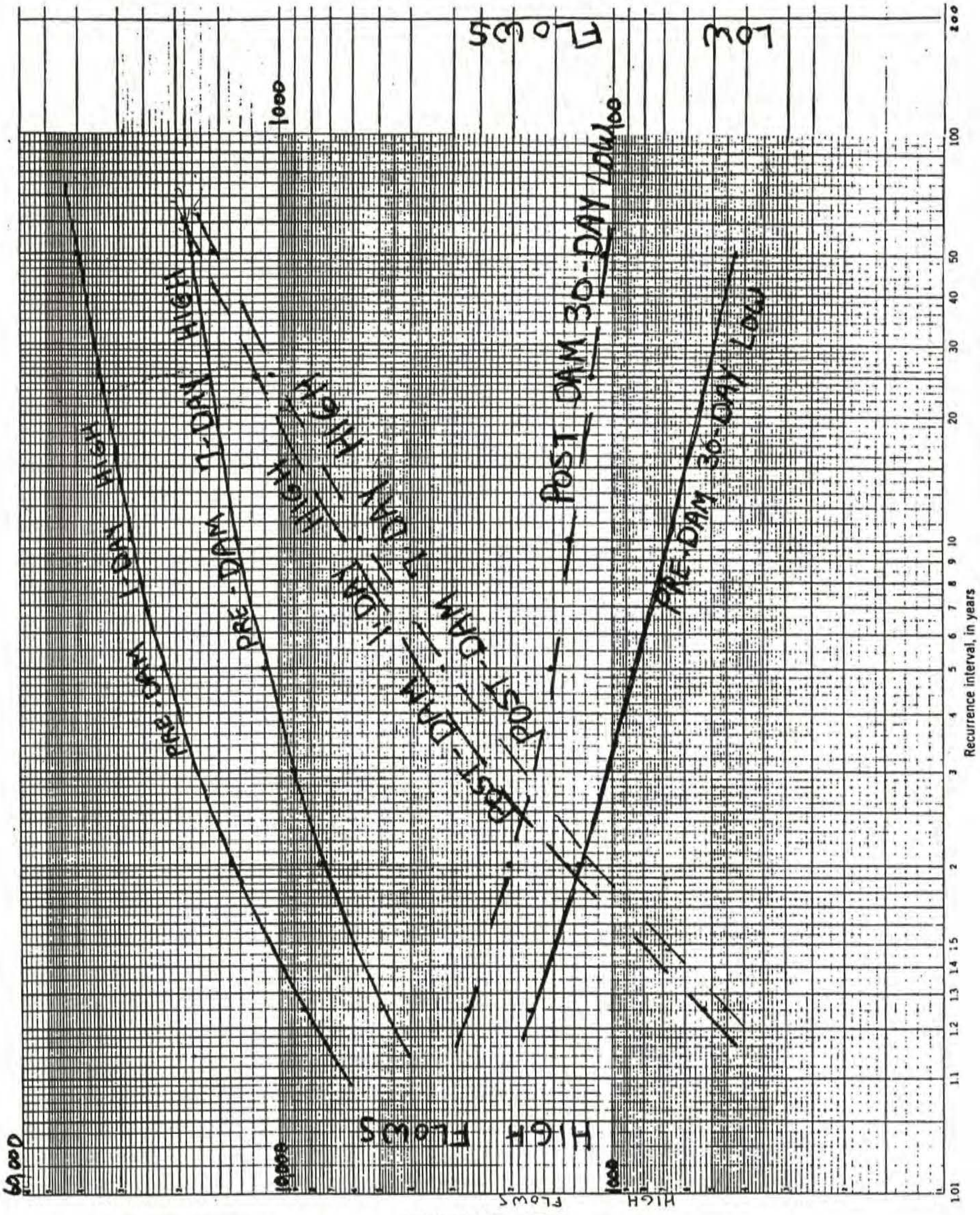


FIGURE CMFP-2

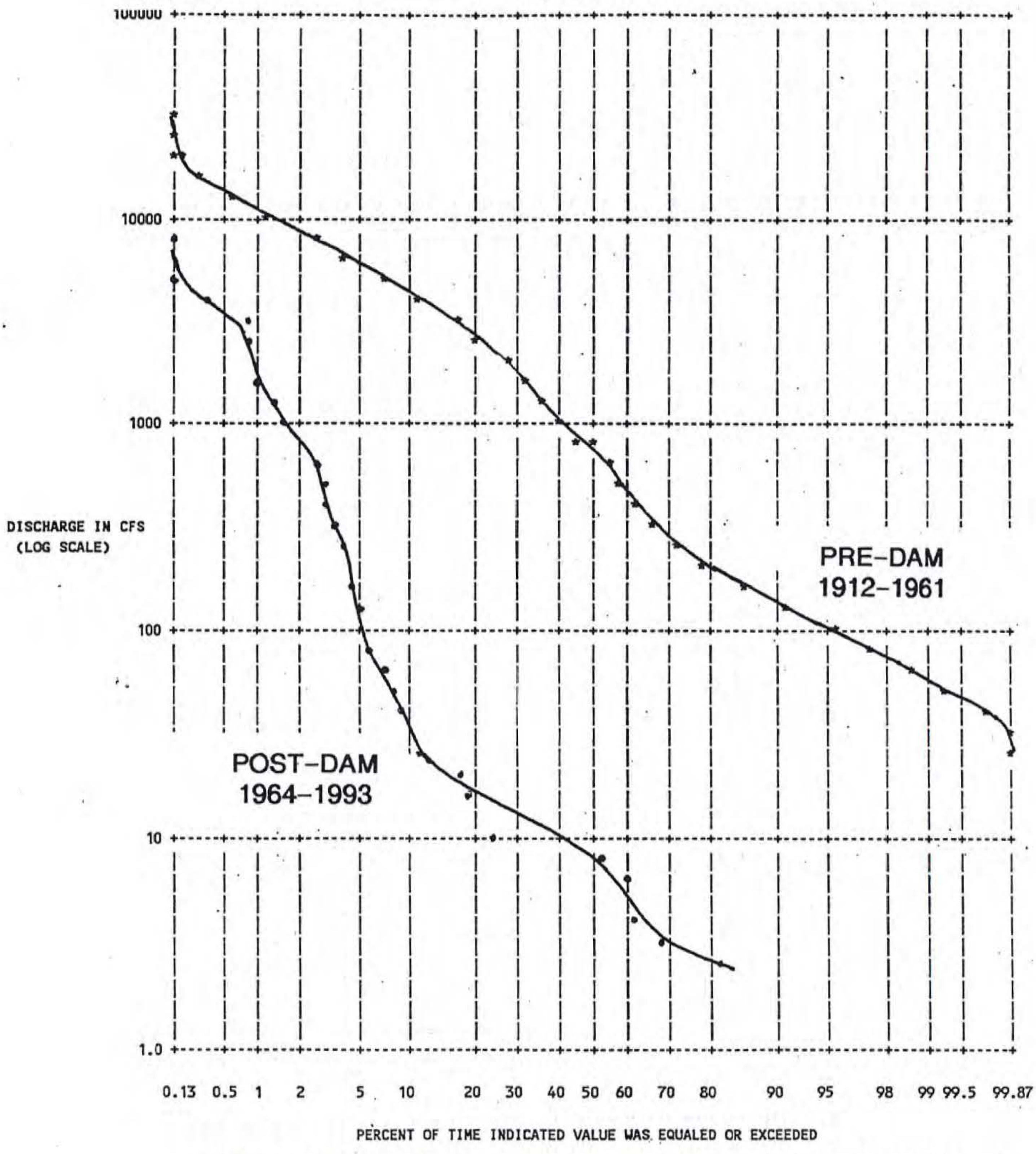


FIGURE CMFP-3. Annual flow duration curve for the Trinity River at Lewiston.

Approximatley 30 years of streamflow record also exists to characterize present flow conditions in the Trinity mainstem since the two dams were closed. Tables CMFP-1 and CMFP-2 and Figures CMFP-2 and CMFP-3 also contain flow statistics for this post-dam period of record. Comparison of statistics for pre- and post-dam periods reveals augmented monthly flows for August and September and greatly reduced monthly flows for November through July as a result of reservoir operations (Table CMFP-1). Impact of the dams on extreme high and low flows is even more pronounced (Table CMFP-2 and Figure CMFP-2). Pre-dam flood events of relatively frequent occurrence (and major floods as well) have been eliminated, as have extended periods of low flows less than 150 cfs during the summer months. Loss of these extreme flow levels has had profound effects on the channel morphology and ecology of the river. The shift in the flow-duration curve of Figure CMFP-3 portrays the overall reduction in flows in the post-dam period, but the effect is even more impressive when individual water-year hydrographs are displayed from the two periods (Figure CMFP-4).

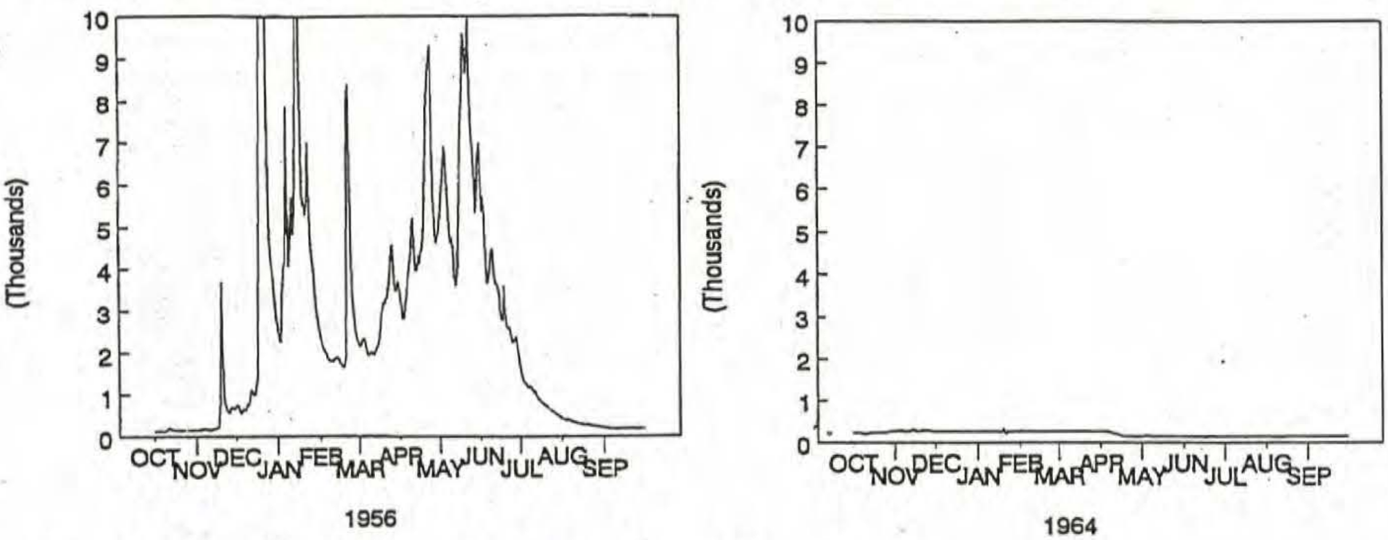


Figure CMFP-4. Selected annual hydrographs for the Trinity River

At the same time that sediment production from tributaries disturbed by logging was increasing, transport capacity of the mainstem Trinity River was almost totally eliminated. Changes in channel morphology were swift and dramatic. The constant water level provided by a regulated year-round flow of 150 cfs fostered rapid establishment of dense riparian vegetation on the floodplain, which previously experienced both frequent scour from winter storms and spring runoff and late summer dessication from low flows in August and September. Floodplain vegetation downstream from the dam trapped sediment from tributaries during runoff events, creating berms that had the effect of channelizing the river. Gone were the annual high flows that scoured vegetation, transported sediment, drove the constant migration of alternate bars, and maintained a clean gravel/cobble sustrate. Within the berms, channel width decreased, stream depth and velocity increased, and fine sediment buried coarse gravel deposits, destroying essential spawning habitat. Wilson (1993) reported that total area of riparian vegetation increased by 282 percent between 1960 and 1989, while 95 percent of open gravel-bar areas had disappeared and open-water habitat had decreased by 45 percent. Numerous other studies also documented encroachment of vegetation on the floodplain, accumulations of sediment in the channel, and changes in channel morphology (Ritter 1968, Knott 1974, Lisle 1982).

River conditions that developed after the closing of Lewiston Dam can be illustrated by comparison of two similar and remarkable flood events. The storm of 1955 provided a peak flow of 70,000 cfs in the Trinity River at Lewiston. Enormous sediment loads contributed to the river system from intensive logging apparently did not damage aquatic habitats over the reach from Lewiston to the North Fork, according to regularly conducted habitat(?) surveys. After closing of the dams, the storm of 1964 produced a measured peak discharge of 110,000 cfs as inflow to the reservoir, and only 150 cfs was released at the base of the dam (compared with the 100,000+ cfs that would have passed by the site naturally). The reservoir contained the entire storm event. Flooding tributaries downstream of Lewiston Dam flowed at unimpeded levels, carrying huge sediment loads that were deposited in the placid flows of the mainstem below the dam. Grass Valley Creek alone discharged an estimated 1,000,000 cubic yards of coarse granitic sand in the river. Spawning beds were completely covered, sediment berms gained feet in elevation, and large deltas formed at many tributary confluences.

A decrease in channel width and an increase in gradient (decreased sinuosity) are predicted for a decrease in streamflow by equation 5 (above). An increase in stream depth would not be expected for a decrease in flow; however, encroachment of riparian vegetation has been so effective at building sediment berms and constricting the channel that depth has been maintained (and possibly increased) by severe constriction of channel width. Reduction in channel width following elimination of frequent flooding also is predicted by hydraulic geometry relations (Figure CMFP-1). From Table CMFP-2, the 1.5-year flood (assumed roughly equal to bankfull flow) decreased from about 10,000 cfs prior to dam construction to about 1000 cfs following dam construction. Corresponding bankfull widths from Figure CMFP-1 are about 180 feet for pre-dam conditions and about 55 feet for post-dam conditions. Thus, significant reductions of channel width were to be expected for the flow regime originally planned for Lewiston Dam.

Recent attempts to restore lost aquatic habitat have focused on removal of the sediment berms. These projects attempt to re-create the alternate bar morphology that existed when the river had a natural flow regime. While initial attempts to restore bar habitat for juvenile salmonids looks promising, long-term success at maintenance of such features will be strongly dependent upon a new flow regime from the dams. Without periodic flood flows and control of tributary sediment loading, such efforts are doomed to failure, as the fluvial processes that created the berms are natural responses of a river system attempting to adjust to the flow and sediment supplied to it.

Management Recommendations

Management opportunities to restore aquatic and riparian ecosystems of the mainstem Trinity River and its tributaries are linked to restoration of a natural flow and sediment regime for the watershed. In addition, restoration of these habitats may be expedited by mechanical removal of dam-induced sediment berms and other stream corridor restoration activities.

Restoration of Natural Flow and Sediment Regimes

Opportunities to restore a more natural flow regime to the Trinity River below Lewiston Dam are the subject of a 12-year study authorized by the Secretary of Interior in 1984. Alternative flow regimes being proposed for wet, normal, and dry water-supply years will be analyzed in an Environmental Impact Statement scheduled for completion in 1996. Proposed flow scenarios should be evaluated for their ability to maintain physical processes responsible for shaping channel morphology and for their ability to transport sediment inputs to the river below the dam . Flows that mimic the natural range of variability likely will be most effective in restoring physical processes that shaped the pre-dam channel; thus, evaluation of proposed flow scenarios should include analysis of extreme high and low flows of extended duration (such as Table CMFP-2 above). In addition, sediment discharge functions developed in this Watershed Analysis (and elsewhere) should be useful for evaluating sediment-transport efficiency of the recommended scenarios. However, a totally restored natural hydrograph is unlikely due to a number of constraints (discussed below).

A number of factors constrain management opportunities for restoring a completely natural hydrograph. Competing water uses, particularly Bureau of Reclamation contracts for Central Valley Project water, limit flexibility for restoring a natural flow regime. Structures, especially private residences, on the floodplain below the dam constrain opportunities for restoring natural flood flows similar to pre-dam conditions. Flood flows similar to pre-dam levels are also constrained by size of the outlet works at Lewiston Dam.

Significant social, economic, and physical constraints exist for restoring a completely natural hydrograph; thus, the flow evaluation study likely will propose dam-release scenarios for wet, normal, and dry years that are somewhat less than natural inflow to the reservoirs. Information developed from Trinity River research, along with material presented in this Watershed Analysis, should be useful for assessing the suitability of those scenarios. For example, Wilcock (1995) suggests that discharges in the range of 5000 to 6000 cfs provide the greatest efficiency for moving sand through the mainstem Trinity River in the WA area, while keeping gravel loss to the minimum required to mobilize the gravel bed. Similarly, Trush and McBain (1995) suggest that flows of 8500 cfs are required for mobilization and limited migration of alternate bars and tributary delta deposits. Trush and McBain (1995) also recommend duration of high and low flows tied to water supply conditions (e.g., wet, normal, and dry years).

Table CMFP-2 (above) also may be used to relate high flow durations to water-supply conditons. For example, assume the distribution of wet, normal, and dry years over the period of record (1912-1995). is as given in Table CMFP-3 below, and that flow releases in the ranges given in the previous paragraph are assigned to wet and normal years as shown:

Table CMFP-3. Hypothetical distribution of wet, normal, and dry conditions, and assigned flow releases for each.

Water-Year Condition	Frequency	Assigned Flow Release
Wet	1 of 5 years	8500 cfs
Normal	3 of 5 years	5500 cfs
Dry	1 of 5 years	?? cfs

A flow release of 8500 cfs has been identified for maintaining geomorphic processes (Trush and McBain 1995) during wetter than normal water-supply years. Because this condition occurs on average one year in five in our hypothetical example, the recurrence interval would be a five-year event. Table CMFP-2 reveals that a flow of 8500 cfs occurred for a duration of about 13 days for a five-year event in the pre-dam period of record. Thus, the recommended duration of the 8500-cfs release would be about 13 days. Flows of longer duration in Table CMFP-2 could be used to help shape the runoff hydrograph. For example, the 30-day average flow for the five-year event was 6500 cfs on the pre-dam hydrograph; thus, the constructed release hydrograph would average 8500 cfs for 13 days and 6500 cfs for 30 days. If one year in five is deemed too infrequent for these channel maintenance flows, the column for two-year floods could be used, and the durations and magnitudes adjusted accordingly.

A similar flow scenario could be developed for normal water-supply years. Normal years occur three years in five in our hypothetical example. Because wet years would produce flows greater than would be produced in normal years, the flow scenario for normal years would be equalled or exceeded four years out of five (three for the normal year and one for the wet year). Thus, the recurrence interval would be 5/4 or 1.25 years. Table CMFP-2 reveals that the 5500-cfs release identified for normal years occurred for about five days with a 1.25-year recurrence interval in the pre-dam period of record. The remainder of the release hydrograph would average nearly 5000 cfs for seven days, 4000 cfs for 15 days, and 3350 cfs for 30 days to approximate the pre-dam runoff condiion (Table CMFP-2).

Dam-release scenarios developed in this fashion likely will come as close as possible to the natural hydrograph, given the various constraints that exist. Once developed, however, the scenarios should be evaluated to determine if they are adequate to transport sediment inputs to the Trinity River estimated in this analysis. In other words, will the proposed flow regimes and their respective frequencies of occurrence combine to transport the long-term average sediment load supplied to the Trinity River by its tributaries below the dams? Analysis of the sediment-transport capability of the proposed release scenarios should use the sediment transport functions developed by Wilcock (1995) or those developed from measured data in the sediment budget of this Watershed Analysis. (Preferably, the EIS would do both.) The sediment-transport functions could be used with either hydrographs of daily values or flow-duration curves (such as was done in the sediment budget of this analysis) for the flow regimes being proposed.

Channel Restoration Activities

There are four kinds of information that should be incorporated into design of site-specific restoration projects for the Trinity River and its tributaries:

1) Streamflow Analysis
2) Fluvial Geomorphology/Hydraulic Geometry
3) Interpretation of Aerial Photos
4) Identification of Habitat Needs

From the Trinity River Restoration Program, the Flow Evaluation Study, this Watershed Analysis, and the research supporting these efforts, virtually all the information identified above is now readily available for site-specific project planning.

A streamflow analysis to characterize the flow regime of the Trinity River below Lewiston Dam was presented above. In addition, three Trinity River tributaries in the Watershed Analysis area have at least 10 years of systematic streamflow record, and the North Fork Trinity River streamgage also provides useful information for this analysis. Table CMFP-4 summarizes the existing record available for estimating tributary flow characteristics.

Table CMFP-4. Systematic streamflow data available for Trinity River tributaries.

STREAM	PERIOD OF RECORD	MAY BE USED TO ESTIMATE RECORD FOR:
Grass Valley Creek	1975-present	Deadwood, Hoadley, and Indian Creeks
Weaver Creek	1959-1968	Rush Creek
Browns Creek	1957-1966	Reading Creek
North Fork Trinity R.	1912-1980 (partial)	Canyon Creek

Although tributary flow regimes likely have changed little as a result of timber harvest, the short period of record (10 years) associated with the Weaver and Browns Creek gages could result in over- or underestimation of streamflow characteristics if these 10 years of data are not representative of a longer period. Thus, it was important to determine if the period from 1958-1968 was much wetter or drier than long-term average conditions. A statistical comparison of these 10 water years with long-term flow conditions at the Trinity River below Lewiston gage was not possible, as the period from 1958-1968 included several years when the dams were in operation. Thus, another site with long-term streamflow data was required for testing the shorter period of record.

The Trinity River streamgage above Coffee Creek has been in operation since 1958 and is upstream of all water-supply storage projects in the Trinity Basin. Flow-duration characteristics were computed for this gage for two periods: 1958-1968 (11 years) and 1958-1993 (36 years). The results are shown in Figure CMFP-5. The two plots are nearly identical, indicating that the shorter period of record for this gage very closely matches a much longer record. From this analysis, it appears that the short record for Weaver and Browns Creek likely is representative of a longer period and should be useful for estimating the natural range of variability.

Tables CMFP-5 through CMFP-8 and Figures CMFP-6 through CMFP-9 summarize the natural range of variability of streamflow in the gaged tributaries of the Trinity River below Lewiston Dam. When streamflows are converted to cfs per square mile of watershed, the North Fork Trinity River has the highest unit-area runoff, probably because of the higher mean basin elevation for this watershed. Grass Valley, Weaver, and Browns Creeks produce somewhat similar unit-area runoff throughout most of the range of flow, but Browns Creek has slightly lower numbers at the highest flows. Weaver Creek has distinctively lower unit-area flows in the dry season due to many diversions in the vicinity of Weaverville. At the lowest end of the flow range, Grass Valley Creek has higher unit-area flows than even the North Fork, likely because the predominantly sandy soils in this watershed favor infiltration of precipitation and sustenance of base flow.

Flow regimes of Trinity River tributaries below Lewiston are wild and nearly pristine, so restoration of natural flow regimes is not an issue. Opportunities for flow enhancement are constrained by absence of storage facilities. But channel restoration efforts on these tributary streams will need streamflow estimates for design purposes; thus, the information presented in Tables CMFP-5 through CMFP-8 and Figures CMFP-6 through CMFP-9 will prove extremely useful.

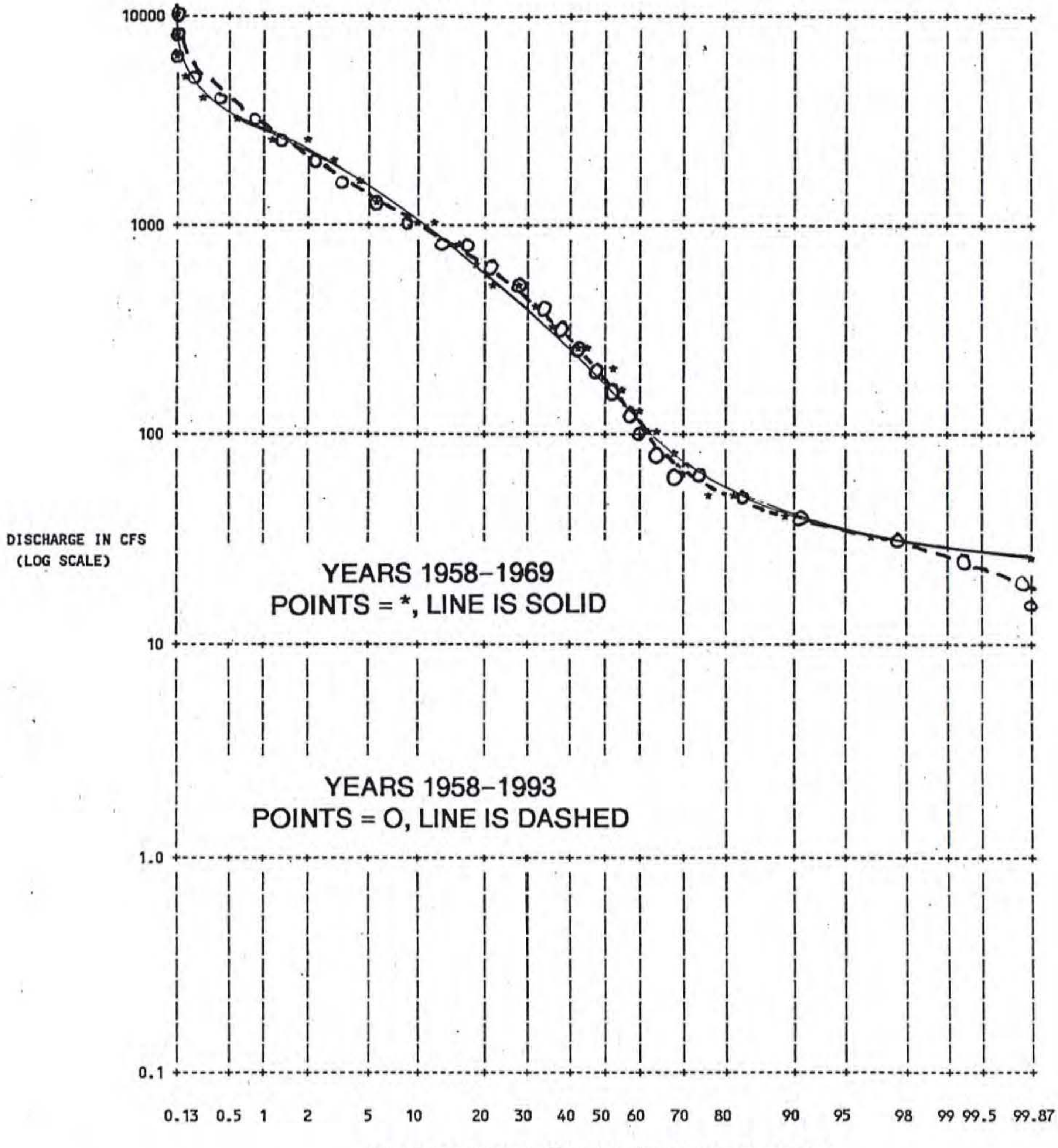


Figure CMFP-5. Flow duration plot of daily data for the Trinity River above Coffee Creek for two periods of record, 1958 - 1969, and 1958 - 1993.

Stream Name:		GRASS VALLEY CREEK AT FAWN LODGE NEAR LEWISTON, CA				
Period of Record:		1975-1991				
			Recurrence Interval			
	1.25 Year	2 Year	5 Year	10 Year	25 Year	50 Year
High Flow Duration						
1 Day	106	243	607	1,013	1,797	2,639
3 Day	83	189	476	801	1,442	2,144
5 Day	75	160	393	665	1,218	1,846
7 Day	70	144	343	572	1,034	1,556
10 Day	65	129	293	478	843	1,247
15 Day	59	111	244	389	673	983
30 Day	48	88	181	279	463	657
Low Flow Duration						
1 Day	10	9	5	3	2	1
7 Day	10	8	6	6	5	5
30 Day	11	9	7	6	5	5

Table CMFP-5. Flow duration data for Grass Valley Creek at Fawn Lodge.

Stream Name:		WEAVER CREEK NEAR DOUGLAS CITY, CA				
Period of Record:		1959-1968				
			Recurrence Interval			
	1.25 Year	2 Year	5 Year	10 Year	25 Year	50 Year
High Flow Duration						
1 Day	779	1,298	2,075	2,608	3,291	3,799
3 Day	567	880	1,322	1,614	1,980	2,247
5 Day	453	684	1,044	1,309	1,671	1,960
7 Day	375	564	869	1,100	1,424	1,691
10 Day	322	468	700	846	1,124	1,328
15 Day	272	395	558	661	785	874
30 Day	194	259	349	410	486	543
Low Flow Duration						
1 Day	1	1	0	0	0	0
7 Day	1	1	0	0	0	0
30 Day	2	1	1	1	0	0

Table CMFP-6. Flow duration data for Weaver Creek near Douglas City.

Stream Name:		BROWNS CREEK NEAR DOUGLAS CITY, CA				
Period of Record:		1957-1966				
			Recurrence Interval			
	1.25	2	5	10	25	50
	Year	Year	Year	Year	Year	Year
High Flow Duration						
1 Day	817	1,145	1,768	2,313	3,186	3,992
3 Day	581	819	1,290	1,713	2,408	3,065
5 Day	491	679	1,045	1,371	1,899	2,393
7 Day	414	577	914	1,228	1,761	2,279
10 Day	337	480	790	1,091	1,618	2,148
15 Day	302	404	637	872	1,294	1,729
30 Day	230	306	478	649	956	1,268
Low Flow Duration						
1 Day	5	2	1	1	0	0
7 Day	6	3	2	1	1	1
30 Day	7	4	3	2	2	1

Table CMFP-7. Flow duration data for Browns Creek near Douglas City.

Stream Name:		NORTH FORK TRINITY RIVER AT HELENA, CA				
Period of Record:		1912-1979				
			Recurrence Interval			
	1.25	2	5	10	25	50
	Year	Year	Year	Year	Year	Year
High Flow Duration						
1 Day	3,089	5,479	9,283	12,014	15,610	18,357
3 Day	2,370	3,953	6,545	8,493	11,187	13,349
5 Day	1,994	3,192	5,176	6,700	8,858	10,632
7 Day	1,734	2,690	4,301	5,566	7,398	8,938
10 Day	1,513	2,252	3,499	4,483	5,919	7,137
15 Day	1,296	1,872	2,821	3,557	4,615	5,503
30 Day	993	1,388	1,964	2,378	2,933	3,370
Low Flow Duration						
1 Day	27	21	16	13	10	8
7 Day	27	23	14	14	11	9
30 Day	31	26	20	17	14	12

TableCMFP-8. Flow duration data for the North Fork Trinity River at Helena.

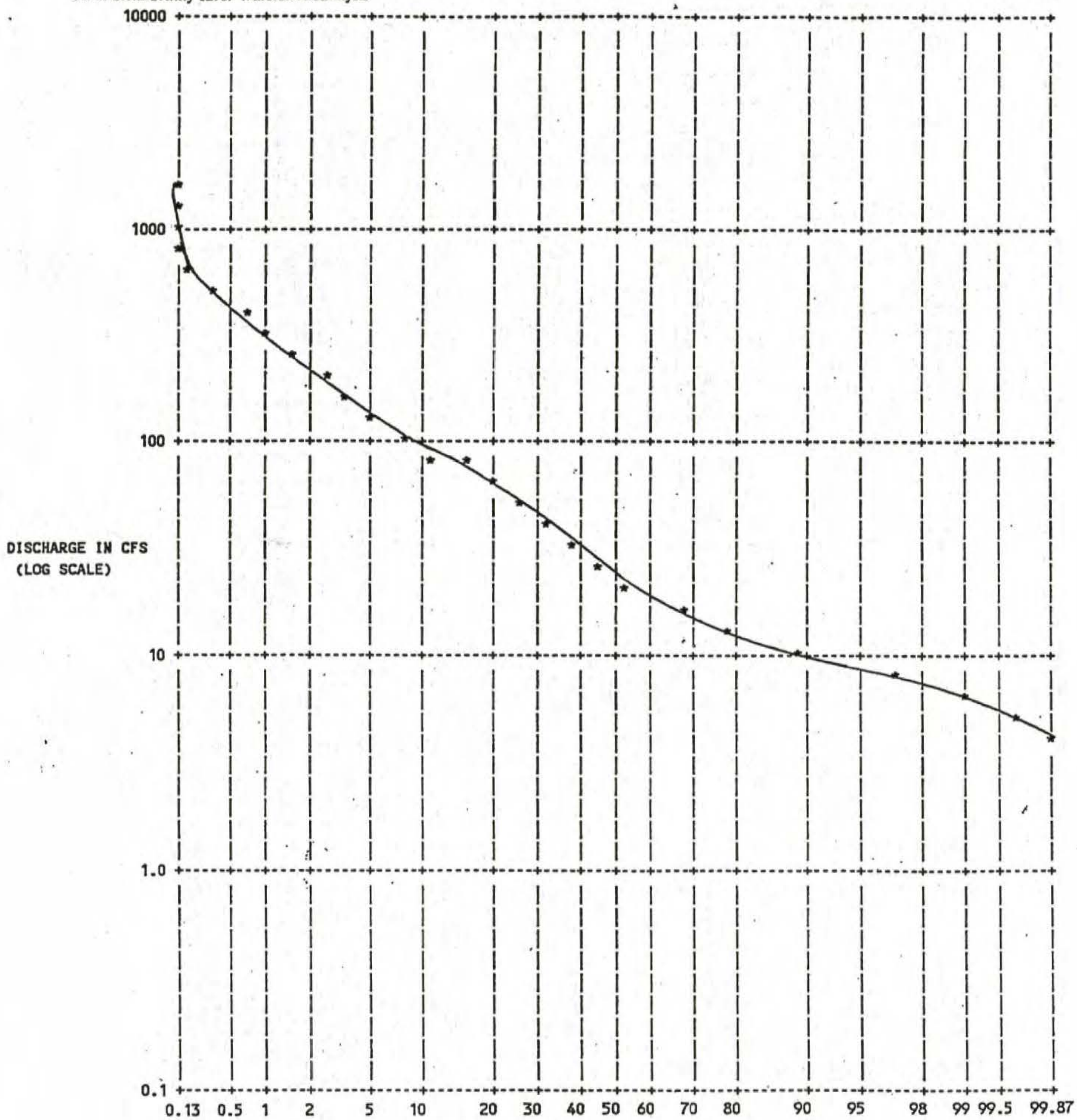


Figure CMFP-6. Flow duration plot of daily data for Grass Valley Creek at Fawn Lodge for water years 1976 - 1993.

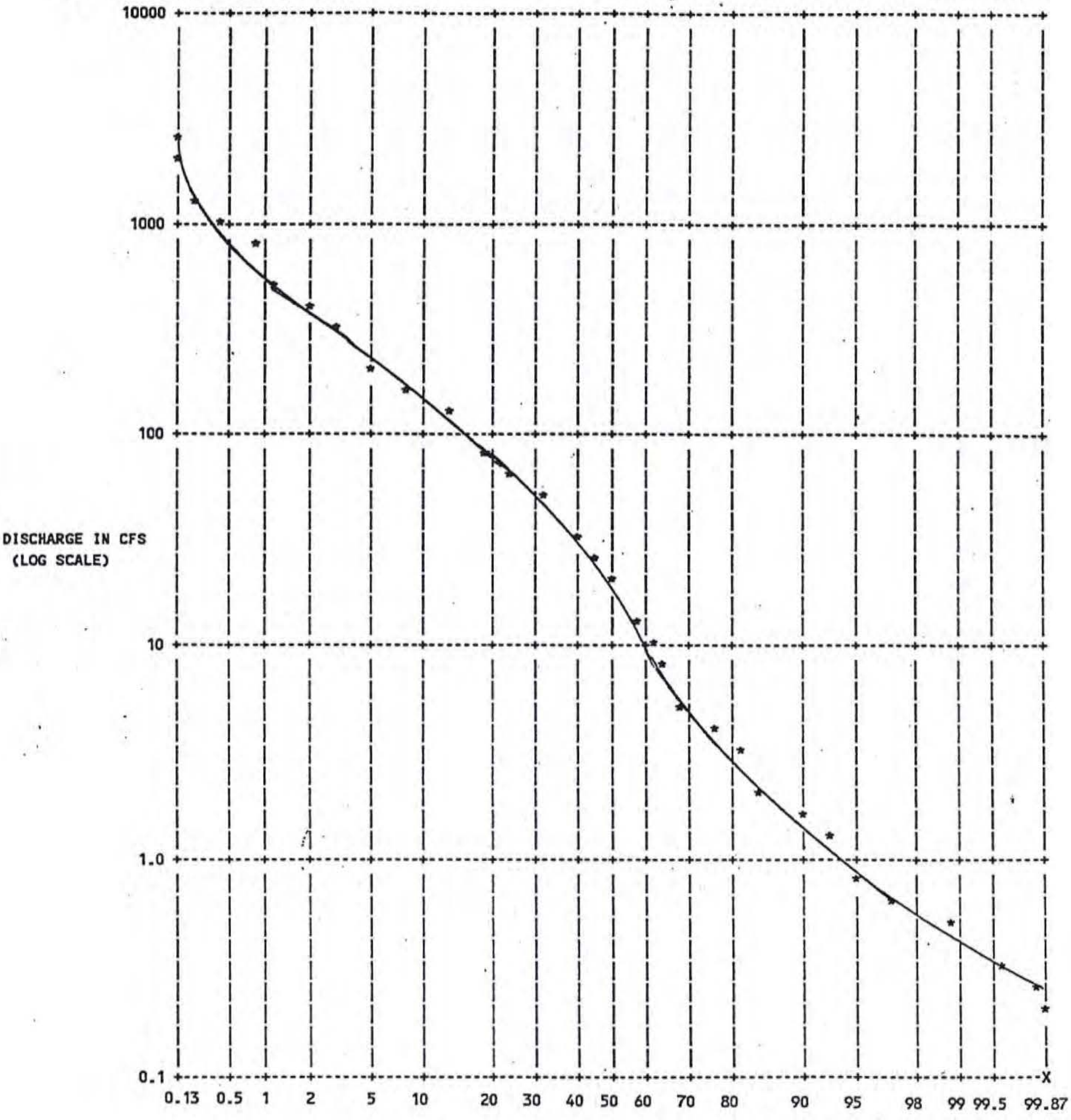


Figure CMFP-7. Flow duration plot of daily data for Weaver Creek near Douglas City for water years 1959 - 1969.

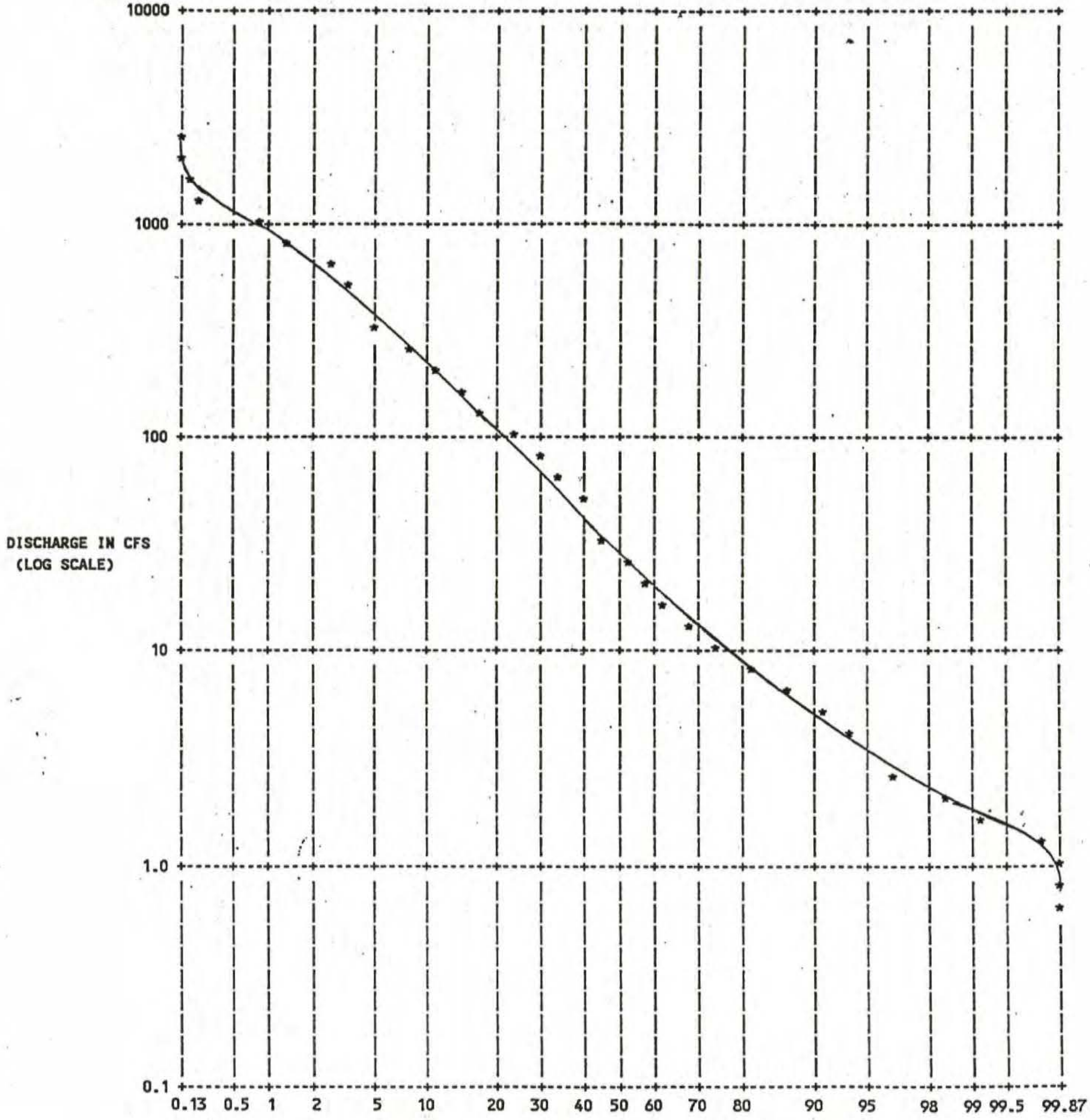


Figure CMFP-8. Flow duration plot of daily data for Browns Creek near Douglas City for water years 1958 - 1967.

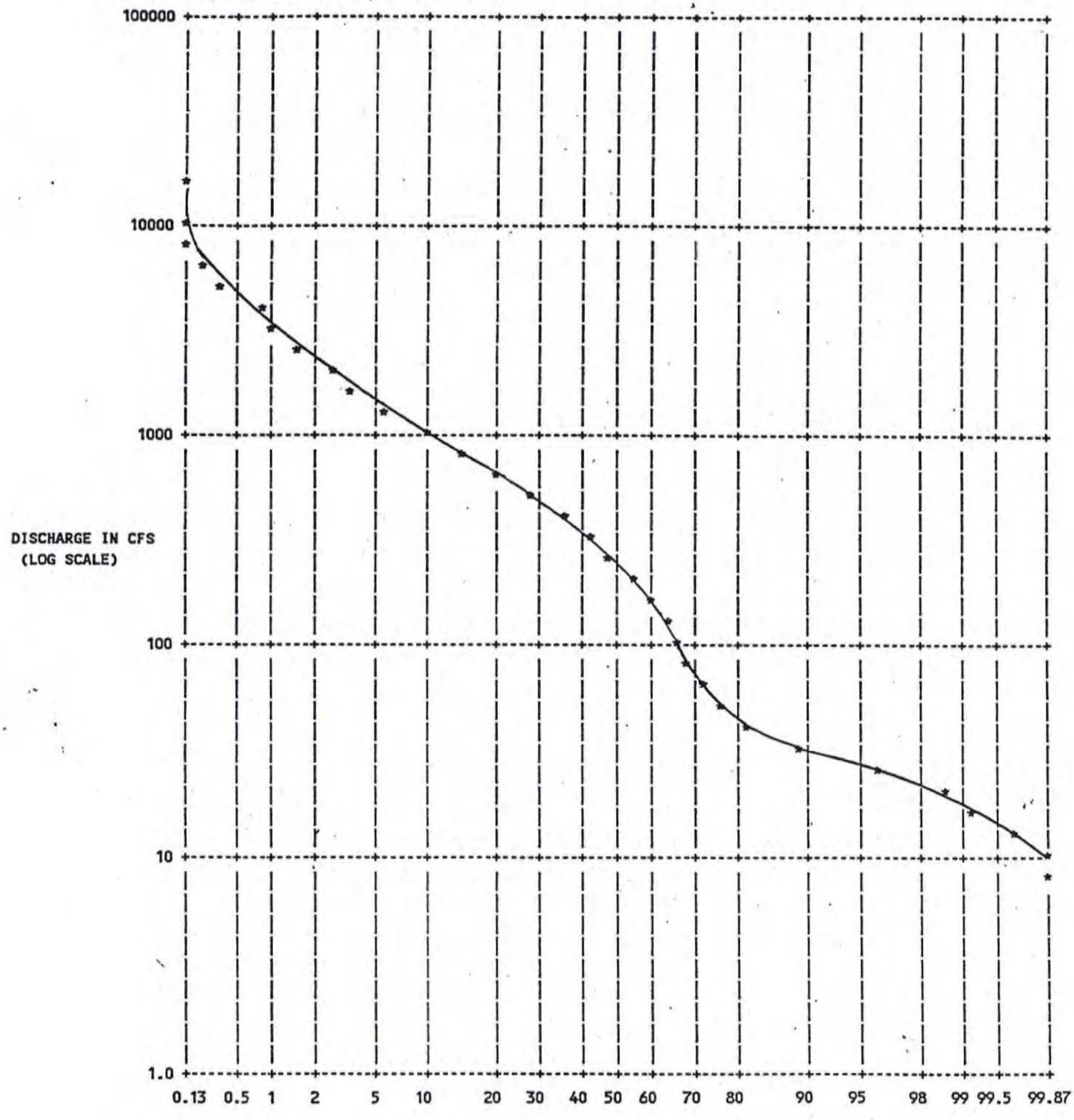


Figure CMFP-9. Flow duration plot of daily data for North Fork Trinity River at Helena for water years 1912 -1980.

High and low flows of various frequency and duration may be estimated for ungaged sites with the information presented in Tables CMFP-5 through CMFP-8 , while flow-duration curves for ungaged sites may be constructed from the plots given in Figures CMFP-6 through CMFP-9 . The procedure is relatively straight-forward and is based on a simple pro-rating of flow values from gaged to ungaged streams using the ratio of drainage area at the restoration site to drainage area at the streamgage of choice.

Table CMFP-4 identified the best streamgage to use for estimating flow characteristics on ungaged streams in the analysis area. One exception to Table CMFP-4 should be noted. Because of diversions in the Weaver Creek drainage above the old streamgage, Weaver Creek data will underestimate low flows for Rush Creek. Thus, estimates of low flows in Rush Creek should probably be developed from Browns Creek data.

The procedure for estimating flow characteristics is illustrated for a hypothetical restoration site on Indian Creek near the mouth. Drainage area of Indian Creek is about 35 square miles, and drainage area of Grass Valley Creek at the gage is 30.8 square miles. Thus, streamflow values given in Table CMFP-5 and Figure CMFP-6 are multiplied by a factor of about 1.14 (35/30.8=1.136) to obtain flow estimates for the restoration site. The results are illustrated in Table CMFP-9 and Figure CMFP-10.

Once the flow regime for a restoration site has been determined, a severely degraded channel must be properly dimensioned to its expected bankfull flow. Hydraulic geometries presented in Figure CMFP-1 (above) were developed from gages throughout the Trinity Basin and are generally applicable to both the mainstem and tributaries. Assuming bankfull flow is equal to a 1.5 to 2-year recurrence interval flood, high-flow estimates developed for the restoration site may be used with the hydraulic geometries (CMFP-1) to estimate bankfull width and depth for design. The procedure is equally applicable to tributary streams that have been severely disturbed by mining and to the mainstem Trinity River after a new flow regime is implemented following completion of the EIS.

Table CMFP-9. Estimated flow duration data for Indian Creek generated from flow duration data for Grass Valley Creek.

Stream Name:		**INDIAN CREEK NEAR TRINITY RIVER**				
Period of Record:		**1975-1991**	(GENERATED FROM FAWN LODGE GAGE)			
			Recurrence Interval			
	1.25	***2***	***5***	***10***	***25***	***50***
	Year	***Year***	***Year***	***Year***	***Year***	***Year***
High Flow Duration						
1 Day	120	277	692	1,155	2,048	3,008
3 Day	95	216	542	913	1,643	2,444
5 Day	85	183	448	758	1,388	2,104
7 Day	80	164	391	652	1,179	1,774
10 Day	74	147	334	545	961	1,421
15 Day	67	127	278	444	767	1,121
30 Day	55	100	206	318	527	749
Low Flow Duration						
1 Day	12	10	6	4	2	1
7 Day	12	9	7	6	6	5
30 Day	13	10	8	7	6	6

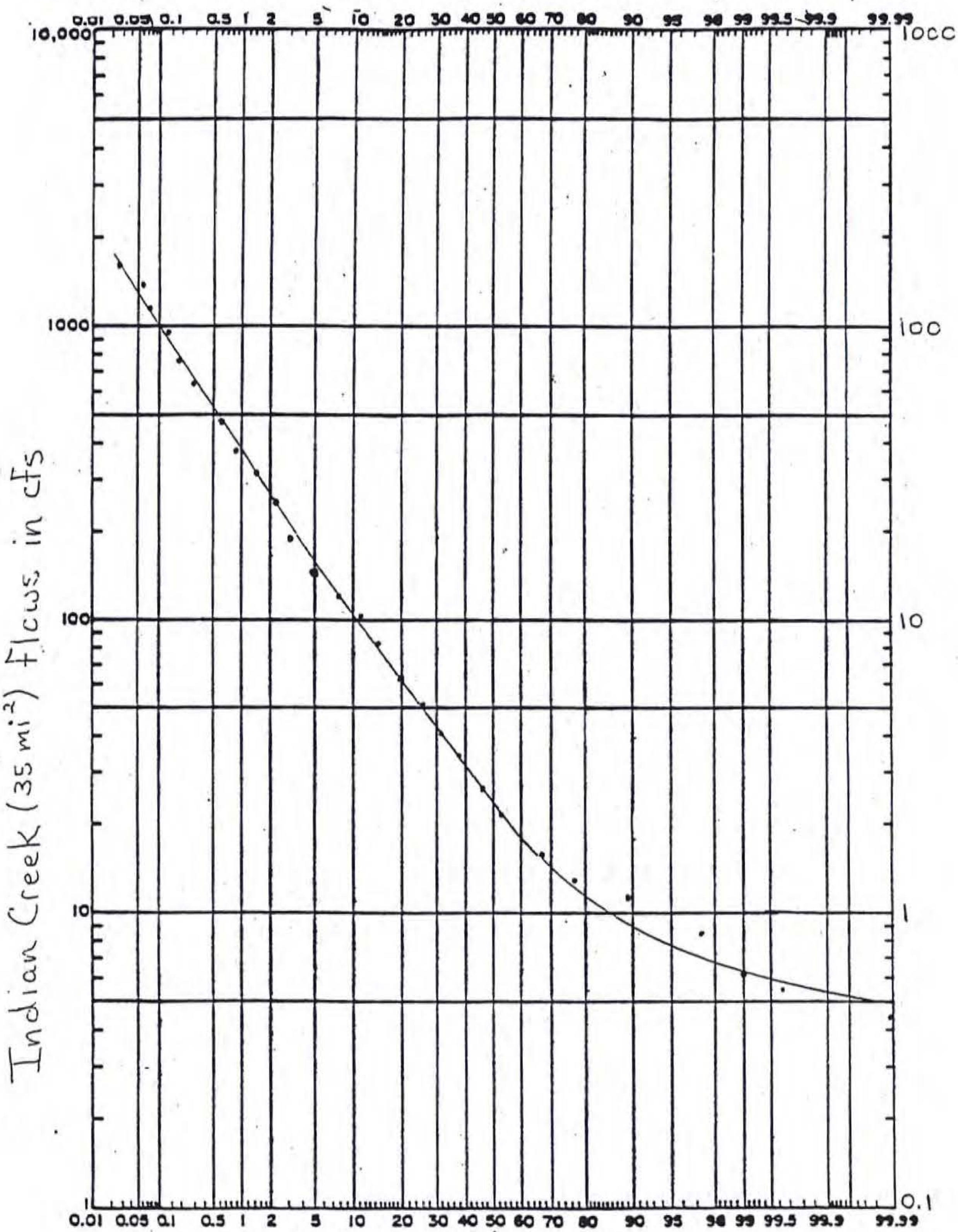


Figure CMFP-10. Estimate flow duration curve for Indian Creek.

Interpretation of historical aerial photographs should be used to supplement and extend information derived from the hydraulic geometry relationships. Other geomorphic features, such as bend width or bend radius, may then be related to channel dimensions associated with bankfull discharge. For streams in the basin that are not subject to regulation or diversion, recent air photos likely are sufficient for identifying channel and meander patterns and other geomorphic features, such as point-bar slopes. Features relevant to fisheries habitat, such as location, number, and length of side channels, should be quantified for undisturbed channels in the basin. Such information will help guide restoration efforts toward mimicking naturally occurring habitat characteristics.

Additional information needed for channel and habitat restoration efforts includes explicit definition of habitat conditions required for recovery of salmonid species. This should include the kind of habitat needed for the fisheries (e.g., rearing habitat), the time of year during which the habitat is needed (e.g., winter rearing), and the kinds of channel features that usually provide these habitats (e.g., pools, side channels, or feathered edges). The kinds of habitat needed should then be translated into a range of depths and velocities needed over certain kinds of substrate or in certain kinds of cover. The time of year associated with various habitat needs will enable restoration efforts to target specific conditions during certain "design" flows typical for that time of year.

Virtually all the information identified above is readily available throughout the Trinity Basin and may be used for locating and designing channel restoration and habitat enhancements. For example, if the primary habitat need of the fishery is for winter rearing habitat to escape high flows, suitability-index curves from the U.S. Fish and Wildlife Service could be used to identify the depths, velocities, and cover desired by fish for escape areas. Analysis of old aerial photographs may provide evidence that, before construction of the reservoir, this habitat was provided by channel margins, overflow areas, and side channels associated with large bends in the river. Analysis of present conditions likely would show that channel margins and overflow areas (alternate bars) have been lost to vegetation so that high-flow depths and velocities now exceed the usable range of the fisheries.

In order to recover and/or restore these habitats, it will be necessary to recreate the channel features that provided them historically. The new Trinity River channel will adjust to the anticipated flow levels that occur as a result of the Flow Evaluation Study. Using the streamflow analysis, the hydraulic-geometry relationships, and the expected new flow regime, one could estimate the approximate width, depth, velocity, and various bend characteristics toward which the river would evolve. With an estimate of bankfull width and bend radius, an approximate size and shape of future point bars may be anticipated.

Restoration efforts in this example are targeted toward providing rearing habitat for escape from high winter flows. Using estimates of December/January flows from regionalized streamflow data or the projected hydrograph from the Flow Evaluation Study, a design flow or flows can be developed that represent typical streamflow levels for that time of year. The biologist now knows the depths and velocities of water that will provide the optimum habitat, the approximate size and shape of the channel in which they will be working, and the streamflow levels that are present at the time of year for which the habitat is needed. At this point, restoration efforts have a target habitat in a target location for a target flow level (time of year). The remaining step is the design and modeling of the constructed enhancement.

Once the above information has been developed for the project location, site-specific design of habitat enhancements should include computer modeling of pre- and projected post-construction conditions for the reach proposed for enhancement. Hydraulic and fish habitat models such as XSPRO, HEC-2, and

PHABSIM all would be useful for improving habitat design. Such models require some of the information described above, such as design flows and target habitat conditions, and can be used to predict the response of certain variables (e.g., water-surface elevations, depth, and velocity) to the proposed modifications. When used in conjunction with aerial photos and hydraulic geometry relationships, it should be possible to design enhancements that mimic naturally occurring habitats and are in equilibrium with the flow regime of the river.

For example, the hydraulic model HEC-2 could be used to design a side channel that diverts no more than X-percent of the streamflow from the main channel. The habitat model PHABSIM could then be used to estimate the amount of winter rearing habitat available at various levels of flow in the side channel. If too much water enters the side channel at high flows, the entrance could be raised to reduce the flow through the side channel. If velocities are too high in the side channel, small riffles could be added to drop the gradient in steps with flatter water between the riffles. Pre-construction modeling would help in design of such modifications; post-construction modeling and monitoring of enhancements as built would provide a feedback mechanism to document the usefulness of the model for predicting habitat changes.

VI-2 FISH HABITAT AND POPULATIONS - Historic Conditions

Fisheries habitat and communities have changed continually over time in the Trinity River due to both natural and human causes. Commodity extraction, dams and diversions, commercial harvest of fish, introductions of various exotic species, and various natural impacts. have all affected habitat and populations in the Trinity River.

Fisheries Habitat

Significant human causes of change likely began in the mid-19th century following settlement during the gold rush era. Timber extraction and associated roads have also had more recent effects on fisheries habitat and populations. With the construction of Trinity and Lewiston dams, the morphology and therefore the fisheries habitat of the Trinity River underwent some of the most drastic changes to date.

Prior to these changes, the river likely resembled other large anadromous fish rivers with alternating point bars of cobble and gravel on the inside bends of the river. Riparian vegetation would have been minimal on these bars due to annual high flows during winter and spring that scoured these areas combined with desiccation during low flow periods. Wilson (1993) determined that historically, open bar habitat was much greater and riparian vegetation was much less than at present. Outside bends of the river would have remained steep due to continual erosion of these areas by the force of water against the outside banks. Riparian vegetation may have therefore occurred relatively close to the banks of the river in these areas.

According to historic reports, the channel was much wider and deeper during much of the year with cool, deep pools, riffles composed of relatively course gravel and intermittent runs with flows of moderate velocity. The following account from the historic files of the Trinity Journal dated June 1, 1889 describes a river that differed greatly in size from the present day.

> W.S. Lowden (County Surveyor 1872 - 1882) reports: From Trinity Center to its mouth, the river has an average grade of 15 feet to the mile. Average width, 150 feet at low water and 600 feet at high water. At low water the river is two feet deep and at high water 25 feet deep.

Average annual discharge and peak instantaneous flows near Lewiston before the construction of the Trinity and Lewiston dams were both significantly greater than post-dam flows. Annual discharge was approximately 1.2 million acre feet. Instantaneous peak discharge past Lewiston averaged approximately 18,500 cfs annually, however, instantaneous flows much greater than this have occurred during various floods throughout the years. Flows greater than 6,000 cfs would occur for several days at a time during spring every couple of years. These types of flows had major impacts on channel and floodplain morphology and ecology. Flows of these extremes maintained the deep pools required by oversummering adult salmonids; these deep pools also benefitted juveniles that remained in the river for extended periods.

The fish of the Trinity naturally evolved with these varying flows. Floods that have the ability to cause extensive damage to human habitations were probably the types of events that maintained the diversity of habitat that is needed for fish populations. Low flow periods would have allowed for recolonization

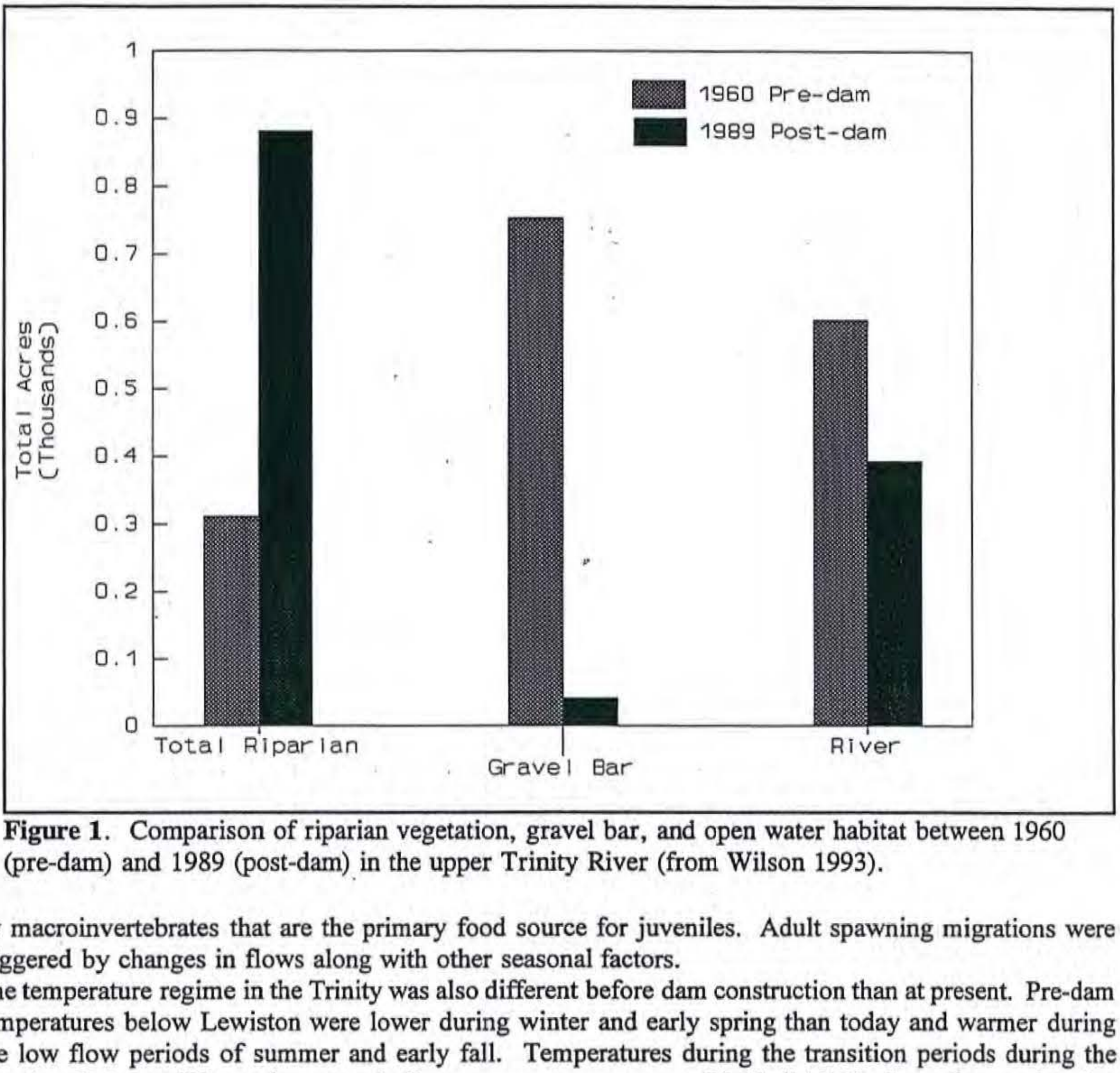


Figure 1. Comparison of riparian vegetation, gravel bar, and open water habitat between 1960 (pre-dam) and 1989 (post-dam) in the upper Trinity River (from Wilson 1993).

by macroinvertebrates that are the primary food source for juveniles. Adult spawning migrations were triggered by changes in flows along with other seasonal factors.
The temperature regime in the Trinity was also different before dam construction than at present. Pre-dam temperatures below Lewiston were lower during winter and early spring than today and warmer during the low flow periods of summer and early fall. Temperatures during the transition periods during the months of May and November were similar to present temperatures (Hubbell 1973). Juvenile outmigration patterns likely evolved with the temperature and flow changes that occurred in the river. As mentioned previously, juvenile chinook salmon (Oncorhynchus tshawytscha) generally stopped downstream movement during summer low flow periods and would begin migration again in the fall. Although no information on growth rates of juveniles prior to dam construction could be located, these fish probably evolved to achieve optimal growth that correlated with temperatures that were much different than today.

Natural causes of change have always occurred; however, natural impacts were often intensified by human changes to the local environment. High intensity floods that change the morphology of the river, extended dry periods and wildfire are all significant natural factors in the Trinity River basin. All of these and many other events have continually altered the fisheries populations in the Trinity River; the extent of

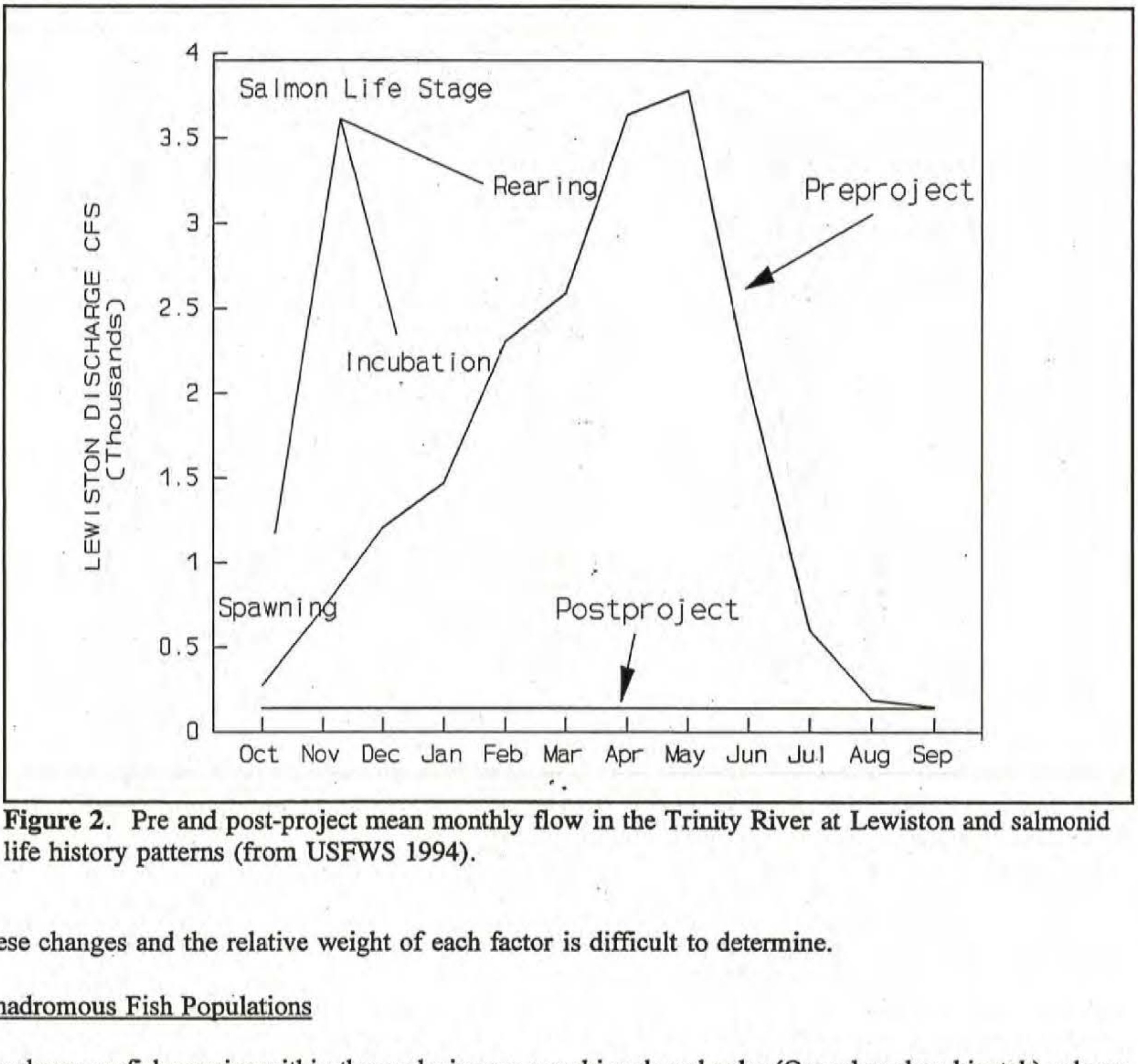


Figure 2. Pre and post-project mean monthly flow in the Trinity River at Lewiston and salmonid life history patterns (from USFWS 1994).

these changes and the relative weight of each factor is difficult to determine.

Anadromous Fish Populations

Anadromous fish species within the analysis area are chinook and coho (Oncorhynchus kisutch) salmon, steelhead (Oncorhynchus mykiss), and Pacific lamprey (Lampetra tridentata). There are other anadromous species such as green sturgeon and American shad that may enter the Trinity basin; however, they are generally limited to the lower reaches of the Trinity. The life histories and habitat needs of the anadromous fish pertinent to this analysis are described below.

Chinook salmon

Chinook salmon in the Trinity River consist of two distinct races, the spring and fall runs. Adult spring run chinook salmon usually enter the Trinity basin beginning in March and continuing until July. Timing of initial entrance to the basin varies from year to year and historically coincided with peak spring flows associated with increasing snowmelt. Prior to the Trinity and Lewiston dams, the earliest spring run chinook would migrate past Lewiston during June and July. These fish would then hold in deep pools between Lewiston and Trinity Center until spawning, which usually began in early October. A later summer run migrated beyond Lewiston during August and September and were often seen in the large pools between the North Fork Trinity River and Trinity Center (Moffett and Smith, 1950). These deep pools offered thermal refuge (and probably refuge from predators) since the river was usually at its lowest flow during late summer and temperatures would increase substantially. Spawning fish were seen in early October between Grass Valley Creek and the Stuart Fork. Later in the month, spawners would be scattered for approximately 65 miles from the North Fork upstream to the East Fork.

The spring chinook race may reasonably have comprised the largest run of chinook entering the Trinity River before the invasion of gold seeking miners around 1850. Snyder (1931) cites an undated paper by R.D. Hume claiming this as fact. This claim is logical based on the quality of the fish habitat in the upper Trinity River and the inclination of the spring run to migrate far upstream early in the year to utilize this habitat. But Hume's paper, presumed to have been written around 1900, already declared the Trinity River spring chinook race as nearly extinct by 1892.

It is feasible that this could have resulted from intensive mining activity in the upper Trinity River system beginning around 1855. Placer and hard-rock hydraulic gold mining unquestionably destroyed historic spring chinook habitat and even occasionally blocked migration access routes. The degree to which the spring run may specifically have "recovered" during the first half of this century is unclear. But total chinook salmon spawning estimates for the entire Klamath River Basin ranged from 350,000 to half a million during the first 60 years of this century.

After construction of the dams, the upper reaches of the Trinity were not accessible to the spring chinook. Since then spring chinook have had to "summer-over" in whatever deep pools were available below Lewiston until the fall when spawning begins. Flows below Lewiston since dam construction have not been adequate to move sediment out of the mainstem that is contributed from tributaries. Pools below Lewiston have thus filled in partially and may become too warm for adult salmon during low flow periods. Releases from Lewiston reservoir are generally much lower in June and July than historical flows, but are now often held at artificially high levels during late summer in order to provide cool water for the spring chinook adults.

Migrations of adult fall chinook have always coincided with the first fall rains and subsequent increased river flows. Historically, the fall chinook would reach Lewiston sometime in early October. Spring chinook would have already begun spawning by then but reproductive organs of fall fish were usually not yet fully developed and spawning by these fish occurred later in October. Spawning by fall fish probably overlapped slightly with spring fish during November but often lasted until mid to late December. The actual timing of migration and spawning after dam construction has remained similar to historic trends. Artificially low spring and early summer flows and high late summer flows probably have effects on migration rates and the actual time that these fish enter the Trinity basin.

Chinook fry begin to emerge from spawning gravel as early as January followed by peak emergence in February and March. Some fry begin to distribute downstream almost immediately upon emergence seeking shallow, slow-moving rearing habitat adjacent to areas of higher water velocities for feeding. As fry increase in size, they actively migrate, utilizing rearing habitats with higher water velocities and greater depths as they proceed downstream. Active downstream migrations generally begin in March, peak by May, decrease in early summer and usually cease among wild fish by July or August. Historically, emigration would resume following the first fall rains and would persist at low levels until the following spring. Evidence of overwintering by juvenile chinook has been limited during recent outmigration observations. However, there have been occasional captures of 1+ (in their second year of life) chinook salmon by the USFWS during outmigrant monitoring in the spring (Glase 1994a).

Coho salmon

In the Trinity basin coho salmon migrate upstream from October through December and spawn from November through December. There is little information on coho in the upper Trinity from investigations during the 1940's. However, there were some reports of coho salmon in the upper South Fork Trinity. Moffett and Smith (1950) reported that coho salmon were usually in the Hoopa area (in the lower Trinity River) in October. Other reports indicated figures of approximately 5,000 coho above Lewiston prior to dam construction (USFWS/CDF&G 1956). Presently, coho salmon do migrate as far as the Lewiston dam and juveniles have been observed from the North Fork up to the Lewiston dam.

Fry emerge from gravel beginning in late winter and early spring. Rearing takes place throughout the upper mainstem from the North Fork to Lewiston. Mainstem rearing habitat consists primarily of backwater areas, slow water and the margins of pools. Outmigration usually occurs during the following spring after juveniles have reared in the river for about a year. Salmon and steelhead emigration studies from 1968 - 1971 indicated that juvenile coho salmon were captured well upstream of the South Fork in the mainstem Trinity near Big Bar, California during the spring of 1968. They were presumed to all be naturally reproduced fish since there were no releases of coho salmon from the Trinity River Hatchery that spring. Captures of 1+ coho salmon in recent years during USFWS outmigrant trapping efforts have been consistent, but numbers have been very low (Glase 1994a).

Steelhead

Adult steelhead historically would move into the river during several months of the year. Steelhead entering during spring would reach Lewiston in some years by early June. These runs, although not always abundant, would continue into July. Moffett and Smith (1950) reported that it was common to see adult steelhead holding in deep pools below the North Fork during summer months. These fish would then begin moving upstream with other fish entering the river during the fall. Spawning usually began in February and peaked during March or April; spawning was typically completed by early June. Spawning was extensive in many tributaries and was often considerable in the mainstem as well.

As with the spring chinook, the holding habitat for spring/summer-run steelhead has been reduced substantially. The largest portion of the steelhead runs in the Trinity now consist of fall and winter fish. These fish still spawn during winter and spring but a significant amount of their habitat has been eliminated by the construction of the dams. The dams block a purported 109 miles of steelhead access (USFWS 1983). The reliability of such measurement appears questionable, however, with no map apparently ever drawn depicting historic ranges in the various tributaries.

Steelhead are unique among Trinity River anadromous salmonids in that they do not necessarily die after spawning but may spawn up to four times during their life. After spawning, steelhead begin a migration back to the ocean. Downstream migrating adults can sometimes be seen in the Trinity River into the month of July. Moffett and Smith (1950) observed that many of the emigrating adults were in very poor condition and succumbed to parasite or fungal infection. Nearly 80 percent of the dead steelhead they observed were males.

Juvenile steelhead are also unique in that many will remain in fresh water to rear for two or three years before emigrating to the ocean. Fry emerge in spring, usually beginning in April, and seek areas of clean cobble where there is refuge from high velocities. In years when mainstem spawning activity above Lewiston was high, large numbers of steelhead fry would disperse downstream from spawning areas. Apparently, these fish were seeking satisfactory rearing areas rather than actively moving downstream towards the ocean. Some downstream movement continued during summer and fall but ceased by the following winter (Moffet and Smith 1950). As juveniles, steelhead utilize riffles and runs that provide macroinvertebrates for food and cobble cover. Since they rear in freshwater for as long as three years, overwintering habitat, consisting of clean cobble substrate with sufficient cover for juvenile fish, is critical. Active emigration by juveniles begins in spring, usually in April, with peak movements historically occurring in June and July.

Pacific Lamprey

Adult lamprey migrate upriver and spawn during spring in riffle areas similar to those used by salmon. Adult lamprey migrations were not effectively monitored throughout the year during early investigations. Small numbers of lampreys apparently migrated upstream during the summer months, but Moffet and Smith (1950) stated that, "Larger upstream migrations undoubtedly take place during the winter months." Turbid water during high flow periods usually hampered monitoring, and lampreys easily passed through the fish counting weirs without being captured. Spawning adult lampreys were observed in tributaries where nests were usually located in gravel above riffles or in riffles with moderate current. No specific tributaries were mentioned.

Adult lamprey are still observed in the mainstem and in tributaries but specific population information is still lacking. Spawning adults have been observed by USFWS\snorkelers in swiftwater areas in the spring grasping large gravel with their mouth apparently attempting to move substrate for building redds. Eggs hatch into larvae, known as ammocoetes, with undeveloped eyes and mouth. During the larval stage, lamprey burrow into sand or silt substrates to mature. They remain as larvae in the river bottom, feeding on organic material, for four to five years before metamorphosing into adult form and emigrating to the ocean.

Resident fish

Resident fish in the Trinity basin include rainbow trout, brook trout (Salvelinus fontinalis), brown trout (Salmo trutta), stickleback (Gasterosteus aculeatus), smallscale suckers(Catostomus rimiculus), sculpin, and dace (Rhinicthys osculus). It is possible that brown trout, an introduced salmonid from Europe, may become anadromous in the Trinity. There have been sufficient verbal accounts of large brown trout that show physical signs of anadromy; however, scale studies from CDF&G (unpublished files, CDF&G, Redding, CA.) have failed to show this type of life history in brown trout.

Rainbow Trout

Rainbow trout are the same species as steelhead, but spend their entire life in fresh water rather than migrating to the ocean. This fish was extremely important in the sport fishery before dam construction. In 1941 it was estimated that 389,900 rainbow trout were harvested by anglers in the Trinity River. How many of these reported rainbow trout were steelhead that may have migrated to the ocean is unknown. Information from the California Dept. of Fish and Game (unpublished files, CDF&G, Redding, CA.) indicate that rainbow trout were stocked for several years in many of the tributaries of the Trinity.

Brown Trout

The brown trout is a European fish that was introduced to the Trinity River in the late 1800's. Spawning habitat of brown trout consists of areas of slower water and smaller substrate, overlapping salmon and steelhead spawning habitat. Juvenile brown trout have been observed in a variety of habitats in the Trinity River. After emerging from the gravel, they often seek out deeper slow water for rearing; as they grow larger, they are also found in swift areas with large substrate that is suitable for cover (Glase 1994b). Because of this they may often compete directly with juvenile steelhead for rearing habitat in the Trinity. Larger fish may dominate the best pool habitat, exhibiting highly territorial behavior. Predation by brown trout on juvenile steelhead and salmon is known to occur. The significance of this predation, however, has not been determined.

Brook Trout

The brook trout is another exotic species introduced from the eastern United States. This species was first stocked in the Trinity basin in 1909 (Frederiksen and Kamine 1980). Populations of brook trout were limited and usually occurred only in the upper extremities of the Trinity and it's tributaries. Brook trout spawn in the fall and fry emerge from spawning gravel in the spring. They are generally less tolerant of warm water than species such as brown trout and steelhead and may not have been able to thrive in much of the Trinity due to a preference for colder smaller streams. Brook trout sometimes show anadromous tendencies but the California Department of Fish and Game has stated that there are no records of sea going brook trout (Frederiksen and Kamine 1980). Specific tributaries with brook trout populations were not mentioned in early investigations.

Non-Game Fish

During Moffet and Smith's (1950) investigations from 1942 to 1946, the only "course" or non-game fish observed that were known to spend their entire life cycle in the Trinity River were the speckled dace (Klamath black dace) Rhinicthys osculus klamathensis and the fine-scaled Klamath River sucker Catostomus rimiculus.

Speckled Dace

Adult speckled dace in the Trinity River seldom grow to lengths much over three inches. The speckled black dace was apparently the most numerous fish in the Trinity River drainage during surveys in the 1940's and inhabited all sections of the drainage except for the headwaters of some tributaries. Currently, they are most abundant in cobble riffles, feeding on algae, small crustaceans, snails and insects. They are night feeders, resting during the day. They spawn in the spring after the waters warm.

Fine-Scaled Sucker

Fine-scaled Klamath River suckers were reported to be as widely distributed throughout the Trinity drainage as the speckled dace, although they were not as abundant. They prefer slow run and/or pool habitats, spawn in spring, and feed on insects, algae and other organic matter.

Stickleback

This species historically occurred in the lower Trinity and was apparently accidently introduced to the upper Trinity during trout stocking programs. These fish inhabit quiet water among abundant aquatic vegetation and are known to feed with schools of chinook salmon. They spawn in spring in nests built out of aquatic vegetation. They actively defend nesting areas, chasing away anything that does not pose an immediate threat.

Sculpins

This fish lives on stream bottoms associated with cobble substrates that occur in swift run and riffle areas. They require cold water and were not mentioned in Moffett and Smith's investigations, although they have been observed in some tributaries. They are seclusive during the day and feed at night on various organisms including small fish.

Tributaries

Information indicating salmon use of the tributaries between the North Fork and Lewiston prior to the dams is limited. The tributaries were undoubtedly very important for steelhead as this species usually seeks smaller streams and areas far upstream for spawning. Certainly, some of the larger tributaries would have provided adequate spawning and rearing habitat for chinook and possibly coho salmon. There was reference by Moffet and Smith (1950) to tributary use by fall chinook in the statement, "since these fish spawn later, many are able to enter smaller tributaries after the first fall freshets." Specific tributaries were not named. However, spawning chinook salmon were reported in Rush, Reading, Brown's, and Canyon Creeks as well as the North Fork Trinity in later investigations (LaFaunce 1965).

During investigations of the Trinity basin in the 1940's, impoundments in the upper limits of Rush Creek and Browns Creek were suggested as possible means to increase salmon spawning capacity in these streams. These impoundments would have been used to store water then provide adequate flows to recruit salmon into these streams during the spawning season. There usually was not adequate water in these tributaries for spawners until later in the fall or winter when rains increased the flows. There were also suggestions to remove several artificial dams and diversions in Browns and Rush Creeks that restricted fish movement during low flow periods (Moffet and Smith 1950). Other tributaries that were suggested as potential sites for storage reservoirs were the North Fork Trinity, Canyon Creek and Indian Creek with the implication that these streams were little used by salmon at the time (Wales 1950).

Regarding steelhead in tributaries, Moffet and Smith reported that,

> Steelhead enter the larger tributaries such as North Fork, Browns Creek, and Stewart Fork following the first fall rain. Smaller tributaries are entered during the first rain in February after which these streams maintain a flow sufficient to insure adequate spawning conditions. Spawning peaks by the end of March and early April but some scattered spawning occurs until June. Spawning in tributaries occurs mostly in gravel pockets between boulders, however, spawning in the few available large riffle areas is so dense that individual redds can not be discerned.

Actual timing would have varied depending on the weather and river flow patterns in any given year. A 1972 steelhead spawning survey (Rogers 1973) indicated that steelhead use in several tributaries had declined since 1964. It is possible that the numbers of steelhead using tributaries below Lewiston in 1964 were higher than use prior to the dams due to the elimination of considerable amounts of habitat upstream of Lewiston. Fish that would normally have spawned further upstream would have been forced to compete with lower river fish for adequate spawning habitat in these tributaries. Over time, the numbers of steelhead may have declined towards levels that could normally be sustained by these tributaries below the dams.

Historic Information on coho salmon in analysis area tributaries is very limited. There were reports by residents of Hyampom on the South Fork Trinity that described a run of coho salmon in that river, other anecdotal evidence suggests runs of coho in Hayfork Creek, in the South Fork Trinity basin however, the time of these migrations is not known. Apparently, there were no definite indications during Moffett and Smith's (1950) investigations that they had ever migrated upriver as far as Lewiston. However, as evidenced from recent surveys, it is likely that coho utilized accessible tributaries in years when returning adult numbers were high. Salmon carcass surveys in 1995 (unpub. data. USFWS 1995) indicate substantial usage in many of the tributaries from the North Fork upstream to Deadwood creek. Surveys in the 1980's (Ebasco Environmental 1989, 1990; USFS 1988) revealed coho in some tributaries.

Canyon Creek

A survey in 1988 (USFS 1988a) found juvenile coho salmon, chinook salmon, steelhead and Pacific lamprey. Juvenile steelhead were the dominant salmonid observed and there were relatively few chinook and coho salmon observed. Non-anadromous fish observed were brown trout, brook trout, Klamath smallscale suckers, and speckled dace. There is a complete barrier to upstream migration (Lower Canyon Creek Falls) at approximately mile 15.5; the observed brook and brown trout were above these falls.

One interesting observation was the stocking of golden trout in upper Canyon Creek in August 1963. Apparently, these fish did establish spawning populations that were observed in 1966. I haven't found any information on recent observations of golden trout in this stream.

The dominant habitat types during the USFS survey were main channel pools, and low and high gradient riffles. Riffles comprised over two thirds of the habitat area while pools made up almost one third of stream volume. Habitat was rated as "generally in good condition."

The most important historic (pre-dam) information on habitat quality described two dams on Canyon Creek that were at least partial barriers to fish migration. There was a P.G. & E. dam for power generation approximately eight miles upstream from the confluence with the Trinity and another dam for mining purposes about four miles from the confluence. According to a letter in the CDF&G files in Redding, CA. the lower dam was removed in 1951, allowing fish to migrate as far as the PG & E dam. At this time there were "no other important dams left in Trinity County which are without satisfactory fishways except the PG & E dam on Canyon Creek." There was opposition to removal of this dam due to the amount of gravel backed up behind the dam. Estimates ranged from 40,000 to 4,000,000 yards of gravel behind this dam. Some local residents were concerned that downstream gravel migration would raise the stream bed and cause flooding in Junction City.

Connor Creek

Steelhead were the only fish observed in an August 1989 Ebasco survey of the lower 3.0 miles of this stream. The lowest 0.2 miles of this stream flow through a man made trench and a 120 foot long tunnel that were constructed to convey mining material. Apparently, the natural channel confluence with the Trinity occurred several hundred feet upstream of the man-made channel. Several potential barriers to upstream fish migration were observed. Barriers included debris jams, road culverts, and waterfalls with poor jump pools below.

A 1991 Forest Service watershed inventory (USFS 1992a) referred to information from a fisheries habitat survey performed in 1980 on Connor Creek. No specific report was referenced, however, it stated that the first 1.5 miles of stream was considered Class I because of winter steelhead use and as a domestic water source. Observed steelhead densities were 30/100 feet and spawning potential was rated good. The upper reach, above 1.5 miles, was rated as Class II because of the steep gradient. No fish were observed in this section. The inventory did not state how much of the actual stream was surveyed in 1980.

Soldier Creek

A 1991-92 Forest Service watershed inventory (USFS 1992b) referred to a fishery survey report from the Big Bar district in 1980 that stated steelhead and resident rainbow trout juveniles and fry were observed. Juvenile densities were 30/100 feet in the lower reach. No other fish species were mentioned and no information on migration barriers was included in the inventory. Fish habitat was rated as fair. Primary limiting factors were few adequate spawning areas and a low pool to riffle ratio. The greatest potential impacts to fish habitat is erosion associated with stream crossings (roads) and ditch relief culverts.

Dutch Creek/Maple Creek

A 1991-92 Forest Service watershed inventory (USFS 1992c) referred to a 1980 survey that reported steelhead and rainbow trout in Dutch Creek with no fish observed in Maple Creek (tributary to Dutch). Dutch creek was divided into three reaches with the two lower reaches considered Class I "because they are used for spawning by steelhead and salmon." Spawning habitat was rated good since gravel was fairly free of silt. The middle reach contained some class A pools and habitat was rated as good. The upper reach was Class II due to migration barriers. Juvenile steelhead averaged

20-50/100 feet of stream. Maple Creek was rated as a Class II stream and fish habitat was poor because of lack of pools and high amounts of sand.

Ebasco Environmental (1990) performed a survey in the lower 2.7 miles of Dutch Creek in August, 1989. Steelhead, chinook salmon and coho salmon were all observed. No coho salmon were observed above mile 1.5 and chinook salmon were only observed in two units at mile 0.2 and 1.0. No other fish species were observed. Several potential upstream migration barriers in the form of large debris jams were observed above mile 1.5. No barrier falls were observed in the study area.

Brown's Creek

Historic information was limited to post dam surveys and stocking reports. Surveys by LaFaunce (1965) indicated that "Steelhead use every bit of the drainage available to them. In 1964, an estimated minimum of 1,703 fish spawned in the main creek. During the same period, 424 others spawned in the tributaries (to Brown's creek).... In the fall of 1963, 137 carcasses of king salmon were counted - to a point seven miles above the mouth."

Reading Creek

Ebasco (1990) surveyed the lower 9.0 miles of this stream in 1989 and reported populations of steelhead, coho salmon and chinook salmon. Chinook were only observed in five habitat units in the lower five miles of stream. Other fish species observed were brown trout, speckled dace three-spined stickleback, Klamath small-scale sucker and Pacific lamprey. There were at least six diversions in the surveyed section. One diversion dam created an upstream migration barrier for chinook and coho salmon at mile 7.2; steelhead were the only salmonid observed above this point. No other barriers to upstream migration were observed. The diversion dam at mile 7.2 also created dry stretches of stream the acted as outmigrant barriers during low flow periods. Habitat type composition did not appear to be a limiting factor in Reading Creek according to this report. The only recommendation for habitat enhancement was to modify a dam at mile 7.2 to increase upstream accessibility.

East Weaver Creek

Ebasco (1990) surveyed the lower 5 miles of this stream in 1989. The dominant age and species of observed fish were 0+ steelhead. They also observed 1+ and 2+ steelhead as well as 0+ coho salmon. Other species present were speckled dace, three spined stickleback, klamath small scale sucker, and Pacific lamprey. No upstream migration barriers to steelhead were observed but the tunnel under Highway 3 could present a high flow barrier in some situations. No barrier to coho migration was mentioned.

Potential limiting factors included spawning area, water temperature, sediment loads, migration barriers, water diversions and poor water quality. Habitat enhancement structures were recommended along with erosion control measures.

Little Browns Creek

Ebasco (1990) surveyed the lower 7.5 miles of this stream in 1989. The dominant age and species of fish observed were 0+, 1+ and 2+ juvenile steelhead and speckled dace. No other salmonid species were observed; they did not mention any observations of other non-salmonid species. They noted six small debris jams that could potentially create migration barriers during high flows. They also mentioned an abandoned gravel sluicing operation at mile 6.7 that consisted of a low man-made cement weir, metal screening, steel bars and a gravel sluice. This structure present a low flow barrier, a high flow barrier, and a potential endangerment to fish due to exposed metal edges from screening that projected into and across the flow of water in the channel. Habitat enhancement recommendations focussed on slope stabilization to reduce sediment loads, instream structures to increase cover and pool depth, and structures to increase habitat diversity.

Democrat Gulch

Ebasco (1990) surveyed the lower 2.5 miles of this stream in 1989. Age 0+ steelhead were the only species and age class of fish observed. Cover deficiencies and lack of depth in pools was considered a possible limiting factor for juveniles. Lack of spawning habitat, partially due to 80% embeddedness from high sediment loads, was another potential limiting factor for production. Intermittent stream flows at the mouth and at mile 1.4 during July and August may also pose problems since steelhead spend one to three years rearing in streams before downstream migration.

Weaver Creek

Ebasco (1990) surveyed the lower six miles of this stream in 1989. Age 0+ steelhead were the dominant age class and species of fish observed. Coho and chinook salmon and brown trout were other salmonid species observed. Other fish species observed were speckled dace, three spined stickleback, klamath small scale sucker, and Pacific lamprey. No barriers to upstream migration for salmonids were observed. Migration into Democrat Gulch or Little Browns Creek may not be possible during low flows due to steep gradients at the mouths of these tributaries. Specific habitat types were apparently not a limiting factor. Spawning habitat may have been limiting due to armoring of gravel from sedimentation; considerable sediment loading from bank erosion was observed in some areas. They also noted that a newly constructed road crossing at mile 5.9 contributed "major" amounts of sediment to lower Weaver Creek.

Indian Creek

Douglas Parkinson and Associates (1991) surveyed sections of the mainstem, south and north forks of Indian Creek in 1989. They surveyed approximately 8.3 miles of the mainstem, 1.7 miles of the north fork, and 0.4 miles of the south fork. Juvenile steelhead (0+,1+ and 2+) were present in all sections surveyed and 0+ chinook were present in the mainstem. No other fish species were mentioned; however, due to their presence in several other streams, it is likely that non-game species such as dace, stickleback, sucker and lampreys were present. Potential limiting factors were spawning habitat, sediment load and water temperatures.

Grass Valley Creek

The USFWS (1984) reported observations of chinook and coho salmon, steelhead, brown trout, Klamath small scale sucker, speckled dace, and lamprey (species not identified) in GVC. Steelhead were found from the mouth upstream for 12 miles. A barrier at mile 11.2 prevents upstream migrations so fish above here are considered resident rainbow trout. Most of Little Grass Valley Creek is also populated by this species, however, several barriers on this stream may indicate that these are resident rainbows as well. In April of 1984, the estimated population of juvenile steelhead was 11,000. This would have been a low estimate however, since steelhead emergence from gravel would not have been complete until June or July of the year.

Chinook salmon were observed up to mile 7.5. There were no observations of chinook in Little GVC. An estimated 3,000 juvenile chinook were residing in GVC in April 1984 during the survey. There may have been some outmigration of juvenile chinook prior to the survey that would not be included in the estimate.

Coho salmon were observed seven miles upstream of the mouth of GVC. Use of Little GVC was not known at the time of this survey. Numbers were very low for coho; only one yearling was captured in 1984 and 184 were captured in 1985. No population estimates could be made due to such low numbers captured.

Brown trout were captured up to and in Sawmill gulch (approx. 1.5 miles upstream from confluence of GVC with Trinity river). Only 11 brown trout were captured and no population estimate was made.

The greatest negative impact to habitat in Grass Valley Creek has been the enormous amounts of decomposing granitic sand (d.g.) found in this basin. Spawning habitat as well as over-wintering habitat for steelhead are degraded by this course sand as gravel and cobble substrates become highly embedded. The USFWS report indicated that juvenile and spawning habitat could be increased dramatically in some areas after the Grass Valley debris dam began operating since much of the d.g. may be eliminated from the lower reaches of this stream.

Deadwood Creek

A 1990 fisheries habitat and population survey (Ebasco, 1990) reported steelhead, coho and chinook salmon and Pacific lamprey in the lower 2.35 miles of this stream. There is a 20 foot waterfall at mile 2.35 that acts as a barrier to upstream fish migration. This report did not indicate other fish species present or if there were resident trout above the barrier at mile 2.35. Habitat enhancement recommendations were for spawning gravel stabilizers and pool forming structures, channel scouring structures and increased instream cover. There are large erodible or eroding banks as well as erosion problems from mining operations; thus, bank stabilization for erosion prevention was also recommended.

Causes of Change in Populations and Habitat

Dams and Diversions

Completion of the Lewiston and Trinity dams in 1963 resulted in the diversion of up to 90 percent of the average annual discharge in the Trinity River at Lewiston and blocked access to 109 miles of spawning and rearing habitat to migrating salmon and steelhead. The Trinity River Hatchery was constructed at the base of Lewiston Dam to mitigate for those habitat losses that occurred upstream of the Trinity River Division. Fishery flows of 120,000 acre-feet per year were released downstream of the project to maintain existing salmon and steelhead populations below Lewiston. Unfortunately, these measures were not sufficient to maintain the fishery, and both salmon and steelhead populations have continued to decline since the project was completed.

In addition to the lost habitat above the dams, changes in habitat below Lewiston dam began to occur almost immediately. Recruitment of substrate from above Lewiston was eliminated. With decreased flows came a decrease in the ability of the river to flush fine sediment out of the mainstem. At the same time, increasing logging and road construction in the basin added substantially to fine sediment loading to the river.

The result has been a river with a greatly increased proportion of fine materials that tend to seriously degrade spawning and rearing habitat for salmonids by filling in clean cobble and gravel. Mainstem riffles where chinook spawning occurs offer limited chances for survival of fry due to the inability of these fry to emerge from gravel that is embedded with sand. Overwintering habitat for steelhead is also substantially reduced since these fish require interstitial spaces found in clean cobble for winter cover. Holding pools used by spring and summer run adult fish have lost much of their volume and depth due to continual filling with sand.

Greatly reduced, stable flows from May through October, combined with the lack of abrasive high flows, created ideal conditions for the establishment of riparian vegetation along the river banks (Evans 1979). The deposition of large amounts of sand along the river also enhanced the establishment of riparian vegetation by providing favorable soil conditions for seed germination and growth, and undoubtedly, created additional new areas for riparian vegetation establishment that were previously unsuitable. Once the riparian vegetation became established, its presence along the edge of the river trapped sand during high flows. This process started the development of sand berms along the waters edge in the riparian corridor that still continues today. As a result, the river has become narrower and deeper, causing a reduction in rearing and spawning habitat (USFWS 1994). Wilson (1993) found through comparisons of aerial photographs taken in 1963 and in 1989 that the total acreage of riparian vegetation present in the upper Trinity River had increased by 282%, while gravel bar and open water habitat had decreased by 95% and 45% respectively. Pelzman (1973) stated that riparian growth negatively impacts habitat of anadromous fish by binding together stream gravel so that they are no longer available for use by anadromous salmonids. By lining the banks of the river channel, the riparian vegetation has eliminated lateral recruitment of new gravel and cobble substrates to the river which are critical for maintenance of healthy salmon spawning and rearing habitat.

Mining

Mining undoubtedly changed the fisheries habitat of the Trinity basin and would have therefore had effects on populations. Specific numbers related to populations are almost non-existent however; usually, only anecdotal information is available. Hydraulic mining which began in the 19th century introduced thousands of tons of fine sediment to the system when entire hillsides were washed to move gold into streams for extraction. Spawning beds and holding pools would certainly have been impacted even if the river were more capable of moving sediment. Large scale dredging operations, which followed the hydraulic operations, processed perhaps millions of tons of large cobble and gravel. During the process, this material was essentially discarded and placed on the flood plain of the river and out of what was then the active channel. In essence, much of the habitat that was once in the channel in the form of cobble and gravel was removed. At times the entire flow of the river was blocked in order to create a ponded area in which the large dredgers could operate. These operations would have created a much different channel that was probably deepened and highly incised at mining locations. Occasional large floods may have moved some of the material back into the active channel. However, immense tailing piles composed of gravel and cobble can still be seen along much of the Trinity.

Commercial Harvest

Obviously, populations of the Trinity River were not affected only by events within the Trinity basin. Early large scale harvest of millions of pounds of fish from the Klamath River and the Pacific Ocean for commercial purposes substantially affected Trinity River populations. Canneries operated on the Klamath River from about 1892 until 1933 when they were ultimately forced to close (Moffett and Smith 1950). Commercial in-river fishing was also outlawed, yet the ocean trolling harvest continued, with declining catches that reached a record low by 1938 (McEvoy 1986). Commercial ocean harvest continued to have impacts that may have caused steady declines in Trinity River populations into the 1980's (Fredriksen and Kamine 1980). Harvest continued at relatively high rates until the early 1990's; in 1992, harvest restrictions initiated greatly reduced harvest rates in the Klamath Management Zone.

Logging

Logging within this basin has had much greater effects on habitat and populations than agriculture. Commercial logging on a large scale did not occur in the basin until about the mid-twentieth century. Once extensive logging did occur, this vulnerable watershed became impacted by extensive sedimentation due to erosion from logging and road building associated with logging. Fragile systems such as the Grass Valley Creek watershed were particularly hard hit by logging and the impacts will be seen within the basin for years to come. The Grass Valley watershed itself has been choked with sand that is derived from decomposing granite (d.g.) and fisheries habitat in this stream is highly degraded. The d.g. that is moved out of Grass Valley Creek tends to fill pools, spawning areas, and cobble substrate in the mainstem. Prior to dam construction, the Trinity had a much greater capacity to flush some of this d.g. out of the mainstem. With year round low flows, this capacity is lost and d.g. continues to accumulate along the banks and in the channel of the Trinity.

Human Settlement

Encroachment on the river floodplain has been occurring since dam construction. Direct impacts of this encroachment are few but some, such as increased nutrient loads from septic systems near the river, "rip-rapping" of the banks in order to protect houses from high flows, or diversions for domestic uses do exist. Nutrient loading may be increasing in certain areas near Lewiston where stands of cattails and other aquatic vegetation not usually found in riverine habitats have become extensive. Rip-rapping is a process where river banks are lined with large rock or other material to keep the river from eroding these banks. Unfortunately, in many cases, these erosive banks are areas that would normally be continually changing in a free flowing river. A process that eliminates this natural feature of a river inevitably reduces the river's capacity to create channel diversity because river flow is confined to an unnatural channel. This practice has not been common along the Trinity, however, it has occurred. The floods of January and March, 1995, which were no more than 7 to 10 year events resulted in a massive project in which several tons of boulders were placed along the banks and in the channel of the Trinity River upstream of the North Fork Trinity. With further encroachment will come more damage, and homeowners that are naive enough to build new homes literally a stones throw from the river will ultimately be requesting assistance to save their dwelling when the next threatening floods occur.

Drought

Drought, simply stated, is a period of time when precipitation deviates negatively from the norm. In California, dry periods are not rare phenomena. Perhaps when put in the scope of a human lifetime, it may seem as though the eight years of drought in the 1980's and 1990's has been an "extended" drought. When put in the scope of generations of fish that have existed in the Trinity basin for millennia, an eight year drought could be just another period of hard times when spawning runs and emigrations were altered to adapt to the dry period. In other words, drought is a condition that the fish of this area have evolved with and adaptations by local populations would have occurred during dry periods.

The drought of the late 20th century, which, through 1995 contained the third driest year on record, must certainly have had a negative impact on fish populations. However, the period of record is short; only about 83 years. Dry periods of much longer duration have occurred in the past. Tree ring studies that reveal past precipitation patterns indicate a dry period that lasted from approximately 1760 until 1820. Rainfall during this entire period was below the mean precipitation for the period of 1901 to 1963. Dry periods of similar intensity occurred from 1600 to 1625, and 1865 to 1885 (Fritts and Gordon 1980). Studies of relict tree stumps submerged in lakes in the Sierra Nevada indicate extreme and persistent dry periods that lasted for more than two centuries before the 1100's and another dry period of more than 140 years during the 1200's and 1300's (Stine 1994). Other tree ring research in the Sierra Nevada area indicates that the high precipitation levels of the mid 20th century have occurred only three times in the previous 1000 year period (Graumlich 1993). Graumlich concludes that the drought of the late 1980's and early 1990's is not an anomaly when considered in the long term context.

Drought combined with other factors such as altered flows from reservoirs and highly degraded in-river habitat could have much more deleterious effects than a drought in a natural, pristine system.

These unnatural changes brought about by human actions in the basin have occurred fairly rapidly and on a large scale. As the fish of the Trinity basin have not evolved with these changes over time, the ability to adapt becomes much more difficult and chances of continual decline are greater. At the same time, however, we can also say that the ability to keep the Trinity River at flows higher than those that occurred naturally during late summer could help alleviate some of the effects of a drought such as increased water temperature. Once again though, if the river were not in such a degraded state, it is likely that these temperatures would not be a problem.

<u>Trinity River Hatchery</u>

The Trinity River hatchery was constructed in order to mitigate for the loss of salmonids that were historically produced above the dam sites. Each year, the hatchery artificially spawns returning adult chinook and coho salmon and steelhead. Numbers of returning adults have varied widely with each species since the hatchery began operation (Table VI-2-1). Returns of chinook salmon have ranged from 2,586 to 36,386; coho returns have ranged from 12 to 23,338, and steelhead returns have ranged from 13 to 6,941.

Numbers of juveniles released from the hatchery have varied as well. Recent releases (1991-1995) for fall run chinook fingerling have ranged from 202,275 to 2,342,037; spring run fingerling releases have ranged from 828,406 to 1,498,015. For the same time period, coho and steelhead yearling releases have ranged from 384,555 to 627,739 and 323,791 to 1,158,171 respectively (Table VI-2-2).

Table VI-2-1 **Summary of Fish Runs to Trinity River Salmon and Steelhead Hatchery**

	Chinook Salmon			Coho Salmon			Steelhead	Brown Trout
Dates	Males	Females	Grilse	Males	Females	Grilse		
1958-59	1,269	1,744	878	240	343	33	2,880	80
1959-60	1,716	2,833	2,701	49	44	26	2,071	52
1960-61	1,493	1,287	4,130	84	54	70	3,526	82
1961-62	885	1,613	2,899	158	160	37	3,243	35
1962-63	1,308	1,608	6,535	7	0	9	1,687	49
1963-64	1,569	2,627	2,539	32	40	11	894	34
1964-65	1,974	3,042	1,287	23	25	2	6,941	145
1965-66	477	1,077	1,521	2	1	9	992	100
1966-67	1,052	1,002	2,876	45	173	807	135	152
1967-68	1,620	1,250	1,746	287	519	59	232	231
1968-69	1,797	2,102	873	3	1	34	554	170
1969-70	624	832	1,130	153	132	1,711	241	70
1970-71	773	725	2,946	1,410	1,396	341	87	23
1971-72	3,648	4,645	928	28	11	8	242	7
1972-73	5,217	4,825	339	28	30	2,612	271	11
1973-74	2,483	1,152	1,577	3,808	3,787	468	162	39
1974-75	4,547	2,840	677	33	22	40	372	32
1975-76	2,958	3,405	860	68	109	2,060	175	24
1976-77	2,845	1,901	2,878	1,171	1,414	223	13	49
1977-78	1,841	1,318	2,562	381	317	1,230	285	0
1978-79	4,478	5,135	1,287	580	995	2,080	683	0
1979-80	1,138	1,480	1,452	1,241	1,547	1,253	382	0
1980-81	2,745	2,271	2,242	753	1,070	1,500	2,019	0
1981-82	2,214	2,514	1,146	830	1,164	2,529	1,007	0
1982-83	1,874	1,683	4,112	1,686	2,112	1,000	715	0
1983-84	2,764	3,256	903	223	256	227	603	0
1984-85	1,923	1,157	664	574	676	7,611	142	0
1985-86	6,548	2,821	14,533	3,729	3,919	4,138	461	0
1986-87	13,109	9,376	5,462	1,309	1,593	5,230	3,780	0
1987-88	12,374	8,593	5,273	9,165	11,243	2,930	3,007	0
1988-89	19,391	12,594	4,401	5,713	5,802	1,301	817	0
1989-90	8,218	7,728	426	2,509	2,324	136	4,765	0
1990-91	1,677	2,166	413	666	706	263	927	0
1991-92	1,837	2,088	447	1,430	1,056	202	350	0
1992-93	2,237	2,452	1,110	1,157	1,084	1,351	551	0
1993-94	1,483	1,744	997	1,136	920	138	882	0
1994-95	4,394	3,078	5,313	69	43	76	376	0
Totals	128,500	111,964	92,062	40,780	45,088	41,775	46,470	1,385

From:
Annual Report - Trinity River
Salmon and Steelhead Hatchery
1994-95

FALL CHINOOK			SPRING CHINOOK		
YEAR	DATE	NUMBER	YEAR	DATE	NUMBER
1995	OCT. 2	950,015	1995	OCT. 2	474,980
1995	JUN 1	2,153,982	1995	JUN 1	1,458,984
1994	OCT 3	213,563	1994	OCT 3	800,205
1994	JUN 10	202,275	1994	JUN 1	1,498,015
1993	OCT 1	972,074	1993	OCT 1	485,260
1993	JUN 16	2,342,037	1993	JUN 16	488,219
1992	OCT 2	933,796	1992	OCT 2	n/a
1992	JUN 22	581,539	1992	JUN 5	210,188
1991	OCT 9	643,910	1991	OCT 8	600,262
1991	MAY 28	n/a	1991	MAY 28	1,439,541
	MAX	2,342,037		MAX	1,498,015
	MIN	202,275		MIN	210,188
	AVE	999,243		AVE	828,406

COHO			STEELHEAD		
YEAR	DATE	NUMBER	YEAR	DATE	NUMBER
1995	MAR 15	549,983	1995	MAR 15	879,841
1994	MAR 15	480,790	1994	MAR 15	323,791
1993	MAR 29	384,555	1993	APR 14	337,589
1992	APR 3	439,523	1992	APR 17	962,579
1991	MAR 18	627,739	1991	MAR 18	1,158,171
	MAX	627,739		MAX	1,158,171
	MIN	384,555		MIN	323,791
	AVE	496,518		AVE	732,394

Table VI-2-2: Recent releases of juvenile salmonids from Trinity River hatchery.

Introduced Species

Effects of introduced species has not been thoroughly studied in the Trinity basin. Species within the analysis area that may have impacted native populations are brown trout, brook trout, and three-spine stickleback. Brown trout will compete directly for food and cover with all native salmonids in the river. Brown trout become very territorial and larger fish will tend to dominate areas where habitat is suitable and food sources are good. Larger brown trout will undoubtedly cause direct mortality by preying on juveniles of other species. Brown trout populations however, do not appear to be very high in the Trinity, and the degree to which they impact native species is not known. Brook trout tend to be in the upper extremities of the Trinity and have probably not had much of an impact on native species. There could be competition between brook trout and steelhead juveniles that may be in some of the upper tributaries. One interesting bit of information is a record of the stocking of golden trout (Oncorhynchus aquabonita) in upper Canyon Creek in August 1963. This species is native to the Sierra Nevada area but not to the Trinity basin. Apparently, these fish did establish spawning populations that were observed in 1966 but no other observations were recorded after this date. Stickleback were not present in the upper Trinity historically, however, since introduction they have possibly had some indirect impacts on juvenile salmonids due to their aggressive nature when nesting and possibly through competition for food.

Agriculture

Agriculture in the watershed analysis area was not as extensive as in areas of the upper Trinity before the dams. Most of the section of the watershed in the analysis area was forested and floodplains likely were not conducive to agricultural practices. Some higher terraces may have supported limited agriculture for homesteads established along the river. Most tributaries within the watershed analysis area flow through steep terrain and did not support extensive agriculture either. Direct effects of agriculture on the fisheries populations and habitat would therefore, not have been extensive. Practices such as grazing cattle in the alpine meadow areas of the upper Trinity probably had effects on habitat for species such as steelhead and perhaps spring chinook salmon since these fish tend to use the upper reaches. Erosion from streamside grazing and the input of cattle waste into streams would have had the greatest effect on habitat. Populations were not likely impacted by agriculture nearly as much as by other land management practices in the basin.

Habitat Modifications

From approximately 1988, until 1993, intentional streambank modifications within the mainstem Trinity known as "side channels" and "feather edges" have been implemented with the intent to restore some habitat and hopefully positively influence fish populations. Pool dredging has also been used to deepen filled pools that were once critical for holding adult salmonids. Side channels are constructed behind the banks of the river in order to create slow water habitat for juvenile salmonids. These are essentially high flow channels that have been further excavated by mechanical means to maintain flows during low flow periods in the river. These channels have been used extensively in some cases by salmon, steelhead and brown trout. The cover and velocity shelters created by side channels have proven to be beneficial to rearing juveniles, and are also used by spawning adults (Glase 1994b). Feather edges are an attempt to restore historical point bars along the river where riparian berms have become established. As mentioned in the fisheries habitat section, these bars have changed drastically since dam construction and the ensuing low flows in the river. Construction of feather edges has removed some of the extensive growth of alders and willows that have become established on some of the historic point bars. Removal of this riparian and the associated berm areas has allowed the river to become more free flowing during higher flows, and a meandering river with greater habitat diversity at these locations has been the result. The floodplain has also become directly "connected" to the river again, adding additional habitat as flows increase in the river.

Direct benefits to fish related as use by juvenile salmonids has been difficult to quantify thus far. To determine use by these young fish is difficult in winter and early spring due to the flashy flows of the river at this time of year. Additionally, during the fry stage, when juveniles would be most likely to benefit from these modifications, these fish use the substrate as cover making it truly difficult to enumerate them.

VI-5 EUROPEAN SETTLEMENT 1848 - W.W.II

In the Trinity Journal June 1, 1889, W. S. Lowden described the Trinity River. From Trinity Center to the mouth, the river has an average grade of fifteen feet to the mile. The average width is 150 feet at low water and 600 feet at high water. At low water, the river is two feet deep and at high water it is 25 feet deep. As the stream and its tributaries flow across auriferous rocks for much of their total lengths, they have been the sources of vast amounts of placer gold. In the Lewiston and Douglas City Districts, the river makes a number of extremely sharp bends that have formed several wide bars. In the southern portion of the county, there is a broken, mountainous region, but highly adapted for grazing and pasturage. Reports indicate that in the early days high and low water levels were more extreme than in our time. These conditions appear to have been caused by the regular but mild wildfires that kept the hillside vegetation from reaching the dense state that now exists.

The Trinity River was a clear, beautiful mountain stream. Soon the waters of Weaver Creek alone began to change color, and in a few months a stream of red, muddy water took the place of the once clear river. Tall pines gave way before the miner's axe. The pick and shovel began to make great havoc with the hills. Cloth houses gave way to wooden ones, and fire caused wooden houses to turn to brick (Trinity Journal 1856).

The winters of 1850-51 and 1851-52 were very mild, with very little snow in the mountains. In the winter of 1852-53 for forty-two days in succession, it snowed or rained continually. The snow on the streets of Weaverville was five feet deep. No mining could be done while the snow was so deep. In the spring when the snow melted, there was plenty of water and the miners did well. In the summer of 1852, the Trinity River very nearly approached the condition of having water only in pools at many places in its bed. The low stages of water in the river and the tributaries and pleasant weather conditions had been favorable for mining operations. In 1912, the average annual rainfall was nearly forty-two inches a year. From the Trinity Journal November 29, 1856, the winters were mentioned as growing gradually milder since 1849. The rainy seasons in California from 1849-1856 were as follows:

1849-50 - 76 days of rain
1850-51 - 53 days of rain
1851-52 - 65 days of rain
1853-54 - 54 days of rain
1854-55 - 44 days of rain
1855-56 - 38 days of rain

The December 1861 flood destroyed every improvement of any kind along the Trinity River. The flood washed away many mining operations and caused many miners to leave the area. Only two bridges remained on the whole line of river, and waterwheels were washed away. Many ranches along the river were seriously damaged by the loss of fruit trees, fences and deposits of sand and rock, while the soil of others were partially or entirely swept away, leaving barren sand bars where before were rich alluvial bottoms. In places where the river was confined, it raised seventy feet above the low water mark. In other places where it was wide, the banks caved and carried away well cultivated ranches. Every single mining improvement in the river for one hundred miles had been destroyed, and more than half the bar of the river. Many of the settlers that had left after the flood later returned, and by the mid-1870's, new settlers were arriving. In the flood of 1889 and 1890, everything back one hundred feet from the river was swept away. Not a bridge was left standing on the river.

In 1850, salmon were so plentiful, according to the reports of the early settlers, that fording the stream was difficult as the horses were spooked by so many fish. As Sherbourne Cook (1976) pointed out, long term effects on the spawning populations were initiated by the advent of mining operations that washed immense quantities of silt and dirt into salmon-bearing streams, resulting in diminished spawning populations. From the late 1800's to 1940 large quantities of spawning gravels were dredged. Ray Jackson in 1903 said that there were ten thousand fish to ten that we have today. Over a 28 year period of record (1916-1943), an estimated average annual yield of 900,000 pounds of fish were taken from the Trinity River by commercial and sports fishermen.

EARLY EXPLORERS/SETTLERS

White trappers and explorers arrived in the late 1820's to 1840's in Trinity County. Until the 1820's, no white men had entered the mountainous regions of Northern California. The explorations across the inland boundaries of the California territory began in 1826. Trappers may have crossed the northern frontier before that time. The first crossing of the mountains of Northern California belongs to an American trapper, Jedediah Smith. Smith had hoped to find new beaver grounds to the south and west of the Great Salt Lake, and had not intended to go to California. It has been suggested that they crossed the divide to the Hayfork of the Trinity River, reaching it at Wildwood, then followed Hayfork Creek and continued down the South Fork of the Trinity River. By the end of the 1830's, the fur trade had declined. As trade with China expanded and silk became increasingly available, hats were fashioned from this new material rather than from beaver fur. During the 1830's and early 1840's, the foreign population in California remained small.

Pierson Barton Reading began mining on Clear Creek, with the help of Native Americans. He found the first gold there on March 18, 1848. He continued west and at the Trinity River, at the mouth of what is now Reading's Creek (immediately below Douglas City Bridge), he found the bars rich in gold. The locality became known as Reading's Bar. Reading mined at Reading's Bar with the help of several Americans and 60 Native Americans from the Sacramento Valley. There are reports by earlier writers that a Frenchman named Gross had met two men when he crossed Trinity Mountain in the Spring of 1849, who claimed to have been on the Trinity River since 1847. Gross found gold at a place called Rich Gulch, and then moved to Evan's Bar on the Trinity River, where he built the first log cabin in Trinity County. One report suggests that British pirates found gold on the Trinity in 1842. The news of the Northern California gold fields were not immediately known in all parts of the state. According to a San Francisco newspaper report on August 2, 1849, the first gold was found on the Trinity River by the Kelsey Brothers. In 1849 and 1850, gold seekers began to pour into Trinity County. Few of these prospectors had the intentions of assuming permanent residence in Trinity County. Despite sentiments, reports of Trinity County's excellent agricultural land, abundant water, mild climate and immense tracks of timber soon began to attract permanent settlers.

In the summer of 1851, white women entered the Trinity area to settle and courts, schools, and churches appeared. By 1852, Weaverville was a bustling tent city with about 40 permanent buildings and two-hundred miners, and by 1854, Weaverville was a thriving community receiving hay, flour, vegetables, fruit, and dairy products by mule train from Hayfork. By 1858, many of these products may have arrived from North Fork by the wagon road built the year before. In 1873, Trinity County began to boom. More miners arrived, and hydraulic mining was started. As placer mining became exhausted, quartz mining was undertaken, which persisted until well onto this century. Other activities replaced mining, such as stock grazing, farming, fruit orchards, and logging.

The Trinity Journal of November 29, 1856 stated that Northern California has been steadily growing in its wealth and resources, and within the last few years has become a rich and prosperous field for a large and fixed population. In 1850, it required but few mules in the transportation of food to supply the then sparse population. By 1856, it required hundreds of mules each week to keep up the supplies necessary for consumption. There were 75 trading posts or mercantile houses in the county in 1856. The population of California totaled 13,000 at the time of the annexation of California. Within a year of the discovery of gold, it reached one 100,000.

Although the news of California gold reached China in 1848, the large influx of Chinese began in 1850 at the time of the great Tai-Ping Rebellion, started in southeastern China. The rebellion caused a decline in trade and industry, which, in turn, induced many Chinese to go to California. The Chinese were the largest group of immigrants in the mining camps. Their numbers were larger than the numbers from any other foreign country. The real surges in numbers came in 1852. Chinese miners worked mostly those areas which white miners had abandoned. The Chinese also provided cheap labor for building ditches, flumes and later, railroads. In 1854, from 2,500 to 3,000 Chinese had settled in the area from Weaver Creek down to the Trinity River at Douglas City. The number of Chinese in Trinity County in 1865 was 1,600. Large settlements existed in Douglas City, Lewiston, and Junction City. By 1897, the Chinese population had decreased to very small numbers, as they began to return to China.

Although other European immigrant groups were more numerous, the French were more visible and kept their identity to a greater extent. Weaverville had a section known as Frenchtown. The famous La Grange Hydraulic Mine at the head of Oregon Gulch was bought by Baron de La Grange and Associates of Paris. Germans were numerous in Trinity County in its early years; however, there was no section of Weaverville nor any mining camp by the name of Germantown which would indicate that Germans were working there. A census taken in 1852 listed 114 Germans and 40 Frenchmen. The English and Irish were even more numerous than Germans in the mining camps. A Dutch immigrant by the name of Peter Van Matre was one of the leaders of the early pioneers of Weaverville. Swedes and Norwegians were also among the early miners. African Americans, Spanish, Italians, Hawaiians, Poles, Swiss, and Jews were found in early mining camps. Mexicans were active in the mule packing trade. In 1852, foreign residents came from Germany, Ireland, France, Russia, Canada, England, Sweden, Scotland and Switzerland. By 1870, the total population of Trinity County was 3,217, of whom 1,084 were Chinese. In 1890, the population was up to 11,858.

Lewiston was an important town in the 1850's. It was one of the oldest settlements in Trinity County, where it is probable the first ferry was installed for crossing the pack trains conveying supplies from Shasta to Weaverville and other mining points westward. A bridge was constructed in 1851 and was one of the early toll bridges in Trinity County. The Rush Creek area and Lowden's Ranch had active Anglo-American ranching and mining activities. At the mouth of Rush Creek was the 130 acre Chamberlain Ranch, which had a store and a blacksmith shop. At Lowden's Ranch a bridge was built across the Trinity River in the 1850's; at 805 feet in length, it was the longest bridge in the county (Vaughan CA-

TRI-862). The flood of 1861-62 swept the bridge away. The majority of the settlers in Lewiston were miners, although there were several good farms. Some very rich quartz was found in the Deadwood District. Many mining claims were opened up around Lewiston, the mouth of Rush Creek (originally called Humbug Creek) and the Deadwood area. In the big flood of 1861-62, the town of Lewiston was severely damaged, and in May of 1862, Lewiston was nearly burned down. In 1878, quartz claims on Deadwood Gulch began to attract attention. For a number of years, Deadwood produced a large amount of gold. The Lewiston Basin had formations that were adapted to agriculture as well as mining. The banks of the river extended two miles either way. There were large and fertile acres where hay, grain, fruits and vegetables were raised. The ground was highly auriferous. At the head of the basin was one of the most valuable farms in Trinity County, called "Mud Ranch"; whose name was suggested by its rich, black alluvial soil. It was 300 acres in size and was settled in 1850.

In Douglas City in 1859, placer mining was the principal occupation of the citizens. About two miles downriver was Steiner's Flat. Between Douglas City and Steiner's Flat there were seven large water wheels, used to raise the water to work the lower bar. The high water of 1861-62 washed them away. In 1862, a ditch was completed from Weaver Creek to Filibuster Flat. Another ditch from Weaver Creek was completed to work the mines along the creek and Union Hill. At Indian Creek there was a mining camp that paid very richly. On the dividing ridge at the head of Indian Creek, near the boundary line between Shasta and Trinity Counties, there were quartz prospects, and a mill was erected. There was a store, hotel and blacksmith shop at Indian Creek, and several farms in the precinct.

Weaverville was founded on July 8, 1850. By the fall of 1850, Weaverville was well-settled with miners. The town was built on good mining ground. Weaverville for years was one of the major centers of gold mining in the Klamath Mountains. The stream and bench gravels were highly productive during the gold rush. Weaver Bally is significant, because East Weaver Lake and both East and West Weaver Creek originate high on the mountain. These streams provide water for Weaverville. East Weaver Lake was the first source of ice for Weaverville. It was cut there and packed in by mules and horses.

Junction City offered some of the best fields for the prospector of any in the county. The bars and the banks of the river were worked and there were several good ranches in the vicinity. Junction City was originally known as the Mouth of Canon Creek. The name was later changed to Milltown. The community became well known for its horse racing and two very productive ranches - McGillivray's and Sturdevant's. The years 1868 and 1869 were very dry for miners. Due to the scarcity of water, drifting claims were worked. In September of 1897, most of Junction City was destroyed by fire.

In 1855, a sawmill was erected between the two forks of the river (North Fork). A wagon road was built in 1857 connecting North Fork to Weaverville. North Fork had developed as a town, with the construction of the wagon road and sawmill. North Fork was located at the present-day site of Helena. Chinese were noted to reside in North Fork. In the 1880's, Christian Meckel operated a stage between Helena and Weaverville.

TRAILS/ROADS

Many of the first roads constructed in Trinity County followed the bars along the river and its tributaries, crossing and recrossing the stream to avoid heavy grading between bars. For a great portion of the year wagon travel over these roads was impossible, because of high water in the Trinity River and its tributaries.

By 1851, a new road was built up the Sacramento Valley, and Shasta became a trans-shipping center and gateway to the mines along the Trinity, Salmon and Scott Rivers. In 1857, efforts were made to build wagon roads to connect settlements on the Trinity River and at Weaverville, Trinity Center, and Hayfork with Shasta and Red Bluff. In May 1858, the Buckhorn, or Grass Valley, Toll Road was completed, the first road to provide communication from the outside world into Trinity County. William Spencer Lowden, known as the father of good roads, was the person responsible for organizing the toll road construction. In 1857, Lowden had formed a stock company for the purpose of building the Grass Valley toll Road. The stock company was known as the Weaverville and Shasta Wagon Road Company. The road was 24.5 miles in length. The first stage came to Weaverville on this road in 1858, and the first freight teams to arrive in Weaverville came on May 10, 1858. Freight was generally carried by eight and ten mule teams.

The most populous places in Trinity County were connected by wagon roads. William Spencer Lowden built a route to Weaverville from Clear Creek Mine. The route was finished in 1907. It followed the present 299 West route much of the way, though it kept to lower ground, using the Willow Creek and Grass Valley Creek watercourses. In 1860, a free public wagon road from Weaverville to Hayfork was opened. A stage ran to the Terry Mill above Round Mountain, and after the turn of the century, stages ran to French Gulch, then backtracked about one-half mile and went over the Tom Green Road to the Brown Bear Mine (Deadwood), Lewiston, and on to Weaverville. Stages on these routes were all changed to motor stages around 1915. Prior to 1920, all mail in the area of Trinity County was carried on trails by horseback. The first state highway in Trinity County was completed in 1925.

Glennison Gap was a main thoroughfare from Canyon City and Canyon Creek to Weaverville. The trail was used mostly for foot and horseback traffic. It became the western terminus of the "Dolly Road". The "Dolly Road" was used in the early years of the 20th century to transport the pipe used to construct the Sweepstakes siphon. This siphon came across West Weaver Creek and Bear Gulch to bring the waters of East Weaver Creek to the Sweepstake Mine on Oregon Mountain. The abandoned "Dolly Road" was used for many years by cattlemen, miners and hunters as a convenient route into the upper West Weaver area.

In 1912, the first complete map of the National Forest was assembled by Oscar Evans. At about that time a railroad was promoted from Eureka to Red Bluff, through Trinity County. What happened to the railroad plans no one seems to know, but presumably the advent of WWI put a crimp in railroad expansion plans. Construction of Forest roads and trails was heavily pushed during this period. After the end of WWI, attention was concentrated on the improvement of transportation. At the same time work progressed on the road down the Trinity River.

TIMBER/LOGGING

In mining communities, lumber was needed for construction of sluices, flumes, wagons, tunnels, mills, and houses. Prior to the establishment of mills, the miners felled their own timber and cut boards in sawpits or shaped the logs with adzes and broadaxes. Early sawmills were able to produce larger quantities of lumber than hand methods, and it was not long before mills dotted the larger waterways. The Trinity Journal of February 23, 1856 stated that there were four sawmills in operation in the vicinity of Weaverville. They were scarcely able to supply the demand for lumber.

Until the 1880's, the lumber business in the county was characterized by many small, undercapitalized companies engaged in sporadic on-and-off operations. There were very few mills that had a history longer than a few seasons. During this era of the lumber business, yellow and sugar pine provided the bulk of the timber supply. Only the finest, most mature trees were secured. When the first sawmills were operating, there was no legal manner in which a lumberman could acquire large holdings of timberland. They would cut trees from the public land without permit or fee. The sawmills were no great threat, because the owners cleared their own land and obtained trees from neighbors. As long trains of immigrants came west, the government began to pass laws to allot land to the people.

The Homestead Act of 1862 permitted any citizen to acquire 160 acres for a fee of ten dollars. The only condition was that he had to live on the property for five years and cultivate the land. The Timber Culture Act, signed into law on March 13, 1873 was designed to increase the lumber supply. It gave 160 acres of additional land to any homesteader who would plant one quarter of the acreage in trees within four years.

The timber industry did not really begin to attain a sound economic position until after WWII. One of the objectives of the Forest System was prevention of depletion of timber supplies through sustained-yield management. In 1925, the total lumber production in the Shasta-Trinity National Forest was 12.5 million board feet. By 1939, the figure was 45 million board feet, and a year later it had doubled to 73 million board feet. By 1948, it had reached 203 million board feet. The overall trend of the timber industry in the Forest was one of development from small operations serving local needs to large, heavily capitalized companies serving national and even international markets.

Transportation was the primary concern of the lumber industry. Early methods of transporting logs and lumber were poorly developed and costs were high. Water was used for transporting timber in v-shaped flumes or by rivers to markets or points of connection where mills could cut the logs. Other modes used in the early days were oxen, sturdy horses, and mule-driven wagons. In many areas pack trails were the only developed routes. It was usually more economical to move a mill than create more trails. Logs were rarely cut more than two miles from the mill or waterway, which was used to float the logs to the mill. Mills were placed as close to areas of demand as possible. Many of the early mills were set up to provide lumber for a specific flume or mine. Several mills had very short lives, as brief as a few months. When Cox wrote his Annals of Trinity County in 1858, nearly every mining camp had its own sawmill.

In the 1880's, changes occurred in logging practices and transportation, which led to the alteration of this pattern. Before, trees were felled with single-bit axes and bucked with crosscut saws. Double-bit axes began to replace single-bit axes in making undercuts, and backcuts were made with crosscut saws, reducing the time required to fell a tree by eighty percent. By the late 1890's, even small logging operations had power equipment, which reduced the cost of yarding and skidding by as much as half when compared to the use of teams. In addition, band saws were developed. The railroad affected logging as well as milling; railroads could be used to haul logs to mills as well as lumber to markets. Logs could be hauled ten to fifteen miles on rails for no more than it cost to haul one or two miles with oxen, an important factor as timber stands close to the mills were depleted.

In 1873, the American Association for the Advancement of Science petitioned Congress and the State Legislatures to enact laws for the protection of forests. In 1891, the Forest Reserve Act was established with Section 24, authorizing the president to reserve certain forest lands from the public domain. The Trinity Forest Reserve was created by proclamation of President Theodore Roosevelt on April 26, 1905. The headwaters of the Trinity River were within the Forest and most of the area within Trinity County was timberland, and therefore included in the reserve. In addition to the protection of timber, the regulation of water was listed as an important reason for reserves. There were also policies on farming, mining, transportation, public buildings and grazing. Farming on agricultural land within the forest was desirable, prospecting and mining were permitted; roads, trails and irrigation canals needed permits, schools and churches could be constructed, and grazing was permitted if it could be shown that it was not damaging.

A year after national forests were established, the Forest Homestead Act was enacted. When the boundaries were originally laid out, it was not possible to exclude all agricultural land along streams and in small valleys surrounded by timber. In order to insure that all agricultural land would be available to homesteaders, Congress passed a law on August 10, 1912, which directed the Secretary of Agriculture "to select, classify, and segregate all lands within the boundaries of the National Forest that should be opened to settlement and entry". In the Trinity National Forest, the inaccessibility and lack of railroad transportation have probably been the reasons for its preservation as one of the few remaining virgin forests in California. In 1912, the total stand of government and private timber within Trinity County was estimated to be 17 billion board feet, of which 13 billion were on National Forest Land. About 77 percent or 1,780,960 acres of the county lies in the National Forest. By 1912, 18 sawmills, run principally by steam and water power, contributed 5 million board feet of lumber to the markets and mines. In 1931, the government ownership of the forest included approximately 11 billion feet of timber, consisting of Douglas Fir (55%), Western Yellow Pine (25%), Sugar Pine (13%), White Fir (6%), and a small amount of incense cedar, red fir, oak, madrone, bigleaf maple, ash, yew, alder, cottonwood and willow.

AGRICULTURE/GRAZING

Between 1845 and 1926 potatoes, beans, corn, tomatoes, onions, carrots, turnips, lettuce, radishes, cabbage, celery, asparagus, alfalfa, hay and clover were the chief agricultural products. Fruits grown were peaches, apples, pears, grapes, plums, prunes, apricots, cherries and berries. In 1926, dairying became a very important industry for the county. Cream was shipped to creameries outside of the county. The principal stocks were cattle and hogs, butt here were also sheep, goats, horses and mules. By the end of 1853, nearly all the parcels of land in the county suited for cultivation were identified and many were cleared, fenced and seeded for crops of hay and grain. Settlers often used fire to clear the land of brush and trees in order to make good farm land and improve pastures for grazing.

Lowden's Ranch, at the confluence of Grass Valley Creek and the Trinity River, was among the most valuable of mountain farms. It was 640 acres, 200 of which were cultivated. It was purchased by

William Lowden in 1851. Crops grown on the ranch consisted of 75 acres of barley, five acres of oats, two of corn, 32 of potatoes, four of turnips and beets, two-and-one-half of onions, seven of Timothy grass, five of melons and pumpkins, and three of cabbage. There were 1,500 apple trees, 1,000 peach, 15 pear, 300 plum, 40 cherry, 200 currant plants, 200 grape plants and one-half acre of strawberries. There were also some cattle, mules and horses. In 1858, the ranch yielded 200,000 bushels of potatoes, 120 tons of onions, 50,000 pounds of cabbage and 8,000 melons. Grass Valley Creek provided water sufficient to irrigate every part of the farm, and was carried by ditches and flumes to convenient places. The Weaver and Shasta turnpike road passed through the center of the ranch and crossed a bridge.

The Trinity Ranch was located at the confluence of the Trinity River and Weaver Creek. It was first settled in 1851 and had 300 acres, of which 150 acres were cultivated. There were several natural springs on the ranch. Another ranch, the Smith Ranch, was comprised of 100 acres and located near Reading Creek and Brown's Creek.

The Sky Ranch or Sturdevant Ranch was located in Junction City and was founded in 1853 by Joseph Sturdevant. It had a ditch which ran from Canyon Creek and crossed a trestle at Oregon Gulch. Before 1853 the place was a noted mining camp. It had a flour mill, sawmill and water races for mining. It lay on the main route of travel down the Trinity River. It was an important stopping place and the location of a wagon bridge crossing on the Trinity River. At the time, the road downriver ran on the south side of the river because of the bedrock bluffs west of Junction City. A large portion of the ranch was dredged in the 1930's.

In 1912, Trinity County listed 350 farms. There wee 10,000 fruit-bearing trees, as well as 15,00 acres planted in alfalfa, grain and grass hay. On Trinity National Forest land approximately 11,000 head of cattle and horses, 22,000 sheep and goats and 400 head of hogs were grazed under Forest Service permits. Trinity County produced all of the fruits, vegetables and hay necessary for home consumption. On hill lands and river bottoms the productivity of the soil was comparable to the best in California. Irrigation was necessary during the summer months. Trinity County was particularly favored for stockraising insofar as climate, range and native grasses were concerned. Owners of herds in neighboring counties summered their stock on the grassy slopes of the Trinity ranges.

After the discovery of gold the land was valued primarily for its mineral wealth. Only after the placers became exhausted did the majority of the population look to farming, horticulture, and ranching. The mules and horses used for transportation needed hay, and miners provided a market for grain, vegetables, fruit, dairy and meat products. Since there was a demand for meat in the many mining camps, agriculture was frequently combined with pastoralism, and many homesteaders kept large herds of cattle.

According to a Forest Service map of the Trinity National Forest from 1915, each year approximately 10,000 head of cattle and horses and 19,000 sheep and goats grazed the Forest. By 1931 the number of livestock had decreased to approximately 7,800 and 10,000, respectively. Large parts of the Forest were limited to summer grazing, but there were portions where livestock could graze throughout the year.

In an early grazing report done by the Trinity National Forest in 1909, climate conditions were described as being greatly varied throughout the Forest, with rainfall amounts diverse from one area of the Forest to the next. In 1908-09 the Forest had drought conditions and there was drought damage to early grasses at lower elevations. The early grass was burnt up before reaching a sufficient height to be cropped.

Sheep grazing was most damaging to Forest growth, and was discouraged and reduced in numbers as much as could be done. Before grazing was done to any extent in the mountains, opened stands of timber and the higher glades contained a luxuriant growth of wild pea vine and natural grasses. A perennial California bunchgrass was most prevalent on the open oak slopes. These grasses and forage plants have almost disappeared, except in places inaccessible to stock. The grazing report of 1910 stated that rain and snowfall came in a four month winter/spring period. The remainder of the year had little rainfall and was an intensely hot period. Forage grasses and shrubs will never reach the same state of natural perfection it was before grazing began. Old settlers claimed that the grass and forage plants covered the ground like hay. The Grazing Report of 1911 stated that before the Forest Service took over, grazing sheep were brought in and cleaned up a large part of the range desired by cattlemen. Sheep had damaged many roads and trails. In 1912, the revegetation of depleted ranges with native seeds and grasses was recommended. It was said that the tame grasses could not compete as well as the native species. In 1915, there were heavy cold rains through May and then little or no rain for 250 days.

MINING

The Gold Rush hit Trinity County in 1851-52. Gold was the major industry in Trinity County from 1850-1900. During 1850, a large number of gold seekers came into the county. By the end of 1851, all the gold-bearing sections of the county had been explored or prospected. In the spring of 1852 there were occupants of every bar along the Trinity River from Salyer to Carrville, and every tributary leading into the Trinity River within the county had been traversed and prospected. During the first winter, the early mining camps around Shasta and along the Trinity River were completely cut off from the rest of the world. When spring came, the small settlements (mostly consisting of tents), grew rapidly, and within a few years many of them had a population of several thousand. In 1854, the mining population of Trinity, Siskiyou and Klamath was much larger than ever before. There were 6,300 miners licenses issued in Trinity County in 1854. J. W. Bartlett wrote in 1926 that by the end of 1853, nearly all the land suitable for cultivation had been claimed by location, and that most of the auriferous gravel that could be worked by simple placer mining methods had already been discovered and worked. By 1890, Trinity County was essentially a mining county and all industries were dependent upon that industry.

Gold occurs in many different types of rocks and in different geological environments. Gold processes from two principal deposits, lode and placer. Lode deposits occur in bedrock. Placer deposits are formed by the processes of erosion. The first gold discovered in California was placer gold. The first device used for washing the gold was an Indian basket, then a tin pan or wooden bowl was used. The more efficient rocker replaced these implements and was the main implement used by the Chinese miners. The next improvement used was a "long tom", but the sluice box provided even greater efficiency than the "long tom". Sluicing was a method by which water passed over gravel, loosening it, and then through a long sluice box where the small, heavy particles of gold were trapped. In many of the claims, the paydirt (soil worth digging for) was overlain with clay or sand. Miners had to strip off this layer first in order to get at the dirt that was worth washing. One method, known as 'coyoting', was to sink a hole to the bedrock and dig side tunnels into the paydirt.

Often deposits were found where water was not available, which prompted miners to dig ditches for a water supply. The construction of ditches required large labor crews and money. The Chinese often provided the labor, and money was raised by selling stock. Large ditches had been built since the earliest years to bring water to the dry diggings - usually river terrace deposits or buried stream channels - that then could be mined by sluicing. Water ditches brought about new methods for washing the grounds in the higher mineral deposits. One of the earliest attempts at ditch building on a grand scale was that of the Trinity River Canal Company, organized in 1857. This company's first objective was the transportation of water from a point on the Trinity River below Lowden's Ranch (Lewiston) to the mines at Steiner's Flat (near Douglas City). The canal was destroyed in the flood of 1861. In 1854, Ohio Flat brought out the first High Ditch. It carried their portion of the Grass Valley Creek water across the river in a flume and conveyed it to the foot of Poker Bar (between Lewiston and Douglas City). In 1860, a ditch to Poker Bar was constructed from the ditch at Steiner's Flat.

Water wheels in most cases surpassed in water quantity the water ditches. For ten years, the water wheels were the main source of water supply used in ground sluicing the river bars in all parts of the county. Most of the wheels were destroyed by the floods in the winter and spring of 1861-62.

Types of dams used along the Trinity River for mining were wing dams, pot dams and coffer dams. When the river was dammed, the stream was turned entirely out of the bed and the water was carried either in a race dug through the adjacent banks, or a flume laid above the bed. When dams on the creeks were built, the miners would select a favorable-looking place on a riffle, pry up and roll away a few boulders and would reach the soft, shelly slate rock underneath. Miners generally damned the river in the late summer during the low - water season. Wing dams and pot dams were the general methods used. When building a wing dam, logs would be cut from the mountainside and rolled down to the river. Two parallel lines of logs would be set up in the middle of the channel, where they were fastened together and the space filled with earth. When the wing was completed, a head dam would be put in, forcing the water through one half of the channel. The bed of the river would be laid partly bare on one side. The wing dam was built upon the best paying ground in the claim. For over 30 years this method was used by the Chinese miners at various places along the Trinity River, especially along what was known as the Canon of the river extending from Helena to Big Bar (out of the analysis area). A pot dam was a space ten or twelve feet square next to the shore, enclosed with a wall of rocks and earth. A coffer dam was constructed in the current, and was built of bags partly filled with sand. The dam was bailed out with a bucket. The earth was generally dug out and piled on the bank to be washed at leisure. In 1850, the Arkansas Dam was constructed across the Trinity about four miles above Junction City. The object of the Arkansas Dam was to dam the Trinity River and divert its entire flow through large flumes, there by making the streambed immediately below the dam available for mining. They expected to throw all the water of the Trinity River into its old course and lay bare or nearly dry up the whole bed for three quarters of a mile. The dam was rebuilt several times after being destroyed by heavy flows. Eventually, it was built to last several seasons. The days of the wing and pot dams left the river lined with logs and timbers of various kinds, which the first flood of each year would set in motion.

Many small flumes, built to bring needed water to the dry diggings, had been constructed in Trinity County prior to 1853. Flumes were used in areas where ditches were impractical. In 1851, Weaver and Company constructed a flume from Little Weaver Creek, and Dove and Company constructed a two mile long water race from Little Weaver Creek.

Alongside the river was a low bar, always covered during high flows. This low bar was generally 20 to 50 feet in width and very shallow. At times it would be covered by sandbank and a growth of willows. High bar mines were built in areas of bedrock and would cut through the flinty rim. It was one of the hardest jobs connected with mining. They used picks, sledges and drills to cut through the bedrock. In the back of each bar was generally a 'second bench'. The Ohio Flat Company was the first to bring water onto one of the upper benches. The Texas Bar was a long wide bar, with the upper part showing a gravel wash, while 30 or 40 acres of the lower end was covered with a rich black soil which, with irrigation, yielded boundless crops.

The gold discovered at Reading's Bar was of the character known as 'riverdust', fine and of high quality. At Union Bar, very little gold was discovered from the banks, so it was decided that the gold must be in the bed of the river. A race was dug, and to force the water of the stream through it, it became necessary to build a dam 14 feet in height. In the early days, the Douglas City area was extremely rich where the highly productive Weaver, Indian and Reading Creeks empty into the Trinity River. At Douglas City there was little necessity for wheels because the tributaries supplied plenty of water. In the Junction City district, the river had been dredged for a distance of at least eight miles. The bench gravels were extensive and thick, and some of the hydraulicked banks were several feet high. The largest bench deposits were at Cooper's Bar, Hocker Flat, Benjamin Flat and Chapman Ranch. At Canyon Creek near Dedrick, Canyon Placers, Incorporated acquired a number of properties amounting to a total of 1,500 acres in 1933. They installed a water system on the upper tract. Some 20,000 feet of ditch and flume brought water from Canyon Creek. A million gallon reservoir provided for around-the-clock mining. In addition, two miles of private road was constructed and the old road from Junction City was repaired, including bridges. Deadwood Diggings at Deadwood Creek and Lewiston were other mining camps. The bed of Deadwood Creek was mined three times for a distance of six miles from its mouth.

The abundant rainfall, heavy deposits of snow on the mountains, the abrupt grades of the streams, and the unlimited deposits of gold-bearing gravel made Trinity County an ideal area for hydraulic mining. This activity benefited the local lumbering industry, which supplied large quantities of cut wood for sluices and flumes. The La Grange Mine is still located in Oregon Gulch, a few miles west of Weaverville. It was opened in 1851 and was one of the major hydraulic mines in California. Large-scale hydraulic mining began in 1862 and continued until 1918. More than one hundred million cubic yards of material were excavated from the La Grange Mine. Water was delivered from Stuarts Fork via a 29 mile system of canals, flumes and tunnels. Five million dollars in gold were recovered from the mine. The peak production of the mine was from 1909-1915. When the La Grange system reached its greatest length, the highest source of water came from the Upper and Lower Stuarts Fork Lakes in the Trinity Alps (Sapphire and Emerald). In the early 1900's, a dam was constructed at the lower end of the lake. A dam on the Upper Lake was started, but the mine closed before it was completed.

From the dam, the La Grange system carried water down the Stuarts Fork of the Trinity River for about seven miles, until its confluence with Deer Creek. At this point, a diversion dam was built and the waters from Stuarts Fork and Deer Creek were diverted into the head of the flume. Beginning at the flume, the water was carried 29 miles through a system of flumes, siphons, ditches and tunnels to the penstocks at the mine above the pit on Oregon Mountain. The tailing dump of the La Grange Mine filled Oregon Gulch with gravel, rocks and boulders from 20 to 200 feet deep.

The La Grange holdings and operations worked under a 600 foot pressure, delivering eight-inch streams of water against hillsides 500 feet high, demolishing the mountains at the rate of 9,000 cubic yards every 24 hours, carrying the debris through hundreds of feet of sluices with a miniature river of water measuring 3,600 inches (Egilbert 1912). With hydraulic mining, whole hillsides could be broken down within a short period of time.

Conditions for hydraulic mining were regarded as exceptionally good in 1889. The longest ditch (40 miles long) in Trinity County was built by the Buckeye Water and Hydraulic Mining Company in 1875, but was abandoned in 1931. The hydraulic mines that were listed in the Report of the State Mineralogist (1913-14), totaled over 7,500 acres. The mines had some impact on the forest, as the ditches often cut across timberland, or the water used was diverted from the river. High terraces of the Trinity River and those of a few of the tributaries were most extensively worked. There were 71 hydraulic mines in Trinity County, and it remained important in Trinity County at least into the early 1940's.

William H. Brewer traveled through Trinity County in September 1862. He described a section of the river near Douglas City which was hydraulically mined. The description of what he observed is as follows:

The river here makes a curve. A stratum of soil twenty or thirty feet thick forms a flat at the curve of the river, of limited extent. The 'bed rock' beneath this is of metamorphic slates, much twisted, contorted in every shape by former volcanic convulsions, and much of it very hard. The soil above is very hard, like rock itself, made up of loose rounded boulders, cemented by a firm red clay into a mass as hard as ordinary sandstone. In this the gold is found. Deep ditches are cut, not only through this, but deep down into the hard bed rock beneath, often twenty or more feet into the latter, and running out into the river. In these are the 'sluices' - merely long troughs for conveying the water. The bottoms of these sluices are made of blocks sawed from the ends of partially squared timber, so that the end of the grain is presented to the surface, sometimes of a double row, sometimes, however, of but a single row of blocks. These do not lie perfectly square and level, so, as the water flows swiftly over them, they cause a ripple, like water flowing swiftly over the stony bed of a stream. The bottom of the box or trough, below these blocks, is perfectly tight, and quicksilver is poured in and collects in all the holes between the blocks. Ditches from miles back in the mountains, bring the water up against the hillside, far above the surface of the flat and a flume, or 'raceway', built on high stilts, over 70 or 100 feet high, brings the water directly over the 'claim'. A very stout hose, often six inches in diameter, conducts the water down from this high head, and has at its end a nozzle like that of a fire engine, only larger. Now, this stream of water, heavy and issuing with enormous force from the great pressure of so high a head of water, is made to play against this bank of hard earth, which melts away before it like sand, and flows into sluices - mud, boulders, gold. The mud is carried off in the stream of thick, muddy water; the boulders, if not too large, roll down with the swift current; the heavier gold falls in the crevices and is dissolved in the quicksilver, as sugar or salt would be in water. In some mines these sluices are miles long, and are charged with quicksilver by the thousands of pounds. This washing down banks by such a stream of water under pressure is "hydraulic mining". After a certain time the sluices are 'cleaned up,' that is, the blocks are removed, the quicksilver, amalgamated with the gold, is taken out, the former being then driven off by heat - 'retorted' - and the gold left. From this flat near Douglas City over a million dollars has already been taken, and it looks as if as much more was yet to be got.

During the 1870's, farming became more important than mining, and farmers protested the accumulation of debris in the rivers. The Anti-Debris Association was formed, which began a struggle in the courts against the California Miner's Association. The court ruled in favor of the farmers in the Sawyer Decision on January 23, 1884. Hydraulic mining came to an end in those counties where farming or navigable streams were economically important. In Trinity County, only a small percentage of land was used agriculturally, and there were no navigable rivers. The Sawyer Decision did not put any restraints on hydraulic mining in Trinity County. The State Mineralogist's Report for 1914 quoted the U. S. Deputy

Surveyor William Lowden, as saying that "there was no mining land in the county situated in such a way that the working of the mines would damage any agricultural land". The little farming that was done was generally above the river bed.

Construction of the first dredge in Trinity County, the Kise Brother's Dredge, began in 1887. It was built on the Trinity River about three miles from Lewiston. The exact place of construction was about one-quarter mile above the portal of the tunnel which would carry water from the Trinity River to Clear Creek in Shasta County. Dredge mining has been actively pursued since about 1900 on the lower parts of the bars of the Trinity River at Lewiston and Junction City. No brand of mining had as great an economic impact in a short period of time than dredge mining. In 1900, $29,104 worth of gold was produced in Trinity County from dredging operations. Between 1900 and 1905, the total output from dredging was $84,596. Dredge mining was as controversial as hydraulic mining had been earlier. There were those who claimed that dredge mining was destroying orchards and vineyards and discoloring the water, though it was estimated that less than 1,000 acres of orchard were destroyed.

A dredge, which was developed in the 1870's, basically consisted of a many storied, flat-bottomed, shallow hull with excavation machinery for digging, a steam engine and placer equipment for separating the gold. The dredge's forward end consisted of an endless conveyor belt with scoops or shovels to carry the material to the top, where it was separated. These dredges worked the same way as placer mining by letting gravity wash the material through riffle boxes. These boxes caught the gold and dumped unwanted tailings into the stream bed or along the banks. Evidence of these tailings can be seen along most of the Trinity River. Most dredges were built on site, and were then largely abandoned once the mining was completed (Sloane).

As early as 1850, some attempts were made to extract gold from surrounding bedrock, which proved to be difficult. Most miners continued to work the placers, and only when they were depleted did they turn their attention to quartz mining. Quartz mining involved three principal tasks: the mining of the ore, reducing it to powder, and extracting the gold from the powdered rock. Although much money was invested during the 1850's in quartz mining, this method accounted only for a fraction of the state's gold production. In the 1860's and 70's, the production from quartz mining showed a substantial increase, due in large part to improved technology. Quartz mining received little attention until about 1880. Rich mines were discovered on Deadwood Mountain at the Brown Bear Mine. The Brown Bear Mine eventually opened to a depth of more than 1,000 feet below the outcrop, and was worked continuously until 1912. The chief seats of quartz mining were in Deadwood, East Fork, New River and Canyon Creek. The Globe-Chloride Mining Area was located at Canyon Creek and Little East Fork. In 1894, the mine was a quartz operation, and an aerial tram conveyed the ore from the mine to a stamp mill below. The millsite was above Dedrick on Canyon Creek, and the sawmill operated across the creek. A pack string transported the lumber and mine timber up the hillside to the mine three miles above. A cyanide plant was part of the milling process. When the mill was in operation, Canyon Creek became as white as milk. The mill ceased operations in 1906.

Gold production declined during the 1860's. It was not until the 1890's that any substantial mineral production other than gold was recorded in the county. Limestone, soapstone, and lime were used locally as building stone and in mortar, and red ochre was used as a paint pigment. Quicksilver was mined from surface deposits of mercury-bearing rock in northeastern Trinity County as early as 1872. About 1,000 flasks of liquid mercury are said to have been produced before the Altoona Quicksilver Mining Company took over the property in 1875. Production of granite was first recorded in 1894, and intermittently from then until 1903. The quarry was located on Rush Creek near Baxter Gulch, and during its active life yielded 16,840 cubic feet of rock. The fined-grained granodiorite was used locally as ornamental stone on buildings and for monuments. Other ores that were mined in the county were copper and chromite. In Trinity County, the copper deposits were widely scattered and small. Their inaccessibility has, in most cases, prevented a profitable operation. Chromite deposits in Trinity County were first worked in 1916, with peak production occurring in 1918. Some 2,729 tons of mined ore remained at the mines after WWI, because of the transportation difficulties due to rugged terrain and shipping point distance. Platinum was found in a number of places in the county. A serpentine belt extends across the entire county, which yielded a considerable amount of platinum and iridium. A large amount of platinum has been saved in dredge mining conducted in Trinity County since 1900.

During WWI, the gold output decreased over time until 1929. From 1930 on the production again increased, mostly because of the depression. The miners were camped on nearly every level spot and bar on the Trinity River and its tributaries, wherever a road gave access. Mines that had long been idle were reconditioned, and new development work was done. Mining was shut down during WWII. Dynamite, metals men were needed for the war effort. Gold mining made a feeble comeback after the war.

VI-5 HUMAN AND SOCIAL IMPACTS AND LAND USE PATTERNS AFTER WWII

Human activity and related impacts to the watershed have increased significantly in this basin since the 1950's. Natural resource development, especially timber harvesting, fishing, water diversions, mining and agriculture, have had an impact on the fisheries and wildlife, along with periodic natural events such as floods, droughts and landslides. Urban development and road construction have also left their imprint on this land. Other than the construction of the Trinity River and Lewiston dams, it is not possible to segregate out any one of these human activities as the major cause of the decline in fish populations in this watershed analysis area; it is most likely the cumulative combination of events.

This area is dependent on the abundance of natural resources. The economy has been tied directly to the productivity and utilization of the resources of the land. The timber, and more recently, tourist industries, provide the major economic base in Trinity County. These industries are seasonal in nature in terms of employment and revenues generated and rely upon external economic conditions, such as demand factors and the strength of the economy in the rest of the state.

Timber Harvesting- A Significant Land Use In the Basin

In the mid-1940's logging became an important industry in many of the tributary watersheds of the Trinity River Basin. The economic boom that was stimulated by WWII production, while seemingly far away from this area, impacted Trinity County in the form of an increased demand for goods and resources, most importantly, lumber. Timber production peaked in 1959 in Trinity County with production of 439 million board feet (MMBF). In 1994 the volume of timber harvested in the county was 94.9 MMBF. Twenty-six mills have closed in the county since 1961, with only two remaining. The trend toward fewer, larger and more efficient mills has accounted for some of this reduction. However, the survival of the present mills is threatened by recent timber scarcities. These shortages have driven up the prices of raw timber dramatically. Employment within the lumber industry in Trinity County is being hurt by the limited amount of forest lands available for harvesting. The Forest Service has reduced its sales of timber, and environmental concerns and regulations have further limited lands available for timbering.

Some tributary watersheds, including large blocks of private lands, were logged intensively starting in the late 1950's. Logging practices of the times were not cognizant of sensitive lands or streams, and many roads, landings and stream crossings were constructed. Crossings were poorly constructed and road density was excessive. Timber management of National Forest lands also began in the late 1950's, with large portions of the watershed logged under the concept of 'unit area control' (Haskins 1988). There were several incentives for the clearcutting method, one of which was the add-valorum tax on land and timber; if at least 70 percent of timber was cut, the timber was off the tax roles for 40 years. Another incentive was that performance in the U.S. Forest Service districts was based on increased production. The Dwyer decision put a hold on clearcutting.

Most of the early timber harvest was simply an exploitation of the resource with little regard for the resources. (USDA 1972). Logging on steep slopes has led to a decrease in slope stability and higher erosion rates. The impact of logging can be found far from the actual harvest site. Clearing and disturbing the land results in a decrease in the water-holding capacity of the watershed, which increases surface runoff, with an attendant increase in stream velocity and erosion potential. This process results in sediment-laden streams with high turbidity. The most significant impact of logging on the watershed has been the construction of roads for access into remote areas, as these roads cause accelerated erosion. Increased erosion and sedimentation has contributed to the fisheries decline by reducing the carrying capacity of hundreds of miles of tributaries as well as the mainstem of the Trinity River (VTN 1979).

Prior to 1970, general forest practices were not very stringently regulated. Logging roads that were poorly engineered, constructed and/or maintained have been a source of substantial amounts of sediment into streams. Improper timber management practices adjacent to streams have led to increased sediment loads, higher water temperatures, lower dissolved oxygen concentrations and higher nutrient levels. Logging debris has also resulted in anadromous fish migration barriers (Klamath River Basin Fisheries Resource Plan 1985). Conservation measures, as required by the California Forest Practices Act, have not always been observed by logging operations (VTN 1979). As early as 1977, 42 percent of the Trinity River watershed (2172 km2) had been logged; 26 percent of the total area was clear cut and 16 percent of the basin was harvested using a selective cut method (DWR 1980).

The county's lumber production activity in 1990 totaled 224.2 MMBF, with a value of $59.4 million. In 1994, according to state timber tax records, total Trinity County timber harvest amounted to only 94.9 MMBF with a value of $44.5 million. This timber came from private lands. Prior to 1990, the majority of timber came off of public lands; now the majority of timber is harvested off of private lands. However, due to the increased value of the timber, tax receipts to the county from timber yields have actually increased since the mid-1980's, according to the County Auditor. The timber yield tax is about 2.9 percent times the value of the harvested timber, which varies from year to year (NHI 1986). Only five counties in the state produced more timber than Trinity County, including Shasta, Siskiyou, Mendocino, Humboldt and El Dorado Counties.

According to the Department of Forestry, Trinity County has 1,081,000 acres of commercial forest land out of a total of 2,052,980 acres. In 1986, the US Forest Service owned 672,000 acres of the total, another 39,000 acres were publicly held by other than the Forest Service, private timber companies owned 98,000 acres, 161,000 acres were owned by other private timber growers, and the remaining 111,000 acres were owned by other private interests. By 1993, commercial forest land managed by the Forest Service and capable of producing 20 cubic feet or more per acre per year of industrial wood, and not withdrawn by statute, ordinance, or administrative order from timber utilization, was only 483,000 acres (California Statistical Abstract 1994).

Mining

Mining in the Trinity River Basin has been a source of both wealth to the economy and degradation to stream habitat (Frederiksen 1980). Mining was the primary economic activity in Trinity County until after WWII, when logging became the predominant industry (DWR 1980). Mining claims on federal lands along the Trinity River and its tributaries increased significantly in the early 1980's as the price of gold rose astronomically during the high inflationary years. Both small- and large-scale mining in the area has been extensive, as evidenced by the huge amounts of tailings along much of the Trinity River and many of its tributaries. According to the Bureau of Land Management (BLM), there are currently 7,064 mining claims in Trinity County. Current gold mining operations are predominantly restricted to riverbed suction dredging.

Past mining activities have caused water quality problems in the past, particularly along Indian Creek. Heavy metal and high mineral concentrations resulted in local fish kills during the 1940's, '50's and '60's. Apparently, this is no longer a problem (CH2MHill 1985). Mining methods have varied over time, resulting in various levels of degradation to stream habitat. Hydraulic mining used high pressure hydraulic nozzles and water brought through miles of ditches, flumes and tunnels to wash away large portions of hillsides and streambank material. LaGrange Mine, in Junction City, was one of the largest hydraulic mining operations in the world, and deposited well over 90 million cubic yards of gravel into Oregon Gulch. This form of mining ended by the early 1950's. Bucketline dredging has created the large gravel piles located along the Trinity River and many of its tributaries. This practice was used from 1901 to 1958, when the Fairview Placer dredge was shut down. Most of the historically productive mines are now idle. Gold is primarily mined on a small-scale or recreational level and activity fluctuates with its market price (Frederiksen 1980).

During the 1950s the value of non-auriferous productions exceeded that of gold for the first time in the county. Nearly $6 million worth of mineral commodities, including chromite, copper, iron ore, manganese, quicksilver, platinum, silver, lead, asbestos, coal, crushed and broken stone, and sand and gravel were produced, compared to gold production of less than $2 million. The construction of the earth-fill Trinity Dam itself required more than 29 million cubic yards of material. Dredge tailings and river gravel was taken from above and below the damsite and several quarries in the area provided crushed and broken stone (Trinity Yearbook 1962).

The estimated output of the value of placer gold from the Trinity River is $35 million, according the California Division of Mines and Geology. For Trinity County as a whole, estimated gold production between 1848-1965 amounts to $75 million. The Douglas City area, where the very productive Weaver, Indian and Reading Creeks empty into the Trinity River, was extremely rich in gold during the early days of mining. The bench gravels are extensive and thick from past mining activities in the Junction City district, and the hydraulicked banks are several hundred feet high. The largest bench deposits from mining activities are at Coopers Bar, Hocker Flat, Benjamin Flat and Chapman Ranch (CDMG 1970).

Production of sand and gravel and crushed stone has become a more important industry; its products are used for roads and other construction purposes. The value of sand and gravel has become greater than that of gold. The high cost of transporting the product, however, keeps the market relatively local. In 1994, the value of construction sand and gravel produced in California came to $465 million, while the value of gold produced was $383 million (California Geology 1995).

Mining activities have been a source of turbidity and sediment to stream channels and have actually changed the configuration of many of the tributaries and the mainstem of the Trinity River. This has degraded fish habitat and spawning areas of both resident and anadromous fish populations. The major impacts on the Trinity River from mining took place many years ago when dredging and hydraulic mining were done on a large scale. Canyon Creek, which has been heavily mined in the past, shows little if any turbidity today, indicating significant recovery. Indian Creek is known to have huge sedimentation problems from past mining activities.

The attached map indicates the type and location of the mines. In the Trinity River watershed the mines depicted are primarily placer and lode gold mines, with a few sand and gravel and limestone mines. Gold mining is done on a much smaller scale today than in the past, especially since most of the accessible placer deposits have already been worked. New activity is concentrated in small subsurface and suction dredging operations. The impacts of these smaller dredges on gravel sorting and discharge of fines in the river, and the fish habitat, are unknown.

Sand and gravel operations can have a positive impact on the Trinity River system if done in a controlled method to remove accumulated deposits. The positive effects are sediment removal, if done correctly, but the operations tend to have a negative effect on the appearance of the immediate surroundings. There are regulations in place to minimize or abate turbidity/sediment problems. The Forest Service and North Coast Regional Water Quality Control Board have indicated that mining-related turbidity and sediment problems in this area are now under adequate control because California Department of Fish and Game enforces mining regulations that are designed to protect fish habitat.

Fisheries

The value of the anadromous fisheries in this watershed is very high, although it is difficult to place a dollar value on this resource. One way to gauge a part of the value of the fisheries industry is to look at the commercial value. In 1993, commercial fishermen in California landed 2,576,531 pounds of salmon, which had a market value of $5,811,489. Only tuna, rockfish and swordfish had more value (California Statistical Abstract 1994). This does not take into account the recreational value of the fishery, which is significant to the Trinity River area. According to Frederiksen, Kamine & Associates' 1980 report, the commercial and sport fishing at the 1950-60 population level contributed more than $17.3 million annually to California's economy. In a 1984 report to CH2M Hill, Meyers Resources, Inc. describes multiple benefits and various aspects of fisheries values, including commercial, sport, recreation, subsistence, social and cultural values as well as the aesthetic values associated with the existence of the fisheries in the Klamath Basin, of which the Trinity River is a part.

As the commercial fishery harvest developed more efficient techniques, moving from single hand lines to multiple lines with sophisticated lures and fish finding gear, it is believed to have seriously depleted fish runs, and a significant level of exploitation continues to occur. Sport anglers and the effects of the Indian fishery catches are also thought to have contributed to the declines in populations of anadromous fish in this basin (VTN 1979). Overfishing has been part of the problem, as the harvest of salmon from the Trinity River system is clearly in excess of their capability to sustain themselves. The majority of ocean-caught salmon from the Trinity River are landed at Crescent City, Eureka and Fort Bragg (FKA 1980). Harvest management in the Trinity River Basin is now being dealt with by the Klamath Fisheries Management Council, which advises the Pacific Fisheries Management Council, who in turn assists the Secretary of Commerce in setting harvest rates (TCC 1994).

Recreation/Tourism History Trends and Status

The Trinity River attracts visitors who take advantage of its cool waters and scenic setting. Opportunities for camping, hiking, boating, hunting, and especially fishing during the fall and spring anadromous fish runs, draw many people to the area. Recreation and tourism are very important to the Trinity River community and are becoming increasingly more so. They bring in a significant source of revenue and provide employment opportunities. Tourism provides 50-75 percent of the summer business and about 25 percent of the winter business activity, according to Bureau of Reclamation EIS (1986).

A portion of the Trinity Alps Wilderness Area is located in the analysis area. This area is dotted with sparkling alpine lakes. Many people are attracted to the Alps for the pristine conditions and natural attractions, which provide some of the best mountain scenery in California. Cabin, camp and resort developments occur at several locations near the Wilderness boundary. Pack service and guides are also available. Much of the use is by backpackers (DWR 1965).

The Trinity River watershed is located off main travel routes and at a considerable distance from most major population centers. Thus, the tourism industry and the number of recreational visitors has grown only modestly over the years, although as more people look for places to escape from the city, this area is one where people are increasingly coming to get away from it all. There are several developed campgrounds located in the analysis area along the Trinity River and its tributaries. These include Steel Bridge Campground near Lewiston, the Douglas City Campground, BLM's campground below Junction City and East Weaver Campground in Weaverville.

According to California Department of Fish & Game, the number of resident sport fishing licenses sold in Trinity County in 1993 was 5,149, which amounted to $117,140 in fees. The number of one day sport fishing licenses sold were 1,902 bringing $15,216, and 51 nonresident sport fishing licenses sold for $3,124. Hunting licenses (resident) in the county amounted to 762, generating fee income of $17,526. See the chart in the appendix following this text for historical information on hunting and fishing license sales in the county.

If the restoration work in the Trinity River watershed improves the fisheries, there will likely be an improved business climate as a result of additional recreation use in the county. Potential increases in the fish populations in the Trinity River would result in increased sport fishing, it would stimulate the recreation-related economy of the county and it would create a possible rise in recreation-related employment opportunities. The area has tremendous recreation potential and it is expected that there will be continued expansion in recreational activity, due to increases in regional population, increased leisure time and the desire to explore wilderness areas.

Agriculture

There is not much land suitable for agriculture in the analysis area because the terrain is so rugged. Trinity County produces fewer agricultural products than any other county in the state. Only 5.7 percent of the land in this county was in farmland as of 1992. The agriculture that exists in Trinity County primarily involves beef cattle production. In this watershed analysis area there are several ranches, one along Browns and Indian Creeks; the RK Ranch. Two others are located near Junction City along Soldier Creek drainage - the Carter Ranch and Chapman Ranch; and the Lowden Ranch lands are located in the flat land near Lewiston. Most of these, however, are not currently producing cattle. Most of the agricultural land in the county exists in the Hayfork Valley, outside of this analysis area. Land in this county used to be primarily open range, but the trend has been moving more towards a closed range system, requiring fencing to keep cattle enclosed. There are a total of 113 farms covering 116,083 acres in the county, with an estimated $2.2 million total value of production for livestock (Department of Finance 1994). Cash receipts from crops in the county amounted to $113,000 in 1990.

Fire Regimes

Fire is a natural process in the ecosystem and a necessary component to the health of the landscape. Frequent low-to-moderate intensity fire is historically one of the most important ecological processes in the Klamath Province. Fire return intervals range from 7-35 years, with most sites having a return interval of 10-17 years in Douglas-fir and mixed Douglas-fir and ponderosa pine stands. Evidence indicates that these fires were most likely late season burns, specifically late summer through early fall. For the past 40-60 years the practice has been to suppress fire. Fire suppression results in a change in forest succession. Suppression of fires tends to result in forests with heavier fuel loads. which lead to fires of greater intensity. In more normal fire patterns the forest was most likely less dense with a more patchy look than currently exists. Two to five fire cycles have now been missed, leading to increased fuel loads and greater potential fire risk.

It is widely accepted that the contemporary fire regime contrasts sharply to that of the pre-European settlement. Fire suppression has become the norm, which does not allow for natural regeneration. Trees have become very dense and rather spindly, and when a fire does occur, it tends to be much more catastrophic in nature than used to be the case. Suppression of fires has contributed to an overall deterioration or displacement of wildlife habitat (Frederiksen et al 1979). Fires, especially catastrophic fires, tend to have a similar impact on a watershed as clearcutting, although burn areas do not suffer as much disturbance from roads, landings and skid trails. Revegetation is critical following a burn, especially as heavy rains could result in large soil losses (Department of Water Resources 1980).

Urban Development

Trinity County is basically rural, without such urban trappings as stoplights. A very small percentage of the land is privately owned; thus there is not a significant potential for large scale development in the near future. There has been an increase in housing development in this watershed since the 1960's, but at a much slower rate than for the state as a whole. The clearing of land for houses and mobile homes has led to an increase in erosion and changes in runoff patterns. The increase in the human population has caused additional problems in some areas due to water pollution from the leaching of septic tanks, the cumulative effects of which are an additional threat to the anadromous fisheries (VTM 1979). Increased population has also resulted in increasing levels of nutrients in the river, and although nutrient levels are within normal standards, the effects of algae growth that they encourage are of consequence (Frederiksen et al 1979).

Floodplain Encroachment

Population has increased within the riparian zone of this watershed, particularly in the floodplain of the Trinity River. Extensive damage occurs to property from storms or higher flows released from the dam. In 1955, prior to the construction of the dam, a large flood event knocked out bridges in Lewiston, Douglas City, Junction City, Big Bar, Hawkins Bar and Willow Creek. The Trinity River crested early on December 23rd and left many people stranded on the far side of the river (Young 1971). After this event, flood control became a more urgent requirement or necessity in the minds of many local residents.

The Department of Water Resources has indicated that the primary areas of concern regarding floodplain encroachment are the Indian Creek/Douglas City area (which has 12 homes located within the 100-year floodplain), followed by Poker Bar, Steel Bridge, Salt Flat and Bucktail locations. Salt Flat and Steel Bridge locations would be likely to lose bridges and part of a road during very high flows. DWR is currently preparing a report modeling various flow regimes and the impact on various structures. The current floodplain delineation is 8,500 cfs below Lewiston according to USFWS, but flooding of some structures occurs at levels as low as 6,700 cfs.

Waste

As population increases, so does the need for refuse depositories. There used to be a dump near Douglas City on BLM lands, but that was closed in the early 1980's. The Weaverville landfill, located near East Weaver Creek, is nearing capacity and may close within two years. There is no suitable location for a new landfill in the area. Waste is likely to be transported to Redding.

Water Use and Diversions

Large amounts of water have been diverted from the Trinity River and its tributaries for mining, agricultural and domestic uses, which has been detrimental to the anadromous fisheries. Small dams built in some of the streams for diversions blocked fish from spawning areas, and the reduced flow caused by the diversions reduced critical rearing habitat. Unscreened diversions are also effective in removing fish from the stream systems (VTN 1979). Moon Lee Ditch, a diversion of West Weaver Creek, was constructed in the late 1800's by the Chinese and continues to operate today for several Weaverville water users, as well as the Weaverville Cemetery.

As population increases so do the demands for water. More pressure is also placed on fish and wildlife resources. Because of the increased awareness of the needs of the ecosystem, more water is now being allocated for fish and wildlife than was considered necessary in earlier years (DWR 1979). Much of the growth and development that has been experienced in Trinity County has been along the river or tributaries to the Trinity River. Areas such as Browns Creek, Reading Creek, Indian Creek, East and West Weaver Creeks, Rush Creek, Steiner Flat, Steel Bridge Road, Poker Bar and the Bucktail subdivision have all grown fairly rapidly since the 1970's, and homes were often constructed within the riparian zone. Demands for water have increased and often tap into the river to meet domestic needs. The North Coast Water Quality Control Board provided information on Trinity County water supply system and sources:

Site	Source	Location	Pop.	Storage Capacity
Indian Creek Trailer Park	Indian Creek	Douglas City	75	NA
River Meadows Trailer Park	Trinity River	Douglas City	26	NA
Douglas City Elementary School	Trinity River	Douglas City	129	NA
Junction City School	Trinity River	Junction City	30	NA
Chagdud Gompa Foundation	McKinney Creek	Junction City	15	35,000 gals
Lewiston Water Works	Trinity River	Lewiston	70	NA
Rush Creek Mutual Water	Rush Creek	Lewiston	100	50,000 gals
Weaverville CSD	East & West Weaver Creek	Weaverville	3,600	3,000,000 gals

There were 19 other locations listed in these four communities that utilize aquifers for their water supply.

Transportation Networks

Road building has had a significant impact on the watershed and the riparian corridor of the mainstem of the Trinity River, as well as on land use possibilities. The road systems in the watershed act as the arteries of the local economies. Access was difficult or impossible prior to the construction of roads. New roads, however, can increase erosion rates. Road-related erosion usually stems from poor placement, design, construction and maintenance. Highway 299 parallels about ten miles of the Trinity River; only four miles of the river is not accessible by road.

The Department of Water Resources estimated that 5,000 km of new roads have been constructed since the 1950s. Poor maintenance practices, such as sidecasting material and poor use of road fill, have led to an increase in sedimentation of local streams (VTN 1979). Trinity County had 2,074 miles of maintained public road as of 1994. Over half of these are roads on U.S. Forest Service lands, 34 percent are county roads, 10 percent are part of the state highway system and six percent of the maintained roads belong to the BLM (California Statistical Abstract 1994). The majority of these roads are either unimproved (6.5 percent of total road miles), graded (35.2 percent) and gravel roads (24.4 percent) (CSAC 1992).

Dam Development

The most significant impact humans have had in the Trinity River watershed is the construction of the earthen Clair Engle (Trinity) and Lewiston Dams, which were completed in 1963 by the U.S. Bureau of Reclamation as part of the Central Valley Project. The reservoir covers an area of 16,400 acres, has 145 miles of shoreline and has a capacity of 2,448,000 acre-feet. Between 1963 and 1981, nearly 1 million acre-feet of 'surplus' water was diverted annually from the Trinity River to the Sacramento River. Since 1981, minimum flow releases below Lewiston Dam to the Trinity River have been increased from 120,000 acre-feet to 340,000 acre-feet per year (CH2MHill 1985). Water from the Trinity River is being diverted to the Sacramento River at an average rate of 820,000 acre-feet per year. The average annual flows of the Trinity River have been reduced on the order of 90 percent.

This large scale diversion of Trinity River water is primarily for agricultural use, which has a very high economic value to the state. According to Frederiksen, Kamine and Associates in 1979, the value of water diverted from the Trinity River for agricultural purposes to the Central Valley has an annual contribution of $837 million at the state level and $22 million at the national level, following guidelines of the Water Resources Council. The 80,000 farms in California produced a net income of $4.8 billion in 1992 (California Statistical Abstract 1994), and generates $18 billion annually. Electricity is also generated during this transfer by a series of four hydroelectric power facilities. Thus, the effects of changes in the amount of water diverted can be significant.

The construction of Lewiston and Trinity Dams resulted in loss of access to nearly 110 miles of significant upstream habitat for salmon and steelhead trout. Project operations have turned a natural, high volume, fluctuating river into a relatively narrow and stable stream. The reduced flows to the Trinity River due to the Central Valley Project have prevented flushing of sediment, stopped gravel recruitment, prevented scouring of spawning riffles, promoted filling of holding pools and thermal refuges, allowed an increase in riparian vegetation encroachment and changed the temperature regimes in the river, further damaging the salmon and steelhead habitat (VTN 1979).

Natural Events in a Post-Dam Watershed

Floods (especially the 1964 event), droughts (by reducing water supply and increasing water temperatures) and landslides (which have contributed tremendous amounts of sand and gravel to streams) have been particularly devastating to the Trinity River basin. Their impacts have been compounded by the extent to which the river's ecological reserves have been already overtaxed by human activities in the watershed. The effects of these natural perturbations would have been greatly reduced if the Trinity River basin had remained in its wild (undammed) state.

Trinity River Restoration Program (TRRP)

Another human impact on this basin has been the efforts to restore the watershed. In October of 1984 the Trinity River Basin Fish and Wildlife Restoration Act (Public Law 98-541) was passed by Congress and signed by the President. The goal of the TRRP is to restore fish and wildlife populations to levels that existed prior to the construction of the Dam. This calls for a substantial amount of mechanical work to rehabilitate rearing areas, spawning riffles and holding pools. Construction of side channels, feather edges, sediment holding basins and pools, as well as sediment dredging and changing the amount and timing of flow releases, are all projects that have been attempted to correct the detrimental impact of the dam on fisheries habitat in this basin (USFWS 1994).

Trinity River Hatchery

The Trinity River Hatchery was constructed by the Bureau of Reclamation in 1963 at the base of the Lewiston Dam, which is the upstream migration barrier to anadromous fish in the Trinity River. The hatchery was intended to compensate for salmon and steelhead spawning and rearing areas lost by the construction of the dams. Using introduced strains, however, may have caused problems in migration, emigration and survival in the run.

Property Ownership

The land along the Trinity River is a blend of privately and publicly held land. Private land owners include Sierra Pacific Industries, subdivision and mobile park developers and small private owners. Both large- and small-sized parcels are located along stretches of the river. Government agencies, BLM and the Forest Service administer about 43 miles of the riverfront in the area of this study. Public land parcels range from small isolated pieces to entire sections. Along the Trinity River, private property ownership and development has increased. This has become a potential barrier for in-river restoration activities as some land owners are unwilling to cooperate with the agencies involved and have denied access to the work sites.

The area's rugged topography, the large proportion of government land and utility and transportation limitations have served to cluster the population into four small semi-urban areas - the towns of Weaverville, Lewiston, Douglas City and Junction City. Weaverville, the county seat, is not located directly adjacent to the Trinity River and does not have a direct impact on the river; however, its need for construction material, recreation areas, domestic water sources and utility corridors have an impact on this basin (BLM 1983).

Significant impacts on the Trinity River are caused by the prevailing land uses within the watershed. Extensive development on the banks of the Trinity is limited to a large degree by ownership pattern, severe topography, and floodplain development restrictions.

In Trinity County a very high percentage of the land is publicly owned, which has an impact on historical and current land use and also affects expectations regarding access and appropriate uses. BLM owns 20 percent of the watershed analysis area, the U.S. Forest Service owns 32 percent and 48 percent of the area is privately held. The checkerboard pattern of land ownership affects land management activities, reducing to some extent the effectiveness of agency management decisions designed to protect natural resources.

Future use of the land is limited by steep terrain in much of the region, and the large amount of public land in this watershed. Increased population density in the area could result in heightened soil erosion rates and increased domestic water needs. The planning policies for the watershed include maintaining and enhancing the recreational and resource values of the Trinity River and prohibiting development in the 100 year, post-dam floodplain of the Trinity River.

Socio-Economics

Demographics

In the history of Trinity County, the population has grown in a sporadic manner. Many people moved to Trinity County in 1848 when gold was discovered. The population increased sharply during the late 1940's and '50's due to extensive timber production, and then again during the 1960's due to construction of the Trinity Dam. According to the latest census, Trinity County's population reached 13,100 in 1990, or just over four persons per square mile, a very low density for the state. Until 1993 and 1994 Trinity County population growth had been quite low compared to the rest of the state. As of January 1, 1995, the population of Trinity County reached 13,950, a growth of 1.5 percent over 1994, while California's population grew by only 1.2 percent. Recent projections estimate a population of 15,000 people in the county by the year 2000 (See the chart in the following appendix). The population of the county is distributed as follows: Weaverville has 26 percent of the total population, Hayfork - 19.5 percent, Lewiston - 8.9 percent, Mad River - 6.5 percent and the remaining 39 percent of the population live outside the larger towns. The ethnic composition of Trinity County is not very diverse, according to the 1990 Census; 91 percent of the county is white, five percent Native American, and three percent Hispanic.

Demographic data indicate that Trinity County has a below average household size at 2.49 persons and a population much older than the statewide norm, with a median age of 37.8. It is interesting to note that the age distribution of the county is not the normal bell shaped curve of a 'normal population'; rather there is a significant decline in the population in ages 18-30. This indicates that many young people leave the county following high school, most likely to find jobs. There is also a bulge in the curve of people that have reached retirement age, suggesting that this is an attractive location in which to retire.

Housing

In 1990 the housing stock reached 7,540 for the county, up from 5,457 units in 1980. The value of these homes was $4.4 million, with a median home value of $81,800 according to the California Department of Commerce. This compares with a median home value of $195,500 for California. Nearly one third of the housing units in the county are mobile homes. Many housing units in the county are vacant (32 percent); the use of the dwellings for second homes or vacation places is higher than most places in the state. Trinity County tends to have a low vacancy rate for rental housing because there are not many rental units available. The median monthly rent in Trinity County in 1990 was only $292 compared to $561 for California.

Employment

As the following table depicts, employment in Trinity County has been dominated by government sector jobs and is becoming even more so, even though Federal government jobs have declined significantly since 1990. In 1994, nearly 46 percent of all employment in the county was government-related, while only 16 percent was manufacture-based and 17 percent was due to trade. There has not been much growth in the job market overall in this county over the past 10 years, and employment has actually declined since 1990.

Employment in Trinity County by Industry
(annual averages)

Industry	1985	1990	1991	1992	1993	1994
Agriculture	30	40	50	60	50	60
Construction and Mining	130	110	70	60	80	80
Manufacturing	470	450	390	480	470	490
Transportation and Public Util	120	100	90	80	80	90
Wholesale and Retail Trade	420	540	530	490	500	540
Finance/Insurance/Real Estate	80	60	80	80	60	60
Services	500	360	410	410	380	380
Federal Government	330	430	360	300	310	300
State Government	100	130	130	130	130	110
Local Government	740	970	970	960	990	1010
TOTAL	**2,920**	**3,200**	**3,070**	**3,050**	**3,040**	**3,120**

Source: Employment Development Department, numbers may not add due to rounding.

According to the 1990 Census, the labor force in Trinity County included 4,951 people and had an unemployment rate of 8.2 percent. Unemployment is the primary economic problem in Trinity County. Unemployment has been consistently higher than the average for the state of California, which had only a 6.6 percent rate of unemployment in 1990. Unemployment in Trinity County reached 15.7 percent in 1993, compared to 9.2 percent for California, and 7.1 percent for the United States. It improved in 1994 to 14.4 percent, but remains above that of the state and the nation. Manufacturing employment is dominated by the wood production industry in this county, according to the EDD (see the chart in the appendix for the historical trend).

Opportunities for young people to find employment are extremely limited and result in a high rate of unemployment for recent high school graduates.The timber-dependent economic base of the community is facing a difficult transition because harvesting has declined significantly in recent years. Watershed restoration and fisheries enhancement work in this watershed provide a source of employment opportunities for local people. This includes equipment work to remove fill from drainages, road maintenance work and recontouring or outsloping of eroding roads and landings, as well as the manual labor required for revegetation, including seeding, planting and mulching.

Income

Trinity County is considered to be a low income area compared to State and national average incomes. Per capita personal income in Trinity County for 1989 was $10,781. The low income level here is reflected in the fact that 18.5 percent of all people living in the county are below the poverty level, and 15.1 percent of families are living in poverty, according to 1990 census data. This can be compared to the California average of 12.5 percent of the population living below the poverty level. By 1992, per capita income for Trinity County was $15,152, compared with $21,348 for California. This county ranks 47th out of the 58 counties in the state in terms of income.

Services accounted for 20 percent of total income to the county in 1990, while manufacturing represented 17 percent of the total. Government represented the highest portion of income to the county with 39 percent. Many people in this county rely on government transfer payments in the form of unemployment, medical, social security and disability insurance benefit payments. In 1990, transfer payments amounted to $48.6 million to Trinity County according to the Bureau of Economic Analysis. In terms of education, only 12.9 percent of Trinity County residents over 25 years old have a bachelor's degree or higher.

With dwindling timber harvest on public lands, people in forest-dependent rural communities are seeking alternative sources of income. Special forest products, including mushrooms, pinecones, medicinal herbs and wildcrafting are increasingly recognized as a source of income.

Taxable Sales

Taxable sales for the county in 1990 was $53.1 million, 65 percent of which was retail sales. Retail sales in the county have been very weak compared to the rest of the state. Taxable sales in Trinity County fell to $47.9 million in 1993 and retail sales amounted to $32.6 million.

Desired Future Conditions-Land Uses

The desired future conditions for land uses in the watershed analysis area are based on the premise that we are looking for the optimum situation for ecosystem and river health while taking into account and balancing the economic needs of the community. Any human land use affects the ecosystem in one way or another. This community's economic health depends ultimately on the well-being of the ecosystem in that it is a resource-based economy.

Human expectations of river use are important factors to consider in making land management decisions. The diversity of activities at times produces conflicts between the various user groups, as each has their own needs or preferences. A desired future condition would be that the Trinity River watershed continue to contribute to the economic well being of the communities of Weaverville, Lewiston, Douglas City and Junction City by providing recreation opportunity for tourists, commodity outputs and direct employment. Resource and commodity output activities would be sustainable and based on ecologically sound principles that maintain or improve the watershed.

Charts
Human and Social Impacts and Land Use Patterns-After WWII

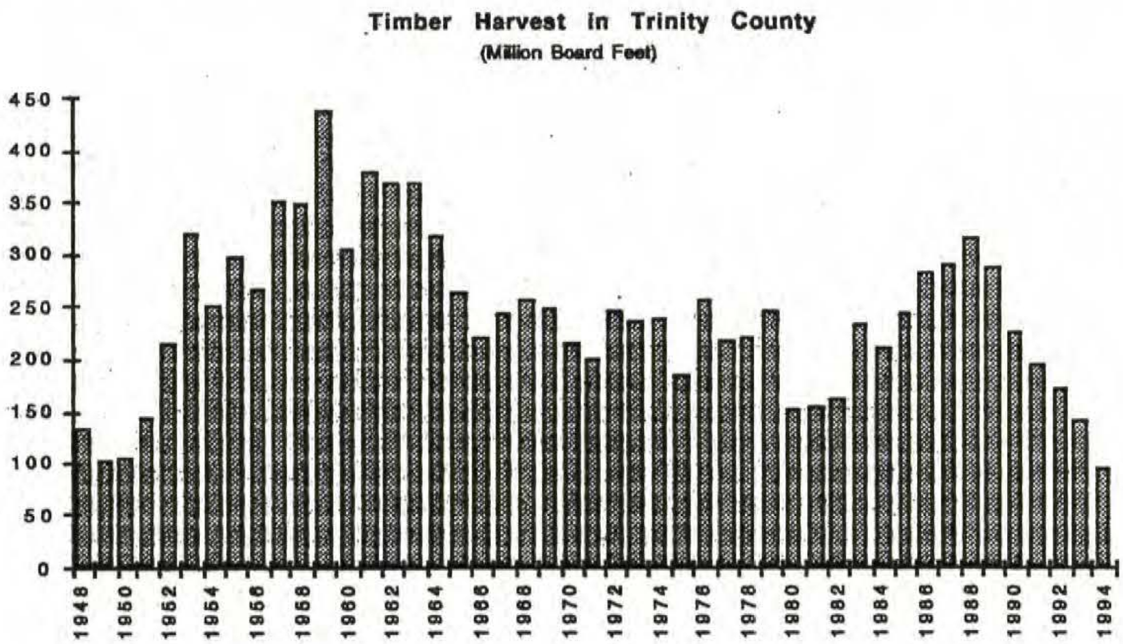
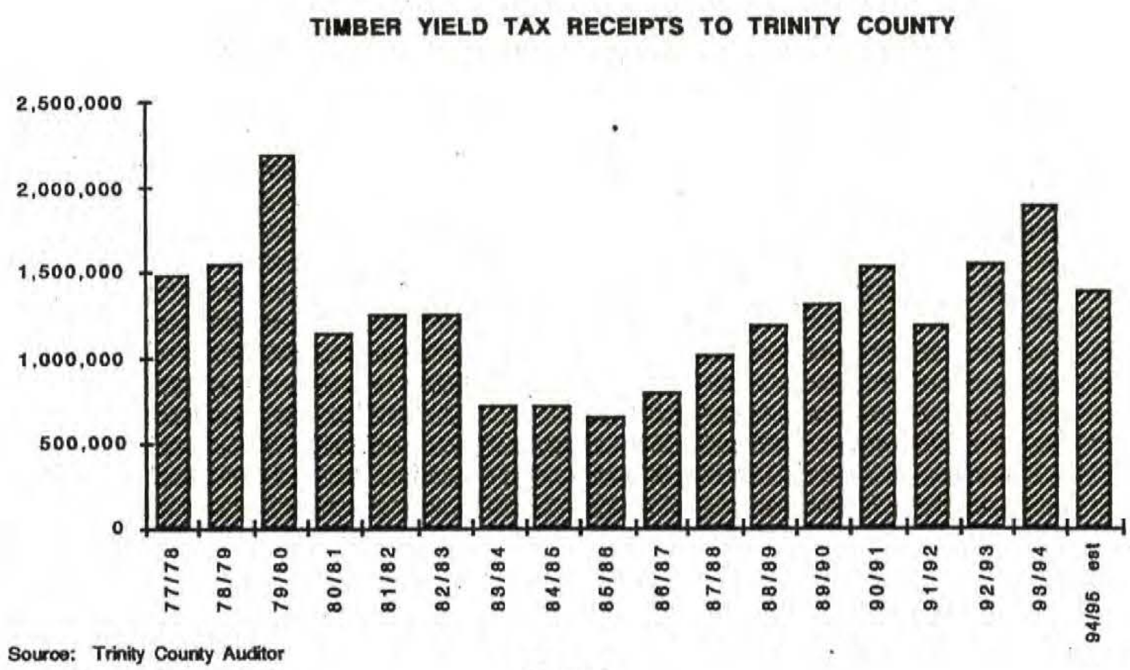


Chart 1



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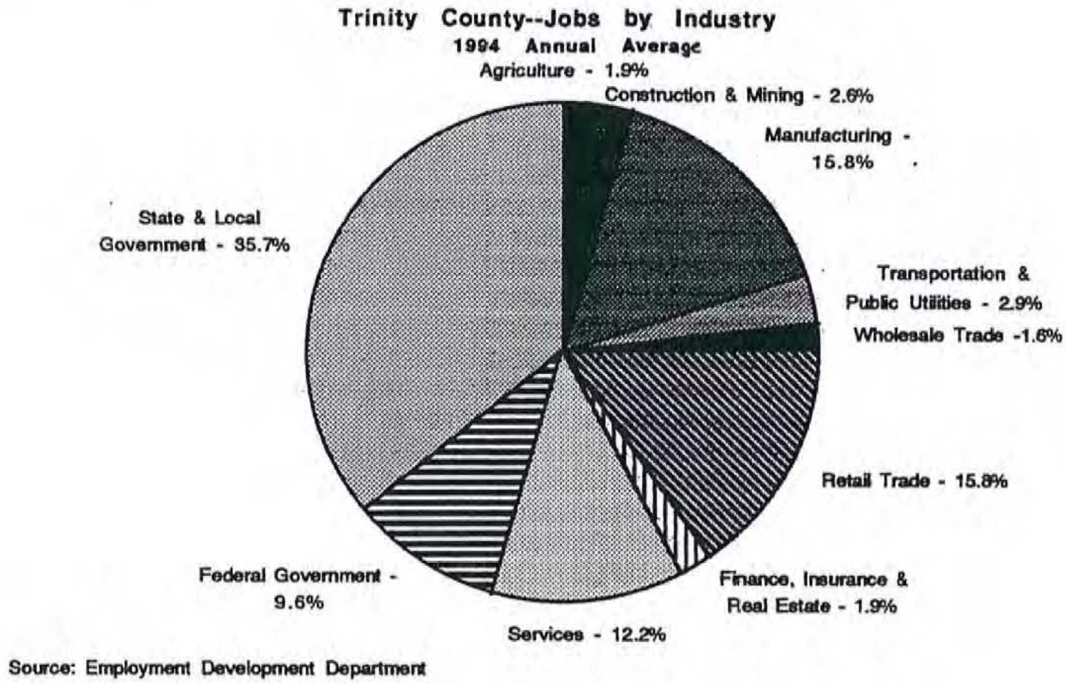

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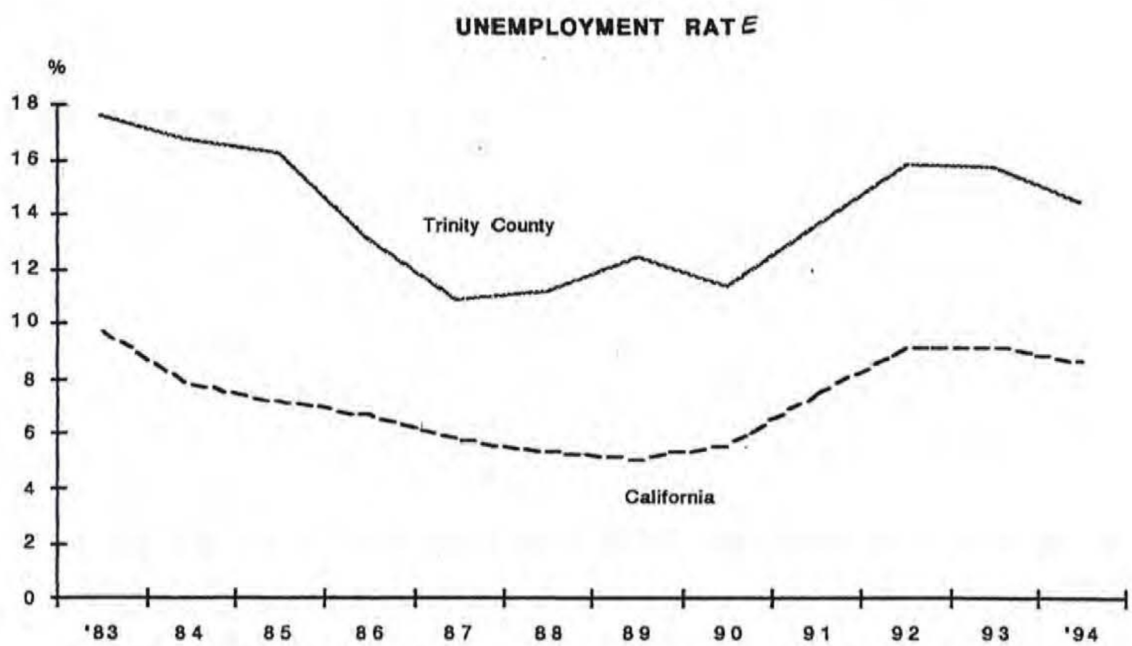

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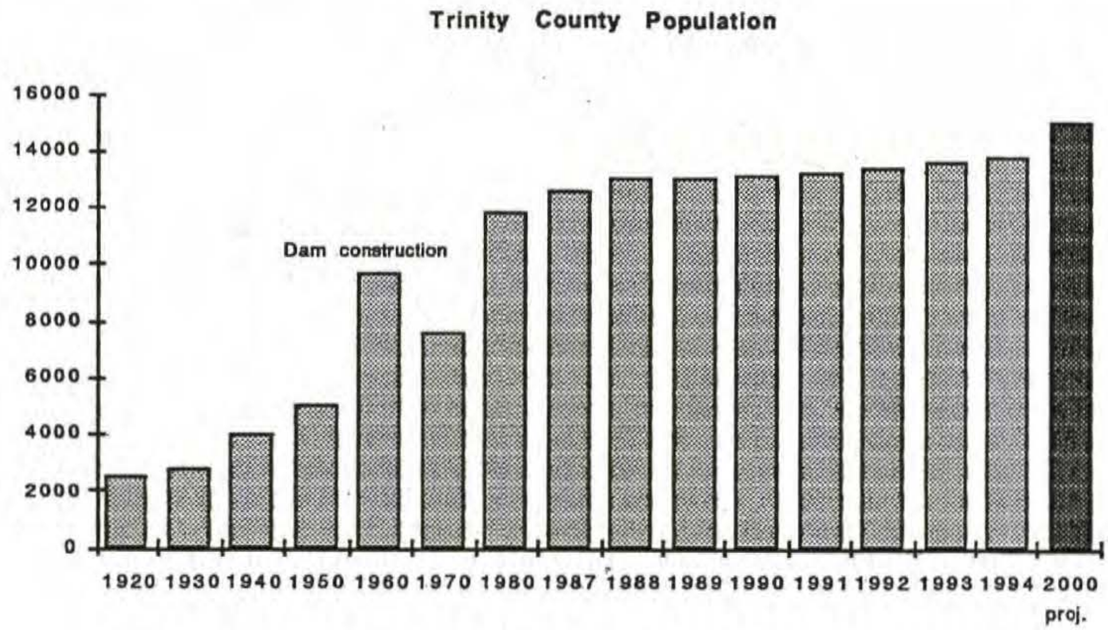
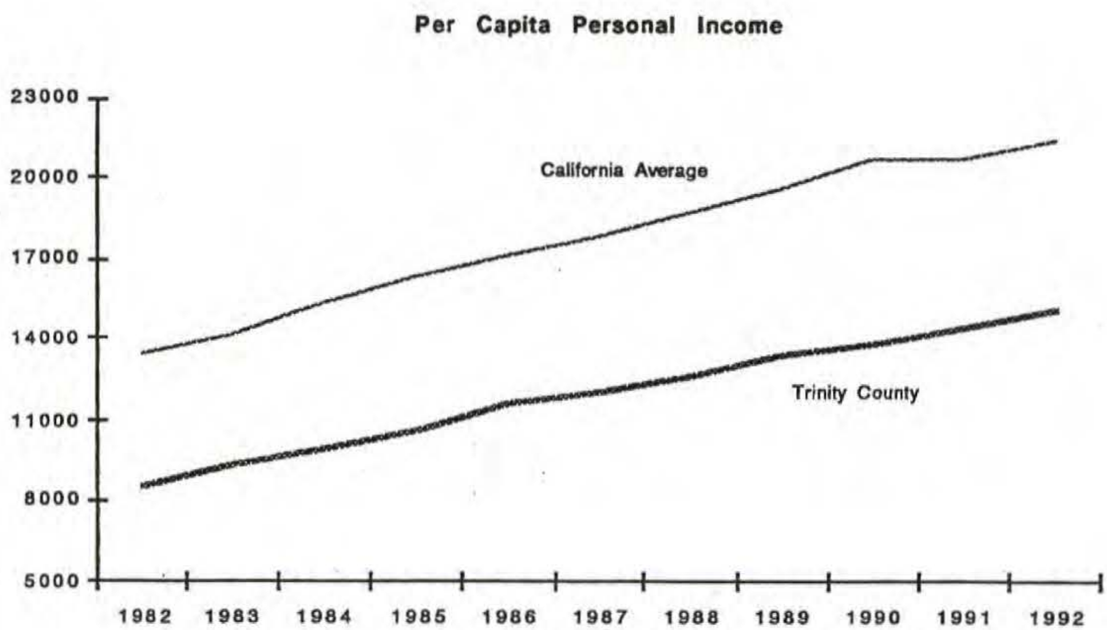


Chart 5



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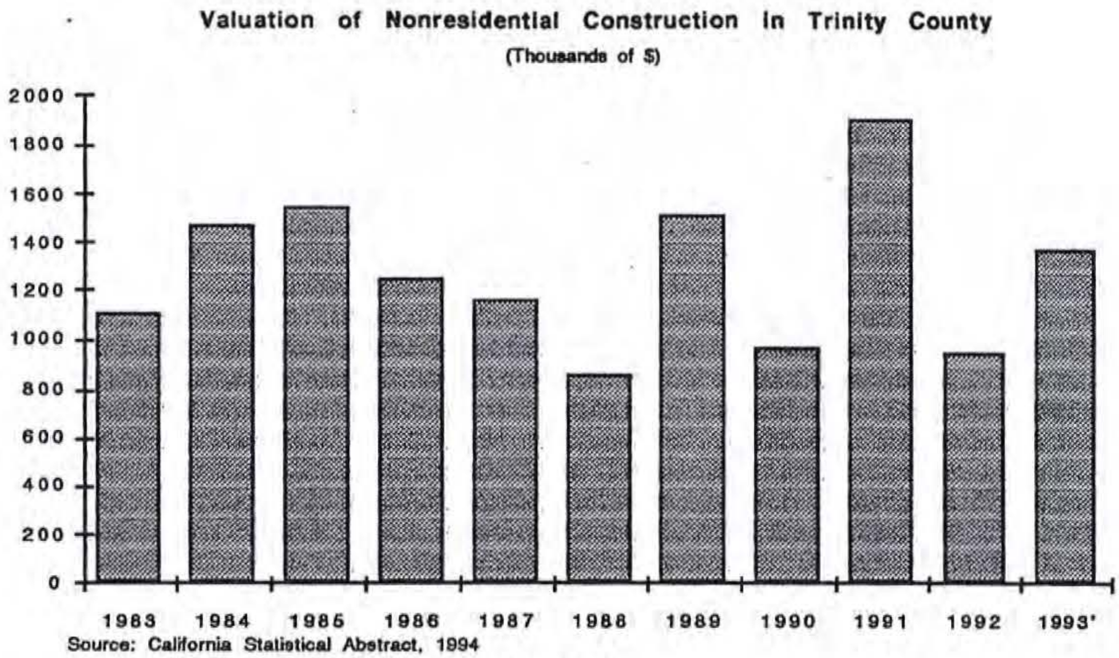

Chart 7

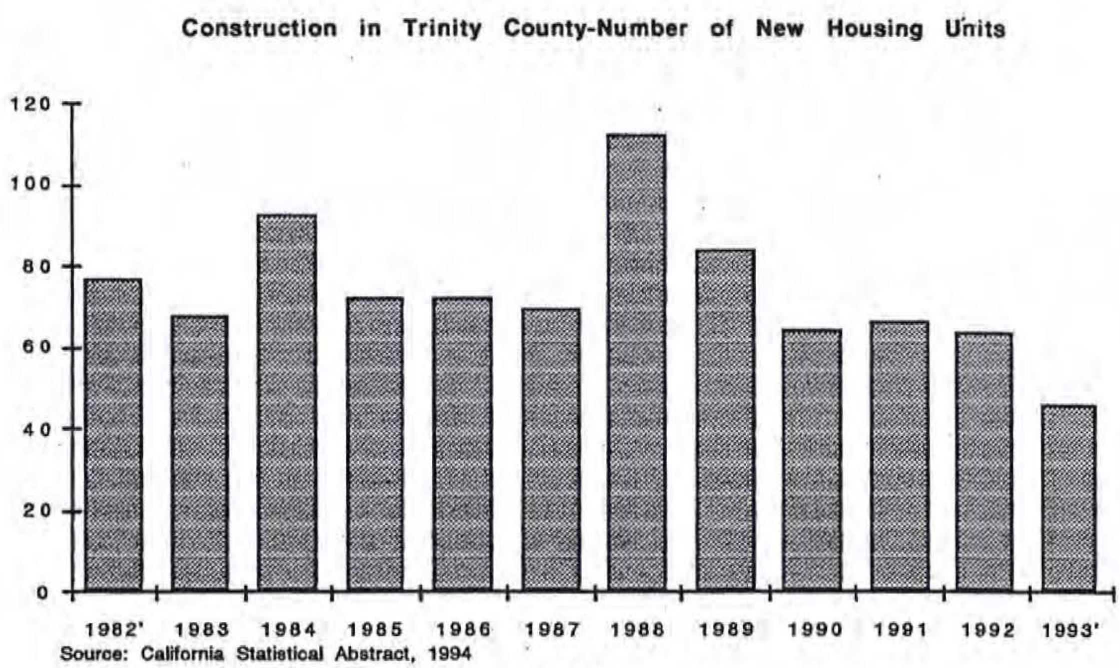

Chart 8

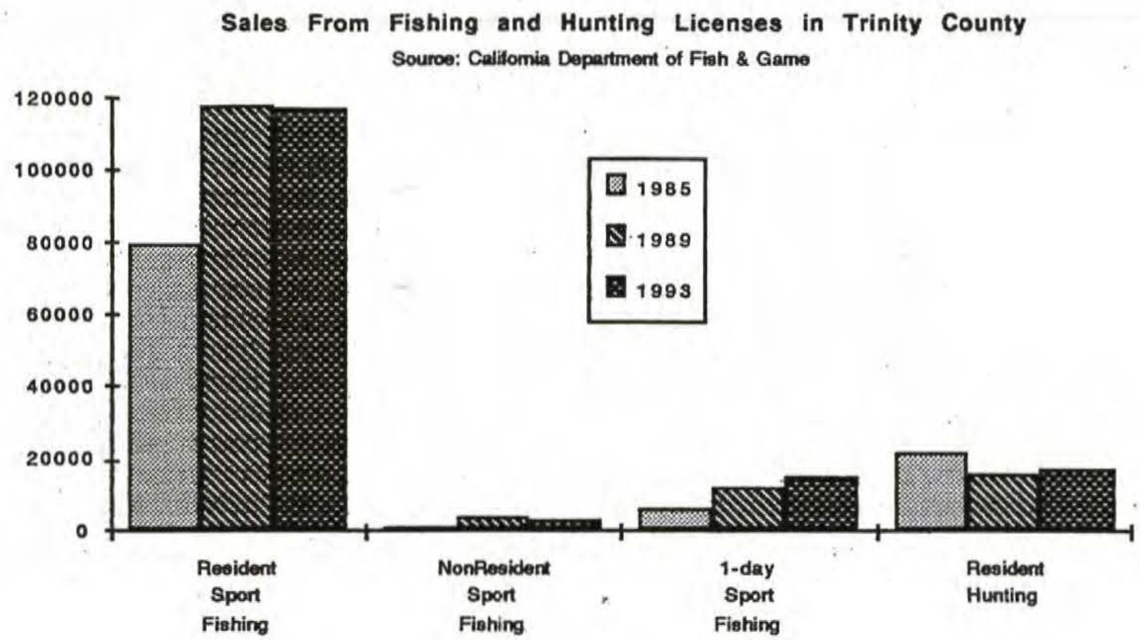

Chart 9

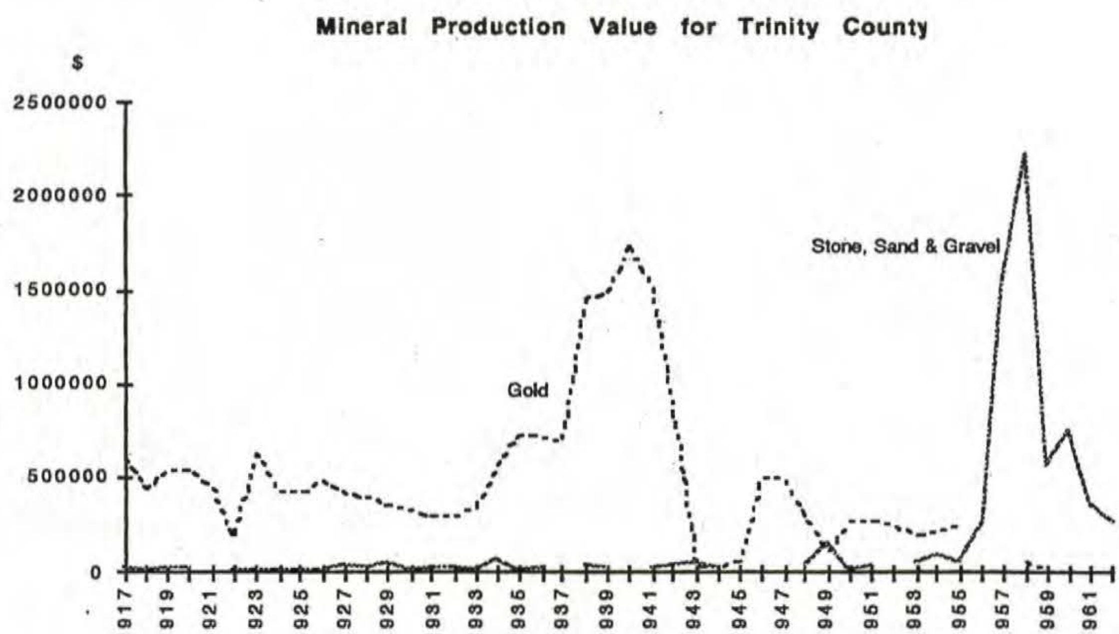

Chart 10

VI-6 VEGETATION - PLANT SPECIES OF CONCERN

The Trinity River Mainstem watershed is part of an area of the Klamath Province noted for its high level of plant species diversity. The relationship between habitat, climate, edaphic diversity and correlated plant species diversity has been well documented (Mason 1946, Stebbins and Major 1965, Kruckleburg 1969).

Plan species of concern in the analysis area fall into four natural ecological groupings based on their preferred habitats and responses to natural and human-caused disturbance. These groupings are: serpentine endemics, rock dwellers, riparian and forest plants.

Serpentine Endemics

The first group is adapted to heavily serpentinized, gravelly ultramafic substrates, often called serpentine barrens. The openness of these barrens is naturally maintained by the infertility of the substrate and a soil chemistry that is inhospitable to most plants. The amount of suitable habitat available for this group of plants is governed by geological and climatic events; how much suitable ultramafic substrate is exposed at the right elevation and aspect. Fire plays a minor role in maintaining these habitats because the plants are often not close enough to each other to carry a fire across such a site. Weathering of the substrate over geologic time will eventually make it unsuitable as habitat for these plants. This group of plants will either adapt at the same time scale to the new habitat or disperse to more recently exposed ultramafic outcrops.

Potential sources of threats include mining, overgrazing, altered soil chemistry from the use of fertilizers and mulching, and the seeding of exotic grasses on serpentine. Threats from logging are minimal since this species does not generally occur in areas suitable for sustainable timber management. Salvage and/or hazard tree removal in serpentine habitats is likely to benefit this species by releasing it from competing vegetation.

There are several "watch" list plants that are serpentine endemics. This group includes Dubakella Mountain buckwheat (Eriogonum libertini), Beegum onion (Allium hoffmanii), Siskiyou onion (A. siskiyouense), serpentine milkweed (Asclepias solanoana) and Tracy's lomatium (Lomatium tracyi). These plants are on a "watch" list due to limited distribution, even though their vulnerability or susceptibility to threat appear low at this time. The plants are uncommon enough that their status and occurrences should be monitored regularly. There are eight populations of Mountain buckwheat found in the Chanchelulla area. It grows on serpentine outcrops, mostly associated with Jeffrey pine at 2,400 to 5,500 feet. Its range is the Northern Coast Ranges in Trinity and Tehama counties and is endemic to the Shasta-Trinity National Forest.

Rock Dwellers

Pale yellow stonecrop (Sedum laxum ssp. flavidum), Canyon Creek stonecrop (S. paradisum), Heckner's lewisia (Lewisia cotyledon var. heckner) and Tracy's beardtongue (Penstemon tracyi) are all obligate rock dwellers found in the watershed. Pale yellow stonecrop can grow on ultramafic, volcanic, metasedimentary and metavolcanic outcrops (and probably other rock types as well). So far Tracy's beardtongue has been found on granitic and metamorphic outcrops, Canyon Creek stonecrop grows mostly on granitic outcrops, while Heckner's lewisia is found on moist, rocky cliffs in montane coniferous forests.

There are two populations of the Forest Service-listed sensitive plant, pale yellow stonecrop, that have been located in the Chanchelulla area on the Yolla Bolla Ranger Dstrict. The plant's range is in the high North Coast and Klamath Ranges. Habitat consists of exposed rock outcroppings of 2,500-6,000 feet. There are a total of 45 populations known to exist, 19 on the Hayfork Ranger District, 25 on the Yolla Bolla Ranger District and one straddling the boundary between the two districts. One population of Canyon Creek stonecrop is found four miles north of the trailhead to Canyon Creek Lakes. Canyon Creek stonecrop grows in narrow crevices of exposed granite that is associated with canyon live oak, Douglas fir and incense cedar. Heckner's lewisia is recorded at Elk Gulch, approximately .25 mile north of Stuarts Fork Road off Highway 3. Heckner's lewisia is found with mixed conifer to subalpine forest on moist rock outcrops of intermittent and perennial streams. Two populations of Tracy's beardtongue are found in the East Weaver Lake area.

Distribution of suitable habitat for rock dwellers is determined by geology and climate. Weathering of their rock habitat will eventually eliminate some suitable habitat, but presumably other rock outcrops will simultaneously be exposed. Landslides probably aid in dispersal of these species. Fire is relatively unimportant in maintaining suitable habitat, except where fire exposes previously shaded rock outcrops that then become better habitat for the sedums. Detrimental effects to rock dwellers occur for rock quarrying, road building and collecting.

Forest

Forest dwelling plant assemblages in the watershed tend to be widespread; fewer rare plant species are found in the forest, since the forest habitat is dominant and does not present a rare or unique set of conditions. Exceptions are those plants which are fire- or disturbance-dependent, require openings or are otherwise poor competitors, or those which are dependent on old growth forests. Fire-dependent species would have prospered from the periodic burning which Native Americans practiced. It is not presently known, however, which of the plants of concern occurring in the watershed are obligate fire followers (seeds require fire for germination). Many annuals and pioneer native plants find suitable habitat along roadsides and plantations, exploiting those niches in lieu of the prehistoric fire-created habitats of their evolutionary past.

Mountain lady's slipper orchid (Cypripedium montanum) and clustered lady's slipper orchid (C. fasciculatum) have been identified in the ROD as old growth associates declining throughout their range in North America (USDA FS, USDI BLM 1994b). They are dependent upon late seral, stable environments for viability and may be threatened by timber harvest activities. It is also thought that these plants are threatened by fire suppression, since they are likely to benefit from the kind of low intensity fires which kept the understory clear in prehistoric times.

Riparian

English Peak greenbriar (Smilax jamesii), a sensitive species, has been found in the East Weaver Creek area. This riparian obligate is found in alder thickets at lakesides and streamsides and on bracken fern slopes in the Klamath Mountain region. English Peak greenbriar is found on variable substrates from 3,300 to 7,500 feet.

A sensitive plant survey has not been conducted for the Trinity River mainstem watershed. Information for this document is taken from known population reports within the Shasta-Trinity National Forest and Rarefind database.

Exotic species of concern found in the corridor include Dalmation toadflax (Linaria genistifolia), tree of heaven (Ailanthus altissima), yellow star thistle (Centaurea solstitialis), bull thistle (Cirsium vulgare), and cheat grass (Bromus tectorum). These pioneer species are adapted to exploiting newly disturbed habitats quickly and competitively. They are often introduced on heavy equipment and other vehicles along transportation corridors, fuel breaks and clearcuts. Roadways are a primary vector for the spread of yellow star thistle. In some instances they may pose a threat to native plant communities and reduce biological diversity. Areas having high levels of disturbance often have abundant populations of these exotic pest species, outcompeting native species. This results in lowered levels of species richness. The yellow star thistle also has allelopathic effects on native vegetation. Cheat grass has successfully colonized serpentine rock outcrops and may present a threat to maintenance of those unique habitats in the future. Dalmation toadflax, a federally listed noxious weed, has naturalized along the Trinity River in disturbed places, especially in floodplains. Tree of heaven is a prolific root sprouter and seeds germinate readily in open environments. Tree of heaven does not compete successfully in forested habitats because root sprouts grow too slowly in the understory, but it may be abundant in ruderal environments of urban areas and roadsides, and is often present in riparian habitats (Hunter 1995). Tree of heaven has successfully naturalized in floodplains and disturbed sites in the analysis area.

RIPARIAN VEGETATION

Current Conditions

The riparian community of the mainstem Trinity River is an almost continuous corridor of hardwood trees, shrubs and, to a lesser degree, scattered forbs, grasses and grass-like plants. This corridor is characterized by a narrow (usually less than 30 meters wide) strip of vegetation on both sides of the river (Evans 1980). Also present are bare rock, gravel and sand bars.

The riparian vegetation overstory consists of white alder (Alnus rhombifolia), yellow willow (Salix lasiandra), black cottonwood (Populus balsamifera spp. trichocarpa), Oregon ash (Fraxinus latifolia) and rarely, Fremont cottonwood (Populus fremontii). The introduced tree of heaven and black locust (Robinia pseudoacacia) are also present in disturbed areas and floodplains. The sub-canopy tree and shrub species may include sandbar willow (Salix sessifolia), dusky willow (S. melanopsis), arroyo willow (S. lasiolepis), narrow-leaved willow (S. exiqua), gray willow (S. bebianna), salmonberry (Rubus spectabilis), Himalayan blackberry (R. discolor), California grape (Vitis californica) and poison oak (Toxicondendron diversiloba). The understory plants may consist of broad-leaved cattail (Typha latifolia), common tule (Scirpus acutus), rushes (Juncus spp.), sedges (Carex spp.), common horsetail (Equisetum aryense), mugwort (Artemisia douglasiana), western goldenrod (Euthamia occidentalis), pale smartweed (Polygonum lapthifolium), curly dock (Rumex crispus), woolly mullien (Verbascum thapsus), sweet clover (Melilotus alba), prickly sow thistle (Sonchus asper), annual smartweed (Polygonum hydropiper), cudweed (Gnaphalium luteo-alba), Mexican tea (Chenopodium ambrosiodes), hedgehog dogtail (Cynosaurus echinatus), toadflax and other various forbs and grasses.

The area closest to the dam exhibits the greatest amount of late seral vegetation because flows are heavily controlled and least influenced by tributary flow variations. This was the first area to be colonized by riparian vegetation after the dam was constructed in 1963. The lower portions of the river corridor were influenced by tributary flows and they experience flow variations which delayed colonization for a short time. Periodic flooding results in the presence of earlier seral stages in this section of the river.

Levee building is most prevalent in the area closest to the dam. The levees (or berms), a result of deposition of sediments at the base of the streamside vegetation, occurs when banks overflow. Levee building is less common downstream where flow variation from tributaries influences the fluvial processes. Where the berms do occur, they may increase in height by each subsequent overflow. The nutrient-rich deposits enhance the growth of riparian vegetation. The root structures anchor the vegetation, allowing it to withstand substantial water velocities. The vegetated banks are then more resistant to erosion from peak discharges. As a result, erosive power has been directed toward the channel bottom, increasing scour. When discharge returns to normal, the river adjusts to its deeper channel by a corresponding reduction in width. The increased scour may expose larger-sized gravel unless sedimentation occur. As the root systems become extensive, they grow into the channel, probing through interstices in the channel gravels. The roots alter the intergravel environment, especially along the river margins, by inhibiting intragravel flow and restricting the movement of gravels and inducing the deposition of fine sediments (Evans 1980).

Mid-channel islands are found in heavily silted areas. The islands are inhabited with riparian vegetation that may help hold them in place when they normally would be a temporary phenomenon due to discharge fluctuations.

Deltas are present at the confluence of the tributaries and are also colonized by riparian vegetation. As with other depositional features, point-bar accumulations expand toward the thalweg in the absence of sufficient flows (Evans 1980).

Relict tailing mounds and dredger ponds are still evident in scattered patches. These tailings can be quite extensive and are most common in the lower one-third of the analysis area, and are evident along Sky Ranch Road (Junction City).

Riparian vegetation along the Trinity River provides habitat for numerous species of wildlife. Surveys conducted in 1990 found 127 bird species. Of this number, 28 were found only in riparian habitats. The willow flycatcher, a special status species, utilizes the willow-dominant or willow-alder mix habitats (Wilson 1991). It is presumed that the increase in riparian vegetation (especially willow) associated with the closing of the dam has led to an increase to date in willow flycatchers and other birds that use these habitats, although there has not been any research or monitoring to support this inference. The yellow warbler and yellow-breasted chat (CA-state designated "species of special concern") are found i both early and late successional riparian communities along the Trinity River (Wilson 1991). This increased abundance of riparian vegetation may also provide additional habitat for beaver, river otter, mink, raccoon, common merganser and adult western pond turtles.

The alder and willow species present are broad-leaved, deciduous trees and shrubs that provide dissolved nutrients to the river through leaf-fall and woody debris to aquatic habitats. The river's food chain is dependent on the dissolved nutrient base and detritus supplied from the surrounding riparian vegetation, particularly the associated deciduous hardwoods. As a nitrogen-fixing species, alder leaves contain four times the amount of nitrogen as non-nitrogen-fixing plants (Hynes 1970). This contributes to increased invertebrate productivity. Riparian vegetation also support terrestrial insects that become available food source through "drop" to fish populations (Evans 1980).

Surveys for plant species of special concern have not been conducted in the analysis area. Species that are likely to occur along the river are Heckner's lewisia, Siskiyou fireweed (Epilobium siskiyouense), Canyon Creek stonecrop, pale yellow stonecrop on rock outcrops, and English Peak greenbriar in the riparian vegetated communities.

Reference Conditions of Riparian Vegetation

Native Americans, the Chimariko and the Wintu, historically inhabited the watershed and presumably utilized the riparian systems to a great degree. Riparian areas are important wildlife habitats, providing food and water sources, shelter, cover and nesting sites and making them probable locations for activities such as hunting deer, small game and birds. Other direct sources of resource came from the riparian plants themselves. Salmonberry, cattails and wild grape were used for food, and willows were used for basketry. Tules, wild grape vines, cattail and willow were used for construction, and common horsetail was used for scrubbing and polishing purposes. Cottonwood and willows were used for drums and flutes. Alder was used to make arrows, a red dye and medicines. Willows were also used for arrows, medicine and tea. It is not known what effect the Native Americans had on the riparian ecosystem, but it was probably minimal or enhanced, as these resources were extremely important in daily living and survival.

The gold miners probably had minimal impacts to riparian vegetation because the types of mining used occurred instream and on gravel bars. When the Chinese came they brought with them the Tree of heaven, which is an invasive, weedy tree that grows easily from seeds or root sprouts in disturbed areas (Hunter 1995) and has established in floodplains and other places on the Trinity River.

Riparian vegetation was probably greatly affected by hydraulic mining by either being washed away or by being inundated by the loosened materials. All the activities associated with hydraulic and instream mining had significant impacts on the riparian vegetation. Possible effects to this vegetation included removal to establish flumes and building access roads, inhibiting the establishment of new growth from seeds by lowering the water table from water diversions and dams.

When logging activity increased earlier this century, only instream logging would have significantly affected riparian communities. Most logging was presumably done in the upland areas where trees were abundant. When hydraulic mining stopped in the 1940's, logging became the chief industry for Trinity County. Timber harvest activities now shifted to the tributaries and steep hillslopes, causing sedimentation to enter the mainstem.

Photographs of the Trinity River before mining activities started could not be located, but an early photograph shows the river as having minimal riparian vegetation and having wide, open banks (12.16.58 photo of Katt property and others). The annual spring floods scoured the river, keeping riparian vegetation at an early seral stage and recruiting large woody debris into the river. Low summer base flows where water recedes may have been a critical factor in riparian seedling survival (Pelzman 1973). As the water recedes, the seedlings become desiccated and die. In addition to seasonal flows, the river is also subjected to wet or drought conditions, which amplified the high flow scouring events in spring and winter, and the low flow desiccation events in late summer and early fall. Prior to the dam, streamside vegetation was much sparser and there was a greater variation in seral stages, with the majority being in early seral states (i.e. sedges and rushes).

Once the Trinity and Lewiston dams were completed in the early 1960's, the regulated, reduced flows caused major changes in the riparian communities downstream from the dams. The reduction in flow volumes and regulation of flows throughout the year caused favorable conditions for streamside vegetation establishment and development of late seral stage plant communities. As stated earlier, the area closest to the dam was the first area encroached upon by riparian vegetation. The flows in this section are more stabilized without the fluctuating flows entering from the tributaries.

Willows release their seed in the spring and germination extends through the summer. The stabilized flows create an ideal seedbed situation for germination and seedling survival when provided with moist soil (Pelzman 1973). A significant increase in vegetation occurred between 1963 and 1977. From the dam to the confluence with the North Fork, vegetated areas increased from 186.6 acres to 853.4 acres, a net increase of 357.5 percent. The rate of expansion of the riparian vegetation on the non-vegetated substrates has abated, but succession continues (Evans 1990) with communities becoming shrub- and tree-dominated.

Analysis of Trends in Riparian Vegetated Communities

A GIS was used to map the riparian vegetation using pre-dam (1960) and post-dam (1989) aerial photography (Wilson 1993). To compare the different vegetation types between pre-dam and post-dam acreages, the vegetation was typed as:

1. willow dominant (representing a young seral) community
2. willow/alder mix (representing a mid seral) community
3. alder dominant (representing a late seral) community
4. gravel open bar (open, unvegetated, rocky areas adjacent to the river)
5. water (the Trinity River with a few side channels and ponds)

For the willow or alder dominant vegetation, more than two-thirds of the canopy consisted of willow or alder species. In the 1960, pre-dam aerial photography interpretation, three additional categories were added. They are:

6. gravel bar above annual floodplain (added because there is a clear difference from the annually scoured gravel bars above)
7. mine tailings
8. bedrock (these are not used for comparison purposes in this analysis)

From 1960 to 1989, willow communities increased from 239 acres (22 percent) to 326 acres (36 percent). The willow/alder mix increased from 67 acres (six percent) to 382 acres (41 percent). Alder increased from seven acres (one percent) to 173 acres (19 percent). Total vegetation increased from 313 acres (29 percent) to 881 acres (96 percent). Gravel bars decreased from 1960 to 1989 from 752 acres (71 percent) to 41 acres (four percent). Water acres decreased from 601 to 393 acres.

UPLAND VEGETATION

A standardized, hierarchical classification system for potential natural communities is used by federal agency ecologists as well as academicians and non-governmental organizations (USDA Forest Service, 1993) . Series level analysis is useful for broad, general regional and provincial questions. The series found in the Trinity River watershed are described here to facilitate the understanding of the current conditions and environmental regimes that the series indicate.

The vegetation of the Trinity River watershed can be divided into four major categories. These are conifer forest, hardwood forest, montane chaparral and grasslands. The conifer forests include the Douglas-fir (Pseudotsuqa menziesii), white fir (Abies concolor), red fir (Abies magnifica var. shastensis), Jeffrey pine (Pinus Jeffreyi), mixed conifer and gray pine (Pinus sabiniana) series. The hardwood forest category includes the black oak (Quercus kelloqqii), Oregon white oak (Quercus garryana) and alder mixed riparian hardwood series. Montane chaparral may include manzanita (Arctostaphylos spp.), huckleberry oak (Quercus vaccinifolia), ceanothus (Ceanothus spp.) and hush chinquapin (Castanopsis sempervirons) types. Grasslands include both wet and dry meadows. Wet meadows are often found at higher elevations and are dominated by native perennial species. Dry meadows are often comprised of non-native annuals. These series are not well sampled, therefore are not described.

Vegetation and Environmental Relationships

The vegetation patterns and plant community composition and structure of the Trinity River flora are controlled by four environmental gradients. They are elevation, precipitation, soil texture as it determines water holding capacity of the soil and the chemical composition of the soil-forming parent rock. Moisture conditions vary by plant association according to soil depth, parent material, slope shape and slope position.

The red fir series is found on the highest elevation sites with the coldest mean winter temperatures. The white fir series occurs between the red fir and Douglas-fir series and replaces Douglas-fir as elevations rise and move into the cooler, frigid soil temperature regimes (Jimerson, 1989).

At higher elevations where temperatures are cooler and soil moisture is abundant, a few white fir plant associations are found. Jeffrey pine is the climax species in frost pockets and on highly serpentinized soils. As soil temperatures and winter air temperatures decrease, the Douglas-fir series dominates. The mixed conifer series occurs on warmer, drier sites characterized by high plant moisture stress, soil drought and light snowpacks. Gray pine and canyon live oak (Quercus chrysolepis) series associations are found on harsh, dry, low elevation sites having skeletal soils and interspersed with rock outcrops.

The dry grassland types are found on hot, mid-elevation slopes. They occur on the warmest sites with the lowest available moisture regimes. These grasslands are most common on hot, southwest facing slopes with shallow soils and high percentage of soil coarse fragments.

The white oak and black oak series are usually found in close proximity to and at the edge of the grassland series, thus forming a mosaic. They are usually found on sites with deeper soils and higher water holding capacity than the grass communities. This is particularly true of black oak.

Disturbance

Stand replacing fire is the primary disturbance agent within the watershed. Fire frequency is related to slope position, vegetation series and aspect. Many Jeffrey pine stands are a result of a low stand replacing fire interval. Here, ladder fuels are low due to the openness of the stands and low productivity. This creates low intensity fires and low fuel accumulations, which contribute to infrequent stand replacing events.

This relationship between age, slope and vegetation series indicates that stand replacing fires occur with higher frequency in upslope positions and are related to vegetation series. Fire size and intensity is low in the red fir and white fir series.

Series Descriptions

The primary vegetation series found in the Trinity River Watershed are derived from the Klamath Province section description (M261A) and EUI mapping of the Trinity National Forest and are described below:

Red fir is of limited extent within the watershed. It is found at the highest elevations on moderately steep slopes, in the upper one-third slope and ridgetop positions, with linear and convex micro-relief, between 4500 and 5500 feet elevation. Here soil temperatures reach their lowest point, with most stands occurring within the frigid soil temperature regime. Soils are primarily derived from igneous intrusive and metamorphic parent material. They can be moderately deep, deep or shallow, with a loamy-skeletal or fine loamy textures and occur in the Inceptisol, Entisol and Alfisol orders.

Red fir forests are generally quite dense (greater than 80 percent canopy closure) except at timberline where they occur as open stands interspersed with lupine-needlegrass dry meadows. Due to the dense overstory and thick duff layer which retards seed germination, understory cover and species diversity are usually low.

Red fir dominates the overstory and may be the only tree species present. At higher elevations western white pine (Pinus monticola) and lodgepole pine (P. contorta ssp. murrayana) may be present in small numbers. Pinemat manzanita (Arctostaphylos nevadensis), huckleberry oak and Ross sedge (Carex rossii) are the primary species found in the depauperate understory. At the lower elevations of the red fir series, white fir may be scarce to common in the canopy. Snowberry (Symohoricarpos mollis), white-veined wintergreen (Pyrola picta) and spotted coralroot (Corallorhiza maculata) are the most common understory species.

White fir is found on moderately steep slopes in the middle and upper one-third slope positions, with linear, undulating and convex micro-relief, between 3500 and 5100 feet elevation. Soils are derived from igneous intrusive, metamorphic and sedimentary parent material. They can be deep, moderately deep or shallow, with loamy-skeletal and fine loamy textures in the Inceptisol and Alfisol orders found in the frigid and mesic soil temperature regimes.

The white fir series differs from the Douglas-fir series in its shift in dominance from Douglas-fir to white fir and the reduction in hardwood cover. The overstory includes the conifer species white fir, Douglas-fir, incense cedar (Calocedrus decurrens), sugar pine (Pinus lambertiana) and red fir, along with the hardwood species giant chinquapin (Castanopsis chrysophylla) and Pacific dogwood (Cornus nuttallii), with snowberry and huckleberry oak often as dominants in the shrub layer. The herb layer is often well developed and diverse and has as its dominant species white-veined wintergreen, prince's pine) Chimaphila umbellata var. occidentalis), Hooker's fairybells (Disporum hookeri), hawkweed (Hieracium albiflorum), bedstraw (Galium spp.), starflower (Trientalis latifolia), iris (Iris spp.), trail-plant (Adenocaulum bicolor) rattlesnake plantain (Goodyera oblonqifolia), little prince's pine (Chimaphila menziesii), stream yellow violet (Viola glabella), California harebell (Campanula prenanthoides), swordfern (Polystichum munitum), twinflower (Linnaea borealis ssp. lonqiflora) and false Soloman's seal (Smilacina racemosa). The grass layer has as its dominant species western fescue (Festuca occidentalis) mountain brome (Bromus carinatus), oniongrass (Melica spp.), blue wild rye (Elymus glaucus), and bearded fescue (Festuca subulata).

The white fir series can be broken down into subseries according to moisture regimes. The moist white fir subseries is associated with stream courses. Pacific yew (Taxus brevifolia) and Pacific dogwood are dominant in the overstory. California hazelnut (Corylus cornuta var. californica) and dwarf Oregon grape (Berberis nervosa) are the common understory indicators of this subseries. They are most commonly found on densely forested riparian areas or moist lower slopes. The common species found in the herbaceous layer include Hooker's fairybells, rattlesnake plantain, bedstraw, stream yellow violet, wintergreen and false Solomon's seal. A portion of the moister white fir plant associations have huckleberry oak as a common indicator. These occur on north and west facing draws and ridges where cool temperatures and shallow slopes are common.

The mesic white fir plant associations are found between 3000 and 4000 feet elevation. Giant chinquapin is a common hardwood associate on mesic north and east facing slopes. Snowberry and prince's pine are the primary indicators for these associations. The herb layer in the mesic subseries may be quite diverse, species such as wintergreen, prince's pine, iris, starflower, trail plant, little prince's pine and hawkweed are common.
The Douglas-fir series occurs on moderately steep, middle and upper one-third slopes, with linear, undulating and convex micro-relief, between 2100 and 4400 feet elevation. Soils are derived from metamorphic, igneous intrusive and sedimentary parent material. They are primarily deep and moderately deep with loamy-skeletal and fine loamy textures, in the Inceptisol Alfisol and Entisol orders and are found in the mesic soil temperature regime.

The Douglas-fir series displays significant differences in stand age by slope position. Douglas-fir stands found in the middle and lower one-third slope positions have a higher stand age, compared to ridgetop positions.

The Douglas-fir series tree layer is composed of the conifer species Douglas-fir, white fir, sugar pine and incense cedar and the hardwood species giant chinquapin, Pacific madrone (Arbutus menziesii), canyon live oak, tanoak (Lithocarpus desiflorus) and black oak. The shrub layer contains wild rose (Rosa gymnocarpa), dwarf Oregon grape, California hazel, snowberry, trailing blackberry (Rubus ursinus), sadler oak (Quercus sadleriana), Oregon boxwood (Pachystima mysrsinites), huckleberry oak, poison oak (Rhus diversiloba) and oceanspray (Holodiscus discolor. The prominence of the herb and grass layers increase in this type due to the more open canopy conditions and lack of a hardwood mid-layer. The herb layer contains princes pine, wintergreen, Hooker's fairybells, rattlesnake plantain, hawkweed, trail plant, swordfern, iris, starflower, little prince's pine, bracken fern (Pteridium aguinum var. pubescens) and twinflower. The grass layer contains western fescue and oniongrass as the dominant species.

The moist Douglas-fir plant associations includes big-leaf maple (Acer macrophyllum) in the overstory. Common understory species include California hazel, dwarf Oregon grape, snowberry and poison oak. Common herbaceous species include swordfern, Hooker's fairybells and false Solomon's seal.

The mesic Douglas-fir plant associations are dominated by the presence of Canyon live oak and other hardwoods, which can be quite dense. The shrub layer contains wild rose and snowberry. The herb layer is comprised of prince's pine, wintergreen, hawkweed, rattlesnake plantain, iris, trail plant, little prince's pine, starflower, twinflower and bedstraw. The grass layer may be diverse, with western fescue, mountain brome, California fescue (Festuca californica) and onion grass as the most common species.

The dry Douglas-fir sub-series is dominated by an overstory predominately of Douglas-fir with white oak. The shrub layer is sparse but may include poison oak and wild rose. The herb layer may include mountain sweetroot (Osmorhiza chilensis), yarrow (Achillea millefolium), bedstraw and iris. The grass layer is prominent, with California fescue being the dominant species along with smaller amounts of Lemmon's needlegrass (Achnatherum lemmonii) and bromes.

Mixed conifer forests generally occupy drier and warmer sites than Douglas-fir forests and are far more complex and variable than other series. Mixed conifer forests are comprised of various amounts of ponderosa pine (Pious ponderosa) Douglas-fir, white fir, sugar pine and incense cedar in the overstory tree layer. In addition to these conifers, the middle and regeneration layers can contain Pacific madrone, giant chinquapin, Pacific dogwood, canyon live oak, bigleaf maple and black oak. The shrub layer may contain a variety of species
including dwarf Oregon grape, poison oak, huckleberry oak, trailing blackberry, wild rose, California hazel, honeysuckle (Lonicera hispidula), snowberry, wedgeleaf ceanothus (Ceanothus cuneatus) and serviceberry (Amelanchier utahensis). The herb layer contains swordfern, bracken fern, rattlesnake plantain, little prince's pine, prince's pine, Hooker's fairybells, starflower, wintergreen, inside-out flower (Vancouveria hexandra), beargrass (Xerophyllum tenax), iris and a wide variety of other herbs and grasses. The mixed conifer series can be further divided into three broad subgroups based on climatic conditions. These are mixed conifer/riparian and mesic, mixed conifer/dry and mixed conifer/canyon live oak.

The mixed conifer/riparian and mesic subseries is found on all aspects but are most common on east and north slopes. The overstory is usually comprised of various combinations of ponderosa pine, white fir, giant chinquapin, Douglas-fir, pacific dogwood, big-leaf maple, incense cedar and smaller amounts of sugar pine. The common understory species include California hazel, dwarf Oregon grape, snowberry, iris and prince's pine.

The mixed conifer/dry subseries is intermediate in productivity, occurring primarily on west and south slopes. This group is mostly characterized by an overstory comprised of ponderosa pine, white fir, Douglas-fir and sugar pine. The understory is usually shrub poor, except where huckleberry oak or wedgeleaf ceanothus occur in abundance. Common herb species include California fescue, iris and hawkweed.

The mixed conifer/canyon live oak subseries occur in canyons and other steep sites with rocky soils. It is commonly on south or west slopes. This subgroup is characterized by an abundance of canyon live oak in the overstory and understory, with Douglas-fir, ponderosa pine, incense cedar, madrone and to a lesser extent, white fir. The understory is often depauperate or may contain swordfern with various other herbs.

Jeffrey pine is of limited extent but is ecologically important due to the diversity of species. Many sensitive, endemic and rare plants are found in the open forests. Jeffrey pine is found mainly on serpentine soils between 1000 and 5100 ft. elevation, in the ridgetop and upper one-third slope positions, with linear and convex micro-relief. Soils are derived from metamorphic and igneous intrusive parent materials. The igneous intrusive category is dominated by ultramafic rocks, while the metamorphic category is represented primarily by serpentine rocks. Soils are loamy-skeletal, fine loamy and loam in texture in the Inceptisol and Alfisol orders and in the mesic and frigid soil temperature regimes.

Jeffrey pine can be the dominant tree species where serpentine rock formations reach the surface. It is found in association with Douglas-fir, incense cedar, sugar pine, gray pine, white fir and knobcone pine (Pious attenuata) . The dominant shrub species on these harsh sites include huckleberry oak, pinemat manzanita, prostrate ceanothus (Ceanothus prostratus), wedgeleaf ceanothus, California coffeeberry (Rhamnus californica), greenleaf manzanita (Arctostaphylos patula), creeping barberry (Berberis repens), and serviceberry. The dominant herbs include iris, yarrow, indian paintbrush (Castilleja spp.) hawkweed and California lace fern (Aspidotis californica) . The grass layer is dominated by California fescue (Festuca californica), Idaho fescue (F. idahoensis), various sedge species (Carex spp.) and western fescue.

Gray pine forests are fairly rare, but ecologically important. They represent some of the least productive and most sensitive sites. This series is found in low montane areas on a variety of geologic types ranging from ultra basic to granitic rocks, including limestone. They occur mainly as small patches on dry, south-facing slopes with skeletal rocky soils where bedrock outcrops are common.

The overstory consists mainly of gray pine with canyon live oak, ponderosa pine or Jeffrey pine. Common understory plants include wedgeleaf ceanothus, greenleaf manzanita, birchleaf mountain mahogany (Cercocarpus betuloides) buckeye (Aesculus californica), poison oak, Idaho fescue and bromes. On serpentine sites leather oak (Quercus durata) or hoary coffeeberry (Rhamnus tomentella ssp. crassifoila) may be found and on limestone sites mockorange (Philadelphus lewisii) may be present.

White oak is of limited extent in the watershed. The white oak series is often found in inner gorge positions, old alluvial terraces or gentle volcanic slopes on shallow or moderately deep soils restricted by clay subsoils at elevations from 2000 to 4000 feet.

Along river systems, stands of white oak are located in close proximity to areas previously inhabited by native Americans. Here they were tended by native American families for acorn production. In areas where this tending has ceased, natural succession in the form of Douglas-fir invasion has begun to reclaim the sites.

The white oak series is commonly associated with open oak-grass savannahs. Common overstory trees are white oak, black oak, gray pine, ponderosa pine, madrone and canyon live oak. Common understory species may include wedgeleaf ceanothus, greenleaf manzanita, birchleaf mountain mahogany, hoary manzanita (Arctostaphylos canescens), whiteleaf manzanita (A. visida), brewer oak (Quercus garryana var.

breweri), Idaho fescue, blue wild rye, squirreltail (Elymus elymoides), bromes and numerous annual forbs and grasses.

The black oak series is also limited in extent. It is found on slightly wetter sites than white oak between 3000 and 4000 feet elevation, in the middle and lower one-third slopes, on sites with undulating micro-relief, usually in association with grasslands. Soils have metamorphic parent materials. They are primarily deep and moderately deep, with loamy-skeletal and fine loamy textures in the Inceptisol and Alfisol orders in the mesic soil temperature regime.

The montane chaparral series is normally found in upslope positions with frequent fire return intervals. In some instances, areas identified as montane chaparral are seral stages of forested series. The montane chaparral series is broken down into the subseries greenleaf manzanita chaparral, serpentine chaparral, huckleberry oak chaparral, upper montane mixed chaparral and foothill and lower montane mixed chaparral.

The serpentine chaparral is found on dry sites between 1000 and 5000 feet elevation. It occurs on side slopes that are moderately steep to steep. Soils are serpentinized periodotite that are stony or gravelly with considerable rock outcrop, found in the thermic-mesic temperature regime. Tree cover is generally less than 10 percent and may include Jeffrey pine, gray pine or incense cedar. Common shrub species may be wedgeleaf ceanothus, leather oak, scrub oak (Quercus dumosa), hoary coffeeberry, whiteleaf manzanita, common manzanita (Arctostaphylos manzanita) and birchleaf mountain mahogany. Common herbs include pacific monardella (Monardella oderatissima), scythleaf onion (Allium falcifolium), flame ragwort (Senecio greenei), common madia (Madia elegans) yarrow, Idaho fescue and cheatgrass (Bromus tectorum).

The huckleberry oak chaparral is found in the frigid (mesic in ultramafic areas) temperature regimes between 4000 and 7000 feet elevation on steep to very steep upper slopes. This series is mostly found on moderately deep to shallow, stony, medium textured soils formed on both residual and glacial ultra basic rock. These soils may also have a high magnesium to calcium ratio which contributes to poor productivity. Tree cover is generally less than ten percent and may include Jeffrey pine, incense cedar, knobcone pine or white fir. Huckleberry oak constitutes the major shrub species in the series, usually 50 percent or more. Other species that may occur are greenleaf manzanita, silk tassel (Garrya fremontii), prostrate ceanothus, pinemat manzanita. Common herbs include yarrow, Idaho fescue and California fescue.

The greenleaf manzanita chaparral is found on various lithologies ranging from granitic to ultra basic. This subseries may be found growing as both a climax community on steep slopes and ridges with shallow, rocky soils or as a fire induced seral type on low quality timber sites. It is most common on xeric south and west aspects. Elevations range from to 3000 to 5000 feet. Tree cover is generally less than one percent and may include ponderosa pine, knobcone pine or Douglas-fir. Greenleaf manzanita is the major component (50 percent or greater) of the shrub layer. Other shrubs may include silk tassel, hoary manzanita, prostrate ceanothus, deerbrush (Ceanothus integerrimus), whitethorn (C. cordulatus) and huckleberry oak. Common herbs include dogbane (Apocynum androsaemifolium), bracken fern, species of lupine and lotus, as well as, various other forbs and grasses.

The upper montane mixed chaparral is found on a wide range of lithologies and soils. Climax stands can be found on steep slopes and ridges with shallow rocky soils on hot dry aspects. More frequently however, this series is a fire induced seral type growing on productive soils capable of supporting conifer species. Tree cover is generally less than ten percent and may include white fir, Douglas-fir, sugar pine or knobcone pine. The diverse shrub layer includes greenleaf manzanita, huckleberry oak, tobacco bush (Ceanothus velutinus) whitethorn, deerbrush, bitter cherry (Prunus emarginata), silk tassel, bush chinquapin, pinemat manzanita, prostrate ceanothus, serviceberry and snowberry. Common herbs are dogbane, bracken fern and various other forbs and grasses. The foothill and low montane mixed chaparral are found on shallow, very gravelly medium textured soils formed chiefly of metasedimentary and metavolcanic rock on hot aspects of steep to very steep lower montane slopes and foothill areas. Temperature regimes range from thermic to mesic and elevations range from 1000 to 3000 feet. A small portion of the area in this shrub community may be fire induced seral types which have developed on deeper more productive sites. Tree cover is generally less than ten percent and may include canyon live oak, gray pine, knobcone pine, ponderosa pine, Oregon white oak or black oak. Dominant shrub species include sticky whiteleaf manzanita, Brewer's oak, whitethorn, poison oak, California coffeeberry, wedgeleaf ceanothus, silk tassel, birchleaf mountain mahogany, California buckeye, common manzanita, shrub interior live oak (Quercus wislizeni var. frutescens), hoary manzanita, greenleaf manzanita, redbud (Cercis occidentalis), deerbrush, skunkbush (Rhus trilobata) and snowdrop bush (Styrax officinallis var. redivivus) . Herbs may include creeping sage (Salvia sonomensis) and various other annual and perennial forbs and grasses. The species composition varies with climate and soil conditions, for instance, shrub interior live oak and common manzanita may dominate the thermic sites, Brewer's oak and greenleaf manzanita may be the dominant species on mesic sites and on xeric sites wedgeleaf manzanita, birchleaf mountain mahogany and California buckeye are the prominent components.

VI-7 SOILS

The soil information used for this analysis is the State Soil Geographic Data Base (STATSGO) prepared in 1988 by the USDA-Natural Resource Conservation Service (NRCS). The STATSGO was designed to be used primarily for regional, multistate, river basin, State, and multicounty resource planning, management and monitoring. The soil polygon data is presented at a scale of 1:250,000. More detailed soils data prepared by the Natural Resource Conservation Service is available in draft, unpublished form for portions of the analysis area. The US Forest Service has published a "Soil Resource Inventory" for the Shasta-Trinity Forest Area which covers portions of the analysis area, however neither source of information is available in GIS at the time this analysis was prepared.

The STATSGO data was compiled by generalizing more detailed soil survey information originally mapped at a scale of 1:24,000. Map unit composition for STATSGO was determined by transecting or sampling areas on the more detailed maps and expanding the data statistically to characterize the whole map unit. Although the STATSGO soil polygons are large in size, the soil attribute information related to the polygons is quite detailed. Each soil map unit may contain information for up to 21 different soil types. Information for each soil type is developed from and presented in the same detail as soil property information in standard NRCS Soil Surveys.

Soils information is presented in several tables, each soil map unit is composed of several distinct soil types. Detailed information about each soil type is available and organized into tables which contain information about the entire soil pedon or the individual soil layers. By selecting information in the tables and relating it to the geographic location, predictions of soil response within a specific area is possible.

The relative erodability of each soil is an important upland watershed issue in this analysis area. The results of various inventories and studies throughout the analysis area indicate the majority of significant sediment sources are correlated with soils formed on granitic rock and landslides. Since the soil map unit polygon boundaries in STATSGO correspond with geologic formation boundaries, the relationship between geologic parent material and inherent soil properties is preserved at this relatively small map scale.

Soil characteristics that are important to erosion and sediment production are available in the STATSGO data. Soil texture, depth, rock fragment content, K factor (detachability), slopes and erosion hazard rating are included in the data. Other soil properties important to vegetation, habitat and fuel characteristics are also present in the data set. Soil available water capacity and soil temperature regime, in addition to some of the properties listed above, interact with climate and slope aspect to strongly influence plant community characteristics.

The results of STATSGO data analysis for the analysis area are presented in the following tables. Table VI-Soil-1 lists the erosion hazard potential rating of each STATSGO map unit, a summary of each erosion hazard rating is included.

Table VI-Soil-2 lists soil properties for each soil type which make up the soil map unit. The soil properties listed were used to evaluate erosion potential and identify important soil characteristics. The column heading abbreviations used in Table VI-Soil-2 are defined below:

MUID	Map unit identification number
SEQ	Sequence number
COMPNAME	Soil name
COMPPCT	Percentage of map unit of this soil type
SURFTEX	Texture of the soil surface
RL	Soil depth range-shallowest depth
RH	Soil depth range-deepest depth
HG	Hydrologic soil group

SL	Slope range-low value
SH	Slope range-high value
ER	Erosion hazard rating
CLASS	Classification in soil taxonomy
KFACT	USLE K-factor, measure of particle detachability

Table VI-Soil-1

		TRINITY WA-EROSION HAZARD RATING					
	ANALYSIS OF AREAS BY MAP UNIT AND EROSION HAZARD RATING						
MAP UNIT SYMBOL	EXTENT (acres)	EHR % SEVERE	AREA (acres)	EHR % MODERATE	AREA (acres)	EHR % SLIGHT	AREA (acres)
009	18,626	85	15,832	15	2,794	0	0
011	43,083	3	1,292	72	31,020	25	10,771
012	20,512	45	9,230	32	6,564	23	4,718
017	0	45	0	40	0	15	0
097	21,362	15	3,204	50	10,681	35	7,477
099	11,580	60	6,948	35	4,053	5	579
100	6,922	75	5,192	25	1,731	0	0
101	28,763	60	17,258	30	8,629	10	2,876
103	25,582	33	8,442	55	14,070	12	3,070
104	20,425	54	11,030	45	9,191	1	204
105	13,632	95	12,950	0	0	5	682
106	11,799	98	11,563	0	0	2	236
107	28,740	70	20,118	27	7,760	3	862
108	2,820	50	1,410	47	1,325	3	85
109	8,638	28	2,419	42	3,628	30	2,591
110	2,953	0	0	96	2,835	4	118
111	1,592	0	0	78	1,242	22	350
139	793	65	515	33	262	2	16
149	0	55	0	30	0	15	0
154	929	67	622	30	279	3	28
TOTALS	268,751		128,026		106,062		34,662
EXTENT OF AREA			48%		39%		13%

MUID	SEQ	COMPNAME	COMPPCT	SURFTEX	RL	RH	HG	SL	SH	ER	CLASS	KFACT
CA009	1	LUMBERLY	40	COSL	20	40	B	15	50		TYPIC XERUMBREPTS, COARSE-LOAMY, MIXED, FRIGID	0.24
CA009	2	CHOOP VARIANT	35	GRF-LCOS	10	20	D	50	75		ENTIC XERUMBREPTS, SANDY, MIXED, FRIGID	0.17
CA009	3	GRAGS FAMILY	10	GR-SL	8	20	D	15	25		LITHIC XERUMBREPTS, SANDY-SKELETAL, MIXED, FRIGID	0.15
CA009	4	ROCK OUTCROP	3	UWB	0	0	D	5	50			0.00
CA009	5	BERTAG	1	SIL	60	60	C	10	30		PACHIC ULTIC ARGIXEROLLS, FINE, MONTMORILLONITIC, FRIGID	0.28
CA009	6	BERTAG	1	CB-L	60	60	C	30	50		PACHIC ULTIC ARGIXEROLLS, FINE, MONTMORILLONITIC, FRIGID	0.17
CA009	7	WAPAL	1	SL	60	60	A	0	30	MO	VITRANDIC XEROCHREPTS, SANDY-SKELETAL, MIXED, FRIGID	0.24
CA009	8	WAPAL	1	GR-SL	60	60	A	30	40	SE	VITRANDIC XEROCHREPTS, SANDY-SKELETAL, MIXED, FRIGID	0.15
CA009	9	INVILLE	1	GR-COSL	60	60	B	30	50	SE	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, FRIGID	0.10
CA009	10	INVILLE	1	ST-COSL	60	60	B	5	30	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, FRIGID	0.10
CA009	11	BIGHILL	1	SL	20	40	B	5	30		TYPIC XERUMBREPTS, COARSE-LOAMY, MIXED, MESIC	0.20
CA009	12	BIGHILL	1	SL	20	40	B	30	75		TYPIC XERUMBREPTS, COARSE-LOAMY, MIXED, MESIC	0.20
CA009	13	CORBETT	1	BY-S	24	40	B	8	75	SE	TYPIC XEROPSAMMENTS, MIXED, FRIGID	0.15
CA009	14	CANNELL	1	GR-SL	40	60	B	30	50		DYSTRIC XEROCHREPTS, COARSE-LOAMY, MIXED, FRIGID	0.20
CA009	15	SKYROCK	1	GRX-L	10	20	D	50	75		DYSTRIC LITHIC XEROCHREPTS, LOAMY-SKELETAL,MIXED, FRIGID	0.05
CA009	16	RUBBLE LAND	1	FRAG	40	40	A	15	50			0.00
CA011	1	NEUNS	10	GR-SL	20	40	C	15	50	MO	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA011	2	NEUNS	15	GR-L	20	40	C	15	80	MO	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA011	3	KINDIG	20	GR-L	40	60	B	15	80	MO	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.24
CA011	4	CLALLAM	5	GR-SL	60	60	C	2	15	SL	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA011	5	DEADWOOD	10	GR-SL	10	20	D	9	30	SL	DYSTRIC LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA011	6	DEADWOOD	15	GRV-SL	10	20	D	30	50	MO	DYSTRIC LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA011	7	SPEAKER	3	L	20	40	C	5	30	SL	ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.24
CA011	8	SPEAKER	2	GR-L	20	40	C	30	75	MO	ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.20
CA011	9	HOLLAND	5	SL	40	60	B	30	50		ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.24
CA011	10	MARPA	1	GR-L	20	40	C	30	50	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA011	11	GOLDRIDGE	1	FSL	40	60	B	30	50		TYPIC HAPLUSTULTS, FINE-LOAMY, MIXED, ISOMESIC	0.28
CA011	12	KINKEL	1	GRV-L	60	60	B	30	50	MO	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA011	13	ETSEL	1	GR-L	4	14	D	30	75		LITHIC XERORTHENTS, LOAMY-SKELETAL, MIXED,NONACID, MESIC	0.20
CA011	14	SHEETIRON	1	GRV-L	20	40	B	30	50	MO	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA011	15	HUGO	1	L	40	60	B	9	30		DYSTRIC XEROCHREPTS, FINE-LOAMY, MIXED, MESIC	0.37
CA011	16	HUGO	1	L	40	60	B	30	50		DYSTRIC XEROCHREPTS, FINE-LOAMY, MIXED, MESIC	0.37
CA011	17	GOULDING	1	GR-L	10	20	D	30	75		LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA011	18	FORBES	1	GR-L	60	60	C	2	50	SL	ULTIC PALEXERALFS, FINE, OXIDIC, MESIC	0.20
CA011	19	BOOMER	1	GR-L	40	60	B	30	50	SE	ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.10
CA011	20	ROCK OUTCROP	2	UWB	0	0	D	10	75			0.00
CA011	21	HOLLOWTREE	3	GR-SL	20	40	C	9	50	SL	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA012	1	WOODSEYE	15	GRV-L	10	20	D	2	30	MO	LITHIC XERUMBREPTS, LOAMY-SKELETAL, MIXED, FRIGID	0.20
CA012	2	WOODSEYE	20	GRV-SL	10	20	D	30	75	SE	LITHIC XERUMBREPTS, LOAMY-SKELETAL, MIXED, FRIGID	0.17
CA012	3	SMOKEY	10	GR-L	20	40	B	15	30	MO	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, FRIGID	0.20
CA012	4	SMOKEY	20	GR-SL	20	40	B	30	50	SE	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, FRIGID	0.15
CA012	5	NANNY	20	GR-SL	60	60	B	0	8	SL	TYPIC XERUMBREPTS, LOAMY-SKELETAL, MIXED, FRIGID	0.10
CA012	6	ENDLICH	1	ST-L	20	40	B	4	25	SL	DYSTRIC CRYOCHREPTS, LOAMY-SKELETAL, MIXED	0.10
CA012	7	ENDLICH	1	STV-L	20	40	B	25	65	MO	DYSTRIC CRYOCHREPTS, LOAMY-SKELETAL, MIXED	0.10
CA012	8	MERKEL	1	SL	60	60	B	0	30	MO	VITRANDIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, FRIGID	0.24
CA012	9	MERKEL	1	SL	60	60	B	30	65	SE	VITRANDIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, FRIGID	0.24
CA012	10	TALLAC	1	GRV-SL	60	60	B	0	30	MO	PACHIC XERUMBREPTS, LOAMY-SKELETAL, MIXED, FRIGID	0.05
CA012	11	TALLAC	1	GRV-SL	60	60	B	30	60	SE	PACHIC XERUMBREPTS, LOAMY-SKELETAL, MIXED, FRIGID	0.05
CA012	12	YOLLABOLLY	1	GR-L	6	20	D	30	50	SL	LITHIC XERORTHENTS, LOAMY-SKELETAL,MIXED,NONACID, FRIGID	0.20
CA012	13	YOLLABOLLY	1	GR-SL	6	20	D	50	75	MO	LITHIC XERORTHENTS, LOAMY-SKELETAL,MIXED,NONACID, FRIGID	0.20
CA012	14	CANNELL	1	GR-SL	40	60	B	15	75		DYSTRIC XEROCHREPTS, COARSE-LOAMY, MIXED, FRIGID	0.20
CA012	15	WAPAL	1	GR-SL	60	60	A	15	65	SE	VITRANDIC XEROCHREPTS, SANDY-SKELETAL, MIXED, FRIGID	0.15
CA012	16	SOFTSCRABBLE	1	ST-L	60	60	C	4	7		PACHIC ARGIXEROLLS, LOAMY-SKELETAL, MIXED, FRIGID	0.15
CA012	17	NEUSKE	1	SIL	60	60	B	30	50	SE	VITRANDIC HAPLOXERALFS, FINE-LOAMY, MIXED, FRIGID	0.43
CA012	18	MERKEL	1	SL	60	60	B	30	50	SE	VITRANDIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, FRIGID	0.24
CA012	19	ROCK OUTCROP	1	UWB	0	0	D	10	75			0.00
CA012	20	RIVERWASH	1	GRX-S	60	60	D	0	4			0.00
CA017	1	MARPA	5	GR-L	20	40	C	5	30	SL	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA017	2	MARPA	5	GR-L	20	40	C	30	50	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA017	3	MARPA	10	GRV-SCL	20	40	C	50	75	SE	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA017	4	GOULDING	10	GR-L	10	20	D	30	50		LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA017	5	GOULDING	10	GR-CL	10	20	D	50	70		LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.20

Table VI-Soil-2 Soil Properties from STATSGO.

MUID	SEQ	COMPNAME	COMPPCT	SURFTEX	RL	RH	HG	SL	SH	ER	CLASS	KFACT
CA017	6	HOHMANN	10	GR-CL	20	40	C	30	50		TYPIC XEROCHREPTS, FINE-LOAMY, MIXED, MESIC	0.20
CA017	7	HOHMANN	5	GR-CL	20	40	C	50	75		TYPIC XEROCHREPTS, FINE-LOAMY, MIXED, MESIC	0.20
CA017	8	NEUNS	5	GR-L	20	40	C	30	50	MO	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA017	9	NEUNS	5	GRV-L	20	40	C	50	75	SE	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA017	10	BOOMER	5	GR-L	40	60	B	15	30	MO	ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.10
CA017	11	BOOMER	5	GR-SCL	40	60	B	30	50	SE	ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.10
CA017	12	ROCK OUTCROP	10	UWB	0	0	D	10	75			0.00
CA017	13	STONYFORD	3	GR-CL	10	20	D	30	75		LITHIC MOLLIC HAPLOXERALFS, LOAMY, MIXED, THERMIC	0.20
CA017	14	SECCA	2	GR-L	40	60	C	2	50		MOLLIC HAPLOXERALFS, FINE, MIXED, MESIC	0.24
CA017	15	HOTAW	2	SL	20	40	C	30	75	SE	ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.24
CA017	16	SHEETIRON	2	GR-L	20	40	B	30	75	SE	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA017	17	MILLSHOLM	2	GR-CL	10	20	D	30	75		LITHIC XEROCHREPTS, LOAMY, MIXED, THERMIC	0.20
CA017	18	PARRISH	1	L	20	40	C	30	50		ULTIC HAPLOXERALFS, FINE, VERMICULITIC, MESIC	0.37
CA017	19	HENNEKE	1	GRV-CL	10	20	D	30	75		LITHIC ARGIXEROLLS,CLAYEY-SKELETAL,SERPENTINITIC,THERMIC	0.15
CA017	20	KINDIG	1	GR-L	40	60	B	30	75		DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.24
CA017	21	RIVERWASH	1	GRX-S	60	60	D	0	4			0.00
CA097	1	MUSSERHILL	9	GR-L	20	40	C	9	30	SL	MOLLIC HAPLOXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.20
CA097	2	MUSSERHILL	35	GR-L	20	40	C	30	50	MO	MOLLIC HAPLOXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.20
CA097	3	WEAVERVILLE	3	CL	60	60	B	9	30	SL	ULTIC PALEXERALFS, FINE-LOAMY, OXIDIC, MESIC	0.24
CA097	4	WEAVERVILLE	13	CL	60	60	B	30	50	MO	ULTIC PALEXERALFS, FINE-LOAMY, OXIDIC, MESIC	0.24
CA097	5	MUSSERHILL VARIANT	17	L	20	40	C	30	50	SE	MOLLIC HAPLOXERALFS, CLAYEY-SKELETAL, MIXED, THERMIC	0.28
CA097	6	ATTER	5	GRX-LS	60	60	A	9	15	SL	TYPIC XERORTHENTS, SANDY-SKELETAL, MIXED, MESIC	0.05
CA097	7	FALLON	17	SL	60	60	C	0	2		AQUIC XEROFLUVENTS, COARSE-LOAMY, MIXED, MESIC	0.37
CA097	8	URBAN LAND	1	VAR	10	10		0	5			0.00
CA099	1	CARIS	25	GRX-SL	20	40	C	50	75	SE	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA099	2	CARIS	7	GRX-SL	20	40	C	75	80	SE	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA099	3	INDLETON	18	GRX-SL	60	60	B	50	75	MO	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.05
CA099	4	HOOSIMBIM	13	GRX-SL	40	60	B	50	75	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA099	5	MARPA	14	GRV-SCL	20	40	C	50	75	SE	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA099	6	BAMTUSH	9	GRX-L	60	60	B	50	75	SE	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA099	7	OLLIERIVAS	4	L	30	50	D	2	9		ARIDIC DURIXEROLLS, FINE, MONTMORILLONITIC, MESIC	0.37
CA099	8	BROWNSCREEK	1	GR-L	20	40	B	30	50	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.24
CA099	9	BROWNSCREEK	1	GR-L	20	40	B	50	75	SE	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.24
CA099	10	GOULDING	5	GRV-L	10	20	D	50	75		LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA099	11	VANVOR	3	GRV-SCL	20	40	B	50	75	MO	MOLLIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA100	1	GOULDING	32	GRV-L	10	20	D	50	75		LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA100	2	VITZTHUM	23	GRX-L	10	20	D	50	75		LITHIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA100	3	VANVOR	16	GRV-SCL	20	40	B	50	75	MO	MOLLIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA100	4	MARPA	5	GRV-SCL	20	40	C	50	75	SE	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA100	5	BAMTUSH	7	GRX-L	60	60	B	50	75	SE	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA100	6	HOLKAT VARIANT	1	GR-L	20	40	B	50	75	SE	TYPIC XEROCHREPTS, FINE-LOAMY, MIXED, MESIC	0.24
CA100	7	HOOSIMBIM	10	GRX-SL	40	60	B	50	75	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA100	8	PARDALOE	6	GRV-L	40	60	B	50	75	SE	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA101	1	BAMTUSH	5	GRX-L	60	60	B	30	50	MO	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA101	2	BAMTUSH	12	GRX-L	60	60	B	50	75	SE	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA101	3	HOOSIMBIM	5	GRX-SL	40	60	B	30	50	SL	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA101	4	HOOSIMBIM	12	GRX-SL	40	60	B	50	75	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA101	5	MARPA	3	GRV-SCL	20	40	C	30	50	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA101	6	MARPA	14	GRV-SCL	20	40	C	50	75	SE	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA101	7	GOULDING	2	GRV-L	10	20	D	50	75		LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA101	8	CARIS	11	GRX-SL	20	40	C	50	75	SE	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA101	9	ATTER	4	GRX-LS	60	60	A	9	15	SL	TYPIC XERORTHENTS, SANDY-SKELETAL, MIXED, MESIC	0.05
CA101	10	BROWNBEAR	5	GRV-L	20	40	B	50	75	MO	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA101	11	ETSEL	4	GRV-L	4	14	D	50	75		LITHIC XERORTHENTS, LOAMY-SKELETAL,MIXED, NONACID, MESIC	0.10
CA101	12	HURLBUT	9	GR-L	20	40	C	50	75	SE	DYSTRIC XEROCHREPTS, FINE-LOAMY, MIXED, MESIC	0.20
CA101	13	VANVOR	1	GRV-SCL	20	40	B	50	75	MO	MOLLIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA101	14	VITZTHUM	4	GRX-L	10	20	D	50	75		LITHIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA101	15	FALLON	1	SL	60	60	C	0	2		AQUIC XEROFLUVENTS, COARSE-LOAMY, MIXED, MESIC	0.37
CA101	16	DUBAKELLA	2	CB-CL	20	40	C	15	30	SL	MOLLIC HAPLOXERALFS,CLAYEY-SKELETAL,SERPENTINITIC, MESIC	0.20
CA101	17	DUBAKELLA	2	CB-CL	20	40	C	30	50	MO	MOLLIC HAPLOXERALFS,CLAYEY-SKELETAL,SERPENTINITIC, MESIC	0.20
CA101	18	DUBAKELLA	1	CB-CL	20	40	C	50	75	SE	MOLLIC HAPLOXERALFS,CLAYEY-SKELETAL,SERPENTINITIC, MESIC	0.20

MUID	SEQ	COMPNAME	COMPPCT	SURFTEX	RL	RH	HG	SL	SH	ER	CLASS	KFACT
CA101	19	HOOSIMBIM	1	GRX-SL	40	60	B	50	75	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA101	20	WEITCHPEC	1	GR-L	20	40	C	30	50	SL	TYPIC XEROCHREPTS, LOAMY-SKELETAL, SERPENTINITIC, MESIC	0.24
CA101	21	DEMOGUL	1	GR-L	60	60	B	50	75	SE	ULTIC PALEXERALFS, FINE-LOAMY, OXIDIC, MESIC	0.24
CA103	1	DEDRICK	23	GRV-L	10	20	D	50	75	MO	LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, THERMIC	0.05
CA103	2	BROCKGULCH	15	GRV-L	20	40	B	50	75	MO	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, THERMIC	0.10
CA103	3	PARDALOE	13	GR-L	40	60	B	50	75	SE	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA103	4	ATTER	8	GRX-LS	60	60	A	9	15	SL	TYPIC XERORTHENTS, SANDY-SKELETAL, MIXED, MESIC	0.05
CA103	5	BROWNBEAR	17	GRV-L	20	40	B	50	75	MO	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA103	6	GOULDING	17	GRV-L	10	20	D	50	75		LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA103	7	HOLKAT VARIANT	3	GR-L	20	40	B	50	75	SE	TYPIC XEROCHREPTS, FINE-LOAMY, MIXED, MESIC	0.24
CA103	8	ROCK OUTCROP	3	UWB	0	0	D	50	75			0.00
CA103	9	FALLON	1	SL	60	60	C	0	2		AQUIC XEROFLUVENTS, COARSE-LOAMY, MIXED, MESIC	0.37
CA104	1	BARPEAK	27	GRV-L	60	60	B	50	90	MO	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA104	2	SHEETIRON	25	GRV-L	20	40	B	50	90	SE	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA104	3	BEARGULCH	8	GRV-L	40	60	B	50	75	MO	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, FRIGID	0.15
CA104	4	SKYROCK	4	GRX-L	10	20	D	50	75		DYSTRIC LITHIC XEROCHREPTS, LOAMY-SKELETAL,MIXED, FRIGID	0.05
CA104	5	BAMTUSH	7	GRX-L	60	60	B	50	75	SE	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA104	6	CARIS	6	GRX-SL	20	40	C	50	75	SE	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA104	7	HOOSIMBIM	9	GRX-SL	40	60	B	50	75	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA104	8	MARPA	12	GRV-SCL	20	40	C	50	75	SE	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA104	9	SKYROCK VARIANT	1	STV-L	10	20	D	50	75	MO	DYSTRIC LITHIC XEROCHREPTS, LOAMY-SKELETAL,MIXED, FRIGID	0.15
CA104	10	ROCK OUTCROP	1	UWB	0	0	D	50	75			0.00
CA105	1	TALLOWBOX	44	GR-COSL	20	40	C	50	70	SE	TYPIC XEROCHREPTS, COARSE-LOAMY, MIXED, MESIC	0.15
CA105	2	MINERSVILLE	28	SL	40	60	B	50	75	SE	TYPIC XEROCHREPTS, COARSE-LOAMY, MIXED, MESIC	0.24
CA105	3	BAMTUSH	14	GRX-L	60	60	B	50	75	SE	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA105	4	HOLLAND	4	SL	40	60	B	30	50		ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.24
CA105	5	HOTAW	5	L	20	40	C	30	50	SE	ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.28
CA105	6	RIVERWASH	1	GRV-S	60	60	D	0	4			0.00
CA105	7	PLINCO	3	GR-SL	60	60	B	2	9		CUMULIC HAPLOXEROLLS, COARSE-LOAMY, MIXED, MESIC	0.20
CA105	8	FALLON	1	SL	60	60	C	0	2		AQUIC XEROFLUVENTS, COARSE-LOAMY, MIXED, MESIC	0.37
CA106	1	VALCREEK	29	GRV-LCOS	20	40	B	30	75	SE	TYPIC XERORTHENTS, SANDY-SKELETAL, MIXED, MESIC	0.10
CA106	2	MINERSVILLE	24	SL	40	60	B	30	75	SE	TYPIC XEROCHREPTS, COARSE-LOAMY, MIXED, MESIC	0.24
CA106	3	CHOOP	20	GRF-LCOS	10	20	D	30	75		TYPIC XERORTHENTS, SANDY-SKELETAL, MIXED, MESIC, SHALLOW	0.10
CA106	4	MINERSVILLE VARIANT	20	GRF-LCOS	20	40	C	50	75	SE	ENTIC XERUMBREPTS, SANDY-SKELETAL, MIXED, FRIGID	0.15
CA106	5	SHEETIRON	5	GRV-L	20	40	B	50	90	SE	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA106	6	PLINCO	1	GR-SL	60	60	B	2	9		CUMULIC HAPLOXEROLLS, COARSE-LOAMY, MIXED, MESIC	0.20
CA106	7	ROCK OUTCROP	1	UWB	0	0	D	30	75			0.00
CA107	1	BROWNSCREEK	10	GR-L	20	40	B	30	50	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.24
CA107	2	BROWNSCREEK	20	GR-L	20	40	B	50	75	SE	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.24
CA107	3	DOUGCITY	2	GR-L	60	60	B	15	50	MO	ULTIC PALEXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.24
CA107	4	DOUGCITY	24	GR-L	60	60	B	50	75	SE	ULTIC PALEXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.24
CA107	5	DEMOGUL	1	GR-L	60	60	B	15	50	MO	ULTIC PALEXERALFS, FINE-LOAMY, OXIDIC, MESIC	0.24
CA107	6	DEMOGUL	2	GR-L	60	60	B	50	75	SE	ULTIC PALEXERALFS, FINE-LOAMY, OXIDIC, MESIC	0.24
CA107	7	CARGENT	2	GRV-SCL	20	40	B	50	75		DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, THERMIC	0.15
CA107	8	CARGENT	1	GRV-SCL	20	40	B	75	90		DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, THERMIC	0.15
CA107	9	SHEETIRON	1	GRX-L	20	40	B	75	90	SE	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA107	10	BAMTUSH	6	GRX-L	60	60	B	30	50	MO	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA107	11	BAMTUSH	8	GRX-L	60	60	B	50	75	SE	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA107	12	ETSEL	4	GRV-L	4	14	D	50	75		LITHIC XERORTHENTS, LOAMY-SKELETAL, MIXED,NONACID, MESIC	0.10
CA107	13	HOOSIMBIM	3	GRX-SL	40	60	B	30	50	SL	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA107	14	SHEETIRON VARIANT	2	GR-L	20	40	C	50	75	SE	TYPIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.24
CA107	15	SPRINGGULCH	8	GR-CL	60	60	B	30	50		HAPLIC PALEXERALFS, FINE, OXIDIC, THERMIC	0.17
CA107	16	VITZTHUM VARIANT	5	GRV-L	10	20	D	50	75		DYSTRIC LITHIC XEROCHREPTS,LOAMY-SKELETAL,MIXED, THERMIC	0.15
CA107	17	DUMPS	1	VAR	60	60		0	20			0.00
CA108	1	WEITCHPEC VARIANT	9	GR-L	40	60	B	30	50	MO	MOLLIC HAPLOXERALFS, CLAYEY-SKELETAL, MIXED, MESIC	0.24
CA108	2	WEITCHPEC VARIANT	24	GR-L	40	60	B	50	75	SE	MOLLIC HAPLOXERALFS, CLAYEY-SKELETAL, MIXED, MESIC	0.24
CA108	3	BAMTUSH VARIANT	7	GRV-L	60	60	B	30	50	MO	HAPLIC PALEXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.10
CA108	4	BAMTUSH VARIANT	16	GRV-L	60	60	B	50	75	MO	HAPLIC PALEXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.10
CA108	5	BAMTUSH	2	GRX-L	60	60	B	30	50	MO	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10

MUID	SEQ	COMPNAME	COMPPCT	SURFTEX	RL	RH	HG	SL	SH	ER	CLASS	KFACT
CA108	6	BAMTUSH	7	GRX-L	60	60	B	50	75	SE	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA108	7	HOOSIMBIM	3	GRX-SL	40	60	B	30	50	SL	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA108	8	HOOSIMBIM	8	GRX-SL	40	60	B	50	75	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA108	9	MARPA	2	GRV-SCL	20	40	C	30	50	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA108	10	MARPA	12	GRV-SCL	20	40	C	50	75	SE	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA108	11	DUBAKELLA	2	CB-CL	20	40	C	30	50	MO	MOLLIC HAPLOXERALFS, CLAYEY-SKELETAL, SERPENTINITIC, MESIC	0.20
CA108	12	DUBAKELLA	2	CB-CL	20	40	C	50	75	SE	MOLLIC HAPLOXERALFS, CLAYEY-SKELETAL, SERPENTINITIC, MESIC	0.20
CA108	13	HURLBUT	1	GR-L	20	40	C	30	50	MO	DYSTRIC XEROCHREPTS, FINE-LOAMY, MIXED, MESIC	0.20
CA108	14	HURLBUT	5	GR-L	20	40	C	50	75	SE	DYSTRIC XEROCHREPTS, FINE-LOAMY, MIXED, MESIC	0.20
CA109	1	BROWNBEAR	12	GRV-L	20	40	B	30	50	SL	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA109	2	BROWNBEAR	22	GRV-L	20	40	B	50	75	MO	TYPIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA109	3	BAMTUSH	1	GRX-L	60	60	B	15	30	SL	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA109	4	BAMTUSH	6	GRX-L	60	60	B	30	50	MO	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA109	5	BAMTUSH	14	GRX-L	60	60	B	50	75	SE	ULTIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA109	6	WEAVERVILLE	7	L	60	60	B	15	30	SL	ULTIC PALEXERALFS, FINE-LOAMY, OXIDIC, MESIC	0.24
CA109	7	WEAVERVILLE	6	L	60	60	B	30	50	MO	ULTIC PALEXERALFS, FINE-LOAMY, OXIDIC, MESIC	0.24
CA109	8	HOTAW	3	L	20	40	C	15	30	MO	ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.28
CA109	9	BROWNSCREEK	4	GR-L	20	40	B	30	50	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.24
CA109	10	ETSEL	14	GRV-L	4	14	D	50	75		LITHIC XERORTHENTS, LOAMY-SKELETAL, MIXED, NONACID, MESIC	0.10
CA109	11	HOOSIMBIM	10	GRX-SL	40	60	B	30	50	SL	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.10
CA109	12	ROCK OUTCROP	1	UWB	0	0	D	15	75			0.00
CA110	1	SPRINGGULCH	53	GR-CL	60	60	B	30	50		HAPLIC PALEXERALFS, FINE, OXIDIC, THERMIC	0.17
CA110	2	BROCKGULCH VARIANT	27	L	20	40	B	30	50		MOLLIC HAPLOXERALFS, LOAMY-SKELETAL, OXIDIC, THERMIC	0.28
CA110	3	DOUGCITY	6	GR-L	60	60	B	30	50	MO	ULTIC PALEXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.24
CA110	4	BROWNSCREEK	7	GR-L	20	40	B	30	50	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, OXIDIC, MESIC	0.24
CA110	5	MILLSHOLM	3	L	10	20	D	15	30	MO	LITHIC XEROCHREPTS, LOAMY, MIXED, THERMIC	0.37
CA110	6	ATTER	3	GRX-LS	60	60	A	9	15	SL	TYPIC XERORTHENTS, SANDY-SKELETAL, MIXED, MESIC	0.05
CA110	7	FALLON	1	SL	60	60	C	0	2		AQUIC XEROFLUVENTS, COARSE-LOAMY, MIXED, MESIC	0.37
CA111	1	MILLSHOLM	57	L	10	20	D	15	30	MO	LITHIC XEROCHREPTS, LOAMY, MIXED, THERMIC	0.37
CA111	2	AZULE	21	SICL	20	40	C	15	30		MOLLIC HAPLOXERALFS, FINE, MONTMORILLONITIC, THERMIC	0.32
CA111	3	ATTER	14	GRX-LS	60	60	A	9	15	SL	TYPIC XERORTHENTS, SANDY-SKELETAL, MIXED, MESIC	0.05
CA111	4	JAFA VARIANT	5	GR-L	60	60	C	15	30	SL	MOLLIC PALEXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.24
CA111	5	PLEASANTON	2	GR-L	60	60	B	2	5		MOLLIC HAPLOXERALFS, FINE-LOAMY, MIXED, THERMIC	0.20
CA111	6	FALLON	1	SL	60	60	C	0	2		AQUIC XEROFLUVENTS, COARSE-LOAMY, MIXED, MESIC	0.37
CA139	1	HENNEKE	32	GR-L	10	20	D	30	65		LITHIC ARGIXEROLLS, CLAYEY-SKELETAL, SERPENTINITIC, THERMIC	0.20
CA139	2	HENNEKE	6	GR-L	10	20	D	10	30		LITHIC ARGIXEROLLS, CLAYEY-SKELETAL, SERPENTINITIC, THERMIC	0.20
CA139	3	STONYFORD	7	ST-L	10	20	D	30	50		LITHIC MOLLIC HAPLOXERALFS, LOAMY, MIXED, THERMIC	0.24
CA139	4	STONYFORD	4	ST-L	10	20	D	50	65		LITHIC MOLLIC HAPLOXERALFS, LOAMY, MIXED, THERMIC	0.24
CA139	5	STONYFORD	3	GR-CL	10	20	D	20	50		LITHIC MOLLIC HAPLOXERALFS, LOAMY, MIXED, THERMIC	0.20
CA139	6	STONYFORD	2	GR-CL	10	20	D	50	65		LITHIC MOLLIC HAPLOXERALFS, LOAMY, MIXED, THERMIC	0.20
CA139	7	STONYFORD	5	ST-L	10	20	D	30	50		LITHIC MOLLIC HAPLOXERALFS, LOAMY, MIXED, THERMIC	0.24
CA139	8	STONYFORD	8	ST-L	10	20	D	50	75		LITHIC MOLLIC HAPLOXERALFS, LOAMY, MIXED, THERMIC	0.24
CA139	9	MAYMEN	18	ST-L	10	20	D	30	75		DYSTRIC LITHIC XEROCHREPTS, LOAMY, MIXED, MESIC	0.20
CA139	10	XERORTHENTS	3	VAR	60	60		50	75		XERORTHENTS	0.00
CA139	11	LITHIC XERORTHENTS	2	VAR	8	20	D	50	75		LITHIC XERORTHENTS	0.00
CA139	12	PARRISH	3	GR-L	20	40	C	30	50		ULTIC HAPLOXERALFS, FINE, VERMICULITIC, MESIC	0.24
CA139	13	ROCK OUTCROP	2	UWB	0	0	D	50	75			0.00
CA139	14	GOULDING	2	ST-L	8	20	D	30	50		LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA139	15	GOULDING	2	ST-L	8	20	D	50	65		LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA139	16	GOULDING	1	GR-L	10	20	D	30	65		LITHIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA149	1	JOCAL	5	GR-L	60	60	B	10	30	SL	TYPIC HAPLOXERULTS, FINE-LOAMY, MIXED, MESIC	0.20
CA149	2	JOCAL	11	GR-L	60	60	B	30	50	MO	TYPIC HAPLOXERULTS, FINE-LOAMY, MIXED, MESIC	0.20
CA149	3	JOCAL	13	GR-L	60	60	B	50	70	SE	TYPIC HAPLOXERULTS, FINE-LOAMY, MIXED, MESIC	0.20
CA149	4	MARPA	8	GR-L	20	40	C	30	50	MO	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA149	5	MARPA	14	GR-L	20	40	C	50	70	SE	ULTIC HAPLOXERALFS, LOAMY-SKELETAL, MIXED, MESIC	0.20
CA149	6	SHEETIRON	12	GRV-L	20	40	B	50	75	SE	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA149	7	SHEETIRON	3	GRV-L	20	40	B	75	90	SE	DYSTRIC XEROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC	0.15
CA149	8	LITHIC XERORTHENTS	5	VAR	8	20	D	9	75		LITHIC XERORTHENTS	0.00
CA149	9	ROCK OUTCROP	5	UWB	0	0	D	30	50			0.00
CA149	10	XERORTHENTS	13	VAR	60	60		30	75		XERORTHENTS	0.00

MUID	SEQ	COMPNAME	COMPPCT	SURFTEX	RL	RH	HG	SL	SH	ER	CLASS	KFACT
CA149	11	PARRISH	3	GR-L	20	40	C	9	30		ULTIC HAPLOXERALFS, FINE, VERMICULITIC, MESIC	0.24
CA149	12	PARRISH	2	GR-L	20	40	C	50	70		ULTIC HAPLOXERALFS, FINE, VERMICULITIC, MESIC	0.24
CA149	13	SITES	2	L	60	60	C	8	30	SL	XERIC HAPLOHUMULTS, CLAYEY, OXIDIC, MESIC	0.28
CA149	14	SITES	2	L	60	60	C	30	50	MO	XERIC HAPLOHUMULTS, CLAYEY, OXIDIC, MESIC	0.28
CA149	15	HENNEKE	2	GR-L	10	20	D	15	60		LITHIC ARGIXEROLLS,CLAYEY-SKELETAL,SERPENTINITIC,THERMIC	0.20
CA154	1	CHAIX	31	SL	20	40	B	50	70	SE	DYSTRIC XEROCHREPTS, COARSE-LOAMY, MIXED, MESIC	0.20
CA154	2	CHAIX	16	SL	20	40	B	30	50	MO	DYSTRIC XEROCHREPTS, COARSE-LOAMY, MIXED, MESIC	0.20
CA154	3	CHAIX	2	SL	20	40	B	5	30	MO	DYSTRIC XEROCHREPTS, COARSE-LOAMY, MIXED, MESIC	0.20
CA154	4	CORBETT	12	ST-LCOS	20	40	B	15	50	SE	TYPIC XEROPSAMMENTS, MIXED, FRIGID	0.10
CA154	5	CORBETT	16	ST-LCOS	20	40	B	50	75	SE	TYPIC XEROPSAMMENTS, MIXED, FRIGID	0.10
CA154	6	SIERRA	1	SL	40	80	B	3	8		ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, THERMIC	0.28
CA154	7	SIERRA	6	SL	40	80	B	8	30		ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, THERMIC	0.28
CA154	8	SIERRA	1	SL	40	80	B	30	50		ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, THERMIC	0.28
CA154	9	HOLLAND	3	SL	60	60	B	15	70	SE	ULTIC HAPLOXERALFS, FINE-LOAMY, MIXED, MESIC	0.28
CA154	10	KANAKA	3	SL	40	60	B	3	30		DYSTRIC XEROCHREPTS, COARSE-LOAMY, MIXED, THERMIC	0.32
CA154	11	KANAKA	4	SL	40	60	B	30	50		DYSTRIC XEROCHREPTS, COARSE-LOAMY, MIXED, THERMIC	0.32
CA154	12	KANAKA	3	SL	40	60	B	50	70		DYSTRIC XEROCHREPTS, COARSE-LOAMY, MIXED, THERMIC	0.32
CA154	13	ROCK OUTCROP	2	UWB	0	0	D	0	75			0.00

VI-7 CLIMATE

The most important of all geologic processes is running water (Morisawa 1968). Water is introduced to the land surface as an element in the "hydrologic cycle", a concept introduced by the American Society of Civil Engineers in 1949 (AFS Special Pub. 1991). Climate generates the variables of rain, snow, fog, evaporation, soil infiltration, percolation, vegetative transpiration, and ultimately run-off, in the form of running water.

Climate can be simplistically described as the summation of daily weather data collection and observations compiled over numerous seasons and years. Ideally, 50 to 100 years of record-keeping is required to get a reasonable impression of "normal" climatic attributes, lengthier cycles, and anomalous extremes. But it is also important to attempt to reconstruct how much longer time periods of climate fluctuation (ice ages, tropical warming periods, etc.) have affected the topography and vegetative characteristics of the specific watershed area under analysis.

The climate of a given area is controlled by local influences (e.g., land surface elevations and aspect orientation) and exogenous sources (seasonal solar angle and day length, the passage of major air masses over the local area, etc.). The climate of this particular analysis area can now be described in these two contexts.

In general terms, climate of this analysis area is that of the "Mediterranean type" in terms of rainfall distribution. Classically as well as locally, this climate category is typified by nearly all of the annual precipitation occurring during the six to eight months centered around the winter season. Nearly all of this precipitation originates well outside the local area (far out over the Pacific Ocean) and is delivered by jet stream winds aloft flowing from west to east. The amount and distribution of this precipitation and the form it takes (rain, snow, hail, etc.) is largely determined by local topographic factors.

The primary reason why these frequent storms of Pacific origin are excluded from northern California in summer is due to the seasonal northern migration of a large area of high pressure over the eastern Pacific. This large, drying high pressure cell is "pulled northward" annually by the 47 degree sun angle migration northward between winter and summer. Once in place, usually in May or June, it acts as a very effective blockade to seasonally weaker storms, deflecting them northward into Canada and Alaska. The drying effect of this massive high pressure cell can lead to virtually many weeks of continuously clear, cloud free weather in the analysis area during the summer. This permits the full intensity of maximum overhead sun angle and day length to greatly affect the local climate during this predictable, seasonal basis.

The temperatures that result during this dry summer season are a product of distance from the moderating effects of the Pacific Ocean and local topographic elevation and aspect. Although the Pacific maritime air continuously affects the weather of the immediate coastline during the summer, up-canyon westerly winds, which can blow daily, reach ambient air temperatures by the time they reach the lower end of the analysis area at the North Fork Trinity River confluence. Absolute shade temperatures throughout the lower elevations of the analysis area routinely peak in late afternoon to between 90 and 110 degrees fahrenheit. Relative humidity is quite low during these hot summer afternoons and associated wild-fire danger is quite high.

South-facing topographic aspects absorb the full brunt of the solar angle and daily maximum temperatures. Associated vegetation below 3,000 feet is xeric and more sparse. North-facing landscapes of steep slopes can be significantly cooler at all elevations, comparatively. This is because of the oblique sun-angle penetration and fewer hours of daily direct solar exposure. The resulting vegetation (often comprised of dense stands of mixed conifers) creates a micro-climate of much cooler air below the tree canopy.

Regardless of aspect, air temperatures are generally cooler by about three to four degrees fahrenheit for every 1,000 feet increase in elevation. The highest elevations of the affected analysis area (up to 9,000 feet) seldom exceed 85 deg. F. in summer.

The humidity gradient that can slightly moderate area temperatures in summer due to ocean influences downriver is responsible for the higher snowfall elevation lines in winter at the western edge of the analysis area. But throughout most of the analysis area, freezing temperatures can be experienced during all but the months of July and August at lower elevations and at any time of year at the highest elevations. Occasional temperatures below ten deg. F. can be experienced at the lowest elevations in winter and well below zero deg. F. at the highest elevations.

Precipitation quantities over the general analysis area range from 35 to 60 inches in a year of "average rainfall" (Barrett 1966). Since such a year seldom occurs, annual fluctuations can lead to seasonal totals ranging from as low as 15 to 20 inches in the driest locations, to over 100 inches in the highest locations in a dry or wet year extreme, respectively. In summary, it may be accurate to say that any given location can see precipitation totals varying by 300-400% over time when the extremes are included in a long-term data base.

Precipitation is predominantly limited to rain or snow in the winter season. The elevation at which snow begins to fall gradually drifts lower and moves east, away from any moderating effect the Pacific Ocean may play. But this relative snow line can vary greatly from one storm to another. Only the highest elevations of the analysis area (7,000 feet and above) receive most of the precipitation in the form of snow; conversely, only the lowest river canyon elevations of the western portion of the analysis area (1,000 to 2,000 feet) receive most of the precipitation in the form of rainfall. Most of the analysis area could be described as falling into a transient-snow/rain zone (AFS Special Pub, 1991).

This large area of transient snow-zone geography can have a leveraging or dampening influence on the relationship between precipitation and run-off. During very cold storms with low elevation snowfall levels, heavy precipitation will not result in large run-off discharges correlatively due to the water storage effect of the accumulated snow. Ideally, and is often the case, the snowpack delivers its water content in late spring, when sun angles are higher. Sometimes, though, the snowpack is prematurely discharged during a warm, or series of warm storm events. Some of the most well-known recent flood events resulted from the combined run-off effects of heavy warm rains originating from a sub-tropical jet stream, falling upon deep snow packs accumulated during preceding colder storm events originating from the Gulf of Alaska.

Occasional summer season thunderstorms are triggered when a southerly flow from the Gulf of California combines high humidity with ambient hot air temperatures. The unstable air mass is most often responsible for rain-free lightning strikes that cause the majority of our naturally started wildfires. But occasionally very heavy and intense rainfall of short duration (one hour or less) can initiate local "flash floods" that can cause local area erosion and channel instability. It is possible for one of these thunderstorm cells centered over a small drainage area to create flood impacts greater than that of a 100 year return interval winter storm. This has occurred several times in the local forest area during the past ten years, and during extended drought periods, such as the one occurring between 1987 and 1993. These events may cause more erosion than the few mild winter storms over a broad area.

Historically viewing the combined effects of snowfall and rainfall accumulation over the analysis area, approximately 1.5 million acre feet of annual run-off often passed through and was yielded from the analysis area at the confluence with the North Fork Trinity River prior to construction of the Trinity Division of the Central Valley Project in 1963.

VI-7 GEOLOGY

North Coastal California contains two parallel geologic provinces which differ in age, lithology, structure, and metamorphism. The margin of the Pacific Ocean is bounded by the coast Range Province, developed on rocks of the Franciscan Assemblage. The Franciscan sedimentary and volcanic rocks were deposited in a deep marine environment. They are often highly deformed and broken, but are generally only slightly metamorphosed. This Coast Range Province occupies a very small area in the watershed.

East of the Coast ranges are the older Klamath Mountains, underlain by metamorphic and plutonic rocks. The two provinces are separated by the South Fork Mountain Schist. To which province this schist belongs is a subject of debate (Blake 1965, Suppe 1973, Bishop 1977, Jim Wright- personal communication*), but it is included here in the Coast Ranges because its surficial aspect is very similar to those of the Coast Ranges.

Klamath Mountains Province

The Klamath Mountains occupy most of the watershed. The Klamaths were divided into the so-called "Eastern Klamath", "Central Metamorphic", "Western Paleozoic and Triassic", and "Western Jurassic" subprovinces (Irwin 1960). The Western Paleozoic and Triassic subprovince is referred to here as the Jurassic to Permian subprovince, because fossils of those ages have been found there.

Rock units dip generally to the east, and in each case the older eastern unit overlies the younger wester unit. Plutonic rocks are found intruding the metamorphic rocks throughout the watershed. Rock units will be described from oldest to youngest, or as they appear from east to west.

Eastern Klamath Subprovince

This subprovince occupies the eastern one-third of the watershed and includes the Trinity ultramafic sheet, Copley greenstone, and Bragdon Formation.

The Trinity ultramafic sheet is the base of the Eastern Klamath subprovince. It is believed to be part of an ophiolite sequence (Goulland 1973). It is composed of largely serpentinized ultramafic rocks and medium- to coarse-grained gabbros and diorites. The gabbros and diorites are relatively erosion resistant, but the serpentinite is readily susceptible to mass movement.

The Copley greenstone of Devonian Age underlies the Bragdon, and consists of slightly metamorphosed spilites and keratophyres. Pillow structures are found locally. The unit is massive and competent.

The Bragdon Formation is the youngest unit of this group. The sediments are slightly metamorphosed, and have retained their sedimentary textures. The unit is estimated to be Mississippian in age. Only the upper part is found in the Trinity River watershed. The unit is generally considered to be stable and erosion resistant.

Central Metamorphic Subprovince

West of the Eastern Klamath subprovince is the Central Metamorphic subprovince. Two medium- to high-grade metamorphic rock units comprise this group: the Salmon Hornblende Schist and Abrams Mica Schist. The Salmon is structurally lower. It is a moderately well foliated amphibolite facies metamorphic rock consisting of hornblende, epidote, and albite. The Salmon Hornblende Schist is an erodible unit, releasing a large number of clay-sized amphibole crystals into the Trinity River.

The Abrams Mica Schist is a greenschist facies metasediment composed primarily of quartz, mica, chlorite and calcite. Slopes underlain by the schist are moderately stable, but the soils are generally erodible.

Jurassic to Permian Subprovince

This subprovince is subdivided into three terranes: the North Fork, Hayfork, and Rattlesnake Creek (Irwin 1972). These were once considered jointly as the Western Paleozoic and Triassic Belt (Irwin 1960). The North Fork and Rattlesnake Creek terranes are believed to be tectonic "slices" of oceanic crust, or ophiolite suites. The Hayfork terrane probably originated as an island arc between the two (Irwin 1972). The terranes are believed to be from Permian to Jurassic in age (Irwin 1977), because fossils of those ages have been found there.

The North Fork Terrane is named after the North Fork Trinity River, located near Helena. It is a disrupted ophiolite sequence at the base, overlain by sediments to the east. Serpentinite, gabbro, and diabase form a practically continuous selvage along the western side. Outcrops of these rocks occur on Highway 3 near Hayfork summit. The ophiolitic rocks are succeeded to the east by silicious tuff, chert, mafic volcanic rock, minor lenses of limestone, phyllite, and locally, pebble conglomerate. The igneous rocks and the sediments produce moderately stable slopes, while the serpentinites produce unstable slopes.

Western Jurassic Subprovince

The western Jurassic subprovince consists of the Galice and Rogue Formations. the Galice is probably Upper Jurassic in age. It consists of interbedded graywacke, mudstone, conglomerate, and some volcanic rocks showing metamorphic variations from slate to schist.

Many debris slides occur in the Galice along the South Fork Trinity, where the river parallels the structure and dip-slopes are formed. The main stem Trinity crosses the structure, and here the Galice has moderately stable slopes. Intercalated with the Galice is the Rogue Formation, consisting of metamorphosed volcanic flows and pyroclastic rocks that generally form stable slopes.

Intrusives

North and southeast of Weaverville are light-colored, coarse-grained, biotite, hornblende, quartz diorites of the Late Jurassic Shasta Bally Batholith and associated Weaver Bally Batholith. Hillslopes underlain by these granitics are deeply weathered. Slopes are erodible and produce large volumes of sediment when protective vegetation is removed. Grass Valley and Little Grass Valley Creeks drain some of this area. To casual examination, they present the appearance of typical streams, hidden in many places by a heavy cover of vegetation. Closer inspection, however, reveals channel bottoms composed almost entirely of medium- to coarse-grained sand derived from highly unstable granitic parent rocks that cover about 80 percent of the basin. **(which basin?)** Through the weathering process, vegetation removal, and human soil disturbance, a large amount of sandy soil eventually reaches the stream channel and is carried downstream. On entering the Trinity River, this sand settles out and blankets the streambed, covering spawning areas and filling deep fish-resting pools below Grass Valley Creek.

The Canyon Creek pluton in the north central part and Ironside Mountain Batholith in the western half of the watershed are light-to medium-colored hornblende quartz diorites. They form steep slopes and rugged peaks and do not appear to present serious erosion problems.

North Coast Range Province (includes Franciscan Assemblage and South Fork Mtn schist)

Cretaceous, Tertiary, and Quaternary Sedimentary Deposits

Great Valley Sequence

Cretaceous rocks of the Great Valley occur as small, isolated patches in the watershed. The patches were part of a sheet of shallow-to-deep marine shelf deposits that at one time covered most of this part of the Klamath Mountains. Most of the sequence is firmly consolidated sandstone, conglomerate, and mudstone, with a more shaley upper part containing thin nodular beds. According to Irwin (1974), the section has an easterly dip. The rocks of the Great Valley are unstable, but are an insignificant part of the watershed.

Weaverville Formation

a large exposure of this unit can be observed at the type locality near the town of Weaverville. A few remnants of this Oligocene continental formation are preserved in fault-bound, down-dropped valleys and as terraces along the Trinity River. The formation consists of weakly consolidated mudstone, sandstone, and conglomerate with an impervious dark green clay matrix, and sparse interbeds of light-colored tuffs (Irwin 1974). The Weaverville Formation tends to be unstable, particularly along roadcuts and streambanks where slopes are oversteepened.

Glacial Deposits

Glacial deposits are present in the northeastern region of the watershed, where the mountains were elevated above the snowline during the Pleistocene. Sharp (1960) defined at least four episodes of glaciation and found evidence for 30 valley glaciers during the latest episode (Late Wisconsian, locally named Morris Meadow).

Two cirque glaciers exist today at the top of Thompson Peak at 2,700 meter elevation. Canyon, Coffee, Swift Creeks and Stuart Fork were once glacial valleys. Glacial till, composed of unsorted gravels and boulders in a sand and clay matrix, is the principal deposit. Glaciation in Swift Creek produced glacial detritus from serpentinite bedrock. These deposits were sources of many debris flows during the Pleistocene. The flows traveled down the valleys from the glacier snouts and deposited sediment almost indistinguishable from till (Sharp 1960).

Terrace Deposits

Much of the Trinity River upstream from Big Bar is flanked by terraces composed of gravel and sand from glacial erosion. Diller (1991) found Pleistocene fossils at the base of 41 meters of gravels at Union

Hill Mine near Douglas City. Downstream from Big Bar to Hawkins Bar the river flows through the Hayfork terrane, which produced a steep, narrow gorge and a few bedrock terraces mantled by a layer of gravel. From Hawkins Bar downstream to the north end of Hoopa Valley, the river is underlain by erodible Galice slates. Here the river forms broad valleys of terrace deposits. Near the confluence with the South Fork Trinity River, there are six terrace levels at elevations 18 to 305 meters above the present stream level. The middle terrace, 92 meters above the stream, has been mined for gold.

Surficial Deposits

Surficial deposits include Recent Alluvium, lake deposits, mined terrace deposits, and landslide debris. The Recent Alluvium consists of well-washed sand, gravel, cobbles, and boulders, with some fines that have accumulated in active creek and river channels. Lake deposits generally consist of fine sand and silt, and mined terrace deposits consist of mounds of coarse gravel. Landslide deposits are combinations of soil and rock. Both active and inactive landslides occur in most of the units in the watershed.

19 January 1996

TO: Trinity River EIS/EIR Team and Technical Committee members

FROM: Colleen O'Sullivan, Editor COS

RE: Addendums to the Mainstem Trinity River Watershed Analysis Report

Please insert the attached material into your Trinity River WA, as it has been updated. Specifically, the changes are as follows:

1. Section VI-5-33 (Land Use and Human Values): please replace this page.

2. Section VI-3 (Wildlife): please replace this entire section with this attachment.

3. Section VIII (Bibliography): please replace this entire section with this attachment.

My apologies for any inconvenience this may cause you, but the addendums improve the quality of information in the document. Thank you.

Employment in Trinity County by Industry
(annual averages)

Industry	1985	1990	1991	1992	1993	1994
Agriculture	30	40	50	60	50	60
Construction and Mining	130	110	70	60	80	80
Manufacturing	470	450	390	480	470	490
Transportation and Public U	120	100	90	80	80	90
Wholesale and Retail Trade	420	540	530	490	500	540
Finance/Insurance/Real Est	80	60	80	80	60	60
Services	500	360	410	410	380	380
Federal Government	330	430	360	300	310	300
State Government	100	130	130	130	130	110
Local Government	740	970	970	960	990	1010
TOTAL	**2,920**	**3,200**	**3,070**	**3,050**	**3,040**	**3,120**

Source: Employment Development Department, numbers may not add due to rounding.

According to the 1990 Census, the labor force in Trinity County included 4,951 people and had an unemployment rate of 8.2 percent. Unemployment is the primary economic problem in Trinity County. Unemployment has been consistently higher than the average for the state of California, which had only a 6.6 percent rate of unemployment in 1990. Unemployment in Trinity County reached 15.7 percent in 1993, compared to 9.2 percent for California, and 7.1 percent for the United States. It improved in 1994 to 14.4 percent, but remains above that of the state and the nation. Manufacturing employment is dominated by the wood production industry in this county, according to the EDD (see the chart in the appendix for the historical trend).

Opportunities for young people to find employment are extremely limited and result in a high rate of unemployment for recent high school graduates.The timber-dependent economic base of the community is facing a difficult transition because harvesting has declined significantly in recent years. Watershed restoration and fisheries enhancement work in this watershed provide a source of employment opportunities for local people. This includes equipment work to remove fill from drainages, road maintenance work and recontouring or outsloping of eroding roads and landings, as well as the manual labor required for revegetation, including seeding, planting and mulching.

Income

Trinity County is considered to be a low income area compared to State and national average incomes. Per capita personal income in Trinity County for 1989 was $10,781. The low income level here is reflected in the fact that 18.5 percent of all people living in the county are below the poverty level, and 15.1 percent of families are living in poverty, according to 1990 census data. This can be compared to the California average of 12.5 percent of the population living below the poverty level. By 1992, per capita income for Trinity County was $15,152, compared with $21,348 for California. This county ranks 47th out of the 58 counties in the state in terms of income.

VI-3 WILDLIFE SECTION

I. GENERAL CONDITIONS

BIRDS

Current Condition

Evans (1980) surveyed the bird species in the Trinity basin and reported 121 species. Fixed point count surveys conducted in 1990 (Wilson et al. 1991) provided information on the relative abundances of 127 bird species, 22 of which were in addition to Evan's list. Table 1 lists the species from both studies. The author specifies that counts are representative of abundance, with the exception of the less vocal species, including herons, waterfowl, spotted sandpipers, American dippers and belted kingfishers. Twenty-eight species were found exclusively in riparian habitats, 6 were exclusively found in upland habitats and 45 were found in both habitats. Of those found in riparian habitats, a few showed an association with a particular riparian type (willow-dominant, willow-alder, mature-alder). These included the willow flycatcher, which occurred only in willow or willow-alder mix (see below). Yellow warblers, yellow-breasted chats, rufous-sided towhees and Wilson's warblers were more abundant in willow vegetation.

Visual surveys conducted by boat in 1990 (Wilson et al. 1991) provided information on the abundances of river dependent birds. Trends in habitat associations of these birds were reported. Green-backed herons and great blue herons were most often observed along runs (as opposed to pools, glides, or rapids). Belted kingfishers were more abundant in the upper reaches (reaches 1-5, Figure 1). This may be attributable to the greater number of snags in the upper reaches, to the greater density of fish prey near the hatchery or to the presence of suitable nesting habitat. Nest locations for belted kingfishers were found on reaches 2, 3, 4, 13, and 16. Common mergansers were more common in the upper reaches. Wood ducks were scarce on the mainstem Trinity; those that did occur were mostly in pools and runs. Mallards were present but apparently not reproducing. American dippers were found nesting, primarily near rapids and runs. Spotted sandpipers were quite abundant, with densities highest in the lower reaches (furthest from the dam). Ospreys occurred in low numbers, as did Cooper's hawks and sharp-shinned hawks. Although some of these raptors were present during the breeding season, only a single osprey nest was found.

In general, bird species richness on the mainstem Trinity River is high compared to other riparian locations in the west (eg. Gaines 1977, Motroni 1984). Wilson et a.l (1991) speculates that the proximity of the upland habitat along the river may result in unusually diverse conditions that can support a variety of birds.

Historic Condition

Although there is no specific information on bird abundances prior to construction of the dams, we can speculate about how the habitat changes may have affected various species. The elimination of seasonal high flows as a result of the dam has promoted the accumulation of dead woody debris along the mainstem Trinity. Historically, the flows would have moved this debris downstream annually. Green-backed herons forage from concealed and shaded perches just above the water (Grinnell and Miller habitats, sampling occurred during the summer when dry conditions may confine them to riparian areas. Western fence lizards occurred in gravel bars and upland traps, but rarely in riparian. Sagebrush lizards were most common on gravel bars, while western skinks were most common in the uplands. The distributions of these lizard species are consistent with what is known about their habitat associations (Marcellini and Mackey 1970, Rose 1976).

Historic Condition

Reptiles and amphibians have such diverse habitat requirements that it is difficult to generalize about how changes along the mainstem Trinity have affected them. Reptiles that are associated with clearings, such as fence and sagebrush lizards, may be more common now than historically as a result of the additional clearings generated by logging activities. In contrast, species that are associated with forest habitats (e.g. skinks), may have declined. Amphibians overall are likely to have been more abundant historically because logging operations, especially along tributaries, have eliminated the cool, moist microhabitats that they require. Also, suitable aquatic breeding habitat for some species (e.g. yellow-legged frog, see below) has become scarce because of flow regulation in the main stem.

MAMMALS

Current Condition

A variety of mammals inhabit the Trinity River basin, including Columbian black-tailed deer, black bear, mountain lion, coyote, gray squirrel, porcupine, raccoon, gray fox, river otter, beaver, muskrat, mink, spotted skunk, striped skunk, ringtail cat, badger, bobcat, fisher, and possibly marten and wolverine (USDA Soil Conservation Service 1981, USDI Fish and Wildlife Service 1983).

Evans' (1980) list of mammals occurring on the mainstem Trinity River included 38 species. A list generated from surveys of the Hamilton site in the vicinity of Grass Valley Creek included 15 observed species as well as an additional 36 expected to occur there (CAL Fish and Game 1986). Nearby surveys of the Buckhorn Mountain site reported 14 species with an additional 45 expected to occur (CAL Fish and Game 1978). Subsequent pitfall trapping (Wilson et al. 1991) provided information on the relative abundance of 11 mammal species along the entire 40 miles of mainstem within the watershed analysis boundary. Table 3 contains a species list compiled from all studies. In general, mammals were more abundant on the middle reaches of the river. Wilson et al. (1991) speculates that this is a result of the confined channel morphology of this section of river, specifically that upland habitats are closer to the river, creating more habitat diversity. Shrews were caught in much greater abundance than any other mammal species. Among the riparian types, shrews were most common in mature/alder habitat.

Other mammals were detected visually during float surveys. These included river otters, which were seen on eleven of the sixteen river reaches. The majority of detections were in run habitats. Beavers were abundant throughout the study area. Like otters, they mostly used run habitat and pools to a lesser extent. Minks were seen on nine reaches and were most common on reach 2.

Management. One goshawk eyrie is known to exist within the watershed area (Cal Fish and Game 1994). It was an active nest that fledged two young in 1980, but failed in 1981. There is no information on subsequent years.

Historic Condition

There is not specific historical information on goshawks within the Trinity watershed. The total breeding population in California is thought to be quite small. Since most of their habitat occurs on public lands, habitat destruction is a small threat, while the threat from logging may be significant (Remsen 1978). Goshawks typically inhabit mature forests with dense canopies and sparse understory vegetation (Bloom et al. 1986, Crocker-Bedford and Chaney 1988, Fowler 1988, Reynolds 1983). They construct nests in the largest trees, often those that occur near small breaks in the canopy. The proximity of riparian areas seems also to be important to this species in that nests are usually within one mile of the water (Bloom et al. 1986). Historic and continuing logging along the Trinity River decreases the amount of mature forest type with which the goshawks are associated. Timber harvest has been shown to reduce nesting success of goshawk populations, eventually resulting in displacement by other raptors (Crocker-Bedford 1990).

Sharp-shinned hawk (*Accipiter striatus*)

Current Condition

The sharp-shinned hawk is state listed as a Species of Special Concern and has been sighted along the mainstem Trinity River.

Historic Condition

Sharp-shinned hawks historically bred in small numbers throughout northern California. The breeding population appears now to be greatly reduced from historical levels, although data are lacking (Remsen 1978). This smallest accipiter species mostly nests in conifer trees within dense stands where nests can be concealed from falcon predators (Moore and Henny 1983, Reynolds et al. 1982). Logging along the mainstem Trinity River is a potential hazard to this species to the extent that it removes or thins conifer stands.

Golden eagle (*Aquila chrysaetos*)

Current Condition

The golden eagle is state listed as a Species of Special Concern as well as California Fully Protected. It occurs along the mainstem Trinity River.

Historic Condition

Golden eagles were once common permanent residents throughout California. Populations are now smaller, but potentially stable (Remsen 1978). Threats to this species include agriculture, shooting and

Prior to 1947, peregrine falcons were fairly common in California (Recovery Plan). After that, the use of organochlorine pesticides, DDT in particular, caused precipitous declines of this species. The primary impact of DDT was to cause eggshell thinning and consequently lowered reproductive success. Prior to construction of the Lewiston/Trinity dams, there were no documented peregrine sightings on the Shasta-Trinity National Forest (Roberts 1993). This may be attributable to the impacts of DDT in that there was a sharp decline in the number of breeding pairs in California throughout the 1950's and 1960's; by 1970 there were estimated to be fewer than five active pairs in the state.

Peregrines utilize habitat for nesting, perching, roosting and foraging. Nesting occurs on cliffs near the water; in contrast to bald eagles, peregrines are not known to nest in trees. The most preferable sites appear to be on tall, sheer cliffs with small caves or overhung ledges. Peregrines forage in wooded areas, marshes, open grasslands, shorelines and bodies of water. Their diet consists almost entirely of birds. Because they utilize a variety of habitats, it is not clear how their foraging needs have been affected by mining, logging and damming along the mainstem Trinity River. It is known that peregrine falcons are particularly sensitive to human disturbance and will abandon nests after humans have been in the vicinity (Pacific Coast Recovery Plan 1982).

Bald eagle (*Haliaeetus leucocephalus*)

Current Condition

The bald eagle is Federally listed as a Threatened Species (having been reclassified from Endangered; Federal Register on July 12, 1995). It also has a California Endangered listing and is a California Fully Protected Species. Bald eagles were detected in low numbers by Wilson et al. (1991). Sightings were restricted to reaches 1, 5, and 10. No nests or young birds were found. However, nests are also known to exist just upstream of the watershed boundary in the vicinity of the dams (Cal Fish and Game 1994). One nesting territory was discovered in 1970 and reportedly was active for several years prior. Although no nesting occurred from 1987-1990, this territory was otherwise occupied and successful. Another nesting territory was identified in 1971. No data was taken until 1977, when one fledgling was produced. It was then not checked until 1981, when it was found to be occupied but not successful. From 1982-1989, there were 1-2 young produced annually. Finally, a third nesting territory was discovered in 1986. From 1986-1987, one young was fledged per year. From 1988-90, two young were fledged per year. Roberts (1993) reports that the bald eagle territories around Trinity and Lewiston Lakes have been monitored since 1989. The average number of young fledged per nesting territory has ranged from 0.4 to 1.0, while the percent of successful nesting pairs has ranged from 25 percent to 100 percent between 1989 and 1993.

Historic Condition

It is not known what the historic population densities of bald eagles were on the mainstem Trinity River. They were undoubtedly subject to the impacts of toxic pesticides (2-4-5-T and DDT) that reduced populations of many raptors throughout their ranges after their introduction in 1947. Eagles may now be in an upswing as those pesticides become more scarce.

Speculation exists about how habitat alterations as a result of logging may have influenced eagle populations. Bald eagles nest in large trees that provide good visibility of the surrounding area

Short-eared owl (*Asio flammeus*)

Current Condition

The short-eared owl is state listed as a species of special concern. Small numbers of this species used to breed locally throughout California in marshes and grasslands. It is not known whether this species occurs on the mainstem Trinity River, which falls within its range.

Historic Condition

No historical information exists regarding the presence of this species on the mainstem Trinity River. Throughout its range few nesting localities remain, primarily as a result of destruction of marsh and tall grassland habitat. Shooting also constitutes a significant impact (Remsen 1986). Although shooting may have reduced populations on the mainstem Trinity River, grazing has not been very prevalent in this region.

Long-eared owl (*Asio otus*)

Current Condition

The long-eared owl is state listed as a species of special concern. It is not known whether it occurs along the mainstem Trinity River.

Historic Condition

Long-eared owls used to be abundant in many parts of California. No specific information exists for the mainstem Trinity River. However, this species has declined throughout its range since the 1940's (Grinnell and Miller 1944, Remsen 1986). Destruction of riparian habitat has been cited as a cause of decline. This suggests that the increase in riparian vegetation since construction of the dam may constitute improved conditions for this species along the mainstem Trinity River. However, the absence of this species from existing riparian habitats indicates that other factors are involved (Remsen 1986).

Northern spotted owl (*Strix occidentalis caurina*)

Current Condition

The spotted owl is State listed as a Threatened Species. It also is Federally Threatened and a U.S. Forest Service Sensitive Species. Spotted owls have been found at 32 locations within the watershed boundary (Cal Fish and Game owl database 1994; Table 5). These "activity centers" were identified at various dates from 1980-1992; they range from single owl sightings to sightings of pairs and/or young. Twenty-one of the activity centers are considered existing and reliable, having hosted territorial singles or pairs at some time during the period of 1988-1993. Nests have been discovered in four of these reliable activity centers.

Historic Condition

The yellow warbler is a riparian obligate species. Speculation exists that is has become more abundant on the mainstem Trinity River since construction of the dams and the resulting increases in riparian acreage. However, it is also susceptible to parasitism by the brown-headed cowbird (Gaines 1974), a species which was found to be very abundant along the Trinity River (Wilson et al. 1991). Since the cowbird inhabits mature riparian plant associations (Grinnell and Miller 1944), it is likely to be substantially more abundant than prior to the dam. The increased abundance of this parasite may more than compensate for any benefits derived by yellow warblers from additional habitat.

Willow flycatcher (*Empidonax trail*)

Current Condition

The willow flycatcher is State listed as an Endangered Species. It is also a Category 1 Candidate for a Federal listing and a U.S. Forest Service Sensitive Species. Surveys conducted during 1990-1992 (Wilson 1995) revealed the presence of willow flycatchers on the mainstem Trinity River. They occurred on the following reaches: 1-4, 9, 14-16 (Figure 1). Table 3 provides details of their specific locations. All the sightings in 1990 occurred in willow-dominant habitats; thus survey efforts were concentrated in these habitats during 1991-1992. Although males were observed counter-singing (a phenomenon associated with breeding), there was no direct evidence for reproductive activity at this site during any of the survey years. The mainstem site may be restricted to providing migratory habitat for this species. Further research is needed.

Historic Condition

Specific information on the historical abundance of willow flycatchers on the mainstem Trinity River does not exist. However, it can be postulated what it must have been, considering their habitat requirements in relation to historical conditions at this site. These birds are known to be associated with willows, preferring a clumped, noncontiguous distribution. Willow cover of 50-70 percent is thought to be optimal (Grinnell and Miller 1944, Kings River Conservation District 1985, Sanders and Flett 1989). Historically, they nested throughout California where mesic willow thickets occurred (Grinnell and Miller 1944). Their decline during the last few decades is believed to result mostly from the loss of riparian habitats.

Willow-dominant and willow-alder habitats have become more abundant on the mainstem Trinity River in terms of total acreage since construction of the dam. Unvegetated gravel bars used to be more prevalent (Wilson 1994). It is likely, therefore, that willow flycatchers have increased in numbers since the construction of the Lewiston/Trinity dams and the consequent expansion of riparian vegetation. Wilson's (1993) surveys on the South Fork Trinity River support this hypothesis. This undammed portion of the Trinity River drainage experiences regular flood stage flows that scour the riverbanks of vegetation, resulting in low densities of willows. In this respect, it resembles the conditions that existed on the mainstem Trinity River prior to construction of the dams. During four days of surveying on the South Fork, no willow flycatchers were detected.

Historic Condition

The abundance of purple martins is tied to availability of suitable nest sites, which consist often of old woodpecker holes in dead trees. Assuming that snag density along the mainstem Trinity River has decreased as a result of logging operations, nest sites may be less available than they were historically. Also, purple martins are known to be impacted by competition with introduced starlings, which have spread into the Trinity area.

HERPETOFAUNA

Black salamander (*Aneides flavipunctatus*)

Current Condition

The black salamander is one of the species intended to benefit from Riparian Reserves, particularly reserves near headwater and intermittent streams. Black salamanders have been found at several locations within the watershed (Lynch, J. 1981). Captures have occurred in both the riparian and upland zone (Wilson et al. 1991).

Historic Condition

There is no direct information on densities of black salamanders in the Trinity Basin. They inhabit coniferous and mixed coniferous-deciduous forests, as well as talus slopes (Nussbaum et al. 1983). We can infer from their habitat requirements that they have been affected by logging in that they utilize the crevices of decaying logs or stumps (Leonard et al. 1993). Like most amphibians, they rely on the presence of moist microclimates. Depending on the intensity of logging practices along the mainstem Trinity River, habitat suitability for this species may or may not have been reduced.

Tailed frog (*Ascaphus truei*)

Current Condition

The tailed frog is a Species of Special Concern in the state of California and a California Fully Protected Species. Tailed frogs have been found outside of the watershed boundary in the east fork of Stuart Creek two miles west/northwest of Covington Mill (Natural Diversity Database). They were also found within the watershed boundary in a reach of Grass Valley Creek (California Department of Fish and Game surveys 1994).

Historic Condition

There is no specific historical information on the distribution of tailed frogs within the Trinity River watershed. This species is restricted to perennial montane streams with a water temperature of less than 15 degrees celsius. Welsh's (1993) work indicates that tailed frogs are associated with habitat variables indicative of older forests (more logs, ferns, canopy closure, etc.). They occur in montane hardwood-conifer, redwood, Douglas fir and ponderosa pine habitats. Thus, logging of old coniferous forests in the vicinity of perennial streams is likely to have a deleterious impact on this species.

and a small tributary of the upper reaches of Canyon Creek. Specimens have been taken from Black Basin in the Deer Creek drainage, Ward Lake in the Swift Creek drainage and Upper Nash Mine (Bury 1973). Discovery of the Trinity Alps populations extended the known range of this species by 50-60 air miles.

Historic Condition

Cascade frogs are currently Category 2 Candidates for a Federal listing. The population in the Trinity Alps region is sufficiently differentiated from populations in the Oregon Cascades that it has been misidentified and may warrant species recognition (Jennings and Hayes 1994). This species oviposits in open, shallow waters of streams and ponds and overwinters in saturated ground. It appears to be associated with aquatic systems that lack predatory fishes. Field surveys indicate that it has become extremely rare at historic locations and is thriving only in lake or ponded stream situations where few fishes are present. Considering that lakes in the Trinity Alps have been stocked with rainbow trout, brook trout and brown trout (Barnhart et al. 1990), there are likely to have been impacts on Cascade frogs. This species was undoubtedly more abundant prior to the arrival of Europeans and the advent of fish introductions.

Western pond turtle (*Clemmys marmorata*)

Current Condition

Surveys conducted from 1991-1994 along the mainstem Trinity River provided information on the abundance of western pond turtles (Wilson et al. 1991, Lind et al. 1992, Reese and Welsh 1994a). Turtles were present on nearly all reaches of the river with highest abundances in reaches 3, 11, 12, and 13 (Figure 1). They were associated with deep, slow-flowing areas such as edge pools and backwater pools.

Population modelling indicates that there are approximately 1300 turtles along this 63-kilometer stretch of river (Reese and Welsh, unpublished data). This translates to a density of 8.3 turtles per hectare. Compared to other sites for which there is current density information, the mainstem Trinity River site has relatively low densities. For example, densities in excess of 1000 turtles occur in some stream sites in California (Holland 1991). Surveys of Hayfork Creek, a stream in relatively close proximity to the mainstem Trinity River, revealed a density of 662 turtles/hectare (Bury 1972).

Historic Condition

The western pond turtle is a State Species of Special Concern, a California Fully Protected species, a Category 2 Candidate for a Federal listing and a U.S. Forest Service Sensitive Species. Its populations are in decline throughout the state due to a variety of factors, including habitat alteration, introduced predators, drought and human exploitation. Historically, this species was extremely abundant in California, particularly in the shallow lakes of the Central Valley (Holland 1991). It appears that viable populations remain in only a few parts of its range, one of which is portions of the Trinity River watershed. Two decades of monitoring on Hayfork Creek indicate that turtle populations there are stable.

River from hydraulic mining may have impacted roosting and hibernation habitat, but also generated new caves that are habitable by this species. The increase in riparian vegetation resulting from flow changes associated with the dam is likely to have benefited pallid bats by providing more breeding habitat. Because they are extremely sensitive to disturbance while roosting, noisy human activities (eg. logging operations, off-road vehicles) may cause them to abandon roosts.

Little brown myotis (*Myotis lucifugus occultus*)

Current Condition

The little brown myotis is a State species of Special Concern as well as a Category 2 Candidate for a Federal listing. It may occur in the Trinity River watershed (CAL Fish and Game 1986, CAL Fish and Game 1979), given its range and habits. It is associated with pine forests at elevations from 6000 to 9000 feet (Barbour and Davis 1969).

Historic Condition

No specific information exists on historical distribution of little brown myotis in the Trinity River watershed. This species breeds in riparian deciduous habitat, as well as dense, mature forest stands. It inhabits a variety of day roosts, including buildings, caves and bark crevices. Hibernation occurs in colonies in humid caves and mine shafts that maintain above-freezing temperatures through the winter (Brown-Berry 1992, U.S. Forest Service 1979). Hydraulic mining is likely to have increased the availability of overwintering caves. Conversely, logging, by eliminating mature stands, may have reduced breeding habitat. Human disturbance of hibernating individuals has been cited a factor in the decline of this species in general (Williams 1986).

Townsend's western big-eared bat (*Plecotus townsendii townsendii*)

Current Conditions

The Townsend's western big-eared bat is a state Species of Special Concern as well as a Category 2 Candidate for a Federal listing. Although sightings have not been reported within the mainstem Trinity River watershed, its range includes this area.

Historic Conditions

No historical information exists for this species in the Trinity River watershed. In general, its populations may have increased prior to the 1950's, due to increased roosting sites in manmade structures (Pearson et al. 1952), but then declined markedly over the last 40 years (Williams 1986). Townsend's western big-eared bat roosts in caves, mine tunnels and buildings (Pierson 1988), which also serve as natal roosts. The hydraulic mining at the turn of the century may have caused immediate disturbance to colonies, with potential increases in mortality (U.S. Forest Service 1979), while providing the long-term benefit of mining caves. This species is most frequently found in old mines (Brown-Berry 1992). In parts of its range, management efforts have focused on preserving mines and gating their entrances (Pierson and Brown 1992, Tuttle 1977).

Historic Condition

Ringtail cats were captured in the Helena area in the early 1900's (Kellogg 1916). Their preferred habitat includes riparian deciduous and open, brushy forest stands, where they forage primarily for rabbits and rodents. They nest in hollow logs, trees or rock crevices and are found near to water. The increase in riparian habitat along the mainstem Trinity River as a result of the dam may have benefited ringtails by providing foraging habitat and increased vegetative cover adjacent to the river. The development of road networks is likely to have been deleterious to this wide-ranging cat that frequents rocky ridges.

Wolverine (*Gulo luscus*)

Current Condition

The wolverine is currently listed as Threatened in California (as well as California Fully Protected), and is a Category 2 Candidate for a Federal listing. Wolverines may exist on the more remote portions of the Shasta-Trinity National Forest, although they are difficult to observe given their solitary, cryptic habits.

Historic Condition

Although there is no specific information on historic wolverine abundances along the mainstem Trinity River, it can be inferred that they must have been more abundant throughout their range prior to the trapping boom at the turn of the century. During this era of intense harvest for pelts, many furbearers suffered drastic declines. Wolverines were believed to be near extinction in the early 1920's (Dixon 1925 and Fry 1923 cited in Banci 1994). Wolverines may have been less impacted than some other species, eg. fishers, because of the wolverine's association with remote high-elevation forests. Habitat for wolverines generally occurs at 6000 feet or above, although they do frequent lower areas during the winter.

Wolverines appear to avoid large openings the forest, typically inhabiting areas that harbor a mosaic of mixed conifer and small grassland openings. Thus, historic logging operations that created large clearcut areas are likely to have had a negative impact on wolverine populations. Overall, refugia (extensive wilderness areas that are not trapped or subject to human land-use practices) appear to be important to this species (Banci 1994). Their habitat is perhaps best defined not by particular plant associations, but by the presence of large wilderness areas with adequate food supplies (Kelsall 1981 cited by Banci 1994).

Wolverines are scavengers of carrion, with large mammal carrion being of paramount importance. In the Trinity watershed, this component is likely to consist mostly of deer. Thus, any impacts to deer herds could have ramifications for wolverines as well. Some land-use activities, such as logging and burning, boost deer herds by promoting early seral stages of vegetation, but may exclude wolverines by interfering with their other life needs (Banci 1994).

recover. The population in northwestern California has remained stable since the early part of the century and may be the largest population in the western states (Powell and Zielinski 1994).
Although only one natal den has been identified in California, information from throughout their range indicates that fishers den high in cavities in dead or living trees. Fishers appear to prefer late successional coniferous forests in the Pacific states, and therefore are likely to nest in conifers. The single nesting record occurred in a ponderosa pine. Powell and Zielinski (1994) propose that females are highly selective of habitat for natal and maternal den sites. If so, fishers are likely to have been heavily impacted by historic logging on the mainstem Trinity River and were more abundant prior to the timber boom.

Forest structure appears to also be relevant to fishers. They are associated with habitats that have high canopy closure and complex physical structure. They avoid nonforested areas, such as recent clearcuts and large forest openings. Powell and Zielinski (1994) propose that the complex structure leads to high diversity of accessible prey populations as well as dens and resting sites. This may explain their more frequent utilization of late-successional forests than early or mid-successional forests in the Pacific northwest. Large openings created by the removal of timber and salvage of dead wood are likely to have decreased habitat suitability for this species.

The diets of fishers in California are composed primarily of mice, voles, shrews, moles and squirrels, in addition to plant materials (Grenfell and Fasenfest 1979, from Powell and Zielinski 1994). To the extent that these small mammals are affected by the dam-related vegetation changes, fishers may be affected as well. Assuming that predator densities are prey-dependent, fishers may have indirectly benefited from the increase in mature riparian vegetation via an increase in shrew abundance.

Fishers usually react to humans with avoidance. They tend to be more common where densities of human are lower and disturbance is reduced. Increasing human settlement along the mainstem Trinity River is therefore likely to have impacted fishers.

Badger (*Taxidea taxus*)

Current Condition

The badger is a State Species of Special Concern. Given its range and habits, it may occur in the Trinity River watershed (Evans 1980, Siperek and Smith 1979).

Historic Condition

There is no specific information on historical abundance of badgers along the mainstem Trinity River. Badger populations in California declined drastically within the last century (Grinnell et al. 1937, Longhurst 1940), primarily as a result of deliberate killing as a 'pest' and their inability to survive on cultivated and urban land (Williams 1986). These impacts are not likely to have been foremost along the Trinity River, considering that human densities are relatively low. Trapping, however, may have had a significant impact; the fur trade during the 1920's-30's was substantial. There was subsequently a lull, during which badger pelts were of low economic value. After 1975, their value increased again, with concomitant increases in capture (Williams 1986).

The Weaverville deer herd appears to have declined substantially as a result of the Lewiston and Trinity dams. The construction of the reservoirs inundated 6,980 acres of winter range, which Kie et al. (1982) deemed responsible for a decline of over 4,000 deer. The Weaverville herd historically was larger than its neighboring herds, but after 1962 was smaller for nearly all years through 1978.

Other factors have also impacted the herd, including logging practices and wildfires, by altering the availability of deer browse. Areas with high herbaceous cover, such as forest edges and clearings, are more suitable for black-tailed deer (USFWS 1986). Kie et al. (1982) propose that the decrease in annual timber harvest in Trinity County, which was creating favorable openings in the forest, has contributed to declines in the herd since 1966. Additionally, the absence of major wildfires since 1964 has not allowed for the natural generation of meadows with early-successional vegetation.

INTRODUCED SPECIES

Brown-headed cowbird (*Molothrus ater*)

Current Condition

This species is present on the mainstem Trinity River as a spring/summer resident (Wilson et al. 1991). It has been detected in both riparian and upland habitats.

Historic Condition

Brown-headed cowbirds were introduced from eastern and midwestern parts of the United States during cattle drives during the early part of the twentieth century. They have increased dramatically in the Pacific Northwest region in recent decades (Paulson 1992). They inhabit both forests and grasslands and parasitize the nests of numerous other birds, thereby reducing reproductive success of native species (Brittingham and Temple 1983, Friedmann and Kiff 1985, Gaines 1974, 1977). Since they colonized the mainstem Trinity River, they are likely to have had a deleterious effects on other bird populations. It is not known, however, whether any Northwest passerine is sufficiently rare or local to be threatened by these effects (Paulson 1992).

European starling (*Sturnus vulgaris*)

Current Condition

This species occurs along the mainstem Trinity River between the dam and confluence with the North fork (Wilson 1991).

Historic Condition

European starlings spread into California from the East coast of North America, where they had been introduced. It is not known when they arrived at the Trinity River. They compete with native birds for nestholes, with potentially negative impacts (Paulson 1992). These include acorn woodpeckers and northern flickers (Troetschler 1976, Howell 1943), both of which are present on the mainstem Trinity River, as well as secondary cavity nesters. The impact of starling competition may be minimal in areas

Snags

Snags are an important resource to many birds for nesting and foraging. It is well-documented that cavity-nesting birds depend on a continuous supply of snags (Morrison et al. 1986, Thomas et al. 1979). The density and diversity of cavity-nesting bird species were found to increase with increasing snag densities in Washington forests (Zarnowitz and Manuwal 1985). Wilson et al. (1991) found that of the riparian types along the mainstem Trinity River, alder-dominant vegetation contained the greatest number of snags. Tree swallows, which are secondary cavity nesters, occurred in greatest abundance where snags were abundant. Four woodpecker species (northern flicker, downy woodpecker, hairy woodpecker and red-breasted sapsucker) were confirmed nesting in snags (Wilson et al. 1991). Because northern flying squirrels commonly use abandoned woodpecker holes (Carey 1991), they are secondarily dependent on snags. Wood ducks and common mergansers, which nest in large tree cavities, were present along the mainstem Trinity River, but were not confirmed nesting. Few cavities large enough for these species were found in the riparian zone, but may exist in the upland zone, which was not searched by Wilson et al. (1991).

Snags are also important to some mammal species. For example, fishers raise their young in protected den sites within tree cavities (Powell and Zielinski 1994, see Fisher section). Snags with loose bark provide roosting habitat for bats. One of the changes that has taken place in Northwest forests is reduction in number of snags. This may be responsible for the rarity of woodpecker species in many forests. It also may have impacted species that nest in cavities constructed by snag excavators; there are numerous bird species that fit this description (Paulson 1992). To the extent that salvage and woodcutting continue to reduce snag density on the mainstem Trinity River, a variety of birds and mammals are likely to be affected.

Downed Wood

Downed woody debris is an important resource for salamanders. On the mainstem Trinity River, this includes rough-skinned newts, Pacific giant salamanders, Ensatina and black salamanders, which can all be found in the cool, moist microclimate under logs (Houck 1979, Nussbaum 1983, Stebbins 1985, Welsh 1993). Of these, Ensatina and the black salamander also lay eggs under downed wood. Downed wood also provides cover for snakes, including rubber boas, ringneck snakes, sharp-tailed snakes and kingsnakes. Small mammals that use downed wood include the shrew mole, deer mouse, pinon mouse and long-tailed weasel.

When woody debris reaches the river, it acquires numerous other benefits for wildlife. Not only does it provide underwater cover for turtles, fishes and amphibians, but it also contributes nutrients to the aquatic system. By trapping sediment, instream logs can generate pooled habitat for amphibian breeding. Coarse woody debris has been shown to be important for the functioning of stream ecosystems (Harmon et al. 1986, Maser and Trappe 1984, Wilford 1984). To the degree that logging practices on the mainstem Trinity River remove downed logs, amphibians are likely to be impacted via reduced quality of both terrestrial and aquatic habitat.

magnitude have also had direct effects on higher order species downstream of the dam, such as elimination of rearing habitat for yellow-legged frogs and enhancement of willow-dominant habitat for willow flycatchers.

Decreased flow volumes have permitted the accumulation of woody debris that historically would have been washed out by high winter flows. A number of species might benefit from the basking and cover opportunities provided by the debris. These include fishes, western pond turtles, beavers and riparian-dependent birds that feed along the river. Alterations in flow timing have also occurred as a result of flow management by the Bureau of Reclamation. For some species, shifts from the natural regime have been clearly deleterious, such as the flushing of yellow-legged frog egg masses from their attachment sites. For other species, such as spring-nesting birds that forage in the river, the impacts of the shifted timing are unclear. Overall, it is likely that native species, which are adapted to the natural regime, will suffer from the shifts.

Finally, the presence of the Lewiston and Trinity dams has led to decreased water temperatures in the river. Cool waters are intentionally maintained via release from the bottom of the reservoir to benefit spawning salmonids. Wildlife species that are ectothermic, such that their body temperatures respond to water temperature (e.g. amphibians, reptiles, aquatic insects), may experience reduced growth as a result. For yellow-legged frogs and other species with aquatic larvae, this could mean slowed development of eggs, delayed metamorphosis and consequently reduced reproductive success.

B. Floods

Periodic, natural floods occur in any riverine system. They are responsible for maintaining deep pools by transporting sediment downstream, exposing gravel bars by scouring vegetation, and depositing fine sediments onto floodplains. Although their immediate impacts on wildlife can be deleterious, these periodic processes renew habitat for riverine species.

Flood flows contribute to the maintenance of a natural river channel and morphology including the formation of river meanders, which create wetlands and microhabitat for native amphibians and reptiles. For example, deep pools are established by high flows and are utilized by western pond turtles. Flood flows also set the stage for renewal of riparian associations, eg. by building the floodplain substrates upon which blackberries will grow and provide forage for birds and mammals. Removal of riparian vegetation by flood flows prevents its maturation and maintains habitat for species dependent on early successional riparian vegetation. While some species may favor mature riparian habitat (e.g. willow flycatchers), those with life cycles attuned to the natural river hydrograph may have experienced declines since reduction of flood flows (e.g. yellow-legged frogs).

Large floods occurred on the Trinity River during the years 1861, 1888, 1955 and 1964. However, the frequency and intensity of the latter was dampened by the Trinity River dams and flow management programs. The flood-related processes that renew habitat, therefore, were undoubtedly lessened. Indeed, coupled with reduced annual flows, floods have not been sufficiently powerful to stall the buildup of sediments in pools on the mainstem Trinity River or to remove willows from gravel bars.

quail, band-tailed pigeons and mourning doves. Harvest statistics for some game species are compiled annually by the California Department of Fish and Game on a countywide basis. The Trinity River Basin comprises 92 percent of Trinity County, so harvest data from the county may be interpreted as nearly coincident with the basin. In 1977, trappers took two beaver, 52 bobcat, 47 coyote, 109 gray fox, 20 mink, 73 raccoon and 11 skunk (U.S.F.W.S. 1983). In 1979, hunters reported a harvest of 2,582 deer and 82 bear in Trinity County. Of these, deer are the most heavily hunted now, with populations maintained by monitoring and habitat enhancements.

E. Human Settlement

Human settlement of the Trinity River watershed began thousands of years ago with the arrival of the Chimariko and Wintu peoples. It is difficult to assess the impact of their settlements on wildlife habitats. Although there were numerous villages, their dwellings were small, composed of native materials and lacking the major erosion contributors (roads, asphalt) of modern settlements. Their direct impacts on wildlife were probably relatively minimal.

European settlement during the mid-1800's, in contrast, brought roads, permanent buildings, large towns, ranches, farms, etc. The result was fragmentation of wildlife habitats, particularly for far-ranging but secretive mammals, such as bears and wolverines. For smaller species, entire home ranges were undoubtedly impacted, such as meadows (utilized by moles, gophers, nesting turtles) that were converted to agricultural fields. Roads and dwellings constructed adjacent to the river contributed to the sedimentation that was already occurring as a result of mining and logging. At the height of human settlement at the turn of the century, these impacts on wildlife were probably substantial.

F. Channel Modifications

Efforts to restore the mainstem Trinity River with respect to spawning salmonids have ramifications for wildlife species. For example, mechanical manipulations of the channel have included construction of side channels, feathered edges and dredged pools. For all three project types, the construction itself is likely to have proximal impacts on wildlife because of noise disturbance and movement of materials. Aquatic and riparian species, including amphibians, aquatic reptiles (garter snakes, turtles), wading birds and willow-associated birds (willow flycatchers, yellow warblers, chats), may respond to construction with departure from the area or changes in behavior.

Completed sidechannels provide shallow edgewater habitat. This microhabitat was available prior to construction of the dams and appears to be favored by salmon fry. Other species that may benefit include yellow-legged frogs, hatchling western pond turtles and wading birds (herons, egrets). Similarly, complete side channels offer slower-flowing river margin habitat that provides substrate for yellow-legged frog eggs and foraging ground for semi-aquatic species of birds and mammals. Dredging of pools recreates the deep, cool water conditions that existed prior to the dams; these benefit not only fish but also adult western pond turtles.

G. Logging

Logging was initiated in the Trinity River watershed in the mid 1800's to supply wood for mining operations and consisted simply of small mills adjacent to accessible stands. There were undoubtedly maintain open valleys and trails, stimulate new growth of grasses and shoots, and combat insects and disease. Their fire management scheme, in keeping with the natural cycle of small, frequent fires, is likely to have benefited wildlife. It maintained meadows for small mammals, nesting turtles and grazing ungulates. It also created edges that are favored by many species. For example, chipmunk, ground squirrel, pocket gopher and deer mice habitat improves with the creation of openings (Barnes 1974, Davis 1976, Williams 1955). Granivorous and some insectivorous birds were found to be more abundant in burned areas of pine forest (Blake 1982, Raphael et al. 1987, Taylor and Barmore 1980). "Cool" fires thin the forest such that remaining trees are released from competition and grow larger, eventually providing habitat for birds that are associated with mature stands (e.g. bald eagles, goshawks, spotted owls).

Fires have the short-term impact of removing dominant vegetation and altering moisture regimes. Immediate impacts on wildlife can include injury or death, reduction in food and cover, and consequently increased exposure to predation. However, several months after a fire, herbaceous plants experience a growth surge in response to the altered conditions, at which time small mammal species and ungulate grazers may benefit (Ream 1981).

The advent of European settlement in the 19th century brought a new strategy of fire suppression, which is likely to have had deleterious effects on wildlife. In the absence of frequent fires, meadows gradually succeed to forest. Trees become dense and spindly. When natural fires do occur, they are catastrophic as a result of the accumulated fuel load in the forest. Severe fires have been equated with heavy logging in terms of their effects (Blake 1982). They burn over huge areas, potentially fragmenting the home ranges of large mammals (e.g. bears, cougars, wolverines). Hot fires can remove all cover, making habitat unsuitable, e.g. for rabbits (Keith and Surrendi 1971). Elimination of large swaths of living trees may displace flying squirrels (Gashwiler 1970). More wildlife are likely to perish immediately in a hot fire, particularly those inhabiting subterranean burrows and nests (e.g. rodents, western pond turtle neonates). Important wildlife features, such as snags (for raptors) and downed logs (for salamanders) may be consumed by the fire. Rainfall after such a large fire can cause substantial sedimentation of the river with its associated consequences for aquatic wildlife.

J. Recreational Vehicles

Off-road vehicles are used along the Trinity River for recreation and, less frequently, transportation. To the extent that they are driven through wilderness areas, they are likely to disrupt the activities of secretive species such as cougars, fishers and wolverines. Heavy, frequent use has the potential long-term impact of destroying vegetation and compacting soils. In meadow areas, this could cause damage to rodent burrows and western pond turtle eggs. In riparian areas, it could destroy habitat for bird species (e.g. yellow-breasted chats, yellow warblers) and small mammals (e.g. shrews). Off-road vehicle use may also increase sedimentation of aquatic habitats and disturb the water in stream channels, potentially affecting aquatic species such as amphibians.

K. Drought

One of the major natural disturbances to aquatic and riparian wildlife species is drought. Water temperatures increase due to lower inflows of snowmelt waters. Species that are sensitive to temperature changes, including fishes, amphibians and aquatic reptiles, may react to this increase.

were introduced from the eastern United States and are detrimental to native species. By parasitizing nests, they reduce the reproductive success of native birds.

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January 7, 1997

To: Editorial Page Editor

From: Gwen Mason, Assistant Director for Communications, Bureau of Land Management, Washington, D.C.

A recent article by the Associated Press presented a highly sensational and grossly inaccurate portrayal of the Bureau of Land Management's wild horse adoption program.

The article maligns the motivations of thousands of conscientious citizens who come to the rescue of the wild horses we offer for adoption and do so solely because of their love for these magnificent creatures.

In response to the Associated Press article, Tom Pogacnik, the Chief of BLM's Wild Horse and Burro Program, has written the attached op-ed. We urge you to find space for this op-ed in your newspaper so that we can set the record straight about this important, noble program.

Should you have any questions you may reach me at 202 208-6913.

Thomas Pogacnik

AP Article A Disservice to Thousands of Wild Horse Adopters

The recent Associated Press article on the Bureau of Land Management's (BLM) wild horse adoption program gave readers the false impression that many of the animals adopted each year are sent to slaughter. This is just flat-out wrong. The article does a terrible disservice to the thousands of people who invest their time, money and heart to provide these animals with good homes. It is rife with inaccuracies and relies heavily on speculation that cannot be verified. It also attributes comments to me that I did not make.

The BLM is committed to doing all that it can to ensure that wild horses are adopted by people who provide humane care. That is why BLM will not issue legal title for an animal until an adopter can prove that he or she has taken good care of the animal for at least a year. During that time, the BLM tracks the animal through computerized records and spot checks adopters. The BLM has regulations that prohibit the sale of the animal, prohibit its use in rodeos, and prohibit neglectful treatment of the animal. The federal government prosecutes people who violate these laws. For example, in the years 1985 to 1995, the BLM investigated numerous possible violations related to the wild horse and burro program resulting in 125 convictions, despite the fact that these are often difficult cases to prove.

After one year of humanely caring for an animal, an adopter can apply for and receive legal title to a wild horse or burro. Once title is issued, the animal is private property. The BLM does not track horses and burros after title is issued. However, if the BLM discovers that an adopter intends to sell the horse for slaughter, title will not be issued. The one-year waiting period serves as a deterrent to people who want to immediately profit by selling their titled animals. The cost of caring for an animal for a year runs between $500 and $1,000 or higher, depending on the part of the country, making it economically impractical for people to immediately profit after title is issued. Despite these safeguards, do some wild horses that are titled and no longer under federal protection wind up in slaughterhouses? Obviously, some do. However, none of the animals cited in the article were federally protected. These animals were privately owned.

It is typical for most domestic horses to pass to new owners several times through sales and auctions throughout their lives. This does not mean that these animals end up at slaughterhouses. There is simply no data to support AP's claim that the majority of wild horses are trucked to slaughter. Moreover, the assertion that I concurred with AP's claim is nonsense. I made no such statement and would not entertain that kind of speculation.

In addition, the article implied that BLM employees routinely profit by adopting wild horses and burros. The BLM does not give preferential treatment to employees in adopting wild horses and burros. They must abide by the same laws and regulations as everyone else. Many BLM wild horse and burro specialists entered the program because of their love for the animals. The reporter spoke to several BLM employees who have adopted animals and have had title to them for years who are dedicated to their animals' care. Unfortunately, those stories were not included in the AP article.

The BLM works hard to strike a balance between ensuring the humane care of these animals and respecting private property rights. Should BLM be responsible for these animals throughout their lives d and not just until title is passed? That is a decision for lawmakers. However, more than 150,000 animals have been adopted since the program first began in 1973. The cost to taxpayers to have the federal government care for these animals throughout their lives would be enormous.

Wild horses and burros have no natural predators and reproduce at rate of about 18 percent a year. The forage and water on the public range, which these animals share with wildlife and domestic livestock, cannot sustain unchecked horse and burro populations. Without intervention, the result for many animals would be a slow, gruesome death from starvation and dehydration.

Adoption is the best tool the BLM has for providing for the humane care of animals removed from the range. The BLM is careful to screen all adopters to make sure they have no convictions for inhumane treatment to animals and to ensure their facilities meet safety standards. The adoption program is extremely popular with the public. We know that many adopters develop lasting relationships with their animals because we see them year after year as volunteers and at wild horse and burro shows throughout the country. These owners take great pride in their efforts to tame and train these wild animals. The AP story paints a distorted picture; it is a disservice to the thousands of Americans who dedicate themselves to caring for wild horses and burros.

Thomas Pogacnik is Chief of the Bureau of Land Management's Wild Horse and Burro Program.