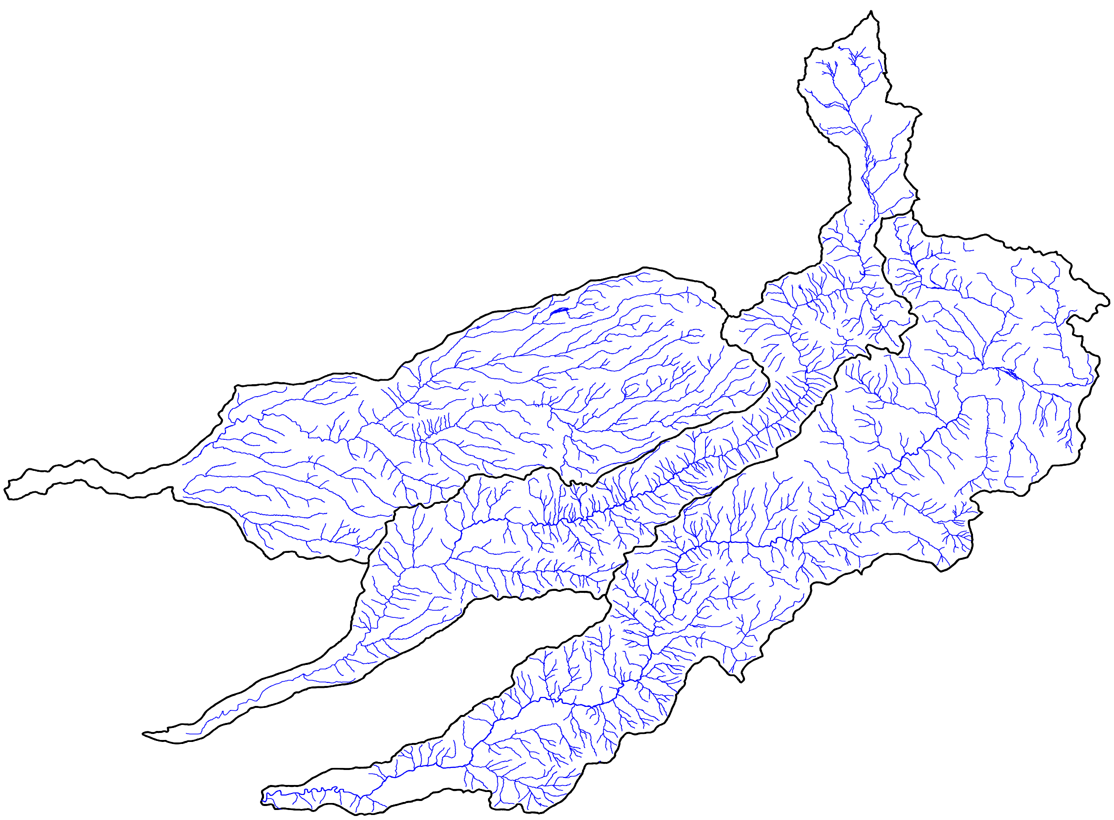
Watershed Analysis
for
Mill, Deer, and Antelope Creeks



Watershed Analysis
For
Mill, Deer, and Antelope Creeks
Almanor Ranger District
Lassen National Forest

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WATERSHED ANALYSIS SUMMARY

I. INTRODUCTION

Objectives of this Analysis:

The impetus for this Watershed Analysis is Pacfish (Interim strategies for managing anadromous fish-producing watersheds on Federal lands in eastern Oregon and Washington, Idaho, and portions of California) that amended the Lassen National Forest Land and Resource Management Plan in March of 1995. Pacfish provided interim direction for management of watersheds supporting anadromous fish, and directed that a long-term strategy be developed to conserve anadromous fish habitat. Watershed Analysis is one means used to determine what should be included in the long-term strategy.

Specifically, objectives of Watershed Analysis outlined by Pacfish as follows:

1. Screen current watershed conditions, by:

    - characterizing the geomorphic, ecologic and hydrologic context of a watershed, and identifying uses in the watershed

    - determining the type, extent, frequency and intensity of watershed processes, including mass soil movements, fire, peak and low streamflows surface erosion, and other processes affecting flow of water, sediment, organic material and nutrients through a watershed

    - determining the distribution, abundance, life histories habitat requirements and limiting factors for fish and other aquatic and riparian dependent species

    - identifying parts of the landscape, including hill slopes and channels, that are either sensitive to specific disturbance processes or are critical to beneficial uses of water, anadromous fish stocks or other species

2. Interpret watershed history, including effects of previous natural disturbances and land use activities on watershed processes

3. Provide information necessary to establish ecologically and geomorphically appropriate boundaries of Riparian Habitat Conservation Areas

4. Provide information necessary to establish ecologically and geomorphically appropriate Riparian Management Objectives

5. Identify potentially necessary adjustments to resource output projections

6. Identify appropriate watershed restoration objectives, strategies and priorities

7. Provide information necessary to design approaches for evaluating and monitoring the effectiveness of standards and guidelines for mitigating impacts of current uses and contributing to the attainment of Riparian Management Objectives, and the effectiveness of restoration efforts in correcting past degradation

8. Monitor and identify appropriate modifications to projects and activities to improve or maintain watershed condition

Additionally, an objective of the analysis is to compare recommended actions with the Lassen Land and Resource Management Plan, to assess the need for changes in that document (as amended by Pacfish).

Approach:

The Watershed Analysis (WA) team used core questions from the Watershed Analysis Guide to focus efforts. Functional specialists characterized the watersheds and attempted to determine how existing condition of important processes, functions and elements compared to historic or reference conditions. These reports are included in the WA as appendices. After collecting information, the team met to discuss and integrate findings, and identify those elements, processes or issues that should be brought forward for further discussion.

The main body of this report is an attempt to summarize the team's discussion, findings and integration. Not all issues, questions, processes and indicators are addressed in this summary. The team for a variety of reasons selected those included. Most were based on a difference between existing and reference condition (at some scale), but others were chosen because of the significance of a watershed resource (at some scale). Other elements are addressed because of Pacfish direction to do so (RHCAs and RMOs, for instance).

Limitations of this Analysis:

The primary objective of this watershed analysis is to assist in development of a long-term strategy for conservation of anadromous fisheries habitat on Forest Service lands within the Antelope, Deer and Mill Creek watersheds. This objective requires a focus on issues and questions that relate to management of federal lands within the basin. If the Watershed Analysis process did anything, it pointed out the degree to which all parts and uses of the watershed are important to its function. Processes and resources do not recognize administrative boundaries. We think the analysis does an adequate job of recognizing processes, issues and elements regardless of their administrative control or location and providing a context into which management of Forest Service lands within the watershed fit. However it does not (because a Forest Service Management Strategy cannot) provide specific recommendations for actions on lands not managed for the public by the Lassen National Forest. As the analysis shows, none of the important issues in these watersheds are limited to Forest Service lands, and many critical activities do not occur on Forest Service lands. Watershed and larger scale issues are discussed; issues relating to lands managed by the Lassen National Forest are emphasized.

II. ENVIRONMENTAL SETTING

Antelope, Deer and Mill Creeks are located within the southernmost extension of the Cascade Range (see figure 1). The Tuscan formation of the Pliocene age, comprised primarily of mudflows, dominates the geology. This formation dips gently and thins toward the southwestern portions of the watersheds. Overlaying the Tuscan formation are flows of rhyolite, which form the Mill and Lost Creek Plateaus. Geologic diversity is supplied by several other influences. These include andesitic plugs that intrude the Tuscan formation along two linear trends, relatively minor exposures of marine sedimentary rocks in the three watersheds, and at lower elevations, quaternary sediments of the Sacramento Valley. Glacial processes shaped some of the higher elevation landforms.

Soils generated from these parent materials are generally productive, erosion rates range from low to moderate on the andesitic soils to high to very high on the rhyolitic soils. Mass wasting is evident in the watersheds, dominated by debris flows in colluvium filled hillslope hollows. Failures are episodic and triggered by extreme precipitation events. Surface erosion, especially on the rhyolitic soils, is the other major source of sediment.

The watersheds are all relatively long and narrow, with moderate to steep slopes. Extended low gradient channel types are uncommon on the mainstems, restricted to Deer Creek Meadows, Upper Mill Creek, McClure Place and reaches in the Valley floor. Steep slopes adjacent to the main channels served as historic barriers to activity, and recent land use allocations have protected these areas such that the main stem near stream environments are essentially undisturbed. The presence of Highway 32 along portions of Deer Creek is a notable exception. Timber harvest and grazing have impacted many of the watersheds' tributary streams.

Though very similar in general description, the extent and distribution of different landforms within the three watersheds causes them to display very different characteristics. Mill and Deer Creeks have more rhylotic soils, and where these are present, they result in increased surface erosion rates relative to other soils. As a result, Antelope Creek has lower surface erosion rates, and also has less mass wasting than the other watersheds. Finally, erosion from recent volcanic deposits in and near Lassen Volcanic National Park, in the headwaters of Mill Creek, contributes turbidity to that stream nearly year round.

Elevations range from a few hundred feet at the creeks' confluences with the Sacramento River to over ten thousand feet at Lassen Peak. This range elevation influences precipitation which varies from 25 to nearly 80 inches, and results in a vegetation continuum from valley grasslands through oak woodland, Ponderosa Pine (historically), mixed conifer to red fir at the highest elevations. Peak flows from the watersheds are dominated by rain on snow events.

Fire helped sustain the natural forest communities, but has been largely removed as an ecosystem process. Tree ring analysis has shown that fires historically occurred every seven to thirty years on average. At the same locations, fire has not occurred since 1920. In recent years, the watersheds have been the sites of large (tens of thousands of acres) fires with intense fire predominating.

The combination of varied geology and vegetation help to support a diverse array of wildlife habitats in the watersheds. These include foothill, old growth and riparian groups and 25 CalVeg habitat types. The species supported by these habitats have regional significance, including numerous species, which have disappeared elsewhere. These include peregrine falcons, bald eagles, California spotted owls and willow flycatchers.

Forests and rangelands within the watersheds have supported local and regional economies. About half of the forest lands are in private ownership, and provide a long term flow of timber products that support local economies and provide wood for national consumption. Historically, range management was a major activity in the watersheds. In the Upper Watersheds, the number of animals grazed has declined substantially over the past hundred years, but ranching still provides beef and limited employment. Range and agricultural uses in the lower portions of the watershed have been in place since European settlement. Water is diverted from all three creeks to support these uses. Pressure increases on ranchers and growers to convert their ownership to residential development. Recreation activities in the watersheds have steadily increased over the past decades with the increased population of the region and the increased mobility of the American recreating public. Lassen National Park and Forest Service Campgrounds in all three watersheds are sites of concentrated use. State Highway 32 provides easy access to stretches of Deer Creek, and it is a major site of recreational fishing.

Aquatic resources in the watersheds have regional significance for a number of reasons. Though there are diversion structures in the valley sections of all three creeks, there are no major impoundments. Anadromous fish (spring and fall run chinook and steelhead) have been able to maintain passage, and native fish communities have survived in the free flowing sections. This is rare in the foothills of the Sierra Nevada and Cascades. Herpetile species, which have declined precipitously throughout the state, are found in the watersheds. These include Cascades and foothill yellow-legged frogs. The anadromous fish habitats (along with Battle and Butte Creeks) are probably the best remaining habitat above the Central valley for these species, and serve as important anchors for their recovery. A fish ladder constructed by the California Department of Fish and Game in the 1930's to provide passage over Lower Falls on Deer Creek extended the historic anadromous habitat by about five miles.

III. HISTORICAL SETTING

The Impetus for a Changing Landscape

Archaeological evidence suggests the area of the Southern Cascade understudy has been occupied by human populations for over four thousand years. The Antelope creek watershed was the ethnographic territory of the Southern Yana and the Mill and Deer creek canyonlands were the homeland of the Yahi Yana. The manner in which the land has been used and the effect different populations have had on the landscape has been radically different.

Native American populations changed the natural environment within the Mill, Deer and Antelope watersheds to suit their particular needs and traditional lifeways. Their effect on the landscape was probably not felt until a sedentary lifestyle was adopted. The exploitation of deer and acorns had the greatest effect on the environment by native populations. The practice of burning to improve forage, acorn crops and travel also resulted in a landscape of large open forests according to early travelers (Read et. al 1944), quite different from dense forest thickets seen today. These effects increased through time to the end of the Dye Creek period (circa A.D. 1500) as populations grew. Site densities were very high in the region between 1000 and 3000 feet where the Yana ranged for most of the year. The accumulation of midden debris on river terraces and in rock shelters is extensive. Possibilities exist that the Yana practiced limited horticulture, possibly planting buckeye nuts or other important plant resources near winter villages.

Land use patterns and the landscape changed most dramatically with the euroamerican settlement of the region. Valley land grants and the California gold rush brought thousands of new settlers into the area causing disruption and the final annihilation of the native peoples. Sheep and cattle ranching caused over grazing and the decimation of native plant species. Burning, especially by sheep herders, changed forest regeneration patterns producing dense stands of shade tolerant species. A boom in the timber industry, brought about by new methods of transportation (flumes, railroad logging etc.), made it possible to harvest vast tracts of timber in the lower Pine belt. These massive logging efforts resulted in deforestation and other resource damage. Water diversions from Mill, Deer and Antelope creeks resulted in many valley lands coming under irrigation allowing agriculture supported increased populations in the region. Construction of the Ponderosa Way road and early campground facilities by the CCC provided the public with access to these watersheds for recreational use. The landscape has changed significantly within the Mill, Deer and Antelope creek watersheds over time brought on by differing land use practices from prehistoric times to the present.

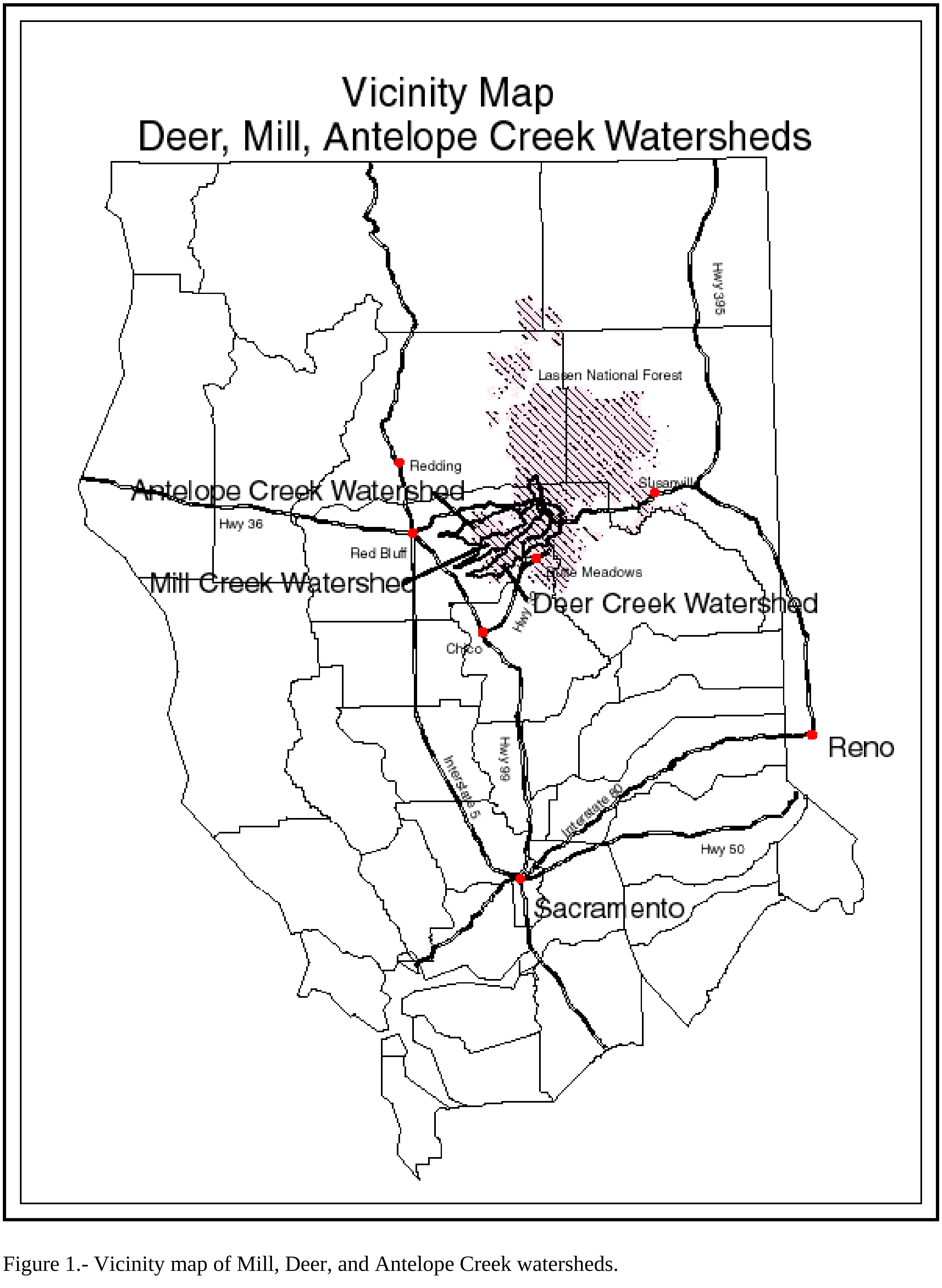

Figure 1.- Vicinity map of Mill, Deer, and Antelope Creek watersheds.

Prehistory
People have lived within or utilized resources from the Mill, Deer and Antelope Creek watersheds for several thousand years. The documented archaeological record for the Mill, Deer and Antelope Creek watersheds begin during the ``middle archaic period" (3000 B.C. - A.D. 500). After 2500 B.C., habitation of this area was common place and by 1500 B.C. ancestral Yana populations were expanding into the foothills of Mill, Deer and Antelope Creek. Based on data from Paynes Cave, Kingsley Cave, Dye Creek and Deadman Cave the ``Southern Cascade Cultural Chronology" was established.

The acorn was an extremely important, fairly reliable, food resource. Exploitation of acorns required a more sedentary lifestyle than earlier nomadic bands practiced and allowed larger populations to flourish. Intense habitation of the Mill, Deer and Antelope Creek watersheds during the Mill Creek period became widespread as suggested by the large, artifact rich midden sites exhibiting increased numbers of house pits and rock rings representing single family structures. Procurement of large and small animals, the all important acorn and a variety of other plant resources continued. Aboriginal populations practiced burning to clear underbrush for travel, improve forage for deer, antelope and elk, and to improve floral procurement areas.

The Historic period was a time of rapidly declining Yana populations from conflict with white settlers. Euroamerican settlers encroached on traditional Yana territories and forced native populations to hide in order to avoid extermination. By 1911 Yana groups living in the Mill and Deer Creek canyons were gone.

History
The first major impact to native cultures within the watersheds of Mill, Deer and Antelope Creeks came following the issuance of land grants to ``foreigners" by the Mexican government in 1828. Large cattle ranches were established on the east side of the Sacramento River as were grist and early lumber mills. Cattle were allowed to range for forage from the valley floor into the foothills. These early ranching operations denied native populations access to their traditional hunting and acorn gathering lands, and caused competition for forage between domesticate species (cow, sheep) and the native deer, antelope and elk populations.

The gold rush of 1849 brought thousands of immigrants from the eastern United States into California to seek their fortune. Many of the immigrants traveled into California via the Lassen Trail. This overland route extended from the mountains into the Sacramento Valley crossing between the Mill and Deer Creek watersheds. Many hardships were faced by immigrants along this trail as well as the native populations who suffered encroachment and competition for resources by thousands of immigrants and their livestock crossing throughout their homeland (Read and Gaines 1944, Delano 1936).

Ranching changed considerably after a severe drought between 1861 and 1862 killed most herds of cattle in Tehama County. Valley oaks were felled by the hundreds during the two year period as feed for starving cattle. The emphasis in ranching changed from cattle to sheep during this period (Large sheep operations were established in the area circa 1870. Sheep herders routinely burned large tracts of land in the foothills and mountains to remove obstructions and increase forage for their animals (Eaton 1941). Through burning practices and trampling by livestock the vegetation mosaic was changed considerably. After the devastating drought years, it became a practice to winter sheep and remnant cattle herds in the valley and drive the herds to the lush mountain pastures in the upper watersheds of Mill, Deer and Antelope Creek for the summer. By the turn of the century, over grazing by large herds of sheep left many foothill lands barren of vegetation causing severe compaction and erosion problems. In 1907, the newly formed National Forest began controlling burning and grazing practices on public lands through permitted grazing allotments.

Lumber production skyrocketed after the gold rush. The demand for lumber from mines, new settlements and valley cities was insatiable. By the 1870s, flumes were built to transport lumber to the valley, opening up vast low elevation pine forests for harvest (Bauer 1992). The Empire Lumber Company began logging operations in 1873 followed by the Sierra Flume and Lumber Company in 1875, the Sierra Lumber Company in 1878, the Diamond Match Company in 1907 which later became the Diamond National Corporation. Early timber logging operations caused many stand replacing fires during timber harvests. Low intensity natural fires became catastrophic fires as flames consumed tons of debris left on the forest floor from logging operations and the forest overstory. These fires were allowed to burn, however, by circa 1910, an effort was made to extinguish fires started in the course of logging. The advent of railroad logging (1920) allowed the harvest of high elevation forests. Commercial timber harvests within the Mill, Deer and Antelope watersheds have been on-going since before the establishment of the Forest Service. With the innovation of truck logging in the 1930s, timber production boomed in the high elevation areas of these watersheds on private as well as public lands. The Forest Service implemented a policy of controlling all fires in valuable timber lands which has caused changes to the natural fire regime.

Limited agriculture was taking place in the bottomlands of Antelope and Mill Creeks between 1844 and 1870s, however, by the late 1880s large areas were planted in wheat and other grain crops. Peter Lassen's Rancho Bosquejo produced wheat, cotton, orchard crops and grapes. Production of these crops especially the vineyards was greatly improved by the subsequent owners, Gerke and Stanford (Moulton 1969, Peninou 1991). After the turn of the century water diversion systems were established allowing agriculture to increase along the valley floor with a concurrent growth in population.

Early maps show place names up and down Mill, Deer and Antelope drainages denoting areas associated with ranching (sheep camp, dead cow flat, deep hole camp, goat camp, stone corral hollow etc.), logging operations (Yellow Jacket, High Trestle, knothole ranches, etc.), and homesteads (McClure Place, Paynes Place Pape Place Avery Place etc.) A trend of settlement along the foothill riparian corridors of these drainages can be traced from 1850s to the 1930s. After 1870, the foothill canyonlands were rapidly populated by Euroamerican settlers filling a void left after the decimation of aboriginal populations.

At the turn of the century the Cone family and the Cone/Ward Company owned vast acres of land south of Antelope Creek extending to the north side of Deer Creek and into the foothills. The Sierra Lumber Company acquired most forested lands within the upper Antelope Creek watershed and the Central Pacific Railroad Company owned forested lands in the upper watersheds of Mill and Deer Creeks. Stanford and Spaulding owned vast tracts of land on the south side of Deer Creek from the valley floor to the foothills. Extensive water diversions projects which included diversion dams, canals, and flumes were constructed at this time to bring water to the valley floor for agricultural purposes, subdivisions and towns (Adams 1913).

Early recreationalists began using the upper watershed of Mill and Deer Creek after the turn of the century drawn by creeks, mountain lakes, hot springs, wildlife and beautiful scenery. The Mill Creek summer home sites were established by the Forest Service circa 1920 and provided the public the opportunity to build summer residences adjacent to Mill Creek. Aboriginal and historic trails used to access homesteads along Mill, Deer and Antelope Creeks were improved and became part of the recreation trail system of Lassen National Forest. During the succeeding decade, the California Conservation Corp (CCC) built Ponderosa Way, the first major north-south road that crossed all three watersheds opening up the ``front country'' to recreation and commercial use. Many Forest Service campgrounds, lookouts and administrative sites were also constructed in the 1930s.

IV. ISSUES AND QUESTIONS

We have termed the questions, processes, functions, elements and indicators brought forward for discussion "Issues and Questions". Table 1 displays the issues and questions. Included in this table is an assessment of the spatial scale at which the issue/question is most relevant, and a matrix which displays the stressors (influences and activities) that have the most impact on that issues or question. An assessment of the trend of the stressor is also included.

Following the table is a brief discussion of each issue/question. Recommendations (limited to Forest Service actions) related to the issue/question are noted following the discussion of each issue/question. A listing and description of each recommendation follows the discussion of issues and questions. Some recommendations reflect the need to collect more information.

Table 1.- Watershed Analysis: Issues and questions with important stressors.

	Scale				Stressors														
Issue/Question	> Watershed	Watershed	Sub-Basin	Site	Sacramento System Water Development	Commercial & Sport Harvest	Hatcheries	Water Diversions	Timber Harvest	Wildfire	Fire Suppression	Range Management	Road Management	Highway 32	Herbicide Use	Poaching	Recreation	Urbanization	Collecting / Looting
Anadromous Fish	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Native Fish Assemblages	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x	x	
Late Seral Vegetation	x	x	x	x					x	x	x	x							
Economic and Social	x	x							x	x	x	x							
Cultural and Heritage	x			x					x	x	x	x					x		x
Reductions of Amphibians	x	x	x	x			x	x	x	x	x	x	x	x					
Changes in Vegetation and Fire Regime	x	x	x						x	x	x	x							
Eastern Tehama Deer Herd	x	x	x						x	x	x	x	x					x	
Changes in Flow Regime		x	x					x	x	x	x		x						
Changes in Erosion Regime		x	x						x	x	x	x	x						
Changes in Human Uses	x	x	x	x				x	x			x					x		
Changes in Channel Condition			x	x				x	x	x	x	x	x						
Nearstream Condition			x	x					x	x		x	x				x		
Soil Productivity			x	x					x	x		x							
Projected Stressor Trend					?	?	?	-	-	+	?	-	-	+	-	+	+	+	+

x = Influence

= Forest Service activities that have or have had an influence

+ = Increase in activity/influence

- = Decrease in activity/influence

? = Do not know

Important Issues and Questions for the Antelope, Deer and Mill Creek Watersheds:

- Anadromous fish (populations and habitats)
- Native fish assemblages
- Late seral stage, spotted owls and other old growth dependent species
- Economic and social outputs
- Cultural and heritage resources
- Reductions in herpetile species populations
- Changes in vegetation and fire regime
- Eastern Tehama Deer Herd
- Changes in flow regime (especially baseflow)
- Changes in erosion "regime"
- Changes in human uses
- Changes in channel condition, and levels of nearstream disturbance
- Soil productivity

IV.1. Anadromous Fish (Populations and Habitats)

At a broad scale, the reasons for the depressed status of many anadromous stocks (although the factors vary depending on species and geographic area) reflect the interaction of diverse environmental factors, such as ocean conditions and past and present management activities including; dam construction and operation, water diversions, habitat modifications, fish harvest (PACFISH 1995) and hatcheries. All of these factors have played some role in the decline of the Central Valley anadromous stocks (see figures 2-5). The numbers displayed in the figures represent a variety of population estimation methods, and are intended only to show a gross trend.

Although the cause of continued declines in Central Valley anadromous stocks cannot be attributed to any one factor, increasing evidence suggests that current water exports from the Sacramento-San Joaquin delta have detrimental affects on fish which live and migrate through the delta (Moyle et. al. 1992; Kjelson and Brandes 1989; Stevens et. al. 1985). In the delta, all runs of chinook salmon have experienced increased juvenile mortality. Kjelson and Brandes (1989) have found salmon survival to be highly correlated to river flow, temperature and the percent of inflow diverted by State and Federal water projects. Additionally, it is recognized that full restoration of the anadromous species within the Central Valley system cannot be achieved without integration of protective measures to restore fish habitat in the delta (Reynolds et. al. 1993).

Unlike most tributary streams of the Sacramento and San Joaquin Rivers that now have major water storage facilities that inundate or block hundreds of miles of historical anadromous spawning habitat, headwater stream habitat in Mill, Deer and Antelope Creeks is still available for utilization by anadromous fish. Total miles of anadromous habitat present within the boundary of the Lassen National Forest is estimated at 43 miles for Mill Creek, twenty-five miles for Deer Creek and seven miles for Antelope Creek. Protection, maintenance and improvement of this habitat is essential to conserving these anadromous stocks considered "at-risk" of extinction.

Sacramento River
Adult Spring-Run Chinook Escapement

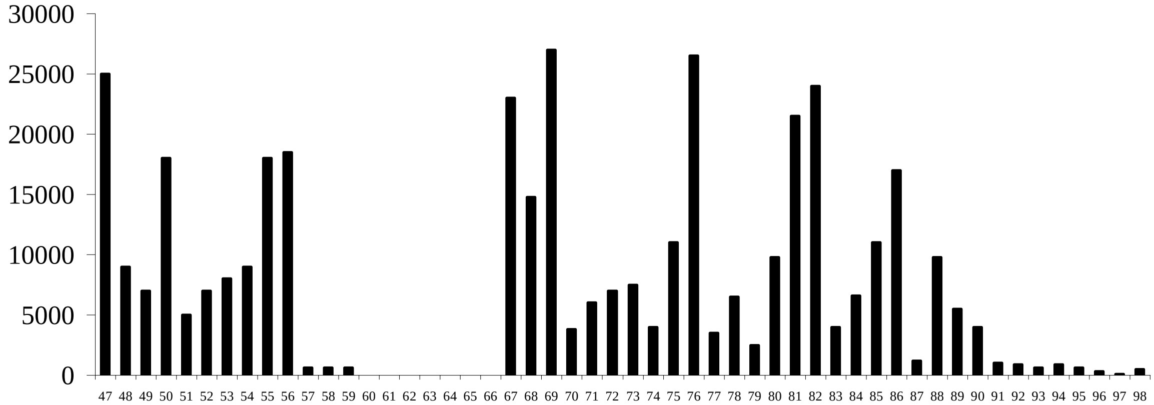

Figure 2.- Adult spring-run chinook salmon escapement estimates for the Sacramento River. No estimates were made between 1960 and 1966.

Sacramento River
Adult Steelhead Escapement
Red Bluff Diversion Dam

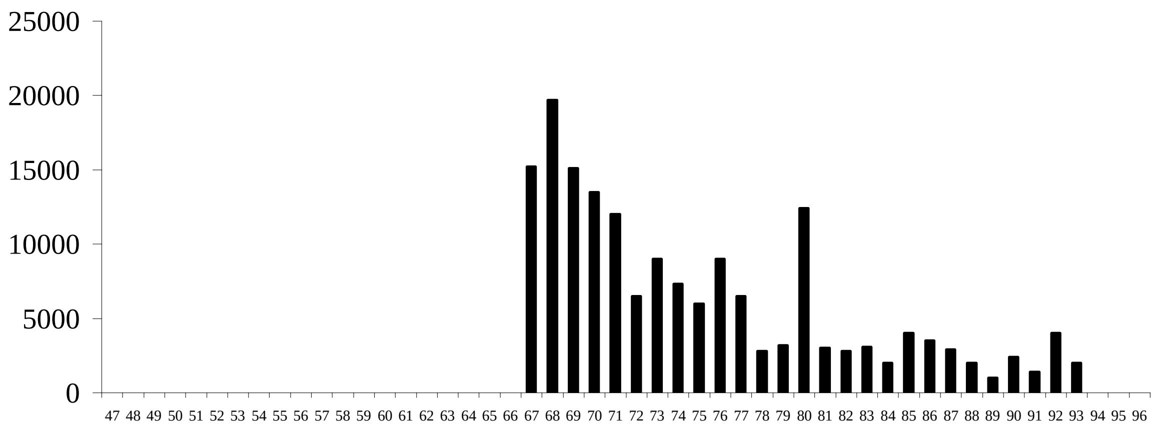

Figure 3.- Adult steelhead escapement estimates for the Sacramento River at Red Bluff diversion dam. Estimates only available between 1967 and 1993.

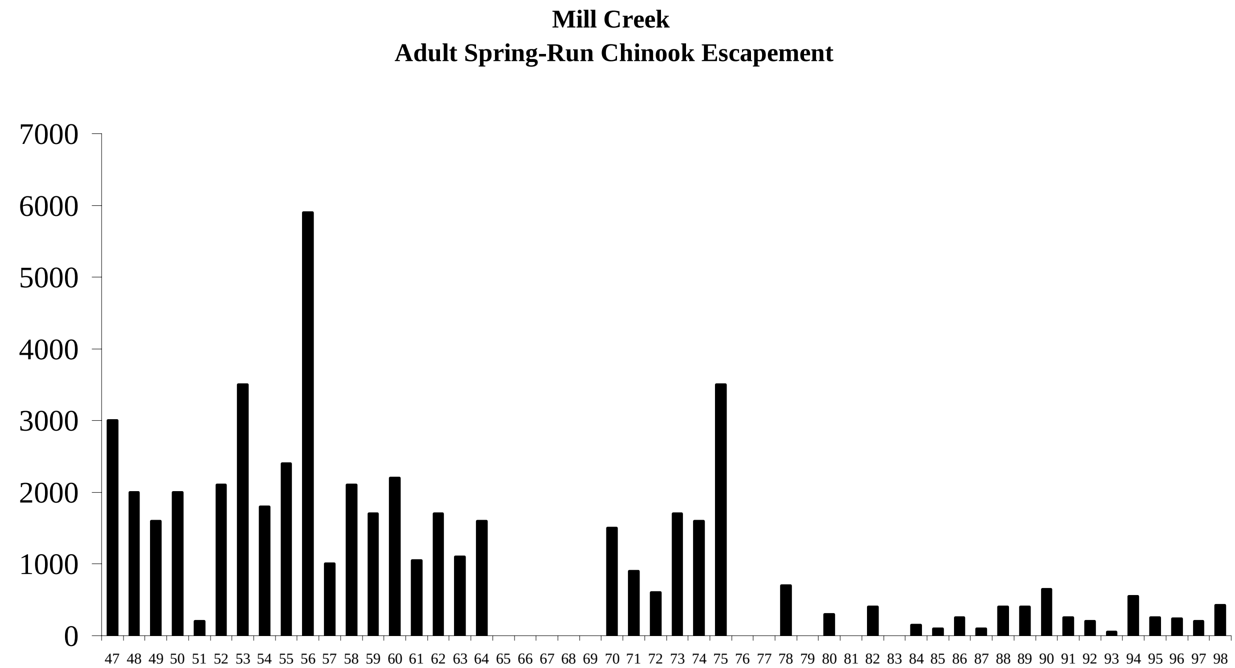

Figure 4.- Adult spring-run chinook escapement estimates for Mill Creek. No estimates were made during 1965-1969, 1976-1977, 1979, 1981, 1983.

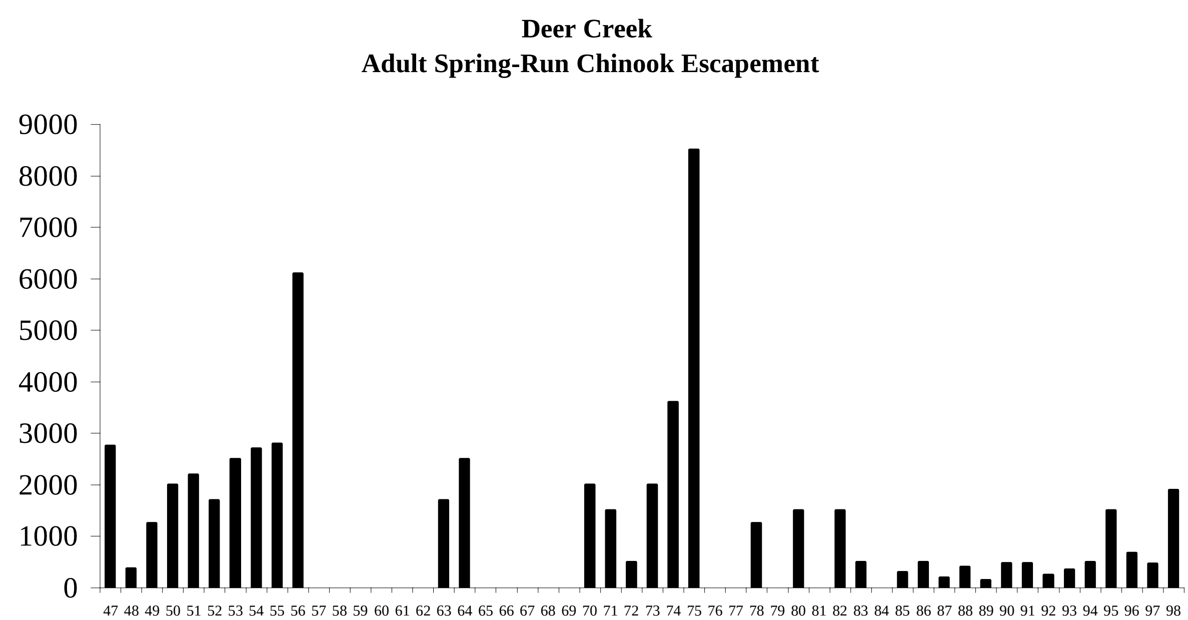

Figure 5.- Adult spring-run chinook escapement estimates for Deer Creek. No estimates were made during 1957-1962, 1965-1969, 1976-1977, 1979, 1981, 1984.

Despite the various past and present management activities within the three watersheds, instream habitat conditions for anadromous fish above the canyon mouths are good overall but are underutilized because of low spawner escapement levels. Mill Creek, Deer Creek and Antelope Creeks are all considered essential to the recovery and perpetuation of the wild stocks of spring-run chinook salmon and/or winter-run steelhead in the Central Valley (Reynolds et. al. 1993; McEwan and Jackson 1996) in part because of their current conditions and available habitat.

Discussion of the past and current watershed activities that have impacted, or have the potential to impact, habitat for these fish species are addressed elsewhere in this report. See erosion (Sec IV.10), channel (Sec IV.12) and near-stream disturbance sections (Sec IV.12) for discussion of timber harvest, roads, range, and wildfire. See the human uses section (Section IV.11) for discussion of recreation, Highway 32, herbicide use and urbanization.

Recommendations Related to This Issue/Question:

Recommendations for each issues are found in the Recommedations section (page 27)

RD1-RD9, EC1, LWD1-2, RC1-4, RM1, C1-C4, RHCAs

IV.2. Native Fish Assemblages

SNEP (1997) provided a comprehensive overview of the state of aquatic communities in the Sierra. Portions of the Upper Sacramento River Basin not addressed in the SNEP report also have problems similar to those south of Antelope, Deer and Mill Creeks. Aquatic habitat has been altered mainly by dams and diversions, which have blocked migration of aquatic species, and/or changed flow regimes. These problems have been exacerbated in many cases, by the introduction of non-native or hatchery bred species. The result is that few streams in California support the native fish assemblages that occurred prior to European settlement. Antelope, Deer and Mill Creeks still support the majority of their original fish assemblages.

In addition to the continued influence of both introduced and hatchery fishes, native fish assemblages in the watersheds have been impacted by water diversions and activities which may negatively affect their habitat. These include timber harvest, road construction and maintenance, range management, and wildfire.

Recommendations Related to This Issue/Question:

RD1-RD9, EC1, LWD1-2, RC1-4, RHCAs, C1-C4

IV.3. Late Seral Vegetation, Old Growth, Spotted Owls and other Old Growth Dependent Species

Changes in the amount and distribution of old growth habitat in the Sierra Nevada are well documented (SNEP, Verner, et al, 1992). These habitats are important for the species they support and their contribution to biological diversity. The amount of Old Growth habitat throughout the Sierra Nevada has declined substantially for a number of reasons, including timber harvest, wildfire, and urbanization (McKelvey, et al, 1992). Using forests in Sierra Nevada National Parks as a reference, Franklin and Fites-Kaufmann (SNEP, 1996) estimate that National Parks now contain 55 percent rank 4&5 Old Growth polygons and 82 percent rank 3&4&5 polygons, while National Forests currently contain on 13 and 42 percent of the same groups of polygons. Reductions in old growth have been linked to a decline in the population of the California Spotted Owl (Strix occidentalis californicus) which is commonly used as an indicator species.

Strategies for conservation of spotted owls and old growth on lands managed by the Forest Service have evolved over the past two decades. Initially, relatively small areas centered around owl nest sides were designated for special management. As needs of owls became better known, the areas expanded in size. Several factors were not considered in the "center" approaches. These included loss of these habitats to wildfire, the lack of connectivity between habitats, and the role of fringe or edge effects on the function and processes of the areas. Current thinking, as outlined by Franklin and Fites-Kaufmann (ibid) is to design a network of relatively large areas for old growth emphasis, over a broad geographic scale. One such strategy is outlined in SNEP, and areas of late successional emphasis (ALSE) are contained in both the Deer and Mill Creek watersheds (see figure 6).

No Recommendations Related to This Issue/Question

Sierra Nevada Old Growth and Areas of Late Successional Emphasis

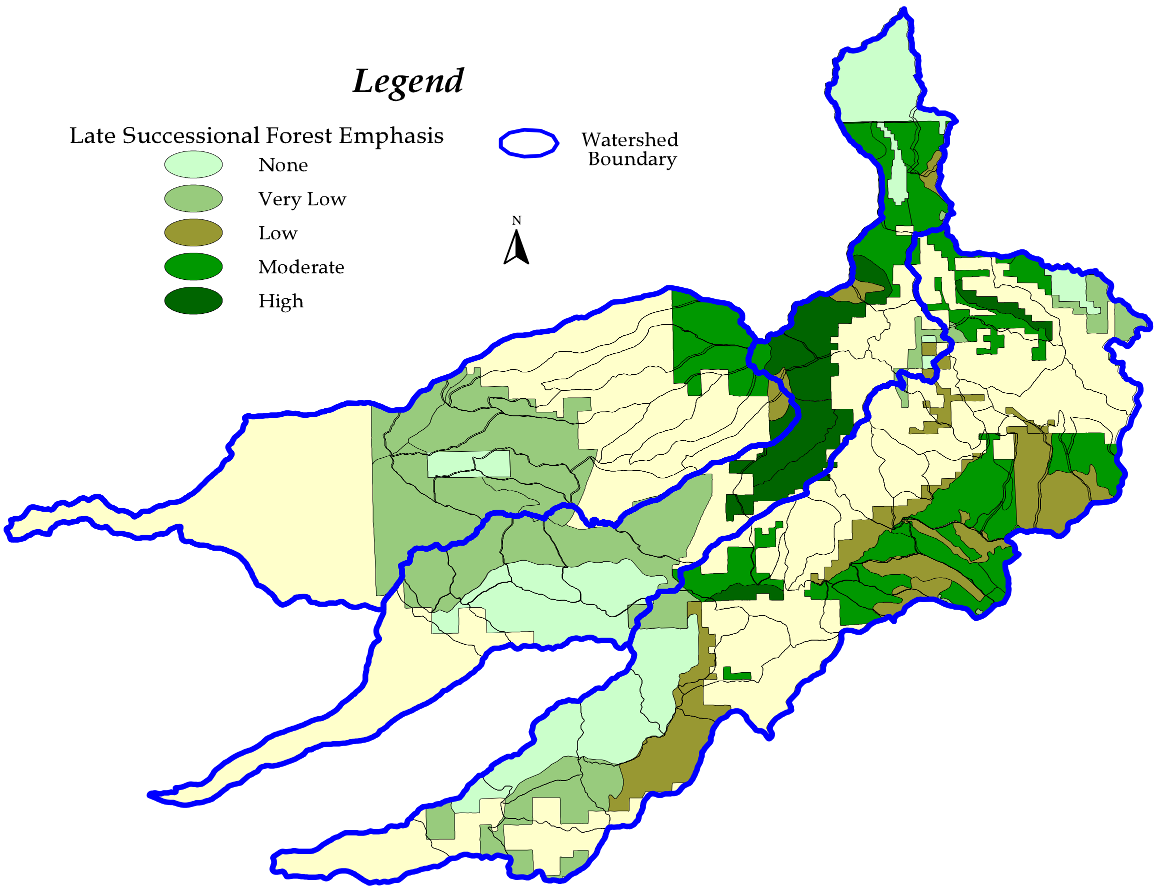

Figure 6.- Sierra Nevada old growth and areas of late successional emphasis in the Mill, Deer, and Antelope Creek watersheds.

IV.4. Economic and Social Outputs

Since settlement by Europeans, the watersheds have provided commodities used in economies outside their borders. These commodities include lumber and cattle, and irrigation water from diversions in the valley. About half of the watersheds are privately owned, and more than half of the commercial timber land is managed by private timber companies. Forest products from both the private and public timber lands are important to regional economies and highly important to the nearby rural community of Chester.

Recreationists are increasingly mobile, and the watersheds, especially the developed facilities in both Mill and Deer Creeks, and in Lassen Volcanic National Park are the destination of recreationists from local, regional, statewide and worldwide origins. Primary use is by local and regional recreationists. This use is increasingly important to local and regional economies.

No Recommendations Related to This Issue/Question

IV.5. Cultural and Heritage Resources

Protection of prehistoric and historic sites from degradation caused by natural forces and human activities.

The watersheds of Mill, Deer and Antelope Creek contain thousands of archaeological sites reflecting use of these areas by human populations for the past 4,000 years. Many of the sites, including prehistoric village sites found in these watersheds hold the key to understanding the past lifeways of early inhabitants gleaned from rich cultural deposits. Each watershed contains significant sites considered eligible for listing on the National Register of Historic Places as ``individual resources" or as ``historic districts." Numerous historic sites also occur, epitomizing use of these areas by Euroamericans as well as Native Americans. These resources are, therefore, important at national, as well as local and regional scales. The loss of integrity of prehistoric as well as historic resources from natural or human caused agents translates into an irretrievable loss of information about past inhabitants and their use of this area.

The destruction of archaeological sites by looters is a growing problem on public lands and has been an on-going problem in the archaeologically rich Mill, Deer and Antelope Creek areas. Archaeological sites are not renewable resources and once the integrity of a site is compromised information about past aboriginal cultures and the historic era is lost.

Natural Causes of Site Degradation

- Channel erosion and flooding--cause erosion of creek banks and terraces and sites located in these areas

- Sheet erosion--erosion to hillsides and sites found on slopes

- Wildfires cause damage to or destroy historic materials

Human Causes of Site Degradation

- Subsurface looting of sites
- Surface collecting artifacts
- Subsurface disturbance caused by campers in primitive or semi-primitive camping areas
- Grazing practices-cause erosion, trampling and subsurface disturbance to sites
- Trail use may contribute to erosion and damage to sites

Recommendations Related to This Issue/Question: HR1-10

IV.6. Reductions in Aquatic-Dependent Herpetile Species Populations

Of thirty amphibian taxa native to the Sierra Nevada, twelve are in need of special protection or are extinct (Jennings, 1996). The decline in many of these species over the period of European settlement has been dramatic. Their decline is the result of numerous factors that include natural causes; alteration of terrestrial, riparian and aquatic habitats; introduction of predators, disease; acid precipitation; pesticides; automobile emissions and UV light. In the Sierra Nevada, alteration of terrestrial and aquatic habitat (and resultant habitat fragmentation) and the introduction of fish are viewed (by SNEP) as the primary causes for the decline in amphibian populations.

Given the decline in populations of many of amphibian species, the conservation of existing suitable habitat and restoration of potential habitat are priority concern. The watersheds of Mill, Deer and Antelope Creeks provide habitat for three aquatic-dependent herpetile species of special concern: the Cascades frog (*Rana cascadae*), foothill yellow-legged frog (*Rana boylii*) and the western pond turtle (*Clemmys marmorata*).

All three watersheds, from their headwaters (at least in Mill and Deer Creeks) downstream to the National Forest boundary (and probably beyond) provide habitat for one or more of the three herpetile species of concern. The mainstem channels are utilized by adult foothill yellow-legged frogs for (at least) foraging and basking although some backwater sites and tributaries are known to be important for other life history stages as well. At least for the two frogs, some tributaries provide critical habitat for egg and larval development and juvenile rearing.

Although all three species are known to be present in the watersheds, and at some sites they are reproducing, not enough information is available to discuss population trends at the scale of these watersheds. Because recent herpetofauna surveys (~ 1994 to present) have been conducted for the primary purpose of determining species presence and relative distribution, they do not necessarily confirm absence of a species or provide a complete picture of their relative abundance beyond the site level. Continued surveys (and monitoring of existing reproducing populations at the site) are needed to further our understanding of the species status and habitat needs at the watershed scale.

Recommendations Related to This Issue/Question:

RD1-9, EC1, RM1, RHCAs, C3

IV.7. Eastern Tehama Deer Herd

The three watersheds encompass a large portion of summer and winter range habitat for the Eastern Tehama Deer Herd (ETDH). This deer herd is composed of Columbian black-tailed deer, a sub-species of mule deer. The ETDH is the largest migratory herd in California with a range of 2,250 square miles (CDFG, 1983). Migration distance from summer to winter range is approximately 100 miles. During the gold rush, the ETDH was decimated by market hunting. The herd began to recover at the beginning of the 20th century and reached peak levels during the period of 1930-1950 (CDFG ibid). The size of the ETDH has fluctuated from between over 100,000 individuals in 1963 (CDFG, 1986) to 30,200 in 1996 (CDFG 1996). Deer herds are highly cyclic by nature. Recruitment of fawns into the adult population is primarily responsible for the population size. Many factors can influence the recruitment rate, including winter and spring conditions, predation, hunting, highway mortality and overall summer and winter range condition. Deer herds have declined throughout the western United States since the 1960s (CDFG ibid). Loss of winter range habitat due to urbanization and reduction in quality of summer range habitat due to loss of forage to fire suppression are thought to be the primary reasons for the decline.

Recommendations Related to This Issue/Question:

RD1-2, TH1-2, C4

IV.8. Changes in Vegetation and Fire Regime

This is an issue with implications at the Sierra Nevada, watershed, sub-watershed and site scales. The existing fire regime in Antelope, Deer and Mill watersheds is very similar to descriptions of condition throughout the Sierra (Skinner and Chang; and McKelvey, et al; 1997). It is unlikely however, that conditions outside the watersheds (with the exception of changes in climate) will affect fire regime within the watersheds, or that a management strategy for fire inside the watersheds would affect fire regimes at a broader scale.

Fire is a key ecosystem element that strongly influenced the composition and structure of forests in the watersheds prior to European settlement. The advent of fire suppression early in this century, together with the reduction of fire ignitions by native peoples, have resulted in fire frequencies much different than those present prior to european settlement. Across the Lassen National Forest, it is estimated that three to ten fire cycles have been removed from lower elevation pine and mixed conifer forests since 1905 (Taylor, 1997). In high elevation red fir, it is estimated that one to three fire cycles have been lost over the same period (ibid).

Within the watersheds, studies were conducted in 1996 by Norman and Taylor (included in the WA as appendix K). This work showed a marked difference between the time since the last fire occurred and the maximum interval between fires before European settlement. As might be expected, there were differences in historic fires with slope elevation (upper slopes are at risk of fire from ignitions below and burned more often). At all sites there were 78 fires prior to 1900 (period of tree ring record 1800-1899), and 3 thereafter. No fires occurred after 1949 (Figure 7). The maximum historic interval between fires at any of the 12 sites was 56 years (minimum, 17 years, average 33 years). The mean historic intervals had a range of 11 to 38 years, with a mean of 20 years.

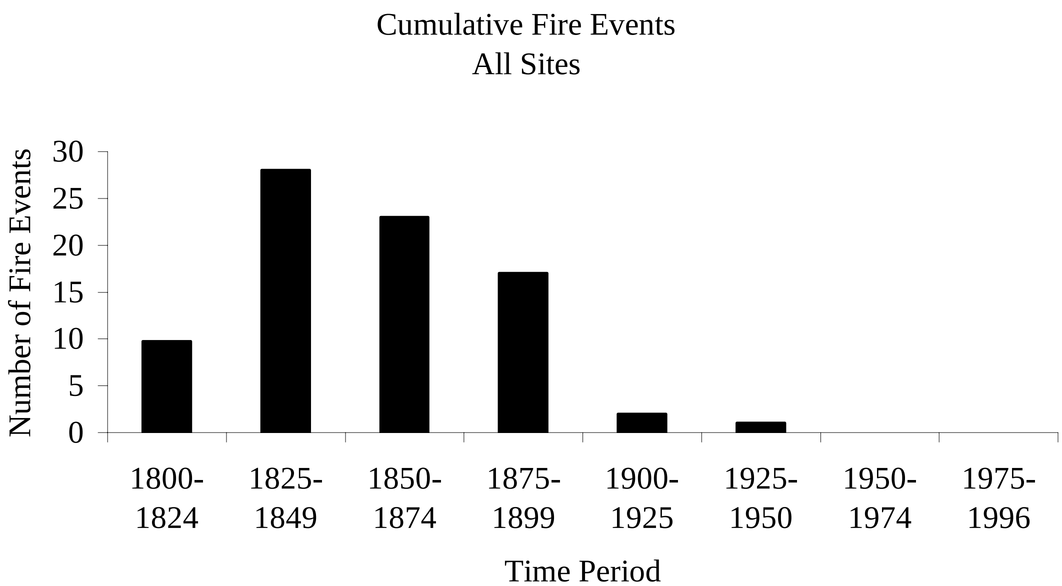

Figure 7.- Cumulative fire events for twelve sites investigated by Norman and Taylor (1996) in the Mill and Deer Creek watersheds.

Inference about pre-European settlement vegetation conditions was made (see appendix L) by considering the pattern of fire frequencies, and analysis of potential forest structure and composition. The low elevation dry sites had frequent fires at regular intervals that probably resulted in low fire severity (low ground fuels). These sites were thinned by fire, and had an open structure. Species resilient to fire were favored.

On moist sites, longer intervals between fires meant more fuels build up (these sites also have greater stocking capacity), and fire severity was more variable than on dry sites, with some burns of moderate intensity. Given the higher potential for stocking and less frequent and more variable fires, the likely forest structure was a mosaic of closed and moderately open aggregates or patches. Fire sensitive species (such as young Douglas Fir) would have been able to survive.

Currently, the dry sites have denser stands than that which occurred historically. Given the scenario above, such stands rarely had canopy closure above 60%. Currently, up to 70% of these sites have canopy closure greater than 60%. The moist sites have changed less in terms of canopy closure.

Changes in the vegetation cover from one that was primarily patchy or open to a more uniform and denser cover not only changes habitat capabilities, it also increases the risk of higher severity fires.

Effects of large wildfires that have high burn intensities will have the greatest impacts on resources at the site and sub-watershed scales. Effects of intense wildfire on watershed and stream resources have been documented to some extent (Roby and Azuma, 1995). Intense wildfire would remove groundcover and in the short term, needle fall to provide ground cover. Large wood recruitment would be lost if contributing near stream areas suffered stand replacing fire. In severe cases, in-stream large woody debris is burned. In the mid term, water yields would be increased in proportion to the amount of the basin burned. If hydrophobic soils were produced, then peak flow increases might also occur.

Multiple historic and current activities have affected vegetation and fire frequency and intensity. Historically, native peoples set fires to achieve a desired condition, these fires were eliminated with the coming of europeans. Sheep herders probably set fires (especially at lower elevations of the watersheds) until early in this century. Over the last half of the century, fire suppression and timber harvest have been the primary influence on vegetation, with grazing having impacts in the watersheds on a more localized basis.

Recommendations Related to This Issue/Question:

RHCAs, FM-1, FM-2

IV.9. Changes in Flow Regime, Especially Baseflow

Antelope, Deer and Mill Creek all have water diversions located below their canyon mouths. There are two diversions on Antelope Creek, four on Deer Creek (three dams and one ditch) and three on Mill Creek. Late spring and early summer diversions resulted in in-stream flows low enough to block access for late-migrating adults. Low flows may also prevent downstream migrating smolts from reaching the Sacramento (CDF, 1996).

Recent evaluations of Sacramento Valley anadromous fishery resources (CDF 1993; USF&WS 1995; CDF 1996) have consistently identified limited flows in the reaches as one factor limiting anadromous fish production in the watersheds. Recognition of these factors has led to progressive cooperative programs between state agencies and water users in Deer and Mill Creeks to replace stream water with groundwater during critical periods of fish passage.

Recommendations Related to This Issue/Question:

C2

IV.10. Changes in Erosion Regime

Historically, we believe that sediment delivery within the watersheds was dominated by mass wasting. Mass wasting events were and are episodic, typically triggered by long duration, high intensity precipitation events (such as most recently occurred in 1997). It appears that management has not substantially altered the frequency of these events (most of the areas prone to mass wasting are not roaded). Rhyolitic soils, especially those on steep slopes are and were also a major influence on the amount of overall erosion. Although the depositional landforms laying at the base of some rhyolitic slopes (Gurnsey Creek and Lost Creek) served to buffer delivery of sediment from this source as they do today. While some slides also occurred in these areas, many occur farther downstream where delivery of sediment to channels is nearly one hundred percent.

Sediment from channel erosion has increased, but to a minor degree relative to other sources. Surface erosion has increased substantially. The overall result is a shift from episodic mass wasting dominated sediment regime to one which overlays chronic production from surface sources on the mass wasting.

Areas of increased surface erosion are not uniform across the landscape. Instead, they appear to be closely linked with certain landforms and management activities. The foremost source is roads. Meadowbrook (1997) estimated that roads contribute from 5-20% of the total average sediment yield from Deer and Mill Creeks. Roads on rhyolitic soils were responsible for delivered sediment estimates almost 4 times greater than the other parent materials. Other sources of sediment are landings and skidtrials associated with timber harvest activities. As with roads, those activities located on rhyolitic soils, especially on steeper slopes, have high erosion potential. Wildfires that burn with high intensity are also a source of increased surface erosion.

We attempted to display the potential for surface erosion on a sub-watershed basis. This is important for two reasons (appendix G). First, impact on aquatic resources from sediment would be most likely to occur close to the source (versus downstream).

Highlighting areas of increased sediment production should be an aid to restoration planning.

Number of Disturbance Criteria Exceeding Moderate Risk

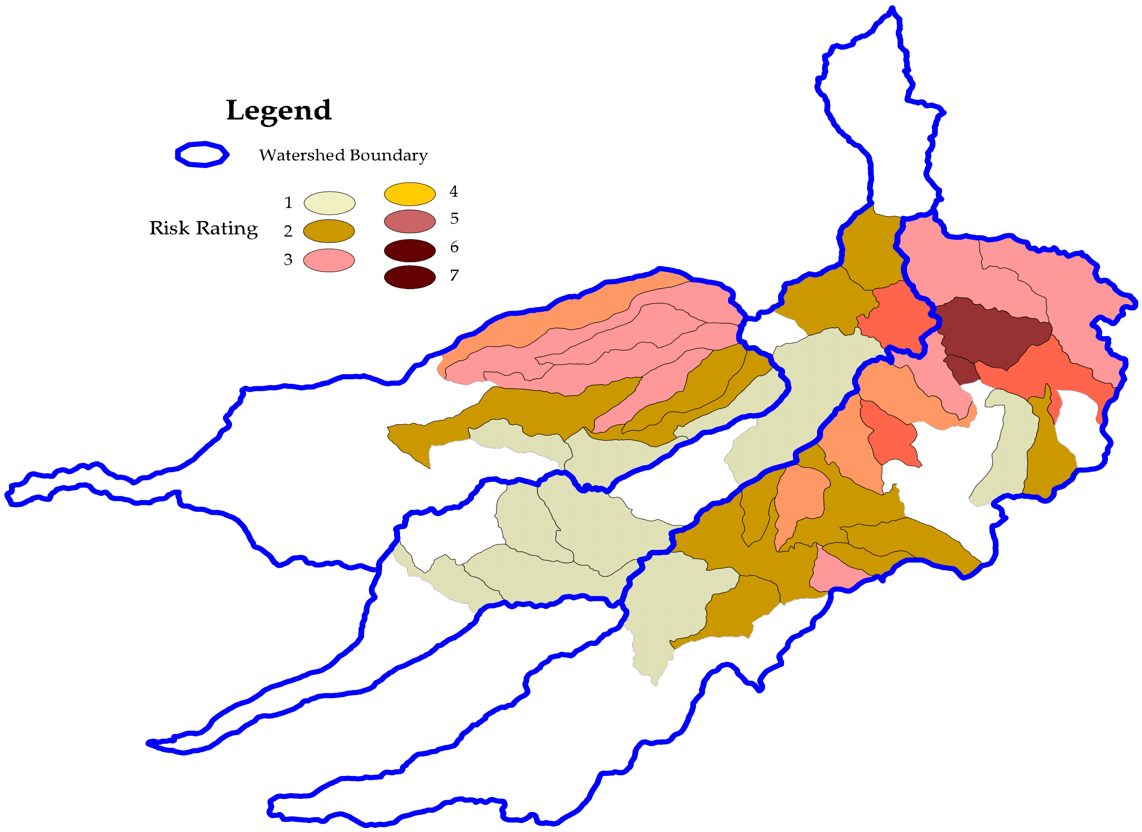

Figure 8.- Number of disturbance criteria exceeding moderate risk in sub-basins of Mill, Deer, and Antelope Creek watersheds.

Rhyolitic Soils as a Percentage of the Sub-basin

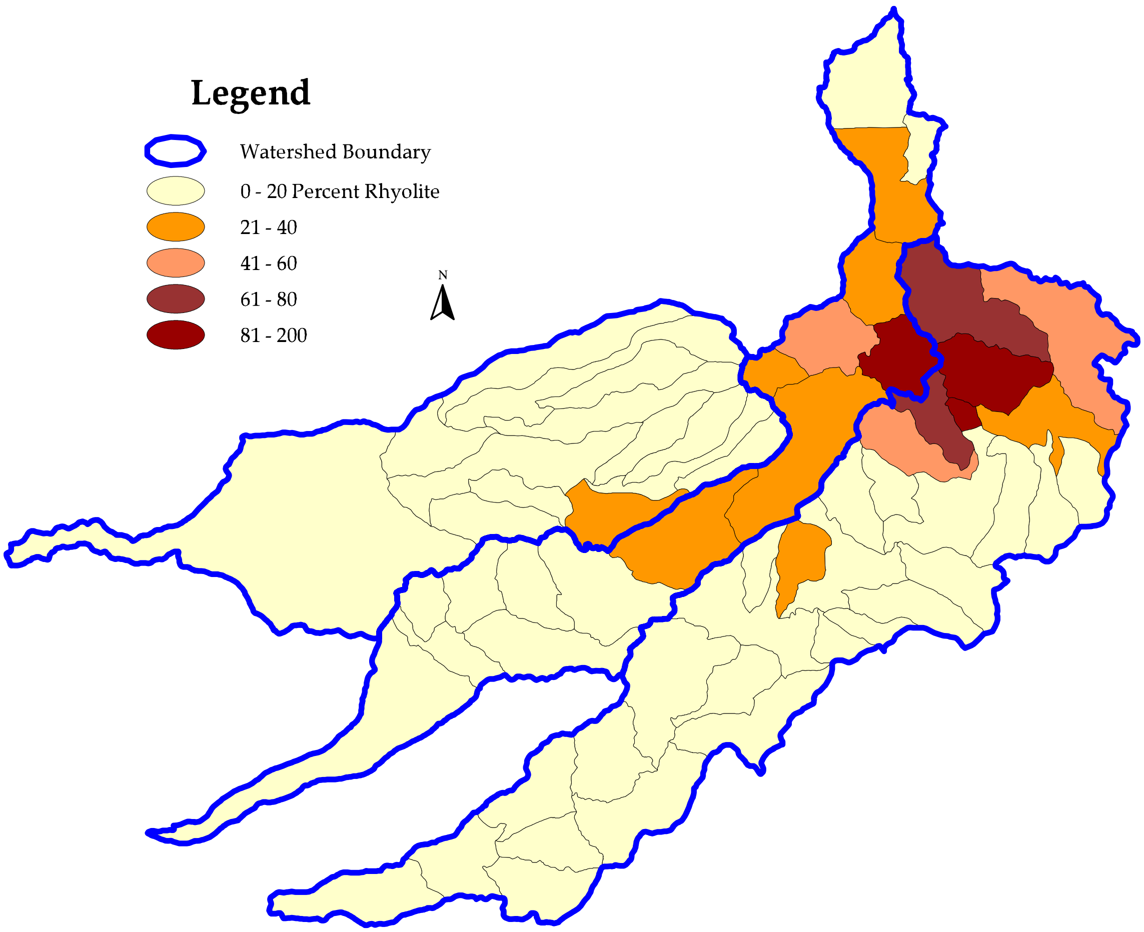

Figure 9.- Rhyolitic soils as a percentage of sub-basin in Mill, Deer, and Antelope Creek Watersheds.

We used several indicators of disturbance to assess the potential for sediment production increases. These were road density, delivered road sediment (estimated), equivalent roaded acres (ERA), number of road crossings per mile of stream, road density in near stream areas, and disturbance (ERA) in near stream areas. These attributes are explained in appendix G. Sub-watershed disturbance levels using these criteria are displayed on Figure 8. Displayed in figure 9 are the relative amounts of rhyolitic soils in each sub-watershed. Note that there is considerable overlap between those watersheds with high disturbance levels and those with high percentages of rhyolitic soils. This represents a high risk of increased surface erosion.

Is higher sediment production manifested in changes to the channels which drain these sub-watersheds? The answer is unclear. Information on channel conditions (especially historic data) is lacking for most of the sub-watersheds with high disturbance and rhyolitic soils. One exception is North Fork Deer Creek (also called Lower Gurnsey Creek), which appears to be in poor condition based on channel morphology (braided channel, unstable banks). Aerial photographs indicate that the channel has changed over the period of the photo record (since 1941). It is difficult to attribute change to increased sediment production alone (see appendix G). Generally, sub-basins with the most channel information are those with low disturbance levels..

Roads are the obvious source of increased surface erosion. As stated above, timber activities, especially skidtrails and landings on steep slopes or located near channels (or roads with increased delivery capability), are other primary sources of sediment. Wildfires with high burn intensities are also major sources of sediment in the watersheds. Recreation sites are limited in scale, but some are located near channels and result in increased sediment delivery. Range management affects sediment delivery primarily as a result of impacts to channels and riparian vegetation, and is more thoroughly discussed in section IV. 12. Below the Forest boundary, ranching, agriculture and urbanization are all sediment sources.

Recommendations Related to This Issue/Question:

RD1-9, EC1, LW1-2, C4, RHCAs

IV.11. Changes in Human Uses

Activities discussed here are recreation (both dispersed and at developed sites), herbicide applications, use and management of Highway 32 (specific to Deer Creek) and urbanization. Recreation at Forest Service facilities within the watersheds (see recreation report in appendix J) is less than it was before the changes in fishing regulations that prohibit take of fish from the three creeks (instituted in 1995). Use has risen slowly since that time, and the expectation is that recreation use will grow, especially on the Deer Creek Campgrounds with close proximity to Highway 32. It is expected that slower (but steady) increase in hiking and other recreation activities of dispersed nature will occur as the state and regional populations continue to grow. Increased visitor use increases the potential for harassment of fish, disturbance of habitat, and poaching.

Very little is known about the application of herbicides in the watersheds. They have been used on Forest Service lands, and more extensively on lands managed by Sierra Pacific Industries over the past few decades. On Lassen National Forest lands, herbicide use is considered for use in plantations to increase survival or growth of seedlings. Plantations resulted from regeneration harvesting prescribed in the 1970s and 1980s, and from wildfires with stand replacing intensity.

The proximity of Highway 32 to Deer Creek poses a threat to anadromous fish because of the risk of a spill of toxic materials into the Creek. Our research found documentation of three spills of fuel since 1960, two of which delivered material to the Creek.

As the regional population grows, there will be increased demand for conversion of agricultural lands to residential development in the lower watersheds. The impact of conversion of lands below the canyon mouths from agricultural to residential uses on the fisheries of the creeks is uncertain.

Recommendations Related to This Issue/Question:

RC1-4, C3, RHCAs, M5

IV.12. Changes in channel condition, and levels of nearstream disturbance

Historic data on channel and habitat conditions is not available, and current information on many of the tributary channels is either lacking or too subjective in nature to draw conclusions with confidence. Stream inventory data from two sensitive alluvial reaches (Deer Creek Meadows and Gurnsey Creek and North Fork Deer Creek) show a high percentage of poorly protected banks, high bank angles and other indicators of less than desirable condition.

More data is available on the amount of near-stream disturbance (including near stream roads). Near stream area has arbitrarily been defined in this WA as 300' (either side of creek) for perennial streams and 150' for other channels. On the main stems of all three creeks (above the Forest Service boundary), near stream disturbance is low. Historically, this was due to the steep slopes along the main stems. In recent time, this physical "barrier" has been reinforced with land allocations that emphasize protection. The HWY 32 corridor is essentially the only significant disturbance to any of the main stems.

In some tributary streams (sub-watersheds), the levels of near stream disturbance are high. Of the 30 sub-basins in Deer Creek, one exceeds 5% NSD for roads, and 17 exceed 5% total near stream disturbance. No sub-basins in Antelope or Mill Creek exceed 5% road disturbance in the near stream area, but 1 sub-basin in Mill and 7 in Antelope exceed 5% total near stream disturbance.

Sub-basins with high levels of near-stream disturbance represent areas of higher potential for delivery of sediment to channels from ground disturbing activities. This risk is increased as slope and soil erosion hazard of the near stream areas increases. In Deer, Mill and Antelope, this risk is highest in areas with rhyolitic soils (as described in the erosion regime discussion). Near stream areas with roads and timber harvest activity may also be lacking in both existing and recruitable large woody debris. Large wood provides a key structural component to many streams and is also important in in-channel sediment storage and transport.

While the condition of tributary streams is important in itself, the streams function as contributors of water, sediment, wood and energy to downstream reaches raises the level of concern for their condition, given the importance of the Antelope, Deer and Mill Creek anadromous fisheries. Over the past twenty years, control of timber practices within streamside areas has grown stricter on both private and public lands, and road location and maintenance practices have generally improved. These factors lead to the conclusion that the trend in near stream conditions is probably improving, but the current levels of disturbance in some sub-basins are a concern.

Activities which have contributed to near stream disturbance are roads, timber harvest, wildfire and grazing. Recreation activities are limited in scale, but are often located in near stream environments. Downstream, ranching and agriculture and urbanization are also activities of concern.

Recommendations Related to This Issue/Question:

RD3-6, RD8, EC1, LW1-2, RM1, RC1, RHCAs

IV.13. Soil Productivity

We have collected no data on soil productivity in the three watersheds. This issue is assumed to be a problem in soils with high erosion rates, as the erosion rate far exceeds the natural rate of soil formation. The rhyolitic soils which have the highest erosion rates also have relatively low water holding capacities, low organic matter content, and very high infiltration rates. Erosion from sites with these soils may be reducing site capability.

Recommendations Related to This Issue/Question:

RD1-3, EC1, C4

V. RECOMMENDATIONS

Recommendations are provided to address the questions and issues. Exisiting direction that deals with the questions and issues is generally not repeated here.

V.1. Long Term Strategy

Adopt a long term strategy for management of aquatic habitats within the watersheds consistent with that outlined in Pacfish. The plan would be applied in the Antelope, Deer and Mill Creek watersheds through implementation of current LRMP standards and guidelines (including those contained in Pacfish, exceptions are specifically outlined below). Elements of the strategy are:

- Restoration
- Riparian Habitat Conservation Areas
- Monitoring
- Collaboration
- Watershed Conservation Practices

Treatment of the three watersheds as "key" watersheds meets a larger scale strategy need of recognizing the watersheds as key to the viability of anadromous fish species in the Upper Sacramento River system.

V.2. Roadless Areas

- Polk Springs
- Butt Mountain
- Cub Creek

Management of these areas as roadless is direction from the Chief's road management policy (1999)

(Wild Cattle, Brushy Mtn, Ishi B, Mill Creek and Indian Creek are already wither wilderness or proposed wilderness in the LRMP)

V.3. Roads

Unless otherwise noted in the recommendation, the following criteria will be used to set priorities for locating road restoration and improvement activities (these criteria were recommended by the road task group):

1- roads in sub-watersheds draining directly to anadromous fish spawning and holding areas or amphibian habitat (biological importance)
2-roads on rhyolitic soils
3-roads in sub-watersheds with road densities greater than 3 miles/square mile
4-roads in sub-watersheds with existing near-stream road densities greater than 5 percent.

5- roads in sub-watersheds with number of stream crossings greater than 1.5 per mile of channel.
6- projects that compliment other restoration work
7- Projects with a high potential for success
8- Projects with a high sediment reduction (or risk reduction) for the cost

RD1: Obliterate or decommission temporary and non-system roads.

RD2: Obliterate or decommission parallel road systems.

RD3: Obliterate or decommission, or when necessary for future transportation needs, move roads located in nearstream zones.

RD4: Work with cooperators to improve drainage, reduce erosion, and reduce risk of crossing failures on co-op roads. Utilize Meadowbrook Conservation Associates (MCA) data base to identify potential priority road segments.

RD5: Schedule and implement work at stream crossings to re-size culverts to accommodate 100 year flow events or to replace culverts with low water crossings or other designs that reduce risk of crossing failure. In addition to above criteria: address crossings from MCA report with high potential delivery.

RD6: Improve drainage on existing roads by outsloping where practical. In addition to above criteria, utilize high delivery road segments identified in MCA report that are not outsloped.

RD7: For level 1 roads, remove culverts and provide adequate surface erosion control.

RD8: Use roads analysis to identify roads that require seasonal closure or surface improvement to protect drainage function from wet weather traffic

RD9: Drop the LRMP recommendation to assess re-opening of road to Big Bend (Management Area 27, Facilities)

RD10: Increase cooperative efforts with private landowners and develop integrated transportation plans

RD11: For roads with densities greater than 2.5 miles/square mile, offset any new construction with equal or greater decommissioning in that sub-watershed.

V.4. Erosion Control

EC1: Apply appropriate erosion control measures to landings, skidtrails and other sediment source areas. Emphasize use of prescriptions that require little to no maintenance. Where revegetation is used, give priority to native species (or non-native species that are not persistent). Priorities are:

(1) Areas within RHCAs
(2) areas that drain to and exacerbate road drainage and erosion problems
(3) areas in sub-basins that drain directly to anadromous holding and spawning habitat
(4) areas in rhyolotic soils.

EC2-Survey and assess the potential for accelerating revegetation of the Upper Mill Creek alluvial floodplain.

V.5. Large Woody Debris (LWD)

LW1- In sub-basins with high near-stream disturbance, survey to identify areas with low LWD and/or poor LWD recruitment. In those areas, develop prescriptions that accelerate development of recruitable LWD while meeting other RHCA standards and guidelines.

LW2- Continue survey of tributary channels, including levels of LWD. Where LWD is absent or extremely low both in-channel and recruitable (and the system historically had wood) consider experimental placement of LWD in channels. Pilot test in areas that minimize disturbance in RHCAs.

V.6. Heritage and Cultural Resources

HR1- Identify and determine the importance of heritage resources within the watersheds especially along major and tertiary creeks

HR2- Correct natural or cultural practices causing erosion to sites

HR3- Stabilize creek banks in areas of unstable midden soils (soils created by human habitation)

HR4- Recover archaeological values from sites frequently impacted from flood events, looting or other activities causing subsurface disturbance (cattle wallowing, campers)

HR5- Conduct post fire inventories

HR6- Relocate trails that contribute to site damage or recover archaeological values

HR7- Restrict overnight camping on archaeological sites that have incurred damage from this activity

HR8- Interpret heritage resources to contribute to visitors knowledge and appreciation of resource protection

HR9- Systematically, monitor significant sites (Sites eligible for listing on the National Register of Historic Places) for natural or cultural caused impacts

V.7. Fire and Vegetation Management

FM1- Work with Conservancies, timber land owners and the State Department of Forestry
and Fire Protection to develop integrated plans for reducing risk of catastrophic fire effects while maintaining watershed, riparian and aquatic condition.

FM2- Continue to integrate and implement coordinated fire suppression plans.

V.8. Range Management

RM1- At Gurnsey Creek, Upper Mill Creek (main stem and tributaries above Highway 32) and on the Cone-Ward Allotment, locate monitoring sites to assess the trend in riparian vegetation age structure and cover.

RM2- Expand efforts to remove feral cattle from the canceled Tehama Allotment until they are eliminated.

V.9. Tehama Deer Herd

TDH1- In priority vegetation types, design projects to meet "high" habitat capability guidelines for Mule Deer.

TDH2- Improve California Department of Fish and Game (CDF&G) partnership and undertake cooperative projects to improve habitat capability.

V.10. Recreation

RC1-Conduct Best Management Practices Evaluation Program (BMPEP) assessments at all developed recreation sites. Develop site specific action plans to address needs identified by those assessments.

RC2- Develop and implement procedures to track vault levels (ID of leakage)

RC3- Work with Conservancies and CDF to improve public education efforts, including knowledge of Regulations pertinent to these watersheds.

RC4- Document instances of habitat alteration and fish harassment at areas of concentrated recreation use.

V.11. Lands (exchange opportunities)

LN1- Explore exchange opportunites with private landowners of sensitive lands within these watersheds.

V.12. Additional Cooperative Efforts

C1- Continue, and as funding allows, increase cooperative efforts with California Department of Fish and Game aimed at enforcement of fishing regulations.

C2- Encourage efforts of Conservancies and CDF&G to secure instream flows sufficient to provide unimpaired migration of anadromous fish and suitable habitat for anadromous fish in all reaches of the three streams.

C3- Encourage Cal-Trans efforts to reduce risk of spills of toxic materials on Highway 32.

C4- Continue cooperative water quality monitoring efforts with Department of Water Resources and other agencies and landowners, continue co-operative holding and spawning surveys with CDF.

V.13. Riparian Habitat Conservation Areas (RHCAs)

Pacfish defines RHCAs as portions of watersheds where riparian-dependent resources receive primary emphasis and management activities are subject to specific standards and guidelines. These areas help to maintain the integrity of aquatic systems by: (1) influencing the delivery of course sediment, organic matter and woody debris to streams; (2) providing root strength for channel stability; (3) shading the stream; and (4) protecting water quality. The watershed analysis is to be used to identify and establish boundaries for Riparian Habitat Conservation Boundaries.

Delineation and management of RHCAs is a key component of the overall conservation strategy. Goals of the Pacfish Strategy to which proper delineation and protection of RHCAs are key include:

1. Maintaining water quality within the range that sustains survival, growth, reproduction and migration of aquatic and riparian species.

2. Maintaining and restoring the physical integrity of the aquatic system, including shorelines, banks and bottom configurations.

3. Maintaining and restoring the sediment regime to that with which the aquatic system evolved.

4. Maintaining and restoring in-stream flows such that riparian, aquatic and wetland habitats are sustained, and patterns of sediment, nutrient and wood routing and channel dynamics are sufficient to sustain aquatic and riparian species.

5. Maintaining and restoring the timing, variability and duration of floodplain inundation, and water table elevation in meadows and wetlands.

6. Maintaining and restoring the species composition and structural diversity of plant communities in riparian zones and wetlands to provide thermal regulation, nutrient filtering, ground cover, bank stability and large wood recruitment.

7. Maintaining the spatial and temporal connectivity within and between watersheds. Connections include floodplains, wetlands, headwater tributaries, intact refugia and upslope areas.

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

Consideration of the Pacfish RHCA "process goals" and the broader scale Pacfish Riparian Goals makes delineation of RHCAs at the watershed scale difficult, because we lack the site specific information required to make adequate delineations. Most obvious is our lack of data about the extent of intermittent and ephemeral drainages. Other site specific data needs include information about the presence of riparian plant species and the location of small scale aquatic habitats, including springs and seeps. We have found that existing mapping is inadequate in identifying these features.

For these reasons, we believe that it is inappropriate to revise the Pacfish interim reserves through this watershed analysis. Further, our analysis has revealed a tremendous variation in channel types and channel and riparian condition. We believe that changes to interim reserves should be made at the site- or sub-basin scales, with consideration given to the linkages between those scales and pertinent watershed scale processes and conditions, and conservation strategy goals. From a practical standpoint, RHCAs are only theoretical until activities are proposed. The value of RHCAs is in applying Standards and Guides within them, and in providing site specific prescriptions for management.

We also recognize that due to the unpredictability of events, the press of duties, reduced staffing and the type of management activity proposed, time is not always available (or warranted) to provide the site specific evaluation of streamside areas as described above. We propose that the interim guidelines (as revised below) be used as default RHCAs and applied to management activities in those cases when site specific evaluation and recommendations are not (for whatever reason) provided.

Proposed "Default" RHCAs:

For all Permanently Flowing Streams: The stream and area on either side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or the outer edges of riparian vegetation, or a distance equal to the height of one site potential tree, or 300 slope distance (600 feet, including both sides of the stream channel), whichever is greatest.

For seasonally flowing streams, wetlands less than an acre, landslides and landslide prone lands: The extent of the landslides and landslide prone areas, the intermittent stream channel to and the area to the top of the inner gorge. the intermittent stream channel or wetland and the area to the outer edges of the riparian vegetation, or the distance equal to the height of one site potential tree, or 100 feet slope distance, whichever is greatest.

We believe that decisions regarding the delineation and management of RHCAs is best done on a site specific basis (which properly considers the connection of the site to larger scales). This is best done by a qualified team of resource specialists who can consider both the ecological and practical consequences of alternative management prescriptions.

The reality is that in most cases where site specific analysis is not completed, default widths will be based on the numerical criteria (300' or 100'), because determination of features like site potential tree and landslide prone are based on field evaluation. Riparian vegetation and inner gorge features are more easily detected from maps or photographs, and, therefore are more likely to be applied in a "default" design.

If site specific RHCA evaluations are conducted, then the same features- inner gorge, riparian vegetation, floodplains, landslides and landslide-prone areas will be included within the RHCA. The "base" RHCA is, therefore, defined by these ecological attributes. Additional width would be added to the base RHCA in most cases. In some cases, this final RHCA width would exceed the 300' and 100' default widths; in some cases the final RHCA would be less than the default widths.

Final determination of the widths requires interdisciplanary field review. The WA has identified some key processes and elements which should be considered during site specific evaluation of RHCAs and developing prescriptions for RHCAs during project evaluation. Some of these factors, with important types within the three watersheds, include:

Soils and Slope: Slopes greater than 35% on all soils, and greater than 25% on rhyolitic soils.

Condition of the streamside area (including shade, in-channel large wood, recruitable large wood, and ground cover): Areas with high historic near stream disturbance (low LWD, shade and LWD recruitment). Areas with high NSD on rhyolite may also have low ground cover compared with reference conditions. Areas that have been the site of intense wildfire are likely to be very low in all structural elements (shade, LWD, etc.)

Channel type: Alluvial channels, extremely steep channels, and/or those with colluvial elements (prone to debris slides).

Overall condition of sub-basin and near stream areas within the sub-basin: Those sub-basins with combinations or high ratings, or very high ratings in terms of road density, ERA, nearstream disturbance, etc. Sub-basins in which nearstream areas are in poor condition, and provide little "riparian" habitat.

Presence of, or potential for, amphibian habitat (or habitat for other species of concern): Especially amphibians and other herpetiles. Springs, seeps, and small "wet" areas that often provide habitat for uncommon aquatic invertebrates.

Consideration of these elements is consistent with the approach for land use buffers outlined in SNEP, 1997 (Vol. II, Chapter 36). The SNEP approach recognizes the ecological function of near-stream and adjacent upslope lands. Among the functions are providing habitat for aquatic and riparian dependent species (the "community area"). The SNEP approach also recommends consideration of an "Energy Area" in streamside management, recognizing the role of nearstream environments in providing food sources and large wood to aquatic systems, as well as modifying thermal and other energy inputs to these systems. These recommendations differ from SNEP in that a "buffer" upslope of the energy area is not defined. Our feeling is that soil quality standards and Best Management Practices apply to all activities, including those located upslope of RHCAs. We feel that as slope and soil erodability increases, further protections should be applied on site (rather than affording protections to streams by increasing buffer width).

It is the intent of the strategy to provide protection to aquatic and riparian species in the watersheds. Given the regional importance of the aquatic resources, there is a question that needs to be addressed: under what conditions would widths narrower than the interim be proposed, based on site specific analysis?

We anticipate such instances would not be common. As the "base" RHCA would include (in all cases) inner gorge, riparian vegetation, floodplains, landslides and landslide-prone areas, the exceptions to interim reserve widths would be those where the widths were narrower than the height of one site potential tree. Such cases would occur in areas where the objectives of the RHCA (bank stability, shade, groundcover, large wood recruitment) would be met by a width narrower than the height of a site potential tree. From a practical standpoint, this means streamside areas that are presently in good condition in terms of these factors, and typically on gentler slopes, soils with that do not have high erosion potential. Existing facilities (i.e. roads, special use home sites) also factor into the analysis. It is likely that and RHCA would be reduced in width from 300 to 250 feet if an existing, stable road lay in the outer 50 feet, since including it in the RHCA would serve no purpose. Such exceptions would only be made after consideration of the RHCA condition in the sub-watershed and watershed.

Pacfish allowed for departure from interim widths when they were not necessary to attain RMOs or avoid adverse affects to salmon. Likewise, the FEMAT plan also recognized riparian reserves set forth in that plan as interim and provided Watershed Analysis as the means to make the necessary determinations: "The result is that the basin is stratified into areas that may require wider or narrower Riparian Reserves than those prescribed for the interim. For example, on intermittent streams in unstable areas with high potential to generate slides and debris flows, Riparian Reserves wider than those prescribed for the interim may be necessary to ensure ecological integrity. Riparian Reserves in more stable areas may be less extensive, managed under upland standards and guides. The ultimate design of Riparian Reserves is likely to be a hybrid of decisions based on consideration of sites of special ecological value, slope stability and natural disturbance processes." Further, "Thus it is possible to meet Aquatic Conservation Strategy Objectives with post-analysis reserve boundaries that are quite different from the interim. Regardless of stream type, changes to Riparain Reserves must be based on scientifically sound reasoning, fully justified and documented."

Just as important as RHCA delineation in meeting RMOs is proper treatment of areas upslope of RHCAs. This includes prescriptions adjacent to RHCAs that will help maintain or restore conditions in the RHCAs, and so will consider effects of activities there on the RHCAs. This is consistent with the conceptual framework for streamside management as outlined in SNEP. Practical examples would include providing prescriptions with more groundcover in broadcast burns on an area with highly erosive soils above an RHCA with poor existing canopy and ground cover than for a prescription on an area with lower erosion potential or upslope of a fully intact and functioning RHCA.

V.14. Monitoring

M1: Adopt the Draft In-Channel Monitoring Plan

M2: Utilize tracking forms developed to monitor CalFed activities for projects conducted in the watersheds to monitor implementation of Standards and Guidelines.

M3: Utilize BMPEP Administrative Evaluation AE-7 (Watershed Restoration) to monitor implementation of restoration activities in the Watersheds.

M4: Utilize the Watershed Management Objectives as a basis to track disturbance at the sub-watershed level. Report at five year intervals.

M5: Monitor the impacts of recreation use at developed sites on anadromous fish holding and spawning.

V.15. Riparian Management Objectives & Watershed Management Objectives

Pacfish describes the utility of Riparian Management Objectives (RMOs) as follows: "RMOs for stream channel condition provide the criteria against which attainment, or progress toward attainment, of the riparian goals is measured." Our intent was to utilize findings from the watershed analysis to identify measures which relate to key processes or elements within the watersheds.

RMOs and WMOs serve two important purposes:

1) During project planning, analysis should consider how alternative activities and alternatives might affect the RMOs. They provide more specificity than the Riparian Goals in terms of evaluating effects, and should assist managers in developing prescriptions that will result in moving towards desired conditions.

2) The RMOs and WMOs are measurable criteria used to track aquatic habitat and watershed conditions over time.

There is considerable overlap between the RMOs and the elements included in the monitoring plan. The monitoring plan does include additional criteria (fish population estimates, macroinvertebrates, and temperature among others) that are not identified as RMOs, because although they are extremely useful in tracking conditions overtime, numerical objectives for these elements could not be developed.

As with the RHCAs, the RMOs developed in this watershed analysis are limited in utility due to the variation in conditions and system types in the watersheds. They are general in nature. Site specific objectives should utilize these watershed scale RMOs as a starting point, but modify or develop additional objectives that best fit the sub-watershed, site or project.

Table 2 and 3 list Riparian Management Objectives (RMOs) developed by the LNF in cooperation with NMFS on January 27, 1999

Table 2.- RMOs for Alluvial Stream Types (Rosgen C and E types); monitoring reaches at Gurnsey Creek, Upper Mill Creek, Carter Creek.

ELEMENT	OBJECTIVE
Bank Angle	Upward trend in angle, with target of 100° average for reaches. Maintain streambanks to ensure the protection of the aquatic systems to which species are uniquely adapted.
Channel Bank Stability	Upward trend in stability, with target of 85% stability for reaches
Bankfull Width-to-Depth Ratio	Upward or stable trend in W/D measures, as compared to reference stream data, measured at flat water habitat types. Target is W/D of 15 or less.
Riparian Vegetation	Target is upward trend in vegetation, to target of age classes and structural diversity and cover of ungrazed stands.
Channel-Floodplain Connectivity	Target is connectivity evident on 90% of all alluvial reaches. Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands.

Table 3.- RMOs for Perennial Stream Reaches (including alluvial); monitoring reaches at 3 sites on Deer Creek, 3 on Mill Creek, 1 on Antelope Creek, and 1 site each on Carter, Slate, Gurnsey, Elam, North Fork Calf, and Rocky Gulch Creeks.

ELEMENT	OBJECTIVE
Shade	Stable or upward trend to percentages obtainable for the vegetation community present. Generic target is 75% average for reach ("forested" reaches); no reduction due to management activities.
Large Woody Debris	Levels appear to represent natural condition in terms of frequency and distribution. Desired to mimic natural conditions; large woody debris is sufficient to sustain physical complexity and stability.
Fines at Pool Tail	< 10% for main stem < 15% for tributaries in non-rhyolitic soils < 20% for tributaries in rhyolitic soils
Embeddedness (riffle and pool tail)	< 10% for main stem < 15% for tributaries in non-rhyolitic soils < 20% for tributaries in rhyolitic soils
Residual Pool Depth	No decrease over time.
Temperature	No increase in water temperature (due to management activities) over reference (historical) conditions.
Large Wood Recruitment	Target is upward trend in vegetation, to target of age classes and structural diversity of unmanaged stands of same community type. RHCAs are trending toward natural range of variability for the site potential natural community.
Soils	Keep ground-covering litter, duff, and/or vegetation on at least 90% of non-rocky riparian areas.
Water Quality	Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems.

We believe that while defining and tracking RMOs is a useful exercise, the concept of RMOs is flawed in that when RMOs are not attained, reduction in the quality of riparian or aquatic habitat has occurred, with the risk of impact to aquatic and riparian dependent species. As we believe that watershed condition and process is inextricably (though perhaps unpredictably) linked to riparian and aquatic processes and condition, we believe that establishing Watershed Management Objectives (WMOs) provide a useful tracking system that may serve as a early warning or rough screen indicator of trend in overall system condition (table 4). WMOs are proposed for measurement and tracking at the sub-watershed scale.

Table 4.- Watershed Management Objectives (WMOs) for Anadromous Watersheds

ELEMENT	**OBJECTIVE**
Road Density	Less than 2.5 miles/square mile
Near-stream Road Density*	Roads occupy less than 3%of all near-stream areas within a sub-watershed
Channel Crossings	Less than 2 road crossings per mile of stream
Equivalent Roaded Acres	ERAs occupy less than 12%of the total sub-watershed
Near-stream Disturbance**	Disturbance from management activities occupies less than 5% of all near-stream areas within a sub-watershed

Near-stream Area: An area encompassing a stream channel and land adjacent to both sides of the channel. For seasonally flowing streams, the near-stream area extends 150' on each side of the channel. For perennial streams, the near-stream area encompasses approximately 300' on each side of the channel.

*Near-stream Road Density: The percentage of near-stream areas that area occupied by roads.

**Near-stream Disturbance: The percentage of near-stream areas with soil compaction or disturbance from roads, skid trails, landings, or other management activities.

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Appendix A Watershed Geology

By: Anita Villalovos

REGIONAL SETTING

Deer, Mill and Antelope Creek watersheds are within the southernmost extension of the Cascade Range. The southern Cascades are bound by the Great Valley to the west, the Modoc Plateau to the east and the Sierra Nevada to the southeast. The Cascades are characterized by volcanic pyroclastic deposits and flows of Quaternary and Tertiary age. These volcanic rocks locally overly Mesozoic and/or Paleozoic metamorphic rocks of sedimentary and volcanic origin that are believed to be correlative with the Sierra Nevada metamorphic rocks. On the west side of the southern Cascade Range marine sedimentary rocks of Cretaceous age locally overly the metamorphic rocks.

LOCAL GEOLOGY

Deer, Mill, and Antelope Creek watersheds consist predominantly of the Tuscan Formation of late Pliocene age (ca. ~3.3 Ma). This formation is primarily comprised of volcanic mudflows but also includes locally derived fluvial deposits, ash-flow and air-fall tuffs, lava flows, and intrusions (Muffler and others, 1989). The Tuscan Formation deposits dip gently and thin toward the southwestern portions of the watersheds. The Tuscan Formation is overlain by voluminous flows of rhyolite (1.2 Ma) which form Mill Creek and Lost Creek Plateaus in the Mill Creek and Deer Creek watersheds.
Andesitic plugs such as Black Rock along Mill Creek and Black Butte on the South Fork of Antelope Creek intrude the Tuscan Formation along two linear trends. One trend is nearly parallel to the northeast trend of Mill Creek and the other intersects it along a west-northwest trend. Peterson and others (1982) observed no obvious features in the Tuscan Formation that would connect the plugs and suggested that major lineaments may exist in the basement metamorphic rocks.
Cretaceous marine sedimentary rocks in the watersheds belong to the Chico Formation. This formation has relatively minor exposures which are located along portions of the creek beds of Deer, Mill and Antelope Creeks. The Mesozoic and/or Paleozoic basement metamorphic rocks are also only minorly exposed along a portion of Deer Creek (near Polk Springs) and in a small patch along Mill Creek (T27N, R3E, Section 3 SW1/4) (Peterson and others, 1982).
Along the lower elevations at the southwestern end of the watersheds the creeks flow over the volcanic rocks of the Cascades onto the Quaternary sediments of the eastern Sacramento Valley.

GEOMORPHOLOGY

Deer, Mill and Antelope Creeks have relatively long narrow watersheds with moderate to steep slopes. The two major geomorphic processes in the watersheds are mass wasting and fluvial. The primary mass wasting process appears to be by debris flows which occur predominantly in colluvium-filled hillsope hollows. These are areas where the sediment supply is likely to be high and where runoff can be concentrated. Flows are episodic and can be catastrophic events often
triggered by abundant precipitation. There is also evidence of rock falls which occur along steep and rocky parts of the watersheds where some of the volcanics have formed pinnacles and along rocky reaches of the creeks.

Large mass-wasting features were observed along upper Mill Creek but appear to be stable now. For example, the entrance station to Lassen Volcanic National Park is built on a 3310 year old landslide that moved 7 km down Mill Creek from the base of Brokeoff Mountain (Clynne and Muffler, 1989).

The fluvial geomorphic type includes the processes of sheetwash, rill erosion, channel erosion, and soil creep. These processes tend to occur on the upper hillslopes and ridgetops of the watersheds where the slopes are less steep.

Glacial processes have shaped some of the landforms at the higher elevations of the Mill and Deer Creek watersheds. The upper portion of Mill Creek is a glacial valley, and glacial deposits have been mapped at the headwaters of Deer Creek on Butt Mountain (Lydon, 1968). Wilson (1961) suggests that the headwaters of Antelope Creek around Turner Mountain have also been glaciated.

FEATURES UNIQUE TO THE MILL CREEK WATERSHED

Deer, Mill and Antelope Creeks share much of the same geologic and geomorphic history. However, the unique geology at the headwaters of Mill Creek, and the geothermal areas located along it are features unique to Mill Creek that warrant a separate discussion.

The headwaters of Mill Creek, located in Lassen Volcanic National Park, are cutting through an ancient andesitic stratocone (layered andesitic lavas and pyroclastic deposits that were erupted at 600-400 ka). The hydrothermal system associated with this ancient volcano has altered the more permeable pyroclastic rocks in the center of it to mostly clay. This has locally enhanced erosion by glacial and fluvial processes and is a significant contribution to the fine-grained sediment load of Mill Creek.

Morgan and Growler Hot Springs are located along Mill and Canyon Creeks just north of Highway 36. The last additional geothermal input into Mill Creek occurs just north of the town of Mill Creek. These springs have a seasonal and diurnal variation but contribute about 10-15 % to the stream flow. Arsenic is added to Mill Creek by the Morgan/Growler hydrothermal system but the clay from the altered volcanics act as a stabilizing influence and adsorb 70% of the arsenic by the time the stream reaches Highway 36 (Sorey, personal communication, 1996).

APPENDIX B - **SOILS**

Introduction

The terrestrial values of Deer, Mill, and Antelope Creek watersheds are diverse, ranging from mountain meadows to dense conifer forests and oak woodlands. A major component of these terrestrial values is the soil in which plant life largely depends. Natural variation in soil type, geology, topography, climate, hydrology, and vegetation contribute to spatial variation in erosion susceptibility and erosion rate. Erosion can occur as a result of land use practices, such as grazing, logging, road building and recreation, as well from natural processes such as rain and flooding. When looking at erosion potential, an important factor to consider is parent material. Some material are more prone to erosion than others, such as rhyolitic dacite. Rhyolite and rhyolitic dacite is a light colored rock, similar to granite, that easily separates from the base rock, especially at slopes greater than 35%.

Another factor important to terrestial values is slope. Slope has an effect on productivity as well as erodability. The higher the slope, the more likely erosion can occur, depending primarily on parent material. The Deer Creek watershed is characterized by areas of steep canyons in the mid portions of the watershed. Slopes less than 35% occupy 71% of the watershed. Slopes greater than 65% occupy 1.8% of the watershed and slopes between 35 and 65 % occupy 26% of the watershed. Mill Creek is characterized by areas of steep canyons in the mid portion of the watershed. Slopes less than 35% occupy 70% of the watershed. Slopes greater than 65% occupy 3% of the watershed, and slopes between 35 and 65% occupy 26% of the watershed. Antelope Creek is characterized by gently sloping areas in the front country of the Sacramento Valley. Slopes less than 35% occupy 86% of the watershed. Slopes between 35 and 65% occupy 10% of the watershed.

DEER CREEK

The soils of the Deer Creek watershed are derived from volcanic breccia, including basalt, andesite, dacite and rhyolite. Dominant soils in the Deer Creek watershed are of the Lyonsville and Jiggs association, Cohasset series, McCarthy series and the Windy series. The Lyonsville soils are generally found along ridges, are moderately deep and well-drained. These soils are gravelly and stoney throughout (LNF Soil Survey, 1986). The Jiggs soils are derived from volcanic flow of rhyolite and are somewhat excessively drained. The lyonsville and Jiggs soils are mapped together in differing proportions, they both have erosive properties due to their rhyolitic component. The Cohasset soils are derived from weathered andesite and breccia. They are geberally found on slopes of canyons in mountainous areas, are moderately deep, moderately coarse textured and have a granular structure. The Windy soils are well-drained soils derived from basic volcanic rocks, andesite and basaltic rocks from volcanic flows, and in some places are cemented together with tuffaceous material. These soils are in mountainous areas.

Table 1-B.- Soil series in the Deer Creek watershed.

Soil Series	% of Watershed Containing Soil Series
Lyonsville and Jiggs	13
Windy	11
McCarthy	11
Cohasset	8

Mill Creek

The soils in the Mill Creek Watershed range in parent material from volcanic breccia, including basalt, andesite, and rhyolite to metamorphic rock. Dominant soils in the Mill Creek watershed are Toomes soils and Supan soils. The Toomes series is a well drained, shallow to very shallow, extremely rocky soil. The Supan series is an erodable soil where runoff is rapid and depth is moderate (LNF Soil Survey, 1986). The erosion hazard is moderate to severe, depending on slope. Much of the watershed is composed of colluvial land which is characterized by steep slopes and is highly erosive due to loose rock and soil material. Following is a summary of approximate proportions of these dominant soils within the watershed.

Table 2-B.- Soil series in the Mill Creek watershed.

Soil Series	% of Watershed Containing Soil Series
Toomes-very rocky/extremely rocky loam	42
Rock land	38
Colluvial Land (volcanic rock)	33
Supan stoney loam	22
Rubble land	5

Antelope Creek

The soils of the Antelope Creek watershed are derived from parent material of andesite, basalt, and breccia. Dominant soils in the Antelope watershed are of the Toomes series, the Cohasset series, the Windy series, and the Supan series. Descriptions of these soils can be found in the previous sections on Mill and Deer Creek watersheds. Following is a summary of approximate proportions of these dominant soils within the watershed.

Table 3-B.- Soil series within the Antelope Creek watershed.

Soil Series	% of Watershed Containing Soil Series
Toomes	18
Cohasset	10
Windy	8
Supan	6

Issues and Key Questions

Erosion hazards are significant in this watershed when considering fish habitat. When a landslide occurs, sediment may enter a stream channel and impare water quality through sedimentation. Soils, slope and disturbance are the main factors to consider in predicting erosion.

Current Conditions

Two indicators of erodability were determined to be parent material of rhyolite and erosion hazard ratings of high and very high.

Deer Creek

The Deer Creek watershed consists of 25 sub-basins, from Lassen Park to the Sacrament Valley floor. The sub-basins vary in size, steepness and dominant soils, as well as in their potential to erode. A summary by sub-basin of the total percentage of rhyolite soil, erosion hazard ratings of high and very high are broken into three slope classes shown in table 4.

Table 4-B.- Summary of soils of concern in the Deer Creek watershed.

Sub-Basin Name	Sub-Basin #	% of Sub-Basin in Rhyolite			% of Sub-Basin with High of Very High EHR No Rhyolite			
		Slope Class						
		0-35%	36-65%	>65%	0-35%	36-65%	>65%	Total
Yahi	D1	0.1	0	0	30.3	14.7	0.8	45.8
Flatiron	D7	0	0	0	32.1	20.9	2.2	55.1
Big Smokey	D8	0	0	0	5.3	3.1	83.9	92.3
Ditch	D9	0	0	0	12.6	3.5	0	16.1
Wilson	D10	0.3	1.1	0.2	6.6	7.8	0.7	15.1
SF Calf	D11	0	0	0	5.7	3.9	0.4	10
NF Calf	D12	0	0	0	58.2	26.7	0	84.9
Dead Horse	D13	13.5	2.9	0	6	1.5	0.3	7.8
Panther	D14	9	13.7	0.2	2.2	2.1	0	4.3
Potato	D15	0.8	2.7	0	18	18.3	2.7	39
Rattlesnake	D16	0	0	0	37.6	3.5	0.2	41.3
Forked	D17	0.4	8	0	16.8	0.2	0	17.1
Falls	D18	0	0	0	16.9	9.1	0	26
Round valley	D19	1.1	0	0	40.2	4.7	1	45.8
Cub	D20	0	0	0	21.8	34.7	1.2	57.7
Slate	D21	40.9	2.2	0	16.7	0	0	16.7
Elam	D22	0	0	0	55	17.8	0	72.8
Carter	D23	2.6	0	0	42.2	24	0	66.2
Upper Deer	D24	2.6	0	0	26.3	16.5	0	42.8
Swamp	D25	69.7	4.8	0	0	0	0	0
Alder	D26	76.5	9	0	0	0	0	0
Deer Creek Meadows	D27	31.7	0.8	0	6.2	0.6	0	6.9
Lower Gurnsey	D28	73.5	8.9	0	0	0	0	0
Upper Gurnsey	D29	57.5	14.9	0	0.3	0.2	0	0.6
Lost	D30	44.6	1.8	0	0.4	0	0	0.4

The upper half of the Deer Creek watershed is dominated by rhyolitic soils. Within the Slate, Swamp, Alder, Deer Creek Meadows, Lower Gurnsey, and Lost Creek sub-basins, the rhyolitic soils are primarily found on slopes less than 35%. There are two sub-basins that have a significant rhyolitic component: Upper Gurnsey contains 25% and Panther contains 13.7%. The largest percentage of soils with high erosion ratings occur on slopes less than 35%. However, the sub-basins with high percentages of soils with high erosion ratings have significantly higher amounts than any other areas, particularly on slopes greater than 35%. The sub-basins with the highest proportion of soils with high and very high erosion ratings are: Big Smoky, North Fork Calf, and Elam, which contain 73%, 85%, and 95% respectively. This is a good indication of potential problem areas.

Mill Creek

The Mill Creek watershed consists of 16 sub-basins, from Lassen Park to the Sacramento Valley floor. The sub-basins vary in size, steepness and dominant soils, as well as in their potential to erode. A summary by sub-basin of the total percentage of rhyolite soil, erosion hazard ratings of high and very high are broken into three slope classes shown in table 5.

Table 5-B.- Summary of soils of concern in the Mill Creek watershed.

Sub-Basin Name	Sub-Basin #	% of Sub-Basin in Rhyolite			% of Sub-Basin with High of Very High EHR No Rhyolite			
		Slope Class						
		0-35%	36-65%	>65%	0-35%	36-65%	>65%	Total
Avery	M5	0	0	0	47	25	0	73
Bear	M1	0	0	0	10	4	0.3	14
Big Bend	M8	15	12	2.5	15	16	3	34
Black Rock	M6	4	0.5	0.08	37	23	3	63
Boat Gunwhale	M3	0.2	0.09	0	49	9	0	58
Canyon	M14	2	0	0	27	5	0	32
Hole in the Ground	M11	40	12	0	14	2	0	16
Kingsley Cove	M2	0	0	0	67	12	0	79
Lassen Park	M15	-	-	-	-	-	-	-
Lower Mill		-	-	-	-	5.2	4.5	-
Mill Tract	M12	23	8	0.03	8	2	0	10
Morgan	M13	13	8	0.4	10	11	1	27
Pape		0	0	0	64	16	0	80
Rocky Gulch	M9	17	6	0	36	7	0	63
Savercool	M7	17	7	2	10	16	2	54
Townview		84	1	0	1	0.2	0	86

Rhyolitic soils dominate in 3 sub-basins within the Mill Creek watershed at all slopes: Big bend, Hole in the Ground, and Mill Creek Tract. Town view sub-basin has the largest rhyolitic component at 84%. Erosion hazard ratings for the soils of Mill Creek range from low to very high, with the majority in the high to very high range. Erosion ratings are based on parent material, depth to impenetrable layer, texture and slope. Within the Mill Creek watershed, the most limiting factor in resin hazard ratings is slope. Avery and Black Rock sub-basins have the largest area in slope classes greater than 35%, both have 26% of the area with soils having high and very high erosion ratings. The canyon area of Mill Creek is dominated by rock land, colluvial land, McCarthy soils and the Lyonsville and Jiggs soil series.

Areas within Mill Creek watershed that are dominated by rhyolitic soils are more susceptible to erosion than those areas that do not have a rhyolitic component. Areas that have both a rhyolitic component and a high resin hazard rating have the highest resin potential. Thus, the Mill Creek watershed is characterized by high to very high erosion hazard soils.

Antelope Creek

The Antelope creek watershed is characterized by low to moderate sloping hills, out of the rhyolite zone surrounding Mt. Lassen. The only sub-basin with a rhyolitic component is Tamarack Road north, which contains 30% rhyolite. Soils with a high and very high erosion rating are found within Round Mountain, Crazy Canyon, Tamarack Road North, Lower South Fork, and Lower North Fork sub-basins. With relatively few numbers of sub-basins containing soils of concern, the Antelope watershed is not much of a concern as Mill and Deer Creek in terms of resin potential. A summary by sub-basin of the total percentage of rhyolite soil, erosion hazard ratings of high and very high are broken into three slope classes shown in table 6.

Table 6-B.- Summary of soils of concern in the Antelope Creek watershed.

Sub-Basin Name	Sub-Basin #	% of Sub-Basin in Rhyolite			% of Sub-Basin with High of Very High EHR No Rhyolite			
		Slope Class						
		0-35%	36-65%	>65%	0-35%	36-65%	>65%	Total
Round Mountain	AC1	1.3	0	0	36.3	5.8	0	42
Crazy Canyon	AC2	5.5	0.6	0	56.3	7.9	0	64
Tamarack Road North	AC3	27.9	0	0	61.4	0.5	0	62
Gunbarrel	AC4	0	0	0	4.1	0	0	4.1
Upper SF Antelope	AC5	1.1	0	0	13.9	0.5	0	14
McCarthy	AC6	0	0	0	2.9	0	0	2.9
Howard	AC7	0.1	0	0	1.5	0	0	1.5
Lower SF Antelope	AC8	0.4	0.1	0	50.1	18	2.7	71
Lower NF Antelope	AC9	0	0	0	49.9	17.3	0	67
Judd	AC10	3.3	0	0	5.3	1	0.3	6.6
Upper NF Antelope	AC11	1	0.1	0	12.6	7.3	0.7	21
Middle Fork Antelope	AC12	2.8	0	0	28	3.3	0.1	31
Deadhorse	AC13	2.6	0.2	0	10.9	0.1	0	11
Lower Antelope	AC14	0	0	0	20.7	1.3	0	22

APPENDIX C - WILDLIFE ANALYSIS

WATERSHED ANALYSIS REPORT

MILL, DEER AND ANTELOPE CREEK WATERSHEDS

Wildlife Analysis

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PART I: Introduction

Deer, Mill and Antelope watersheds, encompassing portions of Tehama, Butte and Plumes counties, contain a diverse array of wildlife habitats and species. Sao et al. (1988) and England et al. (1988) conclude that Mill and Deer Creek watersheds contain wildlife populations and habitats of state and possibly national significance. The three creeks roughly parallel each other, with Antelope creek to the north and Deer creek to the south, all eventually draining into the Sacramento River. The three watersheds share similar species and habitat assemblages, though each has its own unique attributes. The wildlife species and habitats of the watersheds are characterized together in this report. Significant resources unique to a particular watershed are noted.

Species and Habitat Changes in the Watersheds

Animal species have evolved on the changing physical landscape of the Sierra Nevada during the past 400 million years. Pre-historic animal remains have been suggested or found in the southern Cascades. During the Pleistocene period, large megafauna (camels, horses, ground sloths, mammoths, bison and saber-toothed cats) utilized the foothills of the Sierra Nevada (Erman et al. 1996). All of these large mammals became extinct about 10,000 years ago as a result of climate changes and predation by early human arrivals. It is possible these species once utilized the analysis area. Human presence began within the area approximately 11,000 years ago at the end of the Pleistocene period. In more recent times, Spanish and European settlement of the analysis area caused or contributed to the extirpation of at least 4 species since 1850.

Grizzly bears (*Ursus arctos*) were once common throughout the analysis area. Reed and Gaines (1944) describe multiple encounters with grizzly bears along the Lassen trail near Deer Creek. Heizer and Kroeber (1979) also document grizzlies in Deer and Mill Creeks, with sightings of large groups (5) common. These bears were shot on sight for hides and as vermin. The grizzly was extirpated from California by 1922 (Erman et al. 1996).

Gray wolves (*Canis lupus*) were also a common resident of the analysis area. In Reed and Gaines (1944), J.G. Bruff describes "large gray and black wolves" and a smaller "yellow" wolf. These wolves were frequently seen along the Lassen trail in the mid 19th century. Young and Goldman (1944) reproduce a 1939 Forest Service report listing 16 wolves still present on the Lassen National Forest at that time. They further state that by 1944, it was likely that all wolves in California were extirpated.

Least Bell's vireo (*Vireo belli pusillus*) was once common below 2000 feet in the western Sierra Nevada (Zeiner et al 1990). Grinnell et al. (1930) located this species at the confluence of Mill Creek and the Sacramento river. England et al. (1988) state that this species is no longer found in Northern California and their survey efforts in the analysis area failed to detect any. Decline of this species is related to nest parasitism by brown headed cowbirds (*Molotrus ater*) and alteration of willow dominated riparian corridors (Erman et al. 1996).

California Condors may have once lived in Tehama county. Grinnell (1930) cites two references which discuss the presence of condors in the vicinity of Red Bluff and the foothills of Mt. Lassen. There was no trace of this species in 1930.

Many plant communities in the analysis area have been significantly altered since the mid 19th century. Oak woodlands and foothill chaparral have been most extensively modified (Erman et al. 1996). The herbaceous understory of these communities was replaced by introduced European grasses and herbs. A Forest Service report on the Tehama Deer winter range (USDA 1946), which encompasses much of the analysis area, reports that the original plant cover was "completely destroyed" and the existing forage consisted of only introduced annuals. Mayer et al. (1988) describes many exotic grasses and forbs when describing oak and chaparal communities.

Exotic wildlife species have been transplanted or invaded the analysis area. Wild turkeys (*Meleagris gallopavo*) are a common resident and were transplanted to provide recreational hunting opportunities. European starlings (*Sturnis vulgaris*) were brought into the country by European immigrants and have expanded throughout the analysis area. Other known exotics include: wild horses (*Equus caballus*), feral cattle (*Bos taurus*), wild pigs (*Sus scrofa*), bull frogs (*Rana catesbiana*), various fish species, house sparrows (*Passer domesticus*), Norway rats (*Rattus norvegicus*), black rats (*Rattus rattus*), house mouse (*Mus musculus*) and a wide assortment of insect species. The introduced exotics compete with the native wildlife species in various ways.

In addition to invasion by exotic species, control of fire throughout the 20th century has had marked impacts on the composition of nearly all habitat types in the analysis area. Brush has grown decadent in many areas, and stands of mixed conifer are overstocked with white fir. Fires, when they do occur, are large in size and often of stand replacing intensity. Recent examples of such fires are the Barkely fire of 1994 and the Campbell fire in 1992.

Riparian habitats in the analysis area have been extensively modified through water diversions, grazing, timber harvest and settlement. All of the major water diversions on the creeks occur below National Forest lands, but the lack of water downstream may have effects to upstream wildlife. Cattle grazing has occurred year round in the Ishi wilderness area until recently. Many of the high elevation meadows have also been heavily grazed by both sheep (historically) and cattle.

Late successional forests have been modified in the analysis area by timber harvest, road building, control of fire, climatic change and settlement. Mixed conifer and pine forests were generally more open with a greater proportion of large diameter trees. The possible primary factor responsible for this was that the climate of the last 1,000 years was drier than today (Laudenslayer and Skinner 1995), resulting in higher incidence of fire. Timber harvest began in the 19th century to supply logs to mining operations. Mills began operation in the analysis area as early as 1851, with harvest operations continuing at varying levels through the present time.

Many of the habitat modifications in the analysis area are irreversible or so difficult to recover that return to historic conditions is highly unlikely. The best example of this situation is the oak woodland and chaparral vegetation understory in the Ishi wilderness and vicinity. The mixed conifer and true fir communities in the upper and mid elevations of the analysis area are the least impacted. The extirpated species are not likely to return due to the extent of habitat modifications and the large ranges required by wolves and grizzly bears. Many other species in the watershed are considered at risk and will be discussed in detail below.

PART II: Species of Concern or at Risk

At risk species within the analysis area are those which are listed as threatened, endangered or species of concern by the U.S. Fish and Wildlife Service, sensitive by the U.S. Forest Service or listed by the State of California. State of California listed species known to occur in the analysis area are included, though species with information gaps may not be described.

American Peregrine Falcon (*Falco peregrinus anatum*)

The peregrine falcon is classified as endangered by the Fish and Wildlife Service. In 1970, there were only two known pairs of peregrine falcons in California (Pagel and Jarman 1992). Peregrine falcon populations declined drastically worldwide from 1960-1985 due to reproductive failures induced by organochlorine pesticides (Pagel and Jarman 1992). Since 1985, peregrine falcon sites in California have increased and the species is beginning to recover. Long term recovery still remains uncertain until organochlorine contamination of peregrine falcon prey is eliminated. According to Aulman (1991), there has been no steady decrease in DDE levels and resulting eggshell thinning trends in California.

Nesting peregrine falcons have been documented in all 3 watersheds within the analysis area. There are currently 3 known active peregrine eyries, one inactive and several suspected. At this time, Deer Creek has the greatest concentration of active sites. A new active eyrie was located in the Antelope Creek watershed in 1996. Previously active eyrie sites in Mill Creek were not active in 1996, however, surveys were not adequate to cover all the suitable habitat available.

Raptor surveys have been conducted in the Mill and Deer Creek drainages since 1978 (Camarena). Dan Airola (1981) continued surveys throughout the early 1980s. These surveys documented approximately 60 suitable nest cliffs in each drainage. Antelope Creek was not surveyed but probably has at least 30 suitable sites. Prey availability is excellent in the analysis area. Large flocks of band-tailed pigeons (*Columbia fasciata*) are common, as are many other prey species. Habitat throughout the analysis area is ideal for peregrine falcons.

Reproductive success prior to 1996 is only known for one of the currently active sites in the analysis area. This eyrie, in the Deer Creek watershed, was manipulated (eggs removed and replaced with live chicks) several times in the 1980s. Analysis of eggshells taken from the eyrie found 15-26% thinning, indicating significant pesticide contamination (Airola 1984). In 1996, this same eyrie produced 3 fledglings. An eyrie in Mill Creek produced 3 fledglings in 1987 but was not monitored again for 8 years. A new eyrie in Deer Creek produced at least two fledglings in 1996 and the newly discovered eyrie in Antelope Creek is suspected to have failed. The reason for failure could not be determined from ground observations.

Status of peregrines in the analysis area appears to be improving. The discovery of two new eyries in 1996, with limited surveys, indicates that the population has doubled since 1986. There are almost certain to be additional active eyries in the more isolated portions of the analysis area. Levels of pesticide contaminants may still play a role in reproductive success for the analysis area population. Monitoring of eggshell thickness in selected eyries should be completed to determine the significance of this issue. Additional monitoring of suitable habitat is necessary to determine the extent of occupied sites.

Northern Bald Eagle (*Haliaeetus leucocephalus*)

The northern bald eagle is listed as threatened by the US Fish and Wildlife Service. Bald eagles require rivers, streams or large lakes for foraging. Large trees are needed for nesting and roosting. Bald eagles have been observed in many areas of the analysis area. They are commonly seen foraging throughout Deer and Mill Creeks. Probable prey items are chinook salmon (*Oncorhynchus tshawytcha*), steelhead and rainbow trout (*Oncorhynchus mykiss*) and various species of waterfowl. England et al. (1988) reports a winter roost site in lower Mill Creek that is significant to birds foraging in the Sacramento Valley. No known nests are located within the watersheds. The closest known sites are within Lassen Volcanic National Park and along the Feather River at Lake Almanor.

A suspected nest site is in the area of Deer Creek Meadows. A pair of bald eagles is often observed here during the nesting season. No thorough surveys have been conducted to locate this site. Eagles are also seen regularly in the Wilson Lake area. There may be a nest site in the vicinity. No sightings of bald eagles in the Antelope Creek watershed could be documented. It appears Deer and Mill creeks are of greatest significance to eagles.

The bald eagle is recovering throughout its range in California. Recovery goals set in the Pacific Bald Eagle Recovery Plan (USDI 1986) call for 15 recovery territories in the Lake Almanor area. This number has nearly been acheived. The trend in the analysis area for bald eagles appears to be stable or upward.

Willow Flycatcher (*Epidomax traillii*)

Willow flycatchers are small passerines that prefer riparian willow thickets for breeding (Craig et al. 1992). They are neotropical migrants, wintering in Mexico and Central

America. This species has been extirpated as a breeding bird from most of its range in California (Sanders and Flett 1989). Loss or alteration of riparian habitat and nest predation by brown headed cowbirds are suspected factors in the decline. Willow flycatchers are listed as sensitive by the U.S. Forest Service and a bird species of special concern by the state of California.

Inventories for willow flycatchers have been conducted by Almanor Ranger District biologists on all proposed projects within the analysis area since 1982. Small populations have been detected at Spencer Meadows near the Lassen National Park boundary, and at Gurnsey Creek adjacent to Highway 36. Grinnell et al. (1930) reported nests in Battle Creek Meadows and near Mineral. England et al. (1988) surveyed several historic locations in the analysis area. They could only locate birds in the Gurnsey Creek area.

There are many sites in Deer and Mill Creek watersheds which historically have been excellent habitat for willow flycatchers. Cattle grazing has reduced the size and complexity of willow patches in many meadows. Brown headed cowbirds are common throughout the analysis area, especially in meadows frequented by livestock. Sanders and Flett (1989) project that willow flycatchers will disappear as a breeding bird in California if current trends continue. The limited populations in the analysis area seem to support this trend towards extirpation.

As allotment management plans are updated and revised, grazing systems should be implemented which improve willow habitat. Habitat which currently supports willow flycatcher populations should be protected from grazing during the breeding season.

Sierra Nevada Red Fox (*Vulpes vulpes necator*)

The range of the Sierra Nevada red fox includes high elevation habitats (above 4000 feet) within the analysis area. The species is listed as sensitive by the U.S. Forest Service and threatened by the state of California. The Sierra Nevada red fox is the only native red fox in California and is considered one of the rarest forest carnivores in the state (Crabtree and Thelander 1994). A possible cause of this species decline is the introduction of non-native red foxes from the midwest (*Vulpes vulpes regalis*) (Lewis et al. 1995). Cross breeding between the species could destroy the genetic integrity of the Sierra Nevada red fox. Other possible reasons for decline include historic over-trapping, logging, livestock grazing and recreational activities (Crabtree and Thelander 1994). Additional causes of decline may be related to competition with other canids and availability of a suitable year-round food source (Voight 1989).

Red foxes have been sighted in the analysis area. Historically, the largest group of true Sierra red fox sightings occurred in the vicinity of Lassen National Park (Lewis et al. 1995). It is unknown if the recent sightings are true Sierra Nevada red foxes. It is possible they are introduced or crossbred foxes. There were numerous fox farms in the Lake Almanor area prior to 1950 which raised red foxes commercially for fur. The farmed foxes were genetically related to the midwestern U.S. subspecies. Farms were located at Chester, Almanor, Westwood and Susanville in the 1930s and 1940s (Lewis et al. 1995) It is possible that some of these animals escaped and interbred with local populations.

Additional research is necessary to determine the status of this species in the analysis area. It will be necessary to collect genetic information to truly determine if the red foxes present are V.v.necator. Winter track and camera surveys will also help determine the range and size of the population.

American marten (*Martes americana*)

The American marten is classified as a sensitive species by the U.S. Forest Service in California. Surveys for forest carnivores on the Almanor District have located marten primarily in red fir habitat types. Ruggiero et al. (1994) found that marten preferred lodgepole pine in riparian settings and red fir at higher elevations in the Sierra Nevada. High elevation red fir and lodgepole habitats compose only 2% of the total analysis area. Habitat within the analysis area is probably not of major significance to marten.

Primary marten habitats within the analysis area are in the upper reaches of the Mill Creek watershed. Deer Creek and Antelope Creek watersheds do not support habitats that favor martens. The range of the marten in California has decreased due to historic over-trapping and elimination of habitats through timber harvest (Ruggiero et al. 1994). Management activities in the red fir zone should strive to meet the "high" habitat capability guidelines for marten habitat as stated in the Lassen National Forest Land and Resource Management plan (LRMP) (USDA 1992).

Pacific Fisher (*Martes pennanti*)

Prior to European settlement, fishers were widely distributed in forested habitats of California (Ruggerio et al. 1994). Between 1800 and 1940 fisher populations declined dramatically throughout the Pacific States due to over-trapping, non-target poisoning and habitat alteration (Aubry et al. 1995). Fisher populations in California were petitioned in 1990 (USDI 1991) and 1994 (USDI 1996) for listing under the Endangered Species Act. Both petitions resulted in negative 90 day findings due to inadequate information on past and present distribution, status and ecology (Aubry et al. 1995). Fisher are currently classified as Sensitive by the U.S. Forest Service and Threatened by the state of California. There are no confirmed fisher sightings in the analysis area, though several un-confirmed sightings are on file at the Almanor Ranger District. According to Ruggerio et al. (1994), fishers are declining or barely holding steady in the northern Sierra Nevada.

Habitat in Deer, Mill and Antelope creeks appears to be ideal for fishers. Monitoring has not been adequate to determine presence or absence in available habitats. Surveys for fisher using protocol developed by Zielinski and Kucera (1996) will be necessary to truly determine the status of fisher in the analysis area.

Great Gray Owl (*Strix nebulosa*)

The great gray owl is classified as sensitive by the U.S. Forest Service. The only confirmed sighting within the analysis area occurred in the upper Mill Creek watershed in 1956. This sighting was near the Bumpass Hell trail in Lassen National Park and was thought to be a post-breeding owl dispersing (England et al. 1988). Pacific Southwest research station employees surveying for spotted owls in 1996 reported two responses from great gray owls in the Feather River watershed adjacent to the analysis area. Follow-up surveys failed to confirm these responses. England et al. (1988) refers to a historical record near Coon Hollow in 1977 but clarifies that the record my be in error.

No protocol surveys have been completed for great grays in the analysis area. Great grays are very difficult to detect and the limited surveys which have been conducted by England et al. (1988) and Almanor District biologists in 1996, are not sufficient to determine this species presence or absence. According to Hayward and Verner (1994), it is necessary to monitor and survey great gray populations for longer than 3 years to assess any data.

Fire suppression, livestock grazing and timber harvest in the analysis area have probably resulted in both positive and negative consequences for great gray owls (Hayward and Verner 1994). More foraging areas have been opened up by logging, but roosting and nesting habitats have been reduced. Grazing and fire suppression have allowed conifers to encroach on meadows, reducing habitat. Population trends in California overall are not certain. Hayward and Verner (1994) state that persistence of the species in California is not certain, but the species as a whole appears secure over its range.

Surveys of suitable habitat in the analysis area are necessary to determine if a breeding population exists. To provide great gray habitat, management efforts should utilize prescribed natural fires to maintain meadow habitats. Large, late successional trees and snags should be retained in stands adjacent to foraging habitat.

Northern Goshawk (Accipiter gentilis)

The northern goshawk is classified as sensitive by the U.S. Forest Service. It is a forest habitat generalist that uses many different forest types and structures. Goshawks require particular stand characteristics for nesting and others for foraging. It is essential to maintain a mix of age classes and structure to insure suitable habitat is available. Goshawks are an inhabitant of the analysis area. The Lassen National Forest LRMP incorporates guidelines for a network of 113 goshawk management areas (GMAs). This network is designed to insure maintenance of a viable population of goshawks over time on the Forest. According to the LRMP, it is necessary to maintain 90% occupancy in the GMA network to achieve population viability. There are currently 13 GMAs within the analysis area. Each GMA is 125 acres in size, typically centered on a known nest site. If there is no known nest site available, the most suitable habitat is designated.

There are 11 known goshawk nest sites in the analysis area. Of these, only 4 are within designated GMAs. GMAs in the analysis area are not currently meeting the LRMP guidelines for population viability (90% occupancy). It is possible that current LRMP direction is not sufficient to maintain viable goshawk populations in the analysis area even if goals were being met. Woodbridge and Dietrich (1994) found that nest stands needed to be 152 acres or larger to achieve occupancy above 90%. Guidelines for northern goshawk management in Region 3 require 180 acres (USDA 1992). Direction for the Klamath National Forest (USDA 1992) recommends establishing a primary nest zone (504 acres), of which 200 acres is managed as nesting habitat. In addition to the primary nest zone, 1,506 additional acres are managed to provide foraging habitat.

In order to insure goshawks retain viable populations in the analysis area, several steps are necessary. First, vacant GMAs should be relocated to incorporate active nest sites where available. Monitoring of suitable habitat using accepted protocol will insure that most active sites are located. GMAs should then be managed according to the Klamath National Forest direction, which reflects the best available scientific information.

California Spotted Owl (*Strix occidentalis californicus*)

The California spotted owl is classified as a sensitive species by the U.S. Forest Service and a species of special concern by the State of California. Extensive inventories have been conducted for spotted owls in the analysis area. Spotted owls are found in suitable habitat throughout the analysis area.

The ecology and status of the California spotted owl is well documented in Verner et al. (1992) and the California Spotted Owl Interim Guidelines (CASPOW Guidelines) (USDA 1993). A demographic study of owls in the study area has been underway since 1990, lead by the Pacific Southwest Research station. Preliminary results of the study indicate that local populations are declining at a rate of 6.6% per year.

Management at this time follows the the CASPOW Guidelines. These guidelines preserve management options for maintaining viability while a final management plan is written. The projected completion of the updated guidelines is early 1997.

California Wolverine (*Gulo gulo*)

California wolverine is classified as a species of concern by the U.S. Fish and Wildlife Service and threatened by the state of California. Historic range of the wolverine included the analysis area. No confirmed wolverines have been sighted in the northern Sierra Nevada since the early 1980s and the species may be declining (Ruggiero et al. 1994). Wolverines require large home ranges which contain a diverse array of habitats. They are sensitive to disturbance and the presence of roads may have significant effects on habitat suitability. If wolverines still exist in the Sierra Nevada eco-province they may be isolated from other wolverine populations by human disturbance (Ruggiero et al. 1994).

Several un-confirmed sightings of wolverine in the analysis area are on file at the Almanor Ranger Station. A wolverine in a den was sighted by a U.S. Forest Service biologist in 1993. The sighting was near the headwaters of Deer Creek. To determine if a population is present, it will be necessary to implement surveys in accordance with Zielinski and Kucera (1995). Surveys for wolverine can be conducted in conjunction with those for marten and fisher.

Sierra Nevada Snowshoe hare (*Lepus americanus tahoensis*)

Snowshoe hares are found in the upper elevations of the analysis area. They utilize early seral stages of mixed conifer, subalpine conifer, red fir, Jeffrey pine, lodgepole pine and aspen, especially in edges (Zeiner et al. 1990). The status of this species overall in the Sierra Nevada is unknown, but it is classified a species of concern by the U.S. Fish and Wildlife Service and of special concern by the state of California. Zeiner et al. (1990) indicates that numbers of this species may be quite low.

Status of the species in the analysis area is unknown. Sightings of snowshoe have been made in the analysis area but are in anecdotal form. In order to determine the range and status of the species, track surveys should be conducted in conjunction with marten, fisher and wolverine inventory.

Yuma myotis bat (*Myotis yumanensis*)
Fringed myotis bat (*Myotis thysanodes*)
Long eared myotis bat (*Myotis evotis*)
Long legged myotis bat (*Myotis volans*)
Small footed myotis bat (*Myotis leibii*)

The myotis species above are all classified as species of concern by the U.S. Fish and Wildlife Service. No documented surveys have been conducted in the analysis area to assess the status of Myotis bats. General observations in 1996 of foraging bats suggest that many species of Myotis are present. Very few studies have focused on the association of bats with different forested habitats (Christy and West 1993). Bats are highly dependent upon roost sites. Roost sites include cavities in trees, spaces under loose bark on snags and large live trees, crevices and cracks in cliffs and manmade structures such as bridges. Though all Myotis bats are discussed here under one heading, it is recognized that each species has unique habitat requirments and life history.

It is suspected that bat populations are declining (Christy and West 1993). Suspected reasons include loss of habitat and disturbance of roost and hibernation sites. Harvest of late successional habitat may be a key factor in bat population declines. In order to accurately monitor bat populations within the analysis area, it will be necessary to obtain baseline information on species composition, presence/absence and habitat use. A memorandum of understanding needs to be entered into with the Forest Service and California Dept. of Fish and Game to allow for bat monitoring.

Townsend's Big Eared Bat (*Corynorhinus townsendii*)

Townsend's big eared bats historically were considered common in the State of California. They are currently classified as a species of concern by the U.S. Fish and wildlife Service as well as the state of California. No documented sightings of big eared bats have been recorded in the analysis area. These bats require natural caves, tunnels, mines or buildings for roost sites. They are especially sensitive to disturbance and have been known to abandon key roosts sites if disturbed even a single time. All known nursery colonies in limestone caves within the species range in California have been abandoned (Zeiner et al. 1990). The species also seems to be sharply declining throughout the state.

The analysis area contains many caves which are potential big eared bat habitat. Many of the caves are within the Ishi wilderness and are not subjected to disturbance due to their remote or inaccessible locations. It is possible that disturbance is less now then when the area was occupied by native Americans. Surveys need to be conducted to determine the presence and status of the species in the analysis area. It is possible that important maternal colonies exist which should be protected from any disturbance.

Spotted Bat (*Euderma maculatum*)

The spotted bat is classified as a species of concern by the U.S. Fish and Wildlife Service. It is rare in California and there are few capture records for the species anywhere. Spotted bats require or prefer areas with steep cliffs for roost sites (Woodsworth et al. 1981). Relatively little is known about the ecology of this animal.

A spotted bat was detected over the analysis area in 1996. This was the first documented sighting in Tehama County. The analysis area has habitat that appears to be ideal for spotted bats. Additional monitoring and inventory work is necessary to ascertain the status of this species in the analysis area.

Western Mastiff Bat (*Eumops perotis*)

The western mastiff bat is classified as a species of special concern by the state of California. Mastiff bats were detected in 1995 in the Antelope Creek watershed below National Forest land. Mastiff bats require roosts which allow them to drop at least 10 feet prior to becoming airborne (Barbonr and Davis 1969). The Mill, Deer and Antelope Creek canyons contain a wide variety of excellent roosting and foraging habitat. Urine stains were observed on many cliff faces during aerial surveys in 1996. This is an indication of heavy bat use and may suggest the presence of Eumops.

Inventory and monitoring is needed to assess the distribution and status of Eumops in the analysis area. Much of the potential habitat is within the Ishi wilderness and not easily accessible, therefore populations may be undisturbed at this time.

PART III: Management Indicator Species

The Lassen LRMP identifies 18 wildlife and fish management indicator species (MIS). Habitat capability models have been developed to allow management to emphasize high, medium or low habitat capability for each MIS. Each management area designated in the LRMP contains specific direction for MIS emphasis.

Mule deer or Columbian black-tailed deer (*Odocoileus heminous columbianus*)

The analysis area encompasses large portions of summer and winter range habitat for the Eastern Tehama Deer Herd (ETDH). This deer herd is composed of Columbian black-tailed deer, a subspecies of mule deer. The ETDH is the largest migratory herd in California with a range of 2,250 square miles (CDFG 1983). Migration distance from summer to winter range is approximately 100 miles. During the gold rush period in the mid 19th century, the ETDH was decimated by market hunting. The herd began to recover at the beginning of the 19th century and reached peak levels during the period of 1930-1950 (CDFG 1983).

The size of the ETDH has fluctuated between 100,000+ individuals in 1963 (CDFG 1986) to 30,200 in 1996 (CDFG 1996). Deer herds are highly cyclic in nature. Recruitment of fawns into the adult population is primarily responsible for population size. Many factors can influence the recruitment rate, including winter and spring conditions, predation, hunting, highway mortality and overall summer and winter range habitat condition.

Deer herds have declined throughout the western United States since the 1960s (CDFG 1996). No one factor can be related directly to the decline, but urbanization and development may be the primary reason. Road building, residential expansion into forest land (urban interface), increasing recreational use and expansion of campgrounds and trails are aspects of increasing urbanization.

Recently, summer range conditions have been identified as a primary reason for declines in the deer herd (Dave Walker pers. comm.). Control of fire and the resulting loss of forage throughout the summer range areas contributes to low fawn recruitment. Timber harvest throughout the summer range has decreased or methods have changed in the last decade. Forage is being replaced at a very low rate.

The range size of the ETDH can not be increased. Management activities can manipulate the quality of deer habitats. Projects planned within the range of the ETDH should strive to meet the "High" habitat capability guidelines for mule deer where possible. Partnerships with CDFG and other groups should be developed to assist with the improvement of habitat conditions.

Black Bear (*Ursus americanus*)

The black bear is a common resident of the analysis area. Forest carnivore surveys have detected black bears uniformly throughout all three watersheds. Bear sign is evident in most habitats. Increasing conflicts with black bears and forest visitors have occurred within the analysis area. Bears often eat garbage in campgrounds and summer home tracts, sometimes destroying property in the process. Increasing development will continue to create situations where bears and humans come into conflict.

Control of fire and the resulting build up of dead and downed wood may have increased bear populations in the analysis area. Bears forage on insects and small mammals that utilize downed wood. The large amounts of wood available has created ideal foraging conditions for bears.

Project planning should address urban interface issues with bears. Recreational development should emphasize mitigation measures such as bear proof trash cans and signing. "Medium" or "High" habitat capability should be maintained in all management areas.

Hairy woodpecker (*Picoides villosus*)
Pileated woodpecker (*Dryocopus pileatus*)

Hairy and Pileated woodpeckers are primary cavity excavators. Snags are a key habitat requirement for both species and is their primary limiting factor (Thomas et al. 1979). Many other species are dependent upon primary cavity excavators. Cavities created are used as dens, nesting cavities, escape cover, for resting, feeding and thermal regulation. Both species are well distributed in the analysis area. No monitoring has been conducted to establish status in the analysis area.

Snags levels change constantly within the forest. It is assumed that snag levels are high in the analysis area due to control of fire. No actual monitoring of snag numbers has confirmed this. Forest management practices of the past caused the removal of snags over much of the landscape. Firewood collection, hazard reduction along roads and within harvest units and reduction of fire hazards are all present contributors to snag removals. The current management principle of creating defensible fuel profile zones (DFPZs) and community defense zones (CDZs) are examples of fire hazard reduction projects which may affect woodpecker populations. Desante (1995) suggests that logging, pesticide use on forest insect outbreaks and loss of riparian habitats may be contributors to a non-significant 0.8% decline in Hairy woodpecker populations in the Sierra Nevada. Pileated woodpeckers seem to show a stable population trend in the Sierra Nevada, possibly related to the ability of the Pileated to adapt more readily to changing forest conditions as it has done throughout the continent.

In order to insure maintenance of woodpecker populations, monitoring of populations and habitats should be conducted on management activities where snags are an issue. Methodology used would be the area search protocol (Ralph et al. 1993). Combined with this would be a count of snags in each plot, recording tree species, dbh, height, decay status and presence of cavities. Monitoring will validate the assumption that the "Medium" or "High" habitat capabilities are being met for woodpeckers.

Bufflehead (*Bucephala albeola*)

A small isolated bufflehead population breeds in northeastern California, including portions of the analysis area (Airola 1990). Buffleheads have been observed on Wilson Lake, Patricia Lake and Elizabeth Lake in the upper Mill Creek watershed. The primary breeding center for buffleheads in the Northern California area is in the upper Feather River watershed (McCoy reservoir and Susan River). Populations in the analysis area are on the periphery of the larger group.

Habitat improvement projects (placement of nest boxes, creation of snags) may increase the suitability of Wilson lake and other potential habitat in the analysis area. Yearly monitoring of breeding success, including banding of young and adults in partnership with the California Waterfowl Assoication, should be conducted each year.

Other MIS

Many of the remaining MIS have been identified earlier in Part II of this document. Other MIS are not of significance in the analysis area.

Birds (Local and Neotropical)

Avifauna populations in the Sierra Nevada are basically intact despite the rapidly growing human population in the area. Six species are in definite decline throughout the Sierra Nevada: band-tailed pigeon, American robin, red-breasted sapsucker, chipping sparrow, olive-sided flycatcher and white-crowned sparrow (Desante 1995, Erman et al. 1996). Many other species are likely decreasing but monitoring is too limited to establish the significance of declines. Some species are increasing in the Sierra Nevada, including white-headed woodpecker, cliff swallow, common raven and fox sparrow.

There is a significant lack of information regarding the status of local and neotropical landbirds in the analysis area. There are no Breeding Bird Survey (BBS) routes, MAP stations, point counts or other inventories in or adjacent to the analysis area. Desante (1995) indicates the highest priority species for additional monitoring. Species on this list which occur in the analysis area include: band-tailed pigeon, red-breasted sapsucker, olive-sided flycatcher, Swainson's thrush, chipping sparrow and white-crowned sparrrow. To begin adequate monitoring in the area the proposal "Effects of fire and grazing on sensitive and declining bird populations in Mill and Deer Creeks" (Geupel et al. 1996) should be implemented.

PART IV: Habitats of the analysis area

The analysis area contains a diverse array of habitat types. The current composition is reflected in Table 2. Habitat types were delineated using remote sensing. The accuracy of the acreages and types has not been verified with actual field reconaisance and should be viewed as a general indicator of existing conditions.

Descriptions of habitat types and general wildlife species associated with them can be found in "A Guide to Wildlife Habitats of California" (Mayer et al. 1988). Erman et al. (1996) discusses the importance of Sierra Nevada habitat types and lists critical findings regarding each. Their findings for three major habitat types, as well as relevance to the analysis area, are summarized below:

> **Foothill habitats** (mixed chaparral, wedgeleaf ceanothus, scrub oak, montane chaparral, gray pine, blue oak - gray pine, canyon live oak, black oak and interior live oak): 85 wildlife species require these habitat types in the Sierra Nevada. Fire suppression, conversion to grasslands and other developments have threatened the sustainability of these ecosystems. The Ishi wilderness is one of the only wilderness areas in the Sierra Nevada to contain many of these important habitats. The Ishi is of critical importance to wildlife and should be viewed as an area of greatest ecological sensitivity.
>
> **Old Growth Habitats** (Sierra Nevada mixed conifer, ponderosa pine, red fir, white fir, Douglas fir): Eighteen species are dependent upon these habitats in the Sierra Nevada. Loss of old growth is one of the most important identified causes for the decline of Sierra Nevada wildlife. Table 1 identifies the percentage of each conifer habitat type in the analysis area. The dominant size class for all species but Ponderosa pine falls in the medium size class. The remote sensing process did not discern large and two storied size classes in the analysis area. Some of the medium size class is actually late successional old-growth.
>
> **Riparian Habitats** (Wet meadows, white alder, cottonwood - alder and all other categories associated with streams, springs, seeps, bogs and ponds). Eighty two wildlife species are dependent upon these habitats in the Sierra Nevada. Riparian areas in the analysis area have been impacted to varying degrees. Deer Creek has had the greatest impacts due to the construction of Hwy 32 along the majority of its upper reaches. Refer to the aquatic report for specific history and conditions of this habitat.

Table 1-C.- Old Growth Habitat Size Classes (% of Area)

Size Class	Mixed Conifer	White Fire	Douglas Fir	Ponderosa Pine
Non-Stocked	0.5%	0.4%	0%	0%
Seedlings	5%	2%	0%	0.6%
Saplings	2%	1%	0%	0.3%
Poles	1%	2%	9%	4%
Small	44%	7%	32%	76%
Medium	47.5%	87.6%	59%	19.1%

Table 2-C.- Habitats of the Analysis Area

Habitat Type (CALVEG)	Acres
Barren	1,943
Mixed Chaparral-low elevation	19,152
Wedgeleaf Ceonothus	5,432
Montane Mixed Shrub-high elevation	3,756
Scrub Oak	6,753
Montane Chaparal-mid elevation	11,805
Douglas Fir	1,827
Wet Meadows	2,012
Lodgepole Pine	1,889
Sierran Mixed Conifer-Fir	67,719
Mountain Hemlock	303
Sierran Mixed Conifer-Pine	58,576
Gray Pine	892
Ponderosa Pine	18,712
Canyon Live Oak	10,443
Blue Oak-Grey Pine	18,976
White Alder	59
Cottonwood-Alder	73
Black Oak	7,115
Quaking Aspen	197
Interior Live Oak	394
Red Fir	3,226
Sub-Alpine Conifer	86
Water	137
White Fir	12,135
Total	**253,612**

Potential natural vegetation modeling done for the analysis area as part of the watershed analysis is available in the ecology report. Please see this report for more detailed habitat observations. In general, the findings of the modeling indicate that the ecological groups that are the farthest removed from historical conditions are the productive southwest exposures containing mixed conifer. Historically, canopy closures were below 60% in most of this area. Today from 32 to 70% of these sites have greater than 60% canopy closure.

PART V: Conclusion

The Mill, Deer and Antelope Creek watersheds contain a diverse array of wildlife species and habitats, supporting numerous species of concern. Significant changes have occurred over the last 10,000 years. Most recently, the resources of the area have been modified by Spanish and European settlement. Plant communities have been irrevocably changed by the invasion and introduction of exotic grasses and forbs. Exotic wildlife has become naturalized in many locations. Grizzly bears, wolves and least Bell's vireos have been extirpated. Peregrine falcons and bald eagles, once close to extirpation, have begun to expand their ranges in the watersheds. Willow flycatchers and California spotted owls have declining populations. Six other species of birds are in apparent decline. The status of most species is unknown due to limited monitoring. Erman et al. (1996) lists many additional Sierra Nevada wildlife species that are likely decreasing.

There is little question that the wildlife resources of the analysis area are significant. Many species of concern utilize the area. The Ishi wilderness and other remote portions of the analysis area contain some of the least disturbed habitats in the Sierra Nevada. The lack of data for many species and habitats is a critical management gap. It is necessary to establish baseline information on species before true adaptive management can be accomplished. Large scale management proposals implemented in the future should adopt monitoring plans which focus on more than just single species. Trail (1995) discusses a forest monitoring strategy for wildlife habitat that would further the goal of adaptive management if implemented. Plans such as this, adapted to the analysis area, will insure biologists have information to determine effects of proposed actions and can assess the status of species of concern.

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APPENDIX D - AQUATIC SPECIES REPORT

CHARACTERIZATION

Aquatic biodiversity in Deer, Mill, Antelope watersheds

Biological diversity (biodiversity) has been defined as "the variety of life and its processes", and can be further categorized into four levels: genetic, species, ecosystem, and landscape (Noss and Cooperrider 1994). Species diversity is of concern worldwide, as the rate of species extinction is rapidly accelerating. Aquatic species in particular are declining at a faster rate than terrestrial species (Moyle and Yoshiyama 1994). For example, over 25% of fish and amphibian species, and over 60% of crayfish and unionid mussels in North America are classified as rare, imperiled, or some more severe form of endangerment. This compares with percentages of less than 15% for mammals, birds, and reptiles (Noss and Cooperrider 1994).

In California, native aquatic communities are declining. Aquatic habitat has been altered or degraded mostly by dams and diversions, which have blocked migration of aquatic species, and/or changed flow regimes enough to change aquatic habitat conditions. These problems have been exacerbated in many cases by the introduction of non-native or hatchery-bred species. The result is that few streams support the native fish assemblages that occurred prior to European settlement. However, Deer, Mill, and Antelope Creeks still support the majority of their original native assemblages. The three watersheds have been rated as having high "biotic integrity" (defined as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region") (Moyle & Randall 1996).

Native aquatic species common to the three drainages include: chinook salmon (spring and fall runs), steelhead rainbow trout (winter run), resident rainbow trout, riffle sculpin, Sacramento sucker, Sacramento squawfish, hardhead, California roach, speckled dace, Pacific treefrog, and western pond turtle. In addition, the following native species reside in at least one of the three drainages: tule perch, Pacific lamprey, Pacific brook lamprey, foothill yellow-legged frog, Cascades frog, long-toed salamander, rough-skinned newt, California newt, ensatina, and aquatic garter snake.

Table 1-D.- Introduced (non-native) aquatic species are known to occur in Mill, Deer, and Antelope Creek drainages.

Deer Creek	Mill Creek	Antelope Creek
smallmouth bass	smallmouth bass	smallmouth bass
brown trout	brown trout	brown trout
rainbow trout (hatchery)	rainbow trout (hatchery)	rainbow trout (hatchery)
green sunfish	green sunfish	green sunfish
common carp		
largemouth bass		
bluegill		
brook trout		
bullfrog		

The remainder of this report describes the anadromous salmonids that utilize habitat within Deer, Mill, and Antelope Creeks.

Anadromous Salmonids

Anadromous salmonids that utilize habitat in the Deer, Mill, and Antelope Creek watersheds are the spring-, fall-, and late-fall runs of chinook salmon (Oncorhynchus tshawytscha); and winter-run steelhead (Oncorhynchus mykiss).

Spring-run chinook salmon in general have declined in numbers since approximately the 1900's, and are now largely influenced by hatchery-reared fish. The spring-run in Deer, Mill, and Antelope Creeks may be the last remaining "wild" populations in the Central Valley. Fall-run chinook populations have also declined over the past 100 years, although not as dramatically as the spring-run. However, it is believed that hatchery-produced salmon have substantially supplemented the fall-run, and that relatively few "wild" fall-run still exist in the Central Valley. Chinook salmon are currently under status review by the National Marine Fisheries Service (NMFS) to determine whether the species warrants protection under the Endangered Species Act.

Steelhead populations have also declined, and hatchery fish have substantially augmented natural runs. Steelhead numbers in the three drainages are believed to be very low. NMFS proposed to list the Central Valley steelhead as endangered under the Endangered Species Act on August 9, 1996 (NMFS 1996).

This report will focus primarily on the spring-run chinook salmon and winter-run steelhead, because the fall- and late-fall runs of chinook utilize habitat downstream of the Lassen National Forest boundaries. Since they occur mostly on private lands, we do not have much information about fall-run habitat or habitat requirements in the three drainages. While this report will not focus on the fall-run, it is recognized that upstream management activities have the potential to affect downstream habitat that is utilized by fall- and late-fall-run chinook salmon.

Chinook Salmon

Life History: Chinook salmon are anadromous and semelparous (adults die after spawning once). Their life history is variable in terms of: age at seaward migration, length of time spent in freshwater, estuarine and oceanic residence, ocean distribution and migratory patterns, and age and season of spawning migration. These variations apparently derive from the fact that the species occurs in two behavioral forms. The "stream-type" form spends one or more years as fry or parr in fresh water before migrating to the sea; performs extensive offshore oceanic migrations; and returns to natal streams in the spring or summer, several months prior to spawning. Males of this form occasionally mature precociously without ever going to sea, or after spending just a few months in the ocean. The "ocean-type" form migrates to sea during their first year of life, usually within three months after emerging from the spawning gravel; spends most of their ocean life in coastal waters; and returns to natal streams in the fall (just prior to spawning) (Healey 1991).

Chinook salmon may return to their natal river mouth during almost any month of the year. However, there are typically peaks of migratory activity. The runs are named on the basis of the upstream migration season. The fall and late-fall runs spawn soon after entering their natal streams ("ocean-type"), while the spring and winter runs typically "hold" in their streams for up to several months before spawning (characteristic of "stream-type" fish) (Healey 1991). The runs can also be generally differentiated on the basis of their typical spawning habitats: spring-fed headwaters for the winter run, the higher streams for the spring run, upper mainstem rivers for the late-fall run, and the lower rivers and tributaries for the fall run (Yoshiyama et al. 1996).

Spring-run chinook adults migrate from the ocean during March and April, and "hold over" in deep pools throughout the summer. Adults congregate in pools at least one to three meters deep, with a large amount of cover (especially "bubble curtains" and bedrock ledges), some stream shade, moderate velocities, and proximity to gravel beds suitable for spawning. Spawning occurs from late August through October, and adults die soon after. Salmon prefer riffles, runs, and pool tails for spawning that are relatively shallow with velocities ranging between 1.0-3.5 feet per second. Preferred spawning substrate appears to be a mixture of gravel and cobble, with less than five percent fines. Spawning beds must be well oxygenated and relatively silt-free for good egg survival. Eggs and sac fry remain within the gravel for several months, depending on water temperature (temperatures must range between 42 and 56 degrees F for egg and fry survival). Once the fry emerge from the gravel, they may begin migrating downstream (toward the ocean) immediately or remain in the stream for several months to more than a year. Salmon fry feed in low velocity slack water, moving to somewhat deeper and higher velocity areas as they grow larger. (CDFG 1993)

Fall-run chinook adults migrate from the ocean to the three drainages between October and December, with the peak run occurring in early November. They spawn within a few days to a few weeks of entering the streams, and adults die shortly thereafter. Late-fall run chinook adults migrate into the Sacramento River from mid-October through mid-April, and overlaps the fall-run chinook spawning migration. Spawning occurs from January through mid-April (CDFG 1993).

Juveniles in freshwater habitats feed mostly on larval and adult insects. Those that migrate downstream within their first year apparently do so at night, while yearlings migrate during both the day and night. They may migrate immediately to the ocean, or reside in a downstream river or the Delta for several months. Some seaward migrations are associated with high runoff periods from storms; but overall, little is known about what triggers migration in juvenile chinook salmon (Healey 1991).

Juvenile mortality (for anadromous fish in general) during and after seaward migration may be attributed to: predation, starvation, osmotic stress, disease, and ocean conditions. Predation is probably the primary cause of mortality, and size is a factor when considering survival. (Healey 1991) (CDFG 1996a) Other factors to be considered with Central Valley juvenile mortality are: water quality, irrigation pumps with inadequate fish screens, and unscreened water diversions that prevent fish from reaching the ocean (CDFG 1993).

Adult chinook utilize the ocean according to their behavioral form: "stream-type" fish utilize the open ocean, and are widely distributed; while the "ocean-type" fish reside primarily along the continental shelf. Adults are mainly pisciverous, although crustaceans and other invertebrates are also eaten (Healey 1991).

Adult mortality (for anadromous fish in general) occurring in the ocean may be attributed to: authorized and unauthorized high seas drift nets and other harvesting methods, predation, competition, and environmental conditions (water/air temperatures, strength of upwelling, El Nino events, salinity, ocean currents, wind speed, primary and secondary productivity) (CDFG 1996a).

Distribution: Chinook salmon occur throughout the North Pacific Ocean. They utilize streams and rivers throughout the Pacific Northwest, from Alaska to central California (Figure 1). In California, the Central Valley (Sacramento-San Joaquin drainages) historically provided at least 25 streams that were used by at least one run of chinook salmon annually.

Current and historical distribution will be discussed in more detail later in this report; but in general, most of the Central Valley chinook populations have either declined or been extirpated, particularly in the San Joaquin system (Figure 2).

The Sacramento system (historically and currently) supports four seasonal runs: spring, fall, late-fall, and winter; which lends it the uncommon distinction of having some numbers of adult salmon in its waters throughout the year (Yoshiyama et al. 1996). Deer, Mill, and Antelope Creeks are three "eastside" Sacramento tributaries that provide habitat for spring-, fall-, and occasionally late-fall runs of chinook salmon.

Steelhead

Life History: The following discussion about steelhead life history is quoted from the Federal Register, August 9, 1996 (NMFS 1996).

"Steelhead exhibit one of the most complex suite of life history traits of any salmonid species. Steelhead may exhibit anadromy (meaning that they migrate as juveniles from fresh water to the ocean, and then return to spawn in fresh water) or freshwater residency (meaning that they reside their entire life in fresh water). Resident forms are usually referred to as "rainbow" or "redband" trout, while anadromous life forms are termed "steelhead". Few detailed studies have been conducted regarding the relationship between resident and anadromous O. mykiss and as a result, the relationship between these two life forms is poorly understood.

"Steelhead typically migrate to marine waters after spending two years in fresh water. They then reside in marine waters for typically two or three years prior to returning to their natal stream to spawn as four- or five-year-olds. Unlike Pacific salmon, steelhead are iteroparous, meaning that they are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying; most that do so are females. Steelhead adults typically spawn between December and June (Bell 1990). Depending on water temperature, steelhead eggs may incubate in "redds" (nesting gravels) for 1.5 to four months before hatching as "alevins" (a larval life stage dependent on food stored in a yolk sac). Following yolk sac absorption, alevins emerge from the gravel as young juveniles or "fry" and begin actively feeding. Juneniles rear in fresh water from one to four years, then migrate to the ocean as "smolts".

"Biologically, steelhead can be divided into two reproductive ecotypes, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration. These two ecotypes are termed "stream maturing" and "ocean maturing". Stream maturing steelhead enter fresh water in a sexually immature condition and require several months to mature and spawn. Ocean maturing steelhead enter fresh water with well-developed gonads and spawn shortly after river entry. These two reproductive ecotypes are more commonly referred to by their season of freshwater entry (e.g. summer and winter steelhead).

"Two major genetic groups or "subspecies" of steelhead occur on the west coast of the United States: a coastal group and an inland group, separated in the Fraser and Columbia River Basins by the Cascade crest, approximately. Behnke (1992) proposed to classify the coastal subspecies as O. m. irideus and the inland subspecies as O. m. gairdneri. These genetic groupings apply to both anadromous and non-anadromous forms of O. mykiss. Both coastal and inland steelhead occur in Washington and Oregon. California is thought to have only coastal steelhead, while Idaho has only inland steelhead." (NMFS 1996)

Central Valley winter-run steelhead migrate from the ocean between November and March, and spawn during December through March. In general, habitat requirements for steelhead are similar to those for chinook salmon. However, they prefer spawning substrate slightly smaller than salmon, and eggs and fry are less tolerant of fines. Water temperatures that ensure successful reproduction range between 39 and 55 degrees F. Adults either die after spawning, or return to the ocean between April and June. Juvenile steelhead usually remain in fresh water for one to two years before moving to the ocean.

California steelhead spend from several months to three years in the ocean before returning to fresh water. North American smolts enter the Pacific Ocean in the spring, and begin a directed movement into pelagic waters of the Gulf of Alaska. They generally follow a counter-clockwise migration pattern in epipelagic waters (east of 167E longitude), usually within 10 meters of the surface. The southern limit of steelhead migration is approximately Point Reyes, and is closely associated with the 15 degree C sea surface isotherm. The northern distribution extends slightly north of the Aleutian islands, but does not appear to be influenced by water temperature. Also, steelhead stocks are widely dispersed, and extensively intermingled while in the ocean. (CDFG 1996a)

Juvenile and adult mortality are associated with those factors previously discussed under chinook salmon life history.

Distribution: "Historically, steelhead were distributed throughout the North Pacific Ocean from the Kamchatka Peninsula in Asia to the northern Baja Peninsula (Figure 3). Presently, the species distribution extends from the Kamchatka Peninsula, east and south along the Pacific coast of North America, to at least Malibu Creek in southern California (there are infrequent anecdotal reports of steelhead continuing to occur as far south as the Santa Margarita River in San Diego County). Historically, steelhead likely inhabited most coastal streams in Washington, Oregon, and California as well as many inland streams in these states and Idaho. However, during this century, over 23 indigenous, naturally-reproducing stocks of steelhead are believed to have been extirpated, and many more are though to be in decline in numerous coastal and inland streams in Washington, Oregon, Idaho, and California." (NMFS August 1996)

In California, the Central Valley most likely supported more habitat for steelhead than chinook salmon, as steelhead are known to utilize smaller streams, and access higher barriers, than chinook. There is little historical documentation of steelhead in the San Joaquin system, but it is assumed that since chinook salmon were present in these drainages, that steelhead also resided there (CDFG 1996a).

There is evidence that summer as well as winter steelhead historically utilized Sacramento River drainages. However, all Central Valley steelhead today are considered winter-run.

Anadromous Habitat Character and Distribution

Anadromous habitat in Deer, Mill, and Antelope Creeks cannot be discussed without first putting it in context with habitat throughout the rest of the Central Valley streams. The following discussion describes historic habitat conditions in the Central Valley, and is quoted from "Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California" (Yoshiyama et al. 1996):

"The vast expanse of the Central Valley region on California once encompassed numerous salmon-producing streams that drained the Sierra-Nevada and Cascades mountains on the east and north and, to a lesser degree, the lower-elevation Coast Range on the west. The large areas that form the watersheds in the Sierra and Cascades, and the regular, heavy snowfalls in those regions, provided year-round streamflows for a number of large rivers which supported substantial runs of chinook salmon. No less than 25 Central Valley streams supported at least one annual chinook salmon run, with at least 18 of those streams supporting two or more runs each year (Figure 4).

"In the Sacramento drainage, constituting the northern half of the Central Valley system and covering 24,000 square miles, most Coast Range streams historically supported regular salmon runs; however, those "westside" streams generally had streamflows limited in volume and seasonal availability due to the lesser amount of snowfall west of the Valley, and their salmon runs were correspondingly limited by the duration of the rainy season.

"In the San Joaquin drainage, composing much of the southern half of the Central Valley system and covering 13,540 square miles, none of the westside streams draining the Coast Range had adequate streamflows to support salmon or any other anadromous fishes." (Yoshiyama et al. 1996)

The historic change in anadromous fish habitat in the Central Valley is described in detail in the Central Valley Action Plan (CDFG 1993) and briefly summarized below.

Loss of anadromous habitat in the Central Valley began with the discovery of gold in 1849, and culminated in the 1970's with completion of the major water diversion and conveyance facilities. The unrestricted use of hydraulic mining caused sedimentation of spawning gravels, water diversions blocked migrating fish and depleted stream flows, and the sudden human population explosion during the gold rush resulted in significant development and disturbance along the Central Valley streams and rivers. Between 1850 and 1885, hydraulic mining washed tons of silt, sand, and gravel into the Sacramento, Feather, American, San Joaquin, Merced, and Tuolumne Rivers. The most intensive mining occurred on the Feather, Yuba, and Bear Rivers. By 1866, the larger steamboats could no longer reach Sacramento; and by 1876, the channels of the Bear and Yuba Rivers had been completely filled resulting in adjacent agricultural lands becoming covered by sand and gravel.

During periods of flood, large areas of the Central Valley were inundated. Flood control in the Sacramento Valley started with low levees constructed to protect agricultural land. By the 1930's, only 25 percent of the land of the Sacramento Valley floor was subject to periodic inundation.

Logging was not significantly regulated in California until the second half of the Twentieth Century. This hundred-year period of virtually uncontrolled harvest of trees resulted in increased sediment loads and debris jams, making them inaccessible or useless for anadromous fish. During this same time the Central Valley was being developed for agriculture. Water storage and diversion projects were being built, denying anadromous fish access to historic spawning areas.

By 1960, anadromous fish habitat in the Central Valley had been substantially reduced. Friant Dam on the San Joaquin River, constructed in 1949, eliminated spring-run chinook habitat in its headwaters. Shasta Dam on the Sacramento River near Redding, constructed in 1938-44, became a barrier to all anadromous fish migrating upstream of that location in 1942. The Oroville Dam on the Feather River was constructed in 1965, blocking most salmon habitat, including all spring-run chinook habitat. Numerous other dams were constructed on the Yuba, Stanislaus, Tuolumne, and Merced Rivers, and other Sacramento tributaries. These dams collectively reduced anadromous habitat either by blocking access to historic habitat, and/or by regulating flows that don't allow fish access due to inadequate flow or excessive water temperatures.

In 1965, the Harvey O. Banks Pumping Plant in the Delta, the California Aqueduct, and San Luis Reservoir were constructed, which began delivering water to the San Joaquin Valley and southern California. This project affected runs of anadromous fish by reducing Delta inflow and outflow.

Some of the major dams, diversion, and pumping operations in the Sacramento and San Joaquin systems are shown in Figures 5 and 6, respectively.

CURRENT AND REFERENCE CONDITIONS

Anadromous Fish Population Numbers, Range and Distribution

Spring-run Chinook

Population Numbers: Historically, numbers of adult escapement of spring-run chinook were not counted in the Central Valley. However, estimates of historic populations were made by CDFG, using commercial gill net fishery records, upstream spawning estimates, and habitat carrying capacity evaluations. From this data, it was estimated that 170,000 and 100,000 adults utilized the Sacramento and San Joaquin systems, respectively, in the year 1850 (CDFG 1982). During this time, Deer and Mill Creeks each may have supported as many as 5,000 adults (CDFG 1982); and Antelope Creek may have supported 500 adults (CDFG 1993) (these estimates were derived from the amount of available spawning habitat, not from population counts).

Spring-run chinook population numbers for Deer, Mill, Antelope Creeks and Sacramento River (adult escapement) between 1947 and 1996 are shown in Figures 7, 8, 9, and 10. These estimates are the only existing data available regarding historic and current populations. Different methods for population estimates were used over the years (e.g. ladder counts, carcass and redd counts, snorkel surveys), so estimates from year to year may not be comparable. However, long-term population trends can be observed from these numbers, regardless of differences in methodology.

Range and Distribution: Spring-run chinook were perhaps historically the most abundant run of salmon in the Central Valley (CDFG 1993). Spring-run chinook have been extirpated from the San Joaquin River and its tributaries. In the Sacramento River system, spring-run chinook have been extirpated from the Little (Upper) Sacramento, McCloud, Pit, and American Rivers, Stony Creek, and several small Sacramento Valley tributaries. In the Yuba, Feather, and Sacramento Rivers, spring-run chinook have hybridized with fall-run chinook. True spring-run populations in the Central Valley occur only in Butte, Battle, Deer, and Mill Creeks; with occasional remnants utilizing Big Chico, Cottonwood, and Antelope Creeks (Yoshiyama et al. 1996).

Additional habitat on Deer Creek was made accessible by a fish ladder constructed by CDFG on Lower Falls in 1942. Historic and current distribution of spring-run chinook on Deer, Mill, and Antelope Creeks is shown in Figures 11, 12, and 13.

<u>Steelhead</u>

Population Numbers: Historically, the Central Valley supported a total annual run size of approximately 40,000 adults; 30,000 of these fish utilized the Sacramento system upstream of the Feather River confluence. The present annual steelhead run size for the Central Valley system, estimated from Red Bluff Diversion Dam counts, hatchery counts, and past natural spawning escapement estimates for tributaries, is probably less than 10,000 adult fish (CDFG 1996); and may be as low as 4,000 (NMFS 1996). It is estimated that 70 to 90 percent of adults in the Sacramento system are hatchery-produced (CDFG 1996a).

The "wild" stocks in Mill, Deer, and Antelope Creeks are thought to be native or mostly native Sacramento River steelhead. These populations are nearly extirpated (annual counts made at Clough Dam on Mill Creek between 1953-63 ranged from 417 to 2269 adults; only 14 were counted in 1994). Population estimates have not been able to be made in the three drainages in recent years due to the low numbers of fish observed. (CDFG 1996a)

Limited data is available regarding steelhead populations in Mill and Deer Creeks, and is shown in Figures 14 and 15. No estimates have been made for Antelope Creek, but it is believed (based on current potential habitat) that 300 adults may have used this drainage annually (CDFG 1993). Steelhead counts at the Red Bluff Diversion Dam, which reflect trend in steelhead escapement in the upper Sacramento River, are shown in Figure 16.

Range and Distribution: In California, spawning populations are known to occur in coastal rivers and streams from the Smith River near the Oregon border to Malibu Creek in Los Angeles County, and in the Sacramento River system. Current distribution is greatly reduced from historic range (Fig. 17) (CDFG 1996a).

In the Central Valley, steelhead have been extirpated from the San Joaquin drainages; Little (Upper) Sacramento, McCloud, and Pit Rivers; upper American and Feather Rivers (hatcheries on the lower portions of these rivers produce steelhead yearlings); and several other Sacramento River tributaries. Known runs still occur in the mainstem Sacramento, Yuba, Stanislaus, Tuolumne Rivers; and Deer, Mill, and Antelope Creeks.

"Wild" runs of steelhead in the Sacramento system are mostly confined to upper Sacramento tributaries such as Deer, Mill, and Antelope Creeks, and the Yuba River; remnant populations may also exist in Big Chico and Butte Creeks.

Historic and current distribution of steelhead in Deer, Mill, and Antelope Creeks is thought to coincide with the range of spring-run chinook salmon; refer to Figures 11, 12, and 13.

Fall-run Chinook

Population Numbers: Adult escapement of fall-run chinook in Deer, Mill, Antelope Creeks and the Sacramento River have been counted or estimated between 1949 and 1989, and are shown in Figures 18, 19, 20, and 21. As with the spring-run chinook numbers, this is the only data available regarding historic and current populations. Since 1985, too few salmon have ascended Antelope Creek to permit population estimation (CDFG 1993).

No information is available regarding historic and current late-fall-run chinook populations in Deer, Mill, and Antelope Creeks. This run of fish is known to utilize large mainstem rivers, and only occasionally use the lower end of tributaries for spawning. It is not known whether distinct populations utilize Deer, Mill, and Antelope Creeks near their confluence with the Sacramento River, or if only a few strays enter these streams during some years (Harvey 1996).

Range and Distribution: Central Valley fall-run chinook utilize the mainstem rivers and lower portions of their tributaries. In the San Joaquin system, they have been extirpated from the San Joaquin and Kings Rivers, but still occur in the following tributaries: Merced, Tuolumne, Stanislaus, Calaveras, and Mokelumne Rivers. In the Sacramento system, they have been extirpated from the upper Sacramento and McCloud Rivers; but still occur in the mainstem Sacramento, American, Yuba, Feather Rivers; and Cottonwood, Butte, Big Chico, Battle, Deer, Mill, and Antelope Creeks and other small Sacramento tributaries (Yoshiyama et al. 1996). Only remnant runs occur in Big Chico and Antelope Creeks. The fall-run is currently the most abundant run of chinook in the Central Valley, although it is substantially augmented by hatchery fish.

In the Central Valley, late-fall-run chinook were never inventoried in the San Joaquin system; and never enumerated in the Sacramento system until the construction of the Red Bluff Diversion Dam. The fish ladders and trap at this facility enabled biologists to separate fall-run and late-fall-run fish (CDFG 1993).

The fall- and late-fall runs of chinook utilize the lower portions of Deer, Mill, and Antelope Creeks for spawning; refer to Figures 11, 12, and 13 for fall-run range on these streams.

Population Viability of Anadromous Fish in Deer, Mill, Antelope Creeks and the Central Valley

Factors that influence population viability are highly complex, and may vary considerably between populations due to site-specific conditions. Basically, three types of processes can interact to determine population levels: deterministic (those that permanently change a critical component in a species' environment); stochastic (chance events within a species' population or its habitat); and genetic (maintaining genetic diversity within a population). (Rieman et al. 1993)

Population viability has not been defined in terms of minimum numbers of fish for anadromous species in Deer, Mill, and Antelope Creeks. However, current population estimates can be compared with general guidelines discussed in "Consideration of Extinction Risks for Salmonids" (Rieman et al. 1993). This report referenced a study that indicated for a completely closed population, an effective population size of 50 is needed to prevent excessive rates of inbreeding; and that 500 are needed to maintain the genetic variation necessary for long term adaptation. Another study was referenced that suggested genetic variation can be lost with fewer than 5,000 individuals. These numbers refer to genetic risks of extinction alone, without considering deterministic or stochastic processes. Recent studies suggest that populations may be at higher risks of extinction from environmental stochasticity or catastrophic events than through inbreeding or loss of genetic variation.

Current population numbers in Deer and Mill Creek, when compared with the above numbers, suggest that genetic variation may be at risk with spring-run chinook and possibly fall-run chinook. Numbers of steelhead may be so low as to not be considered true populations. Only remnant individuals of spring- and fall-run chinook, and steelhead remain in Antelope Creek; numbers are too low to be considered true populations.

On a regional scale, spring-run chinook in the Sacramento system have been described as being at "moderate risk" of extinction (Nehlsen et al. 1991); and Central Valley steelhead have been proposed as "endangered" under the Endangered Species Act (NMFS 1996). Since numerous populations of both species have been extirpated from historic habitat, the few remaining populations (such as those in Mill and Deer Creeks) become increasingly important for restoration of these species in the Central Valley.

Central Valley fall-run chinook appear to have high enough numbers to prevent extinction. However, some populations have been extirpated from historic habitat; those remaining have been substantially augmented with hatchery-reared fish; and population trend is still declining.

Introduction of salmonids into Deer, Mill, Antelope watersheds

The genetic integrity of native salmonid stocks in the three watersheds may have been influenced by past introductions of fish and/or eggs originating from other locations.

In general, rainbow trout have been the primary fish species stocked in Deer, Mill, and Antelope Creeks by California Department of Fish and Game (CDFG) since about 1941. These fish came from various sources, including Coleman and Darrah Springs Hatcheries. Some stockings (relatively few) of Eagle Lake rainbow trout were stocked during some years. Brown trout were also stocked in these waters; and brook trout were introduced into Deer Creek. Fish stocking no longer occurs within the anadromous reaches of Deer, Mill, and Antelope Creeks since 1994. (CDFG stocking records)

Steelhead juveniles were planted in Deer and Mill Creeks in 1967, and Antelope Creek in 1980 (CDFG stocking records). During 1953 and 1957, yearling steelhead spawned from Battle Creek fish were planted into Mill Creek as part of a program evaluating stocked hatchery-reared steelhead (Hallock et al. 1961).

During 1956-1958, juvenile coho salmon were experimentally introduced into Mill Creek. Eggs from Lewis River, Washington were hatched and reared at Darrah Springs hatchery. A total of 145,000 yearlings were stocked in Mill Creek, and about 2300 adults retured to Clough Dam. About the same number of adults returned to Coleman Hatchery at Battle Creek. However, the run subsequently failed to become established. (DWR 1967)

Between 1902 and 1940, the U.S. Bureau of Fisheries established a hatchery on Mill Creek near Los Molinos. During this time, fall-run chinook salmon were spawned, with an average of 6-7 million eggs taken annually. Juvenile salmon were reared and released in the spring. Attempts were made to spawn spring-run chinook at this site, but were prohibited by warm water temperatures during summer months. (Hanson et. al. 1940)

About 13,000 adult spring-run chinook (some may have been winter- and/or fall-run (Harvey 1997)) from the upper Sacramento River were introduced into Deer Creek during salvage operations resulting from the construction of Keswick dam between 1941-46. (Cramer and Hammack 1952).

During the 1950's, salmon egg survivability studies took place in Mill Creek. Chinook salmon eggs used for these studies originated from Mill Creek fish, the Coleman

Hatchery, and other sources unknown. Survivability in these studies were generally low, and it is not known if these fish survived and returned to Mill Creek as adult spawners. (Gangmark and Broad 1955, 1956, 1956; Broad and Gangmark 1956; Gangmark and Bakkala 1960)

It is not known what genetic influences, if any, the hatchery resident rainbows, hatchery yearling steelhead, and introduced spring-run chinook have had on native stocks in Deer and Mill Creeks. Also unknown is what genetic influence that hatchery rearing may have had on fall-run chinook in Mill Creek.

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APPENDIX E -ANADROMOUS FISH HABITAT

ANADROMOUS FISH HABITAT

MILL, DEER AND ANTELOPE CREEK WATERSHEDS

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INTRODUCTION

On a broad scale, the reasons for the depressed status of many anadromous stocks (although the factors vary depending on species and geographic area) reflects the interaction of variable environmental factors, such as ocean conditions, and past and present management activities including; dam construction and operation, water diversions, habitat modifications, fish harvest (PACFISH 1995) and hatcheries. All of these factors have played some role in the decline of the Central Valley anadromous stocks.

Although the cause of continued declines in Central Valley anadromous stocks cannot be attributed to any one factor, increasing evidence suggests that current water exports from the Sacramento-San Joaquin delta are having detrimental effects on fish which live and migrate through the delta (Moyle et. al. 1992; Kjelson and Brandes 1989; Stevens et. al. 1985). In the delta, all runs of chinook salmon are experiencing increased juvenile mortality. Kjelson and Brandes (1989) have found salmon survival to be highly correlated to river flow, temperature and the percent of inflow diverted by State and Federal water projects. Additionally, it is recognized that full restoration of the anadromous species within the Central Valley system cannot be achieved without integration of protective measures to restore fish habitat in the delta (Reynolds et. al. 1993).

Unlike most tributary streams of the Sacramento and San Joaquin Rivers which now have major water storage facilities that inundate or block hundreds of miles of historical anadromous spawning habitat, headwater stream habitat in Mill, Deer and Antelope Creeks is still available for utilization by anadromous fish. Total miles of anadromous habitat present within the boundary of the Lassen National Forest is estimated at 43 miles for Mill Creek, 25 miles for Deer Creek and 7 miles for Antelope Creek. Protection and maintenance of this habitat is essential to conserving these anadromous stocks considered "at-risk" of extinction.

Despite the various past and present management activities within the three watersheds (refer to erosion regime), instream habitat conditions for anadromous fish above the canyon mouths are in good condition overall but are underutilized because of low spawner escapement levels. Mill Creek, Deer Creek and Antelope Creeks are all considered essential to the recovery and perpetuation of the wild stocks of spring-run chinook salmon and/or winter-run steelhead in the Central Valley (Reynolds et. al. 1993; McEwan and Jackson 1996) in part because of their current conditions and available habitat.

Habitat Discussion: purpose, methods and assumptions

The following discussion is intended to describe the current habitat conditions and how they might differ (or not) to known (or inferred) historic conditions. In doing so, some idea of how close conditions might be to their "natural" state can be better understood. Because historic condition information is limiting, emphasis is largely placed on describing existing conditions.

This report is prepared in support of the ongoing watershed analyses for Mill, Deer and Antelope Creeks and should be considered along with other written sections. The overall goal of a watershed analysis is to match land management activities and watershed restoration to watershed condition and sensitivity in order to protect or improve fish habitat on federal lands. For the Lassen National Forest, the analysis process will be used to help define additional recommended actions that may be needed in order to protect and maintain anadromous fish habitat over the long-term.

For purposes of describing aquatic habitat, particularly in relation to the current condition for anadromous fish in Mill, Deer, and Antelope Creeks, two forms of descriptions (qualitative and quantitative) are drawn upon for discussion in the sections under Anadromous Fish: Mill, Deer and Antelope Creek Watersheds.

Indicators used to describe the stream habitat condition is limited to only some of the important physical (or chemical) characteristics in relationship to certain riverine life history stages. Because of complex interactions between physical and biological properties within aquatic systems, the following discussion does not attempt to address the broad range of factors which may contribute to or limit anadromous fish production throughout their life cycle.

Although the intent of the discussion is to focus on habitat conditions on federal land, some factors which are known to influence parameters important during certain life history stages (such as flows for upstream adult migration) are also discussed. Because the importance of habitat conditions differ by life history stage, some known life history information is also provided. Additional information on life history and habitat requirements of spring-run chinook salmon in California is described in Marcotte (1984).

Habitat conditions described are focused primarily on spring-run chinook salmon habitat (vs. steelhead) only because of our greater understanding of the species and the habitat they utilize in the drainages. In general, where the discussion may apply to both spring-run chinook salmon and steelhead, the term anadromous fish is used.

UPSTREAM ADULT MIGRATION (TIMING)

The following discussion on migration timing has been compiled from available historic information developed many decades after the first development of water irrigation practices in the valley reaches. Because the upstream migration of spring-run chinook salmon is, in part, influenced by streamflows and temperatures and, water diversion operations can affect these conditions to varying degrees, how closely the migration timing reflects the "true" migration pattern of spring-run chinook salmon in these drainages will never be known. In addition, available data on adult migration is fairly limited and the effectiveness of some methods of counting upstream migrants were dependent upon "suitable" run-off patterns for the equipment used. For example, during periods of high flow on Deer Creek, the weir used to count fish during the 1940's required removal. Thus, some migration studies represent only part of the migrating population. Migration timing in Mill and Deer Creeks has been compiled by Fisher (1994) in Attachment 2 and 3

Mill Creek

Upstream migration counts of adult spring-run chinook salmon and winter-run steelhead were made as fish passed through a fish ladder at Clough Dam located, prior to 1997, approximately 4 miles upstream from Mill Creek's confluence with the Sacramento River.

Spring-run chinook salmon:
"Essentially complete counts of spring-run" monitored between 1953 and 1964 (CDFG 1966) provides information on migration timing for Mill Creek. During the ten year study, spring-run chinook salmon were documented migrating upstream on Mill Creek from February through September although 94% of the population (based on the 10 year cumulative count) migrated between mid-April and the end of June (Attachment 3). The (cumulative) proportion of the population that migrated during three time periods is as follows:

Table 1-E.- Approximate period of spring-run chinook migration by percentage of total population in Mill Creek.

Approximate Period	Percent of Migrating Population
April 15 - May 5	9%
May 6 - June 2	48%
June 3 - June 30	37%
Total Percent of Population	**94%**

The months of May and June represented 85% of the migrating adults counted. The peak migration (which accounted for 33% of the total number of adults counted) occurred around the last week in May and the first week in June. The average number of adult spring-run salmon migrating past Clough Dam was 1,839 fish per year.

Winter-run steelhead:
According to records of cumulative totals of steelhead counted during the 1954-1963 time period (Van Woert unpublished, from Harvey 1995), steelhead migrated into Mill Creek during all months from September through June although slightly more than 90% of the cumulative total migrated between the second week in October and mid-March. Approximately 45% of the adults counted migrated between the fourth week in October and late November/early December. Two peak periods of migration occurred; 1) between the last week in October through the second week in November (accounting for 28% of the run) and 2) approximately the first half of February (accounting for 11% of the run). The average annual run size during the 10 year period was 1,160 adults.

Deer Creek

Upstream migration timing of adult spring-run chinook salmon and winter-run steelhead is based on limited (and in some cases partial counts) made in the 1940's and/or 1960's (Needham et. al 1943; Cramer and Hammack 1952; Hayes 1965; Harvey 1995). Counts in the 1940's (exclusive of 1940) were made at a weir located between Stanford-Vina Dam and the Deer Creek Irrigation Dam (DCID). Counts in the 1960's were made at a fish ladder at the Stanford-Vina Dam located 4 miles upstream of Deer Creek's confluence with the Sacramento River.

Spring-run chinook salmon:
Spring-run salmon have been documented migrating upstream on Deer Creek from March through early July. Because data is limiting, migration timing and migration peaks are not well known. In 1944, the peak period of migration was April and in 1945-1948, the peak period was in May (Cramer and Hammack 1952). From available data compiled for Deer Creek and Mill Creek (Fisher 1994), the peak spring-run migration appears to occur earlier in Deer Creek than in Mill Creek (Attachment 2).

In 1964 (Hayes 1965), the onset of adult migration at the Stanford-Vina Dam counting station began on March 13 (approximately two weeks prior to the beginning of migration on Mill Creek the same year) and ended on May 20 (approximately 40 days prior to the end of the Mill Creek migration). The run size in 1964 was 2,878 adults.

According to Cramer and Hammack (1952), the end of spring-run counts made in Deer Creek (from 1940 through 1948) were always brought about by the lack of sufficient water below irrigation diversions for salmon to ascend readily and the onset of high lethal water temperatures for salmon.

Winter-run steelhead:
Migration timing for adult steelhead in Deer Creek is limited to data collected from one season. Between October 13, 1963 and May 29, 1964, a run size of 1,006 steelhead passed the ladder (CDFG 1966).

Antelope Creek

Historical information on migration timing for spring-run chinook salmon and winter-run steelhead is not available.

HABITAT CONDITIONS (UPSTREAM MIGRATION)

Habitat parameters which influence the upstream migration of anadromous fish include streamflows, water temperatures, and instream barriers. In Mill, Deer and Antelope Creeks, water diversion dams (all located within the lower reaches of the streams on the valley floor) affect these parameters to varying degrees Prior to the flood of 1997 (when Clough Dam was removed on Mill Creek), a total of eight diversion dams were present on the streams, with some built as early as the 1910's.

Above the valley floor, the limit to upstream migration is determined by natural stream conditions. In the case of Mill Creek and Antelope Creek, the combined influence of higher stream gradients, reduced streamflows and habitat availability in the headwater reaches appear to set the upper limit of migration. On Deer Creek, the upstream limit is the natural waterfall (Upper Falls) although a fish ladder at the falls is opened by CDFG during the fall season to allow for passage of steelhead.

Spring-run chinook salmon:
The degree to which water diversions and structures can impact spring-run chinook salmon varies between and within the three systems because of differences in stream flow regimes, structural features, water diversion operations, restoration efforts (e.g. water exchange programs) and migration timing. In some years, some or all of the natural flows in the streams may be diverted by water right holders from mid-spring to fall (Reynolds et. al 1993). When this occurs, the number of adult spring-run chinook salmon entering upstream habitat can be reduced if flows are inadequate in the channel to "transport" fish upstream because the combined velocities and depths are too low for fish passage and/or water temperatures become too high (causing direct or delayed mortality and creating a thermal barrier). Additionally, some structures (even those with fish ladders) can block upstream migration under certain flow regimes (S.Cepello, personal communications).

Development of early water diversion structures on Deer and Mill Creek are documented in Clark (1929). On Deer Creek, two irrigation diversion dams (Stanford-Vina and Deer Creek Irrigation District) were built sometime prior to 1929. The Stanford-Vina was built around 1915. In 1929, the dam was five feet high. The height of the Deer Creek dam was not noted but apparently it was never considered an obstruction to adult salmon (Clark 1929; Cramer and Hammack 1952).

On Mill Creek, prior to 1929, three irrigation dams were in place. The tallest dam was Clough, built around 1913. In 1929, the dam was a height of 16 feet.

The two largest dams on each creek (Stanford-Vina and Clough) also had fish ladders. In 1929, the Stanford-Vina ladder was considered good (Clark 1929). Although in the 1940's and early 1950's, the ladder was considered inadequate (Cramer and Hammack 1952). By 1952, the Stanford-Vina dam had both a north and south ladder.

In 1929, the Cough Dam ladder was considered largely ineffective in passing fish due to the low flow conditions (Clark 1929).

The cumulative effects of historical water use on returning population levels is not well known. Available information indicates that in some years (e.g. 1929 (Clark 1929), 1939 (Hanson et. al. 1940), 1946, 1947, 1963, 1964 (CDFG 1966)) adult migration has been impaired, resulting in adult mortalities. Hanson et. al. (1940) also noted that the entire flow of Mill Creek (once it emerged from the canyon) was diverted for irrigation use and that the stream bed between the lower diversion dam and the mouth (a distance of about 4 miles) was dry from May or June until October 15. The implications are, at least for Mill Creek (based on the 1954-63 data), that impaired flows in May and June could impact a large percentage (approximately 85%) of the population migrating to their spawning grounds. In Mill Creek, the primary restoration opportunity noted for the watershed is maintenance of unimpaired migration for salmon as they ascend to (and descend from) the stream system (Mill Creek Conservancy 1997).

In Mill and Deer Creeks, the primary focus for spring-run chinook salmon restoration is on improving flow conditions for upstream migrating adults so they can access important holding and spawning habitat (Mills and Ward 1996). To this end, water exchange programs are underway or in development with cooperating irrigation districts. The programs are intended to develop and operate wells to offset bypass flows needed for spring-run salmon. An example of the current water exchange program and recent fish passage improvements on Mill Creek (taken from the Mill Creek Conservancy report 1997) is described in Attachment 4.

HABITAT RANGE/DISTRIBUTION (MIGRATION, HOLDING AND SPAWNING)

Mill Creek

From its spring origin in Lassen Volcanic National Park (LVNP) to its confluence with the Sacramento River, Mill Creek is approximately 58 miles in length. Nearly all of the mainstem habitat is utilized and/or available to spring-run chinook salmon and winter-run steelhead for one or more life history requirements (e.g. migration, juvenile rearing, etc.).

Spring-run chinook salmon:
Based on observations of spring-run chinook salmon adults holding and/or spawning, the known range of this habitat extends a distance of approximately 48 miles from near the Little Mill Creek confluence (C.Harvey 1996, personal communications) upstream to within 1/2 mile of the LVNP boundary (personal observation of adult holding). Although salmon have been reported spawning in "Middle Creek" (1990 communication with Luke Mason, former caretaker at Hanna Ranch), a small tributary located approximately 2 miles downstream of the park boundary, suitable spawning habitat on the mainstem of Mill Creek extends to near Morgan Hot Springs (approximately three miles downstream of LVNP).

Deer Creek

Deer Creek provides approximately 42 miles of anadromous habitat extending from the confluence with the Sacramento River upstream to Upper Deer Creek Falls. Like the anadromous reaches of Mill Creek, the habitat is utilized and/or available to fulfill one or more riverine life history requirements for both spring-run chinook salmon and winter-run steelhead.

Spring-run chinook salmon:
Our knowledge on the distribution and abundance of holding habitat and its utilization by spring-run chinook salmon is much more complete in Deer Creek than it is for Mill Creek. Surveys conducted in the 1940's, annual monitoring of adult spring-run chinook salmon holding (using snorkeling), and basin-level habitat typing data have helped to define the relative distribution and abundance of adult holding areas.

The known range for adult spring-run chinook salmon holding extends from Upper Falls downstream to near the confluence of Rock Creek, a distance of approximately 25 miles. The downstream extent is based on salmon holding utilization documented during extensive surveys on Deer Creek in the early 1940's (Needham et. al. 1943) and stream investigations in the 1960's (Hayes 1965). Although Rock Creek is considered the downstream extent for holding, Needham et. al. (1943) noted that the greatest concentration of salmon was above Campbellville (at or near Ponderosa Way). At current population levels, this distribution pattern appears to be true today as well.

Without knowing the historic (~ pre-1900) population level, it is not known whether the distribution pattern observed reflects less than ideal holding conditions in the lower reach (compared to the upstream habitat, above Ponderosa Way) or if (assuming adult salmon continue to move upstream over the summer (Campbell and Moyle 1992) into available suitable habitat) the downstream habitat area is underutilized because of low population levels. What is known is that habitat below Ponderosa Way is available and has been used by adults for holding but to what downstream extent suitable holding conditions persist is not known. Most likely, the downstream extent of holding habitat suitability in a given year would depend, in part, on streamflow conditions and water temperatures in the area and adult population density.

Until 1943, when a ladder was built to provide access to habitat upstream of the falls, Lower Falls (at a reported height of 16 feet) was the upstream limit to migration (Cramer and Hammack 1952). Construction of the ladder effectively provided access to an additional five miles of habitat which is now an important area for adult holding and spawning.

Although Hanson et. al. (1940) recommended against the construction of a fish ladder at Upper Falls (because of the loss of scenic values and, above the falls, the habitat was not considered suitable for spring-run given the creeks small size and lack of deep holding pools) a fish ladder was built in the early 1950's. Apparently the ladder was never effective in passing spring-run salmon and it remains closed during their migration.

In some years, anadromous fish (including spring-run chinook salmon) have been observed above Upper Falls (1995 S.Chappell; 1994, P.Randall personal communications), but habitat appears to be utilized only on rare occasions when a few hardy fish are capable of surmounting the falls under suitable conditions.

The known range for adult spring-run chinook salmon spawning extends from Upper Falls downstream to near the mouth of the canyon, a distance of approximately 30 miles. The downstream extent is based on spawning utilization of spring-run chinook salmon (both native and those transferred from the Sacramento River) in 1941 (Needham et. al. 1943). Table 2 shows both carcass and redd count surveys, distributed by reach.

Table 2-E.- Carcass and redd counts and percentages by reach in 1941.

Survey Reach	Caracass Count		Redd Count	
	Total #	% of Total #	Total #	% of Total #
Lower Falls to Wilson Cove	385	26%	581	21%
Wilson Cove to Polk Springs	296	20%	589	22%
Polk Springs to "16 Mile"	632	44%	1164	43%
* "16 mile" to Upper Dam	150	10%	370	14%
Total	** 1463	100%	2704	100%

* "16 Mile" is below Ponderosa Way crossing and Upper Dam is at the canyon mouth.

** Salmon present in Deer Creek in 1941 included an estimated 636 spring-run that were considered successfully transferred to Deer Creek from the Sacramento River as part of the Shasta Salmon Salvage Project.

Intensive or extensive surveys of spawning in Mill, Deer and Antelope Creeks have been conducted only over the past few years (Table 4). Because this information is limited, it is difficult to draw conclusions about timing or distribution of spring run salmon. Virtually no information is available about steelhead spawning characteristics. Based on the limited information on spring-run, a few general statements can be made regarding the location of spawning and the amount of runoff. It appears that in wet years, more spawning takes place lower in the watersheds. This may be related to water temperatures though maximum temperatures showed no difference in the wet and drier years. The other general observation is that in years with a large number of returning adults, all available, suitable spawning habitat is utilized (at least in Deer Creek, where numbers of fish are higher). Spawning habitat utilization has been known to shift between years at some sites with changes in bed composition resulting from high flow events. In several locations, the substrate in an area with heavy spawning activity changed from small cobble to boulder and larger material which was presumably, too big for fish to move and utilize (and no redds were observed). (S.Chappell, personal communications).

Antelope Creek

Antelope Creek provides approximately 30 miles of anadromous habitat from its confluence with the Sacramento River upstream to 2 and 3 miles on the North and South Forks of Antelope Creek, respectively, above their confluence.

Spring-run chinook salmon:
Based on reported observations of spring-run chinook salmon, the range of their distribution in the system extends from approximately 1.6 miles downstream of the Paynes Creek crossing (Airola 1983) upstream to near McClure Place on the North Fork and to Buck's Flat on the South Fork (CDFG 1966). Given this range, the total miles available to holding and spawning spring-run salmon is approximately 9.0.

Mill, Deer and Antelope Creeks

Winter-run steelhead:
Except for some limited data on run size, little is known about the winter-run steelhead in Mill, Deer and Antelope Creeks and the distribution and abundance of their habitat. Considering steelhead life-history requirements, however, their range within the system is likely to include the range described for spring-run chinook salmon, and may actually extend beyond this range (into potentially suitable upstream habitat or tributaries). Because steelhead are, on the average, smaller in size than salmon and can utilize smaller substrate for spawning, potential habitat exists for them beyond the known range of salmon.

Table 3-E.- Deer Creek Holding data collected from 1992 to 1999.

Deer Creek (Holding)	1992		1993		1994		1995		1996		1997		1998		1999	
Reach	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Upper Falls-Potato Patch	12	6	35	14	100	21	267	21	67	11	102	22	14	<1	114	7
Potato Patch-Red Bridge	5	2	17	7	31	6	67	5	44	7	19	4	11	<1	91	6
Red Bridge-Lower Falls	7	3	4	2	4	1	37	3	12	2	9	2	4	<1	28	2
Lower Falls-A line	65	31	54	21	215	44	225	17	170	28	153	33	93	5	241	15
A line-Wilson Coave	13	6	35	14	2	0	134	10	67	11	22	5	98	5	167	10
Wilson Cove-Polk Springs	51	24	4	2	69	14	124	10	88	14	26	6	182	10	158	10
Polk Springs-Murphy Trail	21	10	51	20	56	12	219	17	102	17	59	13	270	14	247	16
Murphy Tail-Beaver Creek	33	16	54	21	7	1	159	12	57	9	74	16	466	25	350	22
Beaver Creek-Ponderosa Way	2	1	5	2	1	0	18	1	1	0	0	0	149	8	39	2
Ponderosa Way-Trail 2E17	ns	0	ns	0	ns	0	45	3	6	0	2	0	476	25	106	7
Trail 2E17 to Dillon Cove	ns	0	ns	0	ns	0	ns	0	ns	0	ns	0	116	6	50	3
Total	209	100	259	100	485	100	1295	100	614	100	466	100	1879	100	1591	100

Table 4-E.-Deer Creek Spawning data collected from 1992 to 1999.

Deer Creek (Spawning)	1992		1993		1994		1995		1996		1997		1998		1999	
Reach	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Upper Falls-Potato Patch	ns	-	ns	-	ns	-	ns	-	133	36	63	23	15	2	126	8
Potato Patch-Red Bridge	ns	-	ns	-	ns	-	ns	-	24	6	30	11	5	1	100	7
Red Bridge-Lower Falls	ns	-	ns	-	ns	-	ns	-	29	8	14	5	27	3	72	5
Lower Falls-A line	ns	-	ns	-	ns	-	ns	-	68	-	94	34	38	5	95	6
A line-Wilson Cove	ns	-	ns	-	ns	-	ns	-	95	-	7	3	31	4	396	26
Wilson Cove-Polk Springs	ns	-	ns	-	ns	-	ns	-	ns	-	1	0	35	4	186	12
Polk Springs-Murphy Trail	ns	-	ns	-	ns	-	ns	-	25	7	26	9	59	7	150	10
Murphy Tail-Beaver Creek	ns	-	ns	-	ns	-	ns	-	ns	-	40	15	351	43	161	11
Beaver Creek-Ponderosa Way	ns	-	ns	-	ns	-	ns	-	ns	-	0	0	22	3	6	0
Ponderosa Way-Trail 2E17	ns	-	ns	-	ns	-	ns	-	ns	-	0	0	119	15	100	7
Trail 2E17 to Dillon Cove	ns	-	ns	-	ns	-	ns	-	ns	-	0	0	105	13	103	7
Total	ns	-	ns	-	ns	-	ns	-	374	100	275	100	807	100	1495	100

Table 5-E.-Mill Creek spring-run chinook spawning survey data collected between 1992 and 1999. Due to poor water visibility holding surveys are not effective and spawning data is used for the population estimate of holding adult.

Mill Creek (Spawning)	1992		1993		1994		1995		1996		1997		1998		1999	
Reach	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Above Highway 36	ns	-	ns	-	ns	-	ns	-	ns	-	0	0	ns	-	ns	-
Highway 36-Little Hole in the Ground	ns	-	ns	-	ns	-	ns	-	ns	-	1	1	1	0	0	0
Little Hole in the Ground-Hole in the Ground	ns	-	ns	-	ns	-	ns	-	ns	-	7	7	2	1	1	0
Hole in the Ground-Rocky Gulch Creek	ns	-	ns	-	ns	-	ns	-	ns	-	1	1	1	0	3	1
Rocky Gulch Creek-Big Bend	ns	-	ns	-	ns	-	ns	-	ns	-	7	7	1	0	11	4
Big Bend-Sooner Place	ns	-	ns	-	ns	-	ns	-	ns	-	53	52	11	5	6	2
Sooner Place-Savercool Place	ns	-	ns	-	ns	-	ns	-	ns	-	19	19	21	10	22	8
Savercool Place-Black Rock	ns	-	ns	-	ns	-	ns	-	ns	-	1	1	25	12	75	27
Black Rock-Ranch House Trail	ns	-	ns	-	ns	-	ns	-	ns	-	5	5	19	9	58	21
Ranch House Trail-Avery Place	ns	-	ns	-	ns	-	ns	-	ns	-	7	7	33	16	52	19
Avery Place - Pape Place	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	39	18		0
Pape Place - Bear Canyon	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	13	6	12	4
Bear Canyon - Blunkall Crossing	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	25	12	23	8
Blunkall Crossing - Little Mill Creek	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	17	8	17	6
Little Mill Creek - below Powerlines	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	4	2	0	0
Total	ns	-	ns	-	ns	-	ns	-	ns	-	101	100	212	100	280	100
[1]Population Estimate of Holding Adults	ns	-	ns	-	ns	-	ns	-	ns	-	202		424		560	

[1]Population Estimate derived from 1:1 sex ratio and 1 female per redd

Table 6-E. Antelope Creek Holding data collected from 1992 to 1999.

Antelope Creek (Holding)	1992		1993		1994		1995		1996		1997		1998		1999	
Reach	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
S.F. @Gun Club to Cedar Crossing	ns	-	ns	-	ns	-	0	0	ns	-	ns	-	4	3	1	3
S.F. @Cedar Crossing - Confluence w/ N.F Antelope	ns	-	ns	-	ns	-	ns	-	1	50	0	-	6	4	2	5
N.F. Falls - McClure Place	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	3	2	5	13
N.F. Antelope @McClure Place - Confluence w/ S.F. Antelope	ns	-	ns	-	ns	-	ns	-	0	-	0	-	6	4	0	0
Mainstem Antelope from confluence to Slab @Payne's Place	0	-	3	100	0	-	2	33	0	-	0	-	77	50	19	48
Slab at Payne's Place - Canyon Mouth	ns	-	ns	-	ns	-	4	67	1	50	0	-	23	15	6	15
Canyon Mouth - Slab @Faucht's Place	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	36	23	7	18
Total	0	-	3	100	0	-	6	100	2	100	0	-	155	100	40	100

Table 7-E.- Antelope Creek Spawning data collected from 1992 to 1999.

Antelope Creek (Spawning)	1992		1993		1994		1995		1996		1997		1998		1999	
Reach	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
S.F. @Gun Club to Cedar Crossing	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	0	0	2	6
S.F. @Cedar Crossing - Confluence w/ N.F Antelope	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	3	5	0	0
N.F. Falls - McClure Place	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	8	13	3	9
N.F. Antelope @McClure Place - Confluence w/ S.F. Antelope	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	4	6	3	9
Mainstem Antelope from confluence to Slab @Payne's Place	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	49	77	15	45
Slab at Payne's Place - Canyon Mouth	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	2	6
Canyon Mouth - Slab @Faucht's Place	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	ns	-	8	24
Total	-	-	-	-	-	-	-	-	-	-	-	-	64	100	33	100

HABITAT CONDITIONS
(holding, spawning and intergravel habitat, juvenile rearing and outmigration)

HOLDING

Two features which help characterize areas utilized by adult spring-run chinook salmon include, low velocity pool (or run) habitat greater than (approximately) one meter (3.3 feet) in depth and cool summer water temperatures.

Pools:
Visual observations of spring-run chinook salmon holding in pools near 3.3 feet (maximum depth) have been made in some years in Mill Creek and Deer Creek although regular observations of salmon holding indicate a preference for deeper pools. Limited studies in Mill Creek, Deer Creek and Antelope Creek (Sato and Moyle 1989; Grimes 1983 and Airola 1983) document holding adult salmon prefer pools with maximum depths 6.0 feet or greater.

For purposes of discussion, holding pools are defined as those greater than 6 feet maximum depth. To understand holding habitat availability, however, general pool composition and characteristics are also described for "all" pools regardless of maximum depth. An overview of the pool data collected between 1990 and 1994 using Forest Service habitat typing methodology (Region 5 Fisheries Habitat Assessment FSH 2609.23) is shown below. A more complete summary of the data collected is in Appendix ____. Stream reaches referenced are shown in Appendix __

Table 8-E.- Percent of total surveyed stream area occupied by pools, total number of pools, total Number of holding pools and percent of all pools that are utilized as holding pools.

Stream	Miles Surveyed	% Stream Area (All Pools) *	Total # of Pools (holding ** / all *)	Holding Pools (% of total #)
Mill - upper	7.6	5%	0/88	0%
Mill - lower	13	13%	20/86	23%
Deer	16.7	30%	98/166	60%
Antelope - Mainstem	1.6	16%	7/13	54%
N.F. Antelope	1.9	6%	0/15	0%
S.F. Antelope	1.7	16%	6/23	26%

* All pools represent the habitat units categorized as pools regardless of their maximum depth.
** Holding pools are defined as pools with maximum depths > 6.0 feet.

Mill Creek

Upper Mill Creek:

The availability of spring-run chinook salmon holding habitat appears to be limited in the upper 7.6 miles of Mill Creek between the Lassen Volcanic National Park (LVNP) boundary and Mill Creek campground. Based on stream survey data collected in 1990, 5% of the area was represented by all pools. Of all 88 pools noted in 1990, none were holding pools.

Lower Mill Creek (canyon):

Downstream of the Mill Creek campground, available holding habitat is more abundant. In 1990 and 1994, 13 miles of approximately 20 miles of stream extending from the campground to two miles downstream of Black Rock were surveyed. Within the surveyed segments, 13% of the area was represented by all pools. Of all 86 pools documented, 20 (or 23% of the total) were holding pools.

Little quantifiable data is available on the distribution of holding habitat from approximately two miles downstream of Big Bend to approximately two miles upstream of Black Rock due to the difficulty in accessing the area. In a 1988 holding survey (CDFG file map, T. Healey 1988), over 200 adult salmon were noted within most of the seven miles of stream not habitat typed, indicating additional suitable holding habitat is present. Given similar channel characteristics such as substrate composition, gradient, etc., holding habitat distribution and abundance would not likely differ greatly from other areas of Mill Creek surveyed in the lower canyon reaches.

Deer Creek

Within the nearly 17 miles of anadromous habitat surveyed (from Upper Falls to approximately 1.5 miles below Ponderosa Way), 30% of the area is represented by all pools. Of 166 total pools, 98 (or 60%) are holding pools.

Antelope Creek

On Antelope Creek, 16% (by area) of the mainstem anadromous habitat surveyed (1.6 miles) was represented by all pools (13 total). The number of holding pools is 7 and represents 54% of all pools. On the North Fork and South Fork of Antelope Creek, all pools (15 and 23 total) made up 6% and 16%, respectively, of the anadromous habitat by area. No holding pools were noted on the North Fork. On the South Fork, there were 6 holding pools which represent 26% of all pools.

Boulders and bedrock are the primary pool-forming processes in Mill Creek, Deer Creek and Antelope Creek. With one notable exception discussed below, large wood does not appear to play a large role in the development of pools in the anadromous reaches. Sedell et. al. (1988) emphasized the ecological value of organic debris in stream productivity but have suggested that steep, narrow canyons cannot develop depositional zones and are thus dominated by boulders rather than large woody debris, a description which fits all three streams. Given the presence of predominately stable bedrock-boulder formed pools, it is highly probable that the relative abundance of pools has not changed appreciably in the anadromous reaches from pre-european times.

In contrast to the bedrock/boulder dominated reaches in the three systems, there is some indication that pool abundance may have been reduced in fairly recent times in the upper alluvial reaches of Mill Creek. Available data (including photos) indicates the channel was once (pre-1937 storm event) more narrow and less braided (see more discussion under stream channels; near stream disturbance, Mill Creek). Given the smaller substrate composition, lower stream gradient and wider valley bottom in upper Mill Creek, the riparian vegetation (including large downed wood) likely had a greater influence on stream channel morphology and the formation of pools in this area.

Temperature:

A review of the biological importance of stream temperature on aquatic organisms can be found in the Forest Service publication titled "Section 7 Fish Habitat Monitoring Protocol for the Upper Columbia River Basin" (USDA 1994). This excellent overview from the literature is provided (verbatum) below.

"Water temperature is one of the most important variables affecting salmonids and other stream biota (Fry, 1947, 1964; Hutchinson, 1976; Armour, 1988; Keaton, 1967). Temperature influences timing of migration and spawning, egg maturation, growth, incubation success, intra- and interspecific competitive ability, and resistance to parasites, diseases, and pollutants (Bjornn and Reiser, 1991; Reeves et. al. 1987). Increased temperatures have been related to reductions in salmonid abundance or changes in their spatial distribution (Platts and Nelson, 1988; Marcus et. al. 1990; Hynes, 1970).

Tolerances vary by life stage and species. Sustained temperatures above 73 to 79 degrees F (23 5o 26 degrees C) are lethal for salmonids; optimal growth occurs from 50 to 61 degrees F (10 to 16 d C) (Brett, 1952; Bjornn, 1978). The duration of temperature elevation and the pre-elevation acclimating temperature are important factors that affects salmonid metabolic response to increased water temperatures (Lantz, 1970).

Most information on water temperature/salmonid tolerance has been collected from laboratory experiments. In streams, however, salmonids have behavioral adaptations that allow them to survive brief exposure to lethal temperatures; fish respond by avoiding such areas and move to seek out cool water refuges (e.g., groundwater seeps, mouths of tributaries)(Brett, 1952; Gibson 1966; Kaya et. al. 1977). The wide thermal tolerances of stream salmonids and natural diurnal cycling of water temperatures enables them to survive such thermal fluctuations (Beschta et. al. 1987)".

Because little data is available which documents the duration of temperature elevation that can be withstood by salmonids in the stream environment, both maximum temperature and duration are recommended for monitoring (as an indicator of change over time)(USDA 1994). For this reason, Table 4 shows the available stream temperature data recorded (with continuous-recording thermometers) in Mill Creek, Deer Creek and Antelope Creek using the maximum (near) surface water temperatures for the month of July or August and the two month (July/August) average maximum temperatures. All temperature recordings were measured within the range of spring-run chinook salmon holding and spawning habitat for years 1963-1964 (Hayes 1965) and 1992-1995 (CDFG-IFD). This data provides not only baseline conditions (for monitoring conditions over time) but also is an indicator of conditions relative to critical lifestages, in this case adult holding.

Because maturing adult spring-run chinook salmon enter streams during the spring months and spend the summer holding in deep pools (prior to fall spawning), they are present in the stream system when temperatures are at their peak (generally July and August). During this time, spring-run salmon may be exposed to elevated water temperatures. Chronic exposure to elevated water temperatures during the pre-spawning period has been identified as a factor which adversely affects adult survival (Marine 1992).

On Deer Creek (at A-Line) and Mill Creek (at Black Rock), the highest two month (July/August) average maximum surface temperature for the period of record is 65 degrees F and 66 degrees F, respectively. Based on (near) surface water temperature data collected within primary holding areas on Deer and Mill Creeks (summarized in Table 9,and 10 for the years available) and visual observations made during the holding period (including August holding surveys), conditions are suitable for adult salmon holding even when maximum (near) surface water temperatures reach 70 - 71 degrees F. In Deer Creek above the canyon mouth, Needham et. al. (1943) also observed, on several occassions in 1941, salmon holding in deep pools when surface water temperatures measured 73 degrees F.

Table 9-E.- Maximum (near) surface water temperatures (in degrees Fahrenheit) recorded during the month of July or August for the years 1963-1964; 1992-1995 and the two month (July/August) average maximum temperatures (in parenthesis) within the range of spring-run chinook salmon holding and spawning habitat in Mill Creek, Deer Creek, and Antelope Creek, Tehama County, CA.

Mill Creek
Temperature in Degrees Fahrenheit

Year	Little Mill	Black Rock	Big Bend	Hwy 36
1963	70 (67)8	65 (61)	-	-
1964	-	-	-	72 (68)
1992	-	71 (66)	71 (67)**	-
1993	-	64 (60)	64 (60)	-
1994	-	-	68 (63)	-
1995	-	62 (59)	63 (59)	-

Deer Creek
Temperature in Degrees Fahrenheit

Year	Rock Creek	Ponderosa Way	A-Line
1963	69 (66)*	70 (65)	-
1964	-	70 (67)	-
1992	-	76 (70)	70 (65)
1993	-	-	66 (61)
1994	-	-	70 (63)
1995	-	68 (64)	62 (59)

Antelope Creek
Temperature in Degrees Fahrenheit

Year	Paynes Place Xing
1992	75 (68)
1993	70 (64)
1994	70 (66)
1995	67 (63)

Data sources: 1963-1964; J.M. Hayes, 1965. 1992-1995; CDFG, IFD, Red Bluff
* Temperatures from July 1 - August 5 (Little Mill and Ponderosa Way) and thru August 7 (Rock Crk) were not collected.
** Data collected at Hole-in-the-Ground
- No temperature data collected.

Table 10-E.- Water temperature summaries for mainstem Deer Creek, Mill, Antelope Creeks and their major tributaries.

Watershed	Stream	Year	Start/Stop Date	Maximum Temperature	Date of Maximum	Seven Day Maximum	Seven Day Minimum	Temperature Change	# of Days >65	# of Days >70
Antelope	Antelope	1998	5/22-10/6	71.7	08/14/98	69.9	60.6	9.3	72	12
	MF Antelope	1996	7/1-10/15	66.5	08/14/96	65.4	60.6	4.8	22	0
	MF Antelope	1997	4/9-11/1	68.9	07/21/97	67.8	59.9	7.9	52	0
	MF Antelope	1998	5/21-10/7	66.3	08/14/98	65.1	58.6	6.5	21	0
	SF Antelope	1996	7/1-10/15	76.2	08/18/96	73.7	56.8	16.9	39	12
	SF Antelope	1997	4/9-11/1	59.7	07/21/97	58.7	53.1	5.6	0	0
	SF Antelope	1998	5/21-10/7	59.0	07/20/98	58.5	52.6	5.9	0	0
	NF Antelope	1996	7/1-10/15	60.6	07/15/96	60.0	55.8	4.2	0	0
	NF Antelope	1997	4/9-11/1	62.9	07/21/97	62.2	55.2	6.9	0	0
	NF Antelope	1998	5/21-10/7	61.4	08/06/98	60.7	54.3	6.3	0	0
Deer	Deer Creek @ upper falls	1995	9/7-10/30	58.8	09/14/95	57.1	53.2	3.9	0	0
	Deer Creek @ Red Bridge	1995	9/7-10/30	66.4	09/14/95	65.8	49.8	16.0	14	0
	Deer Creek @ Red Bridge	1996	5/4-10/15	67.0	08/14/96	65.9	60.7	5.3	34	0
	Deer Creek @ Red Bridge	1997	7/2-9/29	65.5	07/21/97	64.6	58.6	6.0	17	0
	Deer Creek @ Red Bridge	1998	Thermograph stolen							
	Deer Creek @ Polk Springs	1996	7/17-10/10	68.4	07/30/96	68.0	62.4	5.5	32	0
	Deer Creek @ Polk Springs	1997	Corrupted file							
	Deer Creek @ Polk Springs	1998	5/21-10/14	69.3	10/14/98	67.6	61.7	5.9	49	0
	Deer Creek @ Ponderosa Way	1996	6/1-10/10	72.8	07/15/96	71.2	64.8	6.4	79	19
	Deer Creek @ Ponderosa Way	1997	7/15-9/15	72.5	07/21/97	71.5	64.0	7.4	55	22
	Deer Creek @ Ponderosa Way	1998	5/21-10/13							
	Deer Creek Meadows	1998	5/19-10/30	72.2	08/13/98	69.7	50.0	19.7	83	8
	Gurnsey Creek	1995	9/7-10-30	61.3	09/14/95	60.2	51.7	8.5	0	0
	Gurnsey Creek	1996	7/2-10/15	62.7	07/14/96	61.6	50.0	11.6	0	0
	Gurnsey Creek	1997	Thermograph malfunctioned							
	Gurnsey Creek	1998	5/19-10/31	65.0	07/20/98	64.4	50.3	14.1	20.8	0.0
	Cub Creek	1996	7/17-10/15	60.1	07/30/96	59.8	56.1	3.6	0	0
	Cub Creek	1997	4/11-10/1	59.5	08/08/97	58.9	55.7	3.2	0	0
	Cub Creek	1998	5/5-10/31	59.9	08/14/98	57.4	54.9	2.5	0	0
	Slate Creek	1995	9/7-10/30	55.8	09/14/95	54.9	47.0	7.9	0	0
	Slate Creek	1996	9/28-10/15	51.0	10/09/96	50.6	45.5	5.1	0	0
	Slate Creek	1997	4/9-11/1	61.7	06/18/97	60.6	49.3	11.4	0	0
	Slate Creek	1998	5/19-10/6	62.1	07/20/98	61.7	49.1	12.6	0	0
	Calf Creek	1997	4/11-11/1	57.5	07/29/97	57.1	54.3	2.8	0	0
	Calf Creek	1998	7/17-10/5	57.8	08/14/98	56.9	54.0	2.9	0	0
	Elam Creek	1997	4/11-11/1	61.0	07/28/97	59.9	52.8	7.1	0	0
	Elam Creek	1998	5/19-10/31	61.7	07/20/98	60.8	51.6	9.1	0	0
Mill	Mill Creek @ Hole-in-the-Ground	1995	9/8-10/31	62.7	09/12/95	61.7	47.9	13.8	0	0
	Mill Creek @ Hole-in-the-Ground	1996	6/1-10/15	65.8	07/15/96	64.7	52.8	11.9	21	0
	Mill Creek @ Hole-in-the-Ground	1997	4/11-11/1	68.6	07/21/97	67.8	51.2	16.6	57	0
	Mill Creek @ Hole-in-the-Ground	1998	5/21-10/7	68.5	08/13/99	66.0	50.3	15.8	21	0
	Mill Creek @ 36	1997	4/9-11/1	73.0	08/06/97	71.7	52.3	19.3	89	24
		1998	5/21-10/7	69.7	09/04/98	68.4	51.4	17.0	34	0
	Mill Creek @ Black Rock	1997	4/9-11/1	68.7	08/08/97	67.7	59.3	8.4	55	0
		1998	5/21-10/7	65.6	08/14/98	63.7	58.4	5.3	5	0
	Rocky Gulch	1997	4/11-11/1	59.6	08/08/97	58.9	54.7	4.2	0	0
		1998	5/27-10/6	58.5	08/14/98	57.1	53.6	3.5	0	0

A background investigation and review of the effects of elevated water temperature on adult chinook salmon found little information on temperature-induced mortality for wild adult salmon (Marine 1992). From available information however, it was inferred (and largely from experimental studies) that lethal water temperatures for chronic (>1 month) exposures for maturing chinook salmon may begin to occur within the range of 17 degrees C (63 degrees F) and 20 degrees C (68 degrees F). Based on adult spring-run mortalities reported in lower Deer Creek (below the canyon mouth) in the 1940's, Cramer and Hammack (1952) reported temperatures greater than 81 degrees F were lethal to migrating salmon.

Marine (1992) suggested a potential higher temperature tolerance level for certain spring-run stocks of the Sacramento-San Joaquin chinook salmon based on Moyle (1976) who noted that spring-run chinook salmon inhabiting the tributaries "spent summer in deep holes of upstream areas where water temperatures seldom exceeded 21 to 25 degrees C" (or 70 - 77 degrees F).

As previously noted, salmonids have behavioral adaptations that allow them to survive brief exposures to lethal temperatures by avoiding such areas and seeking out cool water refuges. In a behavioural study on adult spring-run chinook salmon, Berman and Quinn (1991) suggested that homing behaviour appeared to be modified to optimize temperature regimes and energy conservation.

In their study, it was demonstrated that during the pre-spawning period (when peak summer temperatures reached nearly 20 degrees C), fish consistently sought out cooler thermal refuges such as sub-surface return flows, deep shaded pools, and cooler tributary inflows. In addition, it was determined (through the use of temperature sensitive radio-transmitters on adults) that fish maintained an average internal body temperature that was 2.5 degrees C below ambient river temperature. This accounted for an estimated energetic savings of 12 to 20% when compared to the energy that would have been expended to maintain basal metabolism at the ambient river temperature (Marine 1992).

In Mill Creek, Deer Creek and Antelope Creek, the behavioral and physiological adaptations of these fish, combined with the presence of deep (and possibly thermally stratified) pools, cool water springs, topographic and vegetative shading, natural diurnal fluctuations in water tempertures, etc, likely play an important role in mitigating the potential effects of elevated surface water temperatures that occur during the warmer summer months.

One area of possible temperature-related impacts on adults above the canyon mouth may be found in the upper alluvial reach of Mill Creek. On at least one occassion (July of 1990) adult mortalities have been reported during mid-summer (M.McFarland, 1990, memo to the files). The fact that the area where the mortalities occurred lacked deep holding pools, 1990 was a drought year, natural hot springs are present and the stream channel is mostly open with little riparian shading and overhead cover, the mortalities seen may have been attributed to a prolonged exposure to elevated stream temperatures.

In general, temperature-related mortalities may occur at some locations and only under certain circumstances (e.g. droughts), but they are likely to be rather limited.

Although inconclusive (because data is limited to only a few years and a few study sites), available historic (1960's) water temperature data appears to be within the general range of what is seen today. Additionally, at a site near Ponderosa Way on Deer Creek, Needham et. al (1943) reported a 70 degrees maximum water temperature taken sometime between July and October, 1941 with a thermograph.

SPAWNING AND INTERGRAVEL HABITAT

As inferred under the life history section for chinook salmon, factors which are important for spawning site selection include substrate size, water velocity and depth. Spring-run chinook salmon spawning areas are generally associated with the tailend of pools, and low gradient riffles and runs but the substrate composition at the redd site is usually highly variable in size, ranging from small gravel to large cobble and with gradations in between. In addition, redds are often found isolated and located nestled between fairly large substrate (e.g large cobble). During the fairly extensive spawning stock surveys of 1941, Needham et. al. (1943) found nearly half of the 2,704 redds counted were isolated nests (and not associated with riffles). Spring-run salmon appear opportunistic in the sense that they are capable of moving rather large substrate to "access" gravels suitable for redd development (T. Healey, personal communications).

Unlike spawning areas of fall-run chinook salmon (as observed at lower elevations in other tributaries of the Central Valley) spawning habitat availability in the upper spring-run reaches on Mill, Deer and Antelope Creeks is not easily to recognize, especially without some idea of utilization. This is because "spawnable" size gravels are not usually found in great concentrations, the substrate is often highly variable in size, and spring-run appear to be capable of maneuvering fairly large substrate mingled with suitable spawning size gravels. For these reasons, no attempts were made during habitat typing surveys to quantify spawning habitat availability.

In 1939 and 1940, however, extensive spawning-bed surveys in Deer Creek were conducted from its mouth to Lower Falls to determine how many adult spring-run chinook salmon could be transferred from the Sacramento River without overcrowding the native population. From these surveys and those conducted to evaluate spring-run salmon spawning bed utilization in 1941 (between the canyon mouth and Lower Falls) it was estimated that there was enough space in Deer Creek for over 15,000 salmon nests (Cramer and Hammack 1952). At the time, it was determined that the native population of salmon was small enough that, after completion of the fish ladder at Lower Falls, it was estimated that 10,000 spring-run chinook salmon adults from the Sacramento River could be transferred (each year) into Deer Creek without causing over crowded conditions. How these estimates reflect the true capability of the stream is unknown.

In a study on Deer Creek, Campbell and Moyle (1992) estimated 53% and 60% spawning success in 1990 and 1991, respectively, for spring-run chinook salmon. These estimates were based on the number of spring-run chinook salmon adults counted during the holding period vs. the estimated number of adults per redd counted during the spawning period along a 2.5 km study reach. Considering adults from holding habitat within the reach may emigrate into available spawning habitat outside the reach, the spawning success reported is questionable without a better idea of adult movement between holding and spawning habitat.

Sediment levels in streams which exceed the stream's natural sediment capacity can have significant effects on habitat for salmonids (USDA 1993). The amount of sediment in the gravel (measured as percent fines and/or cobble embeddedness) can be used as an indicator of introduced sediments and the quality of habitat for incubation (USDA 1993; Phillips 1971). The percent fines considered good in spawning (or gravel) areas range from <10% (USDA 1993) to <20% (Sedell et. al. 1988 draft).

Hard data on the percent surface fines in Mill and Deer Creek is limited to the first year of implementation of a long-term stream monitoring program. In 1996, the percent mean surface fines (measured in pooltail spawning areas) was < 7% in Mill Creek and also in Deer Creek with sample sizes of 19 and 42, respectively. The sampling method used for percent surface fines followed that of Bower and Burton (1993) (K. Roby, personal communications).

Visual observations of spring-run chinook salmon spawning in Deer Creek indicates spawning substrate is in good condition with the percent fines being low in the areas utilized. Deposition of fines in areas utilized for spawning is virtually absent year round. Like Deer Creek, fines are low in habitat available for spawning in Antelope Creek as well.

In Mill Creek, where sediment loading is inherently greater, fines are notable especially in areas of deposition. High gravel embeddedness (or the degree to which larger particles are surrounded or covered by fine particles) has been observed in some areas of spawning use (M.McFarland 1990, memo to the files). The conditions observed, however, do not appear to limit salmon from spawning. Sites where high gravel compaction (or embeddedness) appears visually high, salmon are still capable of constructing redds (T.Healey and C.Harvey, personal communications; personal observations).

Not too surprising, the redd environment is most favorable for embryos immediately after construction because during redd development and spawning, spawners displace streambed particles resulting in the downstream washing of fine sediments (Bjornn and Reiser 1991).

During the incubation period, redds may be disturbed by floods that displace the streambed containing the redd (like the 1997 event) or, redds that remain intact, may become less suitable for eggs if fine sediment settles into in the redd and surrounding substrate. Fine sediment can affect water circulation through the redd needed to supply embryos with oxygen and carry away waste products as well as the movement of sac-fry (Bjornn and Reiser 1991). Factors which potentially affect egg to fry survival (including discharge, channel stability, water temperature, etc) can vary substantially on an annual basis.

Where fines are notably present in some areas (e.g. on Mill Creek), the effects fine sediment may have on spring-run survival from egg to emergent fry is unknown.

JUVENILE REARING

Juvenile summer and winter rearing habitat is considered a major factor in the survival and production of chinook salmon (Raleigh et. al. 1986). Unlike chinook salmon adults, which stop feeding once they enter a system and die soon after spawning, juveniles spend some time (up to three years for some races) in freshwater prior to outmigration.

For purposes of this discussion, juvenile rearing habitat for anadromous fish in Mill Creek, Deer Creek, and Antelope Creek is considered the area within the range of adult holding and spawning habitat for two reasons: 1) juvenile salmonids are known to use this area and 2) the extent and use of potential rearing habitat downstream of this range is largely unknown. The area below the habitat utilized by adult spring-run salmon is, thus, considered primarily in the context of a migration corridor.

In the three drainages, substrate composition in conjunction with pools are likely important physical elements contributing to the production of juvenile anadromous fish because of the high level of habitat diversity and overwintering cover they appear to provide.

Habitat diversity:

The presence and abundance of pools are considered an important indicator of channel unit physical diversity (USDA 1994) and can roughly be translated into an indicator of habitat diversity for the biological resources. In most of the anadromous reaches of Mill, Deer and Antelope Creeks, however, the frequency of pools (defined by the number of pools per mile (PACFISH 1995) roughly greater than 3.3 feet maximum depth (USDA 1994)) is less likely the "best" indicator of habitat complexity.

In a cross comparison for Mill, Deer and Antelope Creeks with the interim PACFISH objective, pool frequencies (by similar channel widths, not provided) are in Table 12.

Table 12-E.- Number of pools with a maximum depth greater than 3.3 feet per mile.

Stream	**Miles Surveyed**	**Existing**	**PACFISH**
Mill - upper	7.6	1.4	~70
Mill - lower	13	5.3	~37
Deer	16.7	9.5	~37
Antelope - mainstem	1.6	7.3	~26
N.F. Antelope	1.9	5.3	~63
S.F. Antelope	1.7	1.7	~70

As previously implied, the anadromous reaches are largely dominated by bedrock, large and small boulders, cobble and gravel. These physical features provide for a wide range of velocities and depths which in turn, increase the diversity and abundance of microhabitats available to salmonids (as well as other organisms).

The importance of microhabitat diversity can be explained, in part, by studies by Lister and Genoe (1970) and Everest and Chapman (1972) on habitat selection by juvenile anadromous fish. In their work, they found that as young chinook salmon and steelhead increase in size, they move to faster and deeper water with larger size substrate where they occupy and defend feeding stations (Raleigh et. al 1986). Everest and Chapman (1972) suggest that a major factor in stimulating the movement of juvenile salmonids into water of progressively higher velocity as the fish grow is explained in the positive correlation they found between water velocity and the quantity of insect drift. By selecting low velocity areas near swifter waters, fish can maximize the quantity of drift food available to them while minimizing energy expenditures needed to remain at feeding stations.

Seasonal movements by many salmonids (especially anadromous fish) occur largely in response to hydrologic changes in a stream's character and reflect the need of individual fish to locate suitable rearing and overwintering areas, however, the patterns of fish movement are not completely understood (Bisson undated). As such, high habitat diversity, as exhibited within the three watersheds, contributes greatly to meeting the variety of needs for juvenile salmonids during their stream residency.

Overwintering cover:
Although overwintering requirements of juvenile anadromous fish have not been assessed specifically in the three drainages, the availability of open interstitial spaces and crevices within the substrate is likely to provide important cover when stream temperatures are low. Bustard and Narver (1975) found that cobble and gravel substrates with suitable interstices was a principal source of overwintering habitat for young steelhead. On the Trinity River (California), steelhead were found exclusively overwintering in cobble and gravel substrates when temperatures dropped as low as 38 degrees Fahrenheit (M.Hampton, personal communications). Everest and Chapman (1972) also found that, of the total freshwater residency time spent by juvenile chinook salmon and steelhead in two Idaho streams, seven out of 15 months and 21 out of 35 months, respectively, were spent overwintering in the substrate.

On at least one occassion in Deer Creek (1994), when CDFG sampled spring-run chinook salmon using electrofishing, yearling salmon were extracted from rock crevices (C.Harvey, personal communications). During the period when the yearlings were sampled (January/February) (Harvey 1995), the average monthly mean daily water temperature was near 39 degrees F. On another occassion (January 18, 1991), a snorkel survey revealed that refuge was sought by the resident fish (primarily rainbow trout) when the stream temperature was 38 degrees F. In over a mile of stream surveyed, only a few trout were seen when typically during the warmer summer months, the same area supports an abundant population.

OUTMIGRATION

The downstream migration of juvenile chinook salmon appears to occur from late-winter through spring when stream flows increase (Marcotte 1984: USFWS 1996). Essential to juvenile salmonid survival during their outmigration to the ocean is an unimpaired migration corridor.

In Deer and Mill Creeks, fish screens have been apparantly in place at all the diversions since the 1920's (Clark 1929; Mill Creek Conservancy 1997; Harvey 1997) although some outmigrant losses into diversions did occur (Cramer and Hammack 1952). Since the 1920's, screens have been revamped and/or upgraded for greater efficiency (Harvey 1997) and today all screens are effective in preventing juvenile entrainment and losses into diversions within Mill and Deer Creek drainages (Harvey, personal communications).

A major factor affecting spring-run chinook salmon abundance today is probably related to juvenile mortality in the Sacramento River and Delta (USFWS 1996). Conditions which apparantly contribute to outmigrant mortalities include irrigation diversions along the Sacramento River which can entrain juveniles and diversions into the Central Delta where juveniles are subjected to predation and entrainment at the State and Federal pumping plants (ibid).

Understanding outmigration patterns of juvenile spring-run chinook salmon in Mill and Deer Creeks is considered critical for negotiating Delta flow standards to protect spring-run juveniles and is currently being investigated by CDFG as part of a spring-run life history study (Harvey 1997).

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ATTACHMENT 1 – SPRING-RUN MIGRATION TIMING

Spring-run Chinook Salmon Counted Upstream Through the Fishway at Clough Dam
During the 10-year Period 1954-63

(Source: California department of Fish and Game. 1966. Department of Water Resources Bulletin No. 137 Sacramento Valley Eastside Investigation. Appendix C, Fish and Wildlife)

Period	Number of Salmon	Percentage	Cumulative Percentage
Feb. 4-10	1	0.01	
Feb. 11-17	-	-	
Feb. 12-24	2	0.01	
Feb. 24-Mar. 3	-	-	
Mar. 4-10	-	-	
Mar. 11-17	-	-	
Mar. 18-24	12	0.06	
Mar. 25-31	20	0.11	
Apr. 1-7	119	0.64	
Apr. 8-14	294	1.58	
Apr. 15-21	334	2.07	
Apr. 22-28	549	2.96	
Apr. 29-May 5	764	4.11	
May 6-12	1414	7.61	
May 13-19	2070	11.14	
May 20-26	2100	11.31	
May 27-June 2	3284	17.68	43.9 66.3 81.5 89.3 93.5 96.2
June3-9	2775	14.94	
June 10-16	2088	11.24	
June 17-23	1467	7.9	
June 24-30	620	3.34	
July 1-7	232	1.25	
July 8-14	130	0.7	
July 15-21	70	0.33	
July 22-28	93	0.5	
July 29-Aug. 4	27	0.14	
Aug 5-11	5	0.03	
Aug. 12-18	1	0.01	
Aug. 19-25	-	-	
Aug. 26-Sept. 1	-	-	
Sept. 2-8	-	-	
Sept. 9-15	-	-	
Sept. 16-22	51	0.27	
Total	18572		

Attachment 1 – spring-run migration timing

ATTACHMENT 2 – STEELHEAD MIGRATION TIMING

(Source: Colleen D. Harvey. 1995. California Department of Fish and Game. Inland Fisheries Administrative Report No. 95-3. Adult Steelhead Counts in Mill and Deer Creeks, Tehama County, October, 1993-June 1994.)

Adult Steelhead counted upstream through the fishway at Clough Dam during ten seasons 1953-54 through 1962-63. a/.

Period	Cumulative Number of Steelhead	1962-63 Number	1962-63 Percent	Cumulative Percentage	b/
Sept. 17-23	9	0		0.08	
Sept. 24-30	52	0		0.45	
Oct 1-7	102	0		0.88	
Oct 8-14	225	0		1.94	
Oct 15-21	369	0		3.18	
Oct 22-28	1315	810	35.7	11.33	
Oct 29-Nov 4	822	477	21	7.08	
Nov 5-11	1088	161	7.1	9.38	
Nov 12-18	609	61	2.7	5.25	20 33.4 48.6 55.5 60.9
Nov 19-25	625	34	1.5	5.39	
Nov 26-Dec 2	737	82	3.6	6.35	
Dec 3-9	438	102	4.5	3.77	
Dec 10-16	441	81	3.6	3.8	
Dec 17-23	403	21	0.9	3.47	
Dec 24-30	80	5	0.2	0.69	
Dec 31-Jan 6	74	6	0.3	0.64	
Jan 7-13	238	2	0.1	2.05	
Jan 14-20	103	0		0.89	
Jan 21-27	282	0		2.43	
Jan 28-Feb 3	278	0		2.4	
Feb 4-10	577	258	11.4	4.97	11 15.6 21.5 25 29.8
Feb 11-17	701	18	0.8	6.04	
Feb 18-24	254	41	1.8	2.19	
Feb 25-Mar 3	407	12	0.5	3.51	
Mar 4-10	296	6	0.3	2.55	
Mar 11-17	322	8	0.4	2.78	
Mar 18-24	221	21	0.9	1.9	
Mar 25- 31	208	5	0.2	1.79	
Apr 1-7	119	4	0.2	1.02	
Apr 8-14	82	3	0.1	0.71	
Apr 15-21	26	0		0.22	
Apr 22-28	16	3	0.1	0.14	
Apr 29-May 5	13	6	0.3	0.11	
May 6-12	17	5	0.2	0.15	
May 13-19	32	25	1.1	0.28	
May 20-26	14	12	0.5	0.12	
May 27-Jun 2	1	1		0.01	
Jun 3-9	2	0		0.02	
Jun 10-16	1	0		0.01	
Jun 17-23	2	0		0.02	
Jun 24-30	4	0		0.03	
Totals	11605	2270			

a/ From Van Woert, unpublished.
b/ brackets indicate two run peaks.

Attachment 2 – steelhead migration timing

ATTACHMENT 3 – SPRING-RUN MIGRATION TIMING

Adult Spring-run chinook Salmon migration in Mill and Deer Creeks

(Source: F. Fisher. 1994. California Department of Fish and Game. Tributary spring-run chinook salmon life history)

Month (Approx)	**Julian Week**	**Mill Creek**	**Deer Creek**
March	10	0.00%	0.00%
	11	0.00%	0.00%
	12	0.10%	0.29%
	13	0.10%	1.07%
April	14	0.60%	1.28%
	15	1.60%	2.85%
	16	2.10%	20.53%
	17	3.00%	12.39%
May	18	4.10%	7.56%
	19	7.60%	11.95%
	20	11.20%	13.00%
	21	11.30%	6.49%
June	22	17.70%	7.64%
	23	15.00%	5.50%
	24	11.30%	4.67%
	25	7.90%	2.78%
	26	3.30%	1.88%
July	27	1.30%	0.11%
	28	0.70%	0.00%
	29	0.40%	0.00%
	30	0.50%	0.00%
August	31	0.10%	0.00%

Mill Creek (Van Woert et al., 1962 Water Projects Office report)
Deer creek (SP. SCI. Report NO. 26)

Attachment 3 – spring-run migration timing

ATTACHMENT 4 – WATER EXCHANGE AGREEMENT

Mill Creek Water Exchange Program and Fish Passage Improvements
(Source: Mill Creek Conservancy, Mill Creek Watershed Management Strategy Report, CH2MHILL 1997)

5.3.A Water Exchange Program

5.3.A.1 Mill Creek Water Exchange Agreement

The Mill Creek Water Exchange Agreement (Agreement) specifies the use of pumped groundwater for irrigation purposes in exchange for in-stream water rights to augment transport flows for adult spring-run chinook salmon between the mouth of the Sacramento River and the Ward Diversion.

In dry years, during the two critical salmon migration periods of May through June (for spring-run) and October (for fall-run), water right holders on the valley floor may divert the entire flow of Mill Creek. As a result, upstream migration of adult spring-run chinook and downstream migration of juvenile salmon and steelhead can be impeded or entirely blocked. Supplemental flows provided through a unique water exchange program are helping to restore this population by allowing migrating adults to reach their holding and spawning habitats, and by providing transportation flows for juveniles en route to the Sacramento River.

Funded by the CDFG and the State Water Contractors DWR, upon the recommendation of the Delta Pumps Fish Protection Agreement Committee, a Three-Party Agreement was completed between CDFG, DWR, and the LMMWC, for Phase I of the Mill Creek Water Exchange Program. Phase I included construction of a new well and restoration of an existing well, both located on The Nature Conservancy's Dye Creek Preserve. Under the Agreement, groundwater is used to supply a portion of LMMWC's water requirement in exchange for leaving an equivalent amount of water in Mill Creek during critical migration periods. The Agreement provides the framework through which fish passage is facilitated on Mill Creek and a mechanism for water banking. The water banking provision allows flows bypassed to the creek during critical migration periods to be repaid over several irrigation seasons.

Trial Mill Creek flow exchanges were conducted in cooperation with CDFG Region 1, CDFG Inland Fisheries Division personnel, and LMMWC in May and June 1990. During a 36-hour exchange flow period an estimated 200 salmon passed through the electronic fish counter at Clough Diversion, compared to the passage of three adult salmon during the precious

3 days. The number of adults migrating to upstream holding areas was encouraging, and established that adequate transportation flows are essential to the restoration of the spring- run salmon population in Mill Creek. Although the Phase I water exchanges were demonstrably successful in increasing the number of adult fish that passed upstream, water exchanges under Phase I were constrained by the capacity of the state's wells (9 cfs).

Phase 2 involves a second Agreement, wherein the LMMWC and a local landowner with priority water rights to Mill Creek forego diversion of an additional 16 cfs from Mill Creek when the water is needed for spring-run salmon migration (or fall-run spawning in dry years). This effectively increases the project's instantaneous capacity of 25 cfs. In exchange, the project pays the landowner's costs to operate an irrigation well and LMMWC uses the un-diverted water when it is not required for fishery purposes. In effect, CDFG acquires an on-demand flow of 25 cfs in Mill Creek for salmon transport and spawning. Although a flow of 25 cfs appears to be marginally adequate for fish passage, the banking provisions of the Phase I Agreement allow for much larger flows, if necessary. Additional study, and investigation regarding the analysis of instream flows is necessary. D.W. Alley and Associates prepared a report regarding lower Mill Creek that needs to be reviewed and the appropriate alternative methods for achieving adequate fish passage evaluated.

5.3-B Fish Passage Improvements/Ward Diversion and Screens

The Ward Diversion (the lower diversion) is located approximately 3 miles from the confluence with the Sacramento River. This diversion is operated by LMMWC. As Water Master, LMMWC provides irrigation water to its shareholders and eight other water right holders.

The structure is low profile and increases water surface elevation by approximately 5 feet The creek bed load upstream of the diversion is the same elevation as the-diversion crest; therefore, little water is impounded upstream.

The fish ladder on the Ward Diversion is functional and during normal flows provides easy fish passage. However, during high flows fish may have difficulty in locating the inlet to the fish ladder because of turbulence. Prior to 1987, upstream migrants which jumped onto the apron at the base of diversion in an attempt to pass were repelled by the vertical wall and then swept back onto the rocks below. This may have caused injuries that could prove fatal before they could spawn in the fall. During very high flows, the fish ladder is impassable because of extreme water turbulence.

In 1996, an agreement between LMMWC and CDFG led to the Ward Diversion being reconfigured from a vertical walled structure with horizontal sill to a gradual inclined ramp. The apron below the diversion was extended approximately 15 feet and the downstream edge of the inclined ramp was placed below the mean low water pool level to prevent salmon from attempting to jump at the dam. The slope of the ramp type diversion will be slight and will allow fish to swim up and over the diversion when moderate to high flows exist in the stream. The Ward Diversion fish ladder will be rebuilt as a pool and weir type fish ladder with increased water capacity which will allow operation at a higher range of stream flows.

The CDFG's Red Bluff Fish Habitat Shop presently maintains a fish ladder and fish screen on each of the three diversions on Mill Creek. The upper Mill Creek diversion has a concrete pool and weir-type fish ladder, and the head of the diversion is screened by a 70-foot-long by 5-foot-deep, vertical, perforated flat-plate fish screen. The fish screen is mechanically wiped by a gang wiping system powered by a paddle wheel.

The Clough Diversion has a concrete pool and weir fish ladder with 10 pools that rise 20 feet. The diversion ditch is screened by a 20-foot-long by 3-foot-deep vertical-diagonal fish screen with a paddle wheel powered reciprocating gang wiper.

The Ward Diversion (Lower Diversion) has a ramp with a rise of 6 feet and a fish weir ladder with six pools. The diversion is screened by a 60-foot-long by 4-foot-deep inclined- diagonal, perforated flat plate screen with an optional trap or direct fish bypass. The screen is cleaned by an electrically powered reciprocating gang wiper. The water diversion locations are shown on the GIS maps.

ATTACHMENT 6 – HABITAT TYPING REACHES

Streeam Reaches Surveyed During Habitat Typing Data Collection, 1990-1994.
Mill, Deer, and Antelope Creek, Tehama County, CA
(Source: Lassen National Forest)

Deer Creek Meadows

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	% Pool Area
1	6691	B3	Resident	Alluvial	34.1	15.3	5.6	0.5:99.5	1	2.7	2.7	0	0.8	0	0.2
2	12877	C4	Resident	Alluvial	17.3	8.4	5.5	5:95	11	4.2	3.3	5	4.5	2.1	5.8
3	NA	NA	Resident	Alluvial	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
4	3559	C3	Resident	Alluvial	12.1	7.1	5.6	28:72	8	3.4	2.8	2	3	3	15
1 to 4	23127	C3,C4,B3	Resident	Alluvial	19.7	9.4	5.5	5:95	20	4.2	3.1	7	4.6	1.6	3.5

North Fork Deer Creek (Gurnsey Creek)

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	% Pool Area
1	10340	C4	Resident	Alluvial	20.4	12.5	6.5	10:90	16	3.2	2.5	0	8.1	0	12
2	9007	B4	Resident	Alluvial	25.1	16.2	8.9	12:88	13	4.4	3.2	6	7.6	3.5	14
3	2845	C4	Resident	Alluvial	15.6	10.1	5.2	13:87	6	4.8	2.8	1	11.1	1.8	17
4	1253	C6	Resident	Alluvial	18.8	6.9	41.5	63:87	2	5	4	1	8.4	4.2	80
5	2753	C4	Resident	Alluvial	14.2	9.5	5.9	13:87	7	3.7	2.6	1	13.4	1.9	22
1 to 5	26198	B4,C4,C6	Resident	Alluvial	19.2	12.4	8.5	14:86	44	5	2.8	9	8.9	1.8	20

NA = No pools, runs or glides in this reach NS = Not surveyed

Antelope Creek

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	Pools > 6ft per reach	Pools > 6ft per mile	% Pool Area
1	3925	B3	Anadromous	Non-Alluvial	27	6.5	6.8	11:89	5	7.8	4.9	4	6.7	5.4	2	2.7	12
2	4704	B2,B3	Anadromous	Non-Alluvial	24	7.2	4	21:79	8	7.6	6.2	8	9	9	5	5.6	22
1 to 2	8629	B2,B3	Anadromous	Non-Alluvial	25.3	7	5.1	16:84	13	7.8	5.7	12	8	7.3	7	4.3	16

North Fork Antelope Creek

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	Pools > 6ft per reach	Pools > 6ft per mile	% Pool Area
1	1214	B2	Anadromous	Non-Alluvial	19.3	5.8	5.4	5:95	1	5	5	1	4.4	4.4	0	0	7
2	1498	B1	Anadromous	Non-Alluvial	13.4	5.8	4.7	5:95	3	4.5	2.9	2	10.6	3.5	0	0	5
3	7283	B2,B3	Anadromous	Non-Alluvial	16.8	6.5	4.8	5:95	11	5	3.8	7	7.9	5.1	0	0	6
4	6077	A2	Resident	Non-Alluvial	15.1	6.3	4.4	9:91	14	5.2	4.2	9	12.2	7.8	0	0	15
1 to 3	9995	B1,B2,B3	Anadromous	Non-Alluvial	16.4	6.4	4.8	7:91	15	5.2	3.9	10	7.9	5.3	0	0	6

South Fork Antelope Creek

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	Pools > 6ft per reach	Pools > 6ft per mile	% Pool Area
1	2367	B3	Anadromous	Non-Alluvial	15.8	5.6	5	9:91	6	4.4	3.1	4	13.3	8.9	0	0	10
2	3752	B2	Anadromous	Non-Alluvial	20.7	7.2	4	20:80	12	10	5.6	12	16.9	16.9	5	7	20
3	2689	B3	Anadromous	Non-Alluvial	18.5	7.3	3.6	9:91	5	7	5.2	5	9.8	9.8	1	2	10
4	4707	A2	Resident	Non-Alluvial	19.1	7.3	5.6	9:91	17	8.5	4.2	12	19.1	13.4	2	2.2	11
1 to 3	8808	B2,B3	Anadromous	Non-Alluvial	18.8	6.8	4.2	12:88	23	10	4.9	21	13.8	12.6	8	4.8	16

Attachment 6 – habitat typing reaches

APPENDIX F - RIPARIAN-DEPENDENT HERPETILES

RIPARIAN-DEPENDENT HERPETILES
Species of Special Concern

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INTRODUCTION

Amphibians are generally considered excellent indicators of ecosystem health for both aquatic and terrestrial environments because they utilize both habitats in their different life stages (Welsh et. al. 1991).

In the Sierra Nevada, of thirty native amphibian taxa, twelve are in need of special protection including six that are extinct or threatened with extinction (Jennings 1996). The watersheds of Mill, Deer and Antelope Creeks have all been identified as high value watersheds for the conservation of amphibians because of the presence of two species of special concern: the Cascades frog (Rana cascadae) and the foothill yellow-legged frog (Rana boylii) (ibid).

In addition to the Cascades frog and foothill yellow-legged frog, the three drainages also support populations of the western pond turtle (Clemmys marmorata) a Forest Service (Region 5) Sensitive Species. Although there are no historical accounts of California red-legged frogs (a species listed as Threatened by the USFWS), habitat potentially suitable for the species may exist in the drainages as well.

On a worldwide basis, acid precipitation, ultraviolet radiation, and global climate change have all been suggested as causes to the decline of amphibians. For some amphibians, however, local conditions may provide a better explanation for causes in declines for some species. In Lassen Volcanic National Park (LVNP), Fellers and Drost (1993) suggest that local factors including the presence of non-native predatory fish, extended drought conditions resulting in reduced habitat quality and, gradual loss of open meadows and associated aquatic habitat, have acted together to cause the near-total loss of the Cascades frog at the southern end of its range in the Cascades.

In California, human disturbance factors causing the decline in two of the states most widespread native ranid species (the California red-legged frog and foothill yellow-legged frog) include; dam building and flood control, mining, farming, urbanization, livestock grazing, commercial exploitation, and bullfrog and predatory fish introductions (Jennings 1988). Negative affects from land use practices on species habitat suitability for reproduction and survival include; 1) creation of warmwater microhabitats in streams; 2) the removal of native streamside vegetation; modification of riparian zones which allows increased solar input, thus raising ambient water temperatures; and 4) reducing or eliminating undercut banks, tree root masses, and gravel substrates by increased erosion and siltation (ibid).

Other herpetile species, such as the western pond turtle, are also experiencing declines. Because western pond turtles forage in the aquatic environment but nest and overwinter in terrestrial environments, they are vulnerable to a wide range of environmental perturbations (Lind et. al. 1992). Like other aquatic dependent species, the reasons for western pond turtle declines are complex and can be generally attributed to the following: habitat alteration and population fragmentation, predation by native and introduced species, droughts commercial exploitation, illegal collection, pollutants, disease, off-road vehicles, roads, and introduced turtles (Holland 1991).

In the Sierra Nevada, the most imperiled aquatic habitats supporting amphibian species of special concern include springs, seeps, and bogs; vernal pools; marshes; and small headwater streams (Jennings 1996).

Recent Surveys

Since 1994, surveys in Mill, Deer and/or Antelope Creek watersheds have been conducted for the primary purpose of determining the presence of herpetile species, especially those of special concern noted above. In 1994, under a cooperative agreement with Dr. Gary Fellers of the National Biological Service, a herp crew conducted surveys in both Deer and Mill Creeks.

In 1995, EA Engineering, Science and Technology (under contract with the Lassen National Forest) also conducted herp surveys with a focus on unsurveyed tributaries of Deer and Mill Creeks. In Mill Creek and Deer Creek, EA surveyed a total of 8.9 miles and 9.6 miles of tributaries, respectively. Species observed during the 1995 surveys are listed in Appendix A.

In 1995 and 1996, some surveys were also conducted in Antelope Creek by Dr. Fellers crew. In 1997, Dr. Fellers crew is continuing herp surveys in unsurveyed areas of the Deer, Mill and Antelope Creek watersheds for the California red-legged frog and to determine habitat suitability for the species. In addition to the more formal surveys noted above, general reconnaissance surveys conducted by Forest Service employees have been done in some years (e.g 1993) and, during other stream assessments, incidental observations of herps have been.

From available historic information, the above surveys, and incidental observations, some information is available on the relative distribution of the herp species in the watersheds. Because surveys conducted to date have been conducted for the primary purpose of documenting species presence and relative distribution, they do not necessarily confirm absence or provide a complete picture of their relative abundance beyond the site level. For this reason, little can be said about their population status as a whole in these watersheds. Continued surveys and monitoring of existing reproducing populations is needed to further our understanding of the species status and habitat needs.

Cascades Frog

Habitat and species overview:

The Cascades frog is a mountain frog most common in small pools adjacent to streams flowing through subalpine meadows. They also inhabit sphagnum bogs and fens, seasonally-flooded, forested swamps, small lakes, ponds, and marshy areas adjacent to streams (Leonard 1993). In Oregon, Cascades frogs are abundant in ephemeral ponds that transition into meadows by the end of summer (D.Olson, 1994, pers. comm.)

Historically, Cascades frogs were discontinuously distributed along the Cascade Range between northern Washington and northern California. In California, Cascades frogs were distributed from the Shasta-Trinity region eastward toward the Modoc Plateau and southward to the Lassen region and upper Feather River system (Jennings and Hayes 1994). The known elevational range of Cascades frogs in California extends from 760 feet to 8250 feet (ibid).

In northern California, north of the McCloud River, Cascades frogs seem to be doing well (Jennings per. comm. 1994). In the southern-most part of its range, however, roughly south of the McCloud River (ibid), recent research has shown that this frog is extremely rare (Fellers and Drost 1993; Jennings and Hayes 1994).

Mill, Deer and Antelope Creek Watersheds:

Surveys conducted on the Lassen National Forest in 1993 documented two reproducing populations of Cascades frogs south of Lassen Volcanic National Park (LVNP), one of which is in the Deer Creek watershed. These two sites are the only places where Cascades frogs are presently known south of LVNP (Fellers 1995).

Based on some historical collections made in the 1960's (Chico State University herp specimens), Cascades frogs were present at elevations around 4600 feet (and higher) in upper Mill Creek (above Hole-in-the-Ground) and in Deer Creek (near Deer Creek meadows). Although our present knowledge of the Cascades frog within the watershed indicates its distribution is limited to the upper portions of the two watersheds, incidental sightings in recent years suggest that the species may be distributed at lower elevations including the area near Ponderosa Way on Deer Creek (1993 personal observation). Extensive herpetile surveys conducted in 1994 (Fellers 1995) and in 1995 (EA 1996) in both Deer and Mill Creeks found no Cascades frogs outside the known population in upper Deer Creek.

Although habitat along the upper reaches of Deer and Mill Creek appear suitable for Cascades frogs where there are historic records for the frog, streams on National Forest lands in general do not appear to provide prime habitat for this species (Fellers 1995). In the downstream and/or tributary reaches, habitat appears less suitable for the species because of gorge-like conditions, steep gradients and/or extensive canopy cover (ibid). Streams with lower gradients and less canopy cover and, ponds, lakes and meadows not yet surveyed may support additional populations of this species.

Based on the two reproducing populations of Cascades frog on the Lassen, early life history stages of the species (e.g. egg and larval development, juvenile rearing, etc) are associated with (non-fish-bearing) marshy seeps, springs or side channels of mainstem streams. Adults and subadults, on the other hand, are regularly observed on mainstem (fish-bearing) channels.

Foothill Yellow-Legged Frog

Habitat and species overview:

The foothill yellow-legged frog is a stream or river frog of woodland, chaparral, and forest. It is usually found near streams with a mixture of all sizes of rock and gravel substrate and some type of low overhanging vegetation at the waters edge. Large boulders are often present in prime habitats as they provide basking sites for adults and escape cover for all size classes. Small streams are also important for this species as they provide nursery sites for recently metamorphosed individuals.

Historically, the foothill yellow-legged frog was known to occur in most Pacific drainages from northwestern Oregon to southern California. In California, it was historically distributed in the foothill regions of most drainages from the Oregon border to the San Gabriel River system (Jennings and Hayes 1994). Its known elevation range in California extends from near sea level to 6400 feet.

Populations once present south of San Luis Obispo County are now extinct and others in the southern Sierra foothills may be extinct. In northern and western California, populations of foothill yellow-legged frogs appear to be surviving fine (Fellers 1995). On the western slope of the northern Sierra Nevada and the extreme southern Cascades, localities at which this species is extant appears widely scattered (Jennings and Hayes 1994). The foothill yellow-legged frog has been eliminated from 45% its historic range within California.

Mill, Deer and Antelope Creek Watersheds:

Mill, Deer and Antelope Creek watersheds all contain reproducing populations of foothill yellow-legged frogs. As previously noted, however, little can be said at this time about their overall population status above the site level.

Foothill yellow-legged frogs utilize the mainstems of the three drainages as well as tributary streams. Some tributaries are known to provide suitable conditions for egg laying, larval development, and juvenile rearing (personal observation) although some shallow backwater areas along the mainstems appear to provide suitable conditions as well (Fellers 1995).

In the Deer Creek watershed, the present range of foothill yellow-legged frog within the National Forest boundary is known to extend from roughly the Highway 32 "Red" Bridge (elevation approximately 3200 feet) downstream into the Ishi Wilderness.

In the Antelope Creek watershed, the foothill yellow-legged frog is known to extend into the North and South Forks (above their confluence) as well as along the mainstem to near Paynes Place on National Forest lands. Based on historical accounts, habitat is also present for the species below Paynes Creek. In 1960, Antelope Creek (from Paynes Place downstream to the City Diversion Dam) apparently supported large numbers of adult "California" yellow-legged frogs and tadpoles (CDFG 1960 stream survey).

In Mill Creek, the present range of the foothill yellow-legged frog is not well known. They are known to be present, however, below the elevation of (approximately) 2500 feet in the vicinity of Savercool pool.

Western Pond Turtle

Habitat and species overview:

Western pond turtles occur in a wide variety of permanent and intermittent aquatic habitats including rivers, streams, lakes, ponds, and other wetlands. Generally they are found in slow-moving waters below 4500 feet elevation. In intermittent streams they are known to use permanent pools that persist after the main stream course drys up. Basking sites such as partially submerged logs, rocks, mudbanks or emergent vegetation appear to be important habitat components. The presence of suitable refugia, such as spaces under rocks, downed logs, holes in banks and most importantly, undercut banks may be a critical factor in the ability of populations to maintain themselves in small streams.

Information on the reproductive and nesting ecology of western pond turtles is limited (Lind et. al 1992). Females are thought to excavate nest depressions in May, June, or July, and will move as far as 1300 feet from water to dig them (Holland 1991). Nests are generally located in open areas dominated by grasses or herbaceous annuals, primarily on south- or southwest-facing, gentle to moderate slopes. Eggs hatch several months later and it is believed at some locations, hatchlings overwinter in the nest (ibid).

Historically, the western pond turtle occurred in a variety of wetlands west of the Sierra Nevada or Cascades crest from Pugent Sound in Washington to Northern Baja California, Mexico. In California, western pond turtle populations on the valley floor (especially the San Joaquin Valley) are now severely reduced in numbers due to the loss or alteration of their natural habitat (Bury and Holland, draft).

Mill, Deer and Antelope Creek Watersheds:

Because no systematic surveys have been conducted for the western pond turtle, little is known about their range, population status or age structure. Based on incidental observations, however, their range appears to be within that which has been described for the foothill yellow-legged frog in the drainages.

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APPENDIX G - EROSION, WATERSHED DISTURBANCE AND STREAM CHANNELS

Antelope-Deer-Mill Watershed Analysis-

Erosion, Watershed Disturbance and Stream Channels

I. EROSION PROCESSES

Three types of erosion processes are common in the watersheds, surface erosion, mass wasting and channel erosion.

Surface Erosion

Surface erosion is the most widespread erosion process (in which we include rill and gully erosion). This occurs at some rate everywhere within the watersheds, but is the dominant process on soils with high erosion rates. Erosion rates increase dramatically on steeper slopes. In the subject watersheds, rhyolitic soils have much higher erosion rates than the other soils. Rhyolitic soils are prevalent in parts of the Upper Deer and Mill Creek watersheds. Table 1 in lists the percentage of each sub-basin in rhyolitic soils.

Mass Wasting

Mass wasting is less common (area wise) than surface erosion, but in the long term, contributes as much or more volume of sediment than surface erosion. Debris torrents are the most common form of mass wasting. Torrents typically originate in steep, concave landforms (source channel reachs), and can be found in all the watersheds' basic soil types. Specific to Mill Creek are relatively small slides originating on channel side slopes which are periodically undercut by very high stream flows. Such slides have high delivery rates as material is deposited directly in the channel. Less common are large rotation slides (one occurred in 1997), which appear also to be found only in the Mill Creek watershed. Mass wasting is triggered by precipitation, and are associated with periods of heavy rainfall of long duration, such as occurred in late 1996 and early 1997. This storm triggered numerous slides in Mill Creek, some in Deer Creek and a few in the headwaters of Antelope Creek.

Channel Erosion

Channel erosion is also common throughout the watersheds, but has the highest unit production in alluvial stream types, which are relatively rare in the watersheds (see section II, channels).

I.I. Changes in Sediment Regime

Historically, we believe that sediment delivery within the watersheds was dominated by mass wasting. Numerous debris torrent and landslide scars have been identified. Events were and are episodic, typically triggered by long duration, high intensity precipitation events. The degree to which warmer, wetter climatic conditions beginning around 1850 affected mass wasting activity is unknown. Therefore, it is very hard to say anything about the trend in mass wasting activity in the long and mid term past. We do believe that very little mass wasting has been triggered by management, because most of the steeper topography with the greatest potential for mass wasting is unroaded. Sediment delivery from mass wasting is probably close to "natural" rates. We believe that surface erosion has increased substantially over the same time period. This is due to increased management addictive in the watersheds, which will be further discussed.

Sediment delivery from channel sources has probably increased somewhat over historic levels, due to reduced channel stability in alluvial reaches such as Deer Creek Meadows and North Fork Deer Creek and Gurnsey Creek (we refer to the reach upstream of the Gurnsey Creek CG Gurnsey Creek). Channel erosion is also episodic to some degree (higher rates during large flow events), but is also influenced by management. Removal of riparian vegetation that provides bank stability (due to grazing) is the primary anthropogenic factor affecting changes in the rates of erosion from the watersheds' low gradient channels. It is likely that current erosion is less than it was soon after the settlement of the area by Europeans through the first third of this century, when grazing intensity was at its peak (SNEP and grazing history, appendix M this report). Increases from channel sources as a result of management are limited (relative to surface erosion) because many of the stream channels in the watersheds are naturally resistant. This holds for nearly all of the main stems of the three streams (those sites along Mill Creek subject to mass wasting are the obvious exceptions) and most of the perennial reaches of channel. Contributions from channel erosion in intermittent and ephemeral channels is not known. Our analysis does indicate that in some sub-basins the degree of nearstream disturbance is high (discussed in further detail later). If nearstream disturbance translates to a lack of large wood in channels, and increased sediment delivery to channels, then unstable banks could result.

Human causes of accelerated bank erosion have been discussed. Human activities have caused a greater increase in the amount of surface erosion, and sediment delivery from that source. Roads are the dominant source of surface erosion in the watersheds; more specifically, road crossings have been shown to be the primary erosion source. Roads on rhyolitic soils have erosion rates at least four times that of other parent materials in the watersheds (Meadowbrook, 1997). Logging (specifically landings and skidtrails which are poorly located or lack proper erosion control) is another common erosion source in the watershed, but at least an order of magnitude below roads as a source. Field observations have shown that logging related sources which intersect roads are the major source of delivery from logging source areas (runoff, rills and gullies originating on skidtrails), as roads increase delivery of "upslope" erosion to channels. We also believe that erosion and resultant sediment delivery from fires is greater than it was historically, as the fuels-vegetation analysis concluded high intensity fires are more likely to occur under current vegetative conditions than they did historically.

Table1-G.- Watershed disturbance by sub-basin.

Watershed Disturbance				Soils		Roads															
			% of Basin in			Road	Crossings			Erosion (tons/square mile)				Ortho.			Ortho	Fire	Collins	Sum	
		Basin	Rain on Snow			Density	Number of	Crossings	# of Crossings	Existing	Potential	Existing	Fire (96)	Disturbance	Road E.R.A.	Forest Service	E.R.A.	E.R.A.	E.R.A.	E.R.A.	% E.R.A.
Sub-basin	Stream	Size (acres)	3600'-5000'	% Rhyolite	* % E.H.R.	(mi./sq. mi.)	Crossings	per mile	in Rhyolite	Erosion	Delivery	Delivery	(acres)	(acres)	(acres)	E.R.A. (acres)	(acres)	(acres)	(acres)	(acres)	
D1	Yahi	70796	0.00%	0.10%	15.40%	0.54	20	0.13	0	10	3.1	8	33187	19.1	65.9	0	9	3834.9		3909.8	5.52%
D7	Flatiron	8136	35.00%	0.00%	23.10%	1.52	11	0.30	0	0.2	0.1	0	7413	44.6	95	0	22.3	768.6	110.8	996.7	12.25%
D8	Big Smokey	5569	70.00%	0.00%	3.10%	2.83	9	1.46	0	5.3	2.1	5.3	668	294.6	79.4	0	147.3	0		226.7	4.07%
D9	Ditch	3312	68.00%	0.00%	3.50%	1.38	24	1.81	0	8.8	5.5	6.1	904	182.7	73.5	0	91.4	0		164.9	4.98%
D10	Wilson	7021	66.00%	0.60%	8.50%	3.78	36	1.13	0	11.6	3.0	9.9	664	385.6	131.8	6.7	192.8	0		331.3	4.72%
D11	SF Calf	1530	81.00%	0.00%	4.10%	2.56	8	1.24	0	67.7	24.5	54.7	0	137.9	22.6	33.4	70	0		126	8.24%
D12	NF Calf	1485	52.00%	0.00%	12.10%	4.42	10	1.57	0	21.4	17.7	21.3	0	0	39.7	54.8	0	0		94.5	6.36%
D13	Deadhorse	1876	58.00%	16.40%	1.80%	4.69	10	1.5	6	8.6	11.1	6.3	0	175.9	53.5	0	88	0		141.5	7.54%
D14	Panther	2762	53.00%	22.90%	2.10%	7	23	2.48	5	131.9	17.3	49.2	0	133.2	100.5	0	66.6	0		167.1	6.05%
D15	Potato	4952	59.00%	3.50%	21.00%	3.17	15	0.76	2	8.4	4.4	6.1	0	459	64.8	179.5	229.5	0		473.8	9.57%
D16	Rattlesnake	3854	28.00%	0.00%	3.70%	2.54	12	1.03	0	7.1	4.8	6.9	0	0	65.8	49.1	0	0		114.9	2.98%
D17	Forked	3493	87.00%	0.40%	0.30%	6.08	15	1.75	0	47.5	11.9	40.1	263	526.8	75.3	3.5	263.4	0	1.6	343.8	9.84%
D18	Falls	6648	60.00%	0.00%	9.10%	2.48	18	0.84	0	3.3	1.8	1.8	73	362.7	75.7	14	181.3	0	10.6	281.6	4.24%
D19	Round Valley	2245	55.00%	1.10%	5.70%	6.09	11	1.6	0	279.4	98.4	251.1	0	250.8	87	0	125.4	0	43.7	256.1	11.41%
D20	Cub	4044	17.00%	0.00%	35.50%	0	0	0	0	0	0	0	507	0	0	0	0	0		0	0.00%
D21	Slate	3891	50.00%	43.10%	0.00%	5.14	21	1.45	14	598.4	38.6	582.8	0	33.5	90.6	16.7	16.8	0	194.1	318.2	8.18%
D22	Elam	4002	7.00%	0.00%	17.80%	2.37	9	0.79	0	1.1	0.7	0.8	80	8.3	54.6	56.1	4.2	0		114.9	2.87%
D23	Carter	3096	4.00%	2.60%	24.00%	0.98	4	0.5	0	0	0	0	0	0	8.8	33.9	0	0	8.9	51.6	1.67%
D24	Upper Deer	2823	15.00%	2.60%	16.60%	0.35	1	0.09	0	0	0	0	0	0	6.5	0	0	0	7.1	13.6	0.48%
D25	Swamp	2842	36.00%	74.50%	0.00%	4.87	9	1.39	6	57	16.2	46.4	0	190.5	55	25.9	95.2	0	41.1	217.2	7.64%
D26	Alder	625	41.00%	85.50%	0.00%	6.4	5	2.79	4	88	27.8	51.6	0	43.9	20	6.6	22	0		48.6	7.78%
D27	Deer Cr. Meadows	4788	65.00%	32.30%	0.60%	5.58	25	1.87	12	137.9	25.5	101.3	0	384.9	173.9	0	192.4	0	175	541.3	11.31%
D28	Lower Gurnsey	5088	43.00%	82.30%	0.00%	4.66	24	1.41	20	233	48.3	197.2	8	435.8	191.1	23	217.9	0	101.1	533.1	10.48%
D29	Upper Gurnsey	7817	35.00%	72.40%	0.20%	3.44	34	1.11	26	89.5	13.5	63.3	318	269.8	106.6	29.9	134.9	0	5.5	276.9	3.54%
D30	Lost	9099	4.00%	46.40%	0.00%	3.94	28	1.5	15	102.8	59.3	75.9	479	402.1	196.6	13.5	201	0	44	455.1	5.00%
M0	Lower Mill	13147	0.00%	5.20%	0.50%	0.93	0	0	0	-	-	-	0	0	66.98					66.98	0.51%
M1	Bear	2620	0.00%	0.00%	4.50%	0	0	0	0	0	0	0	3417	0	0	0	0	311.2		311.2	11.88%
M2	Kingsley	2077	0.00%	0.00%	11.90%	0	0	0	0	0	0	0	2077	0	0	0	0	0		0	0.00%
M3	Boat Gunnel	6119	20.00%	0.30%	9.20%	0.63	1	0.4	1	0	0	0	12550	0	6.9	0	0	1112.8		1119.7	18.30%
M4	Pape	3273	0.00%	0.00%	15.80%	0	0	0	0	0	0	0	4357	0	0	0	0	84.5		84.5	2.58%
M5	Avery	3637	5.00%	0.00%	26.30%	0.2	0	0	0	0	0	0	6972	0	0	2.4	0	423.6		426	11.71%
M6	Black Rock	7441	33.00%	4.90%	26.00%	1.58	24	0.6	1	12.2	5.2	11.9	14480	0	38.2	74.8	0	444.9		557.9	7.50%
M7	Savercool	7485	47.00%	25.10%	17.40%	1.68	19	0.5	10	18.1	47.6	10.2	5434	565	29.8	82.1	30.9	0		142.8	1.91%
M8	Big Bend	10508	53.00%	28.90%	19.60%	1.77	63	1.2	18	70.0	24.0	66.5	1230	2694	71.7	0	196.9	0		268.6	2.56%
M9	Rock Gulch	1810	18.00%	23.50%	6.50%	1.15	6	1.0	3	0	0	0	0	0	0	14.3	0	0		14.3	0.79%
M10	Townview	3660	4.00%	84.60%	0.20%	5.98	40	2.6	22	245.6	85.0	208	11194	2904	91.7	6.6	187.7	1368.4		1654.4	45.20%
M11	Hole in the Ground	4393	51.00%	51.90%	2.20%	4.09	55	2.3	26	58.6	15.3	38.5	0	1063	119.8	80.1	73.9	0		273.8	6.23%
M12	Mill Cr. Track	4036	37.00%	31.00%	1.70%	5.25	47	2.9	5	58.3	14.6	36.1	0	830	107.7	26	52.5	0		186.2	4.61%
M13	Morgan	5810	12.00%	21.30%	12.90%	1.51	11	0.6	5	1.6	0.4	1.3	0	20	46.2	0	1	0		47.2	0.81%
M14	Canyon	1648	0.00%	2.30%	4.50%	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0.00%
M15	Lassen Park	6313	0.00%	0.00%	0.20%	0.86	0	0	0	0	0	0	0	0	53.8			0		53.8	0.85%
A1	Round Mtn.	3819	15.00%	1.30%	5.80%	1.55	4	0.3	0				2594	0	32.8	33.1	0	0		65.9	1.73%
A2	Crazy	2250	44.00%	5.50%	7.90%	3.72	15	1.8	0				1244	43	47.3	23.6	2.2	12.6		85.7	3.81%
A3	Tamarack	3830	99.00%	27.90%	0.50%	4.22	19	1.2	3				3315	0	91.3	0	0	0		91.3	2.38%
A4	Gunbarrel	2654	26.00%	0.00%	0.00%	3.58	13	1.2	0				627	685	54.2	0	44.5	0		98.7	3.72%
A5	Upper South Fork	2945	57.00%	1.00%	0.50%	3.42	11	1.0	0				872	734	56.8	1.5	45.2	0		103.5	3.51%
A6	McCarty	3339	46.00%	0.00%	0.00%	3.7	7	1.5	0				238	1872	70.2	0	96.8	0		167	5.00%
A7	Howard	2841	71.00%	0.10%	0.00%	3.27	5	0.9	0				613	0	53.5	0	0	0		53.5	1.88%
A8	Lower South Fork	7704	32.00%	0.40%	20.70%	2	7	0.3	0				8954	1335	87.7	14.5	79.2	24.8		206.2	2.68%
A9	Lower North Fork	4104	0.00%	0.00%	17.30%	0.6			0				3106	178	13.8	4.6	10.4	31.5		60.3	1.47%
A10	Judd	6202	53.00%	3.30%	1.30%	3.72	6	0.8	1				4458	3252	130.3	0.4	194	288.3		613	9.88%
A11	Upper North Fork	6939	26.00%	1.00%	7.20%	3.21	11	0.7	0				2189	1928	126.3	6.9	111	81.7		325.9	4.70%
A12	Middle Fork	5571	52.00%	2.80%	3.40%	3.13	15	0.9	0				982	2410	98.3	22.3	130	0		250.6	4.50%
A13	Deadhorse	3762	57.00%	2.80%	0.10%	3.63	22	1.8	1				363	2084	76.1	6.7	125.1	0		207.9	5.53%
A14	Lower Antelope	36768	0.00%	0.00%	1.20%	0.58	8	0.1	0				12865	0	-	0.5	0	70.5		71	0.19%

We believe that the erosion-sediment delivery regime has shifted from one historically dominated by episodic mass wasting to one dominated by a combination of chronic surface erosion sources overlaid on the episodic mass wasting events. Sediment delivery has potential impacts on several of the resources identified as important in the watershed (anadromous fish, native fish assemblage and amphibian species). As surface erosion is the process which appears to have been most affected by management activities, and therefore has the most potential for improvement through revised management, a more thorough discussion of that process is warranted.

As discussed earlier, rhyolitic soils have the highest erosion rates in the watersheds. A comprehensive survey of road erosion conducted by Meadowbrook Conservation Associates (1997) estimated existing delivery of sediment from roads (this information is given in Table 1 of appendix). Those sub-basins where rhyolite is the dominant soil had the highest sediment delivery, as might be expected.

I.II. Estimating Watershed Disturbance as a Means of Assessing Risk of Increased Surface Erosion

We did not develop an erosion model, instead, we decided to quantify disturbances associated with known sources of erosion on a sub-watershed basis. As previously indicated, we believe that road erosion is the primary source of surface erosion. We selected four indicators related to road erosion: The first is an estimate of delivered sediment from roads (Meadowbrook Associates, 1997. Second, we counted the number of road channel crossings (this criteria is expressed in terms of crossings/mile). We also calculated the amount of roads in each sub-basin's near stream area (further explained below). Finally, we calculated road density (road miles per square mile). The other disturbance indicators also include roads to some degree. One is Equivalent Roaded Area (ERA), a generalized indicator of overall disturbance, which includes roads, timber harvest activity and fire. We also calculated the amount of roads and timber harvest disturbance in areas near streams (within 150 ft of an intermittent channel and 300 feet of a perennial channel). The amount of disturbance is expressed as a percentage of the total sub-basin in near stream areas. This was done for both perennial channels and all channels. Complete descriptions of the methods used are included in appendix N.

Criteria	**Level of Moderate Risk**
Road Density	3.0 mi/mi2
Road Crossings	2.0 per stream mile
Delivered Road Sediment	> 50 tons per square mile
Equivalent Roaded Acres	10%
NSD* roads	5%
NSD total (all streams)	5%
NSD total (perennial streams)	5%

*NSD = Near Stream Disturbance

Each of these indicators is descriptive of watershed disturbance. In an attempt to summarize the results, we set a level of moderate risk for each criteria, and then tallied the number of criteria exceeding this level in each sub-watershed. The risk levels are based only on professional judgement and may not infer anything about watershed condition. They are used only to distinguish between levels of disturbance between sub-basins. Obviously, very high disturbance levels in a single category (% near stream disturbance or tons of sediment delivered) might have a higher risk of impacting aquatic resources than exceeding several arbitrary "thresholds". The thresholds for each criteria, and the results of the analysis are given below. Figure 1 displays the results of the analysis. Results are summarized in Table 2, and presented in Table 1.

Table 2-G.- Number of watershed disturbance criteria exceeding levels of moderate risk, by sub-watershed

Watershed	Sub-Watershed	# Criteria Exceeding Moderate	Watershed	Sub-Watershed	# Criteria Exceeding Moderate	Watershed	Sub-Watershed	# Criteria Exceeding Moderate
Deer	D1- Yahi	0	Mill	M1- Bear	1	Antelope	A1- Round Moutain	0
Deer	D2	0	Mill	M2- Kingsley	0	Antelope	A2- Crazy	1
Deer	D3	0	Mill	M3- Boat Gunnel	1	Antelope	A3- Tamarack	1
Deer	D4	0	Mill	M4- Pape	0	Antelope	A4- Gunbarrel	1
Deer	D5	0	Mill	M5- Avery	1	Antelope	A5-Upper South Frk	2
Deer	D6	0	Mill	M6- Black Rock	1	Antelope	A6- McCarty	2
Deer	D7- Flatiron	1	Mill	M7- Savercool	0	Antelope	A7- Howard	3
Deer	D8- Big Smokey	0	Mill	M8- Big Bend	1	Antelope	A8- Low South Frk	2
Deer	D9- Ditch	2	Mill	M9- Rocky Gulch	0	Antelope	A9- Low North Fk	0
Deer	D10- Wilson	2	Mill	M10- Townview	5	Antelope	A10- Judd	4
Deer	D11- SF Calf	3	Mill	M11- Hole in Ground	2	Antelope	A11- Up North Frk	3
Deer	D12- NF Calf	2	Mill	M12- Mill Track	2	Antelope	A12- Mid Fork	3
Deer	D13- Deadhorse	2	Mill	M13- Morgan	0	Antelope	A13- Deadhorse	3
Deer	D14- Panther	4	Mill	M14- Canyon	0	Antelope	A14- Low Ant	0
Deer	D15- Potato	2	Mill	M15- LVNP	0			
Deer	D16- Rattlesnake	2						
Deer	D17- Forked	4						
Deer	D18- Falls	0						
Deer	D19- Round Valley	5						
Deer	D20- Cub	0						
Deer	D21- Slate	4						
Deer	D22- Elam	1						
Deer	D23- Carter	2						
Deer	D24- Up Deer	0						
Deer	D25- Swamp	3						
Deer	D26- Alder	6						
Deer	D27- Deer Crk Mdws	5						
Deer	D28- Low Gurnsey	6						
Deer	D29- Up Gurnsey	3						
Deer	D30- Lost	3						

There are several commonalties among those watersheds with the highest risk factors. Of those with 3 or more risk factors exceeded, 10 of 18 have high percentages (>25%) of highly erosive rhyolitic soils. One of the risk factors (sediment delivery from roads) was strongly influenced by soil type, the other factors were largely independent of it. The correlation of the risk factors with the highly erosive soils translates to a high potential for substantial increases in sediment production from these sub-basins.

Number of Disturbance Criteria Exceeding Moderate Risk

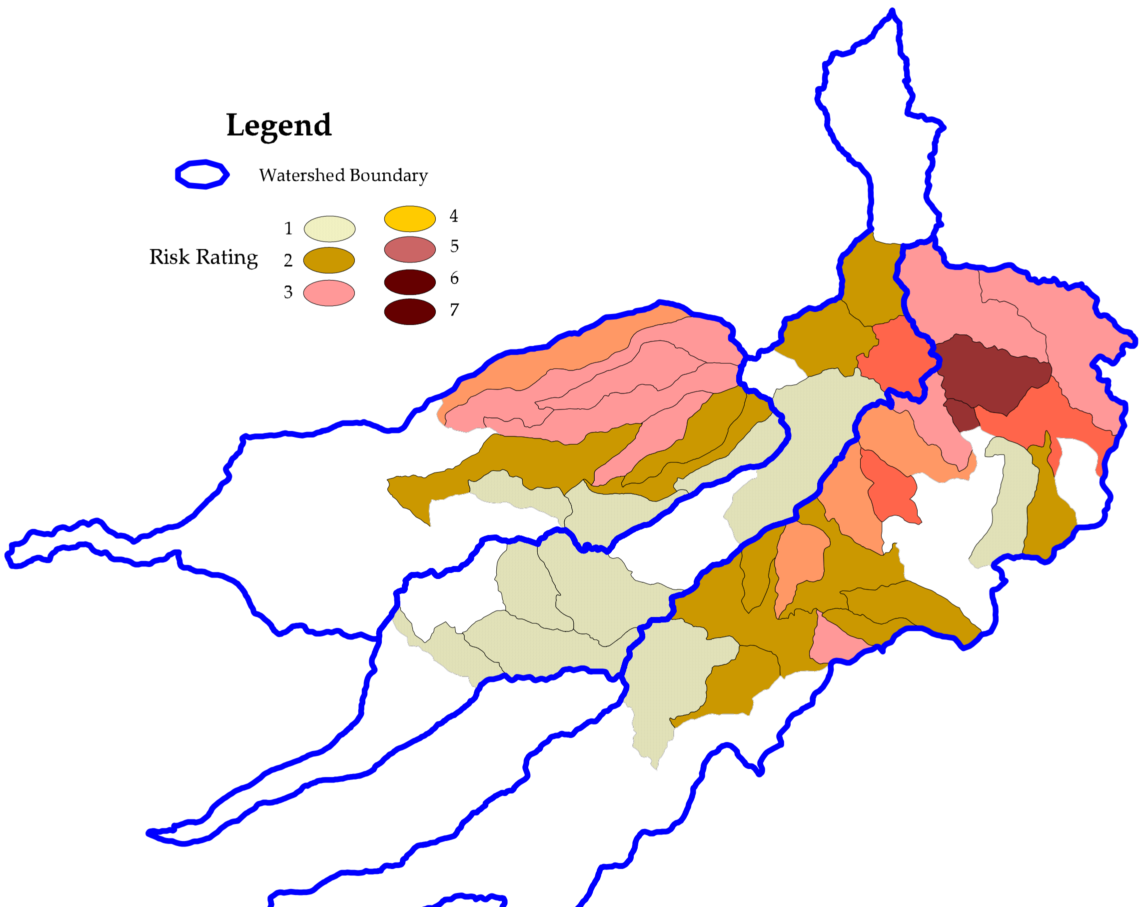


Figure 8-G.- Number of disturbance criteria exceeding moderate risk in sub-basins of Mill, Deer, and Antelope Creek watersheds.

I.III. Trend in Watershed Disturbance

Increases in the amount of surface erosion in the watersheds are primarily the result of timber harvest activity. This activity has occurred to some degree since the settlement of the area by Europeans, but has not remained constant. Using historic maps, we estimated road densities on a sub-watershed basis for the first year of each decade beginning with 1930. As road construction was done primarily to access timber, we think the road density data gives a fair estimate as to the timing and intensity of timber harvest activities in the period 1930 to 1990. Results from this analysis are presented in Table 3, and displayed in figures 2, 3 and 4.

We also calculated watershed disturbance values for the year 1975, to gauge the trend in those values over the past few decades. These results are contained in table 4, and are very similar to the current values. Generally, increases in disturbance levels from 1975 to 1996 in some sub-basins is balanced by reductions in disturbance levels over the same period in other sub-basins.

We think it is reasonable to say that the overall amount of watershed disturbance rose quickly from the mid 1950s through the late 1970's and has held roughly constant since then. More uncertain is the way that these levels of disturbance relate to the processes of concern. That is because timber harvest, road construction and road maintenance practices have improved considerably over the same period of time.

The other major process affecting change in erosion rates in the watersheds is wildfire. As discussed in appendix J, the frequency of fires in the watersheds has changed dramatically since the advent of fire suppression. Over the same period logging slash has increased the amount of fuel in many forested stands. The key question as fire relates to erosion processes is if the change in fuels and fire frequency results in greater burn intensities than occurred prior to fire suppression activities (and the loss of frequent ignitions by native peoples). The fire modeling results indicate that intense burns are more frequent (in some stands, aspects, etc.), though this is the subject of some debate,. We conclude therefore, that at present, and into the reasonably foreseeable future, surface erosion resulting from wildfires is far greater than it was historically. This trend (using the recent Barkley, Campbell and Finley fires as evidence) seems to be increasing.

I.IV. Nearstream Disturbance

Aerial photography of the watershed was reviewed (for each year of coverage) for evidence of disturbances near channels. Orthophotos from 1975 and 1990 were used to quantify the amount of disturbance that occurred near stream channels. Arbitrary buffer widths of 300 feet for perennial channels and 150 feet for other channels were applied. The amount of nearstream road disturbance was estimated using the road and stream GIS layers. These methods are explained in greater detail in Appendix N, results are presented in table 5.

Table 3-G.- Road Density by Decade

Watershed	Sub-basin	Sub-basin #	Road Density (by decade)						
			1930	1940	1950	1960	1970	1980	1990
Antelope	Round Mountain	AC1	0.5	0.7	0.7	0.74	0.74	1.46	1.55
	Judd	AC10	0.98	1.18	1.18	2.15	2.15	3.03	3.72
	Upper N Fork	AC11	0.48	1.19	1.19	1.49	1.49	3.03	3.21
	Middle Fork	AC12	1.21	1.59	1.59	2.2	2.2	3.1	3.13
	Deadhorse	AC13	0.13	0.57	0.57	2.21	2.21	3.42	3.63
	Lower Antelope	AC14	0.01	0.01	0.01	0.03	0.03	0.58	0.58
	Crazy Canyon	AC2	0.49	1.57	1.57	1.7	1.7	3.42	3.72
	Tamarack North	AC3	1.41	1.41	1.41	1.41	1.41	3.57	4.22
	Gunbarrel	AC4	0.76	0.76	0.76	0.76	0.76	3.54	3.58
	Up South Fork	AC5	0.24	0.24	0.24	0.46	0.53	2.5	3.42
	McCarty	AC6	0.14	0.14	0.14	1.03	1.03	3.38	3.7
	Howard	AC7	0.55	0.89	0.89	1.49	1.49	2.78	3.27
	Low South Fork	AC8	0.21	0.66	0.66	0.9	0.9	1.84	2
	Low North Fork	AC9	0.1	0.13	0.13	0.21	0.21	0.49	0.6
Deer	Alder	D26	1.22	1.24	1.24	3.87	3.87	6.4	6.4
	Big Smokey	D8	0.29	0.4	0.4	0.52	0.52	2.81	2.83
	Carter	D23	0	0	0	0.08	0.51	0.98	0.98
	Dead Horse	D13	0.57	0.57	0.57	1.58	1.58	3.55	4.69
	Deer Ck Mdws	D27	0.66	0.85	0.85	3.58	3.58	5.58	5.58
	Ditch	D9	0.26	0.26	0.26	0.54	0.54	0.92	1.38
	Elam	D22	0	0.02	0.02	0.24	0.24	2.37	2.37
	Falls	D18	0.13	0.81	0.81	0.9	0.9	2.48	2.48
	Flatiron	D7	0.41	0.55	0.55	0.94	0.94	1.18	1.52
	Forked	D17	0.42	0.44	0.44	1.74	1.74	4.25	6.08
	Lost	D30	0.76	0.76	0.76	2.04	2.12	3.61	3.94
	Lower Gurnsey	D28	0.48	0.48	0.48	2.78	2.83	4.23	4.66
	NF Calf	D12	0	0.04	0.04	2.26	2.26	3.49	4.42
	Panther	D14	0.21	0.21	0.21	2.54	2.54	5.44	7
	Potato	D15	0.17	0.59	0.59	1.46	1.46	2.34	3.17
	Rattlesnake	D16	0	0	0	0.04	0.04	2.45	2.54
	Round Valley	D19	0.62	0.62	0.62	0.78	0.78	4.93	6.09
	Slate	D21	0.38	0.97	0.97	2.27	2.27	4.14	5.15
	SF Calf	D11	0	0.22	0.22	0.74	0.74	2.15	2.56
	Swamp	D25	1.26	1.26	1.26	3.19	3.19	4.87	4.87
	Upper Deer	D24	0	0	0	0.19	0.19	0.35	0.35
	Up Gurnsey	D29	0.64	0.66	0.66	1.87	1.9	2.68	3.44
	Wilson	D10	0.51	0.87	0.87	1.69	1.69	3.07	3.78
	Yahi	D1	0.01	0.23	0.23	0.23	0.23	0.23	0.54
Mill	Avery	M5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Big Bend	M8	0.08	0.13	0.13	0.83	0.83	1.12	1.77
	Black Rock	M6	0.28	1.16	1.16	1.16	1.16	1.36	1.58
	Boat Gunwale	M3	0.19	0.2	0.2	0.2	0.2	0.2	0.63
	Hole in the Ground	M11	0.85	0.85	0.85	1.88	1.88	3.49	4.09
	Lassen Park	M15	0.81	0.83	0.83	0.83	0.83	0.86	0.86
	Lower Mill	M0	-	-	-	-	-	0.93	0.93
	Mill Creek Tract	M12	1.19	1.21	1.21	2.2	2.62	3.96	5.25
	Morgan	M13	0.4	0.91	0.91	1.07	1.07	1.2	1.51
	Rocky Gulch	M9	1	1	1	1	1	1	1.15
	Savercool	M7	0.25	0.25	0.25	0.25	0.25	1.32	1.68
	Townview	M10	1	1	1	3.73	3.73	4.94	5.95
	Canyon	M14	0	0	0	0	0	0	0
	Kingsley Cove	M2	0	0	0	0	0	0	0
	Pape	M4	0	0	0	0	0	0	0
	Bear	M1	0	0	0	0	0	0	0

The 1941 photos reveal only a few areas of anthropogenic streamside disturbance in the Deer Creek Watershed. Several of these are related to the construction of Highway 32 (notably at the "Red" Bridge and Calf Creek crossings). There are also a few (8) locations where logging removed canopy, placed roads or skid trails in the streamside area, or both.

These instances are relatively high in the watershed in the Lost Creek, Elam Creek and Slate Creek sub-basins. There are also numerous slides observable on the 1941 photographs.

The ortho photos data shows a large increase in the amount of near stream disturbance in the 1960s on both public and private land, and continuing to 1990, especially on private land. The data is displayed in terms of acres in streamside zones (300' from main stem, 150' from tribs, each side of stream). Eleven sub-watersheds in the Deer Creek watershed have estimated nearstream disturbance levels 10% or greater. Nearstream roads occupy greater than 5% of the area in five subwatersheds.

The main stem has had very little near stream disturbance with the exception of grazing in the Deer Creek Meadows and North Fork Deer Creek areas, and disturbance from Highway 32 where it parallels Deer Creek. It appear the primary long term impact of Highway 32 (apart from the risk posed by truck spills) is depletion of large wood input to the channel.

Apart from channel cutting and deposition in the Mill Creek main stem discussed later, the 1941 photos show very little disturbance of nearstream channel areas. Three slides (one discussed earlier) and two road segments in Streamside Management Zones (SMZs) are the extent of visible streamside disturbance. The ortho photo data indicates a high level of nearstream disturbance in only one sub-watershed (Townview). Both Townview and Mill Creek Tract have relatively high densities of near stream roads.

In Antelope Creek, ortho photo data indicates relatively high levels of nearstream disturbance in five sub-watersheds, though none of the nearstream road disturbance values is greater than 3%. The highest levels of disturbance are related to recent wildfires.

In general, the data shows a relatively large amount of nearstream disturbance. This disturbance is more prevalent on ephemeral and intermittent channels than perennial channels. As stated previously, the main stems, especially on Deer and Mill Creeks are largely undisturbed. The disturbance on other channels is important for several reasons. First, disturbance to areas close to channels, especially on soils with high erosion potential, have a high risk of delivering sediment to the channel, which has effects both at the point of delivery and downstream. Near stream disturbances may indicate a reduction in the amount of large wood recruitment. Over the long term, in certain stream types, reduced large woody debris in channels effects habitat in stream, channel stability, and in most channel types, storage of sediment in the channel. Finally, disturbance near stream in perennial channels often reduces stream canopy, which results in higher water temperatures. Preliminary observations are that the primary impact of the nearstream disturbance is on sediment production and sediment storage.

Mill Creek Watershed Road Densities

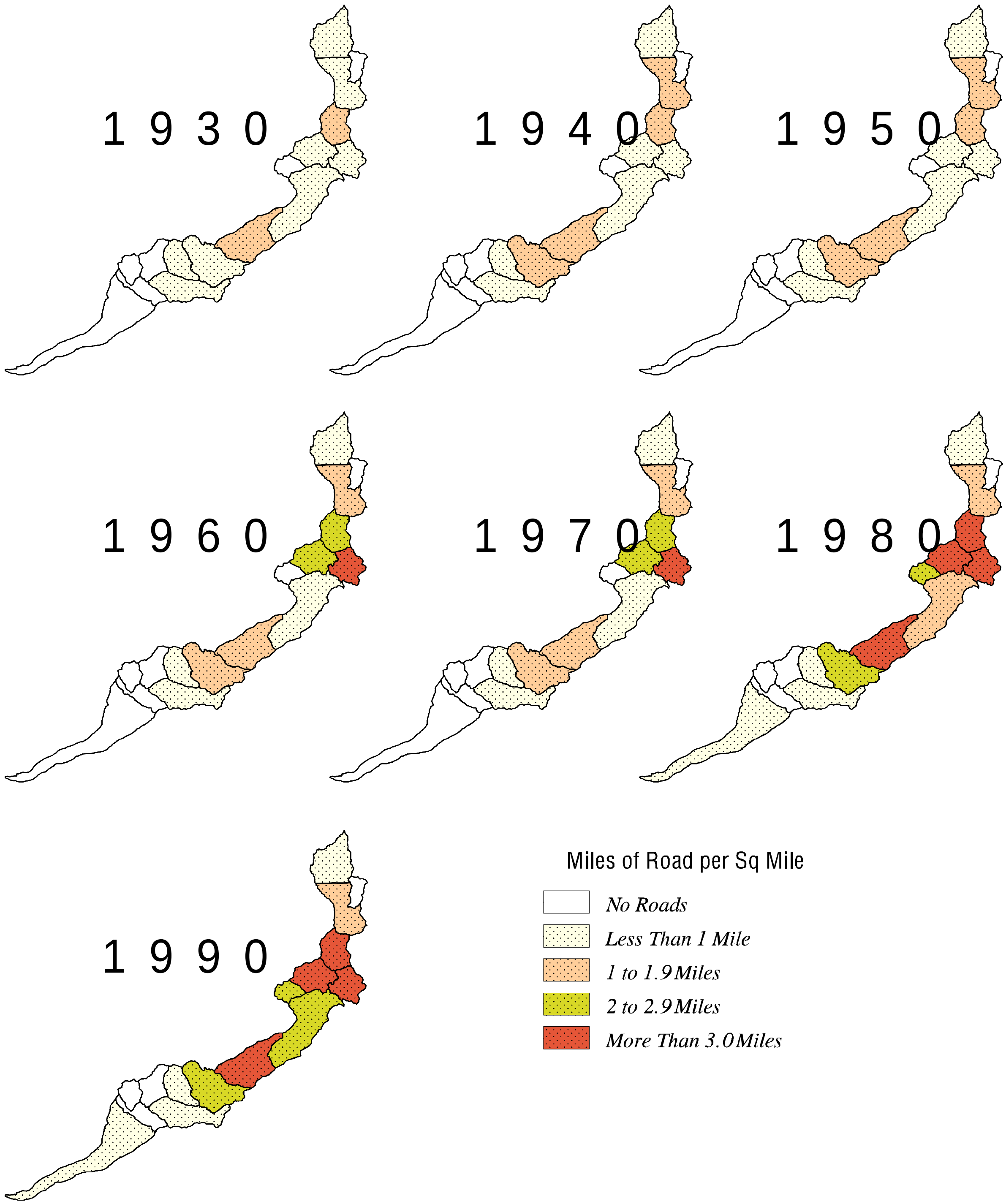


Figure 2-G.- Mill Creek road densities by decade from 1930 to 1990.

Deer Creek Road Densities

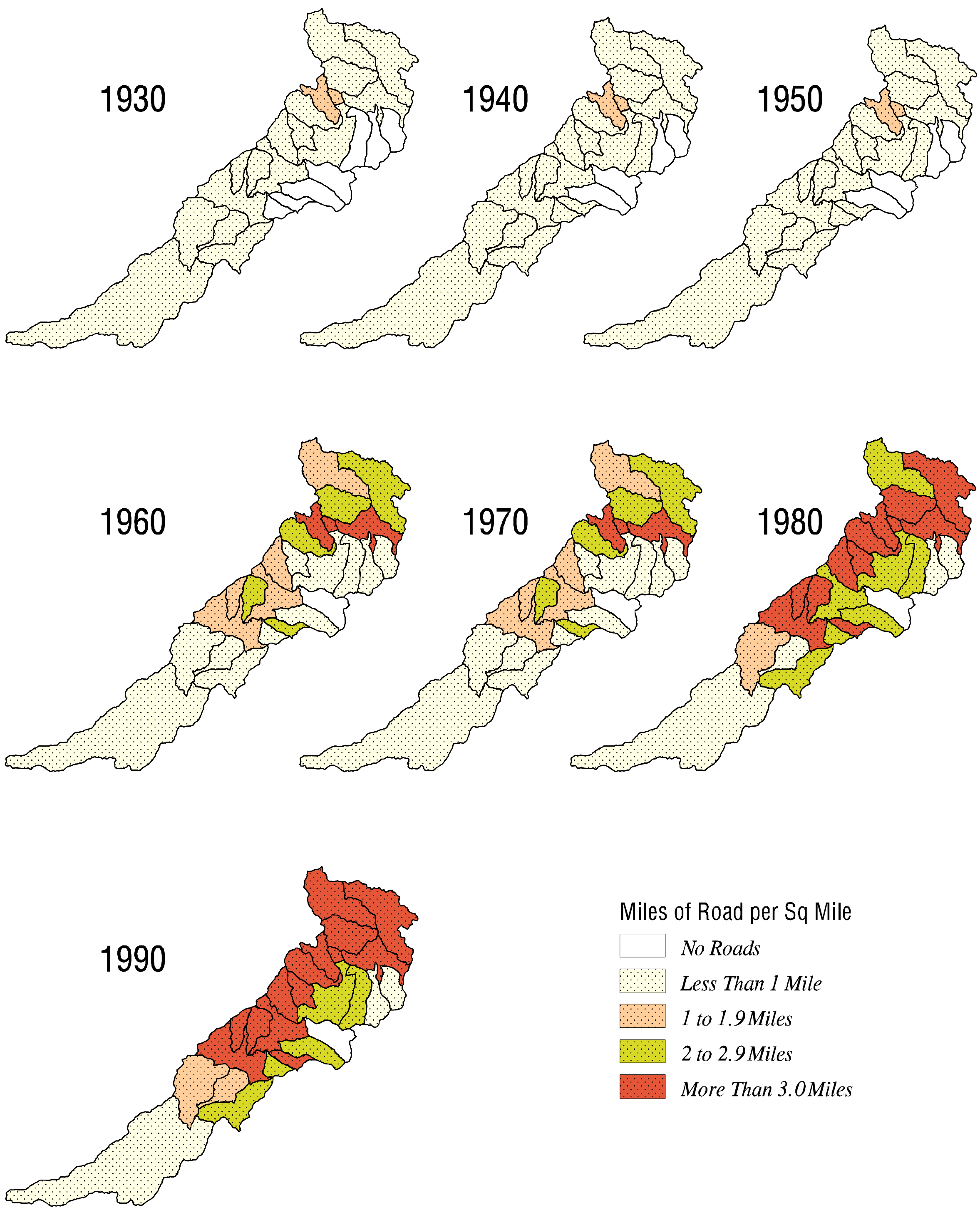


Figure 3-G.- Deer Creek road densities by decade from 1930 to 1990.

Antelope Creek Road Densities

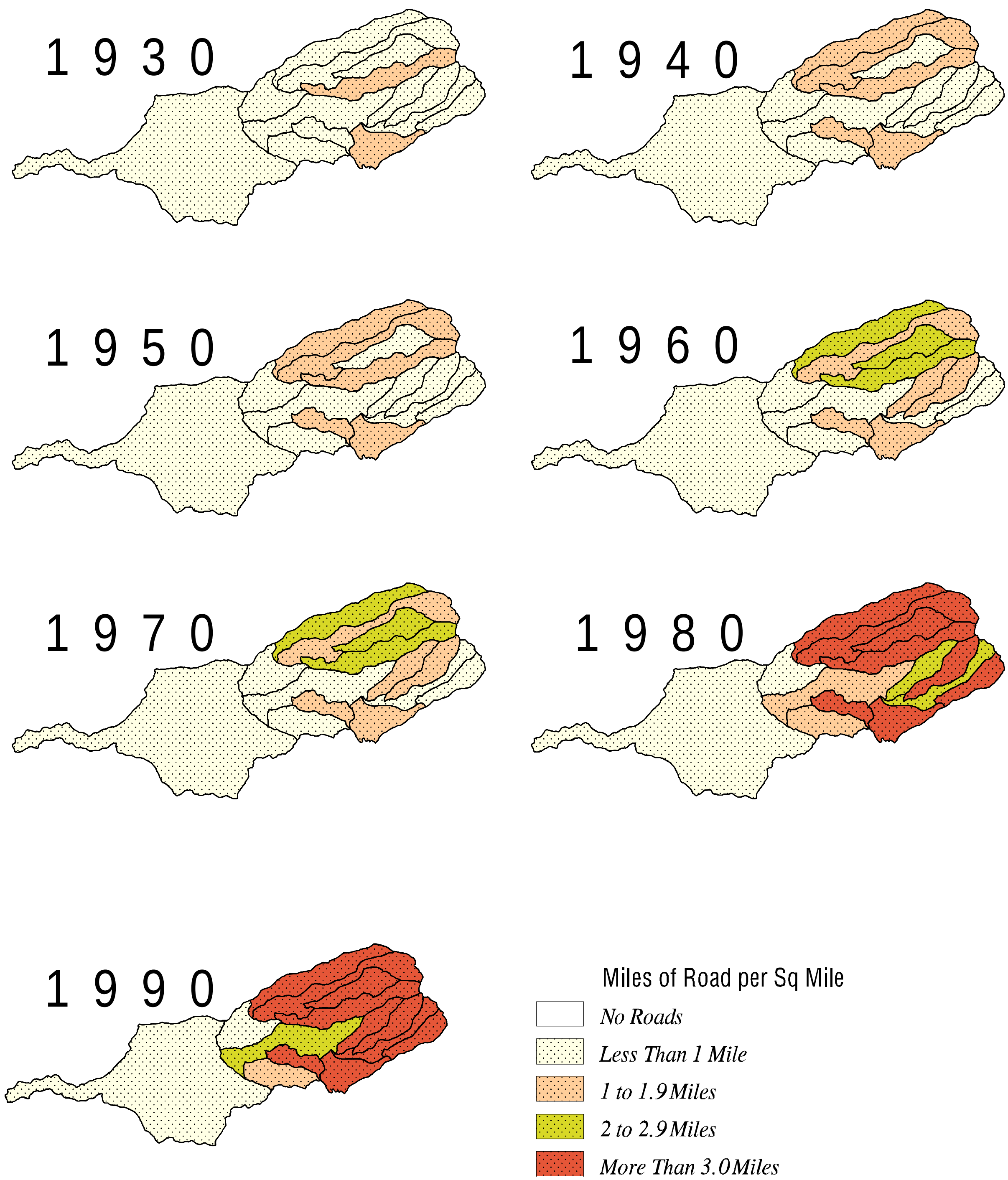


Figure 4-G.- Antelope Creek road densities by decade from 1930 to 1990.

Table 4-G.- Watershed Disturbance-1975

Sub-basin #	Road Density (mi./sq. mi.)	Basin Size (acres)	Fire (96) (acres)	Ortho. Disturb. (acres)	Road E.R.A. (acres)	Forest Service E.R.A. (acres)	Fire E.R.A. (acres)	Ortho. Disturb. E.R.A.(acres)	Sum E.R.A. (acres)	% E.R.A.
D1	0.4	33187	34771	142	75.3	0	0	14.2	89.5	0.27%
D7	1.1	8136	1913	1263	50.9	0	0	32	82.9	1.02%
D8	14.3	5569	668	2129	52	0	0	225	277	4.97%
D9	3.7	3312	904	1528	13.4	0	0	160.7	174.1	5.26%
D10	2.4	7021	664	3920	95.6	18.5	0	402.9	517	7.36%
D11	1.45	1530			12.7	27.1		0	39.8	2.60%
D12	2.9	1485			24.4	69.8		0	94.2	6.34%
D13	1.1	1876		158	11.6	0		15.8	27.4	1.46%
D14	4	2762		2029	62.5	0		202.9	265.4	9.61%
D15	1.9	4952		1084	53.4	84.3		108.4	246.1	4.97%
D16	1.7	3854		0	37.1	168.1		0	205.2	5.32%
D17	3	3493	263	2586	59.6	9.7	0	258.6	327.9	9.39%
D18	1.7	6648	73	3245	64.4	17.1	0	324.5	406	6.11%
D19	2.84	2245		700	36.4	0		70	106.4	4.74%
D20	0	4044	507	0	0	0	0	0	0	0.00%
D21	3.4	3891		2194	75.3	14.2		300.3	389.8	10.02%
D22	1.2	4002	80	87	27.3	0	0	8.3	35.6	0.89%
D23	0.6	3096		0	10.5	0		0	10.5	0.34%
D24	0.27	2823		0	4.4	0		0	4.4	0.16%
D25	4.05	2842		1565	65.5	33		176	274.5	9.66%
D26	5.1	625		490	18.2	3.3		57.1	78.6	12.58%
D27	2.9	4788		3089	78.9	0		328.3	407.2	8.50%
D28	3.5	5088	8	5331	101.1	39.7	0	665.9	806.7	15.85%
D29	2.3	7817	318	3036	102.2	63.7	0	316.6	482.5	6.17%
D30	2.8	9099	478	2934	144.2	37.4	0	324.1	505.7	5.56%
M0	0.9	13147			67.1				67.1	0.51%
M1	0	2620	1003				14.9		14.9	0.57%
M2	0	2077	2077				31.1		31.1	1.50%
M3	0.3	6119	6180		10.5		45.8		56.3	0.92%
M4	0	3273	3621				101.8		101.8	3.11%
M5	0.3	3637	4892		6.2		35.9		42.1	1.16%
M6	0.4	7441	11320	705	16.9		1.1	16.6	34.6	0.46%
M7	2.3	7485	5434	783	97.8		0	15.9	113.7	1.52%
M8	1.1	10508	1230	1184	65.6		0	22.5	88.1	0.84%
M9	2.2	1810		1567	22.5			44.7	67.2	3.71%
M10	4.2	3660	740	1836	87.3		9.1	49.1	145.5	3.98%
M11	3.5	4393		700	87.3			13.3	100.6	2.29%
M12	3.6	4036		162	82.5			3.1	85.6	2.12%
M13	1.3	5810		14	42.9			0.3	43.2	0.74%
M14	0	1648		-	0				0	0.00%
M15	0.9	6313			32.9				32.9	0.52%
A1	1.3	3819	2594		28.4	81.5	9.1		119	3.12%
A2	2.6	2250	1211		33.1	53.6	2.9		89.6	3.98%
A3	2.4	3830	3315		52.4	0	0		52.4	1.37%
A4	2.2	2654	627	703	33.1	20.8	0	70.3	124.2	4.68%
A5	1.5	2945	872	581	25.1	0.6	0	59.5	85.2	2.89%
A6	2.1	3339	238	370	40		0	37	77	2.31%
A7	2.1	2841	613	1485	33.8		0	148.5	182.3	6.42%
A8	1.3	7704	8300	916	15.7	42	59.6	91.6	208.9	2.71%
A9	0.4	4104	2763	0	9.7	4.8	17.9	0	32.4	0.79%
A10	2.6	6202	1421	6044	91.6	18.7	49.2	629.4	788.9	12.72%
A11	2.7	6939	1329	3545	106.5	41.9	3.9	383.6	535.9	7.72%
A12	2.6	5571	982	1292	82.2	52.8	2.2	131.9	269.1	4.83%
A13	2.7	3762	363	1728	57.1	19.4	0	172.8	249.3	6.63%
A14		36768	12122	-			98.2		98.2	0.27%

Road E.R.A.=road miles*5280*30' width/43560

Table 5-G.- Near Stream Disturbance-Deer, Mill, Antelope Creek.

Sub-basin	Basin	Estimated Near Stream Acres			Estimated Orthophotoquad Disturbance (acres)						Estimated Road Disturbance (acres)						Total Disturbance (acres)					
#	Name	Perennial	Intermittent	Sum	Perennial	%	Intermittent	%	Sum	%	Perennial	%	Intermittent	%	Sum	%	Perennial	%	Intermittent	%	Sum	%
D1	Yahi	3201.5	3294.2	6495.7	0	0.00%	0	0.00%	0	0.00%	8.9	0.28%	3.4	0.10%	12.3	0.19%	8.9	0.28%	3.4	0.10%	12.3	0.19%
D7	Flatiron	756	964	1720	0	0.00%	21	2.18%	21	1.22%	0.6	0.08%	18.6	1.93%	19.2	1.12%	0.6	0.08%	39.6	4.11%	40.2	2.34%
D8	Big Smokey	305	71	375.6	0	0.00%	0	0.00%	0	0.00%	3.1	1.02%	2.8	3.94%	5.9	1.57%	0	0.00%	0	0.00%	0	0.00%
D9	Ditch	383	290	673	0	0.00%	20	6.90%	20	2.97%	5.7	1.49%	7.9	2.72%	13.6	2.02%	5.7	1.49%	9.6	3.31%	33.6	4.99%
D10	Wilson	388	966	1354	0	0.00%	60	6.21%	60	4.43%	2	0.52%	13.5	1.40%	15.5	1.14%	2	0.52%	7.7	0.80%	75.5	5.58%
D11	South Fork Calf	3	233	236	0	0.00%	20	8.58%	20	8.47%	0.9	30.00%	2.2	0.94%	3	1.27%	0.8	26.67%	9.5	4.08%	23	9.75%
D12	North Fork Calf	0	231	231	0	0.00%	40	17.32%	40	17.32%	0	0.00%	4.2	1.82%	4.2	1.82%	0	0.00%	44.2	19.13%	19.1	8.27%
D13	Deadhorse	179	153	332	0	0.00%	100	65.36%	100	30.12%	1.7	0.95%	2.6	1.70%	4.3	1.30%	1.7	0.95%	67	43.79%	104.3	31.42%
D14	Panther	243	215	458	0	0.00%	50	23.26%	50	10.92%	6.9	2.84%	6.4	2.98%	13.3	2.90%	6.9	2.84%	26.2	12.19%	63.3	13.82%
D15	Potato	470	483	953	12	2.55%	30	6.21%	42	4.41%	13.5	2.87%	4.6	0.95%	18.1	1.90%	25.5	5.43%	7.2	1.49%	60.1	6.31%
D16	Rattlesnake	355	247	602	0	0.00%	48.9	19.80%	48.9	8.12%	3.2	0.90%	2	0.81%	5.9	0.98%	3.2	0.90%	20.1	8.14%	54.1	8.99%
D17	Forked	0	312	312	0	0.00%	150	48.08%	150	48.08%	0	0.00%	22.4	7.18%	22.4	7.18%	0	0.00%	55.2	17.69%	172.4	55.26%
D18	Falls	575	487	1062	0	0.00%	0	0.00%	0	0.00%	28.3	4.92%	1.7	0.35%	30	2.82%	28.3	4.92%	1.7	0.35%	30	2.82%
D19	Round Valley	170	168	348	20	11.76%	150	89.29%	170	48.85%	9.2	5.41%	7.3	4.35%	16.5	4.74%	29.2	17.18%	93.6	55.71%	176.5	50.72%
D20	Cub	6	479	485	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
D21	Slate	352	350	702	68.4	19.43%	36.9	10.54%	105.3	15.00%	11	3.13%	8.9	2.54%	19.9	2.83%	79.4	22.56%	10.2	2.91%	125.4	17.86%
D22	Elam	404	211	615	2.5	0.62%	11	5.21%	13.5	2.20%	5.3	1.31%	1.2	0.57%	6.5	1.06%	7.8	1.93%	5.8	2.75%	20	3.25%
D23	Carter	372	105	477	0	0.00%	11	10.48%	11	2.31%	26.4	7.10%	0.2	0.19%	26.6	5.58%	26.4	7.10%	10.7	10.19%	37.6	7.88%
D24	Upper Deer	247	266	513	0	0.00%	0	0.00%	0	0.00%	2	0.81%	0	0.00%	2	0.39%	2	0.81%	0	0.00%	2	0.39%
D25	Swamp	361	54	415	19.4	5.37%	13.7	25.37%	33.1	7.98%	14	3.88%	2.2	4.07%	15.2	3.66%	33.4	9.25%	27.6	51.11%	48.33	11.65%
D26	Alder	82	24	106	11	13.41%	0	0.00%	11	10.38%	3.1	3.78%	5.1	6.22%	4.3	4.06%	14.1	17.20%	5	20.83%	15.3	14.43%
D27	Dear Creek Meadow	423	274	697	82.6	19.53%	1.4	0.51%	84	12.05%	18.8	4.44%	9.2	2.17%	44.1	6.33%	101.4	23.97%	9.7	3.54%	128.4	18.42%
D28	Lower Gurnsey	420	409	829	117.2	27.90%	92.5	22.62%	159.7	19.26%	18.6	4.43%	2.6	0.62%	29.2	3.52%	135.8	32.33%	13	3.18%	188.9	22.79%
D29	Upper Gurnsey	759	736	1494	34.2	4.51%	95.6	12.99%	79.8	5.34%	10.5	1.38%	2.4	0.32%	28.1	1.88%	44.7	5.89%	8.6	1.17%	108	7.23%
D30	Lost	517	421	938	126	24.37%	57.1	13.56%	183.1	19.52%	10.8	2.09%	3.2	0.62%	24.5	2.61%	136.8	26.46%	16.8	3.99%	207.6	22.13%
M0	Lower Mill	1686	700	2386	0	0.00%	0	0.00%	0	0.00%	4	0.24%	-	-	4	-	4	0.24%	-	-	-	-
M1	Bear	142	300	442	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
M2	Kingsley	0	225	225	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
M3	Boat Gunnel	439	785	1224	0	0.00%	6.7	0.85%	6.7	0.55%	-	-	0.9	0.21%	0.9	-	0	0.00%	7.6	0.97%	1	0.08%
M4	Pape	409	218	627	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
M5	Avery	425	336	761	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
M6	Black Rock	926	1140	2086	0	0.00%	3.1	0.27%	3.1	-	5	0.54%	6.1	0.66%	11.1	0.53%	5	0.54%	9.2	0.81%	14.2	0.68%
M7	Savercool	674	1280	1954	0	0.00%	23.4	1.83%	23.4	1.20%	0	0.00%	6.3	0.93%	6.3	0.32%	0	0.00%	29.7	2.32%	29.7	1.52%
M8	Big Bend	836	1480	2316	0	0.00%	45.4	3.07%	45.4	1.96%	13	1.56%	10.5	1.26%	23.8	1.03%	13	1.56%	55.9	3.78%	68.9	2.97%
M9	Rock Gulch	178	138	316	2	1.12%	3.6	2.61%	5.6	1.77%	1.9	1.07%	0.7	0.39%	2.6	0.82%	3.9	2.19%	4.3	3.12%	8.2	2.59%
M10	Townview	41	536	577	0	0.00%	66.1	12.33%	66.1	11.46%	1.7	4.15%	14.2	34.63%	15.9	2.76%	1.7	4.15%	80.3	14.98%	82	14.21%
M11	Hole in the Ground	639	530	1169	0	0.00%	0	0.00%	0	0.00%	8.7	1.36%	12.1	1.89%	20.9	1.79%	8.7	1.36%	12.1	2.28%	20.9	1.79%
M12	Mill Tract	519	364	883	0	0.00%	13.1	3.60%	13.1	1.48%	11.6	2.24%	11.5	2.22%	23.1	2.62%	11.6	2.24%	24.6	6.76%	36.2	4.10%
M13	Morgan	1170	62	1232	0	0.00%	0	0.00%	0	0.00%	6.6	0.56%	2.8	0.24%	9.4	0.76%	6.6	0.56%	2.8	4.52%	9.4	0.76%
M14	Canyon	177	0	177	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
M15	Lassen Park	11	1	12	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1.3	-	0	0.00%	0	0.00%	0	0.00%	-	-
A1	Round Mtn	328	361	689	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1.6	0.49%	1.6	0.23%	0	0.00%	1.6	0.44%	1.6	0.23%
A2	Crazy	72	260	302	0	0.00%	6.6	2.54%	6.6	2.19%	0	0.00%	4.7	6.53%	4.7	1.56%	0	0.00%	11.3	4.35%	11.3	3.74%
A3	Tamarack	386	382	768	2.1	0.54%	1.2	0.31%	3.3	0.43%	11.1	2.88%	6.9	1.79%	18	2.34%	13.2	3.42%	8.1	2.12%	21.3	2.77%
A4	Gunbarrel	294	243	537	0	0.00%	0.7	0.29%	0.7	0.13%	8.2	2.79%	4	1.36%	12.2	2.27%	8.2	2.79%	4.7	1.93%	12.9	2.40%
A5	Upper South Fork	578	124	702	2.7	0.47%	5	4.03%	7.7	1.10%	12.5	2.16%	2.6	0.45%	15.1	2.15%	15.2	2.63%	7.6	6.13%	22.8	3.25%
A6	McCarty	160	92	252	11.6	7.25%	0.9	0.98%	12.5	4.96%	1.1	0.69%	2.4	1.50%	3.5	1.39%	12.7	7.94%	3.3	3.59%	16	6.35%
A7	Howard	66	148	214	12.1	18.33%	31.1	21.01%	32.1	15.00%	0	0.00%	6.3	9.55%	6.3	2.94%	12.1	18.33%	37.4	25.27%	49.8	23.27%
A8	Lower South Fork	678	531	1209	53.4	7.88%	13.8	2.60%	67.2	5.56%	2.6	0.38%	3.5	0.52%	6.1	0.50%	56	8.26%	17.3	3.26%	73.3	6.06%
A9	Lower North Fork	232	411	643	9.9	4.27%	0	0.00%	9.9	1.54%	0	0.00%	0.2	0.09%	0.2	0.03%	9.9	4.27%	0.2	0.05%	10.1	1.57%
A10	Judd	239	146	385	15.8	6.61%	89.5	61.30%	105.3	27.35%	1.5	0.63%	2.8	1.17%	4.3	1.12%	17.3	7.24%	92.3	63.22%	119.6	31.06%
A11	Upper North Fork	840	375	1215	126.2	15.02%	54.3	14.48%	180.5	14.86%	14.4	1.71%	1.6	0.19%	16	1.32%	140.6	16.74%	55.9	14.91%	196.5	16.17%
A12	Middle Fork	406	410	816	53.3	13.13%	120.4	29.37%	173.7	21.29%	2.3	0.57%	5.1	1.26%	7.4	0.91%	55.6	13.69%	125.5	30.61%	181.1	22.19%
A13	Deadhorse	262	307	569	60.4	23.05%	146.2	47.62%	206.6	36.31%	2.9	1.11%	7.6	2.90%	10.5	1.85%	63.3	24.16%	153.8	50.10%	217.1	38.15%
A14	Lower Antelope	3417	2374	5791	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-

II. STREAM CHANNELS

General Overview:

Table 6-G.-Miles (and % of total) of Stream by Montgomery-Buffington Type*

Watershed	Source	Delivery	Response	Total
Antelope	8.5 (5.2)	149 (90.9)	6.4 (3.9)	164
Deer	148.8 (29.3)	285.9 (56.4)	72.6 (14.3)	507
Mill	80.0 (30.7)	152.6 (58.7)	27.1 (10.4)	260

* Incomplete: does not include watershed areas in the Central Valley.

Antelope Creek. Channels in the upper watershed (above the forest boundary) are typically steep, confined and well armoured. Relative to Deer and Mill Creek, the main stem is higher gradient with very few sensitive alluvial reaches (only about 4% of the reaches have gradients less than 2%) (table 6). There are also relatively few source (very steep) channels in Antelope relative to Deer and Mill Creeks.

Deer Creek. There is a relatively high percentage of steep "source" channels, these drain the steep slopes connecting the plateaus and main stem channels, and have the highest potential for debris slides, a significant erosion process in the watershed.

About 15% of the channels are characterized as "response" reaches, as they have gradients of less than 2% (Table 5a). This is slightly misleading in terms of sensitivity, as there are two distinct types of lower gradient channels in the watershed. The first are very sensitive reaches, concentrated in the upper watershed and limited to Gurnsey Creek, Carter Creek at Carter Meadows, and Deer Creek Meadows. These channel reaches have very low (~1%) channel gradients and have channel banks composed of fine textured alluvial deposits very susceptible to changes in sediment and flow. These channel reaches are unconfined, with flood flows free to leave the channel and inundate their floodplains. The majority of the "response" reaches are located on the main stem below Deer Creek meadows. These reaches have gradients near or below 2%, and at some locations for short stretches, serve as depositional zones for sediment and bedload, as evidenced by formation of bars. Generally however, these channels have very high bedrock and large rock bank content with inherently stable channels. Importantly, these channels are also quite confined, with a trend toward bedrock walls as one moves downstream. Though they have stable stream banks, the lower gradient mainstem reaches appear to be very important in terms of fish habitat, as they support nearly all of the spawning and holding habitat for spring run salmon. They are more depositional in nature than the steeper mainstem reaches, and may be sensitive to sediment increases (resulting in pool filling ad fines accumulation in pool tail substrate).

Mill Creek. Main stem Mill Creek is predominantly bedrock and boulder dominated, with slopes near 2% for most of the reach within the Lassen Forest (Table 5a). There are slightly steeper sections in areas above Big Bend and above Black Rock (these estimates from topographic maps). The exception is the area which extends from roughly the Mill

Creek Campground upstream about five miles to just above the confluence with Canyon Creek. This reach is predominantly alluvial in nature with lower gradients (<2%).

The amount (percentage wise) and distribution of very steep (source) channels in Mill Creek is nearly identical to that in Deer Creek. Two (relatively) recent debris slides were noted in Mill Creek during stream surveys conducted in 1996. Both of these slides contained enough material to have crossed the creek completely. The first, which is evident on the 1941 aerial photographs, is located about 1 mile downstream of Hole in the Ground. This slide caused deposition of material and bar formation upstream. The second slide occurred on 1995 in a tributary about a mile below Black Rock. Though there is evidence this slide passed across the stream and deposited material above the high water mark on the opposite side of the creek, there is little evidence of deposition above the slide, or by the slide in the main channel. Effects of the 01/01/97 slide in Upper Mill Creek are discussed elsewhere in this report.

II.I Changes to Channels

Four measures are used to discuss the current and historic condition of channels. These are changes in response stream reaches as gauged from historical records and aerial photography, amount of streamside disturbance (just described), data from surveys of the watersheds' tributaries (for Mill and Deer Creeks, only) and from channel surveys.

Aerial photography was used to observe changes in alluvial sections of stream over the period of photographic record. In some cases General Land Office (G.L.O) survey data from 1871-72 was used as a rough reference point for channel widths. Aerial photography was also used to identify areas of nearstream disturbance throughout the photo record period. Data from surveys conducted by EA Engineering in 1995 on the tributaries of Mill and Deer Creek was used to highlight channels with low stability or high sediment production. In-channel information is used mostly in the fish habitat section of this WA, but is referenced here as well and was obtained during surveys of streams within the watershed beginning in 1994. In addition, surveys conducted by Sierra Pacific Industries and Collins Pine are referenced.

The ability to provide a comprehensive picture of channel condition and the trend in those conditions in the watersheds is hampered by substantial data gaps relative to both current and historic condition.

1. Response Channels

1a Deer Creek

The main stem Deer Creek below Deer Creek meadows showed very little change over the period covered by aerial photography (1941-1993). Exceptions to this are site specific disturbances caused by the construction of Highway 32. .

The alluvial channels at and above Deer Creek Meadows have shown change over the period covered by aerial photography, particularly North Fork Deer Creek above the confluence with Deer Creek (also called Gurnsey Creek). This reach of stream shows considerable widening between photo intervals 1941 and 1973. The area immediately above the Highway 32 crossing shows channel widening on the 1941 photo. Anecdotal evidence indicates that this disturbance may have been caused by gravel removal from the creek at this point, for use in construction of the highway. Above this point of localized disturbance, the channel appears to be a narrower and meandering channel in 1941. In the 1973 and subsequent photos, the channel has widened across it's floodplain to widths of approximately 100 to 500 feet for a distance of approximately 1.5 miles upstream of the highway. Bars and channel braiding are common in the later photos, not apparent in the 1941 photos. In addition to upstream and upslope channel disturbance (which will be discussed elsewhere) that occurred after 1941, introduction of beaver into the area in the mid-1950s may have contributed to channel changes. It should be noted that the apparent stability of this alluvial reach in the 1941 photos follows a period when Deer Creek experienced several high flows over a relatively short period of time. The peak flow over the period of record occurred on 12/10/1937 (23,800 cfs), and was followed on 2/28/1940 with the second highest flow on record (21,600 cfs), another high flow of 12,700 cfs (8th highest on record) followed on 2/6/1941.

Deer Creek Meadows shows some, but far less channel movement and enlargement over the period of aerial photo record than North Fork Deer Creek. There is some widening and bar formation below the confluence of North Fork Deer Creek (a length of about 1/3 mile), but above the confluence the channel pattern, width and presence of bars (there are few evident) are consistent over the photo record period. The 1941 photos also indicate Deer Creek Meadows was dominated by grasses, North Fork Deer Creek by riparian vegetation (probably willows). North Fork Deer Creek may have been more susceptible to change from beaver introduction than Deer Creek Meadows.

The response channel in Carter Meadows has no discernible differences in terms of channel width, pattern or bar formation over the period of photographic record.

1b Mill Creek

The alluvial reach of stream above Hole in the Ground has shown dramatic change over the period of record. The first available records of channel width come from the survey of Wm H. Carlton in 1870-71. This was the first land survey of the Lassen area, and the crews routinely noted the location (and in most cases, widths) of streams, meadows, springs and other features that lay on the section lines they were surveying. The "alluvial" reach of Mill Creek is crossed by 6 section lines, all which were noted by Carlton. These widths range from 40 to 80 chains (roughly 27 to 54 feet) with four stream widths noted at 50 chains (34 feet). The accuracy of these notations is unknown.

The next available date of comparison is 1941, the date of the first aerial photography. The channel in 1941 averages about 100 feet in width, with a range of between about 60 and 250 feet. There is substantial braiding, and at the lower end of the alluvial reach, where there is a constriction above steeper gradient channel, gullying through deposited material is evident. Numerous large down trees can also be detected on bars in this area. Although impossible to verify, the braiding and gullying looks relatively recent and we surmise that the channel changes are in response to the record flow of 1937. This correlates well with the anecdotal account of Elizabeth Seward, who describes the 1937 storm event as substantially altering Mill Creek in the alluvial reach, and a mid-1930s photograph at the Highway 36 crossing which shows a much narrower than present day channel (figure 5).

Data collected as part of the Pacfish monitoring effort revealed that in 1995 channel widths ranged from 210 to 358 feet (average = 290 feet). These measures confirm estimates made from 1993 aerial photography. Aerial photos reveal a widening channel in the 1941-1993 interval. 1993 photos indicate some riparian vegetation invasion of floodplains, which is entirely absent in the 1941 photos, and largely absent in the 1965, 1973 and 1986 photos.

The premise that channel changes in the Brokenshire Meadow area resulted from the 1937 storm is consistent with observations of downstream reaches. Short sections of presumably lower gradient stream indicate recent deposition in the 1941 photos. There are four such areas on the photos, each of about 1/4 mile length. Three of these areas are covered with riparian vegetation in the 1993 photos. The other moved upstream slightly relative to the 1941 photos.

The 1997 New Year's storm caused considerable channel movement in this reach, documented in the channel cross sections included as figures 6-8. A large slide occurred on January first, just below Brokenshire, and brought a tremendous amount of material and large wood to the channel. The speed and volume of the slide was sufficient to cross the entire floodplain, though high stream flows passed quickly or immediately through the material and it appears no damming occurred. Upstream of the Highway 36 crossing, the channel displayed considerable realignment. Extensive bank cutting was observed downstream in the vicinity of both Black Rock and Savercool place. The changes look similar to those observed on the 1941 photographs.

The instability of the alluvial reach does serve as a supply of bedload and spawning substrate to downstream areas. Prior to 1997, the reach had a greater width to depth ratio, shallower water and poorer stream shading than other reaches of the stream (see tables 7-9). This translates to higher temperatures, and shallower (and perhaps fewer) pools than in a more stable, narrower, more shaded stream. The 1937 event was the largest on record, but most likely not the highest in history, and similar channel changes probably occurred before and will probably occur again. The unknown is if removal of streamside and bank vegetation by heavy grazing prior to 1937 may have increased the impacts of the floodflow. The post 1997 slide channel is narrower and deeper.

Jones Valley: Jones Valley is the only alluvial tributary of note. It shows no change in channel form between 1941 photos and the present (no section lines pass through this area so 1870-71 evidence is not available).

Figure 5-G.- Photographs taken of Mill Creek from the Highway 36 bridge looking upstream. The top photo was taken in 1934, the bottom photo was taken in 1994. Note the cedar tree to the right, present in both photos.

1c Antelope Creek

There are very few alluvial reaches in the Antelope Creek watershed. The few that do exist show very little evidence of change over the period of the photo record.

2. Stream Condition and Habitat Information

R5 Forest Service Stream Condition Inventory (SCI) data was collected in 1996 and repeated in 1997, 1998 and 1999 at three locations on the main stem of Mill and Deer Creeks, and on one reach of Antelope Creek. Two additional reaches on Deer Creek (above Upper Falls) were inventoried in 1999. SCI data was also collected on reaches of Carter, Cub, Elam, Gurnsey and Slate Creeks. (tables 7-9)

From 1993-95 the Forest also collected data using the R5 Fish Habitat Assessment Protocols on all of the main stem channels managed by the Forest Service. Data was also collected on Carter Creek, Elam Creek and Gurnsey Creek, and forks of Antelope Creek managed by the Forest Service (table 9)

The Lassen Forest contracted with EA engineering to conduct surveys of tributaries of Deer and Mill Creeks in 1995. These surveys included observations on channel stability and erosion sources, and sightings of aquatic organisms.

Collins Pine Company collected data on many of the tributary streams in their ownership in 1996, and Sierra Pacific Industries collected data on streams in the Antelope Creek watershed in 1994 (table 14).

Temperature data has been collected at several main stem locations by the Department of Fish and Game back as far as the 1960s, and consistently since the early 1990s. The Forest Service has collected temperature data at numerous main stem and tributary locations since 1995, Collins Pine and SCI have also collected substantial temperature data in recent years (Forest Service data is summarized in table 15).

Historic information is sparse. Moyle and Sato, and other students from UC Davis collected information on the main stem Deer and Mill Creeks in the mid 1980s. James Grimes collected data on Mill and Deer Creeks in 1982 (this data is summarized in table 15). The California Department of Fish and Game has collected data on the Creeks for many years, and temperature data collected by F&G from the early 1960s.

2a Main Stems

The existing condition of the main stems of all three streams appears to be excellent. This assessment is based on several factors. Aerial Photography shows that with the exception of Highway 32 along Deer Creek, the areas adjacent to the channels have suffered little disturbance, and these key areas are largely intact. One could infer that stream shading and large wood recruitment from streamside zones is essentially unchanged form historic conditions along most of the three mainstems.

Likewise the stream condition inventory and fish habitat assessment data indicate high quality conditions in terms of shade, pool depth, and the measures of sediment in the substrate (percent fine particles, and grid fines measurements). These measures compare

Table 7-G.- Stream Condition Inventory (SCI) Data for Deer Creek tributaries.

Deer Creek Tributaries	Year	# LWD Pieces	# LWD Aggregates	% < 2mm (pebble count)	% Fines (grid method) range	% Fines (grid method) mean	Gradient (percent)	Avg. Bankfull Width (m)	Entrenchment range	Entrenchment mean	Width to Depth range	Width to Depth mean
Upper Gurnsey	1996	193	15	26	2-41	15.2	0.99	12.12	1.0-15.2	8.21	9.4-78.3	27.26
	1997	132	6	28.7	0-26	4.7	1.32	12.54	1.2-5.4	2.37	16.2-107	39.25
	1998	96	4	14.2	0-40	7.8	0.97	12.22	1.1-20	5.37	2.9-81.8	25.15
	1999	65	5	14.4	0-28	7.09	0.88	9.89	1.2-13.85	5.75	6.77-54.0	23.77
Lower Gurnsey	1997	153	12	15.1	0-30	7.8	0.55	21.36	1.39-6.4	2.2	9-93.5	46.2
	1998	75	6	10.4	0-24	10	0.45	19.6	1.9-6.4	3.5	18.9-137.4	45.4
	1999	85	6	13.4	0-10	3.1	0.52	12.7	1.6-4.2	2.5	23-60.8	43.4
Deer Creek Meadows	1996	4	0	23	2-34	14.9	0.75	13.7	1.24-24.4	13.4	19.1-45.9	27.84
	1997	4	0	18	0-26	8.4	0.76	13.2	1.1-16.4	6.7	10-45.9	36.73
	1998	8	0	26	0-14	3.5	0.78	14.3	1.6-17.3	7.4	19.6-59.4	28.31
	1999	8	0	19.04	0-20	7.23	0.51	7.69	1.33-16.95	5.08	21.4-61.9	37.13
Carter Creek	1995	58	6	52	2-22	6.3	0.78	2.7	>3	>3	7.8-12.6	10.37
	1999	38	2	49	2-80	19.1	1.18	2.9	31.8-60.8	51.8	6.6-10.9	9.14
Slate Creek	1996	11	0	9.35	0-64	7.7						
	1997	5	0	5.22	2-14	6	4.6	11.9	1.22-1.8	1.4	17.9-47.1	30.66
	1998	5	0	4.7	0-46	6.9	6.6	10.9	1.2-2.0	1.5	14.6-44	22.93
Lower Cub	1997	4	0	6	0-34	3.8	4.1	7.41	1.3-4.53	1.44	10.95-21.1	16.5
Upper Cub	1997	35	2	2.9	0-8	2.91	6.63	6.64	1.17-2.43	1.62	15.79-21.11	17.02
Calf Creek	1997	18	0	11	0-10	4.6	4	5.1	0.8-13.1	3.5	5.2-29.2	15.77
	1998	20	1	12	2-40	9.8	4.2	5	1.3-2.4	1.7	8.2-26.7	14.6
	1999	39	3	13.2	0.88	14.58	4.43	4.08	1.6-4.35	2.58	5.77-28.42	13.55

		# of Pools	Residual Pool Depth range	Residual Pool Depth mean	# Wood formed pools	% Bank Stability	% Shade range	% Shade mean	Stream Shore Depth (m) range	Stream Shore Depth (m) mean	Bank Angle (degrees) range	Bank Angle (degrees) mean
Upper Gurnsey	1996	18	0.38-1.2	0.7	10	31	1-74	21.9	0-0.8	0.06	34-180	130.5
	1997	21	0.78-1.4	0.6	4	13.3	1-82	25.5	0-0.9	0.06	30-178	144.5
	1998	13	0.32-1.2	0.7	2	27	1-80	28.5	0-0.6	0.07	25-177	137.6
	1999	22	0.17-2.14	0.57	6	8	5-83	25.36	0-0.5	0.04	25-178	131.88
Lower Gurnsey	1997	8	0.27-0.85	0.59	5	15	3-38	14.7	0-0.9	0.03	20-178	154.4
	1998	10	0.46-1.05	0.73	5	12	6-41	16.6	0-0.5	0.02	15-178	148.1
	1999	11	0.38-1.14	0.68	3	10	2-38	14.8	0-0.5	0.02	35-178	149.8
Deer Creek Meadows	1996	9	0.44-1.8	0.94	1	20	0-1	0	0-0.74	0.06	40-177	126.3
	1997	15	0.36-1.4	0.88	1	5	0-8	0.3	0-0.73	0.06	55-180	145.4
	1998	11	0.52-1.3	0.85	1	18	0-4	0.6	0-0.8	0.08	53-178	140.6
	1999	15	0.31-1.24	0.77	1	0	0-3	0.2	0-1.0	0.04	20-180	135.31
Carter Creek	1995	4	0.44-0.61	0.58	4	86	59-100	85.3	0-0.74	0.23	30-165	95.1
	1999	7	0.22-0.45	0.37	4	88	44-98	82.9	0-0.70	0.12	7-175	83.1
Slate Creek	1996	19	0.29-1.1	0.6	0	73	35-95	68.4	na	na	na	na
	1997	5	0.42-1.1	0.8	0	77	8-88	49.6	na	na	na	na
	1998	8	0.42-1.2	0.64	0	76	17-34	55.5	na	na	na	na
Lower Cub	1997	6	0.28-0.72	0.48	0	94	81-99	92.5	na	na	na	na
Upper Cub	1997	11	0.62-1.14	0.73	0	88	66-97	85.26	na	na	na	na
Calf Creek	1997	6	0.18-0.45	0.28	1	83	72-98	91.2	na	na	na	na
	1998	7	0.24-0.49	0.31	1	58	77-99	91.5	na	na	na	na
	1999	8	0.17-0.31	0.26	1	53	82-100	93.9	na	na	na	na

Table 8-G.- Stream Condition Inventory (SCI) Data for Mill Creek tributaries.

Watershed	Stream Name	Year	# LWD Pieces	# LWD Aggregates	% < 2mm (pebble count)	% Fines (grid method) range	% Fines (grid method) mean	Gradient (percent)	Avg. Bankfull Width (m)	Entrenchment range	Entrenchment mean	Width to Depth range	Width to Depth mean
Mill	Mill @ 36	1996	316	35	12	1-12	5.1	1.8	79	0.9-1.7	1.19	69.4-107.3	89.3
		1997	258	31	22	0-22	8.4	1.1	16.3	3.5-9.6	6.56	16.5-65.5	41
		1998	386	26	24	4-48	17	1.6	20.8	2.0-8.6	3.9	19-51.8	37.6
		1999	428	29	21	0-6	2.7	1.5	16.1	0.34-6.7	3.3	22.1-43.8	31.5
	Rocky Gulch Creek	1997	58	4	1	0-24	4.3	10.7	7.6	1.2-2.76	1.72	10.17-28.89	17.05

Watershed	Stream Name	Year	# of Pools	Residual Pool Depth range	Residual Pool Depth mean	# Wood formed pools	% Bank Stability	% Shade range	% Shade mean	Stream Shore Depth (m) range	Stream Shore Depth (m) mean	Bank Angle (degrees) range	Bank Angle (degrees) mean
	Mill @ 36	1996	3	0.33-1.6	0.75	1	10	1-58	19.5	0-0.7	0.05	40-177	138.9
		1997	3	0.4-0.6	0.5	0	8	7-56	22.2	0-0.4	0.01	35-178	156.8
		1998	2	0.6-1.03	0.81	0	9	4-53	20	0-0.61	0.02	30-178	143.4
		1999	2	0.56-1.13	0.85	0	23	5-53	21.5	0-0.6	0.03	30-178	135.3
	Rocky Gulch Creek	1997	8	0.18-1.03	0.51	0	33	61-98	79.78				

Table 9G.- Stream Condition Inventory (SCI) for Antelope Creek and Judd Creek.

Watershed	Stream Name	Year	# LWD Pieces	# LWD Aggregates	% < 2mm (pebble count)	% Fines (grid method) range	% Fines (grid method) mean	Gradient (percent)	Avg. Bankfull Width (m)	Entrenchment range	Entrenchment mean	Width to Depth range	Width to Depth mean
Antelope	Antelope Creek	1996	1	0	20.2	0-14	3.7	ns	ns	na	na	na	na
		1997	3	0	16	0-24	6.4	ns	ns	na	na	na	na
	Judd	1999	62	2	ns	0-74	13.6	3	6	ns	ns	ns	ns

Watershed	Stream Name	Year	# of Pools	Residual Pool Depth range	Residual Pool Depth mean	# Wood formed pools	% Bank Stability	% Shade range	% Shade mean	Bank Angle (degrees) range	Bank Angle (degrees) mean
		1996	6	0.8-2.7	1.5	0	95	6-94	49.9	na	na
		1997	5	0.8-1.8	1.4	0	83	5-87	42.5	na	na
	Judd	1999	8	0.2-0.62	0.38	0	59	65-95	80.6	15-178	134

Table 10-G.- Deer Creek data summaries from 1996 to 1999 from anadromous mainstem reaches 1- 4 and non-anadromous mainstem reaches 1 and 2.

Deer Creek	Reach -Year	# of Pools	Residual Pool Depth (m)	L * Pool (m)	L* Sediment (m)	L*	Pool Tail Canopy	% Pool Tail Fines	% Particles <2mm	Percent Embeddedness	Large Woody Debris # Pieces	# Aggregates
Anadromous reaches												
Range	1-96	12	0.76-5.03	8.4-45	0-21	0-0.43	32-76	0-32	0.9-7.1	ns[2]		
Mean			1.98	25.1	6.04	0.18	57.25	6.72	4.0	ns[2]	107	4
Range	1-97	12	1.25-5.23	16-78	0-26.5	0-0.29	15-76	0-16	0-7.7	0-11		
Mean			2.07	34.62	6.86	0.13	54.08	3.28	3.2	5	4	0
Range	1-98	12	0.95-4.95	18.6-77.1	0-14.3	0-0.30	10-58	0-12	4.8-10.9	9-14		
Mean			2.16	33.08	3.44	0.08	40.25	3.11	7.6	12	17	0
Range	1-99	12	0.9-4.75	19-53.6	0-11.2	0-0.39	23-77	0-18	1.0-7.0	5-36		
Mean			1.88	27.31	7.24	0.21	54.58	4.3	3.0	15.7	79	ns
Range	2-96	18	0.82-3.92	15-100	0-26	0-0.63	10-98	0-16	1.7-5.2	ns[2]		
Mean			1.95	39.2	8.47	0.19	47.22	3.57	4.0	ns[2]	108	10
Range	2-97	17	0.72-3.85	19.4-89.9	0-11.2	0-0.34	7.5-77	0-14	na[1]	5-29		
Mean			1.79	41.27	4.84	0.09	41.38	4.12	2.8	15.6	3	0
Range	2-98	13	0.85-3.6	18.3-102	0-16.3	0-.28	5-64	0-10	2.0-3.8	4-22		
Mean			1.88	39.75	6.05	0.12	39.73	2.71	3.6	12.7	10	2
Range	2-99	13	0.95-3.73	19-105	0-18.2	0-0.37	12-57	0-16	1.9-7.0	5-6		
Mean			1.96	41.75	8.35	0.16	38.08	3.6	4.0	5.3	2	ns
Range	3-96	12	1.09-4.07	18-90	0-29	0-0.39	3-75	0-24	1.8-8.9	ns[2]		
Mean			2.34	40.5	7.75	0.14	26.25	7	5.5	ns[2]	127	5
Range	3-97	12	1.21-3.71	18.9-91	0-29.6	0-0.41	4-65	0-44	2.2-7.1	ns[2]		
Mean			2.31	56.58	14.23	0.2	28.5	11.72	4.3	ns[2]	5	0
Range	3-98	14	0.95-3.4	22-98.7	6.5-30.4	0.14-0.46	8-66	0-20	3.0-7.6	8-20		
Mean			1.87	55.88	19.23	0.25	30.21	4.9	4.8	13.3	24	3
Range	3-99	14	1.0-2.9	22.8-89.0	0-23.3	0-0.38	4-64	0-32	na[1]	na[1]		
Mean			2.29	53.21	11.76	0.15	26.14	8.4	5.3	0[1]	50	ns
Range	4-99	10	1.53-3.66	28-52.4	0-57	0-0.42	28-50	0-22	na[1]	na[1]		
Mean	4-99		2.24	47.67	15.43	0.21	38.3	8.67	4.0	1[1]	10	ns
Non-Anadromous Reaches												
Range	1-99	8	0.48-1.0	7.2-35.2	4.9-18.2	0-0.47	35-73	0-28	5-13	10-31		
Mean			0.74	19.26	9.74	0.31	51.13	9.5	9.7	17.3	42	5
Range	2-99	12	0.75-1.65	17.1-37.7	4.2-29.5	0.15-0.54	32-76	2-70	6-8.9	0-8.9	0.15-0.54	32-76
Mean			1.26	26.10	14.32	0.33	56.44	15.26	5.6	6.7	34	16

Reach #1: Hwy 32 bridge downstream of Alder Creek to Hwy 32 bridge downstream of Elam Creek Campground
Reach #1: Upper Falls to Potato Patch Campground
Reach #2: Lower Falls to Transfer Bridge at A-Line
Reach #3: Ponderosa Way to Iron Creek
Reach #4: Murphey Trail to Beaver Creek (Located upstream of reach #3)
Non-Anadromous Reach #1: Hwy 32 bridge downstream of Alder Creek to Hwy 32 bridge downstream of Elam Creek Campground
Non-Anadromous Reach #2: Confluence of Slate Creek to 1.25 miles downstream at gradient change.

[1] Only one particle count completed due to early spawning act
[2] Percent embeddedness was initiated in 1997

Table 11-G.-Mill Creek data summaries from 1996 to 1999 from mainstem reaches 2, 3, 4, and 5. Reach # 1 is a Stream Condition Inventory reach and is listed in table 10-G.

Mill Creek	Reach-Year	# of Pools	Residual Pool Depth (m)	L* Pool (m)	L* Sediment (m)	L*	Pool Tail Canopy	% Pool Tail Fines	% Particles <2mm	Percent Embeddedness	Large Woody Debris # Pieces	# Aggregates
Range	2-96	7	0.57-2.6	19-48.6	0-11	0-0.28	39-68	0-12	1.3-3.2	ns	72	4
Mean			1.38	32.14	4.99	0.12	52.86	4.52	3.1	ns		
Range	2-97	7	0.6-1.65	17-58	0-18	0-0.51	40-66	2-28	2.7-4.8	ns	81	4
Mean			1.13	29.14	7.57	0.2	55.6	9.9	4.1	ns		
Range	2-98	9	0.65-1.5	20.8-54.6	0-13.8	0-0.36	38-61	0-24	2.9-7.8	9-30	72	3
Mean			1.14	31.03	7.26	0.2	52	5.26	5.5	17.3		
Range	2-99	9	0.5-1.5	16.6-50	2.4-53.6	0.1-0.65	26-82	2-48	13.7-18	18-20	46	2
Mean			1	27.3	12.4	0.3	55.3	11.1	15.3	19.3		
Range	3-96	9	1.18-3.1	21.3-42.4	0-27.3	0-0.4	8-53	0-22	1-12.5	ns	8	0
Mean			1.85	34.21	8.9	0.16	31.29	6.22	5.7	ns		
Range	3-97	7	1.06-2.1	30.2-79	0-18	0-0.19	9-45	0-20	3.8-9.6	ns	56	2
Mean			1.48	41.51	2.57	0.03	21.29	5.52	7	ns		
Range	3-98	8	0.7-2.25	22-93	2-28	0.04-0.4	10-52	0-20	1-6.5	9-33	4	0
Mean			1.4	39.9	9.4	0.2	22.4	4.3	2.8	20		
Range	3-99	8							8.9-12	22-40	34	2
Mean			1.27	38.06	18.66	0.3	18.29	11.75	10	29		
Range	4-99	9	0.8-2.34	22.1-38.6	0-22.1	0-0.46	na[2]	0-30	2-14	6-9	na[2]	na[2]
Mean			1.38	29.01	8.26	0.19	na[2]	10	7.3	9.3		
Range	5-99	10	0.71-2.95	14.3-77.9	0-36.4	0-0.49	na[2]	0-60	na[1]	na[1]	na[2]	na[2]
Mean			1.47	44.98	18.27	0.26	na[2]	20	5	13		

Reach #1 is a SCI-FI reach and is not included in this data set

Reach #2 is from Hole in the Ground to Rocky Gulch Creek

Reach #3 is from Black Rock to Hulsman Place

Reach #4: Sooner Place to Savercool

Reach #5: Little Creek to Springs

[1] Range not available, only one sample taken due to spawning activity

[2] Data not collected (embeddedness was initiated in 1998)

Table 12-G.-Antelope Creek pool data from the mainstem and South Fork. Data collected prior to 1998 is summarized in table 12.

Antelope Creek	**Reach-Year**	**# of Pools**	**Residual Pool Depth (m)**	**L * Pool (m)**	**L* Sediment (m)**	**L***	**Pool Tail Canopy**	**% Pool Tail Fines**	**% Particles <2mm**	**Percent Embeddedness**	**Large Woody Debris # Pieces**	**Large Woody Debris # Aggregates**
Range	1-98	9	0.8-2.45	27-50	0-24	0-0.41	10-67	0-16				
Mean			1.54	37.17	8.78	0.15	40.89	4.22	6	3	48	1
Range	1-99	9	1.0-2.2	26.4-47.6	0-15.5	0-0.28	17-65	0-26	0-2	0-4		
Mean			1.55	34.89	6.93	0.16	39.33	6.48	1	2.3	66	1
Range	SF 1-99	10	1.38-2.73	18.2-35.4	0-15	0-0.33	ns[1]	0-14	1-8.9	4-14		
Mean			1.81	24.82	6.05	0.18	ns[1]	3.93	5.8	8	ns[1]	ns[1]

Reach #1 extends from NF confluence with SF to slab at Paynes Place
Reach # SF1 is on the South Fork from Round Mountain Creek to the NF / SF confluence

[1] Reach established to monitor effects of Gun II fire; shade and wood not inventoried

Table 13-G.- Fish Habitat Assessment Data

Mill Creek

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	Pools > 6ft per reach	Pools > 6ft per mile	% Pool Area
1	4408	A2	Anadromous	Non-Alluvial	15.7	8.4	6.2	14:86	21	3.4	2.4	2	25.2	2.4	0	0	10
2	5069	A3	Anadromous	Alluvial	19.1	8.6	6.2	3:97	10	2.5	2.2	0	10.4	0	0	0	2
3	7298	B3	Anadromous	Alluvial	17.2	10	6.2	2:98	6	3	2.3	0	4.3	0	0	0	1
4	8526	B3	Anadromous	Alluvial	20.5	14.4	6.1	5:95	13	4.6	2.6	2	8.1	2.5	0	0	4
5	8398	B2	Anadromous	Alluvial	21.3	15.2	6.7	7:93	24	4.4	2.7	4	15.1	2.5	0	0	7
6	6396	B2	Anadromous	Alluvial	20.4	13.5	7.5	8:92	14	4	2.8	3	11.6	2.5	0	0	7
7	13004	B2	Anadromous	Non-Alluvial	33.2	12.5	8.3	12:88	25	6.5	3.7	14	10.2	5.7	1	0.4	11
8	6693	B3	Anadromous	Non-Alluvial	33.9	none	6.3	21:79	6	9.3	5.5	5	4.7	3.9	1	0.8	8
9	9861	B3	Anadromous	Non-Alluvial	41.4	15.9	9	8:92	9	9.9	4.8	8	4.8	4.3	1	0.5	8
10	16681	B2	Anadromous	Non-Alluvial	40.6	14.4	6	1:99	14	8.6	6	14	4.4	4.4	6	1.9	8
11	4779	B3	Anadromous	Non-Alluvial	42.7	15.7	9.2	4:96	2	5.2	4.9	2	2.2	2.2	0	0	4
12	6915	B3	Anadromous	Non-Alluvial	44.9	15.3	8.4	27:73	13	9.3	5.5	10	9.9	7.6	2	1.5	28
13	6181	B3	Anadromous	Non-Alluvial	35.4	16.7	6.7	14:86	8	8.6	5.7	7	6.8	6	4	3.4	11
14	4274	B3	Anadromous	Non-Alluvial	42.3	11.7	8.2	38:62	9	10	5.9	8	11.1	9.9	5	6.2	42
1 to 6	40095	A2,A3,B2,B3	Anadromous	Alluvial/Non-A.	19.6	13.5	6.6	6:94	88	4.6	2.5	11	11.6	1.4	0	0	5
7 to 14	68388	B2,B3	Anadromous	Non-Alluvial	38.1	13.5	7.7	10:90	86	10	5.9	68	6.6	5.3	20	1.5	13

Deer Creek

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	Pools > 6ft per reach	Pools > 6ft per mile	% Pool Area
1	6462	B3	Resident	Non-Alluvial	34.3	12.6	7	10:90	8	7.7	3.8	8	6.5	6.5	1	0.8	10
2	8657	B3	Resident	Non-Alluvial	39.1	14.1	8	17:83	14	8.5	3.2	14	8.5	8.5	2	1.2	17
3	1907	A2	Resident	Non-Alluvial	36.8	17.3	6.2	13:87	4	7	5	4	11.1	11.1	2	5.5	12
4	7542	B3	Resident	Non-Alluvial	32.5	11.7	5.6	13:87	12	8.2	4.3	11	8.4	7.7	5	3.5	12
5	2382	A2	Resident	Non-Alluvial	32.4	7.7	6.6	27:73	6	6.6	4.1	6	13.3	13.3	1	2.2	30
6	4059	B3	Resident	Non-Alluvial	32.1	7.4	5.6	13:87	6	6.5	4.3	6	7.8	7.8	3	3.9	13
7	3771	B3	Anadromous	Non-Alluvial	36.1	10.2	5.3	9:91	4	20	8.9	4	5.6	5.6	2	2.8	9
8	1320	A2	Anadromous	Non-Alluvial	30.6	7.5	6.2	13:87	3	6.6	5.8	3	12	12	1	4	15
9	10775	B3	Anadromous	Non-Alluvial	34.2	8.4	5.9	16:84	22	12.3	6.1	19	10.7	9.3	12	5.9	16
10	9234	B3	Anadromous	Non-Alluvial	33.9	8.7	6.1	16:84	14	12.9	7.1	14	8	8	9	5.1	18
11	2373	B3	Anadromous	Non-Alluvial	36.7	NA	NA	0:100	NA	NA	NA	0	0	0	0	0	0
12	6223	B3	Anadromous	Non-Alluvial	34.7	9	5.3	54:86	21	15.5	7.8	21	17.8	17.8	12	10.2	56
13	15475	B3	Anadromous	Non-Alluvial	35.6	11	5.5	15:85	17	9.6	7.6	17	5.8	5.8	13	4.4	17
14	10996	B3	Anadromous	Non-Alluvial	38.7	8.2	6.5	23:77	22	13.2	8.3	22	10.5	10.6	17	9.7	27
15	11816	B3	Anadromous	Non-Alluvial	43.4	9.7	7.5	27:73	19	10.1	6.4	18	8.5	8	12	5.4	29
16	5407	B3	Anadromous	Non-Alluvial	47.8	15	7.3	40:60	11	11.4	6.9	11	10.7	10.7	7	6.8	45
17	4265	B3	Anadromous	Non-Alluvial	46.3	13.7	8.7	36:64	8	10.6	5.9	7	9.9	8.7	4	5	31
18	2336	B3	Anadromous	Non-Alluvial	39.6	8.4	8.9	34:66	8	9.8	5.3	6	18.1	13.6	3	6.8	41
19	3382	A2	Anadromous	Non-Alluvial	48.8	6.3	6.7	36:68	6	9.8	7.2	6	9.4	9.4	4	6.2	25
20	3074	B3	Anadromous	Non-Alluvial	48.3	20.3	10.3	33:67	5	8.2	5.1	5	8.6	6.9	1	1.7	44
21	3830	B2	Anadromous	Non-Alluvial	35.5	8.7	11.3	20:80	6	8.1	3.7	6	4.1	2.8	1	1.4	19
1 to 6	31009	A2,B3	Resident	Non-Alluvial	35.1	12	6.7	15:85	50	8.5	5.5	49	8.5	8.3	14	2.4	15
7 to 21	88054	A2,B2,B3	Anadromous	Non-Alluvial	38.6	10.2	6.8	23:77	166	20	6.9	159	10	9.5	98	5.9	30

Table 14-G.- Fish Habitat Assessment Data (con't)

Deer Creek Meadows

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	% Pool Area
1	6691	B3	Resident	Alluvial	34.1	15.3	5.6	0.5:99.5	1	2.7	2.7	0	0.8	0	0.2
2	12877	C4	Resident	Alluvial	17.3	8.4	5.5	5:95	11	4.2	3.3	5	4.5	2.1	5.8
3	NA	NA	Resident	Alluvial	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
4	3559	C3	Resident	Alluvial	12.1	7.1	5.6	28:72	8	3.4	2.8	2	3	3	15
1 to 4	23127	C3,C4,B3	Resident	Alluvial	19.7	9.4	5.5	5:95	20	4.2	3.1	7	4.6	1.6	3.5

North Fork Deer Creek (Gurnsey Creek)

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	% Pool Area
1	10340	C4	Resident	Alluvial	20.4	12.5	6.5	10:90	16	3.2	2.5	0	8.1	0	12
2	9007	B4	Resident	Alluvial	25.1	16.2	8.9	12:88	13	4.4	3.2	6	7.6	3.5	14
3	2845	C4	Resident	Alluvial	15.6	10.1	5.2	13:87	6	4.8	2.8	1	11.1	1.8	17
4	1253	C6	Resident	Alluvial	18.8	6.9	41.5	63:87	2	5	4	1	8.4	4.2	80
5	2753	C4	Resident	Alluvial	14.2	9.5	5.9	13:87	7	3.7	2.6	1	13.4	1.9	22
1 to 5	26198	B4,C4,C6	Resident	Alluvial	19.2	12.4	8.5	14:86	44	5	2.8	9	8.9	1.8	20

NA = No pools, runs or glides in this reach NS = Not surveyed

Antelope Creek

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	Pools > 6ft per reach	Pools > 6ft per mile	% Pool Area
1	3925	B3	Anadromous	Non-Alluvial	27	6.5	6.8	11:89	5	7.8	4.9	4	6.7	5.4	2	2.7	12
2	4704	B2,B3	Anadromous	Non-Alluvial	24	7.2	4	21:79	8	7.6	6.2	8	9	9	5	5.6	22
1 to 2	8629	B2,B3	Anadromous	Non-Alluvial	25.3	7	5.1	16:84	13	7.8	5.7	12	8	7.3	7	4.3	16

North Fork Antelope Creek

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	Pools > 6ft per reach	Pools > 6ft per mile	% Pool Area
1	1214	B2	Anadromous	Non-Alluvial	19.3	5.8	5.4	5:95	1	5	5	1	4.4	4.4	0	0	7
2	1498	B1	Anadromous	Non-Alluvial	13.4	5.8	4.7	5:95	3	4.5	2.9	2	10.6	3.5	0	0	5
3	7283	B2,B3	Anadromous	Non-Alluvial	16.8	6.5	4.8	5:95	11	5	3.8	7	7.9	5.1	0	0	6
4	6077	A2	Resident	Non-Alluvial	15.1	6.3	4.4	9:91	14	5.2	4.2	9	12.2	7.8	0	0	15
1 to 3	9995	B1,B2,B3	Anadromous	Non-Alluvial	16.4	6.4	4.8	7:91	15	5.2	3.9	10	7.9	5.3	0	0	6

South Fork Antelope Creek

Reach	Length of Reach (ft)	Channel Type	Anadromous or Resident	Alluvial or Non-Alluvial	Avg. wet channel width (ft)	W/D ratio runs,glides	W/D ratio pools	Pool/Riffle ratio	Pools per Reach	Max pool depth (ft)	Mean max pool depth	Pools >1m per reach	Pools per mile	Pools > 1m per mile	Pools > 6ft per reach	Pools > 6ft per mile	% Pool Area
1	2367	B3	Anadromous	Non-Alluvial	15.8	5.6	5	9:91	6	4.4	3.1	4	13.3	8.9	0	0	10
2	3752	B2	Anadromous	Non-Alluvial	20.7	7.2	4	20:80	12	10	5.6	12	16.9	16.9	5	7	20
3	2689	B3	Anadromous	Non-Alluvial	18.5	7.3	3.6	9:91	5	7	5.2	5	9.8	9.8	1	2	10
4	4707	A2	Resident	Non-Alluvial	19.1	7.3	5.6	9:91	17	8.5	4.2	12	19.1	13.4	2	2.2	11
1 to 3	8808	B2,B3	Anadromous	Non-Alluvial	18.8	6.8	4.2	12:88	23	10	4.9	21	13.8	12.6	8	4.8	16

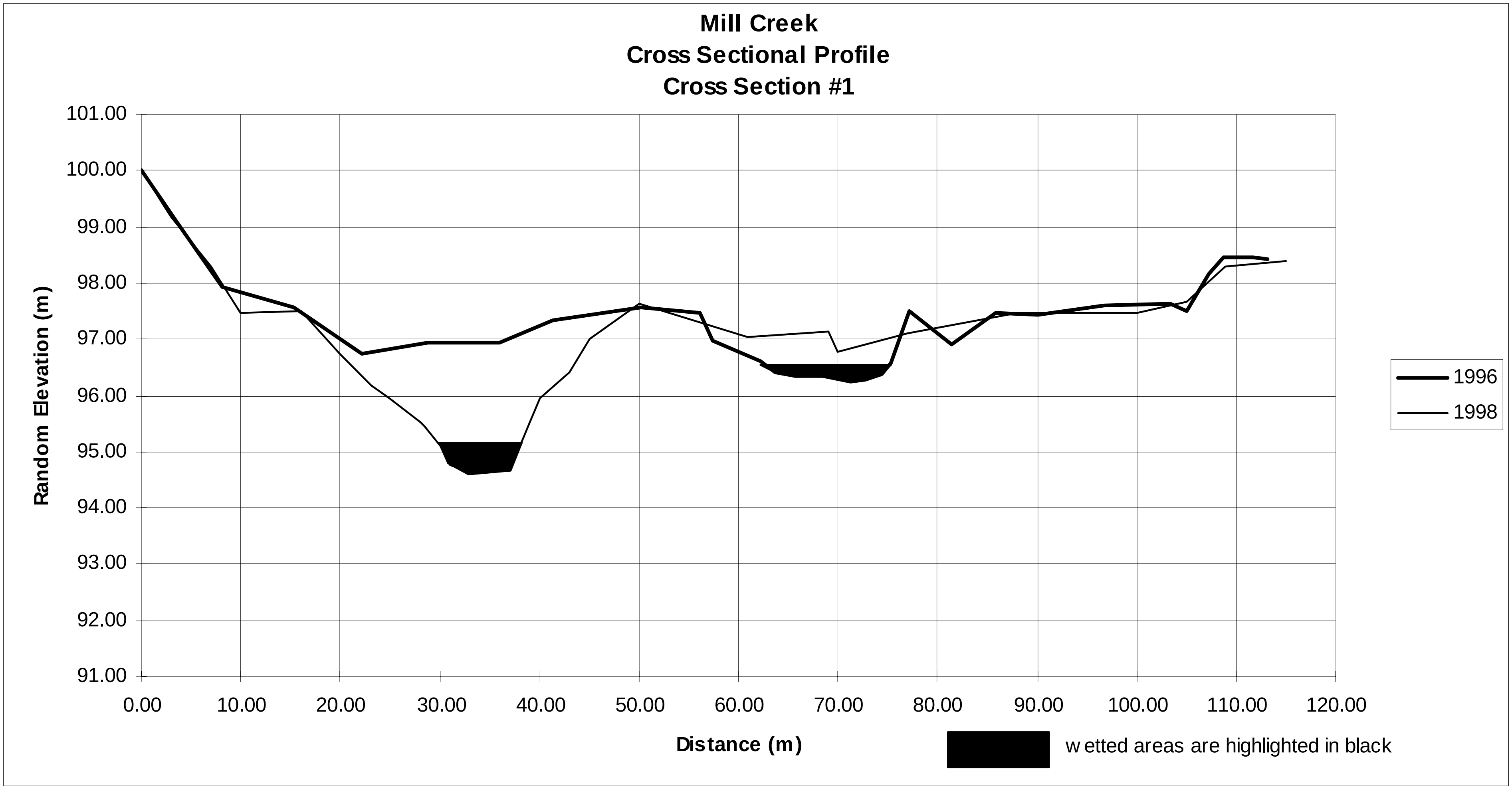


Figure 6-G.- Cross sectional #1 in the alluvial reach of Mill Creek showing comparing 1996 and 1998 profiles. This cross section is located approximately 200 meters downstream of the Hwy 171 slide.

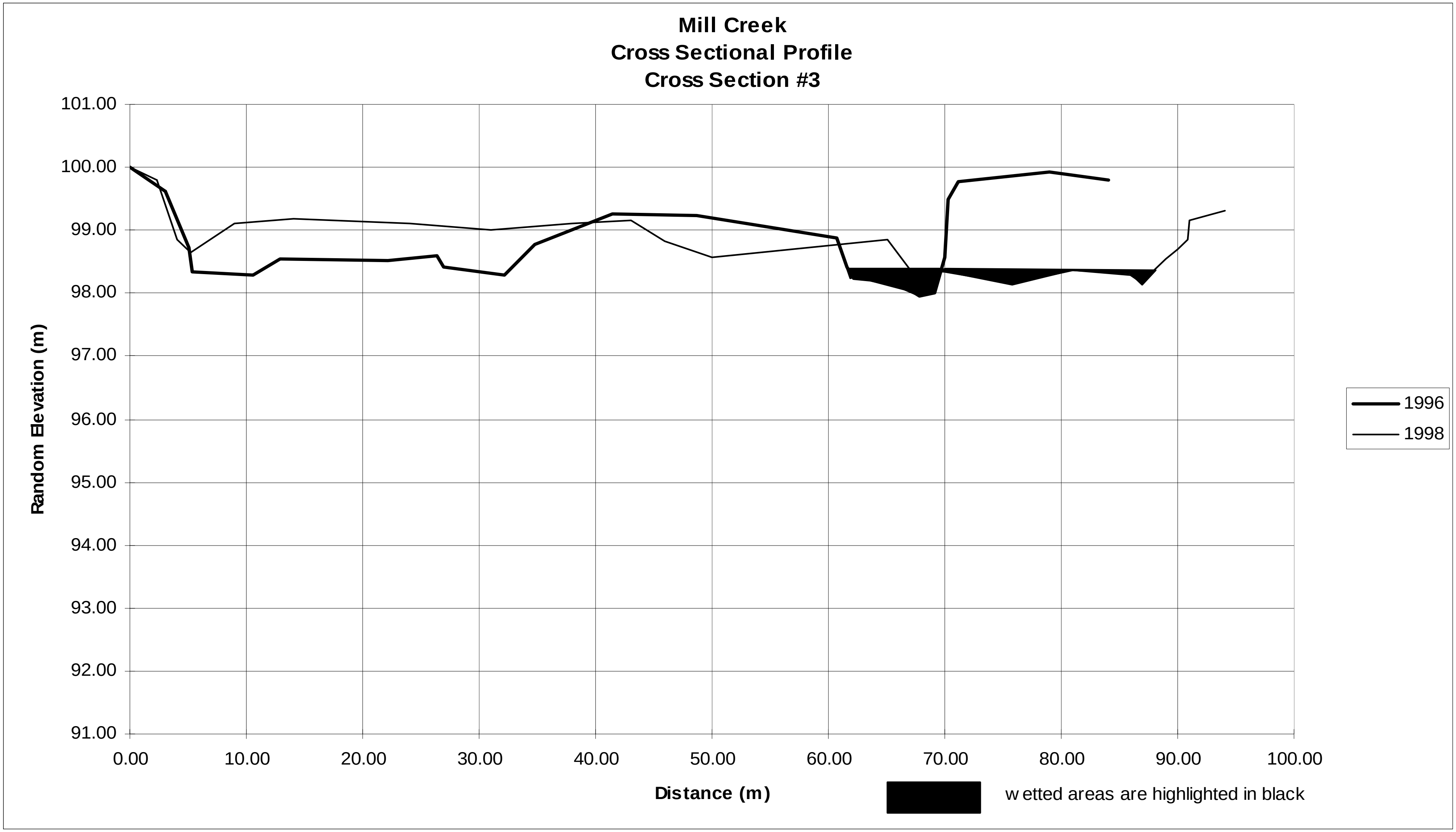


Figure 7-G.- Cross sectional #2 in the alluvial reach of Mill Creek showing comparing 1996 and 1998 profiles. This cross section is located approximately 20 meters downstream of the Hwy 171 slide

Table 15-G.- Stream channel data from Collins Pine Company.

Stream				**Substrate**				**Bank**		**V wave**		**% Canopy**	
Class 1 streams	C#	F.S. Subbasin	Gradient	% Silt & sand	range	% Gravel	Range	% Sed. cont.	Range	Mean	Range	Mean	Range
Alder	2	D26		23.3	20-30	40	30-50	26.7	0-60	12.4	1.1-22	64.7	12-97
Rattlesnake	13	D16			15		45		0		20.2		160
Forked	16	D17		5.0	0-10	11.7	5-15	9	2-20	-	-	82.3	80-85
Lost	9	D30		35	10-50	53.2	25-83	5	0-15	25.9	20.7-50	14.2	5-25
Mill-Hole in the Ground	5	M11		38.3	15-50	26.7	20-35	31.7	10-60	-	-	58.3	40-75
Mill-Rocky Gulch	15	M8		26.7	15-35	38.3	25-60	8.3	0-25	28.2	12.7-48.1	98.3	75-130
North Fork Deer	4	D28		25	15-35	31.7	25-40	11.7	0-35	29.4	10.3-19.1	20.7	2-30
Slate	19	D21		18.5	7-30	25	20-30	2.5	0-5	9.8	3.1-16.5	60	60
Round Valley	17	D19			10		20		20	-	-	5	5
Class 2 streams													
Slate	30	D21		10	0-10	17.5	10-25	42.5	10-75	-	-	62.5	45-80
Gurnsey	24	D28				26.7	20-35	10	5-15	-	-	58.3	45-70
Lost	26	D30		35			5	-	20	-	-		100
Gurnsey trib.	25	D29		36.7	25-55	33.3	30-40	0	0	-	-	90	90
Class 3 streams													
Carter	36	D27		21.7	0-50	36.7	10-75	20	0-60	-	-	68.3	25-120
Slate trib. 1	45	D21		10	5-15	36.7	25-45	26.7	10-60	-	-	70	60-100
Slate trib. 2	46	D21		5	5	6.7	5-10	41.7	0-70	-	-	48.3	20-75
Round Valley trib.	44	D19		12.3	10-15	17.5	15-20	17.5	5-30	-	-	44.5	37-52
Cement trib.	37	D14		21.7	10-40	20	10-30	1.7	0-5	-	-	76	68-85
Upper lost trib.	40	D30			10		5	0	0	-	-	110	70-150
Mill Creek													
Mill trib.	38	M11		16.7	5-25	35	20-50	21.7	0-40	-	-	47.3	42-50
Rock	43	M8		62	10-90	20.7	2-55	46.7	20-70	-	-	29	2-60
Hole in the Ground trib.	39	M11		16.7	5-30	21.7	10-30	0	0	-	-	38.3	10-75
Big bend trib.	34	M8		20	0-60	5	0-20	18.3	5-40	-	-	60	5-95

favorably with other SCI data in the regional database (though the number of streams in the DB is presently very small). They also compare favorably with conditions described as being high quality habitat in the literature (stream temperature and fines).

Not answerable is the question, 'how does existing channel and habitat condition compare to historic condition?' Although we lack that historic data, we can say that stream temperature in the main stem has changed little if at all since measurements were first taken in the early sixties, and that habitat measurements that can be compared from the early 1980s (pool depth) also appear unchanged in Mill and Deer Creeks.

An exception to the "good quality" habitat assessment for the main stems is Upper Mill Creek. As indicated above, the channel in this reach is braided, and as a consequence the reach has very few pools, and the pools that are present lack the depth found farther downstream. The reach has very little shade, and more surface fines and higher embeddeness than other mainstem reaches.

Also of note is the mainstem of Deer Creek above the Upper Falls. This reach has received little attention because it is not believed to provide anadromous habitat (the actual extent of Deer Creek use by steelhead is unknown). Because of visual observations that there is considerably more sediment on the channel substrate in this reach than downstream, two additional survey reaches were inventoried in 1999. Results verified the casual observations, and indicated a significantly more sediment in these reaches than downstream reaches, as expressed in particle counts, pool tail surface fines, residual pool depths and length of sediment lenses in pools. These results establish a baseline for this reach, but also pose many questions. Given the similar nature of these reaches with anadromous reaches downstream (in terms of gradient and confinement), it appears that the lower reaches may be more suseptable to sediment influence than generally thought. Is the sediment in this upper reach diminishing, increasing or static? Is the extent of the “affected” reach expanding or contracting? Are the higher in-channel sediment values the result of elevated sediment production rates in the sub-watersheds upstream or reflective of “natural” processes?

2b Tributary Streams

Historic data on streams tributary to Antelope, Mill and Deer Creeks is generally lacking. In recent years, the Forest has collected data (both SCI and Fish Habitat)in tributaries. These streams are: In Deer Creek; Elam Creek, Calf Creek, Cub Creek, Carter Creek, Deer Creek Meadows, Gurnsey Creek and Slate Creek, In Mill Creek; Rocky Gulch and In Antelope Creek; Judd Creek. Of these, two of the alluvial reaches, Deer Creek Meadows and Gurnsey Creek, have low (relative to other alluvial reaches in the SCI data base) bank stability, high bank angles (another indicator of poor bank stability) and high sediment in channel measures. The other channels appear (again, based on comparison with other SCI data and conditions described in the literature) to be in good condition in terms of temperature, LWD, shade, and in-channel sediment measures (this data is presented in tables 6-8 and 14).

The data from the Collins Pine and SPI surveys are ocular estimates and qualitative ratings rather than measurements, and therefore is difficult to compare to the Forest Service data. No attempt has been made to assess condition using this data, though in later sections it is referenced in discussions regarding links between channel and watershed condition.

EA Engineering surveyed 8 named and 65 unnamed tributaries of Deer Creek in the summer of 1995. As part of the survey protocol, surveyors identified areas that were sources of erosion. Fourteen tributaries were identified as erosion sources. The most common source was bank cutting and eroding banks. Only two of these cases were linked to on site problems (both of these involved Highway 32). EA engineering also surveyed nearly all (114 total) channels tributary to Mill Creek in 1995. This survey identified sources of active erosion and channel instability in 19 of the tributaries. The sources of erosion are divided nearly equally between roads (especially upstream in the rhyolitic soils) and debris slides. EA engineering did not survey the Tributaries of Antelope Creek.

III. WATERSHED CONDITION VS CHANNEL CONDITION

Erosion and sediment production are concerns for a number of reasons. First, loss of soil on site may result in reduced site productivity. Reduced site productivity has obvious implications for commercial forest management. Wildlife habitat can be affected by reduced site potential. Once in the channel, increased sediment delivery may impact both channel morphology and aquatic habitat. When sediment delivery exceeds transport capacity, channels aggrade. Depositional reaches may widen and become shallower, and in the extreme case, display a braided morphology.

Lesser increases in sediment delivery may have more subtle effects on fishery habitat (in addition to those results from the changes in channel morphology). These include the filling of pools, and increase in fine particles in spawning gravels. The impact of this effect on the mortality of salmonid eggs and fry has been well documented in the literature. The key question is to what degree increased surface erosion (and a general shift in the sediment regime) has impacted the aquatic resources of risk in the three watersheds.

The location with the clearest channel response to anthropogenic watershed disturbance is North Fork Deer Creek. As described earlier, this channel apparently changed from a meandering to a braided channel sometime during the 1960s. This corresponds with a high degree of timber management activity (as evidenced by the road density values) in the sub-watersheds upstream of the alluvial reach. It should also be noted that much of the watershed above this reach has rhyolitic soils. In addition, these streamside areas were the site of grazing intensity somewhat higher than recent levels. Another factor (as reported by locals) are beaver, introduced into this system in the late 1950s, which resulted in the removal of what had been thick riparian vegetation. It could also be the channel response is related to all these actions, most likely triggered by a large flow.

Elsewhere in the watersheds, changes and responses are less obvious. Of particular interest in these watersheds is the impact of sediment on the anadromous fish habitat. Watershed disturbance is not evenly distributed throughout the three watersheds. Generally, the greatest amount of disturbance has occurred on the flat to gentle slopes of the Mill Creek Plateau, which lie in the headwaters of Deer Creek, and the mid-section of Mill Creek. The lower portions of

Mill and Deer are basically undisturbed by logging activity (though they have experienced substantial wildfire in the past decade). The Barkley Fire burned over 40,000 acres in 1995. Observations during 1996 noted extensive fresh deposits of sediments in pools below some tributaries draining the burned area. Deposits were obvious at the downstream edge of deep pools, and may have affected pool length and pool depth. These pools were used by holding spring-run salmon in 1996 and 1997. The upper portions of Antelope Creek have also been disturbed more than the lower sub-basins.

Mill Creek confounds attempts to correlate channel condition with anthropogenic watershed disturbance factors. The upper Mill Creek watershed is essentially undisturbed. There has been some channel realignment above highway 32, and there has been grazing, but road densities are low (therefore accelerated erosion rates are low). The upper watershed contains some very unstable landforms and soils that contribute sediment to the channel, and the low gradient reaches of channel are extremely unstable.

Attempts to find linkage between watershed disturbance, stream condition and habitat data is also hindered by the lack of historic channel information. A few inferences can be drawn from the limited data. Those tributaries with channel information that lie in watersheds that are in "good" condition (this inferred from a low number of risk criteria) appear to be in good condition. These include Carter and Elam Creeks.

There seems to be a weak correlation between the watershed disturbance factors and in-channel estimates made by SPI on tributaries in the Antelope Creek basin. Qualitative estimates of channel substrate fines and embeddeness were highest in the Judd and Howard Creek sub-basins. These sub-basins had high road density, ERA and nearstream disturbance values. Stream inventories on Lassen NF land in 1999 in Judd Creek indicated high sediment levels in the channel. Data collected farther downstream on Forest Service managed reaches indicate generally low in-channel sediment values (see tables 9-12). As with Mill and Deer Creeks, it may be that the transport capacity of the main stem channels passes most of the sediment through the system. As in Mill and Deer Creeks, influence of high sediment production rates on deposition in biologicially important, lower gradient stretches is not known.

The amount of rhyolite in each sub-basin affects erosion and sediment delivery, and the stream data shows generally higher in channel sediment values in channels of sub-basins with high amounts of rhyolite (this from both the SCI data: Gurnsey and Deer Creek Meadows, and the Collins Pine Co. data; see tables 6-8 and 13). Are these values higher because they are in rhyolite, because they have relatively high watershed disturbance values, or both? Data from the SCI reach on Slate Creek, a sub-watershed with above average disturbance ratings and a high (43%) amount of rhyolite, show in-channel sediment values comparable to Cub Creek, an undisturbed basin with no rhyolitic soils. The Slate Creek reach is on Forest Service land below most of the watershed disturbance, and is a transport channel reach. These factors certainly contribute to the condition.

While the condition of the tributary streams is important in itself, the regional importance of the anadromous fish habitat make it more important, and by extension, the influence of the tributaries on the anadromous habitat becomes very important. We do know that some tributaries are producing surface sediment at rates higher than they would be if they were undisturbed. We do not know the effects of these increases on the anadromous reaches within the Forest.

Even less can be said about affects to the anadromous habitat below the forest boundary. Increases in sediment delivery from upper watershed sub-basins certainly are diluted downstream, because much of the lower watersheds (in Deer and Mill Creek) are unroaded or have very low watershed disturbance. One would expect responses to be most evident nearest their source. As discussed earlier, such a response may have occurred at North Fork Deer Creek, and may be reflected by the higher in-channel sediment values in Deer Creek above the Falls. Some of the sub-basins with highest sediment production lie downstream of Deer Creek Meadows and North Fork Deer Creek, and though there are low gradient habitat features (which include the longest holding pools) there are no “meadow” type response reaches that would clearly reflect change until the Creek enters the valley, far downstream. There, influences of increased sediment load may be masked (or compounded) by alterations to the floodplain interaction of the Creek, and are very hard to detect.

Likewise, temperature measurements of tributary streams indicate that they are supplying cold water to the anadromous reaches. The three exceptions to this general trend are Deer Creek Meadows, North Fork Deer and Upper Mill Creek. As discussed earlier, the changes in Upper Mill Creek appear to be largely attributable to "natural" processes. Changes to North Fork Deer Creek (channel widening and braiding) have certainly increased temperatures to some degree. Data from Deer Creek meadows shows that water traveling through this reach does increase in temperature (Collins Pine data, average of x degrees). This reach is probably marginally wider and shallower than prior to settlement. It is impossible to say whether or not it once supported a riparian vegetation community that may have provided more shade. Trends in temperature at these locations are most likely improving (except at Mill Creek) due to reduction in grazing intensity.

IV. CONCLUSIONS

At the Sub-Watershed Scale: Though in-channel data is sparse, we believe that the watershed disturbance values, including near stream disturbance, indicate there are drainages within sub-basins in poor condition relative to historic, in terms of large wood and sediment in the channel substrate. At the upper extents of perennial streams, temperature may also be elevated as a result a reduction in shade.

At the Forest Anadromous Fish Holding and Spawning Scale: It appears the channels and habitat are close to their historic condition, though Deer Creek upstream of the Upper Falls (which may provide steelhead habitat) has elevated substrate sediment (from historic conditions). Upper Mill Creek appears to have declined in terms of fish habitat quality, but these changes appear linked to natural disturbances.

At the Watershed Scale: No assessment of reaches on private lands below the Forest Boundary were made. This topic is currently being studied by the Deer Creek Conservancy and the Mill Creek Conservancy.

V. CHANGES IN WATER YIELD AND TIMING

As described in appendix H, the peak discharges from the watersheds are dominated by rain on snow events. On National Forest land, essentially all sub-basins in the watersheds above the wilderness (and nearly all lands NF sub-basins in Antelope Creek) are subject to rain on snow processeses.

The discharge records for the watersheds are described in appendix H, longterm records exist only for stations downstream in the central valley. Therefore, discussion of changes in water yields must be made in terms of potential and risk, rather than on actual data.

In addition to lying within areas subject to snowpack melt from rainfall events, several other factors influence the risk of increased peak flows. These include the amount of road density, the location of these roads relative to drainage ways and the extent to which road ditches flow to channels. Other factors include the amount of timber harvest that has occurred, particularly the degree to which young stands have replaced old growth, the drainage density of the watersheds, and the amount of precipitation an area receives.

There is commonality between these factors and those used to rate the potential for increased surface erosion in earlier sections. Therefore, the sub-basins with highest risk of increased surface erosion also have the highest risk of peak flow and annual water yield increases (because all lie within the rain on snow zone). Subwatersheds located lower in the watersheds which have been burned by high intensity wildfire (Yahi, Flatiron, Avery, etc.) recently also present a high risk of peak flow and annual water yield increases.

Other than the areas burned by stand replacing fire, relatively little of the Deer and Mill Creek watersheds has been clearcut, or other wise put into a young vegetative conditions most conducive to peak flow increases during rain on snow events.

At the Sub-Watershed Scale: The risk of peak flow increases is high in some subwatersheds. They are the same sub-basins that rated high in the watershed disturbance rating. Of these, only North Fork Deer Creek, shows a channel response that might be attributable (at least partially) to increases in peak flows. Other streams draining the sub-basins with the highest risk of peak flow increases (Alder, Slate, Deer Creek Meadows, etc.) do not display extensive bank cutting or other evidence of peak flow increases. They are generally well-armoured transport channels capable of resisting increases in flow.

Trend at this Scale: Similar to the trend for surface erosion.

At the Forest Anadromous Fish Holding and Spawning Scale: The channels are also well armoured and suitable for transport. At this scale, there is a concern for changes in the frequency of flows that might move substrate in which salmonids have nested. Such an estimate is beyond our current ability to undertake. In subjective terms, there is no noticeable evidence (from changes in riparian vegetation, bankfull indicators, etc.) that such changes are occurring. At this scale possible increases at the sub-basin scale are diluted.

At the Watershed Scale: Not measurable. Moving downstream, more area is in an undisturbed condition such that any peak flow increases are further muted.

Annual Water Yield

Detection of water yield increases is also tied directly to scale. Studies that have demonstrated yield increases have been limited to small watersheds (generally less than 2 square miles). Detection of change is hampered by the inherently high variation in the timing and amount of precipitation. At the sub-watershed scale it is likely that annual flows are increased in the watersheds with the highest risk of peak flow increases, and for the same reasons: greater amount of impervious surface and shifts in vegetation from late to early seral stages. Not all vegetation changes have been to those that might use less water. In those stands that have higher stocking levels than occurred historicity, water yield could be reduced. A very broad brush assessment is that there are as many stands in the watersheds with increased stocking as there are in earlier seral stages, and as a result increases in yield are offset by reduction in yields. In any case, it is unlikely that there has been any detectable change in water yields at the watershed scale.

Table 16-G.- Water Temperature data for Mill, Deer, and Antelope Creeks and their tributaries.

Watershed	Stream	Year	Maximum Temperature	Date of Maximum	Seven Day Maximum	Seven Day Minimum	Temperature Change	# of Days >65	# of Days >70
Antelope	Antelope	1998	71.7	08/14/98	69.9	60.6	9.3	72	12
	Antelope	1999							
	MF Antelope	1996	66.5	08/14/96	65.4	60.6	4.8	22	0
	MF Antelope	1997	68.9	07/21/97	67.8	59.9	7.9	52	0
	MF Antelope	1998	66.3	08/14/98	65.1	58.6	6.5	21	0
	MF Antelope	1999							
	SF Antelope	1996	76.2	08/18/96	73.7	56.8	16.9	39	12
	SF Antelope	1997	59.7	07/21/97	58.7	53.1	5.6	0	0
	SF Antelope	1998	59.0	07/20/98	58.5	52.6	5.9	0	0
	SF Antelope	1999							
	NF Antelope	1996	60.6	07/15/96	60.0	55.8	4.2	0	0
	NF Antelope	1997	62.9	07/21/97	62.2	55.2	6.9	0	0
	NF Antelope	1998	61.4	08/06/98	60.7	54.3	6.3	0	0
	NF Antelope	1999							
Deer	Deer Creek @ upper falls	1995	58.8	09/14/95	57.1	53.2	3.9	0	0
	Deer Creek @ Red Bridge	1995	66.4	09/14/95	65.8	49.8	16.0	14	0
	Deer Creek @ Red Bridge	1996	67.0	08/14/96	65.9	60.7	5.3	34	0
	Deer Creek @ Red Bridge	1997	65.5	07/21/97	64.6	58.6	6.0	17	0
	Deer Creek @ Red Bridge	1998	Thermograph stolen						
	Deer Creek @ Red Bridge	1999							
	Deer Creek @ Polk Springs	1996	68.4	07/30/96	68.0	62.4	5.5	32	0
	Deer Creek @ Polk Springs	1997							
	Deer Creek @ Polk Springs	1998	69.3	10/14/98	67.6	61.7	5.9	49	0
	Deer Creek @ Polk Springs	1999							
	Deer Creek @ Ponderosa Way	1996	72.8	07/15/96	71.2	64.8	6.4	79	19
	Deer Creek @ Ponderosa Way	1997	72.5	07/21/97	71.5	64.0	7.4	55	22
	Deer Creek @ Ponderosa Way	1998							
	Deer Creek @ Ponderosa Way	1999							
	Gurnsey Creek	1995	61.3	09/14/95	60.2	51.7	8.5	0	0
	Gurnsey Creek	1996	62.7	07/14/96	61.6	50.0	11.6	0	0
	Gurnsey Creek	1997	Thermograph malfunctioned						
	Gurnsey Creek	1998	65.0	07/20/98	64.4	50.3	14.1	20.8	0.0
	Gurnsey Creek	1999							
	Cub Creek	1996	60.1	07/30/96	59.8	56.1	3.6	0	0
	Cub Creek	1997	59.5	08/08/97	58.9	55.7	3.2	0	0
	Cub Creek	1998	59.9	08/14/98	57.4	54.9	2.5	0	0
	Cub Creek	1999							
	Slate Creek	1995	55.8	09/14/95	54.9	47.0	7.9	0	0
	Slate Creek	1996	51.0	10/09/96	50.6	45.5	5.1	0	0
	Slate Creek	1997	61.7	06/18/97	60.6	49.3	11.4	0	0
	Slate Creek	1998	62.1	07/20/98	61.7	49.1	12.6	0	0
	Slate Creek	1999							
	Calf Creek	1997	57.5	07/29/97	57.1	54.3	2.8	0	0
	Calf Creek	1998	57.8	08/14/98	56.9	54.0	2.9	0	0
	Calf Creek	1999							
	Elam Creek	1997	61.0	07/28/97	59.9	52.8	7.1	0	0
	Elam Creek	1998	61.7	07/20/98	60.8	51.6	9.1	0	0
	Elam Creek	1999							
Mill	Mill Creek @ Hole-in-the-Ground	1995	62.7	09/12/95	61.7	47.9	13.8	0	0
	Mill Creek @ Hole-in-the-Ground	1996	65.8	07/15/96	64.7	52.8	11.9	21	0
	Mill Creek @ Hole-in-the-Ground	1997	68.6	07/21/97	67.8	51.2	16.6	57	0
	Mill Creek @ Hole-in-the-Ground	1998	68.5	08/13/99	66.0	50.3	15.8	21	0
	Mill Creek @ Hole-in-the-Ground	1999							
	Mill Creek @ 36	1997	73.0	08/06/97	71.7	52.3	19.3	89	24
		1998	69.7	09/04/98	68.4	51.4	17.0	34	0
		1999							

Table 17-G.- Grimes Data, 1982.

Mill Creek

Station #	Location	Reach Length (mi)	n	Max Pool Depth (ft)		Residual Pool Depth (ft)	
				range	mean	range	mean
1	Hwy 32-Mill Creek	3	NS	NS	NS	NS	NS
2	Hole in the Gound	1.8	7	4-8	5.5	NS	5.1 *
3	Black Rock	1.1	7	6-15	8.9	NS	8.4 *

Deer Creek

Station #	Location	Reach Length (mi)	n	Max Pool Depth (ft)		Residual Pool Depth (ft)	
				range	mean	range	mean
1	Upper Falls-PP	1.6	2	8-10	9	NS	8.5 *
2	Indicator	1.4	9	6-15	13.1	NS	12.6 *
3	Ponderosa-Iron	1.9	5	9-12	10.5	NS	10 *

APPENDIX H - STREAM DISCHARGE

A Review of Stream Discharge in the Antelope, Deer and Mill Creek Watersheds

Discharge Records

Antelope Creek:

Discharge was measured from 1940 to 1982 at T27N R2W sec 7, about 6 miles upstream of the mouth, and 6 miles east of Red Bluff. Elevation 340 feet.

Deer Creek:

Discharge was measured between October 1911 and December, 1915 and has been measured since March, 1920 at T25N R 1W sec 23, about 0.8 miles above diversion dam and 9 miles northeast of Vina. Elevation 480 feet.

Discharge was also measured from 1929-1932 at Polk Springs and just below Slate Creek from 1929-32 and 1962-70.

Mill Creek:

Discharge was measured from September, 1909 to September 1913 and has been measured since October, 1928 at T26N R1W sec 6, about 5 miles above the mouth and 5 miles northeast of Los Molinos. Elevation 420 ft.

Discharge was also measured from 1929-1932 and 1985-1988 at the Highway 36 bridge about 10 miles east of Mineral.

Runoff Characteristics

All three watersheds have peakflows that are dominated by rain on snow events. This is illustrated in the following table which shows the month in which the maximum flow for each year occurred at the downstream long term stations..

Table 1-H.- Timing of Annual peak Flow Events (by month) for Antelope, Deer and Mill Creeks.

Watershed	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May
Antelope	0	1	3	6	15	14	3	0	0
Deer	0	2	3	13	19	28	6	1	0
Mill	1	2	5	9	17	20	10	0	0

The majority of annual events occur in December, January and February when snow could be expected to be present in the transient snow zone (above about 3,000 feet in elevation). Earlier peaks (Sept-Oct-Nov) are most likely rain events with little snow influence. Later peaks (mid-March through May) indicate snowmelt generated peaks. Evidence of rain on snow events is also provided by the period of record maximum events for each watershed. These events are important in that they may identify times when episodic erosional processes (debris slides, road failures, etc.) as well as changes in sensitive stream reaches may have occurred.

Top 10 discharge events by watershed:

Table 2-H.-Top Ten Discharge Events: Antelope Creek.

Date	cfs	Monthly Precipitation (inches) @ Mineral	Monthly Precipitation (inches) @ Chester	Monthly Precipitation (inches) @ Greenville	Monthly Snow Depth @ CSSL (ft)	Monthly Snow Depth @ Lower Lassen Peak
01/23/70	17,200	27.4	15.84	19.54		85.7 (2/70)
02/22/56	11,500	13.65	10.16	13.61	6.2	92.1
11/15/81	11,300	NR	NR	18.46		NR
02/24/58	11,100	17.03	12.04	13.63		50.7
10/12/64	11,100	23.44	18.78	16.55	0	NR
02/06/42	10,400	10.59	7.8	9.61		79.3
12/01/60	9,830	5.74	9.72	9.21 (Nov)		NR
01/21/69	9,430	23.44	14.86	21.98		57.9 (2/69)
02/10/41	9,180	13.96	10.24	8.58	-	78
12/22/64	8,990	25.85	14.65	19.54	1.2	NR

Table 3-H.-Top Ten Discharge Events: Deer Creek near Vina

Date	cfs	Monthly Precipitation (inches) @ Mineral	Monthly Precipitation (inches) @ Chester	Monthly Precipitation (inches) @ Greenville	Monthly Snow Depth @ CSSL (ft)	Monthly Snow Depth @ Lower Lassen Peak
12/11/37	23,800	15.85	7.57	8.36	-*	115.9 (3/38)
1/1/97	22,000				-	NR
2/28/41	21,600				-	78
1/23/70	20,100	-	-	19.54	1.3	NR
12/22/64	18,800	25.85	14.65	19.54	1.2	NR
2/17/86	16,100	-	-	21.6	4.5	55.6
1/21/69	15,000	-	-	21.98	6	57.5
2/6/42	13,700				-	79.3
2/10/41	12,700	13.96	10.24	8.58	-	78
3/26/28	12,200	-	-	-	-	NR
1/26/83	12,200			10.27	10.4	52.3

Table 4-H.-Top Ten Discharge Events: Mill Creek @ Los Molinos

Date	cfs	Monthly Precipitation (inches) @ Mineral	Monthly Precipitation (inches) @ Chester	Monthly Precipitation (inches) @ Greenville	Monthly Snow Depth @ CSSL (ft)	Monthly Snow Depth @ Lower Lassen Peak
12/11/37	36,400	15.85	7.57	8.36	-*	115.9 (3/38)
1/1/97	22,000				-	NR
1/23/70	17,100	-	-	19.54	1.3	NR
12/22/64	16,000	25.85	14.65	19.54	1.2	NR
10/12/62	14,100	23.44	13.78	16.55	0	NR
1/21/69	12,400	-	-	21.98	6	57.5
2/10/41	12,200	13.96	10.24	8.58	-	78
2/17/86	11,800	-	-	21.6	4.5	55.6
11/16/81	11,400	-	-	18.46	6.2	NR
2/28/40	11,400	13.8	12.57	9.61	-	47.4

* snow depth records begin in 1951

Storms which locals recall as causing flooding and damage on a regional basis show up on these lists. These include the December, 1964 storm; the Columbus Day storm of 1962 and the February, 1986 storm. Of the top ten discharge events, it is likely that all but the October, 1962 events were rain on snow events (the October, 1962 storm was likely a rain driven event). Local snow records are generally not available for these storms. Snow depths from the Central Sierra Snow Lab (CSSL) are available after 1951. The monthly snow depths at CSSL are given on the table above, and there was a snow pack there for all storms after 1951 with the exception of the October, 1962 storm. Snow data from Lower Lassen Peak are also presented, but these data were collected primarily in the spring, and so are incomplete in regard to gauging rain-on-snow events. There is obviously a strong correlation in the events for the three watersheds. The Antelope record is much shorter than that of the other two creeks, and the shorter period is partially responsible for some "different" storms showing up on its list of top flow events.

Mean Monthly flows over the period of record also display a pattern of wet Dec-March periods. The influence of snowmelt on the runoff regime of the watersheds (on Mill-Deer-Antelope in decreased influence) is also evident.

Table 5-H.-Mean Monthly Flow (cfs) (over period of record) Antelope. Deer and Mill Creeks.

Watershed (size m2)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Antelope (123)	51	104	222	315	312	241	218	154	81	44	38	39
Deer (208)	114	198	371	506	614	564	527	378	196	115	97	94
Mill (131)	125	202	341	421	465	440	428	433	322	173	115	105

Mill Creek has both higher elevations and a larger percentage of its watershed in high elevation (snow zone) than the other two watersheds. This is reflected in higher flows during the typical snow melt period of April-June.

Mill Creek also produces more water per acre than the other two watersheds, producing on average 215,000 acre ft (or 2.56 ft/acre) per year, versus 228,700 acre ft (1.72 ft.acre) for Deer Creek and 110,800 acre ft (1.41 ft/acre) for Antelope Creek.

Though the period of record is very short, the data from the gauge at the Highway 36 crossing above Brokenshire Meadows indicates that peak flows in the Upper Watershed are generally later than those measured at the downstream long term gauge. Only monthly mean data were available for the early (1929-1932) record. During this period, the monthly mean was highest in May. The downstream record had a maximum monthly mean for May only in 1932. The 1985-88 record had three annual maximums in April and May with only one (the 1986 storm peak of 2/14) non-snow melt generated peak. Evidently, snow melt, and snow melt peaks are more influential in Mill than Deer, and in Deer than Antelope Creek watersheds.

This is supported by the short term records located nearer the headwaters on Deer Creek. As discussed earlier, gauges were located at Polk Springs and just below Slate Creek for short periods of time (Polk Springs 3 water years, Slate Creek 13 water years). Over this period of record, the latest yearly maximum event at the Polk Springs gauge occurred in March, 1931 (the peak at the Vina Station for the same year occurred in January, indicating some snowmelt influence). At the Slate Creek Station, both the 1931 and 1932 annual peak flows occurred in March, and the 1966 peak occurred in April. At Vina the annual peak occurred in January.

There are no "headwaters" data available for Antelope Creek.

Flood Frequency Curves were generated for the three watersheds and are attached to this report (Figures 1-3).

The recorded maximum flow on Mill Creek is worthy of additional comment. The peak discharge, with more than twice the discharge of the second largest (December 1964) storm, occurred on December 11, 1937. This storm was far above the gauge height (maximum at that time of 14,000 cfs, and was first calculated by USGS at 23,000 cfs. This estimate was later revised to 36,400 cfs.

This is a huge flow relative to the size of the basin. Deer Creek, which has a basin size about 1.6 times as large as Mill Creek, also produced a peak discharge (over the period of record) of 23,800 cfs from this event. On Deer Creek, the peak occurred the day before the Mill Creek peak (Dec 10, 1937). Comparing instantaneous peak and mean daily values for Mill Creek from records for which both are available (all storms but the 12/11/37 event), a value of 21,800 cfs is estimated as the mean flow for 12/11/37. This flow requires a runoff rate of 6.2" from the entire watershed.

Using the flood frequency curve, this is the maximum event, and has the largest flow on record making it a 68 year event (meaning on average a flow of this magnitude would occur once every 68 years). If, however, this flow is dropped from the flood frequency calculations, and a curve with the other 67 maximum flow events is produced (see attachment), and the frequency of the 1937 discharge read, a return interval of about 1100 years is derived (see "hypothetical" Mill Creek curve Figure 4).

The records indicate this was a extreme rainfall event (the peak in Deer Creek indicates that the storm had a long period of intense rainfall) but to generate the extreme runoff, there must have been a substantial snowpack, probably to a fairly low elevation. Unfortunately, no snow records have been found to confirm this supposition.

Low Flows:

While peak events have a significant affect on erosional processes, periods of extended low flow are perhaps equally important influences on biological communities. This is especially true when water is diverted from channels, as is the case downstream in Antelope, Deer and Mill Creeks.

Unfortunately, precipitation records for the headwaters areas which dominate streamflow are scarce, and relatively short term as compared to the streamflow records. The most reliable records seems to be those from the Chester and Greenville Ranger Stations and the Mineral National Park Center station (all three records date to 1937, though there are gaps in the Chester and Mineral data). The best long-term precipitation we were able to locate is from the Central Sierra Snow Lab near Soda Springs. The record at this location dates to 1899. As can be seen from comparison of the peak discharge data from the three watersheds presented earlier, there is variability in the amount of rainfall (as inferred from differences in peak flows) among the relatively small geographic area of the watersheds. Therefore, use of the precipitation data from over a hundred miles away must be done with caution, and obviously can be used only for ascertaining general trends.

Based on review of these records, four periods of low precipitation over the period of record stand out. These are periods when there were at least two consecutive years when precipitation was less than 60 % of the long-term average. These periods are: 1916-19, 1924-25, 1976-77, and 1990-92.

Streamflow data over for these periods is spotty at best:

Table 6-H.- Annual Peak Flows for selected years, Antelope, Deer and Mill Creeks

Watershed	Peak Flow (cfs)									
	1917	1918	1919	1924	1925	1976	1977	1990	1991	1992
Antelope				NR	NR	769	967	NR	NR	NR
Deer				1900	2900	1640	395	3470	3940	4500
Mill				NR	NR	1810	436	2960	3370	4020
Precip @ CSSL (mm) (x=1308)	573	756	571	480	634	965	702	1131	1182	1070

NR= No Record

Table 7-H.- Mean monthly discharge (cfs) for selected months, Antelope, Deer, and Mill Creeks.

Watershed	Mean June Flow (cfs)						
	1924	1925	1976	1977	1990	1991	1992
Antelope	NR	NR	40	33	NR	NR	NR
Deer	66	121	98	75	129	106	96
Mill	NR	NR	139	99	207	195	110

The above records were selected using the arbitrary 2 year-60% of long term average rule. Lower flows have occurred in all the watersheds. In terms of fish migration and out-migration, the affect of low natural flows is exacerbated by diversion of water from all three streams.

Longer Term Climatic Conditions

The SNEP report provides an excellent summary of long term climatic conditions. These long term trends provide a context for the relatively short term period of precipitation and streamflow records. SNEP estimates that the current wet winter/dry summer weather pattern has been prevalent for only the past 10,000 years. Over the past 1200 years, two droughts lasting 100-200 years have occurred. During 1650-1850, a cold phase occurred during which glaciers in the Sierra advanced to positions they had not occupied in 10,000 years. The past 150 years have been relatively warm and wet, and have contained one of the wettest half century intervals of the past 1000 years. Climate obviously plays a huge role in the type of vegetation occupying the landscape, the amount and timing of flow produced by a watershed, and the aquatic and terrestrial organisms they support.

Diversions

Diversions are located in the Central Valley for all three streams.

Antelope Creek: There are two diversions at the canyon mouth. One is operated by the Edwards Ranch, which has a water right of 50 cfs, the other by the Los Molinos Mutual Water Company

(LMMWC) which has a water right of 70 cfs. Flow is diverted between April 1 and October 31. The stream is usually dewatered when both diversions operate.

Deer Creek: There are three diversion dams and four diversion ditches on the 10 miles of stream between the canyon mouth and the Sacramento River. During low flow periods, the existing water rights are sufficient to dewater the stream.

Mill Creek: There are three diversion dams on Mill Creek. Two are operated by LMMWC, one by the Clough and Owens ranches. During low flow periods the existing water rights are sufficient to dewater the stream.

APPENDIX I - RECREATION USE

Recreation Use
In
Deer, Mill, and Antelope Creek Watersheds

Jane Goodwin
Recreation Officer

Current Conditions

The developed facilities listing in this document were built sometime in the 1940's by a combination of CCC and forest service labor. None of the facilities have "as builts" plans for details. With the exception of the trail that have been constructed in the early 1990's other hiking trails date back to the early 1900's and some to the mid 1950's again no plans or exact dates of construction is available.

Portion of all three drainages have been proposed as Wild and Scenic Rivers. The Forest LMP provides direction to preserve the "outstandingly remarkable" values until designation by Congress. Values noted as outstandingly remarkable for these drainages include; heritage, fisheries, recreation, and hydrology.

Developed facilities within the Mill Creek drainage include:

Mill Creek Campground, operated as part of the Mill Creek Resort. These facilities are part of a Recreation Residence Tract with 119 residences. This area is operated under Special Use Permit from the Forest Service to individual permittees. This area is accessed off of State Highway 172, with paved access roads, community water system, septic tanks, electric and phone service. Early in 1996 a land exchange was proposed by the Mill Creek Recreation Residence Tract. This exchange would include purchase of private property in the Ishi Wilderness along Deer Creek to exchange for the recreation residence tract.

The Mill Creek Recreation Residence Trailer Tract is located in close proximity to the Mill Creek Recreation Residence Tract on Highway 172. This tract has 28 residences under Special Use Permit from the Forest Service to individual permittees. Facilities in this tract are more rustic than those found in the Mill Creek Recreation Residence Tract.

There are two dispersed camping areas located along Mill Creek just off of Highway 172. These areas are used during holiday week ends and deer seasons. No facilities are provided, pack it in pack it out is encouraged.

The Morgan Summit Snowmobile Park is accessed on Highway 172 during winter months just past the Mill Creek Resort. The primary development is located on Highway 36 at Morgan Summit. This facility was constructed in the mid 1980's using "greensticker funds". It provides groomed snowmobile trails, parking areas, and a hut/restroom facility. Cal Trans does not plow the Highway 172 from late December to mid April. Approximately 80 mile of groomed snowmobile trails are accessed from this location.

Camp Tehama is an organization camp which was built in the 1950's. It is used primarily by school groups and private groups. Its use is between 6-8 months annually. They have on site caretakers which maintain the facilities. It was under a term special use permit from the Lassen National Forest, which expired in 1994. Currently no new permit has been issued pending NEPA documentation. This facility is located on the west side of Highway 172 just off of Highway 36.

Brokenshire Picnic Area is a day use picnic area which was built in the 1950's. It is located on the east side of Highway 172 adjacent to Mill Creek. It is maintained by the caretakers of Camp Tehama on a weekly basis. It is used occasionally as an overflow area for Camp Tehama. There is a vault toilet, and 5 picnic sites.

Hole in the Ground Campground located on Mill Creek has 13 individual camp sites. The 1995 season occupancy rate was 42%. Prior to changes in fishing regulations in 1994 primary use of this campground was recreational fishing. In 1993 the occupancy rate was 66%. Services provided at this location include two sealed vault toilets, two hand pumps, self service fee station, bulletin boards, access road, road signing, and garbage service.

Black Rock Campground located on Mill Creek has 6 individual campsites. The 1995 season occupancy rate was 40%. Primary use of this facility is access to the Ishi Wilderness, nature study, camping, and hiking. Services provided at this location include one sealed vault toilet, self service fee station, bulletin boards, access road, road signing, wilderness trailhead parking, and garbage service. An interpretive display is located just out of the campground on the north side of Mill Creek. This display discusses the history of the Ishi Wilderness, geology of Black Rock, plant and shrubs, and archaeology values.

Proposed wilderness areas within the Mill Creek drainage:

In late 1984, the California Wilderness Act was passed by Congress and signed by the President. That Act established two further planning areas adjacent to Mill Creek. The Wild Cattle Mountain Further Planning Area located adjacent to the southern boundary of the Lassen Volcanic National Park to Growler Hot Springs on either side of Mill Creek. The Mill Creek Further Planning Area located along Mill Creek from Big Bend to Black Rock Campground.

Currently these areas are being managed as roadless areas. Existing roads within and adjacent to the Wild Cattle Mountain Further Planning area are being closed to prevent motorized access from encroaching wood cutter roads. A special use permit application is pending from the owner of Spencer Meadow for road access into his property as an inholder. No action has been taken at this time.

Hiking trails within the Mill Creek drainage:

The Spencer Meadows National Recreation Trail (4E07) is located on the ridge above Mill Creek. This trail is approximately 10.5 miles in length, and is used by hikers, bicyclists, and horses. Reconstruction and constructed loop trail was completed in the early 1990's. Prior to this construction activity the trail was 5.5 miles in length. Trailhead parking exist on Highway 36 near Childs Meadows. The trail ties into the Twin Meadow Trail inside the Lassen Volcanic National Park. Visitor use is estimated at 600 visitor days per year. Use trends are increasing annually.
In the early 1970's the Childs Meadows Resort had a Special Use Permit for use of the Spencer Meadows trail as part of a stable operations. The resort has been in a decline since a fire destroyed a major portion of the improvments, the stable operations has since been moved to the Prattville area.

The Mill Creek Trail (4E10) is located adjacent to Mill Creek with a trailheads near Rocky Gulch and Black Rock Campground. This trail is 20 miles in length; 15 miles are located in the Mill Creek Further Planning Area, and 5 miles are within the Ishi Wilderness. The Yahi Group of the Sierra Club has adopted the 15 miles of trail in the Mill Creek Further Planning area. They perform maintenance yearly on this trail. Maintenance activities include logging out, brushing, and minor tread work. The trail terminates at the private property at Pape Place. Use of this trail is moderate to high, with a noted increase annually as the story of Ishi becomes more widely known.

The Rancheria Trail (2E03) starts at Peligreen Place and intersects the Mill Creek Trail (4E10) at Pape Place. This trail is used primarily by the owners of Pape Place. A portion of the Rancheria Trail provides vehicle access within Ishi Wilderness for the owners of Pape Place. Use of this trail is relatively low.

Kingsley Cove and Table Mountain Trail are accessed from Black Oak Grove off of the Peligreen jeep trail. These trails are 2 miles and 3.5 miles long respectively. They received very low use.

South Mill Creek Trail starts on the south side of Mill off of the Ponderosa Way. This trail was constructed in the early 1990's. The trail travels west along the south side of Mill Creek for approximately 3.5 miles and then south to the Lassen Trail crossing Boat Gunwale Creek. This trail receives light to moderate use, with a trend of increased use as it is discovered.

The Peligreen Jeep Trail and Indian Ridge Trail are located on the north boundary of the Ishi Wilderness. The Peligreen Trails begins at the end of road 28N57 at Round Mountain Springs. This trail accesses an area commonly referred to at the "Front Country OHV area" Common use of OHV trails in this area include camping at Black Oak Grove, Wild Horse Corral, and Peilgreen Place during deer season. Day use by off highway vehicles is moderate in the early spring, late fall and light in the summer months. This OHV trail is also used to access wilderness trailheads on the north boundary of the Ishi Wilderness. Use of this area is low during most of the year increasing to very high during late season deer hunting.

McCarthy Point Lookout located above Mill Creek off of Collins Pine Main Road 1 from Highway 32. This facility was built in the 1930's by the CCC, and was used as a fire lookout until the mid 1960's. After that time McCarthy Point fell to disrepair and is currently being restored. This restoration is being accomplished by a combination of volunteers and forest service labor. When complete it will be placed on the lookout rental program to be used by the public.

SOUTH ANTELOPE DRAINAGE

Within the North, Middle and South Antelope Creek drainages the following recreation facilities are noted:

Dispersed camping along Middle Ridge is low except during late season deer season.

South Antelope Campground is a small developed site along South Antelope Creek. There is a vault toilet, garbage service, and 5 small camp units. Use of this facility is low, generally less than 15% occupancy. The recent change in fishing regulations on this stream have not effected the use of this campground.

The McClure Hiking Trail (1E01) is located along North Fork of Antelope Creek. This trail is approximately 4.5 miles in length and is accessed from either Payne Place Campground (located on State Lands), or at High Trestle off of Forest Service road 28N23 and Hogsback Road 774A.

The Front Country OHV area is located south of the Antelope drainages, it is referenced above.

DEER CREEK DRAINAGE

The The Pacific Crest National Scenic Trail (PCNST) is accessed via the Carter Meadows trail off of Forest Service Road 28N49. The PCNST travels near the headwaters of Deer Creek at Butt Mountain. Use of both trails is light to moderate. Motorized and mechanized vehicles are prohibited from use on the trail. The PCNST is maintained annually by a combination of forest service employees and volunteers from the Back Country Horsemen Association and the Pacific Crest Trail Association.

Developed campgrounds along the Deer Creek drainage include:

Forest order # 96-2 prohibits camping except in developed campgrounds within the Deer Creek corridor along Highway 32.

Elam Creek Campground/Day Use Area Both located just off of Highway 32 receive high use from April 15 through November 1 at which time the campground closes. The day use area remains open year round. Both of these facilities are operated under a concessionaire permit for care/policing and maintenance. Both of these facilities have new block design SST, sealed vault toilet which were installed in 1991. Fishing restrictions on Deer Creek did not affect this facility.

Alder Creek Campground is a small heavily used campground located on Deer Creek and accessed off of Highway 32. This facility has an 85% occupancy rate. Facilities include, vault restroom, garbage service, stoves, and tables. Interior roads are rough and eroded, camp sites are of low standard. Changes in fishing regulations did not affect this campground. Substantial foot traffic from the campground to the creek is evident.

Potato Patch Campground is a 32 unit located off Highway 32 near Deer Creek. Current use is down significantly since the implementation of special fishing regulation on Deer Creek. Potato Patch has a nature trail which follows the creek. A number of foot trail radiate from the campground to the creek to gain access for fishing and water play. The vault toilet were lined in the early 1990's to prevent leakage into Deer Creek.

The Deer Creek Trail (4E15) is accessed from Highway 32 at the steel bridge. This trail is maintained annually and receives moderate to high use throughout the recreation season. This trail is approximately 4 miles long, and terminates at Wilson Cove. Due to budget cut backs in the 1980's this trail was not maintained from that point. Prior to that the trail was maintained along the south side of Deer Creek near Polk Springs.

A dispersed camping site is located on Deer Creek between Highway 32 and Ponderosa Way. This site is commonly referred to as upper Deer Camp crossing. The above mentioned trail travels through this camp area toward Wilson Cove. This camp area receives moderate to heavy use from early spring to late fall. There are facilities associated with this dispersed site. In recent years the recreation group has made an attempt to clean fire rings and pick up trash in the fall. Formalizing this site with a toilet, firerings and garbage pick has been considered, however budgets prevent implementation. This site is accessed from Highway 32 on the "A" line (taking off at the passing lanes on Highway 32). Use of this site has not decreased with the implementation of special fishing regulations.

A dispersed camping site near Polk Springs receives light use. A large portion of this area was not available to the general public for year due to placement of a gate well away from the private property at Polk Springs. The Big Smokey Trail ((3E18) is no longer maintained as system trail, but is used by forest service employees and public to access Deer Creek. Evidence of tread and trail blazing are evident.

Murphy OHV trail (3E19) is access from the "H" line. This trail is steep, highly eroded and used primarily by jeeps, quad runners and hikers to access Deer Creek and Big Smokey Creek. It is approximately 2.5 miles long and used to tie into the Big Smokey Creek Trail mentioned above. This trail receives light use with a slight increase during hunting season. This trail is under an adopt-a-trail with a valley 4X4 club.

The Devils Parade Ground is designated in the Lassen Land and Resource Management Plan as a 6900 acre semi-primative non-motorized area.

A number of inholder parcel are located in the Ishi Wilderness along Deer Creek. A portion of the Appersons Cow Camp is being considered for a land exchange with the Mill Creek Recreation Residence Tract. Other private lands south of the wilderness boundary are also being considered in this exchange.

A number of dispersed camp site exist along Deer Creek just off of the Ponderosa Way on the east boundary of the Ishi Wilderness. The most popular and heavily use is Gaither Camp. Gaither Camp was improved with the installation of an fiberglass SST design restroom, and regular garbage service. At this time there are no tables or grills. This camp receives moderate to heavy use in the spring and fall. Use at this camp has not changed with the change in fishing regulations. This camp has been vandalized on a regular basis since the installation of the bathroom and bulletin boards. Presumably by locals (Cohassett) who don't want other using this site. This camp is used primarily by visitors to the Ishi and fishermen.

Deer Creek Trail (4E15) and trailhead are located on the west side of Ponderosa Way on the north side of Deer Creek. This trail is approximately 6 mile long and travels along Deer Creek and terminates at private property near Deer Creek Crossing. Use of this trail has increased in the past 5 years, presumably due to the increased interest in the story of Ishi. This trail is maintained annually by a combination of volunteer and forest service labor. Two recent fires in the area have caused loss of vegetation along the trail in places. Parking is limited at the trailhead and occasionally vehicle encroach on the trail. The trailhead is planned for minor improvements during FY 96 by smoothing parking, and placing rocks to restrict motorized access to the trail.

The Graham Pinery (Devils Den) trail (2E09) is 4 mile long and is accessed from Cohasset Ridge Road and the Ponderosa Way south of Deer Creek. This trail is under an adopt-a-trail agreement with the California Horsemen Association. During the Campbell fire a dozer enter the wilderness from the Cohasset Ridge Road and created a wide, extremely steep road which has eroded in places. This is a popular trail, especially the portion along south Deer Creek.

In the past two year two separate outfitter and guide application have been received for use of both Deer Creek Trail (4E15) and the Devils Den Trail (2E09). One proposal included use of stock for multiple day outings, and the other for backpacking multiple days. At this time the Lassen National Forest is in the process of amending the Land and Resource Managment Plan for wildeness and only day use outfitter and guides are being issued until direction is established.

APPENDIX J - FIRE AND FUELS

Fire and Fuels

Judy Forbes
District Fuels Management Officer
10/9/96

Introduction

Fire has played an important role in shaping the structure and composition of montane coniferous forests in the Sierra Nevada and Cascade Mountains of Californina.

Fire severity and frequency range from infrequent severe stand replacing fires that kill mature trees and regenerate new stands, to frequent low severity fires that kill seedlings and saplings and maintain open forest understories (Agee 1993).

The Mill Creek, Deer Creek and Antelope Creek watersheds have experienced significant disturbance during the last few centuries in the form of repeated fire.

Fuel Profile

Dead and down fuel loadings within the three watersheds range from 3 to over 43 tons per acre. Most of the heavier fuel loadings exist at the higher elevations or within the Deer Creek watershed. Portions of the analysis area have been inventoried using the Handbook for Inventorying Downed Woody Material (Brown 1974) and the Photo Series for Quantifying Natural Forest Residues (Blonski and Schramel 1981). An average range of 3 to 43 tons per acre were recorded within the Deer Creek watershed; 6 to 29 tons per acre were found in the Mill Creek watershed; and 3-31 tons per acre within the Antelope Creek watershed.

Fire History

Fire history recods indicate 683 total fires within the three watersheds since 1917.

Deer Creek – 388 total fires. 257 were lightning caused and 131 person caused. 19 of these fires exceeded 100 acres.

Mill Creek – 177 total fires. 117 were lightning caused and 60 person caused. 8 of these fires exceeded 100 acres.

Antelope Creek – 118 total fires. 69 were lightning caused and 49 person caused. 12 of these fires exceeded 100 acres.

Fire Frequency

Fire sizes and fire frequency have varied by time period in California forests. Fire sizes decreased dramatically after a policy of fire suppression was instituted in the Lassen National Forest (Taylor 1990). Fire scar data from trees in Deer Creek and Mill Creek show that over ten fire scars per sample were not uncommon, but most fire scars collected were dated to the ninteenth century (Norman and Taylor 1996).

The twelve sites evaluated in the Deer Creek and Mill Creek study present a wide range of mean fire intervals. In some locations fire return intervals of less than 10 years were common, especially before 1875. Sites lowest in the landscape (lower slopes and bottomland sites) experienced a fire every 26 years on average, while middle slopes averaged 17 years, and upper slopes and ridge tops averaged a fire every 12 years (Norman and Taylor 1996).

The distribution of fire through time also varied considerably. Although fires all but stopped at the turn of the twentieth century, the period from 1875 to 1899 did experience significantly fewer fire events than had the two previous 25-year periods (Norman and Taylor 1996).

In a few locations, the season of burning also varied through time. Most fires occurring in the watersheds occurred during the dormant season, after the trees had stopped growing. Yet significantly, 11% of fires occurred late in the growing season, and 9% occurred during the primary growing season (Norman and Taylor 1996).

The twelve sites studied show significant variation in their fire regimes. Light, ground fires are suggested by low fire-return intervals for some sites. These fires may have been less likely to leave a record of their passing than more intense fires (Norman and Taylor 1996).

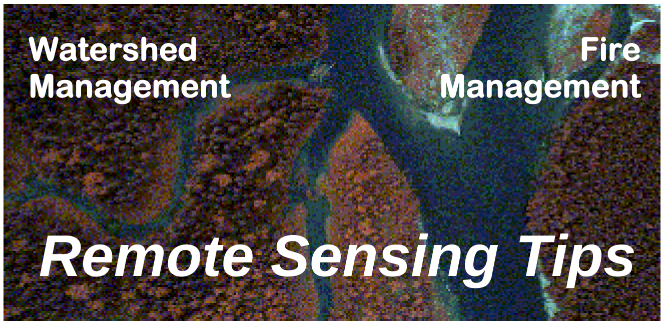
Upper slopes and ridge tops exhibit frequent fires once every 11-13 years on average, but are known to occasionally experience return intervals comparable to some of the least-burned sites. Middle slopes burned every 14 to 24 years on average, apparently independent of aspect. Lower slopes typically burned much less often than sites further up slope and experienced fires every 25 to 30 years on average (Norman and Taylor 1996).

One site, located only 420 ft. above Mill Creek, had a mean fire interval of 13 years, a value low for sites at that position in the landscape. This is probably in part a function of the southwest aspect of the site. A greater than normal Native American influence is possible as well, although there appears to be minimal variation in the return interval between 1795 and 1898 that would be expected if local Natives supplemented the non-anthropogenic fire regime (Norman and Taylor 1996).

These fire-return intervals of the mixed conifer forests of the watersheds appear somewhat consistent with results of other researchers. Solem (1995) described a mean fire interval of 19 years I the mixed conifer communities of the Caribou Wilderness of Lassen National Forest. Farther south, in the Sequoia-Mixed Conifer forests of Sequoia National Forest, fire intervals of 8 to 18 years were noted between 1700 and 1875 (Kilgore & Taylor 1979). In the Siskiyou Mountains of Oregon, fire return intervals averaged 18 years (Agee 1991), (Norman and Taylor 1996).

The most critical results of this study for land management are the marked differences between the time since last fire and the known maximum interval of the range before fire suppression. All study sites have greatly exceeded their maximum fire return interval of the 1800's. Some locations should have experienced at least four fires since the last recorded fire event. The unavoidable increase in fuel loading and probable modification of species regeneration patterns and wildlife habitat that normally follow such a significant change in the natural fire regime may have also reached levels unmatched at any time during the last few centuries (Norman and Taylor 1996).

APPENDIX K -FUEL LOADING & FIRE RISK ASSESSMENT



United States Department of Agriculture
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Fuel Loading and Fire Risk Assessment

Lassen National Forest

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Overview

The role of natural and prescribed fire is in transition throughout public lands in the West. Land managers are reexamining fire policy and developing strategies taking new perceptions into account. This project targets three watersheds within the Lassen National Forest and examines the historical, present, and predicted future impacts of fire using remote sensing and geographic information systems (GIS) technology. Of concern in these areas are cultural, recreational, and timber resources and anadromous fish populations. In addition, homes and small communities are scattered throughout the forest, and the safety of them and their occupants are of critical importance.

A 1994 satellite image was used create a vegetation map which was cross-referenced with fuel types to create a map of fuels. A large burn that occurred late in 1994 was evaluated through a change-detection analysis to update the map and indicate the current status of fire fuels. Fire modeling software was used to simulate fire behavior under extreme conditions using different management scenarios. The results of this project will assist long-term planning efforts for the forest and increase knowledge of fire patterns and behavior. This project was sponsored by the USDA Forest Service Remote Sensing Steering Committee.

Project Objectives

Numerous objectives were fulfilled in this project including:

1. Developing a fuels map revealing current fire risk from a satellite-derived vegetation map.
2. Using historical data to create GIS maps portraying past vegetation cover and the history of fire occurrence and intensity.
3. Evaluating differences between historical and current fuel conditions.
4. Identifying management strategies to protect people and structures within the forest from fire.
5. Applying GIS fire-modeling software to quantify results of fires within the forest.
6. Examining the impacts of a severe burn that occurred in the Lassen National Forest in late 1994 through the use of imagery collected in pre- and post-burn periods.

Project Area

The Lassen National Forest is located in northern California and covers about 1.4 million acres. The streams within the study watersheds provide some of the last habitat for spring-run chinook salmon in California. Estimates indicate that habitat for this salmon has dropped from 6,000 to less than 300 miles. A catastrophic fire would threaten the habitat even further. The natural aquatic resources within Lassen are typical of those currently in jeopardy throughout the region. This situation makes informed management decisions about fuels and other area problems very important.

Fuels Map Development

A map of current vegetation, known as the Classification and Assessment with Landsat of Visible Ecological Groupings or CALVEG, was completed for the study area by the Forest Service Pacific Southwest Region Remote Sensing Lab. The vegetation map was developed from Landsat Thematic Mapper (TM) imagery using automated image classification procedures. Resource specialists from the Lassen National Forest and Forest Service Remote Sensing Applications Center cross-walked the CALVEG map to a fuels map of Northern Forest Fire Laboratory (NFFL) fuel types described by Anderson (1982) (Figure 1). The NFFL system classifies fuel into four groups with further distinctions producing the 13 fuel types. The groups are grasses, shrubs, timber, and logging slash.

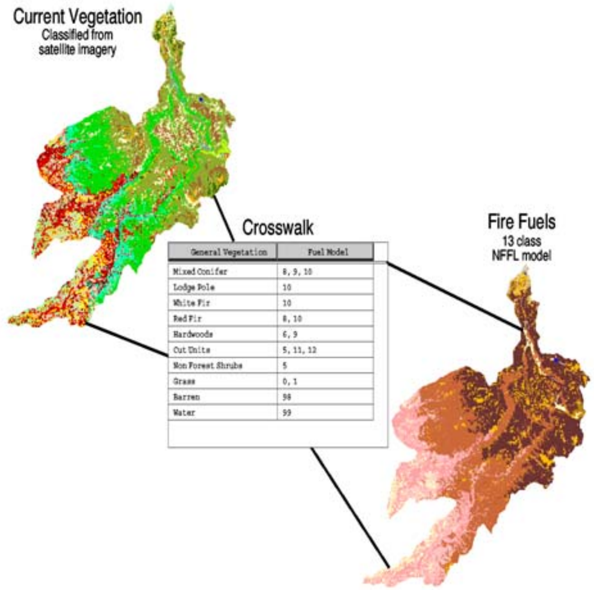

Figure 1-K. Cross-walk of CALVEG map to NFFL fuel type map.

Change-Detection Analysis

An extensive burn, the Barkely Fire, occurred late in 1994 after the imagery used for the vegetation map was acquired. To include the change in fuel loads created by the fire, a change-detection analysis was performed. Landsat TM imagery of the forest was collected for two time periods: pre-burn (1994) and postburn (1996). A map of change was created from the change detection analysis (figure 2). The output from the change-detection analysis was used to update the existing fuel map layers.

Historical Conditions

Pre-settlement vegetation conditions were modeled using two methods. The majority of the study area was modeled from existing data by the regional zone ecologist to approximate natural vegetation conditions. The model integrated information from plot data, soils, slope, aspect, elevation, temperature, and precipitation map layers. Lightning ignition patterns and fire regimes were also used in the model. In areas where data was not available, local knowledge and historic photography were pooled to estimate historical vegetation. The resulting historical vegetation model was cross-walked to the 13 NFFL fuel types.

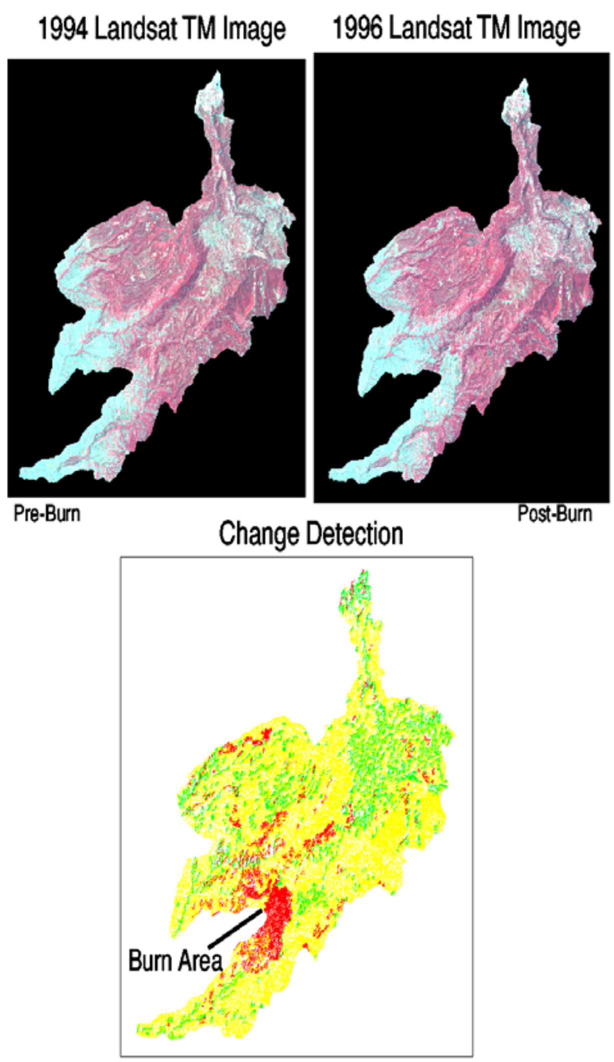

Figure 2-K. Pre-burn and postburn Landsat TM images (top) were used to create a map of change (bottom).

Fire Simulation

The fire-growth model FARSITE (Fire Area Simulator) is being used to simulate fires within the study watersheds (Finney 1993). FARSITE is built upon earlier models such as BEHAVE (Andrews 1986) and offers a spatial approach to predicting fire spread and behavior. The model relies on elevation, slope, aspect, fuel, crown cover, and weather data to make its predictions. Users can select points to ignite fires, select the duration of the burn, and erect barriers to fire spread. Although the terrain and fuel layers are input as raster map layers, FARSITE outputs vectors to represent spatial and temporal fire dimensions (Finney 1996). This output can be exported in numerical or graphical form and displayed in a GIS (Figure 3).

Fires were simulated on the Lassen National Forest in high-risk conditions with three fuel types. Situations included dry, hot conditions with strong winds. The fuel types were grass, shrub, and timber. These simulations were designed to create worst-case scenarios and examine their potential consequences on the study watersheds.

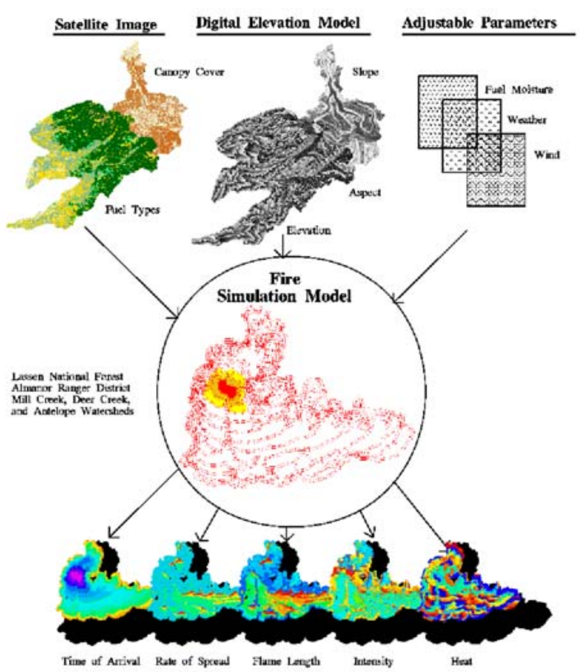

Figure 3-K. Fire simulation results from a three watershed fire on the Lassen National Forest.

Results

A comparison of present and historical fuel conditions shows a shift to more severe fuel types (Table 1). There was a 50,163-acre increase from timber to shrub fuel types. Other results include: 101,644-acre loss of timber fuel type 8 (slow burning ground fires with low flames); 20,875-acre loss of timber fuel type 9 (a slightly faster-burning surface fire with higher flames); and 68,634-acre gain in timber fuel model 10 (fires burning on the ground surface with greater intensity). The results indicate that the chance of a catastrophic fire occurring in these watersheds has greatly increased.

The results of the FARSITE fire modeling reinforce the conclusion that a catastrophic fire is more likely. The three fires simulated in the watersheds for the different fuel types resulted in larger, more intense fires in the present than in the historical fuel layers even though they were ignited in the same place with identical weather conditions. In the grass type, 1,241 acres burned in the historical fire compared to 7,304 acres in the present. In the shrub type, 1,710 acres burned in the historical fire compared to 4,044 acres in the present. In the timber type, 3 acres burned in the historical fire compared to 175 acres in the present. A set of arc-macro-language (AML) programs was developed to compare the FARSITE outputs. The AML builds the FARSITE data into an ArcInfo format and displays the results, which are calibrated to each other for the historical and present layers. The AML also performs a change-detection analysis on the FARSITE output for the area the fires have in common (Figure 4, next page). Change detection is helpful in visualizing the different fire behaviors. The AML can also predict how fires react to different fuel management strategies.

Table 1-K. Difference in acres between the historical and present vegetation.

Fuel Model	Historical	Present	Change
Grass Group	**acres**	**acres**	**acres**
1. Short grass	8,246	11,618	3,372
2. Timber grass understory	0	0	0
3. Tall grass	0	0	0
Shrub Group			
4. Chaparral (6 feet)	19,400	31,262	11,862
5. Brush (2 feet)	5,172	17,754	12,582
6. Dormant brush	690	30,936	30,246
7. Southern rough	4,527	0	-4,527
Timber Group			
8. Timber with normal dead	106,040	4,396	-101,644
9. Open pine with grass	106,068	85,193	-20,875
10. Timber with heavy dead	9,863	78,497	68,634
Logging Slash Group			
11. Light logging slash	0	0	0
12. Medium logging slash	0	0	0
13. Heavy logging slash	0	0	0
Other			
98. Water	134	134	0
99. Barren	1,492		

Further tests will be conducted by the Lassen National Forest before any management decisions about the watersheds are made. Several assumptions were made during the project, such as how fuel moisture impacts the fire model, if historical vegetation map layers are reliable, and whether FARSITE truly reflects the way a real fire behaves. These assumptions and others need to be validated by resource specialists who are more familiar with the forest.

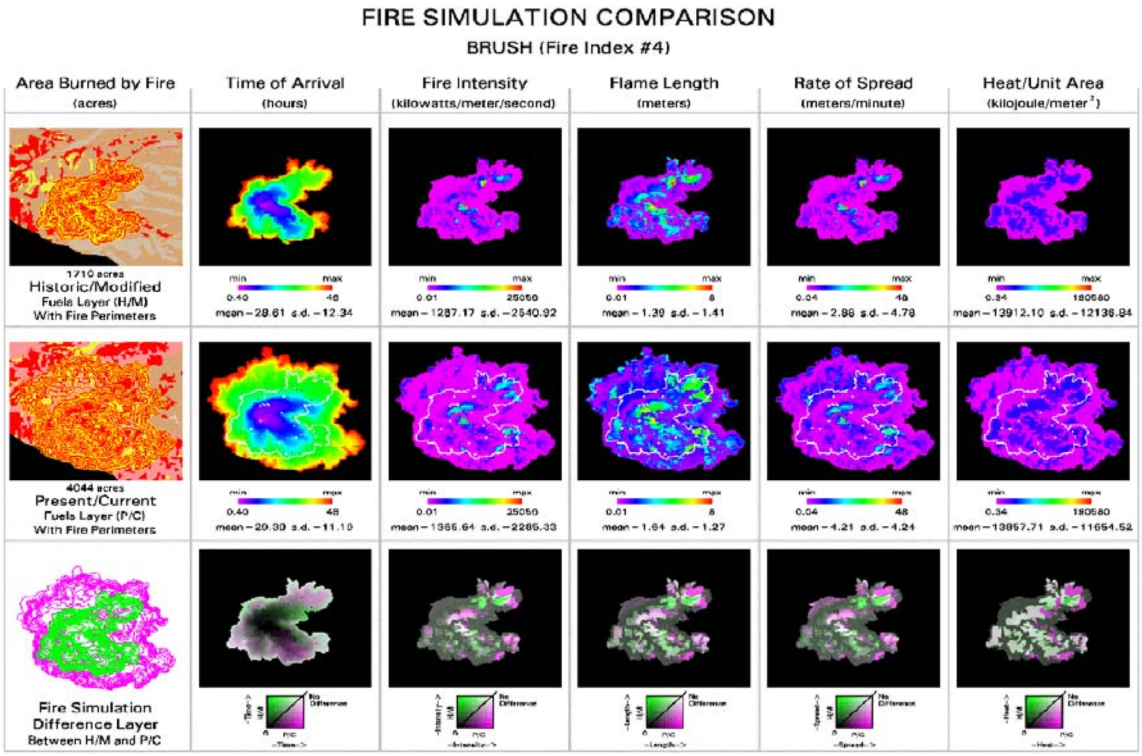

Figure 4K. Comparison of FARSITE data outputs and automated change detection analysis.

Suggested Readings

Suggested Readings

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APPENDIX L - FIRE HISTORY

FIRE HISTORY OF SELECTED SITES IN THE DEER CREEK & MILL CREEK WATERSHEDS LASSEN NATIONAL FOREST, CALIFORNIA

A report submitted to
Lassen National Forest

by Steven P. Norman and Alan H.Taylor Department of Geography
The Pennsylvania State University
26 September 1996

INTRODUCTION

Repeated natural disturbance is an integral component of forest ecosystems (White 1979). During the last few decades, many researchers have documented both the spatial pervasiveness and surprisingly high temporal frequency of pre-Euro-American fire disturbance (Agee 1993, Heinselman 1973, Minnich 1983, Taylor 1993). The historic importance of fire in Western forests is perhaps best demonstrated by the profound ecological changes that have taken place since fire suppression (Agee 1993, Baker 1993, Parsons & DeBenedetti 1979, VanKat and Major 1978).

As a result, a keen understanding of historic disturbance regimes and their effects on the landscape is vital to any successful comprehensive management strategy.
Ile Mill Creek and Deer Creek watersheds in the Almanor Ranger District, Lassen National Forest, California, have experienced significant disturbance during the last few centuries in the form of repeated fire. In this report, the fire history of twelve locations within these two watersheds is presented.

METHODOLOGY

Each of the thirteen ECOS sites were revisited in June of 1996. These sites had been established and marked with metal tags during 1984 and 1985 by previous researchers. At four sites (ECOS 22, 31, 136, and 159), clearcutting, selective logging, road relocation or logging road construction since 1985 precluded a successful rediscovery of the acmal plot tags used to mark the plots' locations, but Forest Service records that included directions from known landmarks, slope aspen and elevation provided sufficient detail to relocate all sites successfully in the field. U.S.G.S. 7.5 minute topographic maps showing the location of these plots were used to confirm the locations, especially when changes in road numbers had occurred since 1985.

At each site, a reconnaissance was made in an area ranging from one-quarter to three hectares that, given the topography of the site, was believed to have experienced a uniform fire history. From two to five samples were collected at each site depending on 1.) their proximity to the ECOS plot, 2.) the number of fire scars noted, 3.) the condition (i.e. structural integrity) of the sample, and 4.) the species. (Cedar is often more difficult to cross date than sugar pine or ponderosa pine).
At one site (ECOS 158) no collectable fire scars were found that could permit a meaningful establishment of the fire history of the site independently from that of adjacent ECOS 157. Only about 100 to 150 meters separate the two sites, and the geometry of the location suggests that fires moving into the area would have probably burned both sites with relative consistency, provided that the slightly steeper slope at ECOS 158 did not remove too much fuel.

Wedges from live trees were sampled using a chain saw according to the methods of Arno and Sneck (1977). Live trees were only sampled when multiple fire scars were apparent in the exposed scar-face. Disks from stumps showing multiple fire scars were also collected; in some sites these were the only fire records available. At times, some excellent records were noted in stumps that could simply not be collected because of pronounced deterioration since logging. Given that the acknowledged fire-frequency at a site increases with the number of trees sampled (Agee 1993), this "deteriorated stump factor” may have resulted in an artificially high fire return interval for some sites. As an advantage though, a few deeply embedded fire scars were sampled from stumps showing no outward evidence of fire whatsoever. Had the site not been logged, these trees would not have been sampled.

In the laboratory, samples were plane-sanded on both the upper and lower face using successively fine textured sand paper. Both live wedges and stump samples were visually cross dated using the known pattern of marker rings according to published chronologies from Lassen Peak and Susanville, California and personal experience in cross dating samples west, south and northeast of the Almanor Ranger District. The principle marker rings used in cross dating were 1992, 1987, 1977, 1960, 1955, 1935, 1931, 1924, 1922, 1918, 1899, 1890, 1867, 1864, 1862, 1859, 1850, 1829, 1822, 1796, 1795, 1783, 1756, 1748, 1690, 1639, 1629, 1580. Both the year of scarification and the season, when possible, was noted.

RESULTS

A total of 36 fire-scarred trees and stumps were collected in the field, although only 30 (80 %) were considered viable for cross dating and interpretation. Some stump samples with eroded outer wood demonstrated complacent growth that precluded reliable cross-dating. Other samples included an insufficiently long record to verify the years in which fire events occurred. In order to successfuly integrate samples from a given site to form a composite record, the year of every event must be finally established, and this criterion was not always met

Samples with over ten fire scars were not uncommon, but most fire scars collected were dated to the nineteenth century, and it is believed that inferences made of the fire regime before the 1790s cannot be made for want of a sufficiently large sample size. This report then, summarizes data collected for the last two centuries, and may or may not suggest prior fire return intervals during the period for which there is no reliable record.

The twelve sites evaluated in this study present a wide range of mean fire intervals (table 1), In some locations fire return intervals of less than 10 years were common, especially before 1875 (appendix I). Sites lowest in the landscape (lower slopes and bottom-land sites) experienced a fire every 26 years on average, while middle slopes averaged 17 years, and upper slopes and ridge tops averaged a fire every 12 years.

The distribution of fire through time also varied considerably (figure I and appendix 1). Although fires all but stopped at the turn of the twentieth century, the period from 1875 to 1899 did experience significantly fewer fire events than had the two previous 25-year periods. In figure 1, no attempt is made to isolate far-reaching, large-scale fires from small local fires. Given the separation of most collection points it is impossible to know if these are one or multiple fires. Consequently, two sites with fire events in the same year are counted twice in figure 1.

In a few locations, the season of burning also varied through time (appendix 1). Most fires occurring in the watershed (80%) occurred during the dominant season, after the trees had stopped growing. Yet significantly, 11% of fires occurred late in the growing season, and 9% occurred during the primary growing season. Of interest, these non-dormant fires were relatively site- specific; i.e. some sites appear more vulnerable to non-dormant season fires than others.

CONCLUSIONS

The twelve sites studied show significant variation in their fire regimes. Light, ground fires are suggested by low fire-return intervals for some sites. These fires may have been less likely to leave a record of their passing than more intense fires. As a result, the inferred fire-return intervals presented here must be deemed maximum intervals. At minimum., the fires burned with this frequency, but more events undoubtedly occurred, which either did not scar the trees or were not sampled. A complete fire record is not possible at the micro-scale level of investigation used in this analysis.

On the whole, the twelve sites considered in this study are relatively consistent when grouped according to topographic position (table 1). This should come as no surprise, as fire burns more readily uphill than downhill, and because places high in the landscape can receive fires from a larger down slope area than places low in the landscape. Upper slopes and ridge tops exhibit frequent fires once every 11 - 13 years on average, but are known to occasionally experience return intervals comparable to some of the least-burned sites. Middle slopes burned every 14 to 24 years on average, apparently independent of aspect. Lower slopes typically burned much less often than sites further up slope and experienced fires every 25 to 30 years on average. Of interest however, the minimum return interval of these sites that burn less frequently is not much different than is the mean interval of the most often burned sites.

One significant anomaly among the lower slope sites is noted however. Site 60, located only 130 meters elevation (420 ft.) above Mill Creek, had a mean fire interval of 13 years-a value atypically low for sites at that position in the landscape (table 1). This is probably in part a function of the southwest aspect of the site. A greater than normal Native American influence is possible as well, although there appears to be minimal variation in the return interval between 1795 and 1898 that would be expected if local Natives supplemented the non-anthropogenic fire regime (appendix 1).

These fire-return intervals of the Mixed Conifer forests of the Mill Creek and Deer Creek watersheds appear somewhat consistent with the results of other researchers. Solem (1995) described a mean fire interval of 19 years in the Mixed Conifer communities of the Caribou Wilderness of Lassen National Forest. Farther south, in the Sequoia-Mixed Conifer forests of Sequoia National Forest, fire intervals of 8 to 18 years were noted between 1700 and 1875 (Kilgore & Taylor 1979). In the Siskiyou Mountains of Oregon, fire return intervals averaged 18 years (Agee 1991).

Perhaps the most critical results of this study for land management are the marked differences between the time since last fire and the known maximum interval of the range before fire suppression. All sites have greatl exceeded their maximum fire return interval of the 1800s (appendix 1, figures 2, and 3). Some locations-sites 23, 55, 60, and 159 in particular-should have experienced at least four fires since the last recorded fire event even when the maximum return intervaal of the last century is applied. The unavoidable increase in fuel loading and probable modification of species regeneration patterns and wildlife habitat that normally follow such a significant change in the natural fire regime may have also reached levels unmatched at any time during the last few centuries.

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5

Attachment 1: Summary of data by site

ECOS 21: 5 km. E. of lshi Wilderness, on upland edge of Deer Creek Gorge
Butte Meadows NW, CA Quad.)

UTM grid location:	6155 E, 44433 N
elevation:	1020 m. (3360 ft.)
aspect:	225 degrees (WNW)
topographic position:	ridgetop

FIRE REGIME

fire years, seasons *(& intervals): 1949-D (28) 192 1 -D (22) 1899-D (I 1) 1888-D (8) 1880-D (7) 1873-D (9) 1864-D (6) 1858-IIE (2) 1856-L (5) 1851 -mE (5) 1846-U (5) 1841 -L (8) 1833-L (22) 181 1 -U (20) 179 1 -D.

mean fire-return interval:	24 years (1791-1949)
time since last fire:	47 years (1949-1996)
previous maximum of range:	28 years (1921-1949)

ECOS 22: W. of Carter Meadow, above Deer Creek Jonesville NW, CA Quad.]

UTM grid location:	6334 E, 44542 N
elevation:	1630 m. (5360 ft.)
aspect:	90degrees (ENE)

topographic position: middle slope
FIRE REGIME
fire years, seasons* (& intervals): 1898-U (I 1) 1887-D (24) 1863-D (34) 1829-D (17) 1812-D (17) 1795-D (26) 1769-D (40) 1729-D
mean fire-return interval: 24 years (1729-1898)
time since last fire: 98 years (1898-1996)
previous maximum of range: 40 years (1729-1769)

ECOS 23: N. of Carter Meadow, above Deer Creek Jonesville NW, CA Quad.]
UTM grid location: 6348 E, 44552 N
Elevation: 1710m. (5600 ft.)
Aspect: 3000 (WNW)
topographic position: middle slope
FIRE REGIME
Fire years,seasons*(&intervals): 1896-eE(15)1881-IE(10)1871-IE(22)1849-D, 0 possible fire about 1818, possible fire about 1796
mean fire-return interval: 16 years (1849-1896)
time since last fire: 100 years (I 896-1996)
previous maximum of range: 22 years (1849-1871)

ECOS 31: 2 km. W. of Deer Creek Meadows above Alder Creek (Child's Meadow, CA Quad.)
UTM grid location: 6309 E, 44585 N
elevation: 1490m. (4900 ft.)
aspect: 40 degrees (NNE)
topographic position: middle slope
FIRE REGIME
.flreyears,seasons*(&intervals): 1892-D(21)1871-D(7)1864-D(9)1855-U(6)1849-D (14) 1835**-U (6) 1829-D (10) 1819-D (43) 1776-D (I 1) 1765-D (14) 1751-D
rmanfire-return interval. 14 years (1751-1892)
time since lastfire: 104 years (I 892-1996).
previous maximum of range: 43 years (1776-1819).

ECOS 55: Above Dead Horse Creek (Deer Creek) [Butte Meadows NE, CA Quad.)
UTM grid location: 6182 E, 4452 N
elevation: 15 1 0 m. (4950 ft.)
aspect: 1150 (SSW)
topographic position: upper slope
FIRE REGIME
fire years, seasons* (& intervals): 1898-L (17) 1881-L (8) 1873-L (4) 1869-D (5) 1864-D (18) 1846-D (2) 1844-D (2) 1842-D (4) 1838-D (9) 1829-D (2) 1827-L (9) 1818-D (19) 1799-D (4) 1795-D (9) 17WD (7) 1779-D (7) 1772-D.
mean fire-return interval: 13 years (1772-1898)
time since last fire: 98 years (1898-1996)
previous maximum of range: 19 years (1799-1818)

ECOS 60: East of Jones Valley above Mill Creek (Mineral, CA Quad.)
UTM grid location 6233 E, 44640 N
Elevation: 1460 m. (4800 ft.)
Aspect: 225c (SSW)
Topographic position: lower slope

FIRE REGIME
Fire years, seasons*(&intervals): 1898-D(15)1883-D(13)1870-D(9)1861-D(6)1855-D (14) 1841-D (12) 1829-D (17) 1812-D (17) 1795-D.
Mean fire return interval: 13 years (1795-1898)
Time since last fire: 98 years (1898-1996)
Previous maximum of range: 17 years (1812-1829)

ECOS 61: Mineral Summit above Mill Creek (Mineral, CA Quad.)
UTM grid location: 62009 E, 44645 N
Elevation: 1585 m. (5200 ft.)
Aspect.- 140 degrees (SSE)
Topographic position: upper slope

FIRE REGIME
fire years, seasons* (& intervals): 1903 -D (33) 1870-D (9) 186 1 -D (I 2) 1849-D (3) 1846-D (2) 1844-D (3) 184 1 -D (7) 1834-D (22) 1812-D (26) 1786-D (6) 1780-D (I 1) 1769-IE (4) 1765-D (2) 1763-D.
Mean fire-return interval: 11 years (1763-1903)
Time since last fire: 93 years (1903-1996)
Previous maximum of range: 33 years (1870-1903)

ECOS 69: Near trailhead above Jct. of Rock Gulch Creek and Mill Creek 2.8 km S. of Hole in the Ground Campground (Mineral, CA Quad.)
UTM grid location: 6216 E, 44602 N
elevation: 1335 m. (4380 ft.) aspect. 115-D (ESE)
topographic position: lower slope (95 m. elevation above Mill Creek)

FIRE REGIME
Fire years, seasons* (& intervals): 1884-mE (19) 1865-mE (40) c. 1825-U
mean fire return interval: 30 years
time since last fire: 112 years (1884-1996)
previous maximum of range: 40 years (I 825-1865)

ECOS 136: By Slate Creek Bridge along Deer Creek (Jonesville NW, CA Quad.)
UTM grid location: 63 1 0 E, 44549 N
Elevation: 1317 m. (4320 ft.)
Aspect: none (at base of SSE facing slope)
topographic position: bottomland (terrace of Deer Creek)
FIRE REGIME

fire years, seasons (& intervals): 1896-U (24) 1872-D (34) 1838-D (56) 1782-D.
mean fire-return interval 38 years (1782-1896)
time since fire: 100 years (1896-1996)
previous maximum of range: 56 years (1782-1838)

ECOS 137: N. of Slate Creek Bridge above Deer Creek (Jonesville NW, 6A Quad)
UTM grid location: 6323 E, 44552 N.
elevation: 1347 m. (4420 ft.)
aspect: 3600 (NNW)
topographic position: lower slope

FIRE REGIME
fire years, seasons* (& intervals): 1898-D (34) 1964-U (25) 1839-U (10) 1829-D (47) 1782-L (10) 1772-L.
mean fire-return interval. 25 years (1772-1898) time since last fire: 98 years (1898-1996)
previous maximum of range: 47 years (1782-1829)

ECOS 157: NW. of Colby Mtn. Lookout above S. Fk. Calf Creek of Deer Creek (Butte Meadows NE, CA Quad.)
UTM grid location: 6236 E, 44457 N
Elevation. 1067 m. (3500 ft.)
Aspect: 55 degrees (ENE)
topographic position: lower slope

FIRE REGIME
fire years, seasons* (& intervals): 1898-L (34) 1864-D (23) 184 1 -D (I 9) 1822-D (26) 1796-D (Other probable fires at c.1777(suppression), c.1723,and 1632.)
mean fire-return interval: 26 years (1796-1898) 98 years (1898-1996)
time since last fire:
previous maximum of range: 34 years (1864-1898)

ECOS 158: No data was directly obtained from this site for want of collectable material. It is probably that even with the local WNW aspect of ECOS 158, its fire history is comparable to adjacent plot ECOS 157 (c. 100- 150 meters separate the two sites).

ECOS 159: NW. of Colby Mtn. Lookout above S.F. Calf Creek of Deer Creek (Butte Meadows NE, CA Quad.)
UTM grid location: 6224 E, 44463 N
elevation: 1244 m. (4080 ft.)
aspect: 2600 (WSW)
topographic position: middle slope

FIRE REGIME

fire years, seasons* (& intervals): 18WD (16) 1864-D (16) 1848-D (19) 1829-U (7) 1822-ID (IO) c. 1812* *-U

* Season of scarification inferred when possible from the position of the scar within the annual growth ring. Letter codes are as follows: D, dormant; L, late growing season (latewood); mE, middle; eE, early earlywood, U, undetermined.

** estimated

Table 1-L.- Site characteristics and fire history* sorted by 1.) topographic position and 2.) elevation

Site	Topo-position	Elevation (m)	Aspect	Mean Fire Interval (years)	Maximum Interval (years)	Minimum Interval (years)
ECOS 21	ridgetop	1020	NW	11	28	2
ECOS 61	upper slope	1585	SE	11	33	2
ECOS 55	upperslope	1510	SW	13	19	2
ECOS 23	middle slope	1710	NW	16	22	10
ECOS 22	middle slope	1630	NE	24	40	11
ECOS 31	middle slope	1490	NE	14	43	6
ECOS 159	middle slope	1244	SW	14	19	7
ECOS 60	lower slope	1460	SW	13	17	6
ECOS 137	lower slope	1347	NW	25	47	10
ECOS 69	lower slope	1335	SE	30	40	19
ECOS 157/8	lower slope	1067	NE	26	34	19
ECOS 136	bottomland	1317	none	38	56	24

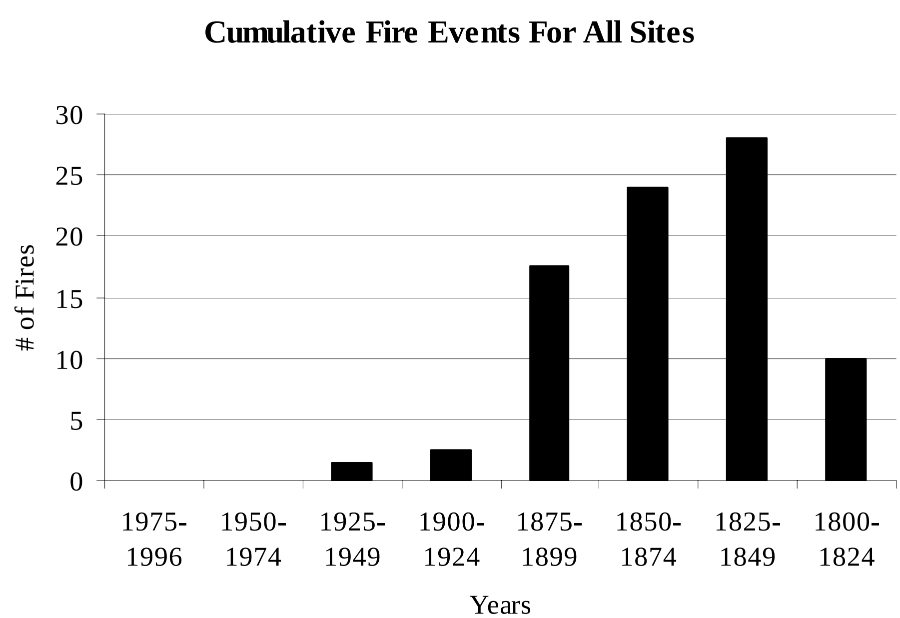

Figure 1-L.- Cumulative fire events for all sites in Deer, and Mill Creek watersheds

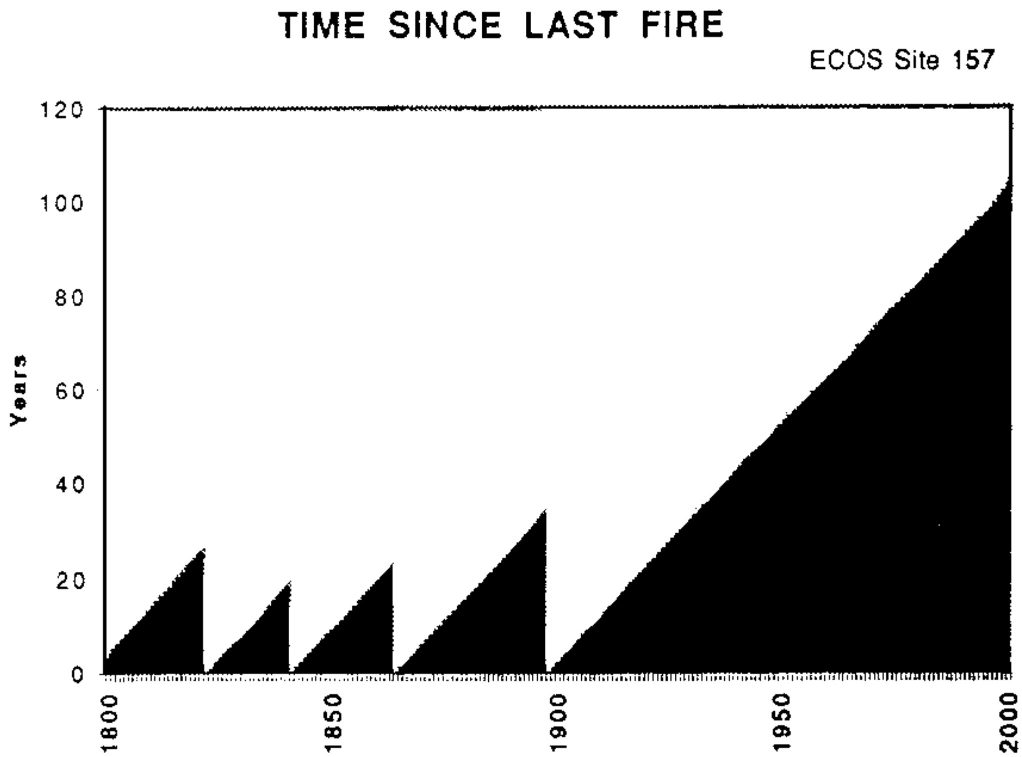

Figure 3-L.- Time since last fire at ECOS site 157.

APPENDIX M - HISTORIC RANGE OF VEGETATION

HISTORIC RANGE OF VEGETATION: INFERENCES FROM GENERAL LAND OFFICE SURVEY DATA, POTENTIAL NATURAL VEGETATION INFORMATION AND FIRE HISTORY PATTERNS

Deer, Mill, and Antelope Watersheds Lake Almanor Ranger District Lassen National Forest

Jo Ann Fites Ecologist April 24, 1997

INTRODUCTION AND BACKGROUND

Potential natural vegetation is a concept that relates to differences in the potential for different vegetation composition, structure and ecological characteristics and responses across the landscape. As such, potential natural vegetation provides a useful tool for mapping desired condition categories based upon the potential for the site and reconstructing spatial patterns of historic vegetation and disturbance, including fire. For example, if a travel corridor for fisher is desired in the watershed, the potential natural vegetation layer can be used to predict where high quality habitat can develop and where it will never develop due to limiting soils. By relating summaries of General Land Office Survey (GLO) data, fire history dam and ecology plot data in remnant stands to the potential natural vegetation types, spatial patterns of historic vegetation can be inferred. The comparison of existing vegetation layers (i.e. Region 5 timber strata or CALVEG, stand maps) with the inferred historic vegetation layer allows an assessment of changes in vegetation over time. A comparison of potential forest structure and composition with desired condition allows refinement of the desired condition layer based upon where the desired condition matches the potential condition for the site.
The objectives for this project were:

1. Develop a potential natural vegetation layer at a scale suitable for watershed assessment (ecological groups);

2. Infer historic landscape patterns of vegetation composition and structure by linking the potential natural vegetation layer with GLO data (collected in the late 1800's), fire history data, and ecology plot data in remnant stands;

3. Delineate potential areas for restoration by comparing existing vegetation with historic composition and structure landscape patterns by overlaying the inferred historic patterns and existing vegetation layers. Forest canopy cover and vegetation continuity are the primary variables that were compared.

ASSESSMENT

Modeling Potential Natural Vegetation

For this assessment, potential natural vegetation was modeled based upon the westside mixed conifer classification (Fites 1993) and ecological unit inventory map legends for the red and white fir forests on the Plumas National Forest. Groups of plant associations that occur in similar environments (i.e. elevations, soil depths, aspects) (Table 1) were mapped spatially by applying the model to spatial layers of environmental variables with ARC-INFO. Descriptions of the plant association groups are included in Appendix I.

Comparison of Existing Tree Canopy Cover with Modeled Historic Ranges

The CALVEG layer was overlaid with the potential natural vegetation layer to compare existing with modeled historic levels of tree canopy cover.

Estimates of historic ranges of tree canopy covers were developed by combining information on potential natural vegetation types and fire history data collected as part of this study and from others nearby. Ranges of canopy covers measured in existing remnant stands were adjusted for fire exclusion based upon mean fire interval and variability in interval. These ranges were applied to the landscape scale by applying the ranges to the potential natural vegetation maps.

Analysis of Historic (1870's) General Land Survey Forest Data

In the late 1800's, township, range and section lines were surveyed by USGS. Each section comer was documented by distance and direction to four (and sometimes fewer) trees. The diameter and species of each tree was recorded. This data was entered into a database and species and diameter frequencies calculated by each section comer and averaged by township and range. There are strengths and weaknesses to the GLO data in applying it to estimate historic ranges of vegetation.

Weaknesses include bias in tree selection and uncertainty of species identification. There may have been biases in the selection of comer trees that could make the estimates of species and diameter frequencies differ from representative forests. For example, preference may have been given to large trees of certain species. In general, larger trees were preferred making the data representative of overstory structure and composition, rather than of the entire stand. Sometimes there is ambiguity in species identification. A large area in the watershed that currently contains considerable Douglas-fir, only showed few records of Douglas-fir in the survey and a lot of "fir".

The strengths of the GLO data applied to historic vegetation reconstruction include quantitative method and systematic sampling across the entire area. Quantitative data on historic forest structure and composition is generally lacking. The GLO data provides one of the few sources of such data. The measurement of trees at each section comer, which are systematically placed in a grid, provides a good sampling strategy for systematically characterizing landscape patterns.

Table 1-M.- List of modeled potential natural vegetation types and associated environmental characteristics in westside forests of the northern Sierra Nevada and southern Cascade Range. Topographic position codes are: 1- ridge, 2- upper- 1/3 slope, 3- mid- 1/3 slope, 4- lower- 1/3 slope, 5- bottom or stream.

Ecological Groups	Primary Environmental Characteristics			
	Elevation (ft)	**Aspect**	**Topographic Position**	**Soil Depth (in)**
Low-Mid Elevation Mixed Conifer: Douglas-fir and ponderosa pine	2500-4800			
mixed conifer/dry productive (901)		SW	1,2,3,4	>20
mixed conifer/dry rocky (915)		SW	1,2,3,4	10-20
mixed conifer/moist productive & moderate productive		NE	2,3,4,5	>20
		SW	5	
mixed conifer/moderate or moist rocky (785 or 770)		NE	2,3,4,5	10-20
		SW	5	
High Elevation Mixed Conifer: white fir and yellow pine	4800-6000			
mixed conifer/dry productive (901)		SW	1,2,3,4	>20
mixed conifer/dry rocky (915)		SW	1,2,3,4	10-20
mixed conifer/moist productive & moderate productive		NE	2,3,4,5	>20
		SW	5	
mixed conifer/moderate or moist rocky (785 or 770)		NE	2,3,4,5	10-20
		SW	5	
Upper Montane: red fir, white fir, and Jeffrey pine	>6000			
red fir - white fir or Jeffrey pine/dry productive (651)		SW	1,2,3,4	>20
red fir - white fir or Jeffrey pine/dry rocky (669)		SW	1,2,3,4	10-20
red fir - white fir/moist productive & moderate productive (695,649)		NE	2,3,4,5	>20
		SW	5	
red fir - white fir/moderate or moist rocky (697)		NE	2,3,4,5	10-20
		SW	5	
Non-Forested or Scattered Trees	all	all	all	
rock or chaparral				<10
meadow				all

Summary Analysis of Ecology Plot Data
Ecology plots were placed in the analysis watersheds in the early 1980's in remnant, unharvested forest stands in mixed conifer forests. Detailed data was collected on forest structure, plant community composition, environment and soils. For this assessment data on forest structure and composition for these watersheds were summarized. These data provide a source of information on potential forest conditions that can be used to develop restoration goals in combination with goals for other areas such as fire, watershed function and wildlife habitat.

ASSESSMENT FINDINGS

Landscape Patterns of Potential Natural Vegetation
Four different zones of potential natural vegetation occur within the analysis watersheds. The zones change with increasing elevation, from west to east going from foothill, to low elevation mixed-conifer, to high elevation mixed-conifer, and upper montane forests. mixed conifer types comprise the majority of the watersheds on U.S. Forest Service lands (Table 2).

At the lowest elevations, generally below 2500 feet elevation, the foothill zone is found. Open, park like woodlands of scattered gray pine and blue, interior five oak, white oak, or black oak occur in a mosaic with extensive patches of chaparral, grass or rock outcrop in the foothills. Some smaller areas have enough moisture to support ponderosa pine groves or sometimes Douglas-fir. Often, the woodlands or forests may only comprise one-third of the landscape.

Above the foothills, extending to 4800 or 5000 feet elevation is the low elevation mixed conifer forests. Ponderosa pine, incense cedar, Douglas-fir are the most prevalent conifers. White fir is common component above 4,000 feet. Sugar pine and incense cedar occur throughout but are generally sub-dominant components. Black oak is common, especially on drier, productive sites. Canyon live oak dominates steep, rocky slopes on the larger canyon walls.

The higher elevation, white fir mixed conifer forests generally occur from 5,000 to 6,000 feet. Sometimes it extends higher on very xeric sites with shallow soils. White fir is the dominant species, with a mixture of ponderosa pine and/or Jeffrey pine occurring in varying amounts depending upon aspect and soil depth. Pine is most prevalent on the drier sites or those with shallow soils. This zone inter-grades gradually and indistinctly with the white fir and red fir zone that occur above.

Above 6,000 feet the upper montane zone encompasses mixed red fir and white fir, pure red fir, and lodgepole pine forests. Small natural openings of rock outcrops or meadows are most prevalent in this type.

Table 2-M.- Area in different potential natural vegetation (PNV) groups.

Potential Natural Vegetation Groups	% Area	Area (Acres)
Low-Mid Elevation Mixed Conifer: Douglas-fir and ponderosa pine	**33**	**67871**
mixed conifer/dry productive	13	26946
mixed conifer/dry productive & dry rocky	2.3	4754
mixed conifer/dry rocky	2.6	5384
mixed conifer/moist productive & moderate productive	13	26798
mixed conifer/moist or moderate productive & moist or moderate rocky	1.2	2531
mixed conifer/moderate or moist rocky	0.7	**1458**
High Elevation Mixed Conifer: white fir and yellow pine	**34**	**70117**
mixed conifer/dry productive	9.6	19880
mixed conifer/dry productive & dry rocky	6.4	13213
mixed conifer/dry rocky	0.3	586
mixed conifer/moist productive & moderate productive	11	22925
mixed conifer/moist or moderate productive & moist or moderate rocky	6.2	12886
mixed conifer/moderate or moist rocky	0.3	627
Upper Montane: red fir, white fir, and Jeffrey pine	**8**	**16389**
red fir - white fir or Jeffrey pine/dry productive	4.2	8642
red fir - white fir or Jeffrey pine/dry productive & dry rocky	0.1	216
red fir - white fir or Jeffrey pine/dry rocky	0.02	42
red fir - white fir/moist productive & moderate productive	3.6	7378
red fir - white fir/moist or mod productive & moist or moderate rocky	0.06	111
red fir - white fir/moderate or moist rocky	0	0
Non-Forested or Scattered Trees	**22**	**46677**
rock or chaparral	21	44147
meadow	1.2	2530

Relationships of Potential Natural Communities and Historic Fire Frequency: Implications for Reconstructing Historic Ranges of Tree Cover

Fire sear samples were collected in the four mixed conifer ecological groups to relate fire frequencies to vegetation. Differences in the mean and variability in intervals was similar to that found previously on the Eldorado for the lower elevation mixed conifer forests. No other fire history data is available for westside, high elevation mixed conifer forests in the northern Sierra Nevada.

The mean interval for the low elevation, dry sites was lower (fires more frequent) and the range less variable (regular fire intervals) than for the moist low elevation mixed conifer sites (Table 3). The mean on the dry sites ranged from 11 to 14 years with two sites showing minimum intervals of 2 years and two sites showing maximums of 19 years. The mean interval for the moist, low elevations sites were all greater than 25 years, varying from 25 to 38 years. Fire intervals were more variable and the high range greater, with high intervals of 34, 47, and 56 years.

Table 3-M.- Pre-European settlement fire interval (years between fires) data by ecological group for the four productive mixed conifer groups. The area sampled is less than 5 acres and generally about I acre. Each mean is the composite of several samples at each location.

Ecological Group	Sites (ecology plot number)	Mean Composite Interval (years)	Range of Composite Interval (years)
Low elev - mcon moist	136	38	27-56
	137	25	10-47
	157/8	26	19-34
Low elev - mcon dry	21	11	2-28
	55	13	2-19
	159	14	7-19
High elev - mcon moist	22	24	11-40
	23	16	10-22
	31	14	6-43
High elev - mcon dry	55	13	2-19
	60	13	6-17
	61	11	2-33

The high elevation mixed conifer sites showed similar patterns to the low elevation areas on the dry sites. The mean and ranges of intervals was very similar. There were two sites again with minimum intervals of 2 years. The moist site showed a more complex pattern than the moist sites at lower elevations. Two sites had intervals more similar to the dry sites at low and high elevations, between 14 and 16 years, but with greater range of variability in longer intervals.

These patterns of fire frequencies considered with the likely successional processes and potential forest structure and composition of each ecology group provide a basis for inferring the pre-European settlement vegetation conditions. The low and high elevation dry sites had frequent fires at regular intervals. Such frequent fire intervals makes it likely that fire severity was generally low because of the recurrent consumption of fuels. This suggests that forests would have tended toward more open structure, as a result of the thinning effects of low severity fires, with species resilient to fire favored, especially the pines. The GLO data for higher elevations did show high levels of white fir, indicating that at the higher elevations the pine was mixed with fir.

The greater and more variable intervals between fires at the lower elevations on moist sites, suggests that fire severity would have ranged more from low to moderate severity. This is both because there would have been intervals of time where greater fuels would have accumulated but also because the moist sites have the capacity to carry greater stocking and thus capacity for fuel production. Given the higher potential for stocking and less frequent and more variable fires it is likely that forest structure was a mosaic of closed and moderately open aggregates or patches. Species less tolerant to fire at younger stages, such as Douglas-fir would have been better able to survive. Pine would have been less competitive in the denser forests.

The higher elevation moist sites showed more frequent intervals than the low elevation moist sites. This suggests that ignitions from lightning or Native Americans were more frequent.

These inferred relationships between historic fire intervals and vegetation were used to estimate historic ranges of tree canopy closure. The comparison of these estimated historic ranges with existing levels is described below.

Comparison of Existing and Estimated Historic Tree Cover: Implications for Priorities in Restoration

The ecological groups with the greatest difference between estimated historic ranges and current levels of tree canopy cover are the mixed conifer dry productive types (Table 4). Both the low and high elevation dry types currently show from 32 to 70% of the area in canopy closures greater than 60%. For both of these types the estimated historic range of canopy closure was primarily below 60% canopy closure. This difference must be considered as a general pattern rather than exact figures, since the historic range is estimated. However, the trend is consistent with changes in vegetation expected with fire suppression on productive sites. These sites have a capacity to carry higher densities because of the productive soils. Frequent fires kept them more open because of the thinning effect of the fires.

The moist productive mixed conifer ecological groups are less changed in terms of total tree cover from historic levels. The lower elevation group may have more open forest than historically, with up to 48% in forests with canopy covers less than 60%. However, with the longer and more variable fire intervals found on the low elevation, moist productive mixed conifer sites, it could be that a patchy pattern of fire severity would have resulted in more variable canopy closures than expected.

Little information is available to estimate historic ranges of canopy cover in upper montane forests dominated by red fir and white fir. Current forest canopy cover generally exceeds 60% in the red and white fir stands in this analysis area. In Leiburg's survey for USGS in 1902 of the area just to the south of this project area, he described the red fir forests as follows:

> "Where the Shasta-fir type has not been decimated by fire it is apt to form thick stands, especially if it consists of pure growth."
>
> "The type as a whole is scattering and patchy. Everywhere along the main divide of the Sierra it is made up of blocks of forest, separated by sedgy or weed covered openings or by tracts of naked rocks".

Table 4-M.- Comparison of tree canopy density from the existing vegetation layer and estimated historic levels from the potential natural vegetation layer and fire frequency data.

Potential Natural Vegetation Groups	Historic Canopy Densities (%)	Exisiting Vegetation Densities (%)					
		<10	10-20	20-40	40-60	60-80	80-100
Low-Mid Elevation Mixed Conifer: Douglas-fir and ponderosa pine							
mixed conifer/dry productive	30-60	18	7	8	21	37	8
mixed conifer/dry productive & dry rocky	10-60	14	7	9	22	38	10
mixed conifer/dry rocky	1-40	62	10	12	10	6	<1
mixed conifer/moist productive & moderate productive	50-90	13	5	8	22	41	9
mixed conifer/moist or moderate productive & moist or moderate rocky	50-90						
mixed conifer/moderate or moist rocky	1-70	44	8	14	16	17	<1
High Elevation Mixed Conifer: white fir and yellow pine							
mixed conifer/dry productive	40-60	8	<1	3	15	52	18
mixed conifer/dry productive & dry rocky	10-60	17	<1	10	39	27	5
mixed conifer/dry rocky	1-40	14	<1	24	39	18	1
mixed conifer/moist productive & moderate productive	50-90?	7	<1	5	18	48	20
mixed conifer/moist or moderate productive & moist or moderate rocky	20-90?	16	<1	10	44	23	5
mixed conifer/moderate or moist rocky	1-70						
Upper Montane: red fir, white fir, and Jeffrey pine							
red fir - white fir or Jeffrey pine/dry productive		17	<1	2	8	42	28
red fir - white fir or Jeffrey pine/dry productive & dry rocky	30-80	4	0	0	7	40	49
red fir - white fir or Jeffrey pine/dry rocky	1-40	9	0	0	6	65	21
red fir - white fir/moist productive & moderate productive	40-90	10	<1	<1	10	46	30
red fir - white fir/moist or mod productive & moist or moderate rocky							
red fir - white fir/moderate or moist rocky	1-70	13	0	0	10	55	23
Non-Forested or Scattered Trees							
rock or chaparral	0-10[1]	42	6	9	16	21	5
meadow	0-70[2]	65	<1	5	16	11	2

Historic Tree Overstory Composition Data from the 1870's GLO
Tree composition data from the GLO surveys in the 1870's show several distinct changes with township and range going from west to east that seem to roughly correspond with the major zones described in the potential natural vegetation section (Figure 1).

The most western areas, T27N RIE and T26N R2E, show a high proportion of oak (30-50% of trees) and non-forested (5-25% of points) areas. The area in T27N R2E also shows a high proportion of oak but considerable yellow pine (10-50% of trees) as well. A little Douglas-fir also occurred in T26N R2E, most likely restricted to riparian or very moist microsites. These areas represent lower elevation oak woodlands and yellow pine forests.

The next area to the east, in R3E of T26N, T27N and T28N, begin to contain incense cedar, and various mixtures of yellow pine, fir and some Douglas-fir. Oak still occurs but is generally less than 20% of the trees measured. The percent of trees recorded as fir range from 15 to 45%. This zone generally represents the same area as the lower elevation mixed conifer delineated in the potential natural vegetation layer.

In the R4E areas, a similar composition is found but with Douglas-fir lacking and sometimes a greater proportion of fir. Fir comprised up to 60% of the trees measured in T28N. This area likely represents both the lower and high elevation mixed conifer zones of the potential natural vegetation layer. Fir is dominant in the easternmost and highest elevation portions of the analysis area, in R5E, ranging from 80 to 90% of the trees measured.

It is not clear what species "fir" represented in these surveys. Levels of Douglas-fir are lower than those expected from the ecology plot data in remnant stands. It could be that these were recorded as "fir" by some of the surveyors. It also seems that there was little or no distinction made between red and white fir at higher elevations.

Historic Tree Structure: Data from 1870's GLO and Ecology Plots
Quantitative data on pre-European settlement forest structure is the most difficult of all historic data on vegetation to obtain. Analysis of diameter distributions of the GLO data is limited by possible biases in sampling trees of a particular size for section corner markers; often times the smaller or very large trees may not have been included. The ecology plot data in remnant stands has varying degrees of change from historic conditions due to in-growth from fire suppression. No substantial conclusions can be drawn except that large trees were likely more prevalent historically than in present stands due to a long history of selective harvest of large trees.

Foothill Vegetation and Influences of Grazing on the Hydrologic Cycle
The foothill woodlands and valley grasslands that comprise the lowest elevation portions of these watersheds has a dominantly grassy understory. This vegetation zone has likely undergone the most extensive changes following European settlement of any

type both because of the more extensive length of time of European activity and greater concentration of activity. The primary settlement activity that would have influenced the hydrologic cycle in this zone is grazing, although changes in tree cover may also have an effect. There are both direct effects of grazing on vegetation cover and indirect effects on species composition and soils that can influence the hydrologic cycle.

Grazing can influence the water balance by decreasing total vegetation cover, thus reducing the transpirational surface and potential for transpirational water loss. However, prior to European settlement, extensive herds of Tute Elk were observed in the Valley (Kinney 1996) and deer were likely abundant in the foothills. Therefore, grazing had an influence on vegetation cover even prior to European settlement. It is likely that the density of European grazing by cattle and sheep was greater than that of the herds of native elk and deer (Menke et al. 1996) and therefore the effect of this grazing would have been to increase water yields.

Removal of oaks for firewood and decreases in density attributed to grazing may also have influenced the transpirational surface and thus water yields. However, a recent study showed little change in water yield from removal of up to one-third of the oak canopy (Epifanio et al. 1991).

The most profound influence of settlement and grazing on the hydrologic cycle is likely the result of extensive shifts in species composition from native perennial grasses to exotic annual grasses. In the late 1800's millions of sheep and at least a million cattle were brought to the coastal Spanish missions (Standiford et al. 1996). These livestock brought exotic seed and the grazing pressure that opened up growing space for them to take over the native perennial grasslands and oak woodland understories. A greater number of invasive exotics have been noted in the foothill woodlands and valley grasslands than any other ecosystem in the Sierra Nevada (Schwartz et al. 1996). These exotic annuals have a different seasonal pattern of water use than the native perennials that may have changed low flows. The exotics use more water during the spring and early summer, while the native perennials use more water throughout the growing season. As a result, late season soil moistures are lower in areas dominated by exotic annuals than in areas dominated by native perennial grasses.

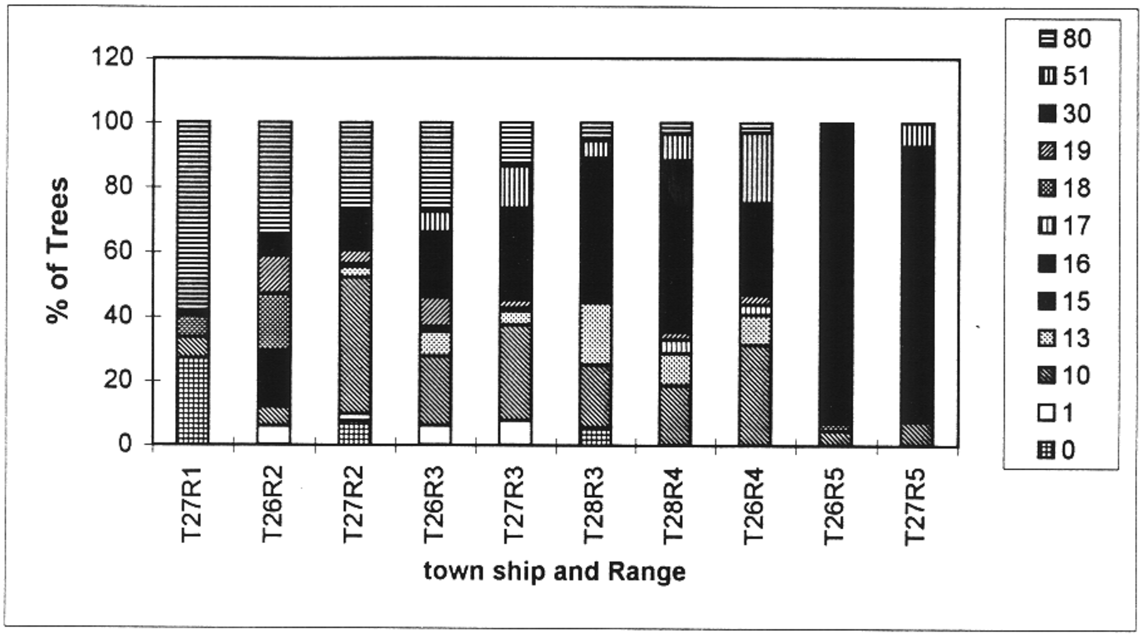

Figure 1-M. Frequencies of different species of trees based upon general land survey data from the 1870's. Data is grouped by township and range. Species codes: 0- non-forested; 1 -Douglas-fir, I 0- yellow pine, 13-sugar pine, 15-pitch pine, 16- gray pine, 17-lodgepole pine, 18-1 9-other hardwoods, 30 - fir (likely includes white fir and possibly Douglas-fir), 51 -incense cedar, 80- oak.

APPENDIX N - POTENTIAL NATURAL VEGETATION

DESCRIPTIONS OF POTENTIAL NATURAL VEGETATION for Modeled Ecological Groups of Mixed Conifer Plant Associations

by Jo Ann Fites, Ecologist March 27, 1996

INTRODUCTION

This document contains descriptions of potential natural vegetation to accompany ecological unit inventories for the northern Sierra Nevada. The descriptions are based upon vegetation classifications by the Pacific Southwest Region Ecology Program. In addition, brief explanations of underlying concepts to the vegetation classification are included below.

Vegetation classifications provide a useful tool for categorizing the landscape into classes that reflect differences in: 1) floristic composition of the overstory trees and understory trees, shrubs, herbs and graminoids, 2) productivity, 3) kind and timing of successional trends, 3) structure (i.e. canopy layering, canopy density, size of large trees), and 4) potential fuel types and configurations. The Pacific Southwest Region Ecology Program has developed and continues to develop vegetation classifications with the objective to provide ecological data in support of ecosystem management.

Potential Natural Vegetation Concept: The classifications of the Ecology Program are based upon the concept of potential natural vegetation. The potential natural vegetation is the assemblage of plant species that will develop and occur on a site over time in the absence of major disturbance. Of course disturbance is an important and continual influence on vegetation. Potential natural vegetation is a concept that is useful in classifying the environmental variation that results in different capacities of plant species to occur on a site and responses to disturbance, from management or non-human origin. Therefore, although absence of disturbance is part of the concept of potential natural vegetation, because the concept integrates environmental and vegetation influences it also reflects differences in disturbance regimes and responses to disturbances. An example is fire.

Disturbance and Potential Natural Vegetation: There is no doubt that fire was and is an important disturbance process in the Sierra Nevada and has an influence on vegetation composition, structure and landscape pattern. However, vegetation influences fire by its effects on fuel types, levels and configuration. Since the potential natural vegetation concept is based upon differences in environment that influence vegetation composition, structure and processes (such as succession), the concept also reflects environmental differences that influence fire, such as slope, temperature, humidity and precipitation. Therefore, potential natural vegetation patterns provide insight and correspond with patterns in fire regimes or disturbance regimes in general. There are other influences on fire regimes that are independent of vegetation however, such as lightning ignition patterns.

Hierarchical Classification Scheme: A hierarchical classification scheme has been adopted for potential natural vegetation in the Pacific Southwest and Pacific Northwest Regions. A hierarchical classification is one where there are nested levels of categories from very general classes to very specific classes nested within the general classes. There are two types of potential natural vegetation hierarchies that are used in the Sierra Nevada. The first is a taxonomic hierarchy. which emphasizes similarities in floristic composition. The second is an ecological function hierarchy, which emphasizes similarities in ecological characteristics such as productivity, vegetation structure patterns, successional responses and disturbance regime patterns.

The primary taxonomic hierarchy used in this region includes series, which are the most general class, subseries and plant associations, which are the most detailed or specific class. Plant associations, the primary level in the classification hierarchy, refer to a "potential natural plant community of definite floristic composition and uniform appearance" (PSM 2090, 1990). Series, the highest level in the hierarchy, refers to an aggregation of taxonomically related plant associations that take the names of the climax species that dominate or have the potential to dominate the principle layers. Examples of series include: red fir, Douglas-fir, canyon live oak, and sagebrush. Subseries are groups of plant associations within series that share several potential dominants. Examples of subseries include: Douglas-fir - canyon live oak and ponderosa pine/sagebrush.

The ecological function hierarchy, applied in the northern Sierra Nevada and in the Pacific Northwest Region, includes plant associations, ecological groups, series and formations. For applications of the potential natural vegetation classification to management, such as ecological unit inventories, the ecological function hierarchy is most often used. Plant associations are the same as in the taxonomic hierarchy, with the same definition and representing the most detailed and primary level of the hierarchy. Ecological groups are groups of plant associations with similar ecological characteristics, such as disturbance regimes, response to disturbance or management, productivity and potential stand and landscape structure. Series are defined the same as in the taxonomic hierarchy. Formations are aggregations of ecological groups and/or series that occupy a geographic area with similar climate. Examples are eastside montane, subalpine, westside foothill and westside upper-montane. The same taxonomic series or ecological group may occur in different formations and will have different ecological characteristics in the different formations.

For example, the Douglas-fir - mixed conifer series occurs in both the eastside montane and westside montane formations. Within each of these different formations however, the productivity, fire regime and potential canopy closure and vertical diversity of the series differ.

Potential Natural Vegetation Model Layer: For the ecological unit inventories at the Landtype and Landtype Association scales, ecological groups of plant associations are the primary mapping unit for potential natural vegetation. In some cases series is mapped in place of ecological group when less detailed information is needed or it is not possible to map ecological group. For the northern Sierra Nevada, ecological groups were modelled for the three mixed conifer series in the westside montane formation. The three series include: ponderosa pine-mixed conifer, Douglas-fir - mixed conifer, and white fir-mixed conifer.

Descriptions Of Ecological Groups: Descriptions for the series and ecological groups are the primary content of this document. For each ecological group vegetation composition, landscape patterns and potential structure and primary associated disturbance regime characteristics will be described. The individual plant associations that are likely to be found vary by the geographic location and thus will differ by ecological unit inventory area, Forest or District. Historic ranges of specific vegetation elements (i.e. large tree size, density of large trees, canopy closure) for each ecological group where quantitative information is available are presented. Table 1 lists the current list of plant associations, ecological groups, series and formations that have been used for mapping potential natural vegetation. As mapping progresses across the northern Sierra Nevada and as classifications are completed the list changes.

Map Units vs. Individual Ecological Groups or Series
In the actual application of a potential natural vegetation classification to mapping vegetation, map units are used instead of individual classes, such as series or ecological groups, to label the vegetation within a polygon. The Pacific Southwest Region has adopted standard protocol for labeling potential natural vegetation on maps. The adopted standard is for map units that are very similar in concept to those used in soil surveys.

In general, there may be up to two primary vegetation classes assigned to each polygon. The first class is the dominant one in the polygon and the second class is the subdominant type. Up to three inclusions may also be included in the label for each polygon. Inclusions occupy no more than 20% of the polygon but generally more than 10%. For riparian vegetation mapping, up to three primary vegetation classes may be assigned to an indidivual polygon or line. This is because riparian vegetation tends to vary more on a finer spatial scale.

There is no fixed combination of individual potential natural vegetation classes that can be used, as there is in soil mapping. Because of the ability to mix and match different primary and secondary map unit components, descriptions are provided for the individual components, such as ecological groups, rather than the map units (combinations of two or more ecological groups). For developing interpretive layers for analysis of the potential natural vegetation layer it is necessary to consider how different combinations of ecological groups are different or similar in regards to the interpretation of interest. The

Zone ecologist can provide information for determining how different units should be aggregated or kept separate for specific interpretive layers, such as historic ranges of tree composition.

Table 1-N.- Structural characteristics of ecology plots on the Almanor Ranger District, summarized by ecological groups. Mean values are followed by standard deviation in parentheses. For use in developing restoration goals.

Potential Natural Vegetation Groups	Structural Characteristics					
	Conifer BA	Hardwood BA	Conifer volume	21-29" dbh	29-38" dbh	>39" dbh
	ft^2/acre		ft^3/acre	number of trees/acre		
Low-Mid Elevation Mixed Conifer: Douglas-fir and ponderosa pine						
mixed conifer/dry productive (901)	311 (70)	13 (19)	122 (28)	6 (18)	12 (4)	6 (5)
mixed conifer/moist productive (775)	313 (89)	14 (32)	107 (31)	28 (23)	10 (6)	6 (3)
mixed conifer/moderate productive (765)	231 (8)	18 (20)	97 (5)	19 (13)	14 (5)	3 (6)
High Elevation Mixed Conifer: white fir and yellow pine						
mixed conifer/dry productive (841)	418 (86)	7 (10)	165 (38)	29 (23)	12 (7)	12 (6)
mixed conifer/dry rocky (845)	333	0	138	61	18	2
mixed conifer/moist productive & moderate productive (850)	0	0	128 (32)	38 (25)	10 (7)	10 (6)

DESCRIPTIONS OF MIXED CONIFER ECOLOGICAL GROUPS

The following descriptions are based upon the "Ecological Guide to Mixed Conifer Plant Associations: Northern Sierra Nevada and Southern Cascades' by Fites (1993). For specific information on individual plant associations refer to this guide.

A list of the ecological groups and representative plant associations that are included in the modelled potential natural vegetation layer are shown in Table 1. In general, there are high elevation groups that fall into the white fir-mixed confier series and low elevation groups that fall into the Douglas-fir -mixed conifer or ponderosa pine-mixed conifer series. The elevation at which these different series are separated in the model varies with latitude. For example, on the Eldorado National Forest, the elevation cut-off is at 5,000 feet for the white fir - mixed conifer series, whereas on the Plumas National Forest it is at 4,500 feet. Within each of these elevations the other major breaks are based upon productivity, modelled with soil depth, and moisture, modelled with aspect and topographic position. Areas with tanoak were the most complex to model. Both precipitation and information from District personnel and ecology plots were used to approximate tanoak distribution. Vegetation associated with serpentine substrates were modelled using soil type.

Douglas-Fir Mixed Conifer Series

Landscape Ecology and Environment: The Douglas-fir - mixed conifer series occurs at lower elevations and moister sites (higher precipitation or soil moisture and humidity), more often on north or east-facing lower or mid slopes.

Vegetation: Douglas-fir typically dominates or sometimes co-dominates a diverse tree layer. White fir, incense cedar and sugar pine are frequently present as subdominants. Ponderosa pine and black oak sometimes occur, increasing where disturbance has occurred or on ecotones to drier sites. The moist or wet site harwoods and Pacific yew, that occur in the mixed conifer zone are most always associated with the Douglas-fir - mixed conifer series. This includes mountain dogwood, white alder, big-leaf maple and tanoak.

Douglas-fir -mixed conifer/moist productive group

Landscape Ecology and Environment: This group occupies large patches across entire slopes to narrow, linear stringers. It is found on moist, northerly or easterly aspects where soils are moderately deep to deep. Most typically this group is restricted to mid and lower slope positions but it may be also found on upper slope positions if soil moisture is present. Geologic contacts between volcanic and metamorphic substrates just below ridges often results in sufficient soil moisture to support the plant associations found in this group. Complex topographic patterns with mixture of concave and convex surfaces may result in a mosaic pattern of moist productive vegetation on the concave surfaces juxtaposed with moderate productive or dry productive vegetation on the convex surfaces. This is most common on highly dissected south or east trending slopes with small areas of east and west or north and south facing areas occurring adjacent to each other.

Vegetation: Moderately dense to dense mixed conifer forests, with Douglas-fir as a dominant or co-dominant, and a well developed and/or herb layer typifies the Douglas-fir -mixed conifer/moist productive group. Total vegetation cover is high. A diverse canopy is common, with four to six layers typical.

Douglas-fir, white fir and incense cedar are the usual overstory co-dominants. Sugar pine is also common but in variable amounts. Mountain dogwood and big-leaf maple are frequent midstory associates or dominants. Pacific yew is more closely associated with this group than any other.

The understory is variable but usually well developed with a diverse mixture of decidous shrubs and herbs. The most common species include: hazelnut, thimbleberry, creeping snowberry, rose, trailplant, mountain sweet-cicely, fragrant bedstraw, queen's cup, Hooker's fairy bells, and starflower. The most prevalent graminoids are red or western fescue.

<u>Typical Plant Associations:</u>

Douglas-fir - mixed conifer-mountain dogwood/trailplant
Douglas-fir - mixed conifer-mountain dogwood/hazelnut
Douglas-fir - mixed conifer-big-leaf maple/trailplant Douglas-fir - mixed conifer/hazelnut

Douglas-fir -mixed conifer/moist rocky

Landscape Ecology and Environment: This group indicates moist sites with shallow soils and limited rootability. Sites are often steep. Patches in the landscape are often small in extent, surrounded by the moist productive group but may be extensive in large canyons. When the sites are in large canyons it is most often mapped for specifically in the Douglas-fir - mixed conifer-canyon live oak group or subseries.

Vegetation: Forests are characterized by moderate to open canopies (50-80%) with little vertical diversity. The herb may be sparse or well developed. Moss cover is often very high on the prevalent rock surfaces.

Douglas-fir, incense cedar and sugar pine are the typical co-dominants. White fir is occasionally present. Ponderosa pine may occur, more commonly than in the moist productive sites. Canyon live oak may be present in scattered amounts to a well developed midstory. Big-leaf maple occurs in variable amounts on the wetter sites, particularly where subsurface water flow is present.

The understory is variable in composition and amount depending on substrate and humidity. Typical shrub species include hazelnut and wood rose. Swordfern, alum root, western fescue, red fescue, false Solomon's seal, fairybells and white-flowered hawkweed are common herbs, graminoids and ferns. Pacific stonecrop also occurs on some sites.

Typical Plant Associations:

> Douglas-fir - mixed conifer/hazelnut
> Douglas-fir - mixed conifer/small-flowered heuchera
> Douglas-fir - mixed conifer-canyon live oak/swordfern

Douglas-fir -mixed conifer - canyon live oak

This type belongs in the Douglas-fir -mixed conifer/moist rocky group but is often mapped as a distinct type where possible because it has unique ecological characteristics.

Landscape Ecology and Environment: This type is found in similar areas as the Douglas-fir -mixed conifer/moist rocky group, with shallow soils and poor rooting. It occupies large patches, primarily in large canyons on steep slopes.

Vegetation: A moderately dense to dense forest with a strongly bi-layered conifer and hardwood canopy is typical. Overstory canopy cover is low to moderate (10-60%). The hardwood mistroy is well developed with moderate to dense cover (20-80%).

Douglas-fir is a dominant or co-dominant in the overstory with incense cedar. Ponderosa pine often occurs as a minor component or co-dominant, particularly on mid-slope locations. Sugar pine and white fir are occasional associates. Canyon live oak dominates or co-dominates the overstory tree layers. Black oak or big-leaf maple may occur but are usually present in low amounts.

The shrub layer is often sparse or absent. Swordfern is the most consistent understory species, prevalent across many sites.

Typical Plant Associations:

> Douglas-fir - mixed conifer - canyon live oak/swordfern
> Douglas-fir -mixed conifer-tanoak/moist

Landscape Ecology and Environment: This group indicates wet or moist areas with high annual precipitation. It is found at mid elevations in the mixed conifer zone on north or east-facing slopes or in drainages. Soils are typically moderately deep to deep. It tends to occupy large continous patches in the landscapes but may occur in narrow linear stringers when associated with riparian areas or drainages.

Vegetation: A dense, multi-layered stand with tanoak in the midstory or regeneration layers and moist site herbs or shrubs in the understory characterize this type.

Douglas-fir is the most prevalent dominant conifer found in both the overstory and understory. Sugar pine, white fir and incense cedar frequently occur as co-dominants or minor associates. Ponderosa pine and black oak sometimes occur but in low amounts. Tanoak typically forms a moderately dense to dense

midstory layer. Other hardwoods that often occur in varying amounts include madrone, bigleaf maple, and mountain dogwood. Pacific yew occasionally occurs on the moistest sites.

The shrub layer is often sparse, due to the dense overstory tree canopies. Hazelnut and wood rose are the most common shrubs. The herb layer is variable under the dense tree overstory, but can be well developed, dominated by moist site indicators such as star flower, trail plant, false Solomon's seal, and sweet-cicely. Shade tolerant, moderate site indicators including pine violet and Hartweg's iris may occur, suggesting slightly drier conditions, often in transitional areas to drier types.

Typical Plant Associations:

Douglas-fir - mixed conifer - tanoak/hazelnut
Douglas-fir - mixed conifer - tanoak - mountain dogwood
Douglas-fir - mixed conifer - tanoak dry group

Landscape Ecology and Environment: This group occurs where precipitation is high (annual average greater than approximately 55 inches) but soils are dry. Ridges and south or west aspects are the typical locations. Soils are primarily moderately deep to deep. A closely related group, Douglas-fir - mixed conifer/shrubby tanoak, occurs on similarly dry sites but with shallow or very rocky soils with limited rootability. This type tends to occupy large patches on the landscape where tanoak is continous but smaller patches where tanoak distribution is patchy.

Vegetation: A moderately dense to open conifer overstory, tanoak in the midstory and a sparse understory of dry site herb and shrub indicators is characteristic. Stand structure is often bi-storied with a conifer overstory and tanoak midstory. Total vegetation cover is moderately high to high.

Douglas-fir, ponderosa pine and sugar pine dominate or co-dominate the overstory in various mixtures. White fir and incense cedar are typical minor associates. Tanoak may form a scattered or dense midstory and tanoak regeneration is often high. Black oak and madrone may co-dominate the midstory with tanoak.

The shrub and herb understory is often sparse and scattered because of the dense mid and overstory tree layers. Creeping snowberry and woodrose are the most common shrubs. At lower elevations, poison oak may be prevalent. Iris is the most consistent species in the understory, indicating dry sites. A mixture of dry and moderate site herb indicators occur in low amounts, including for dry sites, Bolander's bedstraw, milkwort, dogbane, and iris, and for moderate sites, pine violet, western prince's pine, and multi-stemmed sedge. Starflower which is a moderate or moist site indicator, often occurs but in low amounts, indicating slightly moister but warm sites.

Typical Plant Associations:

Douglas-fir - mixed conifer - tanoak/iris
Ponderosa pine - mixed conifer - tanoak/bearclover
Douglas-fir -mixed conifer/moderate productive

Landscape Ecology and Environment: The moderate productive group occurs on sites intermediate between moist and dry areas, most notably upper 1/3 slopes on north or east-facing slopes. Patches on these sites may be large but tend to have a large portion of the patch in a broad ecotonal area between adjacent dry sites on the ridges and moist sites on the mid or lower slopes. Where prominent noses of ridges extend far down.slopes producing a repeated pattern of convex and concave surfaces on north or east aspects, the moderate group may be found on the convex surfaces adjacent to moist types on the concave surfaces. Patches found in this pattern tend to be smaller in size and less distinct. Soils are moderately deep to deep. Small patches may occur in swales or ridge saddles on south aspects interspersed amongst the dry productive group.

Vegetation: This group contains a wider variety of vegetation conditions than almost any other productive mixed conifer group because of its typical location in transitional areas between moist and dry types. Forests range from open to dense cover, with variable levels of vertical diversity. Generally, forest cover is moderate to high but vertical diversity is low.

Douglas-fir, ponderosa pine, sugar pine and sometimes white fir are typical co-dominants. Ponderosa pine is rarely a dominant, like on the adjacent dry types. Incense cedar and black oak occur as minor associates or sometimes co-dominants.

Shrub cover is variable in amount and composition. Often a mixture of moist and dry species occur, such as hazelnut, wood rose and manzanita or white-thorn. On disturbed sites, deerbrush is common. Patterns of herbs are similar to shrubs with variable levels and mixtures. The most typical species are starflower, white-flowered hawkweed, iris, milkwort, Hooker's fairy bells, mountain violet, and false Solomon's seal.

Typical Plant Associations:

Douglas-fir - mixed conifer/starflower
white fir - mixed conifer/false Solomon's seal-Hooker's fairy bells
Douglas-fir - mixed conifer/moderate rocky

Landscape Ecology and Environment: Small areas of shallow soils or rocky substrates with poor rooting on north or east-facing upper 1/3 slopes are the typical locations for the

Douglas-fir - mixed conifer/moderat-e rocky group. Patches are generally small because of the limited extent of the habitat.

Vegetation: This group has been poorly sampled, therefore little information is available on vegetation composition or structure. Depending upon soil moisture, the vegetation may be similar to either the dry rocky or moist rocky groups. When the sites occur next to drainages or geologic contacts resulting in higher humidities and soil moisture, the vegetation is similar to the moist rocky type. However, ponderosa pine would likely be a more important component of the overstory, often a co-dominant in the moderate rocky group. Where soil moisture is not prevalent, then the vegetation would be similar to the dry rocky group.

<u>Typical Plant Associations:</u>

Douglas-fir - mixed conifer/huckleberry oak
Douglas-fir - mixed conifer/small-flowered heuchera Douglas-fir - mixed conifer/serviceberry

Ponderosa Pine – Mixed Conifer Series

Landscape Ecology and Environment: The ponderosa pine-mixed conifer series occurs at lower and mid elevations on sites with high potential annual solar radiation. This includes primarily south and west aspects as well as ridges.

Vegetation: Ponderosa pine is a dominant or co-dominant in the overstory on both sites. Incense cedar and black oak are common co-dominants or minor associates. Douglas-fir and sugar pine are also common, especially in association with moister microsites or ecotones to moister sites. White fir sometimes occurs, especially at higher elevations, but in low amounts. Canyon live oak is a frequent associate or co-dominant on very steep or rocky sites. Under a pre-European settlement fire regime, ponderosa pine would have been the dominant understory tree species on most sites. In current stands, with little evidence of past harvest, ponderosa pine regeneration is more prevalent in this series than in any other.

Bearclover, deerbrush, whiteleaf and greenleaf manzanita are the most prevalent shrubs. A diverse mixture of dry site herbs and grasses occur. Bolander's bedstraw, milkwort, multi-stemmed sedge, and iris species are the most prevalent.

Ponderosa pine - mixed conifer/dry productive

Landscape Ecology and Environment: This group is found on dry, warm or hot sites with moderately deep to deep soils. Sites are south or west-facing ridges or upper to mid-slopes, typically with convex surfaces. Solar insolation is high. It generally occupies large patches on the landscape unless the topography is highly dissected.

Vegetation: Forests are typically open to moderately dense. Conifers comprise the upper layers but vary from scattered trees to a continous layer. Oaks commonly co-dominate or dominate the midstory.

Ponderosa pine, sugar pine, incense cedar, and occasionally Douglas-fir co-dominate the overstory in various mixtures. Ponderosa pine may dominate in some areas. White fir is a minor associate in the overstory but is often prevalent in the midstory since fire suppression. Ponderosa pine regeneration occurs in low amounts currently but would have been higher under a natural fire regime.

The shrub layer is sparse or absent, sometimes with scattered creeping snowberry. The herb layer is comprised of scattered dry and moderate site indicators. Dry site indicators include Bolander's bedstraw, milkwort, iris, dogbane and Silene species.

Typical Plant Associations:

> Ponderosa pine - mixed conifer/bearclover/Bolander's bedstraw Ponderosa pine - mixed conifer/Bolander's bedstraw-milkwort
> Ponderosa pine - mixed conifer/dry rocky

Landscape Ecology and Environment: This group occurs on dry, south or west exposures or ridges where soils are poorly developed or rocky. It may also be present on north or east aspects on rocky sites on upper 1/3 slopes. The patch size is often small unless there are extensive areas of shallow soils. Most often it occurs in small islands, interspersed between the dry productive group.

Vegetation: An open woodland to scattered trees over a well developed shrub or herb dominated understory is typical. Tree cover most often ranges from 10 to 40% but occasionally is greater where canyon live oak is prevalent. Vertical diversity is typically low.

Ponderosa pine, incense cedar, and canyon live oak are the typical domiants or co-dominants in various mixtures. Sugar pine, Douglas-fir and black oak may be present but mostly in low amounts.

The shrub layer is absent or comprised of patches or dry and/or rocky site indicators. The most typical species are whiteleaf and greenleaf manzanita and poison oak. The herb layer is highly variable and where the tree layer is sparse, it may be very high in diversity, comprised of species that are not found in other habitats.

Typical Plant Associations:

> Ponderosa pine-mixed conifer-canyon live oak/bearclover
>
> Ponderosa pine-mixed conifer-canyon live oak/Bolander's bedstraw Douglas-fir - mixed conifer/serviceberry

Ponderosa pine - mixed conifer/manzanita-bearclover Ponderosa pine - mixed conifer/manzanita

Ponderosa pine - mixed conifer/shrubby canyon live oak-huckleberry oak

Ponderosa pine - mixed conifer-canyon live oak

Landscape Ecology and Environment: The ponderosa pine - mixed conifer - canyon live oak group occurs in similar environments to the ponderosa pine - mixed conifer dry rocky group but primarily in large canyons with steep slopes.

Vegetation: A woodland to moderately dense forest (30-60% canopy cover) with a conifer overstory and hardwood mistory is characteristic. Canopy layering is moderate, most often bi-layered.

The overstory cover is low to moderate and codominated by ponderosa pine, Douglas-fir and sometimes incense cedar or sugar pine. White fir is absent or scarce. Canyon live oak dominates the midstory (20-60%). Black oak may co-dominate the midstory.

The shrub layer is often absent or comprised of patches of dry, and/or rocky site indicators: whiteleaf and greenleaf manzanita, and poison oak. The herb layer is absent or low in cover with dry site and rock outcrop indicator species commonly dominating, including naked-stemmed buckwheat, iris, milkwort, soparoot, and Bolander's bedstraw.

Typical Plant Associations:

Ponderosa pine-mixed conifer-canyon live oak/bearelover

Ponderosa pine-mixed conifer-canyon live oak/Bolander's bedstraw

Wild Fir Mixed Conifer Series

Landscape Ecology and Environment: This series occurs at higher elevations within the mixed conifer zone, bordering the transition into white fir and red fir series. The elevation at which the series occurs depends on latitude, ranging from 5,000 feet on the Eldorado National Forest to 4,500 feet on the Plumas National Forest. Much of the precipitation is in the form of snow.

Vegetation: White fir dominates the tree layers on most sites. In some locations it is a co-dominant. Sugar pine and incense cedar are the most prevalent associated tree species but typically occur in low amounts. Historically, sugar pine may have been a dominant or co-dominant across much of the extent of this series, according to historic accounts of early surveyors such as Lieberg (1902). Douglas-fir and red fir occur less frequently, associated more with transitions to the Douglas-fir -mixed conifer or red fir series. Ponderosa or Jeffrey pine may be present, particularly on drier sites or shallow soils.

The understory in the white fir-mixed conifer series is generally poorly developed. A sparse or patchy shrub layer is typically comprised of creeping snowberry, bush chinquapin, serviceberry and Sierra gooseberry. With disturbance, greenleaf manzanita or mountain whitethom are the prevalent shrubs. Common herbs include kellogia, white-veined wintergreen, pine violet, white-flowered hawkweed, little prince's pine, false Solomon's seal, western prince's pine, rattlesnake plaintain orchid, and bracken fern.

White fir/moist productive

Landscape Ecology and Environment: This group is found on cool, moist sites at higher elevations with moderately deep to deep soils. Sites are usually north or east-facing lower and mid slopes, swales or benches. It often occupies large continous patches in the landscape, unless the area is highly dissected.

Vegetation: A moderately dense to dense forest, with high vertical diversity dominated by white fir is characteristic. Three or more canopy layers are common. White fir dominates the overstory with sugar pine and incense cedar as consistent minor components. Sugar pine may occur as a dominant or major co-dominant in some areas. Ponderosa or Jeffrey pine may occur but are generally absent or sparse.

The understory is highly variable ranging from sparse to well developed. The shrub layer is mostly absent but may include creeping snowberry, thimbleberry, pallid serviceberry or wood rose. Low growing mountain dogwood, that shows evidence of distorted stems from snow may occur. Bush chinquapin is sometimes present. Commonly occurring moist site indicating herbs include trailplant, mountain sweet-cicely, starflower, false Solomon's seal, and fairy bells. Other species that are often present that indicate moderate sites are: white-flowered hawkweed, little prince's pine, Ross's sedge, kelloggia, rattlesnake plaintain, and western fescue.

<u>Typical Plant Associations:</u>

White fir-mixed conifer/trailplant

White fir-mixed conifer/false Solomon's seal-Hooker's fairy bells

White fir/moist rocky

Landscape Ecology and Environment: This group occurs on sites similar to the white fir-mixed conifer/moist productive group but where soils are shallow or rocky. It most commonly comprises small patches in the landscape, surrounded by larger blocks of the more productive moist group.

Vegetation: This type has been very poorly sampled or mapped. Little information is available for developing vegetation descriptions. White fir dominates the overstory and regeneration layers, with incense cedar the most typical minor associate. Sugar pine or Jeffrey pine may occur but typically in low amounts.

There is no information on typical understory species but it is likely that a mixture of the same species found on white fir-mixed conifer/moist productive sites and dry rocky sites occurs.

Typical Plant Associations:

No information is available on representative or typical plant associations.

White fir - mixed conifer/dry productive

Landscape Ecology and Environment: This group occurs on south or west aspects or ridges at higher elevations in the mixed conifer zone. Soils are moderately deep to deep. It tends to occupy large continous patches in the landscape, broken up by smaller patches of rocky openings in some areas.

Vegetation: An open to moderately dense conifer forest (40-70% canopy cover) with a sparse understory characterizes this group. Canopy layering is moderate with two to three layers typical. White fir and Jeffrey pine co-dominate the overstory in various mixtures. Incense cedar is consistently present as a minor component.

The shrub layer is often sparse or absent. Creeping snowberry is the most prevalent species on less disturbed sites. Bush chinquapin may be present on both undisturbed and disturbed sites. Greenleaf manzanita or mountain whitethorn are common on disturbed sites. The herb/graminoid layer is often diverse, comprised of dry, open site indicator species. Western needlegrass, California groundsel, lupine, squirreltail, naked stemmed buckwheat and mountain monardella are typical species.

Typical Plant Associations:

White fir-mixed conifer/Ross' sedge

White fir-mixed conifer/creeping snowberry/kelloggia

White fir-mixed conifer/creeping snowberry/western needlegrass-groundsel
White fir-mixed conifer/bush chinquapin

White fir - mixed conifer/dry rocky

Landscape Ecology and Environment: This group occurs on sites similar to the white fir-mixed conifer dry productive group but where the soils are shallow or very rocky. It tends to occupy small patches in the landscape. This group may extend higher in elevation than any of the other mixed conifer groups, occurring on exposed sites within the transition to the white fir or red fir series because of the warmer microclimate. This type has not been heavily sampled.

Vegetation: Scattered trees (10% canopy cover) to an open forest (40% canopy cover) over a well developed shrub layer are characteristic. Canopy layer diversity,is low with one or two layers typical.

The overstory is co-dominated by white fir and Jeffrey pine in various mixtures. Incense cedar is a typical minor associate or co-dominant. Sugar pine is sometimes present but sparse.

The shrub layer is often well developed with huckleberry oak the most prevalent species. Creeping snowberry, mountain whitethorn or bush chinquapin may also be present.

The herb layer varies from sparse to well developed, dominated by dry, open site indicators. Prevalent species include mountain monardella. mule's ears, penstemon species, and Hoboell's rock cress.

Typical Plant Associations:

White fir-mixed conifer/huckleberry oak

Note: this type has not been heavily sampled or mapped and there are likely other plant associations that are common.

MAPPED TYPES NOT INCLUDED IN MIXED CONIFER MODEL

Canyon Live Oak Series

Landscape Ecology and Environment: Extensive patches of canyon live oak are mostly found in larger canyons on steep, exposed slopes. It often occurs in a mosaic of shrub or herb dominated openings of various sizes or with patches of ponderosa pine-mixed conifer-canyon live oak or Douglas-fir - mixed conifer-canyon live oak subseries.

Vegetation: An open to moderately dense oak woodland (30-80% canopy cover) characterizes this series. Canyon live oak is generally the only tree species present. Occasional, scattered conifers may occur, but they have low cover and often have high mortality in drought periods. Black oak sometimes occurs as a minor component, although generally when black oak is present, it indicates more productive soils and the potential for conifer co-dominance in later seral stages. The understory in canyon live oak stands is often sparse but can be very diverse in small openings. Scattered shrubs of poison oak or white-leaf manzanita are typical.

Red Fir Series

Landscape Ecology and Environment: The red fir series occurs at higher elevations, generally above 6,000 or 7,000 feet in the northern Sierra Nevada. The dominant form of precipitation is snow. Landscape patterns are highly variable, but the tendency is for a complex, often high contrast mosaic of open and closed forest interspersed with non-forested openings of rock outcrop or meadow. The patches of red fir most often occur in areas with better soil development that are well drained, the Jeffrey pine series on the sites with shallow or rocky soils, and the lodgepole pine series on wetter sites with poor soil drainage.

Vegetation: Red fir generally dominates the tree layers. But lodgepole pine, white fir, western white pine or Jeffrey pine occur frequentlyu as minor associates or co-dominants. Frequently at the lower elevations mixed stands, co-dominated by white fir and red fir occur. The understory is often sparse or may be absent.

Red fir/dry productive

An open to moderately dense forest (30-70% canopy cover) dominated or co-dominated by red fir are characteristic. Jeffrey pine may co-dominate the overstory or be absent. Lodgepole pine, western white pine, white fir or sugar p3.ne may be present in varying but often low amounts.

The understory is often sparse or poorly developed. Common species include mule's ears, mountain monardella, Brewer's golden aster and needlegrass. Mountain whitethorn may be extensive on disturbed sites.

Jeffrey Pine Series

Landscape Ecology and Environment: Sites are generally harsh, with skeletal or shallow soils and high solar radiation. Ridges, south aspects and windswept areas are the most typical locations. Patch size varies with the extent of soil conditions to which the Jeffrey pine series is most typically associated. This varies from large, extensive patches where glacial scouring has created large openings to small patches where rock outcrops are more limited in extent.

Jeffrey pine/dry rocky group

Jeffrey pine dominates the overstory and regeneration layers of the Jeffrey pin/dry rocky group. Forests range from scattered trees (10% canopy cover) to open woodlands (40% canopy cover).

The understory is variable from a well developed shrub layer to a sparse but often diverse herb and graminoid layer. Huckleberry oak is the most common shrub species but greenleaf manzanita is often prevalent.

APPENDIX O – RANGE USE

Livestock Grazing in the Mill, Deer, and Antelope Creek Basins
Almanor Ranger District, Lassen National Forest
Prepared by: Howard Brown
1997

INTRODUCTION

The northern Sierra and southern Cascades have been impacted by livestock grazing since the mid 1800s when early settlers migrated into the area. Since the onset of livestock grazing, use has been periodically dominated by both sheep and cattle. Rangelands, particularly meadow and foothill areas have been an important source of livestock forage in summer months. In drought years, and every year on some allotments, forest rangelands have been utilized from spring to fall. Rangeland grazing trends have been followed since the 1920s and rangeland condition trends since the 1950s. It is likely that more than a century of livestock grazing has had a pronounced effect on aquatic and riparian condition.

REGIONAL RANGE HISTORY

Detailed data on rangeland use within the Mill, Deer, and Antelope Creek basins do not exist for years prior to the creation of the Forest Service when records began to be kept in 1920. General accounts of livestock abundance in the northern Sierra do exist. Johnston (1992), and McKelvey and Johnston (1992) report that prior to the gold rush, livestock grazing was negligible. Cattle grazing was established by 1860, but a severe drought from 1862-1864 terminated many cattle operations and caused a shift from cattle ranching to sheep herding.

In 1870, there were an estimated 2,768,00 sheep in California, and by 1880 there were 5,727,000. Over one half of these sheep were in the Central Valley and many of them grazed in the Sierra Nevada mountains from spring through fall (Johnston, 1992). The Sierra Nevada Ecosystems Project (Menke, Davis, and Beesley, 1996) states that the Lassen National Forest received heavy use, accounting for 25% of total grazing because it served as a driveway for sheep traveling to and from Nevada, northeastern California, and Oregon. By 1900, 125,000 sheep grazed seasonally on the Lassen Forest Reserve, and another 125,000 sheep grazed for shorter periods as they traveled through. Grazing by sheep declined sharply by 1905 when the Lassen National Forest implemented a grazing permit system and placed restrictions on sheep herding (Taylor, 1990). In 1915 the U.S.F.S. fixed allotment lines to grazing areas. Detailed records of livestock use of the Deer, Mill, and Antelope basins are available beginning in the 1920s.

Data detailing historic livestock use of meadows within Lassen Volcanic National Park do not exist, however livestock grazing in the park probably began in 1850 with the opening of the Noble Emigrant Trail. In 1854, more than 33,000 livestock traveled this trail. Cattle, horses, and sheep were also grazed in the park meadows by ranchers in the mid-1860s. Sheep numbers apparently increased between 1850 and 1870 and meadows within the park were grazed heavily in the mid-1880s (Taylor, 1990). Taylor (1990) also reports that grazing pressure on Lassen Volcanic National Park was high at the turn of the century, but after 1905 stock numbers were reduced when the Lassen Forest Reserve introduced a grazing permit system. Sheep grazing declined sharply after this date, but cattle grazing decreased more slowly. Cattle and sheep grazing inside Lassen National Park was reduced after the park was established in 1916 with only 200-500 sheep allowed to graze within park boundaries although grazing pressure was still high in park meadows in 1920 (Mather, 1920).

Sheep dominated livestock grazing on National Forest land until the 1920s when allotment sizes were reduced and permits were converted to cattle. Since this period, livestock grazing within Mill, Deer and Antelope Creek has been dominated by cattle (Sierra Nevada Ecosystems Project, 1996).

In the mid-1930s the Taylor Grazing act went into effect in an effort to reverse the trend of overgrazing by cattle and stabilize the grazing industry. In 1978, the Public Rangeland Improvement Act amended the Federal Land Policy Management Act of 1976 allowing for Allotment Management Plans to be prepared for grazing permits. Currently, grazing management practices are being reviewed and allotment management plans are being updated in order to improve riparian conditions and habitat for riparian-dependent species.

It is likely these regional grazing trends correspond with grazing trends in the Mill, Deer, and Antelope Creek basins. Large meadows such as Childs, Deer Creek meadows and the open range of the foothills were probably utilized extensively by livestock. Deer Creek meadows went into private ownership in 1871, 1891, and 1904, and Childs Meadows in 1878, 1905, and 1907, indicating that these areas were in use by range animals at this time.

REGIONAL HISTORIC RANGE IMPACTS

Several accounts indicate that the intensity of sheep grazing in the Sierras and southern Cascades led to extensive over grazing of grasses, forbs, herbaceous shrubs and young trees, contributing to significant soil erosion:

> "The soil being denuded of grass is broken up by thousands of sheep tracks, and when the rains come this soil is washed down the mountainsides into the valleys, covering up the swamp and meadows, destroying these natural reservoirs

> (1894, report to the Acting Superintendent of Sequoia and General Grant National Parks, as quoted by Vankat, 1970)."

> "There are practically no grasses or other herbaceous plants [in the Sierra Nevadas]. The forest floor is clean. The writer can attest the inconvenience of this total lack of grass forage, for in traveling over nearly 3,000,000 acres not a single day's feed for saddle and pack animals was secured on the open range. From a study of long protected forest land in the same region and from statements of old settlers, it is evident that formerly there was an abundance of perennial forage grasses throughout the forests of this territory It would seem that this bare condition of soil surface in the open ranges has been produced only through years of excessive grazing by millions of sheep and constant overstocking of the range (Sudworth, 1900)."

> "My trip to Lassen [National Park] showed every meadow in the park was grazed to the ground. Unless things change there will be no beauty in Lassen meadows" (Lewis, 1924).

In the 1940s, and 1950s, in response to rangeland encroachment by brush, herbicide spraying was undertaken to eradicate unwanted species and open rangeland to increase forage. Following his inspection of an allotment in 1949, Lassen National Forest Supervisor Philip B. Lord writes:

> "In the Government pasture at Little Grizzly willows are beginning to appear again. Ranger Bacon plans to spray these with 2,4-D and also some skunk cabbage that is in the pasture…the permittee is interested also in alder eradication (1949 Annual Grazing Report, Lassen National Forest)."

Although there is no documentation of similar treatments in the Mill, Deer, and Antelope basins, it is possible such treatments did occur because we believe they were widespread. Lord also describes general range condition at the allotments he inspected in 1949. He reports overstocking with resulting trampling and rangeland deterioration at the Cone-Ward allotment, Wilson Lake, and Childs Meadows, and heavy usage at Deer Creek Meadows with wet areas breaking up due to constant overstocking throughout the season.

MILL, DEER, AND ANTELOPE CREEK RANGE HISTORY

Data that can be traced to individual basins are not available until the 1920s when the Lassen National Forest began keeping track of the number of livestock on allotments. Prior to the 1960s livestock numbers were monitored, but strategies focusing on optimal range use had not been established. By the 1980s, total grazing capacity for each allotment had been estimated based on available forage, season, and duration of use. This information was used in the development of the Lassen National Forest Land and Resource Management Plan. Current grazing capacities are adjusted to meet Forest Plan resource standards and guidelines.

Mill Creek

Rangeland use in the Mill Creek basin has been dominated by cattle since 1924. Prior to this date, Mill Creek received heavy use by sheep, particularly allotments in the lower basin abutting the Central Valley. These lower basin allotments were heavily utilized by drift and trespass sheep before private rangelands were fenced. Some Mill Creek allotments received year long use between 1927 and 1940. Deteriorated range conditions leading to high cattle mortalities resulted in allotments being converted to temporary permits.

Intensity of rangeland use in the Mill Creek basin has not been consistent since the 1920s at the inception of documented grazing records (figure 1.) All allotments within this watershed have experienced changes in stocking intensity throughout the period of record. Allotment boundaries have changed over time, so we have evaluated trends in grazing intensity over time by looking at all allotments within the Mill Creek basin. This cumulative perspective reveals that the intensity of rangeland stocking in Mill Creek has shown a decline since 1920 (figure 2.). In 1920, there were approximately 4112 animal unit months (aums) of actual use in Mill Creek. This intensity declined to 2329 aums in 1940 before rising to 3796 aums in 1950. Since 1950, grazing intensity in Mill Creek has declined. In 1995, permitted use was reduced to 360 aums with the cancellation of the Tehama allotment permit in 1995.

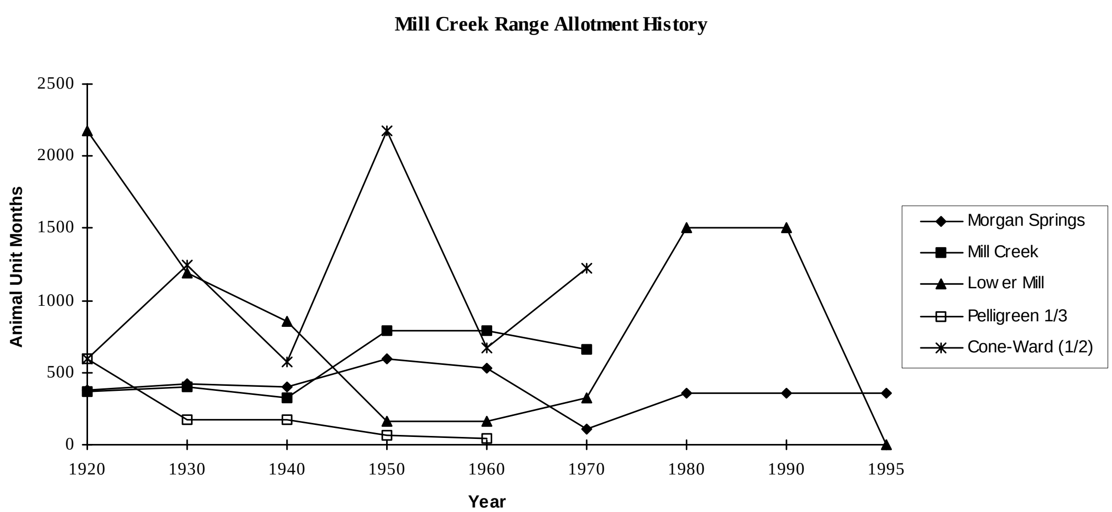

Figure 1-O. Animal unit months on each allotment within the Mill Creek basin from 1920 to 1995.

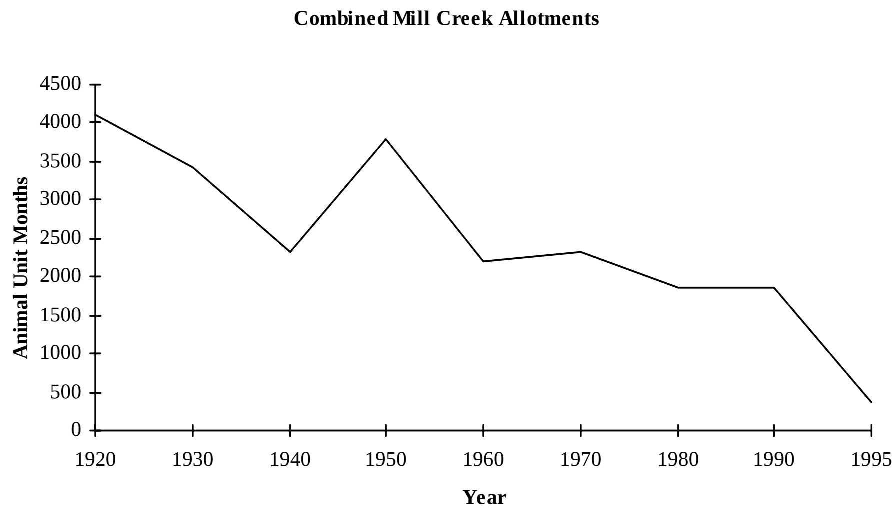

Figure 2-O. Animal unit months on all allotments within the Mill Creek basin from 1920 to 1995.

Deer Creek

Cattle have dominated the allotments within the Deer Creek basin since 1936. Prior to this time, allotments were used by both sheep and cattle.

Rangeland use in the Deer Creek basin has also gone through changes in intensity since the 1920s (figure 3.) Most of the dramatic changes have occurred in the early period of record. The Deer Creek allotment, occupying Deer Creek Meadows, has received the most intense use. In 1920, the Deer Creek allotment supported 4000 aums, reaching a peak in 1930 with 5742 aums. By 1940, use in the Deer Creek allotment had crashed to 317 aums. Since 1950, use in the Deer Creek allotment has stabilized at close to 2000 aums.

As with the Mill Creek data, the easiest way to display use over time is to combine use from all allotments in the Deer Creek Watershed. Figure 4. illustrates an overall reduction in range use since 1920. In 1920, there were approximately 5600 animal unit months of actual use in Deer Creek. This intensity increased to 8300 aums in 1940 before declining to 2230 aums in 1995. Grazing intensity in the Deer Creek basin appears to have remained relatively stable since 1950, ranging between 2170 and 3500 aums.

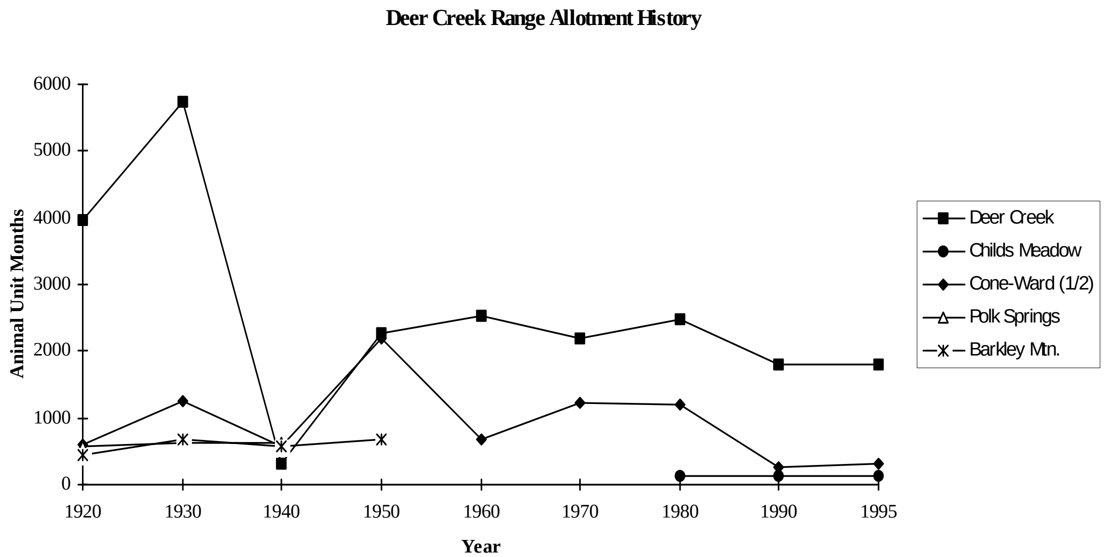

Figure 3-O. Animal Unit months on each allotment within the Deer Creek basin from 1920 to 1995.

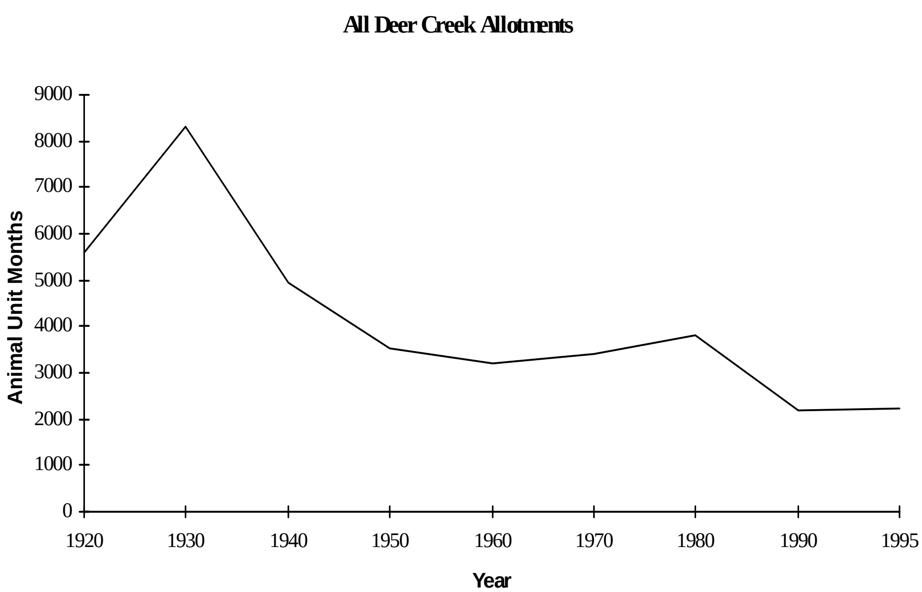

Figure 4-O. Animal unit months on all allotments within the Deer Creek Basin from 1920 to 1995.

Antelope Creek

Allotments within the Antelope Creek basin have been utilized by both cattle and sheep on temporary and yearlong permits since the 1920s. The earliest use was on a yearlong basis, converting to temporary permits in 1948 as rangeland carrying capacity became better understood. Between 1923 and 1947 the Lyonsville allotment received heavy use by both sheep and cattle. Sheep use in the Lyonsville allotment was discontinued in 1949. From 1924 to 1947, the Antelope allotment was used primarily by cattle with short periods of sheep use. Since 1959, the Antelope allotment has been used primarily by cattle.

As with allotments in the Mill and Deer Creek basins, the allotments in the Antelope Creek Basin have shown considerable changes in stocking intensity since the 1920s (figure 5.) Again, changes in grazing intensity were most erratic between 1920 and 1960, with the Lyonsville allotment displaying the most change. Lyonsville rose from 2770 aums in 1920 to 5280 aums in 1940 before crashing to 200 aums by 1960. Lyonsville is currently supporting 140 aums.

When considered cumulatively the use on all allotments with the Antelope Creek basin reveal a consistent decline (figure 6.) In 1920, Antelope Creek supported a total of 5014 aums. By 1940, it was supporting 5752 aums before beginning a steady decline to 740 aums in 1995.

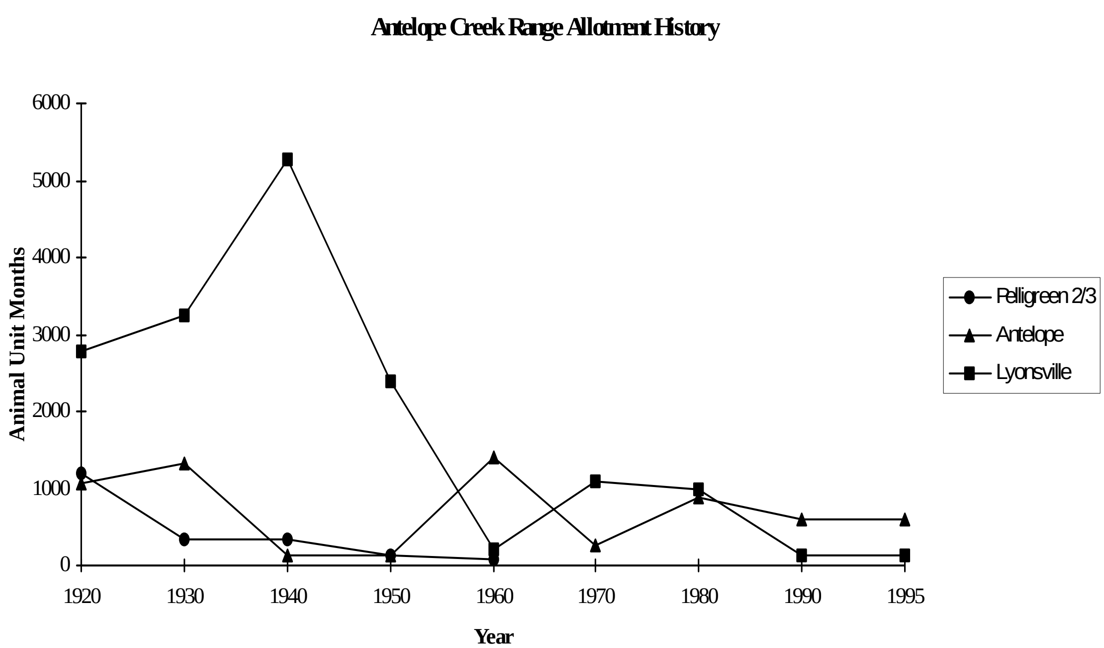

Figure 5-O. Number of livestock grazed on each allotment within the Deer Creek basin from 1920 to 1995.

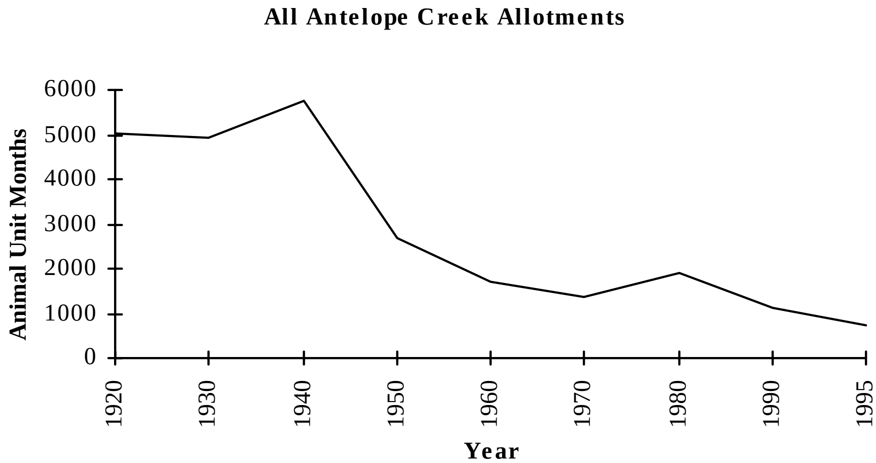

Figure 6-O. Animal unit months on all allotments within the Antelope Creek Basin from 1920 to 1995.

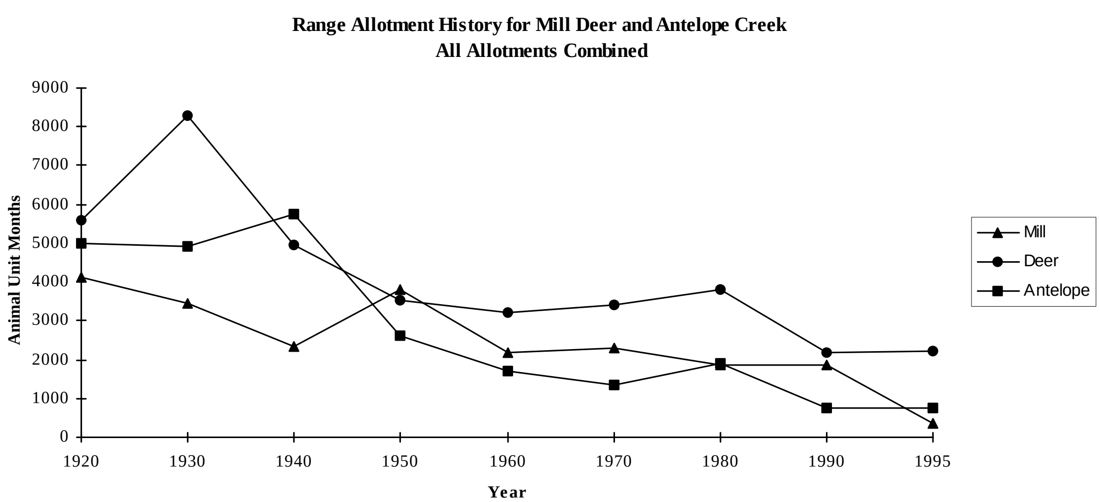

Figure 7-O. Animal unit months grazed within each WA basin from 1920 to 1995.

CONDITION AND TREND MONITORING

Mill Creek

Condition rating data were collected on allotments within the Mill Creek watershed from 1957 to 1967. Allotments within the Mill Creek basin showed no net change in soil and vegetation condition between these dates (figures 8 and 9.) The Cone-Ward allotment, cluster 1 showed and improvement in condition, with a soil rating increase from poor to fair and a vegetation rating increase from poor to good. The Morgan Springs allotment, cluster 21 showed a decline in condition in soils and vegetation.

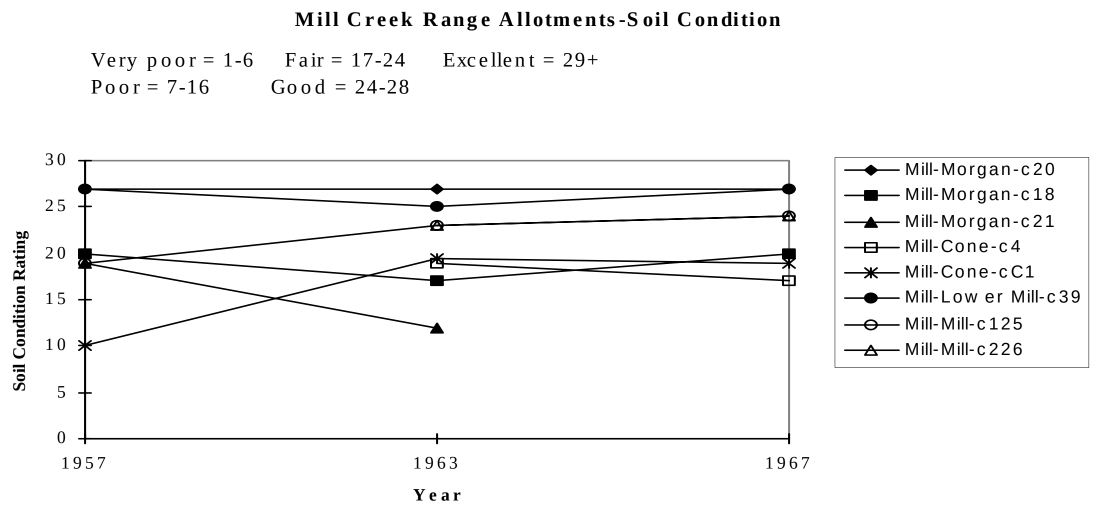

Figure 8-O. Soil condition ratings for allotments within the Mill Creek basin from 1957 to 1967.

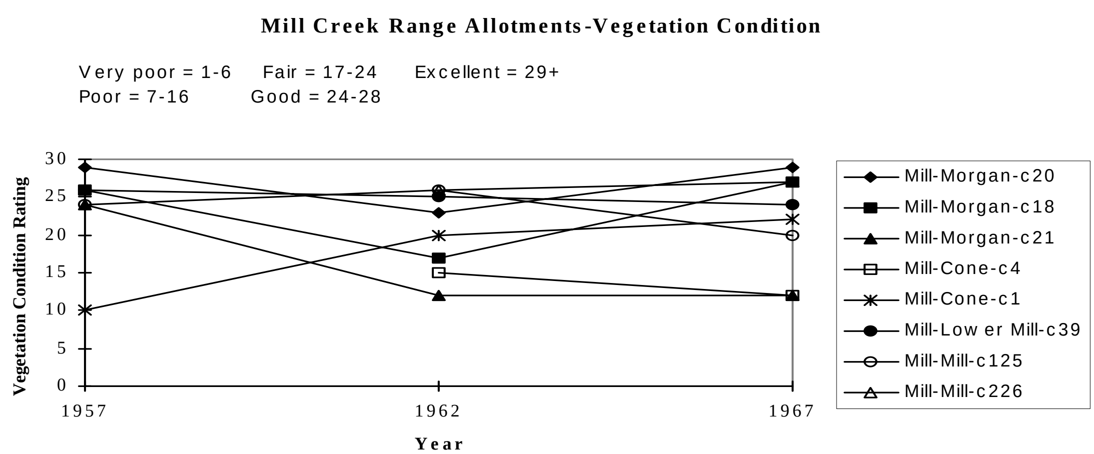

Figure 9-O. Vegetation condition ratings for allotments within the Mill Creek basin from 1957 to 1967.

Deer Creek

Condition rating data were collected on Deer Creek from 1957 to 1986. Condition ratings in Deer Creek allotments exhibit a trend similar to Mill Creek allotments. There appears to be no appreciable change in soil or vegetation condition between 1957 and 1986 (figures10 and 11.) Soil condition ratings ranged from poor to good in 1957. All allotments that were still being monitored by 1986 had soil condition ratings of fair to good (figure10.) Vegetation condition ratings ranged from very poor to good in 1957. By 1986, the allotments monitored were rated in fair to good condition, yet only three of the original seven were still being evaluated. The only noticeable change occurred on the Cone-Ward allotment, cluster lM2; the vegetation condition rating changed from very poor to fair between 1957-1986 (figure 11.)

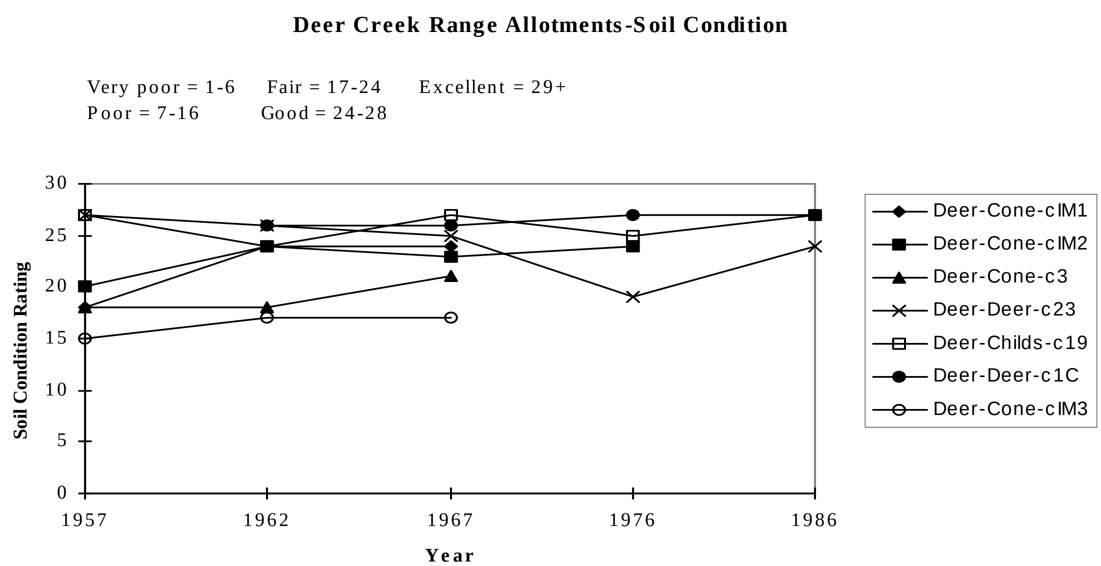

Figure 10-O. Soil condition ratings for allotments within the Deer Creek basin from 1957 to 1986.

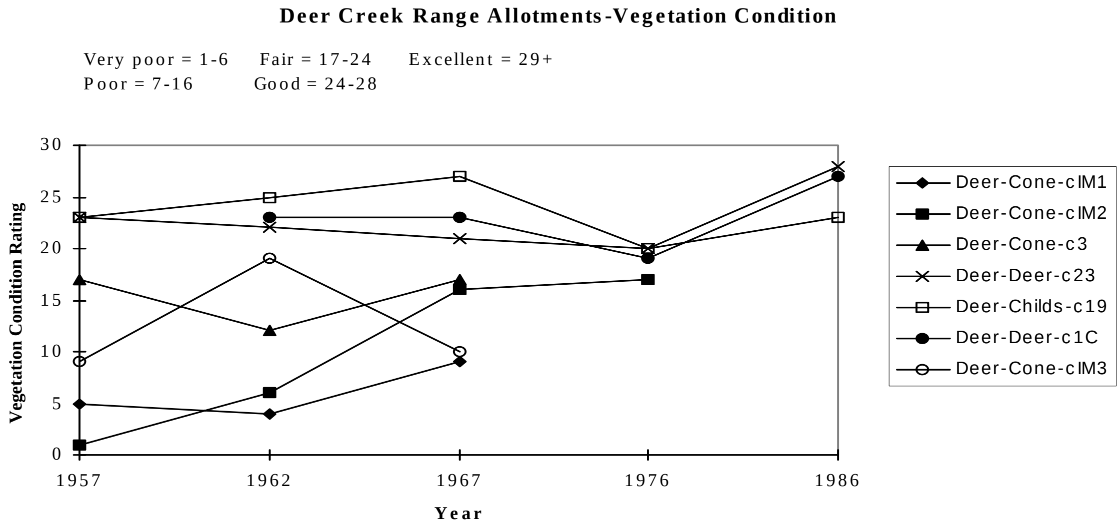

Figure 11-O. Vegetation condition ratings for allotments within the Deer Creek basin from 1957 to 1986.

Antelope Creek

Condition rating data were collected on Antelope Creek allotments from 1957 to 1976. There appears to be no net change in soil condition during the period of record (figure 12.) The Lyonsville allotment, cluster 22 shows an initial improvement in soil condition from poor to good between 1957 and 1962, but declines to a poor condition between 1962 and 1976. The soil rating for the Antelope allotment, cluster 126 improved from poor to good between 1962 and 1976. Vegetation ratings for the Antelope Creek basin show a moderate increase in net improvement (figure 13.) Vegetation condition ratings ranged from very poor to fair in 1957, and increased to a range of poor to good in 1976 with only one of six allotments, Lyonsville, cluster 22, rated as poor in 1976.

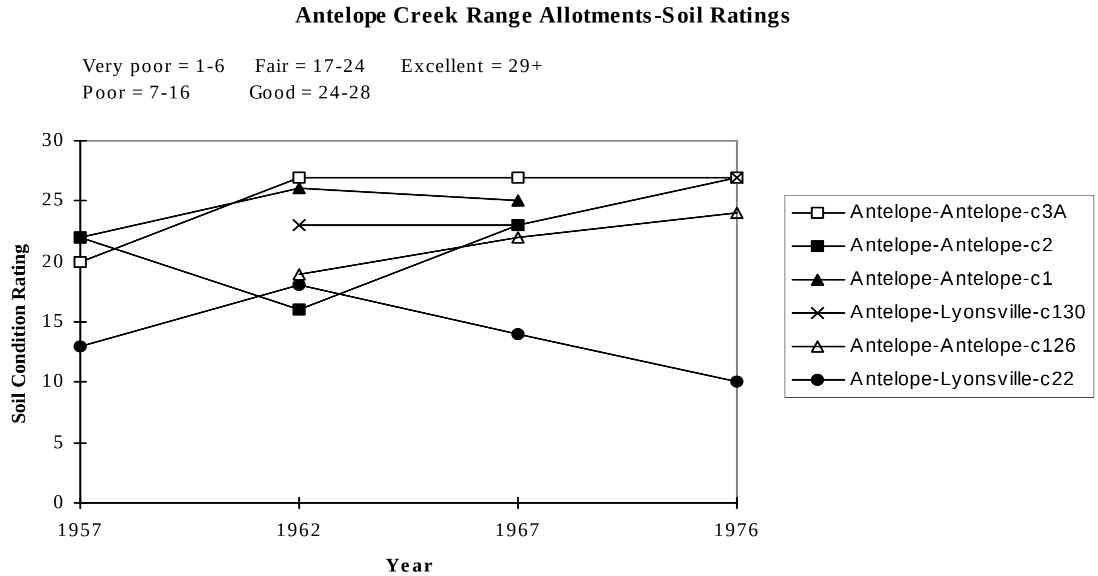

Figure 12-O. Soil condition ratings for allotments within the Antelope Creek basin from 1957 to1976.

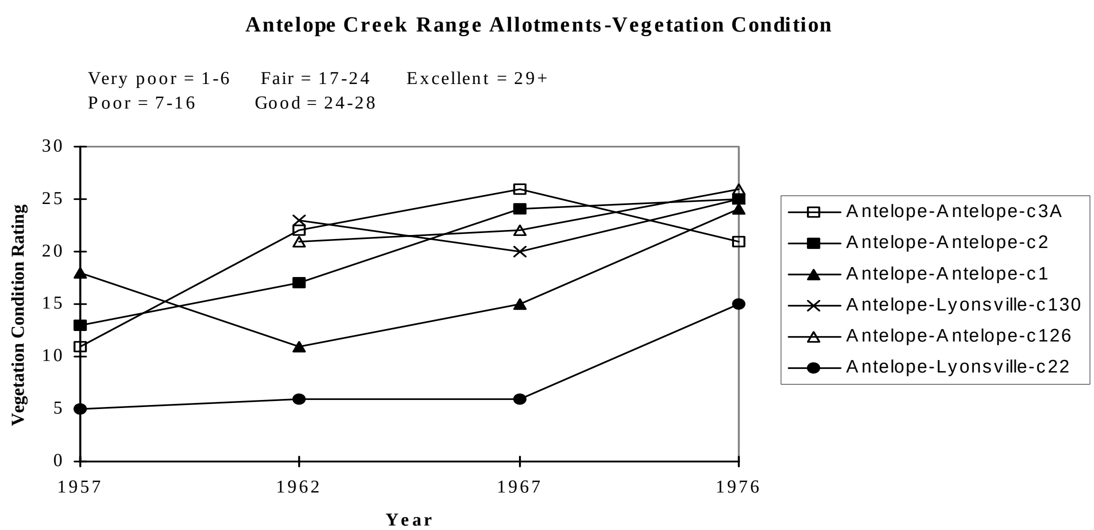

Figure 13-O. Vegetation condition ratings for allotments within the Antelope Creek basin from 1957 to 1976.

SUMMARY

Early livestock grazing in the Mill, Deer, and Antelope Creek basins was dominated by sheep. Sheep numbers peaked at the turn of the century and slowly declined between the 1920s and 1930s as allotment boundaries were fixed and permits were converted to cattle grazing. Cattle have dominated range use since then.

Historically, the Deer Creek basin has supported greater grazing intensity and total use than the Mill and Antelope Creek basins. This ability to support more intense grazing is possibly due to the extensive amount of rangeland in Deer Creek Meadows, the larger size of the Deer Creek allotment, and the greater size of the Deer Creek basin . Mill Creek has historically supported the lowest amount of grazing. All allotments experienced erratic changes in grazing intensity between the 1920s and the 1950s before leveling to a point at which they are close to today. In the 1920s allotment use in the basins ranged between 4000 and 5577 aums, while in 1995 aums ranged between 360 and 2230.

Many historical accounts discuss the effects of livestock grazing on rangelands in the Sierra and southern Cascades regions. Most of these describe a deteriorated condition of soil and vegetation. Efforts to eradicate unwanted riparian and other brush species have been undertaken since the early days of sheep herding when fires were set to clear rangeland, and continued into cattle grazing days with herbicide applications and other eradication strategies.

Periodic condition and trend monitoring was conducted on some allotments between 1957 and 1986 to evaluate range condition. Although some allotments have exhibited improved or declining condition ratings, a substantial change in the soil and vegetation ratings did not occur on grazing allotments within the Deer, Mill and Antelope Creek basins within the monitoring periods. The only exception to this would be the Antelope Creek vegetation condition rating. The allotments within this basin showed an overall increasing trend in condition between 1957 and 1976.

Efforts to monitor rangeland utilization and condition are increasing as evaluative techniques improve. Along with monitoring upland condition, streams and riparian corridors are being monitored in order to evaluate the condition of core aquatic habitat attributes. These steps to improve the monitoring of rangeland condition are designed to track if Forest land use objectives are met.

If aums were very much higher historically, as records show from 1920 to 1990, and speculated use was higher still prior to 1920, and there is a correlation between range and riparian condition, then we can surmise that conditions in grazed areas of the watershed were substantially worse historically. However, if grazing intensity has continued at a level in which riparian conditions were not able to recover, then conditions may not have improved even as range use has been reduced and modified.

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APPENDIX P - WATERSHED ELEMENT DESCRIPTIONS

Watershed Element Descriptions
for
Disturbance, Erosion, and Stream Channels

WATERSHED SENSITIVITY ELEMENTS

- Basin Size: Sub-Watershed Area, in acres
- % of Basin in Rain on Snow: This element is an attempt to reflect the risk of a rain on snow precipitation event, and is based entirely on elevation. We selected the 3600'-5000' elevation band as the dominant rain on snow zone. The number is the % of the basin in the 3600'-5000' band.
- % Rhyolite: Data source is the Forest (Lassen and Tehama County) Soil Surveys. Reflects the % of the sub-watershed identified as rhyolitic soils. All slope classes are represented.
- % EHR: Same data source as above, overlaid with the slope map. This element reflects the % of the sub-basin in non-rhyolitic soils classes as having High, or Very High Erosion Hazard rating on slope greater than 35%.

WATERSHED DISTURBANCE ELEMENTS

- Road Density: The miles of roads in the sub-basin divided by the watershed area provides a value of road density in miles per square mile. Values from the Meadowbrook Conservation Associates (MCA) road evaluation were used. The MCA values were supplemented with mileage of the State Highways in the Mill and Deer Watersheds (not included in the MCA survey). Values for Antelope Creek were derived by GIS overlay of roads and sub-basins. The road layer was checked against Ortho photos (1990) and roads not on the GIS coverage added. These values have a high accuracy for Mill and Deer Creeks (field verified by MCA), and a moderate-high accuracy in Antelope Creek (Forest Service values were consistently higher than MCA values in Deer and Mill Creeks).
- Crossings per Mile: An attempt to look at the number of crossings on a "density" basis, this value is the quotient of the number of crossings in a sub-basin divided by the miles of stream in the sub-basin. Crossings have been shown to be a major

source of road related sediment. These values have a moderate to-high accuracy. As discussed later, the stream channel delineations have not been field verified.

- # of Crossings on Rhyolite: A subset of the Number of Crossings element, this is a count of the crossings on the rhyolitic soils (from the GIS soils, stream and road layers). Rhyolitic soils have been shown to be high sediment producers. This value highlights both the soil and crossing sediment risks and has a high accuracy.
- Existing Erosion: From the MCA road report, and estimate in tons per square mile of existing erosion based on site evidence (rills, sloughs, gullies, etc.)
- Potential Delivery: Also from the MCA report, this is an estimate (also in tons per square mile) of likely erosions, also derived from the site evidence. This estimate has unknown accuracy, again it is likely to be better for comparative purposes than absolute erosion volume estimates.
- Existing Delivery: This is the Existing Erosion value multiplied by a delivery coefficient. Accuracy of the estimates are unknown, but good for comparative purposes.
- Fire: Acres of fire in the sub-watershed, data from the Forest GIS overlay. Fires date back to 1911. Acres are the total burned, without reburn acres subtracted. In some cases, fire acres exceed basin acres due to reburns. Only fires greater than 100 acres are included in the data base. This results in a value lower than the actual, but it is likely that fires less than 100 acres had low burn intensities relative to larger fires. Overall, the accuracy of these values is rated as moderate-high.
- Ortho. Disturbance: This is an estimate of timber harvest related to disturbance in acres. These values were used for Private lands only; Forest Service history is described below. Orthophotos were used for this analysis, the accuracy is affected by several factors. Orthophotos were available for 1975 and 1990. Activity on those photos was attributed to the year of the photo when, certainly, a large percentage of the activity had taken place earlier than the photo date (this impacts the ERA values). Activities on Forest Service and Collins Pine Company lands after 1990 were added, and the ERA values reflect those activities. Post 1990 activities on other lands was not added, so in sub-basins where Collins and Forest Service are not major land managers, the estimates may be low. Secondly, harvest activities were designated as light, heavy or clearcut. Clearcuts were easy to distinguish , as were very light and very heavy cuts. Distinguishing between the two designations was difficult, and also affects the ERA values. Accuracy of these values is rated as moderate.
- Forest Service ERA: ERA is an acronym for Equivalent Roaded Acres. Forest Service records were searched for location and type of timber harvest. Units were mapped and transferred to GIS. ERA is an attempt to express the amount of overall disturbance in a watershed. All disturbances are equated to road disturbance. Coefficients are applied in an attempt to reflect the degree of disturbance relative to a road. Coefficients are also applied to reflect recovery from the disturbance over time. Coefficients used in this analysis are listed in table 1. Recovery was estimated to be complete 30 years after treatment (except for roads which are assigned no recovery value). Assumed recovery is not linear,

with 15% recovery in each of the first two years following disturbance, 10% in year 3, 5% in years 4-6, 2/12% in years 7 and 8 and 2% per year for years 9-29.

Table 1-P.- ERA coefficients used in the Watershed Analysis for Mill Deer and Antelope Creeks.

Disturbance	**Value**
Road	1.00
Tractor Clearcut	0.35
Wildfire	0.30
Cable Clearcut	0.20
Ortho Photo "Heavy" Cut	0.20
Group Selection	0.20
Leave Tree	0.20
OSR/IS/Shelterwood	0.20
Ortho Photo "Light" Cut	0.10
Salvage	0.10
Helicopter Logging	0.05

- Ortho ERA: The orthophoto disturbance values described earlier, with activity and recovery values applied. All disturbance on the 1990 photos was assumed to have occurred in 1990, all on the 1975 photos in 1975, hence these estimates are certainly high.
- Fire ERA: The fire disturbance acres described earlier, with activity and recovery values applied.
- Collins ERA: These values are derived from the Collins GIS harvest record, they are used only for the period 1991-1995 and have the appropriate recovery periods applied. All were given disturbance coefficients of 0.1.
- Sum ERA: A sum of all the ERA based disturbance elements in the sub-basin (Sum ERA = Road ERA + Ortho ERA + FS ERA + Fire ERA + Collins ERA). Accuracy of these values is estimated at moderate. As with the road erosion values they have far more value for comparative purposes than absolute values.

NEAR STREAM DISTURBANCE

Areas close to streams have been recognized for their importance in influencing channel conditions (through contributions of wood and sediment, providing shade, influencing channel stability) as well as buffering the stream from impacts of upslope disturbance. Estimates of near stream disturbance are an attempt to assess condition of these important areas.

- Estimated Near Stream Acres: Near Stream acres were estimated using the GIS stream layer (taken from USGS topo maps). Identification of channels from maps has proven problematic, as they have not been field verified as either perennial or intermittent. Our guess is that the designation of perennial streams has a moderate to high accuracy and intermittent designations have a lower accuracy. We feel that the mapping probably underestimated the length of channels that is actually providing flow during most years. As with many other attributes discussed earlier, it is the relative comparison between sub-watersheds that is of most value, rather than the acres themselves. Near Stream Area for perennial streams was calculated by buffering the perennial streams 300’ on both sides of the stream (600’ total width). Near stream area for intermittent streams was calculated by buffering these streams 150’ on both sides (300’ total width). Areas are expressed in acres.

- <u>Orthophoto Disturbance</u>: This attribute is similar to the watershed wide estimate of activity discussed earlier. Activities near streams were identified on the photos, and then overlaid with the “buffered” stream layer (stream channels with the 300’ or 150’ buffer widths). Areas that overlapped were counted as near stream disturbance. Though activities were initially classified by disturbance types (canopy removal, landings, skidtrails) the values displayed have all types lumped. These estimates were made for both private and Forest Service lands. The estimates are “high” because no attempt was made to apply recovery coefficients to the treated areas (versus standard ERA type analysis, which does factor in recovery). The exception to this “high” estimate is in the sub-watersheds with high fire incidence. Near Stream Disturbance has not yet been calculated for burned areas.
- <u>Road Disturbance</u>: These values were derived from overlaying the road layer with the buffered stream layer. Road lengths that were within the 300’ and 150’ widths were counted as near stream. A 30’ effective width was used to convert the road length to acres. These estimates were based on the Forest Service road layer (versus MCA), so these estimates are probably higher than actual.
- <u>Sum</u>: Orthophoto and road near stream disturbance are summed and displayed in terms of the number of acres near perennial and intermittent streams, and as a percentage of the perennial, intermittent and total (perennial + intermittent) near stream acres, by sub-watershed.

WATERSHED DISTURBANCE

Some of the same attributes were calculated using the 1975 orthophotos, Forest Service records for timber harvest and fire history up to 1975, and estimates of road density from Forest Service records. Disturbance on the 1975 photos was taken to have occurred in 1975, therefore, the ERA numbers are “high”.

STREAM DATA

1. Fish Habitat Assessment Data was collected in the early 199s on the entire length of Mill, Deer, and Antelope Creeks upstream of the Forest boundary (to the LVNP boundary on Mill Creek). Most primary tributaries in drainages with dominant Forest Service ownership were also surveyed. Some explanation of technique is necessary to take into account when comparing to other data.

- Shade: Calculated with a densiometer, the average of readings in the four cardinal compass directions.
- Residual Pool Depth: Maximum pool depth minus pool tail depth.
- % Fines at LGR: These are ocular estimates of the percentage of silt and sand in Low Gradient Riffle habitat types.
- Pool Tail Embeddedness: These are ocular estimates of the degree (% from 0-100) to which pool tail substrate is embedded in fine (sand) material.
- Erosion: This is an estimate of the length (and % derived) of the stream channel bank that showed signs of active erosion.

2. Forest Service Stream Condition Inventory (SCI) Data. Collected in 1996. Data utilizes a recently developed Forest Service Region Five protocol. Reaches of stream are are selected for fairly intensive survey. Attributes are measured (except for bank stability, which is an ocular estimate). Some of the attributes and their measurement techniques are listed below.

- Shade: Measured with a solar pathfinder, so canopy closure is weighted toward those areas which provide shade during the middle of the day. Measurements are taken facing south.
- % Fines: Measurements are taken on pool tail substrate. A 14" square grid with 50 intersections is tossed at systematically chosen locations. Intersections covering sand or silt (materials < 2mm) are counted as fines. Tallly is multiplied by two to derive a percentage.
- % Particles <2mm: The tally of particles less than 2mm diameter, derived from a pebble count of 100. The count is conducted in a zig-zag pattern from the downstream extent of the surveyed reach.
- D50: Also derived from the particle count, this number represents the median particle size of the 100 measured.
- Bank Stability: 100 systematically located streambank sections (1ft wide from water's edge to bankfull) are rated as stable, vulnerable or unstable, based on vegetative or other bank cover, and the evidence of erosion (cutting, sloughing, etc.).

3. Lassen National Forest PACFISH Monitoring. A subset of the SCI protocols, selected to collect data on the most important reaches in the Mill, Deer, and Antelope Creek watersheds. Two of these attributes differ from the Regional SCI.

- % Particle <2mm: At PACFISH sites, particle counts are limited to spawning gravels versus the zig-zag survey of all habitat types in SCI.
- L*: Is a measure of sediment in pools. It is the measured maximum lengths of any sediment lens deposited in a pool, divided by the maximum length of the pool.

APPENDIX Q -**CULTURAL RESOURCES**

A Chronological Look at the Changing Pattern of Human Use

In the Watersheds of Mill, Deer and Antelope Creek

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Michael A. Dugas, Archaeologist
Almanor Ranger District, Lassen National Forest

PAST LAND USE IN THE WATERSHEDS OF MILL, DEER AND ANTELOPE CREEKS

INTRODUCTION

This report will present a chronology of past land use in the Mill, Deer and Antelope Creek watersheds. Land use will be traced from the earliest known aboriginal occupations in this area to circa 1945. The purpose of this investigation is to show the changing patterns of land use in these watersheds over time and the effect these changes have had on the landscape.

SOUTHERN CASCADE PRE-HISTORY

Native American occupation of the Southern Cascades and adjoining Sacramento Valley has fluctuated through time. These fluctuations are the result of resource availability, catastrophic events, cultural conflict, and migration. California is unique in its diversity of Native American languages. At historic contact, linguists identified numerous language groups in Northern California (Kroeber 1925; Shipley 1978), many of which could be traced to similar language stocks found elsewhere in the western United States. These language groups were thought to coincide with tribal territories as defined by early ethnographers. Complicating the picture was the fact that ethnic territories frequently shifted in California (Heizer 1962; Kroeber 1959).

The majority of the land irrigated by the Antelope, Deer and Mill Creek drainages is within ethnographic Yana territory. Mill and Deer Creek flow through Yahi Yana territory while Antelope Creek flows within Southern Yana territory. The lower reaches of these drainages flow through territory occupied historically by Wintuan linguistic groups (see figure 1). It is questionable, however, whether or not the territory was under control of any one tribal group at historic contact (Johnson and Theodoratus 1984:209). Kroeber (1925) puts the western boundary of the Yana at the start of the foothills while Waterman (1918) places the boundary arbitrarily at the 1.000 foot contour line. A Native American informant, Sam Batwi, said the Yana had regular fishing stations on the Sacramento River, though this is not documented. Prior to the establishment of the Yana culture group, Native American land use was more ephemeral, as migratory bands ranged far in quest of food and shelter. Their highly mobile lifestyle required frequent residential moves leaving very little archaeological residue behind.

The prehistory of the Southern Cascades is fairly well documented archaeologically for the last 4000 years. Prior to this time, the archaeological record is less complete, as Native American populations were more mobile and fewer in number. While not specific to the watersheds of Antelope, Deer, and Mill Creeks, the earliest documented occupation in the region dates to approximately 9000 B.C. Native American land use over the last 11,000 years has fluctuated significantly from highly nomadic bands to semi-sedentary groups with large investments in material culture. Although, much of the archaeological record is undocumented, the following narrative describes the known information within each time period for this region.

Early Holocene (9000 B.C. - 6000 B.C.)

Also referred to as the Paleoindian Period, the early Holocene was a period of increasing aridity, although the climate was cooler and wetter than today. Much of the Great Basin was covered with pluvial lakes that were beginning to dry up. Evidence of prehistoric occupation is scant, consisting of small sites with large fluted dart points. Fluted points are distributed throughout the United States with isolated specimens represented in California including Lake Almanor, Borax Lake and the Redding area (Wallace 1978:26). The Fluted Point Tradition is characterized by small migratory bands hunting large game with spears tipped with Clovis points. Clovis points date to a period of megafauna roaming the land, including the native American horse, camels, mammoths, and ground sloth. Clovis points have been found in association with megafauna suggesting an important food resource of aboriginal populations, however, evidence has not been found in the Southern Cascade region. As the climate became drier, the pluvial lakes shrank, leaving desert shrubs in place of open grasslands that formerly supported megafauna. This changing habitat led to the proliferation of smaller species including deer, mountain sheep, and antelope (Kowta 1988:51)

During the later part of the early Holocene Period, human habitation appears to have become more focused on the shorelines of old pluvial lakes. Characterized by large stemmed projectile points and “crescent stones”, this period is thought to represent a lacustrine (lake) adaptation. Several sites with large stemmed points have been found in the area including specimens from Marian Creek that lie near the headwaters of Deer Creek. It is postulated that an increased use of marshland resources replaced megafauna as the primary resource base. Resource procurement would have centered more on water fowl and plants associated with marshland habitat surrounding the dwindling lake margins. The “lacustrine adaptation” is still tentative, since sites with large stemmed points and crescent stones have also been found outside of lakeshore environments. Kowta (1988:54) suggests caution, assigning a lacustrine adaptation to the Western Pluvial Lakes Tradition. Sites from this period tend to have only surface manifestations and represent highly mobile bands that left very little impact to the environment.

Early Archaic (6000 B.C. - 3000 B.C.)

The Early Archaic also referred to as the Millingstone Horizon (Kowta 1988:58), is characterized by a mixed subsistence strategy that included the processing of hard seeds with milling equipment (i.e. mano and metate). While hunting also occurred, it was probable that it was more generalized, including smaller game as well as large. Hallmarks of this period include millingstone use as well as basketry production, both of which are part of the “ hard seed production technology.” This new technology may have contributed to a slightly more sedentary lifestyle. Projectile points associated with this period (i.e. Pinto, Northern Side-notched, etc.) closely mirror the distribution of mountain sheep populations on the eastern crest (Kowta 1988:60). Evidence from this period is also found on the western side of the Sierra Nevada but it is scant. Wide stem points associated with this period have been found at Borax Lake and Squaw Creek on the west side of the Sierran crest. Kowta (1988:63) has suggested that the distribution of these wide stem points correspond with the historic distribution of the Roosevelt Elk in California. Overall, this time period is not well documented within this study area (i.e. Antelope, Deer and Mill Creeks), however, much of the region has not been inventoried. It is probable that the study area received some aboriginal use during this period.

Middle Archaic (3000 B.C. - A.D. 500)

Evidence of human habitation in the Southern Cascades begins in the Middle Archaic. There still remains a void of information at the start of this period for the area under study. To the south, however, in the northern Sierra Nevada, began a period termed “Martis” which is generally associated with high elevation sites (2,500 - 6,000 ft.) with a tool assemblage dominated by basalt. The Martis Tradition is thought to represent an early adaptation to drier climatic conditions in which hunting was the main emphasis of resource procurement. This tradition is thought to cover the period between 2,500 B.C. -

A.D. 500 (Zeier and Elston 1986:17). It is hypothesized that dry conditions led to a higher elevation distribution of oaks, which may have resulted in the movement of deer and other medium to large mammals upslope (Kowta 1988:68-69). During this period, there was also a proliferation of intensively utilized occupation sites. Sites associated with this cultural tradition provide evidence of house structures and midden accumulations scattered from Plumas and Lassen County, south to the Lake Tahoe Basin.

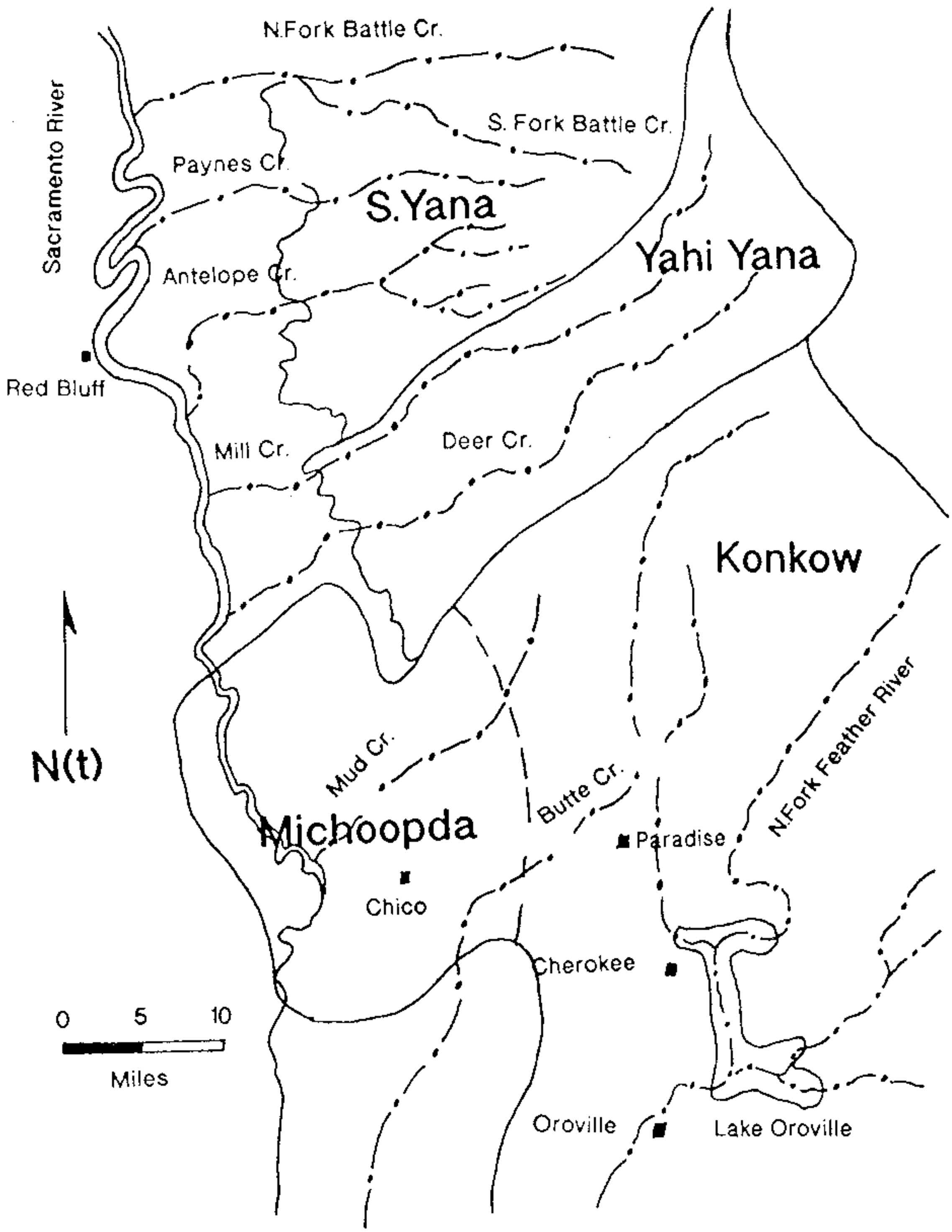


Figure 1-Q. Tehama Watershed Analysis Project Area.

Archaeological sites dating to the period between 2,500 B.C. and A.D. 500 have been located on the Sacramento Valley floor and in the foothills in Yana territory. J. Johnson presents a model regarding population developments in the Southern Cascade foothills and Sacramento Valley (Johnson and Theodoratus 1984). In his model, Johnson indicates that the northern Sacramento Valley was only sporadically used between 4500 B.C. and 2500 B.C. by Hokan speakers. During this period only the extreme north end of the Sacramento Valley was occupied primarily in the foothills within the Pit River and its tributaries. Between 2500 B.C. and 1500 B.C., parts of the Northern Sacramento Valley were beginning to be occupied. A continuation of the use of milling equipment is noted although hunting was still relatively important. By 1500 B.C. ancestral Yana populations were expanding into the Southern Cascade foothills along Mill and Dye Creeks. It is from this period on that a local sequence was formulated covering the areas within the study area. Based on studies at Paynes Cave and Kingsley Cave (Baumhoff 1955, 1957), Dye Creek (Johnson N.D.), and Deadman Cave (Greenway 1982) the “Southern Cascade” cultural chronology was established

Deadman Complex (1500 B.C. - 500 B.C.)

Sites located on Mill and Dye Creeks in Yahi and Southern Yana territory have evidence of Deadman period occupation. These sites are either rock shelters (Mill Creek) or midden villages (Dye Creek). While numerous rock shelters and open sites are common to Yana territory, it is probable that numerous other sites in the vicinity were occupied during this period. During this time period, aboriginal populations used the foothills sporadically as part of their seasonal round in search of food (Johnson 1994:6). Large projectile points and knives made primarily from basalt and milling equipment represents a large part of the artifact assemblage. There is no evidence of acorn processing at this time, mortars and pestles are absent from the archaeological record. However, manos and metates were used for processing a variety of plants. There is no evidence of a fishing taking place during this period (Johnson 1994:7). It is likely, therefore, that subsistence activities focused on hunting of medium to large mammals and a diversified diet of plant resources. The presence of Haliotis shell beads and pendants, and olivella shell beads indicate that trade networks with groups in coastal settings had been established. Shell artifacts are, for the most part, rare at this time.

Kingsley Complex (500 B.C. - A.D. 500)

Sites dating to this period are well documented in the archaeological record. Of the ten sites excavated by Johnson (Johnson and Theodoratus 1984:213), six had evidence of intensive use and an additional two showed sporadic use during this temporal period. These include open sites on Dye Creek in the lower foothills of Tehama County and rock shelters on Mill Creek at about the 2000 ft. elevation. Additional work done by Lassen National Forest has identified open midden village sites on Antelope, and Deer Creeks, which were heavily occupied during this period. Sites excavated by the Forest Service on Antelope Creek revealed an extremely high representation of artiodactyl remains (probably deer) indicating exploitation of artiodactyl was important. It appears that site densities were higher during this time period based on Dye Creek site data (Johnson N.D.).

Johnson (N.D.) has identified artifact associations within this period, which may provide some clue as to the land use. The first evidence of hopper mortars, in addition to milling equipment, suggest a higher investment in the procurement of plant remains, namely acorns. An acorn processing technology necessitated a more sedentary existence, requiring the use of non-portable processing equipment. Additionally, the processing of acorns took many days to complete and often times required storage facilities (i.e. baskets, rock lined granaries, etc.) to extend their future availability in resource poor times. Johnson indicates that single and multi-family structures were in use at this time. Projectile point styles were still relatively large, probably used in conjunction with spears rather than bow and arrow. Basalt was still the dominant material type although obsidian specimens occur. Greenway indicates that Kelly Mountain and Tuscan obsidian were the major obsidian types used during this period (Greenway and Nilsson 1986). Salt water shells were still used for beads and ornaments and were found in conjunction with burials.

Dye Creek Complex (A.D. 500 - A.D. 1500)

The Dye Creek period is documented at virtually every site tested in Yana territory. It is, therefore, a period when Yana territory was extensively used. Site densities are extremely high along Mill, Antelope, Deer, and Dye Creeks. Virtually every flat river terrace or habitable rock shelter has evidence of Yana occupation within Mill or Dye Creek canyons. This pattern is found on many of the smaller intermittent drainages as well as the major ones. Site densities appear to far outnumber the ethnographic population estimates made by early ethnographers and explorers. This increased site density could relate to any of three factors: 1) Yana populations continued to expand as a result of resource intensification, 2) sites were not occupied simultaneously as the Yana frequently changed residential locations from year to year, or 3) they may have expanded from the valley into the foothills as a result of the hypothesized late entrance into the Chico area by the Northwestern Maidu between A.D. 700 - 1000 (Whistler 1977).

Although this period is characterized by many of the same ground stone artifacts, important changes in raw material usage occurred that may reflect land use changes. The former dominance of basalt for chipped stone tools was largely replaced by obsidian, primarily from the Tuscan source. Kelly Mountain obsidian is present but in significantly smaller quantities (Greenway and Nilsson 1986:Table 3). This raw material change has been noted elsewhere at sites on Antelope and Mill Creeks on Forest Service lands. It has been suggested by Greenway and Nilsson (1986) that this change may relate to Maidu intrusion into the Kelly Mountain area, thus cutting off the Yana from this toolstone supply. An alternative explanation is that better access to the Tuscan source (a far superior glass), through trade, etc. precipitated the change. Another significant development occurred, the bow and arrow technology, which may be connected with the raw material shift. The use of arrows required significantly smaller points. Tuscan obsidian source occurs most frequently in small (2-4 cm) nodules, which was more usable for small projectile point manufacture than for the large spear points. Bone awls and other tools as well a clam shell beads were also in use at this time.

Mill Creek Complex (A.D. 1500 - 1845)

The Mill Creek Complex is also well represented at sites within the study area. Several of the sites investigated by Johnson (N.D.), however, are lacking this later component. Interestingly, these sites are on the western edge of the foothills. These sites may have been abandoned after the Maiduan entrance into the region. A similar lack of very late period artifacts have been noted in Deer Creek Canyon at the southern end of Yahi territory. While a total abandonment of the southern and western fringes of Yana territory is not likely, there does appear to have been a territorial emphasis to the north and east at the time.

The use of hopper mortars and pestles for processing acorns and milling equipment for other floral processing continued to occur. Obsidian is still the dominant chipped stone material although silicate (CCS) materials become more common. Very small serrated projectile points are common and arrow fragments made from elderberry have been recovered at rock shelters on Mill Creek. Twined and coiled basketry and twined cordage has been found at rock shelters in the region. A variety of plant species were used for basketry including redbud, willow, cottonwood bark, grapevine fiber, hazel, pine roots, sedge, and maidenhair fern (Sapir and Spier 1943:260). Pitted boulder petroglyphs and rock rings are also found at sites from this time period. J. Johnson (1994:82) suggests that these rock rings represent single family structural foundations. Sites have been identified as having from one to 28 house rings.

Historic (Protohistoric) - Ethnographic Yana Complex (A.D. 1845 - A.D. 1911)

This time period represents a span of seventy years when the few remaining Yana attempted to avoid extermination at the hands of Euroamerican settlers. Within this period, the Yana incorporated Euroamerican artifacts into their tool inventory as well as Euroamerican foods. Historic items used include: bottle glass for projectile points, square nails for flintknapping and spear points, glass trade beads among miscellaneous other artifacts (e.g. metal, buttons, needles, nails, cloth, etc.). Cattle were herded and butchered by the Yana and cabins were raided for food (Anderson 1909). Much of the deer population had been killed off by Euroamerican settlers making it difficult to secure enough food for the remaining Native American population.

Traditional Yana settlement deviated considerably during this period. Many of the rock shelters which Ishi claimed were the “haunts of the old ones” and not used by the Yahi (Kroeber 1961) were, in fact utilized as evidenced by bottle glass arrow points, etc. The Yana were no longer free to move into the valley where Euroamericans lived and their movements were blocked to the south and east by white settlers and Maidu groups. Ishi and his group of five were forced to set up camp in a craggy brush covered area on a bluff above Deer Creek (“Bears Hiding Place”) to escape detection. While still living an aboriginal lifestyle, Ishi and his group escaped capture until 1911 when he turned himself in at Oroville.

Sacramento Valley Sites

The sequence identified for the Yana covers the territory drained by Antelope, Mill and Deer Creeks and their tributaries from their origins near Lassen Park to the western edge of the foothills. Several studies have indicated that the areas containing the mouths of these creeks at the Sacramento River were largely unoccupied (Johnston 1978, Johnson and Theodoratus 1984). There are, however, several recorded sites within the vicinity that should be considered. A perusal of the site records at the Northeastern California Clearinghouse at Chico State University turned up 46 known sites in the area bounded by the lower foothills in the east, the Sacramento River to the west and the Antelope Creek watershed in the north and the Deer Creek watershed in the south. Very few of these have been excavated, but the few that have, indicate a relatively early presence in the region and a trend toward abandonment by the start of the Mill Creek Complex.

Temporal data from sites within this region indicate occupation as early as 2000 B.C. (Johnson and Theodoratus 1984). It has been postulated by Kowta (1988), Dreyer (1984), Deal (1988) and others that the earliest occupation in this part of the valley are Hokan speaking groups, possibly ancestral Yana. Dreyer (1984) reports on excavations performed in the Chico vicinity showing a similar trend towards early occupation of valley sites with a south to north sequence of site abandonment at the start of the Late Horizon (circa A.D. 1000). This may coincide with the hypothesized Maiduan entrance into the Chico area.

In addition to temporal data, subsistence data hints at land use variability in the valley sites. Dreyer (1984) looked at the data from several sites in Michoopda territory in the Chico vicinity. He noted a correlation between fish and water fowl procurement and proximity to the Sacramento River. Sites further away, in close proximity to the foothills had diverse faunal assemblages with artiodactyl representing the most dominant taxa. Sites closer to the river were dominated by waterfowl and aquatic resources (i.e. shellfish, fish). Interestingly, there was a trend towards exploitation of aquatic resources later in time, whereas early on, riverine sites focused more on waterfowl than fish. It is possible that this shift towards aquatic resources late in time coincides with the Wintuan arrival into the area from the north. It has been suggested by Johnson (1984) and others that the Wintu brought a technology into the area, emphasizing a riverine adaptation, and were able to implement this strategy upon arrival in the northern Sacramento Valley. The late shift towards riverine resources may indicate ancestral Yana and Wintu occupations. It is likely that the Sacramento River fishery was not significantly exploited until after A.D 1000.

Regional Land Uses

The watersheds considered here (Antelope, Deer, Mill Creeks) extend from the vicinity of Lassen Park at elevations around 7,000 feet down to their mouths near sea level in the Sacramento Valley. There are different land use areas along the length of these watersheds that should be explained. As each drainage has its own physical characteristics, they will be discussed individually.

Antelope Creek: Antelope Creek originates from several small lakes lakes located above 6000 feet. The North Fork starts at Turner and Diamond Lakes and the South Fork starts at Pear Lake. No sites have been located in the upper stretches of the North Fork although two isolated projectile points were found in the vicinity of Diamond and Turner Lakes. The upper stretches of the North Fork runs through unsurveyed private land. Sites are well documented beginning in the vicinity of McClure Place at around 2,200 foot elevation. In this area, sites are densely clustered middens, some with housepit depressions and pitted boulder petroglyphs. This cluster of occupation may represent, a single triblet, the largest functioning political entity among the Southern Yana. Another cluster of sites exists about 2-1/2 miles down stream at the confluence of the North and South Forks of Antelope Creek. Several of these sites have been excavated by Lassen National Forest, all have well developed late period attributes (i.e. Dye and Mill Creek Complex), and a few have artifacts dating into the early Kingsley and possibly Deadman period. These sites produced large faunal assemblages (mostly deer remains), which suggests hunting was an important activity.

There is a paucity of sites recorded between the Forest Service boundaries west to the Sacramento River. The sites that have been identified thus far include small lithic scatters and rock shelters. Sites along the Middle and South Forks of Antelope Creek are few and appear to be small task sites occupied during the summer months. As much of the area is steep and only accessible in the summer, it is probable that these small high elevation lakes provided important resources. Unlike scarce milling equipment , projectile points are very common at lakeshore sites, which suggests hunting to be the main activity. Waterfowl are known to migrate into the region in the summer and may have been targeted as a supplemental food source. Although, the pattern of prehistoric deer migration into higher elevations is unknown, it has been suggested by Wiant (1980), that the present migration patterns did not occur prehistorically.

Mill Creek: Mill Creek originates within Hot Springs Valley in Lassen Park and extends southwesterly down to the Sacramento River near Los Molinos. The highest elevation sites within this watershed lie at about 7,000 feet in elevation. Sites are primarily small lithic scatters representing task sites used while hunting. A pattern of small task sites (lithic scatters) lacking ground stone continues south of the park until the Childs Meadows area is reached. Along its fringes, numerous lithic scatters exist, many of which are very dense and contain ground stone assemblages that include hopper mortars, pestles, manos and metates. These sites probably represent summer base camps used by the Yahi Yana while hunting in the vicinity. The fact that mortars exist indicate that acorns may have been procured. Black oaks do occur in the higher elevations and may have had been considerably more prevalent prior to recent climatic shifts. Black oak acorns were highly valued by most Native American groups.

Very few sites are found downstream from Childs Meadows until about 2,800 feet in elevation at the oak woodland interface. At this point, the canyon opens up in places providing occasional flat terraces and exogene caves which were occupied during the winter months. From this point downstream to the Sacramento Valley are Yahi occupation sites with midden accumulations and evidence of house structures. Excavated sites in the region indicate occupation from fall through spring. Many of the sites in the vicinity of Black Rock are extensive, occupying large terraces. The large sites in the Black Rock area were probably created by the same groups returning to these areas year after year. The large size of these sites does not necessarily indicate a larger population. The few sites in the area that have been studied indicate deer was the dominate resource and acorns the favored vegetal food. Hopper mortars and milling equipment are found in high quantities in the region. Although, black oaks are present in the region, blue and live oak species were the most commonly exploited variety. A plethora of other plants could be found in the vegetative interface zone where conifer forest and oak grassland habitats converged.

Virtually every rock shelter or flat near water was occupied along the entire length of Mill Creek below this point. Sites are predominately middens, many with houspits. Generally most housepit villages have less than seven structures. Villages are also found along the intermittent drainages indicating very high site densities in the lower elevations. Outside of the main canyon of Mill Creek are found large lithic scatters with accumulations of basalt debitage (probably from Black Rock source), obsidian debitage (from the Kelly Mountain near Chester, CA and the Tuscan source near Redding) and an occasional ground stone implement. These base camps are commonly found near intermittent drainages on bluffs overlooking the Mill Creek canyon. Tasks sites, representing individual procurement or processing areas are found throughout the region, often away from water sources. These sites may be represented by ground stone scatters adjacent to productive oak groves (especially black oak) or lithic scatters associated with hunting or butchering locations.

<u>Deer Creek</u>: The headwaters of Deer Creek consists of Upper Gurnsey Creek, which originates at Childs Meadows at about 4,900 feet and upper Deer Creek, itself which originates at 7,300 foot elevation near the top of Butt Mountain. Sites within the vicinity of upper Deer Creek are predominately sparse lithic scatters or task sites associated with a single activity (i.e. butchering, hunting). These sites tend to occur along drainages and are associated with deer hunting activities. One exception is a rock ring on top of Butt Mountain (FS 05-06-51-299). This rock feature is found in association with very late period artifacts including the desert side-notched projectile point style and raw material types suggesting Maiduan affiliation (Dugas 1995, Kowta 1988). The headwaters of Gurnsey Creek in the vicinity of Childs Meadows is largely on private land and has not been completely inventoried. This region however, is densely covered with archaeological sites including task sites and seasonal base camps (as reported for Mill Cr.). Southeast of Childs Meadows there is a surprising lack of sites. The lack of sites in

this area may correspond to the cultural boundaries between the ethnographic Yahi Yana and Maiduan language groups.

Southwest (downstream) of the confluence of Gurnsey and upper Deer Creeks at Deer Creek Meadows, the canyon becomes steep with a heavy riparian overstory. For the next eight miles, not a single site has been located in the canyon itself. However, a single basalt quarry is located up an ephemeral drainage one mile to the east. Eight miles down Deer Creek Canyon lies a scattering of sparse lithic scatters. These sites begin appearing at an elevation of about 4,000 feet, and are evident until open air midden sites emerge at an elevation of about 3,000 feet. At this point, exogene caves and larger river terraces are utilized for winter villages by the Yahi Yana. From this point heading downstream, virtually every stream terrace and rock shelter was occupied on the north side of the creek. Sites were occupied throughout the winter months and may have been occupied in all seasons with the possible exception of the summer. Many archaeological sites have be found on bluffs overlooking the Deer Creek Canyon within the Ishi Wilderness. These sites range from small task sites to larger base camps.

The area below 1,000 feet is not well documented archaeologically as systematic surveys have not been conducted. A scattering of occupational middens have been located in the valley bottom along Deer Creek and a few further upstream. Overall, Deer Creek has far fewer sites than does Mill Creek between the 3,000 and 1,000 foot elevation. This is probably indicative of the rugged topography of the Deer Creek canyon. Numerous sites have been found along nearby intermittent drainages (Sulfur Creek, Big & Little Dry Creeks) demonstrating use of the area by aboriginal populations. These sites tend to be small rock shelters or housepit villages with middens consisting of ground stone and lithics remains. The sites tend to be smaller than those located on major drainages and were probably occupied throughout the winter.

Overall, it appears that Deer Creek was utilized in much the same way as Mill Creek. Sites distributions are similar except for the paucity of sites within the steeper segments of the canyon, which is due to the topographic nature of the canyon. Additionally, bedrock mortar stations have been identified at sites on Deer Creek and Sulfur Creek. Their presence indicates a possible connection with bordering Maiduan groups who are known to have used bedrock mortars. According to ethnographic literature, the Yana did not use this mortar type.

Other differences from Mill Creek sites at the same elevation (2,000 feet) were noted during the testing of several sites on Deer Creek near the Ponderosa Way bridge. These sites lacked artifacts associated with the Mill Creek Complex (A.D. 1500 - 1845). Also, these sites had a much smaller faunal assemblage, suggesting that deer processing, which is well represented at Antelope and Mill Creeks, was not as common on Deer Creek. The paucity of bone may be the result of poor preservation, differing processing practices, procurement strategies or time of occupation. Antelope Creek sites have the largest faunal assemblages (primarily artiodactyl) and the best represented late period artifacts. Together, these factors suggest that Deer Creek was used differentially during the Mill Creek Complex the reason for this hypothesized is not clearly understood.

Aboriginal Land Use

The project area extends from elevations between 7,000 feet and near sea level in the Sacramento Valley. The area was occupied by the Southern and Yahi branches of the Yana Indians. Kroeber (1925:339) estimated the precontact population of the Yahi division at 200-300 and 300-500 for the Southern Yana. According to Kroeber, the Yana had a maximum population of approximately 1,800 at any one time. It appears that the maximum population of the Yana was achieved during the later part of the Dye Creek period before Euroamerican diseases and competition for resources decreased their numbers.

Areas within the 1,000 to 2,000 foot elevation band saw the most use and habitation by aboriginal populations (Johnston and Budy 1982). Villages in this region situated near water and acorn groves and occupied at least three seasons of the year. During the summer months, the Yana migrated up to the higher elevations, in search of faunal and floral resources no longer available in their winter territory. Some of the more important high elevation floral resources include seeds from wyethia and buttercup, as well as squaw potato, camas, and epos. Faunal resources available in the upper elevations in the summer months include deer, waterfowl, fish and other small mammals. While there are currently large deer herds occupying the coniferous zone in the summer, it is unclear whether these herds always migrated into the region. Wiant (1981:129) indicates that deer may not have migrated into the higher elevations in sufficient numbers to be an important faunal resource. It is suggested that meadows and wetlands in the upper elevations were more numerous prehistorically offering habitat more conducive for waterfowl procurement. Johnston and Budy (1982, Figure 6) indicate that waterfowl range included areas in the vicinity of Childs Meadows at the headwaters of Mill Creek. Lakeshore sites in the Turner Mountain area (Southern Yana territory) would tend to support the premise of waterfowl procurement.

In the fall, the Yana exploited a variety of oak species including blue oak, black oak, live oak and canyon oak. While blue and black oaks were the favored variety, other species were collected when other acorn crops failed. During the early fall, deer hunting was intensified as they returned to their winter range in the foothills and October began the fall run of salmon exploited by the Yana. While Wiant (1981) suggests that salmon was the most important faunal resource, this is not supported by faunal data recovered from tested sites in the region. Clark (1929) has indicated that both fall and spring run salmon were present historically on Deer, Mill, and Antelope Creeks. Deer and Mill Creeks supported thousands of spring and fall run salmon. While it is clear that salmon were exploited prehistorically, the use of spears (instead of nets) limited the numbers of salmon taken.

During the winter months the Yana relied heavily on stored foods (i.e. acorns, dried deer and salmon) and occupied their winter villages. In the spring months a variety of small mammals, plants and fish were available in their winter range. Otter, bobcat, and other animals were exploited for their fur while most small mammals provided fresh meat.

Many grasses were collected during the spring for basketry and other manufactured items. The enhancement of basketry materials was accomplished through fall burning which made grasses more supple and easy to prepare. While there is no documentation for the Yana, the nearby Maidu burned the underbrush annually, to make hunting easier. Fires were set in grass and brushlands as well as in forests (Kroeber 1976:396; Dixon 1905:201) to promote better travel, hunting, and crops of food plants. Intentional burning was common practice in California and was probably a part of the Yana's agenda. The effects of fire would have reduced underbrush and promoted oak species over conifers in the region. This practice may have seriously altered the vegetative regime of the study area.

The traditional lifeways of the Yana were forever changed after the Mexican government began issuing land grants in 1844 and immigrants began passing through Yana territory on the way to the Sacramento Valley and the gold fields.

HISTORIC LAND USE

Mexican Land Grants

The earliest historic use occurred within the upper Sacramento valley by Euroamericans in association with Mexican land grants. In 1828, the Mexican government began issuing land grants to "foreigners" with the proviso that the land was to be used and improvements made. Several grants were issued within the Mill, Deer and Antelope Creek watersheds in 1844 along the east side of the Sacramento River. Primer Canon or Rio de los Berrendos "River of the Antelope" was granted to Job F. Dye and consisted of 26,637 acres of land along the lower reach of Antelope Creek. Rio de los Molinas "River of the Mills" began south of Rio de los Berrendos and was associated with the Mill Creek watershed. This land, approximately 22,200 acres, was granted to Albert G. Toomes. The most southerly land grant of concern was located at the mouth of Deer Creek, Rancho Bosequejo "sketch." This grant was about 22,206 acres in size and was granted to the infamous Peter Lassen (Figure 2).

Several land grants were also established along the west side the Sacramento River in 1844 including the Rancho de Barranca Colorado "Red Bluff" granted to Josiah Belden (18,000 acres); Rancho Flores "flower" granted to William Chard (13,000 acres); and Rancho Saucos "elder trees" granted to Robert H. Thomes (22,200 acres).

Cattle ranching was the main occupation of the Rancho's occupying the east side of the Sacramento river. The first herd of approximately 350 Spanish "long horn" cattle in addition to 150 horse and mules was purchased at Sutters Fort and brought to the upper Sacramento valley, specifically, Rancho Bosquejo by Peter Lassen in 1844. Albert Toomes and Job Dye began ranching operations about three years later (1847), also stocking their land with "long horn" cattle brought up from Monterey (Dye 1951). Cattle from these ranches were allowed to range for forage from the valley into the upper watersheds of Antelope, Mill and Deer Creeks. Activities from rancho's located on the east side of the Sacramento River had the first substantial impact on the local Native American Wintun, Southern and Yahi Yana populations. These groups for the most part were spared the cultural disruption and decimation caused by earlier Missionization and the Hudson Bay Trappers. Cattle grazing resulted in native groups being denied access to traditional hunting and acorn gathering areas in the valley and lower foothills, pushing the Yana further up into the hills. Cattle grazing also caused competition with the native animal populations for forage including deer, antelope and elk. By the turn of the century, over grazing of the area resulted in the replacement of native flora with non-native species

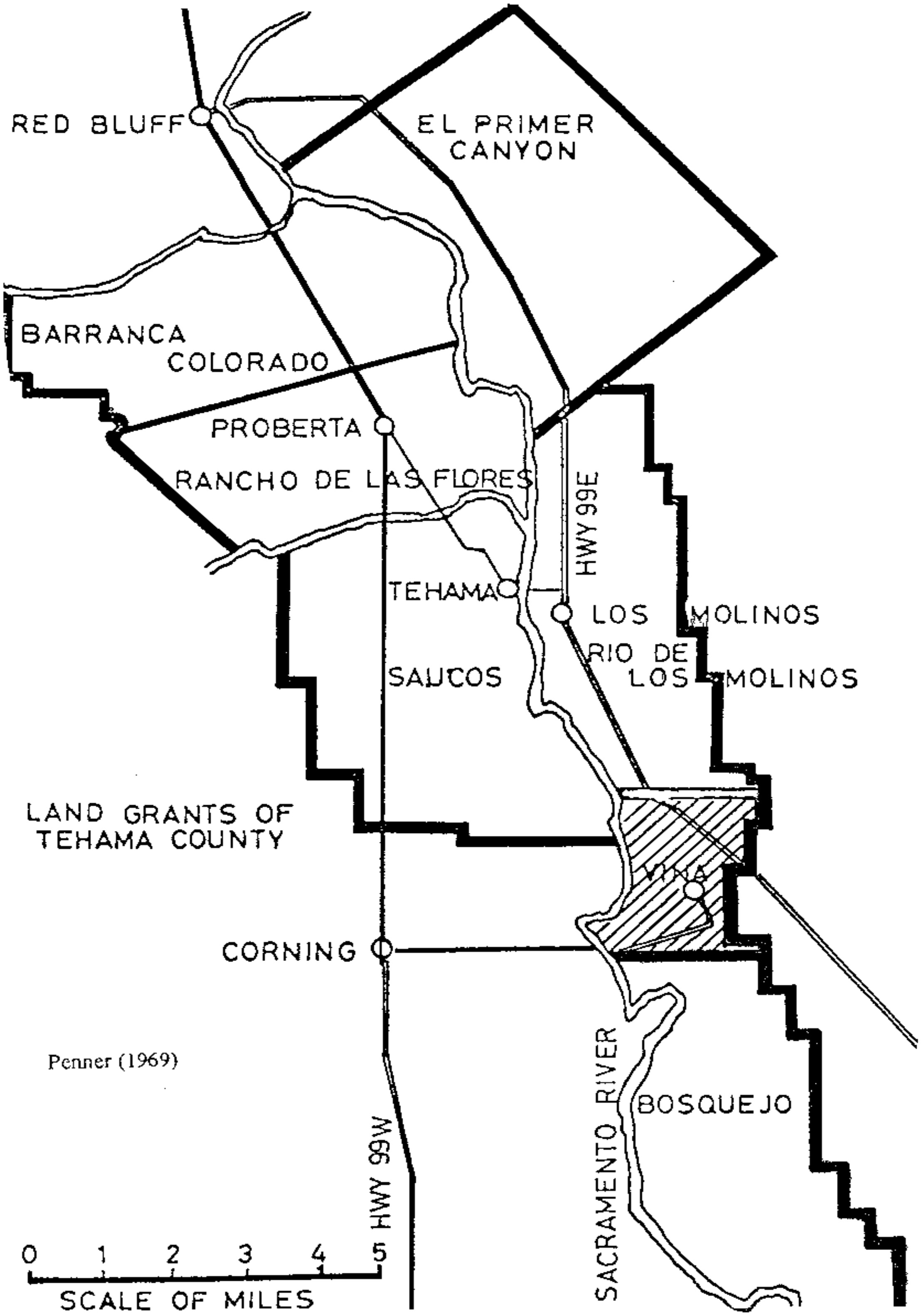


Figure 2-Q.- Land Grants

Lassen Trail

The gold rush of 1849 brought thousands of immigrants from the east into California seeking their fortunes in the gold fields or a better way of life in the west. Peter Lassen developed and advertised an overland route “the Lassen Trail” as a shortcut to the upper Sacramento Valley (Swartzlow 1964). His trail veered off from the established Applegate trail and ventured south along the Pit River, crossed Big Meadows (now Lake Almanor), proceeded west through Round Valley, along Round Mountain to the Narrows and followed an East/West trending ridge to Lassen’s Rancho Bosquejo in the valley. The Lassen Trail was not the short cut to Eden (Sacramento Valley) as described by Peter Lassen based on descriptions in the immigrant diaries of Goldsborough Bruff and Alonzo Delano (Read & Gaines 1944, Delano 1936). The hardships along this route suffered by immigrants were so extreme, use of this trail was abandoned as an overland route by 1851, only three years after the trail was established. The lack of forage for livestock was a serious problem faced by immigrants as described in the following passage.

> “When I found the Pines began to give place to ever-green oaks.....I observed many trees that had been cut down, so that the poor hungry cattle could browse upon the tender branches- a substitute that would scarcely sustain life”
> (Delano 1936).

The influx of people across the Lassen Trail in concert with ranching activities in the valley and foothills disrupted the native cultures and caused competition for forage between native animal populations and the large numbers of mules, oxen and horses brought across the trail as well as competition for deer and other game between immigrants and native peoples (Read & Gaines 1944). By the 1860’s, pressures brought to bear on native populations by immigrants and settlers would eventually result in conflict and the subsequent decimation of native American Indian populations of this area within twenty years (circa 1870).

Ranching

As mentioned earlier, ranching first began in this area by Peter Lassen and others after receiving land grants east of the Sacramento River from the Mexican government. J.S Cone recorded one of the earliest brands in California, the “pilot wheel” used on his herds located on the west side of the Sacramento River. The face of cattle ranching changed considerably in Tehama County as a result of a severe drought, which killed the majority of cattle herds between 1861 and 1862 in California (Vankat 1970). Approximately 30,000 head of cattle were lost in Tehama County from starvation during this period. In order to reduce cattle mortality many oak groves were felled to provide feed to starving herds. The drought also resulted in a significant change in emphasis from cattle to sheep ranching in Tehama County and provided the impetus to begin the practice of summering livestock on the abundant feed found in mountain meadows.

J.S Cone also brought sheep ranching into the area by 1856. Cone purchased portions of the Rancho Rio de Molinos in 1869, sold his cattle and went into the sheep business. By the 1860's, three million sheep ranged in California and almost half were located in the Central Valley. At this time, Tehama County had more than 300,000 head of sheep. The numbers of sheep in California doubled by 1876 to six million head. The Ward brothers, Ephiram and James, also started in the sheep business by 1870. Fourteen years later (1884), Cone bought out the interest of James Ward, merging the two companies into the Cone/Ward sheep company. Sheep ranching would continue by Cone/Ward firm until the late 1930's.

Another large sheep operation was established in the 1870's owned by Leo L. McCoy out of Red Bluff. McCoy was a prominent sheep rancher in the Red Bluff area for many years (Daily News N.D.). Although, sheep ranching was the emphasis in the watersheds by 1870; cattle ranching also continued on a smaller scale. The first black cattle "Galloway Bulls" were brought into the Lyonsville area by Jack Turner circa 1870. Turners' cattle were wintered in the vicinity of the Antelope Creek canyon (Daily News 1956, 1970).

In 1868 J.S Cone began acquiring large tracts of land. He purchased portions of the Rio de los Berrendos 1868 (acquiring the rest by 1887), the Adobe Ranch (near Red Bluff) in 1882, and portions of the Rio de Los Molinos rancho in 1884. Cone also acquired large tracts of land from the Central Pacific Railroad Company in the Mill and Antelope creek watersheds. Near the turn of the century, the first purebred herefords were brought into Tehama County by Doug Cone, J.S Cones' son. From about 1886 through 1909 the Cone operation "free grazed" cattle and sheep on Forest Reserve lands. By 1907, the Forest Reserves had been converted into National Forest lands. Permitted range allotments were set-up on National Forest lands to control grazing practices on public lands. Past grazing practices had severely impacted native vegetation replacing native species with exotic grasses and forbs. Over grazing especially by sheep had left vast tracts of barren land in the foothills and erosion problems. The Forest Reserves and later the Forest Service were established to protect the landscape from the earlier abuses. However, the advent of World War I brought an increased need for meat. Grazing practices on National Forest lands were immediately relaxed in the face of the National emergency. The price of meat skyrocketed and stockmen were allowed to graze unrestricted to fill the need.

> "Cattle and sheep ranchers, seeing the prices soar, increased their herd sizes. These enlarged herds were then grazed on lands that had previously been carefully managed to prevent overgrazing, or any grazing at all. The result included massive overgrazing, and poor animal quality from starvation. Between the 1920's and 1930's, many ranchers went bankrupt" (Prather 1995).

This resulted in extreme over grazing of National Forest allotments and the surrounding areas.
Along with many other ranchers, this also appears to have contributed to the demise of the Cone/Ward outfit by 1938.

Burning brush in the fall to make travel easier and forage better the following year was a standard practice of sheep herders. Sheep herders of the northern and southern Sierras were known to constantly burn downed fuel, small trees and understory vegetation resulting in devastating effects to forest regeneration and commercial timber.

> "Stockmen had an agreement among themselves that the last one out of the mountains in the fall were to set fire to the brush and let it go until fall rains put it out" (Eaton 1941).
>
> "Sudworth (1900) describes forest fires as so prevalent (late August to late October) that travel was often difficult because of dense smoke" (Johnston 1992).
>
> "We can reasonably infer that the intensity of sheep grazing for nearly 40 years in the Sierra Nevada impacted stand structure and regeneration patterns, producing lasting changes in mixed communities of grasses, forbs and shrubs......In the absence of competing vegetation, regeneration (of mixed conifer forests) was rapid and dense when sheep and fires ignited by sheep herders were no longer prevalent in montane forest" (McKelvey & Johnston 1992).

Sheep fell out of favor due to their destructive nature on the landscape and the negative effect of burning on commercial timber stands. For the most part, cattle ranching replaced sheep in the Mill, Deer and Antelope creek watersheds circa 1930. Ranching operations appear small compared to the early years of the livestock industry. Cattle were wintered in the valley and brought up to private lands or Forest Service allotments in the foothills and mountains during the summer.

Lumber Industry

Several early sawmills were constructed along the lower reaches of Mill Creek. James Payne built the first sawmill near the town of Los Molinos close to the site of Sesma in 1851. The "Tehama Mill Property" owned by James Payne was subsequently sold to Crosby in 1857.

Early mills were also constructed in the vicinity of Antelope Creek. A consortium of investors, S.W Hooker, B.G. Hooker, J. Chaffee and Albert Wayland built "Antelope Mills" on Job Dyes Rancho in 1855. Sawmills on Mill and Antelope Creek provided wood to the mill town of Sesma, located in the valley, which in turn supplied lumber to mining towns, new foothill and valley settlements, the railroad and mine operators. These early sawmills were located in the valley along the lower reaches of the creeks under study.

Lumber production in California skyrocketed after the Gold Rush (1850) from production of five million to 170 million board feet by 1870 (Johnston 1992). The logging boom was taking effect in Tehama and Butte Counties. The first areas to be logged within the three watersheds were the low elevation pine forests, areas providing rich timber resources in close proximity to the valley and transportation routes.

Circa 1870, C.F Ellsworth decided to sell his Empire Mill at Butte Meadows and start a larger, permanent logging and mill operation in the vast timber stands located in the mountains above Red Bluff and Los Molinos. He acquired the “Old Champion” mill on the south fork of Antelope Creek from Herbert Kraft and the Belle Mill near Lyman Springs from Kellum Powell between 1869-1870. From this location, Ellsworth felt he could fulfill the insatiable need for lumber in the valley harvesting extensive timber stands in the upper reaches of the Antelope watershed. Ellsworth solved the transportation problem of hauling logs to the valley in a virtually roadless area with the construction of the Antelope Flume. It was planned that the flume would end at Sesma located on the east side of the Sacramento River in order to take advantage of shipping on the California and Oregon railroad (Bauer 1992). Construction of the flume began at Belle Mill in 1871 and snaked its way down through the foothills to Sesma on the Sacramento River. The Antelope flume took three years to complete and was made entirely of wood requiring approximately 135m board feet of lumber per mile of flume. Part of the way down the flume a bog, now known as Finley Lake, was filled and transformed into a holding pond, which supplied water to the lower sections of the flume. With the help of flume tenders logs were transported along the flume using water from the South Fork of Antelope Creek and Dead Horse Creek traveling about 40 miles to the valley (Daily News 1963, 1976, N.D.).

> “From the meadow of Belle Mill, crystal mountain waters carried Sierra lumber through forests, down ridge tops, along lava canyons, spanning gorges and boulder fields until it spilled at last into the deep and beautiful Sacramento River-forty miles of wooden towers, trestles, and arches, every foot hand built” (Carlise 1987).

Ellsworth established the Empire Lumber Company corporation in 1873 which was short-lived and taken over after his death in 1875 by the Sierra Flume and Lumber Company. The Sierra Flume and Lumber Company also bought out all the remaining major flume and logging operations in this area which included the Blue Ridge Flume and Lumber Company operating north of Antelope Creek in the Battle Creek watershed and the Butte Flume and Lumber Company which operated up the ridges out of Chico, Figure 3 (Daily News 1973a,b).

> “By the end of the first full year of operation, the firm owned 10 sawmills, 23 miles of logging tramway, 156 miles of flume, 250 miles of telegraph line (which connected with all of these operations), 3 planing mills, 2 sash, door and blind factories, 3

> combined wholesale-rental lumber yards, plus a main office and export agency in San Francisco" (Hutchinson 1956, 1974, Borden 1968).

The company produced 51,000,000 feet of lumber during its first year in operation (Hutchinson 1974).
In 1878, creditors of the Sierra Flume and Lumber Company took the company over and reorganized into the Sierra Lumber Company (Corning 1963). Lyonsville became the center of operations for this company. Portions of the original Antelope flume were rerouted to Red Bluff and the section of flume running to Sesma and the factory were abandoned in 1881 (Bauer 1992). The new technology of narrow gauge railroad logging was instituted by Sierra Lumber Company in 1881 in the Lyonsville area and along Big Chico Creek in Butte county (Borden 1968). This provided a more efficient means to log areas further and further from established Mills and flumes. The steam donkey engine was also put into use skidding logs in a fraction of the time required by ox teams, however, resource damage caused by use of this machine was extremely high including soil compaction and constant forest fires which were left to burn the natural regeneration of forest stands. Between the years of 1887 and 1904, A.E. Engebratsen contracted with Sierra Lumber Company to build a water mill and a steam mill in the Antelope Creek watershed.

By 1907, many of the holding of the Sierra Lumber Company were acquired by the Diamond Match Company headquartered in Sterling City (Figure 4). After 1907, Diamond National Corporation continued to log the pine belt within the Mill, Deer and Antelope Creek watersheds. Logging by
Diamond stressed sustain yields of forest resources and the protection of timberlands from fire, which were new concepts in the California lumber industry. New technologies were put into place such as spark arrestors on machinery, the use of fuel oil in locomotives (instead of wood) and the construction of fire lookouts in order to inhibit the devastating effects of forest fires on the natural regeneration of timber stands. At the same time the newly formed Forest Service did not allow fires to be set on public lands and as a standard practice began suppressing all fires, man made or natural.

With the advent of railroad logging and better transportation routes into the higher elevation mixed conifer forests, the upper portions of the Mill and Deer watersheds were the next areas to be targeted and affected by timber harvests. The Forest Service has also allowed logging in these watersheds from 1930s until the recent past when resource concerns became an issue. Over the last century, timber harvests have denuded the landscape of large conifers, which were replaced by brush, and dense thickets of young trees.

Agriculture/Water Diversions

Limited agriculture appears to have taken place in 1844 after issuance of the Mexican land grants. Dr. Lewis Crosby constructed the first gristmill in 1851 along Mill Creek. The earliest evidence of water diversion on Mill Creek was in 1855 by Crosby, damming Mill creek above his gristmill and building a mill race that diverted water from the dam to his mill downstream. Moses Ellis acquired the Crosby grist mill in 1874, which operated around the clock because of demand for milling service until it sold out to the "Tehama Milling Company" in 1886 (Bauer 1992). By the 1880s, J.S. Cone who owned at least 100,000 acres in the Mill Creek watershed had planted most of his valley property in wheat, which was shipped via railroad to urban markets. The Tehama Milling Company was subsequently sold to the Los Molinos Land Company in 1913 (Bauer 1992).

By 1859, Job Dye had also built a flour mill on his ranch property along Antelope Creek. It can be assumed that many acres of grain were planted to supply the established grist mills. Forage crops may also have been grown during the early years of the cattle industry (1845-1860s).

The Coneland Water Company, established in 1907 in the Los Molinas area, dramatically increased irrigation and agriculture in the Mill Creek bottomlands through a systematic water conveyance system

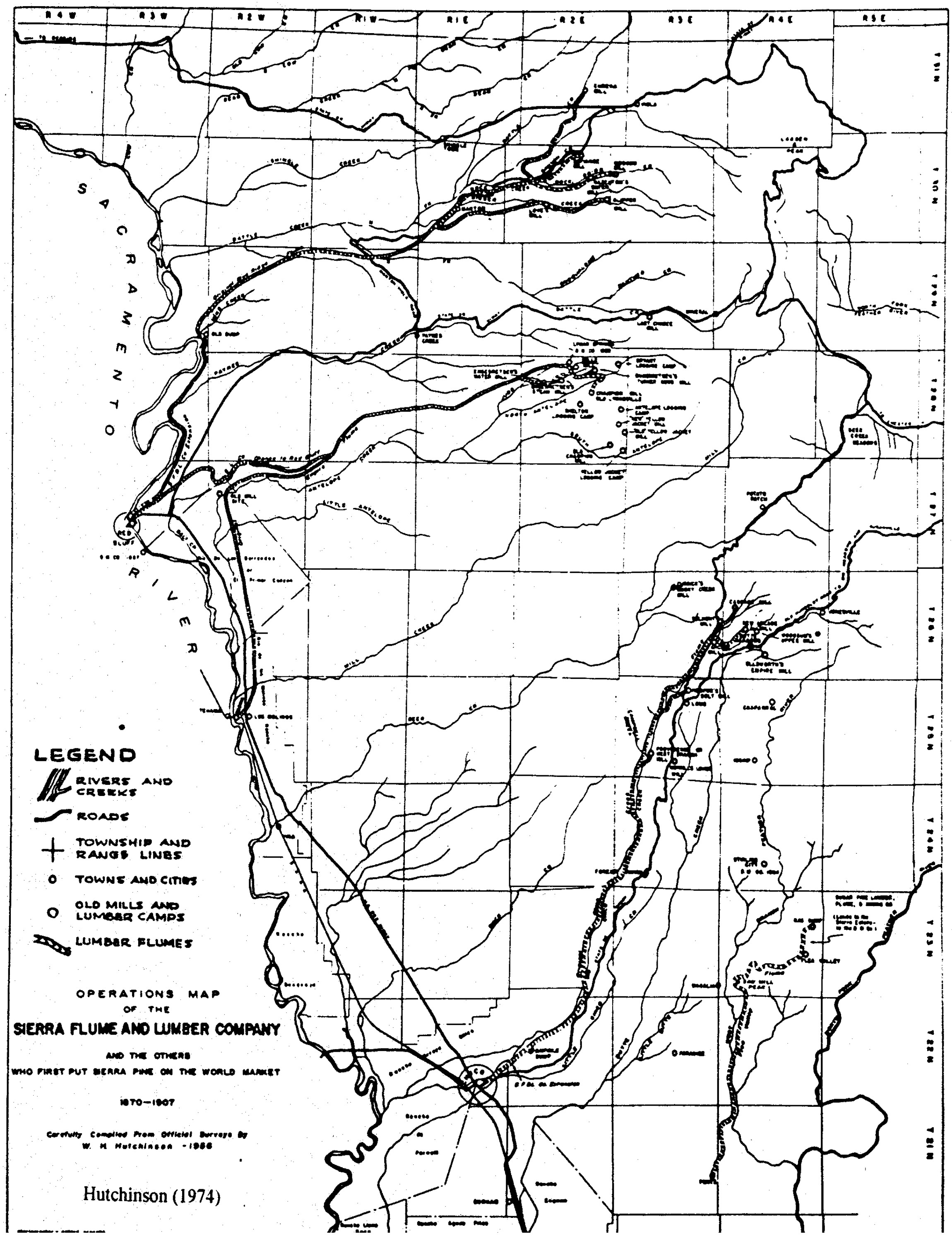
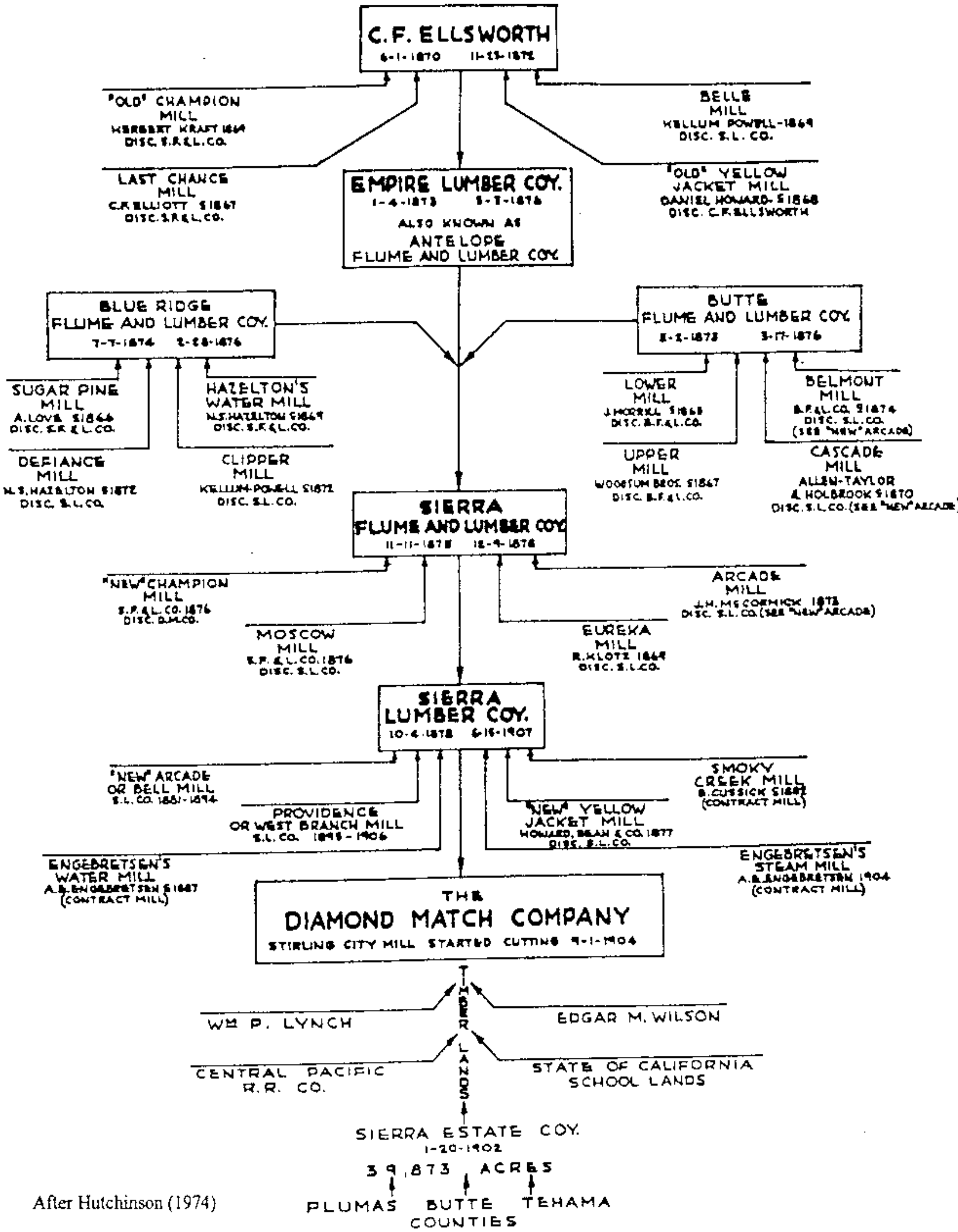


Figure 3-Q.-Operations of Sierra Flume and Lumber Company



After Hutchinson (1974)

Figure 4-Q.-Calfornia Family Tree of Diamond National

which provided water through contract to the Los Molinos Land Company. The land company owned approximately 12,000 acres within a ten mile stretch adjacent the Sacramento River starting four miles south of Red Bluff. The land was subdivided into ten acre parcels irrigated by use of a gravity ditch system fed from Mill and Antelope Creeks (Figure 5). The Los Molinos Land Company increased the population base of the area by emphasizing the irrigation potential of the parcels and productivity of the area for agriculture (Los Molinos Land Company 1912).

Construction of the water conveyance system that included canals, diversion dams, flumes etc., began in 1907 and was completed six years later. Five diversion dams were initially built, four diverting water from Mill Creek (Main, Runyon, Clough, Subdivision 7 Dams) and one from Antelope Creek (Antelope Main). After the 1937 flood only two dams, the Main and Runyon, remained on Mill Creek. Coneland Water Company created an extensive 130 mile system of main canals (18 miles) and smaller feeder ditches (112 miles, Figure 6). In 1934, the amount of water available from the Mill and Antelope Creek diversions was calculated at 4,360 acre feet during the month of August. The Coneland Water Company was sold to the Los Molinos Mutual Water Company in 1948 (Eaton 1944, Bauer 1992).

On Deer Creek, Peter Lassen farmed wheat and cotton and started a small vineyard on his rancho Bosquejo that was greatly improved by Henry Gerke after purchasing Lassens' property in 1852. Gerke planted extensive acres of land in vineyards and orchards and appears to be the first to use a water conveyance system of ditches diverting water from Deer Creek to irrigate planted fields. A map of the ranch shows several diversions from Deer Creek and a ditch system in place during the Gerke ownership of this land. By 1867, the Gerke ranch was the largest grain producer (wheat and barley) and vineyard in Tehama County and became steadily larger each year. The town of Vina got its start as a labor camp for Gerke workers and later employees of Leland Stanford who bought the Gerke ranch in 1881 (Harbison 1977). Stanford established significant diversions from Deer Creek to irrigate large acreage's of grape, orchards and grain fields on the north and south sides of the creek (Moulton 1969). Valley oaks were also removed to make way for vineyards (Peninou 1991). A map of the "Stanford Vina Ranch Irrigation Company" shows the location of miles of ditches feeding numerous tracts of land by 1920 (Polk & Robinson 1920).

A 1912 irrigation map of Northern California shows a large diversion from Antelope Creek extending to Red Bluff (presumable the Antelope Flume). Three main canals are shown diverting water from the lower reaches of Mill creek in a westerly direction, to the north and to Los Molinos area. Three diversions were also present along Deer Creek extending to the north, south and to the town of Vina. This early map clearly shows several miles of irrigated fields upstream along Deer Creek at the valley/foothill interface (USDA 1912). Water diversion systems for Mill, Deer and Antelope watersheds were developed primarily for the irrigation of valley lands for agriculture and settlement (Adams 1913). The exception was the Antelope flume whose purpose was to transport lumber to shipping points in the valley.

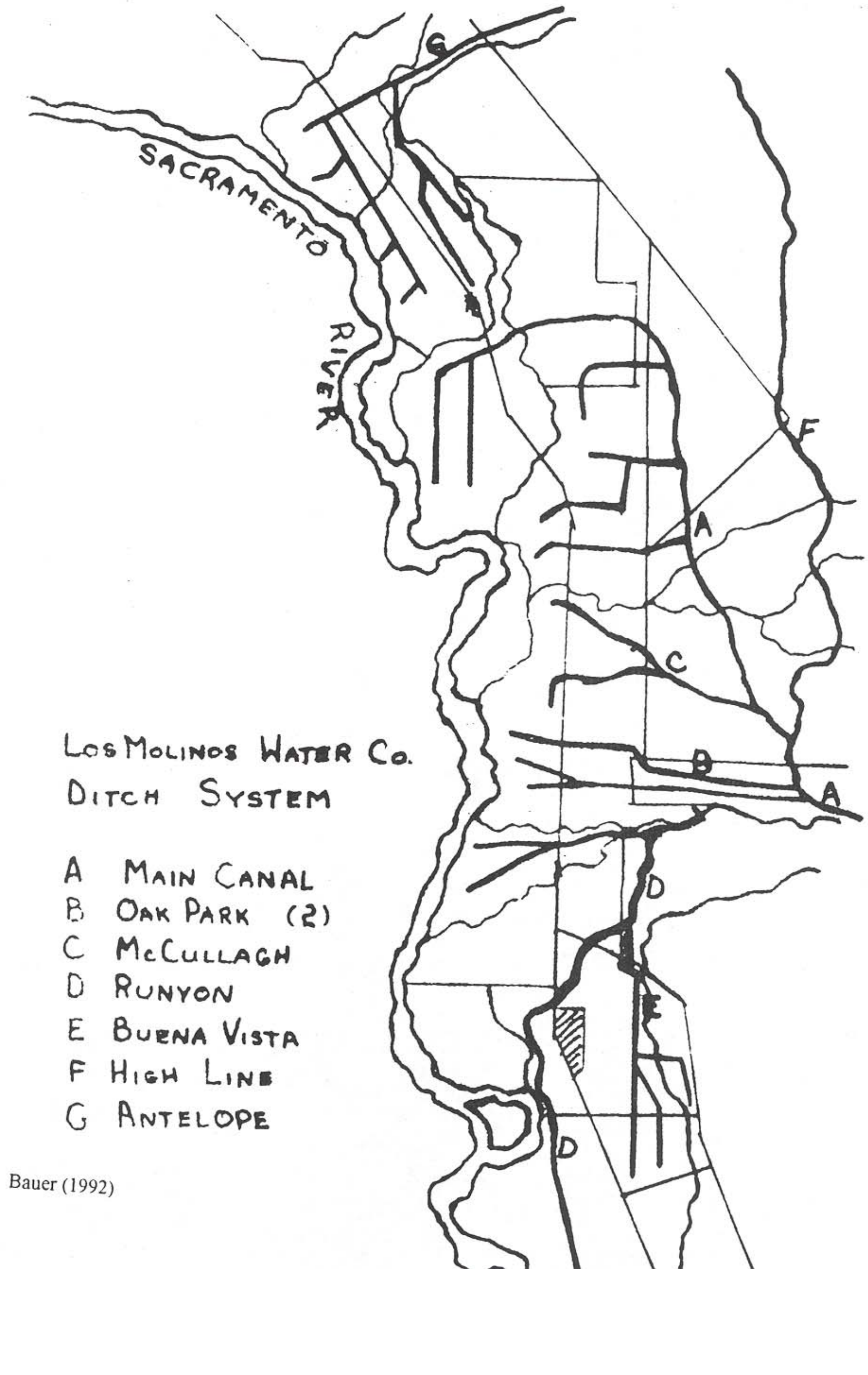
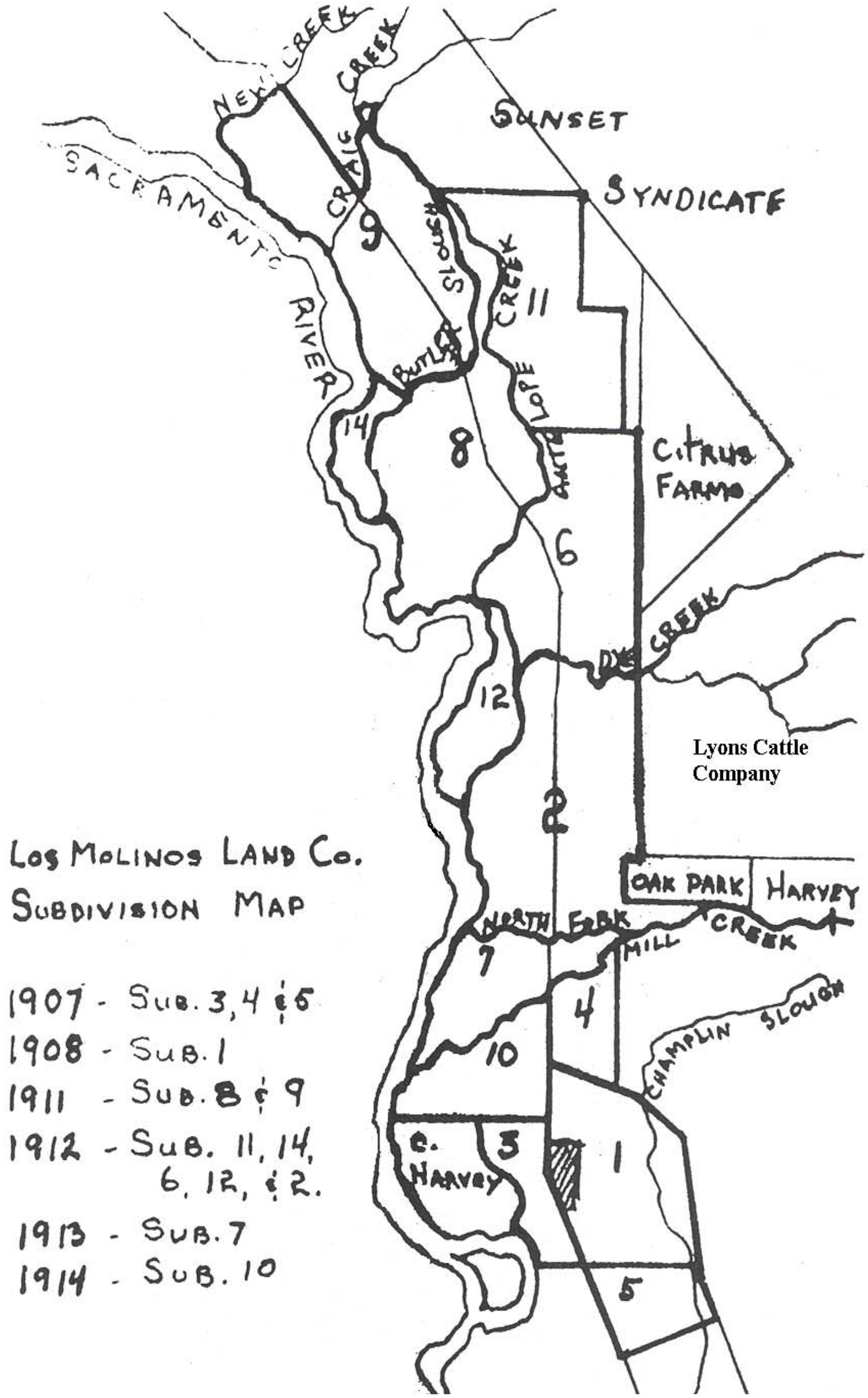


Figure 5-Q.-Los Molinos Land Subdivision Map



Bauer (1992)

Figure 6-Q.-Los Molino Water Company Ditch System

Mining

Apparently, mining was not an important activity historically or in recent times within the Mill, Deer or Antelope Creek watersheds. An early GLO map of 1907 and later 1932 Geological Survey Map shows the location of mines along Deer Creek (Occidental, Jackson and Polk mine) in the vicinity of Polk Springs (Department of the Interior 1907, U.S Geological Survey 1932). Historic sources also mention inconsequential placer mining taking place on several homesteads (Savercool Place, Avery Place, Paynes Place, McClure Place, Polk Place) located adjacent Mill, Deer and Antelope Creeks (Swanson 1971, Little 1975). No significant mining ventures or mineral deposits have been noted in either of the watersheds as highlighted by the total lack of mineral locations on a 1946 "Tehama County Mineral Location Map".

Land Ownership/Homesteads/Squatters

A 1903 map of Tehama County (Luning 1903) shows the various land owners in the three watersheds at the turn of the century. Individuals of the Cone family and the Cone/Ward company owned vast acres of land from south of Antelope Creek to the north side of Deer Creek extending east into the foothills. The Sierra Lumber Company acquired most lands within the upper Antelope Creek watershed (forest areas) and the Central Pacific Railroad Company also owned forested lands in the upper watershed of Mill and Deer Creeks. Leland Stanford and Spaulding owned lands on the south side of Deer Creek from the valley floor to the foothills. After the turn of the century huge tracts of land in the upper reaches of Deer Creek were owned by the Central Pacific Railroad, Red River Logging and Curtis, Collins and Holbrook Company.

Will Morgan first settled the upper reaches of Mill Creek in 1849. The Morgan family maintained ownership of Morgan Springs and surrounding lands until 1912. Vern Wooley and Leon Bly bought these lands in 1912 and again sold the property in 1914 to William Hamlin. In 1926 joint tenantship was granted to R.W Hanna by Camilla Hamlin. R.W Hanna gifted the Morgan Springs lands to his four children in 1955.

Early maps also show many place names up and down Mill, Deer and Antelope drainages which denote use of these areas associated with ranching (sheep and cow camps-- sheep camp, dead cow flat, deep hole camp, Drennan camp, skeleton camp, delay camp, goat camp, stone corral hollow etc.), logging operations (Yellow Jacket, High Trestle, knothole ranches along the Antelope Flume, etc.) and habitation (homestead/cabin locations --Johnson house, Peligreen Place McClure Place, Paynes Place, Pape Place, Avery Place, etc.). A trend of settlement along the foothill riparian corridors of the Mill, Deer and Antelope drainages of legitimate homesteaders as well as squatters can be traced originating from the 1850s to the 1930s. After 1870, the foothill canyonlands were rapidly populated by Euroamerican settlers filling a void left after the decimation of aboriginal populations. The high elevation headwaters of these drainages saw summer occupation mostly associated with ranching activities and summer pasturing of livestock by 1860s.

Recreation

Early recreationalists started using this area after the turn of the century drawn by hot springs, creeks, wildlife, beautiful scenery and the Lassen Peak region. The Forest Service established the Mill Creek recreation residence tract in the 1920s and began providing recreational opportunities (facilities and trails) to the public by 1930. Trails along Mill, Deer and Antelope creek as well as trails descending from the canyon rims accessing the creeks are shown on early GLO maps circa 1850-1880. Presumably, many of the routes were first established by aboriginal inhabitants. In the rugged canyonland environment, trails were the only available means of travel by early settlers and many trails including Rancheria Creek trail, McClure trail, Peligreen trail and the Devils Den trail were used to access specific homesteads. These early trails have been used as recreation trails for at least the last fifty years.

The California Conservation Corp (CCC) constructed the first north-south road, Pondersosa Way, bisecting the watershed of Mill, Deer and Antelope creek in the 1930s. This route was constructed to provide access into this area for the suppression of forest fires and serve as a fire break between low elevation chaparral communities and the commercially valuable pine forests. Ponderosa Way also opened up recreation opportunities in the low elevation “front country.” Many of the Forest Service campgrounds including Black Rock, Hole in the Ground, Mill Creek, South Antelope, Elam, Alder and Potato Patch were built between 1930 and 1945 by the CCC or Forest Service personnel. These campgrounds have been upgraded over time and are still favorite spots for recreating today.

SUMMARY OF LAND USE

Native American populations changed the natural environment within the Mill, Deer and Antelope watersheds to suit their particular needs and traditional lifeways. Their effect on the landscape was probably not felt until a sedentary lifestyle was adopted by the end of the Kingsley period. The exploitation of deer and acorns had the greatest effect on the environment by native populations. The practice of burning to improve forage, acorn crops and travel also resulted in a landscape of large open forests according to early travelers (Read et.al. 1944), quite different from dense forest thickets seen today. These effects increased through time to the end of the Dye Creek period (circa A.D. 1500) as populations grew. Site densities were very high in the region between 1000 and 3000 feet where the Yana ranged for most of the year. The accumulation of midden debris on river terraces and in rock shelters is extensive. Possibilities exist that the Yana practiced limited horticulture, possibly planting buckeye nuts or other important plant resources near winter villages.

Landscapes within the Mill, Deer and Antelope watershed were dramatically altered with Euroamerican settlement of the region. Valley land grants and the California gold rush brought thousands of new settlers into the area causing disruption and the final annihilation of the native peoples. Sheep and cattle ranching caused over grazing and the decimation of native plant species. Burning, especially by sheep herders, changed forest regeneration patterns producing dense stands of shade tolerant species. A boom in the timber industry, brought about by new methods of transportation (flumes, railroad logging etc.), made it possible to harvest vast tracts of timber in the lower Pine belt. These massive logging efforts resulted in deforestation and severe resource damage. Water diversions from Mill, Deer and Antelope creeks resulted in many valley lands coming under irrigation allowing agriculture and increased populations in the region. Construction of the Ponderosa Way road and early campground facilities by the CCC provided the public with access to these watersheds for recreational use. The landscapes within the Mill, Deer and Antelope Creek watersheds have been significantly modified through time by changing land use practices.

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