HIDDEN VALLEY, PLUMMER CREEK, & RATTLESNAKE CREEK WATERSHED ANALYSIS

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1. WATERSHED CHARACTERIZATION

The purpose of this chapter is to provide an overview of the physical, biological, and cultural/social settings of the watershed analysis area (WAA). This characterization of the watershed provides the context to identify and evaluate the relevant elements (including components, structures, and processes) involved in the various functions within ecosystems that are addressed in the analysis.

1.1 General Location and Setting

The Hidden Valley, Plummer Creek, and Rattlesnake Creek areas that encompass the WAA is a group of 5th-field watersheds located within the South Fork Trinity River basin in northwestern California. Since the Hidden Valley and Plummer Creek areas do not drain to a common point, they are not considered true watersheds but rather USDA Forest Service watershed-scale planning units. The South Fork Trinity River is a designated Tier 1 Key Watershed in the Northwest Forest Plan. It drains an area approximately 970 square miles. The South Fork Trinity flows into the mainstem Trinity River and then to the Klamath River before reaching the Pacific Ocean. The WAA is located south to southwest of Hayfork, California in Trinity County and within the boundaries of Shasta-Trinity National Forests (Map 1-1).

Hidden Valley watershed encompasses an area of approximately 33,580 acres with 24,250 acres in National Forest System lands. Plummer Creek watershed drains a total area approximately 32,650 acres with 30,060 acres in National Forest System lands. Rattlesnake Creek watershed drains a total area approximately 30,100 acres with 26,940 acres in National Forest System lands. Private ownership in the Hidden Valley watershed is primarily Simpson Timber Company, and in the other two watersheds private ownership is primarily by small landowners. Most private land ownership is located in Hayfork, Hyampom, Salt Creek, and Wildwood Valleys.

Elevations in the South Fork Trinity River basin range from more than 7,800 feet above sea level at the headwaters in the North Yolla Bolly Mountains, to less than 400 feet at the confluence with the mainstem Trinity River. The climate within the WAA is variable and generally described as mild, with hot, dry summers and wet winters.

The terrain in South Fork Trinity River area is predominantly mountainous and covered with forests with restricted farming areas (especially located in Hayfork Valley). Before European settlement, the South Fork Trinity River area was dominated by conifer forests and smaller areas of grass-oak woodlands; however, since the mid-1800s the area has undergone progressively more intensive land-use, including grazing, mining, housing development, timber harvesting, and road building.

1.2 Land Allocations and Management Prescriptions

Table 1-1 and Map 1-2 illustrate the land allocations and management prescriptions for Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds. Based on the Shasta-Trinity National Forests' Land and Resource Management Plan (LRMP) and Northwest Forest Plan, the land allocations in the WAA included approximately 34 percent in Late-Successional Reserves, 15 percent in Administratively Withdrawn Areas, 48 percent in Matrix, and 3 percent in Adaptive Management Area (i.e., Hayfork AMA). Within the three 5th-field watersheds, the management prescriptions include the following: Rx I- Unroaded Recreation; Rx II- Limited Roaded Recreation; Rx III- Roaded Recreation; Rx VI- Wildlife Habitat Management; Rx VII-Late Successional Reserve and Threatened, Endangered, & Sensitive Species; Rx VIII-Commercial Wood Products Emphasis; and Rx IX- Riparian Management.

Table 1-1. Land Allocations and Management Prescriptions for National Forest System lands in Hidden Valley, Plummer Creek, and Rattlesnake Creek Watershed Analysis Area.

Land Allocations/Management Prescriptions	Hidden Valley (acreage)	Plummer Creek (acreage)	Rattlesnake Creek (acreage)
Late-Successional Reserves:			
Rx VII – Late-Successional Reserve	20,130	9,155	2,159
Rx VII – TE&S Species (7F)	-	621	230
Matrix:			
Rx III – Roaded Recreation	1,682	1,313	11,420
Rx VI – Wildlife Habitat Management	248	1,213	-
Rx VIII – Commercial Wood Products	5,806	11,450	16,282
Administratively Withdrawn Areas:			
Rx I – Unroaded Recreation	662	8,651	-
Rx II – Limited Roaded Recreation	5,058	242	-
Total Area (S-T National Forests & Private Lands)	33,586	32,646	30,091
Total Area (Private Lands Inclusions)	9,330	2,590	3,160

1.3 Geology

The WAA lies within the Coast Range and Klamath Mountains geologic provinces. The South Fork of the Trinity River is located at the approximate boundary between the two geologic provinces. South Fork Mountain Schist and Franciscan bedrock geologies underlie the west-side of South Fork Trinity River; whereas, metamorphic and plutonic rocks underlie the east-side of the South Fork Trinity River. The Hidden Valley watershed lies along the western side of the South Fork Trinity River and is mainly composed of the South Fork Mountain Schist, with minor portions of other assemblages towards the north end of the watershed. Plummer and Rattlesnake Creeks watersheds lie on the eastern side of the South Fork Trinity River in the Klamath Mountains geologic province and are composed mainly of the Galice Formation and the Rattlesnake Creek Terrane respectively, with some igneous and volcanic rocks mixed in both watersheds. The underlying geology strongly influences the geomorphic processes at the surface, which varies widely within the WAA.

1.4 Geomorphology

In general, the South Fork Trinity River is characterized by steep, unstable slopes with significant erosion hazards. The WAA was subject to relatively rapid tectonic uplift, resulting in deeply incised and dissected mountain slopes. Due to the unstable nature of the South Fork Mountain Schist and the Galice Formation, most of the WAA is classified as highly to extremely unstable (CDWR 1979). The South Fork Mountain Schist, which dominates the Hidden Valley watershed, is prone to rotational-translational and block-glide landslides, and shallow debris flows (PWA 1994). The Galice Formation, found primarily in the steep inner gorge of the South Fork Trinity River in Plummer Creek watershed, is also highly prone to landslides. The Rattlesnake Creek Terrane is more stable than the other geologic types, and has a moderate erosion hazard rating (CDWR 1979). Mass wasting is the erosional process of principal concern, although stream channels, roads, and land management activities also contribute sediment to watercourses.

1.5 Soils

Since soil properties are strongly influenced by the underlying bedrock, the soils in the WAA are variable. Soils in the Hidden Valley watershed forms on the South Fork Mountain Schist and associated metasediments and is either in the frigid or mesic temperature regime. Soils in the Plummer and Rattlesnake Creeks watersheds form in metasediments, ultramafics, granites and diorites, and some serpentine outcrops. Soils that form from serpentine tend to have higher magnesium to calcium ratios, which limit productivity and support endemic plant communities. Soils derived from granite and diorite tend to form loosely consolidated soils that are highly erodible. Soil productivity in the WAA is highly variable, and dependent on factors such as slope, depth, aspect, organic matter content, nutrient availability, texture, and moisture availability.

1.6 Hydrology and Water Quality

Most precipitation in the WAA falls between October and April and ranges from about 80 inches annually on South Fork Mountain to about 35 inches annually in Hayfork Valley, located about 15 miles to the northeast. Snow occurs during the winter months above about 2,000 feet in elevation, and rare occurrence of rain-on-snow events will cause extreme flow events. The flood in 1964 was the largest on record in northern California, and had a significant impact on the hillslope areas and stream channels in the WAA.

The South Fork Trinity River flows northwestly along a fault zone between the Coast Range and Klamath Mountains geologic provinces. Rattlesnake and Plummer Creeks watersheds drain along the eastern side of the Hidden Valley watershed. Stream densities are the highest in the Rattlesnake Creek watershed with 4.9 miles per square mile, and the lowest in Hidden Valley watershed with 3.2 miles per square mile (USFS 2000). The total length of mapped streams located within the WAA is approximately 601 miles, of which 172.5, 180.5, and 247.7 miles exhibit perennial, intermittent, and ephemeral streamflow characteristics, respectively.

Water quality issues are primarily concerned with sediment discharge and transport. In 1992, the South Fork Trinity River was added to the federal Clean Water Act Section 303(d) list with sediment as the stressor pollutant, which resulted in the development of a TMDL (total maximum daily load) for sediment (EPA 1998). In 1998, temperature was added to the water quality impairment list for the South Fork Trinity River and monitoring efforts have been initiated (EPA 1998).

1.7 Roads

Forest roads in the WAA range in width and use from seasonal logging roads to the paved Highway 36. Roads contribute to management related sources of sediment production (CDWR 1979). Increased peak flows, rate of fine sediment production and mass wasting are impacts associated to road construction (CDWR 1979). Road densities (not including tractor skid trails) are the greatest in Rattlesnake Creek watershed at 5.2 miles per square mile, followed by Hidden Valley and Plummer Creek watersheds at 3.8 and 2.6 miles per square mile, respectively. Rattlesnake Creek watershed has the highest road density of the fourteen 5th-field watersheds within the South Fork Trinity River basin (USFS 2000).

1.8 Forest Vegetation

Based on California Wildlife Habitat Relationships classification system (Mayer and Laudenslayer 1988), the existing vegetation/habitat types in the WAA consist of Douglas-fir (or mixed evergreen), Klamath mixed conifer, Montane hardwood-conifer, and Montane riparian. Other associates of vegetation/habitat types, with varying distribution in the WAA, include ponderosa pine, white fir, and red fir.

The USDA Forest Service's ecological subregion classification of California (Miles and Goudey 1997) describes the WAA to include Eastern Franciscan (subsection M261Ba), Pelletreau Ridge (subsection M261As), and Rattlesnake Creek (subsection M261Au). Subsection M261Ba covers a portion of Hidden Valley watershed; Subsection M261As covers parts of Plummer Creek, Rattlesnake Creek, and Hidden Valley watersheds; and Subsection M261Au covers portions of Plummer and Rattlesnake Creeks watersheds.

Predominant natural plant communities in subsection M261As are mixed conifer series and Douglas-fir–tanoak, with red fir and white fir series in areas of frigid soil temperature regimes. Douglas-fir series and Douglas-fir–tanoak series are the predominant natural plant communities in subsection M261As, with white fir series occurring at higher elevation. Mixed conifer series, Douglas-fir series, Douglas-fir–ponderosa pine series, and ponderosa pine series are the predominant natural plant communities in subsection M261Au, with Jeffrey pine series occurring on serpentinized peridotite. Canyon live oak series is common on very steep rocky slopes with stony soils in subsections M261As and M261Au. Other significant vegetation communities found in the WAA include deerbrush ceanothus, wet meadows, oak-woodlands, and ultramafic outcrops.

1.9 Fire and Fuels

Vegetation types for this region are dominated by fire adapted/resistant species. The recurrence of fire and the recovery of the ecosystem from the effects of fire are important processes for maintaining the health of the forest. The process has historically been a significant component that formed the structural diversity and maintained forest health within the WAA. Fire suppression efforts have successfully removed the natural fire regimes of less severe ground fires that had periodically purged the forest of individuals that were weakened by attack of insects or pathogens. The exclusion of fire, along with other anthropogenic disturbances, has initiated a transition to a fire regime characterized by less frequent, high intensity fire events and associated vegetation type changes (i.e., greater abundance of white fir, and increased occurrences of dwarf mistletoe and cytospora canker in red fir stands on South Fork Mountain). Vegetation on the ultramafic soil types of the WAA does not show this vegetation transition, or show a lesser degree of change.

Skinner and Taylor's (1998) fire history analysis of the Happy Camp Ranger District found that fire return intervals varied greatly with the longest return interval occurring during the suppression period of 1900 to 1992 with a return interval of 24.5 years, and the shortest return interval during the 1850 to 1900 settlement period. The study shows that the European settlement had impacted the fire regime by first increasing the return period and then decreasing the return period through suppression. Fire suppression actions first took a passive form using animal grazing, and then later active suppression actions were instituted.

Based on Skinner and Taylor's (1998) study, pre-European settlement fires were generally less severe (low to moderate severity) and had shorter return intervals than post-settlement fires regimes. These shorter fire return intervals had less fuel buildup available and would burn in patterns that would kill some overstory trees and thin out or kill understory trees. Frequency and severity of fires may be an important factor contributing to the overall structural diversity of the stands in the area (Skinner and Taylor 1998). Lightning that occurs mostly in the late summer months has been identified as the primary source of fire in this region, although human caused fires have also occurred.

The status of fuel composition has been in transition. Fuels have changed from primarily surface fuels at a low level of loading to moderate or high levels of surface fuel loading, and with a vertical ladder connecting the surface fuels to the crowns of the dominant conifer trees. This vertical fuel ladder is of primary concern and threatens to cause serious damage to the stands dominated by larger and mature trees as well as young plantations with smaller trees. Such damage occurred recently in the WAA as a result of the 1987 fire complex. The 1987 fire complex included the Friendly, Flume, Cold, Jessie, and Wallow Fires. These wildland fires were lightning-caused and collectively burned approximately 25,000 acres within Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds. The 1987 fire complex was by far the largest landscape-scale disturbance event in the WAA since European settlement.

1.10 Plant Species of Special Concern and Noxious Weeds

Suitable habitat for federally threatened or endangered, Forest Service sensitive and endemic, and Northwest Forest Plan survey and manage plant species exists within the WAA. A limited number of focused field surveys for the plant species that potentially occur have been conducted to establish species occurrence or distribution. A list of plant species of special status with known or suspected occurrence within Hidden Valley, Plummer Creek, and Rattlesnake Creek WAA is presented in Table 1-2. The list of special status species potentially occurring in the WAA includes 20 vascular plants and 3 brypohytes.

The Northwest Forest Plan's Survey and Manage Standards and Guidelines were revised in January 2001, resulting in emphasis on the species discussed in this document. Prior to January 2001, seven fungi species required analysis and field survey prior to ground-disturbing activities. These survey and manage species were dropped from the initial list due to commonness or lack of feasibility for identification.

In addition to the Forest Service's rare plants of concern, two California rare plants that are known to occur in the vicinity of the WAA are included. The State rare plants of concern are

Table 1-2. Federally Threatened or Endangered, Forest Service Sensitive and Endemic, Northwest Forest Plan Survey and Manage Plant Species of Suspected/ Known Occurrence within Hidden Valley, Plummer Creek, and Rattlesnake Creek Watershed Analysis Area.

Taxa	Common Name	Scientific Name	Status[1]
Vascular Plants	McDonald's rock-cress	*Arabis mcdonaldiana*	FE
	Shasta chaenactis	*Chaenactis suffrutescens*	FSS
	Brownie lady's slipper	*Cypripedium fasciculatum*	FSS/SM (C)
	mountain lady's slipper	*Cypripedium montanum*	FSS/SM (C)
	Oregon willow herb	*Epilobium oreganum*	FSS
	Brandegee's woolly-stars	*Eriastrum brandegeae*	FSS
	Serpentine goldenbush	*Ericameria ophitidis*	FSE
	Dubakella Mountain buckwheat	*Eriogonum libertini*	FSE
	Niles harmonia	*Harmonia doris-nilesiae* (=*Madia doris-nilensiae*)	FSS
	Stebbins harmonia	Harmonia stebbinsii (=*Madia stebbinsii*)	FSS
	Water howelii	*Howellia aquatilis*	FT
	Elmer's lupine	*Lupinus elmeri*	FSS
	Peanut sandwort	*Minuartia rosei*	FSS
	Howell's montia	*Montia howellii*	FSS
	Canyon Creek stonecrop	*Sedum paradisum*	FSS
	Coast checkerbloom	*Sidalcea oregana* ssp. *eximia*	FSS
	Red Mountain catchfly	*Silene campanulata* ssp. *campanulata*	FSS/CE
	Clustered green gentian	*Frasera umpquaensis*	FSS
	Mingan moonwort	*Botrychium minganense*	FSS
	western goblin	*Botrychium montanum*	FSS/SM (A)
Bryophytes	Pacific fuzzwort	*Ptilidium californicum*	SM (A)
	goblin's gold	*Schistostega pennata*	SM (A)
	bent-kneed four-tooth moss, ant spearmoss	*Tetraphis geniculata*	SM (A)

[1]FT–Federal Threatened; FE–Federal Endangered; CE–California State Endangered; FSS–Forest Service Sensitive; FSE-Forest Service Endemic; SM–Northwest Forest Plan's Survey and Manage (A or C).

white beaked-rush (*Rhynchospora alba*, California Native Plant Society [CNPS] List 2) and coast checkerbloom (*Sidalcea oregana* ssp. *exima*, CNPS List 1B).

There are four introduced weedy plants with serious potential to spread aggressively within the Hidden Valley, Plummer Creek, and Rattlesnake Creek WAA. These are diffuse knapweed (*Centaurea diffusa*), spotted knapweed (*C. maculosa*), yellow star thistle (*Cirsium solistitialis*), and Canada thistle (*C. arvense*). The four plant species aggressively displace native herbaceous plants, especially along roads and in disturbed sites on hillslopes.

1.11 Fish and Wildlife Species and Habitats

Steelhead trout, chinook salmon, and coho salmon are known to occur, or to have historically occurred, within the WAA. Steelhead trout are the dominant anadromous salmonid within the

WAA. Spring chinook is frequently observed during stream surveys in the South Fork Trinity River within the WAA. The upstream distribution of coho salmon is currently believed to extend into the WAA as far as the Butter Creek sub-watershed. Approximately 962 miles of mapped streams are located within the WAA, of which 109 miles are considered to be accessible to ocean-run fish species. Resident rainbow trout populations are also present in the WAA, but are generally upstream of anadromous migration barriers. Brown trout were historically present but are considered extirpated from the WAA.

Coho salmon have been listed as a threatened species under the federal ESA. Steelhead trout and chinook salmon in the vicinity of the WAA were considered as candidate species for listing under federal ESA. The determinations for both these species were that listing was not warranted. Nevertheless, chinook salmon continues to be a Forest Service sensitive species (Table 1-3).

Aquatic habitat quality and quantity within and downstream of the WAA is linked to the conditions of stream corridors, especially related to riparian areas and the balance of inchannel sediment and water. The instream habitat of downstream aquatic species could be modified as the result of land management related disturbances in the WAA. Land management activities such as silvicultural practices and road building potentially impact the stream ecosystem through sediment and solar energy inputs, large woody debris recruitment, and aquatic habitat fragmentation by in-stream barriers. Upslope and stream riparian forests play an important role in instream habitat formation processes.

Forest management has varying impacts on the vegetation mosaic and stand structure available for terrestrial animals. Species distribution and occurrence are functions of available suitable terrestrial and aquatic habitats on the landscape. Limited focused field surveys have been conducted for occurrence and/or distribution of special-status species within the Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds. Based on general species-habitat associations, a list of animal species of special status that potentially occur in the WAA is presented in Table 1-3. The list of special-status species includes eight birds, seven mammals, one reptile, three amphibians, three fishes, and five terrestrial mollusks. Aquatic mollusks are not included in the list of species of special status evaluated.

Ecosystem diversity components such as richness, evenness, and pattern of vegetative resources are important attributes to be included for landscape and species-habitat management. Special considerations should be given to providing habitats to maintain or enhance populations of all known special-status species in the WAA. The overall intent in landscape management for wildlife is to avoid or minimize habitat fragmentation and provide habitat connectivity, especially for species associated with late-successional and old-growth forests.

Table 1-3. Special Status Fish and Wildlife Species of Known Potential for Occurrences within the Hidden Valley, Plummer Creek, and Rattlesnake Creek Watershed Analysis Area.

Taxa	Common Name	Scientific Name	Status[1]
Fish	Coho salmon	*Oncorhynchus kisutch*	FT
	Steelhead trout	*Oncorhynchus mykiss*	FC/NW
	Chinook salmon	*Oncorhynchus tshawytscha*	FSS/FC/NW
Birds	Bald eagle	*Haliaeetus leucocephalus*	FT
	Northern spotted owl	*Strix occidentalis caurina*	FT/CH
	American peregrine falcon	*Falco peregrinus anatum*	FSS/DL
	Northern goshawk	*Accipiter gentilis*	FSS/FSC
	Willow flycatcher	*Empidonax trailii*	FSS
	Flammulated owl	*Otus flammeolus*	SM
	White-headed woodpecker	*Picoides albolarvatus*	SM
	Pygmy nuthatch	*Sitta pygmaea*	SM
Mammals	Pacific fisher	*Martes pennanti pacifica*	FSS/FSC
	American marten	*Martes americana*	FSS/FSC
	California wolverine	*Gulo gulo luteus*	FSS/FSC
	Pallid bat	*Antrozous pallidus*	FSS
	Townsend’s big-eared bat	*Corynorhinus townsendii*	FSS
	Western red bat	*Lasiurus blossevillii*	FSS
	Red tree vole	*Phenacomys longicaudus*	SM
Amphibians/ Reptiles	Northwestern pond turtle	*Clemmys marmorata marmorata*	FSS
	Foothill yellow-legged frog	*Rana boylii*	FSS/FSC
	Southern torrent salamander	*Rhyacotriton variegatus*	FSS/FSC
	Northern red-legged frog	*Rana aurora aurora*	FSC
Terrestrial Mollusks	Church’s sideband snail	*Monadenia churchi*	SM
	Klamath shoulderband snail	*Helminthoglypta talmadgei*	SM
	Oregon shoulderband snail	*Helminthoglypta hertleini*	SM
	Pressley hesperian snail	*Vespericola pressleyi*	SM
	Hooded lancetooth snail	*Ancotrema voyanum*	SM

[1] FT–Federal Threatened; FC–Federal Candidate for Listing; FSS–Forest Service Sensitive; FSC–Federal Species of Concern; SM–Northwest Forest Plan Survey and Manage, DL–Delisted; CH–Designated Critical Habitat; and NW–Not Warranted Listing Determination.

1.12 Cultural Heritage and Human Uses

The WAA encompasses ethnographic territories of the northwestern California culture subregion identified by natural features and neighboring ethnic groups as defined by Kroeber (1925). Athapascan and Penutian family groups are represented in this subregion. Of the former, the Hupa, Chilula, and Whilkut occupied a portion of the analysis area. Of the latter, the Wintu are identified with the lands northeastward from the South Fork of the Trinity River. The Nor-Rel-Muk or Hayfork Wintu still practice traditional native arts and ceremonies in the area. The Chimariko of the Hokan language stock predated the Wintu and other Indian groups within the analysis area. Ethnographic and linguistic records suggest that the Chimariko territory originally included the main Trinity River from Burnt Ranch to Junction City southward to Hayfork Valley recorded in 1849. Chimariko territory attracted Euro-American miners and conflict over land developed. The hostilities ultimately took a toll and by 1906 only a few Chimariko people survived (Kroeber 1925; Silver 1978).

Human uses of the WAA can be documented by the archeological record identifying resource hunting, fishing and gathering activities and occupation over time for thousands of years. Archeological discoveries of specific locations in the South Fork Trinity River basin suggest land use approximately 8,000 to 10,000 years ago. South Fork Mountain was occupied by early Native Americans. Archaeological surveys and test excavations preformed by Sonoma State University and Forest Service staff have yielded cultural material from the Borax Lake Pattern (M. Arnold, personal communication 2001). The South Fork Mountain ridgeline system is a National Register Eligible Historic District. Archeological research from cultural resource management projects of the general bioregion indicate more pronounced human activity beginning 5000 years B.P. Archeological evidence associated with prehistoric land use includes sites at locations along the Trinity River, South Fork of the Trinity River, and South Fork Mountain. Heritage resources associated with these archeological cultures may represent antecedent lifeway activities of those groups who inhabited the ethno geographic territories of the watershed area into historic times.

Although the Native people's subsistence centered on the riverine resources provided by the Trinity River, this subsistence was balanced with acorn and pine nut gathering along with hunting a wide range of game animals. The prehistoric people in the analysis area utilized fire to manage and conserve their resources. Controlled burning promoted growth of desired plants, increased edible seed yield, prevented encroachment of vegetation on grasslands, enhanced forage for deer and other game, and was employed in game drives. Systematic burning was the single most important environmental modification by the California Indians, allowing them to control plant successions and, locally, to maintain biotic communities such as grasslands and oak savannas (Moratto 1984). The cultural practice of fire management for sustaining a prolific environment soon diminished after the arrival of Euro-American settlers and the establishment of the U.S. Forest Service in 1905 on native territories in the analysis area.

Early exploration of the Trinity River basin occurred in the 1820s and 1830s. The first Euro-Americans to visit the analysis area were fur trapper-explorers. Jedediah Smith and his men were the first to explore the basin in 1828, and encountered the Nor-El-Muk. Although the area was first used extensively by trappers, a subsequential wave of Euro-Americans followed. By the late 1840s gold mining was the primary activity along the Trinity River, followed by logging and ranching. Placer, hydraulic, and hard rock mining took place during the latter half of the 19th century and with isolated mining pursuits continuing into the 1940s. The logging and milling industry ranged from large- to small-scale operations over time and provided an economic resource base for the local populations. After World War II timber harvesting and milling were the primary industries in Trinity County. Roadway networks were constructed for these purposes.

Some early settlers began ranches for grazing livestock around the mid-19th century. The agricultural pursuits integrated well with the supply and demand of mining and logging activities of the camps in Weaverville and outlying areas. Farmers grew oats, hay, onions, and potatoes in

Hayfork Valley. Some agricultural production from the Hayfork Valley was distributed to Weaverville and the Trinity Alps area; however, a higher percentage was exported via the Humboldt Trail along South Fork Mountain to Eureka and the Sacramento Valley. Weaverville and the Trinity Alps primary agricultural suppliers came from the Upper Trinity area of Minersville and Trinity Center.

In 1905, the Trinity Forest Reserve was established, encompassing thousands of acres, and subsequent land management policies were enacted that altered the historic land-use within public land boundaries. The cultural landscape was characterized by the resource management activities of mining and ranching in the early years. Timber production increased in time and became a major economic interest after World War II. Environmental concerns of the 1970s gradually changed Forest Service's management policies from a focus on timber commodity production to one of ecosystem management.

2. WATERSHED ISSUES AND KEY QUESTIONS

The purpose of this chapter is to focus the analysis on the core elements of the ecosystem that are most relevant to management objectives, human values, and resource conditions in the watershed. Major watershed issues are identified and framed, and key questions are developed to evaluate the resource conditions and to identify future management opportunities and priorities. Watershed issues are identified using various sources. The relevant sources include the following: Ecosystem Analysis at the Watershed Scale, Federal Guide for Watershed Analysis, version 2.2 (August 1995); Northwest Forest Plan and Aquatic Conservation Strategy objectives; best professional judgment in relation to landscape-scale resource conditions and management directions; and public involvement regarding watershed concerns.

Past human-induced (i.e., logging, road building, grazing, mining, housing development) and natural disturbances (i.e., wildland fires and floods) have altered the existing hillslope, inchannel, and riparian conditions in the WAA.

Issue — Riparian Management

The purpose of the analysis will be to identify management actions, by locations and conditions, to enhance the riparian reserve network in the WAA.

Key Questions:

- What management activities have occurred in the riparian areas? What are the current conditions of the riparian reserves? What is the desired future condition for the riparian vegetation?

- What vegetation treatments can be used to enhance riparian reserves and associated benefits to terrestrial and aquatic species within stream corridors?

Issue — Watershed Enhancement/Restoration

The purpose of the analysis will be to identify restoration activities, by conditions, to enhance, maintain, or restore aquatic conditions as described in the Aquatic Conservation Strategy.

Key Questions:

- What erosional processes are dominant within the watershed? What erosional processes have been accelerated by natural and human induced disturbances? What role do forest roads play in erosion processes and sediment contribution to stream channels? Where do erosion processes deliver sediment to stream channels? What measures can be implemented to reduce delivery of sediment to stream channels? Which stream channels would benefit from the implementation of channel stabilization or restoration measures? What effects did the 1987 fires have on erosion processes and stream channels? What areas of Hidden Valley, Rattlesnake Creek, and Plummer Creek watersheds are of high soil erodibility and require special management emphasis?

- What are the dominant hydrologic characteristics and other notable hydrologic features and processes in the watershed? What beneficial uses dependent on aquatic resources occur in the watershed? Which water quality parameters are critical to these uses?

Issue — Stream Channel and Aquatic Habitat

The purpose of the analysis will be to identify management actions that would restore the dynamic equilibrium of stream channels in the Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds that were impacted by past natural (i.e., flood of 1964, fires of 1987, and others) and human-induced disturbances. The altered equilibrium condition has affected the instream habitat quality and quantity within the watersheds, especially for at-risk anadromous fish species.

Key Questions:

- What are the processes that create and maintain instream habitat over long periods of time? Have these processes been altered? If the natural processes have been altered, how have they affected anadromous fish habitat, especially in relation to sediment yield, transport and deposition? How have human-induced disturbances altered these processes?

- What watershed processes have deviated from equilibrium, and which streams would benefit most from channel stabilization and restoration efforts?

- What is the predicted future condition for aquatic habitats (especially anadromous fish habitat) if the Aquatic Conservation Strategy (ACS) is implemented?

Issue — Fire Re-Introduction and Fuels Hazard Reduction

The purpose of the analysis will be to evaluate the re-introduction of fires into the terrestrial ecosystem, and identify areas and priorities for fuel hazard reduction, including forest health issues by location. Fire suppression efforts have successfully removed the natural fire regimes of less severe understory fires and increased the risk of catastrophic, high intensity fires. Increases in fuel loading that resulted from fire suppression activities have changed the fire hazard patterns that may result in catastrophic disturbance.

Key Questions:

- What are the current fire regimes and major causes of fires?

- What is the existing fire hazard pattern? What is the risk of catastrophic fire associated with Late-Successional and Riparian Reserves?

- What are the areas of concern with respect to wildland/urban interface, rural communities, and high value resources at risk in terms of catastrophic wildland fires? Which of these areas are of highest priority for fuels reduction treatments and assistance for adjacent communities?

- What vegetation treatments are needed to reduce the risk of catastrophic fires? Which areas would benefit most by prescribed fires for fuel hazard reduction and terrestrial habitat improvement? What silvicultural treatments are needed to reduce fuel ladders prior to prescribed fires to provide for post-fire stands that are healthier?

Issue — Commercial Wood Products

The purpose of the analysis will be to identify forest stand conditions in the Matrix lands related to (1) forest health needs, and (2) regulated, sustainable timber harvest according to the silvicultural objectives of the LRMP. Timber production has been identified in the LRMP as an objective for the Adaptive Management Areas/Matrix land allocations. Obtaining an optimum timber yield of wood fiber products within the context of ecosystem management is a goal for these forestlands.

Key Questions:

- What are the past and current vegetation conditions (structure and composition) and patterns?
- Are there any known threats to forest health? What treatments can be employed to maintain or improve the health of the existing forests?
- Are designated Matrix lands currently being regulated to provide predicted timber outputs? What regeneration harvesting opportunities are available to move the Matrix lands toward a fully regulated timber land-base? What intermediate cutting opportunities are available to maintain tree-stocking levels that will reduce susceptibility to insect or disease attacks and maintain stand growth and vigor?
- What silvicultural treatments, besides for commodity production, could be implemented that would improve existing conditions for biological diversity and other non-consumptive uses of the forests?
- Are there potential fuelwood cutting opportunities in selected Late-Successional Reserves that could reduce risk of loss of forest stands with overstocked conditions to catastrophic fires, and/or accelerate the trend towards desired late-successional forest conditions?

Issue — Forest Vegetation, and Wildlife Species and Habitats

The purpose of the analysis will be to gather and synthesize information on status and trends related to forest vegetation and wildlife species of special status and associated habitats. The forested landscape in the analysis area consists of a mosaic of vegetation with varying composition, structure, and age classes. There are known or potential for occurrences of special-status species and suitable habitats within the watershed analysis area. Natural and human-induced disturbances on the forestlands have affected the available suitable habitats and consequently species occurrences and distribution.

Key Questions:

- What is the existing vegetation distribution by composition and structure? What is the current landscape condition of the vegetation mosaic, with special emphasis on habitat connectivity related to Late-Successional and Riparian Reserves?

- What are the distribution status and trends related to special-status fish and wildlife species (i.e., federally threatened or endangered, federal candidate for listing, federal species of concern, Forest Service sensitive, and Northwest Forest Plan survey and manage) and associated habitats?

- What management opportunities exist to improve habitat capability for special-status species, and also to maintain and/or enhance species-habitat diversity?

Issue — Plant Species of Concern and Noxious Weeds

The purpose of the analysis will be to synthesize existing information to describe the status, trends, risk, and opportunities related to plant species of special status and noxious (or invasive exotic) weeds. Suitable habitat for special-status plant species exists within the watershed analysis area. Livestock grazing may have potential impacts on habitat components of plant species of concern. There are known occurrences of noxious weeds in the analysis area, with a serious potential to spread aggressively.

Key Questions:

- What are the distribution status and trends of special-status plant species (i.e., federally threatened or endangered, Forest Service sensitive and endemic, and Northwest Forest Plan survey and manage) and associated habitats? Are there management opportunities to protect and/or enhance the existing habitat conditions?

- What natural plant communities and associated special habitats (i.e., plant species with special adaptation to mineralized soils) of concern exist? Are there management opportunities to enhance and/or protect the exiting special habitat components and associated plant communities?

- What are the distribution status and trends related to noxious weed (or invasive exotic plants)? Are there opportunities to identify and control spread of the noxious weeds?

- What sensitive habitats for plant species are potentially affected by existing livestock grazing activities? What are the status and trends for livestock grazing allotments? Are there opportunities to redirect livestock grazing away from, or exclude them from, sensitive areas?

3. CURRENT CONDITIONS

The purpose of this chapter is to describe current watershed conditions by collecting and collating existing information. The relevant issues and key questions identified will direct the data assembly and review for the description of current conditions. The current range, distribution, and condition of the relevant ecosystem elements are described.

3.1 Erosion Processes

3.1.1 Geology

The South Fork of the Trinity River, which flows along the east-dipping South Fork Mountain thrust fault, divides the WAA into two major physiographic provinces. The Klamath Mountain province dominates Rattlesnake Creek and Plummer Creek watersheds and the eastern side of the Hidden Valley watershed. The California Coast Range province occurs along the western edge of the Hidden Valley watershed. See Map 3-1, Combined Geologic Units within Watershed Analysis Area.

The Klamath Mountain Province is predominantly composed of Paleozoic to Mesozoic (450 to 140 million years before present) sedimentary and volcanic rocks with Jurassic (150 million years before present) granitic intrusions. The province has been subdivided into four north to northwest trending "belts"; the WAA falling on the two western subunits of the Western Paleozoic and Triassic belt and the Western Jurassic Belt. The Western Paleozoic and Triassic Belt consists of three parallel subunits, or terranes, called the North Fork, Hayfork, and Rattlesnake Creek terranes. The Western Jurassic Belt crops out in a band along the South Fork of the Trinity River and consist primarily of the Galice Formation.

The portion of the Coast Range found in the WAA is the Franciscan Complex, which is composed of three belts, the easternmost of which is found in the WAA. The Yolla Bolly belt dates from the Cretaceous age (130 million years before present) and contains the Pickett Peak and Yolla Bolly terranes. The western side of the Hidden Valley watershed consists mostly of South Fork Mountain Schist of the Picket Peak terrane with minor portions of Yolla Bolly terrane Broken Formation.

The South Fork Mountain Schist consists of mica-schists that are light-brown to gray and are banded with quartz albite. Minor meta-basalt gneiss inclusions are found throughout. There is a strong foliation parallel to the eastern face of South Fork Mountain creating an unstable surface that is prone to landslides (see Geomorphology section).

The South Fork Mountain Schist is divided from the Galice Formation of the Western Jurassic Belt and the Klamath Mountain Province by the South Fork Mountain Fault. Although there is no evidence of recent seismic activity, it is associated with the active San Andreas Fault system to the south, and there is a potential for deep-seated earthquakes in the area (USFS 1996). The fault zone lies on the west side of the South Fork Trinity River, is about 1,000 feet wide, and consists of intensely sheared bodies of serpentinite, diorite dikes, Galice metasediments, and schist.

The Galice Formation is the westernmost belt of the Klamath Mountain Province. It extends eastward to the Rattlesnake Creek Terrane, where it is separated by the sharply eastward-dipping Bear Wallow Fault. The formation is composed of metasediments that dip steeply to the northeast, with a few igneous intrusions of Jurassic age. The Galice Formation is particularly unstable and subject to debris slides (USFS 1988).

Plummer Creek and Rattlesnake Creek watersheds to the east are dominated by the Rattlesnake Creek Terrane, which is the remnant of an island-arc system and is extremely complex. Through subsequent faulting associated with its accretion onto the western margin of the North American Plate, the resulting terrane is a mix of blocks with differing lithologies and structural orientations in serpentine matrix. The blocks range in size from a few acres to thousands of acres and include felsic plutonic rocks, ultramafic serpentinites, metavolcanic blocks, and a slice of Franciscan marine sedimentary rocks (USFS 1982a). The Rattlesnake Creek Terrane is noted for instability; in particular, the shear zones are weak and prone to failure. The larger blocks of igneous and volcanic rocks in the watersheds are more stable.

Terraces located along the S.F. Trinity indicate rapid uplift, which would contribute to instability and increased rates of erosion. These terraces have not been dated (Raines 1998).

To simplify the analysis and interpretation, geologic units within the river basin were grouped by similar geomorphic properties by Mark Smith of the Six Rivers National Forest (in Raines 1998). Table 3-1 lists the combined and basic geologic units in the WAA.

3.1.2 Geomorphology

The WAA lies in a region of deeply dissected mountains composed principally of the unstable rock formations of the South Fork Mountain Schist, the Galice Formation, and the Rattlesnake Creek terrane. As a result, the erosion rates in the watershed and sediment loads in the South Fork Trinity River are extremely high compared to most rivers. The mean annual sediment discharge reported in a 1972 study was 1,650 tons/mi2 for the S.F. Trinity for the period 1940 to 1965 (SCS 1972 in PWA 1994). In comparison, at two locations in the Klamath Mountain Province, the North Fork of the Trinity River at Helena had an annual suspended sediment yield of 210 tons/mi2 and the Trinity River at Lewiston had an annual suspended sediment yield of 160 tons/mi2 (Hawley and Jones 1969 in PWA 1994).

The South Fork of the Trinity River has been the subject of several studies following the 1964 flood, which was the largest on record. Following the flood, fish populations declined severely and currently remain below pre-flood levels (see Fish Habitats and Species section). The continued high rates of erosion and sedimentation are considered a major contributor to the depressed anadromous fish runs in the river basin (PWA 1994). The South Fork of the Trinity River has one of the highest sediment loads in northern California. The high sediment loads have been attributed to unstable geology, management activities, and storm activity (Raines 1998).

Table 3-1. Combined and Basic Geologic Units for the Watershed Analysis Area.

Combined Geologic Unit	Basic Geologic Unit	Unit Description	Hidden Valley (acres)	Plummer Creek (acres)	Rattlesnake Creek (acres)
DG		**Igneous & Volcanic**	2,559	7,510	6,526
	Jm	Ammon Ridge mafic			
	M	metavolcanic blocks			
	P	felsic plutonic rocks			
	Tc	Tule Creek Granite			
	Um	ultramafic, serpentine			
FR		**Franciscan & affiliated**	186		658
	Ks	marine sedimentary			
	Ybc	Chicago rock broken fm			
JG		**Galice Formation**	5,829	13,401	3,267
	Jgs	metasedimentary			
QA		**Valley Fill**	116		
	Qa	Weaverville Fm & alluvium, terrace materials, glacial deposits			
RC		**Rattlesnake Creek Terrane**	3,317	11,741	19,653
	Rcm	volcaniclastic melange & sheared volcanic rocks			
SC		**SF Mountain Schist**	21,485		
	Sfm	quartz-mica schist & semi-schist			
Unclassified			87	-	-
Total Acreage			33,580	32652	30104

In 1994, the South Fork Trinity River was added to the Clean Water Act §303(d) list for sediment impairment triggering the development of a TMDL that was completed in 1998. In support of the TMDL, a detailed sediment source analysis was completed for the South Fork Trinity River basin (Raines 1998), which included Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds. Raines (1998) used aerial photographs dating from 1944 to 1990 to map landslides and mass wasting features, used road survey data with a GIS-based model (SEDMOD) to estimate road erosion rates, estimated erosion rates applied to the harvest history of upland areas to estimate hillslope erosion rates, and existing river data to estimate stream bank erosion rates. This report is the most detailed study to date on the South Fork Trinity River watershed and is the basis of this geomorphic description for the WAA.

The sediment source analysis (Raines 1998) divided the entire S.F. Trinity River watershed into three main subdivisions, and also into the smaller planning watersheds delineated by the Forest Service. The WAA falls into the Upper S.F. Trinity River subdivision, which includes the planning watersheds above Hyampom to the headwaters and excludes the Hayfork Creek subdivision. The results from this subdivision can reasonably be applied to Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds since the geology, land management, and ecosystem processes are relatively similar throughout the whole subdivision.

The study divided the sediment sources into management-related and non-management-related sources, and three time periods based on aerial photograph availability and major changes in watershed activity. The first period was from 1944 to 1960, when timber harvest began in the basin; 1961 to 1975, when timber harvest was increased with pre-forest practices regulation and the largest storm event on record occurred; and 1976 to 1990, when timber harvest increased under newer regulations, and wildfires and three major floods occurred.

Figure 3-1 shows the sources of sediment in the Upper South Fork subbasin of the Trinity River from 1944 to 1990 and their relative contributions. Non-management sediment sources accounted for two thirds of the sediment supply in the Upper South Fork subbasin, and non-management related mass wasting contributed half of the total sediment to the S.F. Trinity. Non-management related bank erosion accounted for 14 percent of the total sediment supply and road related erosion contributed 17 percent of the sediment supply. The next sections in this document examine in more detail the sediment contributions due to mass wasting, roads, surface erosion, and stream bank erosion. It should be noted that the separation of sediment loads into management- and non-management-related is somewhat arbitrary and difficult to estimate. For example, timber harvesting could increase peak flows, which in turn could increase the rate of inner gorge mass wasting (USFS 2000), which would not be considered management-related by Raines (1998). The results of the Raines (1998) report are based on a combination of methods to assess sediment delivery including aerial photo interpretation (for large-scale mass wasting), complex numerical modeling (SEDMOD model for road erosion and delivery), and numeric estimates (for streambank erosion and surface erosion). Results from this study should be interpreted by keeping in mind the complexity of geomorphic responses and the differing methods used.

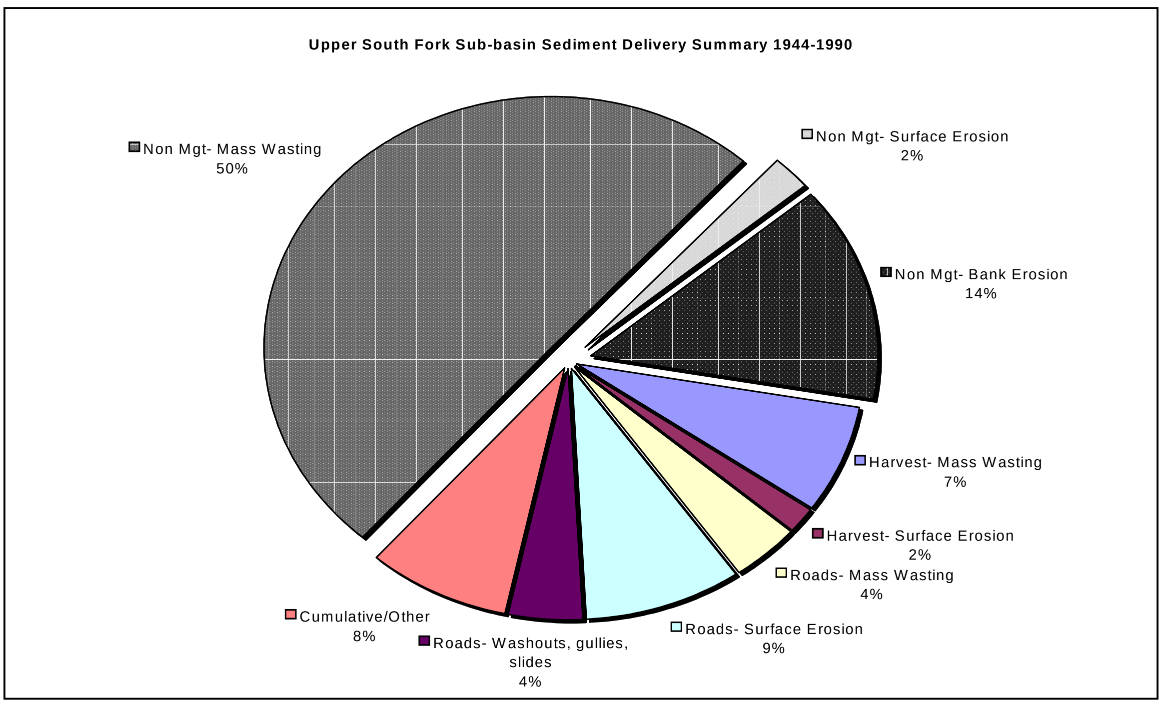


Figure 3-1. Sources of Sediment in the Upper South Fork subbasin of the Trinity River, 1944 to 1990. Adapted from EPA (1998).

Mass wasting is the principal source of sediment in the S.F. Trinity River basin accounting for 61 percent of the sediment supply to the S.F. Trinity River, including road-related mass wasting (Figure 3-1). The underlying geology of the landscape determines the type and prevalence of landslides in the WAA. The S.F. Trinity River flows through a steep inner gorge composed of the Galice Formation, which is structurally weak and prone to shallow landslides. Although the Galice Formation underlies a relatively small portion of the WAA, it is a major source of sediment to the S.F. Trinity River since the river flows through the formation most of the length of the WAA. See Map 3-1, Combined Geologic Units within Watershed Analysis Area.

The east-side of South Fork Mountain in the Hidden Valley watershed is underlain by the South Fork Mountain Schist, which is prone to deep-seated rotational-translational and block-glide landslides. “Nearly the entire eastern slope of the mountain is covered by nested dormant rotational-translational slides” (Haskins et al. 1980 in PWA 1994). Due to this inherent instability, the entire area was given an “Extreme” rating in the Instability and Erosion Hazard map by the California Department of Water Resources during sediment investigation in 1992 (Figure 3-2).

The Rattlesnake Creek Terrane, which dominates Rattlesnake Creek and parts of Plummer Creek watersheds, has abundant inactive and ancient landslides composing 13 percent of the landscape (PWA 1994), but is more stable than the Galice Formation or South Fork Mountain Schist. Table 3-2 shows the number of landslides for each geologic grouping in the WAA. The Galice and South Fork Mountain Schist in the Hidden Valley watershed are the most prone to landsliding, with double the landslide density of Plummer Creek and Rattlesnake Creek watersheds.

Table 3-2. Density of Landslides by Geology Type in the Watershed Analysis Area. Adapted from Raines (1998).

Watershed	Geology				No. of Landslides	Landslide Density (#/ mi^2)
	Igneous & Volcanic (DG)	Galice Formation (JG)	Rattlesnake Creek Terrane (RC)	S.F. Mtn. Schist (SC)		
Hidden Valley	8	79	4	59	150	2.9
Plummer Creek	3	43	26		72	1.4
Rattlesnake Creek	1	12	5		18	0.4

The type and location of the landslide influences whether it will deliver sediment to the river. Raines (1998) divided landslides into landslide type by combined geologic unit, slope position, and size class. Five size classes were delineated on aerial photos, and measured in the field. Results from the study are summarized in Table 3-3. Table 3-4 shows the percentage of each landslide type contributing sediment by geologic type for the S.F. Trinity River basin, which includes watersheds to the north and south of the WAA. Most of sediment was from shallow debris slides in the Galice Formation, which the S.F. Trinity River flows through in the majority of the WAA.

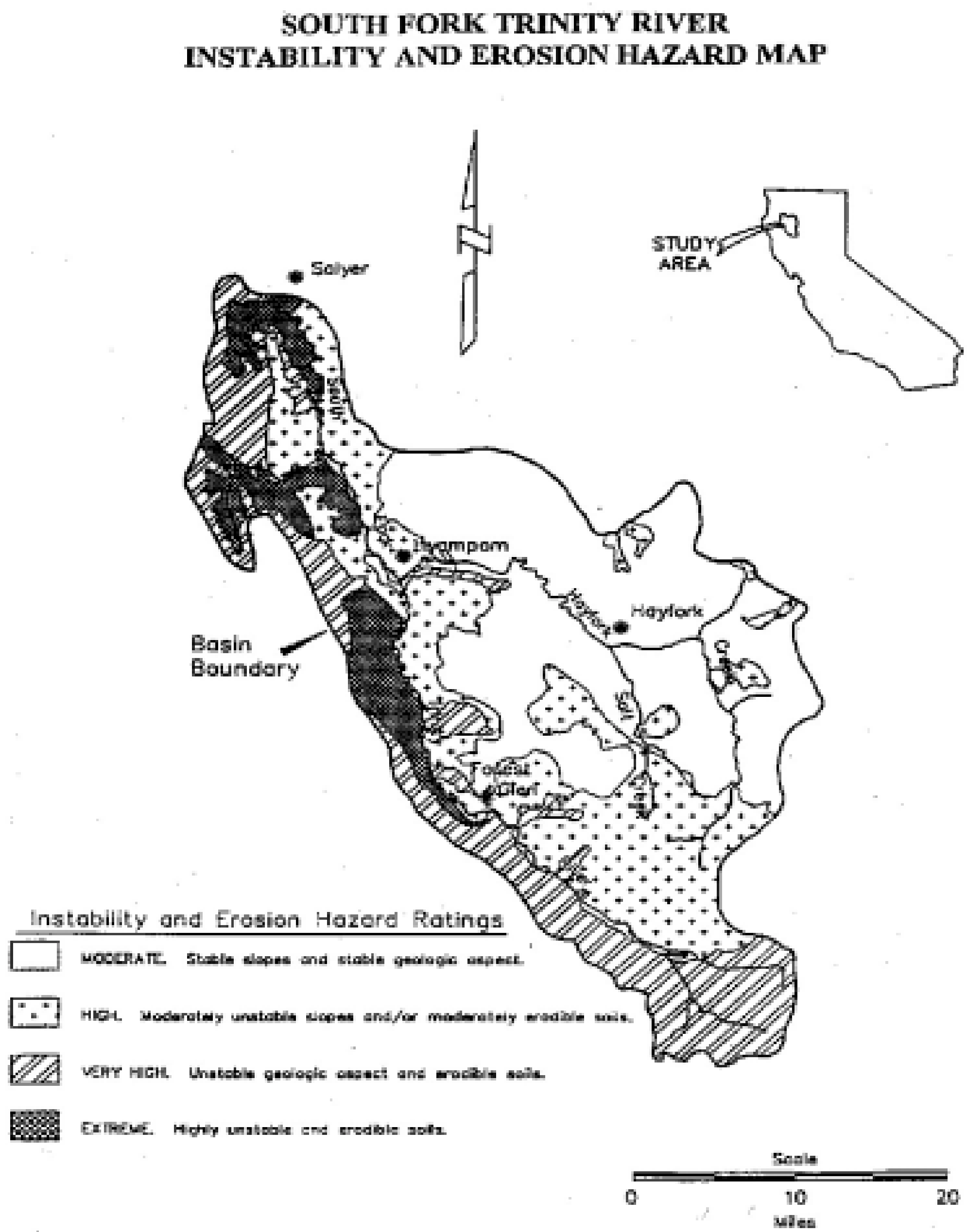


Figure 3-2. Instability and Erosion Hazard Ratings for South Fork Trinity River.
Source: CDWR 1992.

Table 3-3. Landslide Size Classes and Delivered Volumes for the S.F. Trinity River Basin. Adapted from Raines (1998).

Landslide Size Class	Mean Volume (yd^3)	Standard Deviation	Median Volume (yd^3)	No. of Measurements
1	1,706	1,201	1,378	34
2	6,607	5,476	5,385	44
3	15,581	13,424	10,932	40
4	77,370	62,716	50,925	16
5	261,324	428,702	100,000	9

The slope position of the landslide is a factor in whether a landslide will deliver sediment to a watercourse. Inner gorge landslides were the most frequent at 64 percent of the total, and likely had the highest probability of delivering sediment to the S.F. Trinity River. Table 3-5 lists landslides by slope position and the combined geologic unit. The Galice Formation had the highest rate of landslides, with 42 percent of the total, out of the combined geologic units. The study also divided mid-slope landslide into those that delivered sediment to the river, and those that did not. Only 38 percent of the mid-slope landslides contributed sediments to watercourses.

Table 3-4. Landslide Types by Combined Geologic Unit for S.F. Trinity River Basin. Adapted from Raines (1998).

Combined Geologic Unit	Complex slides, slumps, large deep-seated (%)	Shallow rapid/debris slides (%)	Debris torrent (%)	Rock fall/talus (%)
Igneous & volcanics (DG)	54.2	40.8	5.0	0.0
Franciscan & affiliated (FR)	7.8	82.0	10.1	0.1
Galice Formation (JG)	22.7	74.4	2.9	0.1
Rattlesnake Ck. Terrane (RC)	31.4	65.6	0.0	3.0
S.F. Mountain Schist (SC)	5.6	85.2	8.6	0.6

Table 3-5. Landslides by Combined Geologic Unit and Slope Position for S.F. Trinity River Basin (excluding Grouse Creek). Adapted from Raines (1998).

Combined Geologic Unit	Inner Gorge	Mid-slope, delivers	Mid-slope, no delivery	Upland	Total No. of Landslides	Percent of Total
Igneous & volcanics (DG)	15.0	9.0	9.0	2.0	35	3.2
Franciscan & affiliated (FR)	54.0	19.0	3.0	32.0	108	9.9
Galice Formation (JG)	320.0	56.0	83.0	0.0	459	42.0
Rattlesnake Ck. Terrane (RC)	137.0	25.0	113.0	4.0	279	25.5
S.F. Mountain Schist (SC)	174.0	26.0	11.0	1.0	212	19.4
Total	700.0	135.0	219.0	39.0	1,093	
Percent of Total	64.0	12.4	20.0	3.6		

Management activities such as road building and timber harvest contributed to mass wasting sediment delivery and were analyzed by Raines (1998) for the period of the study, 1944 to 1990. Figure 3-3 shows the amount (in tons) of sediment contributed by management and non-management activities for the three watersheds in the WAA. Hidden Valley watershed has the highest management and non-management related mass wasting of the three watersheds, and has a ratio of non-management to management sediment delivery of 7.8 to 1. Mass wasting in Plummer Creek watershed is less than in Hidden Valley, and the non-management to management ratio is higher at 12.5 to 1. This is likely due to the low level of management activity in the lower portions of the watershed that overlay the landslide-prone Galice Formation. In contrast, Rattlesnake Creek watershed has a non-management to management related mass wasting ratio of 0.59 to 1. Rattlesnake Creek watershed has less of the unstable Galice Formation, no South Fork Mountain Schist, and relatively high road densities compared to the other watersheds in the WAA (Table 3-18). Although the Galice Formation composes about 11 percent of the Rattlesnake Creek watershed, over half of the landslides occurred in this geologic unit.

Table 3-6 shows the relative percentage of landslides caused by management (roads and timber harvest) and by slope position for the S.F. Trinity River basin, including Grouse Creek and the active area north of the WAA. The table illustrates that management activity accounts for a higher portion of the mid-slope landslides that do not deliver sediments to watercourses. The inner gorge is dominated by non-management related landslides, which is probably due to the limited amount of road building and timber harvest in the steep inner gorges.

Road Erosion

Roads are the dominant management-related sediment source in the WAA. They deliver 13 percent of the sediment in the WAA, behind mass wasting and bank erosion (Raines 1998). The processes of erosion from roads are surface erosion including sheetwash and rill erosion of the road prism, ravel from the cutslopes, gullying of the cutslope, slides too small to be tallied on the aerial photos, and washouts at stream crossings. Raines (1998) used the model SEDMOD to estimate sediment delivery from roads in the entire S.F. Trinity River basin. Extensive road inventories conducted in the 1990s were used as data sources for the model (in Raines 1998). The model produced estimates of sediment delivery for three time periods, of which the most recent period 1976 to 1990, is reported here because it most closely reflects current conditions.

The results of the SEDMOD model were affected by several factors that need to be noted. The model was based on limited road construction history information, an enhanced stream layer that was known to over-predict the occurrence of streams (and hence sediment delivery rates), and traffic volumes that were likely considerably higher in the 1980s due to higher levels of timber harvest in the WAA. Road surface erosion on unpaved roads is very sensitive to traffic volumes, and lower use on moderate- to light-use roads in the 1990s could reduce erosion rates by a factor of 4 to 5. The Shasta-Trinity National Forest has begun to decommission roads since road construction ended in the WAA following fire restoration efforts in 1993.

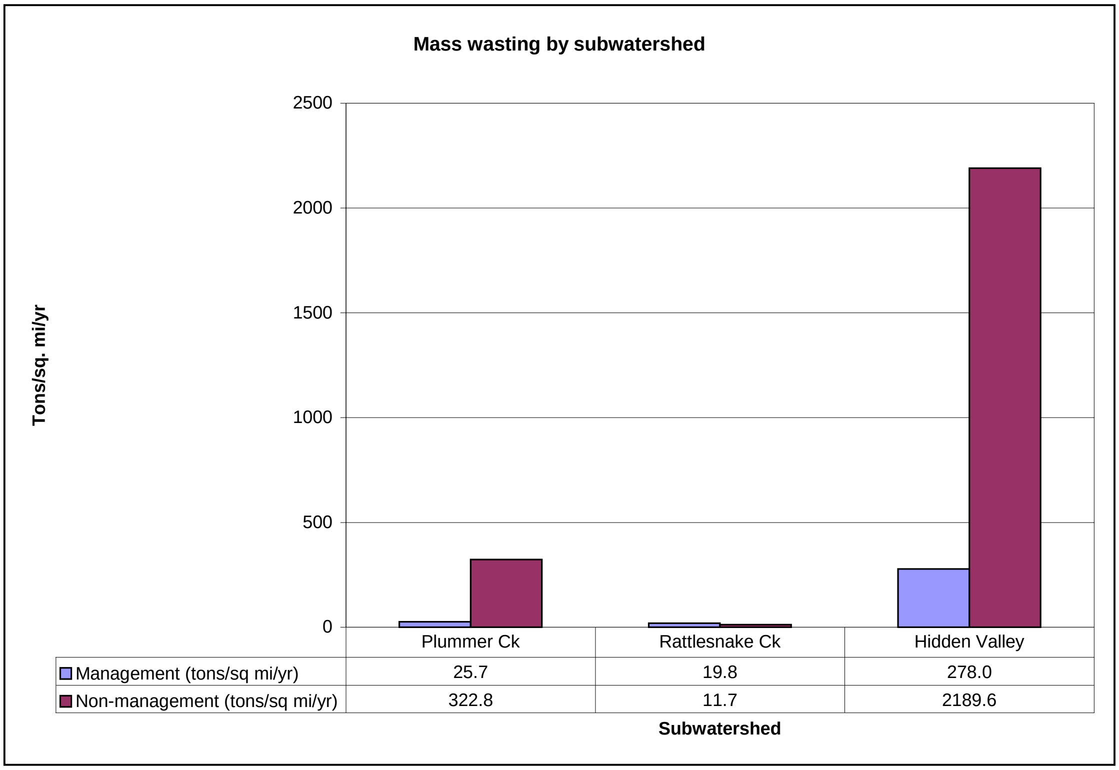


Figure 3-3. Mass Wasting Sediment Delivery in Watershed Analysis Area. Adapted from Raines (1998).

Table 3-6. Landslides by Slope Position and Land Management Associations for S.F. Trinity River Basin. Adapted from Raines (1998).

Slope Position	Management[1] (%)	Non-management (%)
Inner Gorge	19	81
Mid-slope, delivers	52	48
Mid-slope, no delivery	68	32
Upland	42	58
Total	34	66

[1]Management-related landslides includes slides caused by roads and timber harvest.

Detailed information on road lengths and densities, and road-stream crossings by watershed will be presented in the Roads section. Table 3-7 presents data on average surface erosion rates from roads included in the study for the period 1976 to 1990.

Rattlesnake Creek watershed has the highest sediment delivery rate of the three watersheds in the WAA due to the high road density and the proximity of roads to streams. Hidden Valley watershed, however, has higher average rates of road erosion per mile of road than Plummer Creek and Rattlesnake Creek watersheds. Several factors could be contributing to the higher rates of erosion in Hidden Valley watershed, including more precipitation on South Fork Mountain, higher average slopes, and most importantly, the higher observed rates of erosion in the schist lithologies that dominate South Fork Mountain (Raines 1998).

Table 3-7. Surface Erosion Rates from Roads for the Watershed Analysis Area. Adapted from Raines (1998).

Watershed	Area[1] (acres)	Road Length[1] (miles)	Miles of Direct Delivery Roads	Miles of All Roads Delivering	Average Adjusted Erosion Rate (tons/ yr)[2]
Hidden Valley	32,606	147	23	36	8,780
Plummer Creek	32,633	107	19	35	3,090
Rattlesnake Creek	30,019	238	53	103	10,440

[1]Watershed acreages and road lengths are from Raines (1998) Sediment Source Analysis and do not exactly match the current WAA.

[2]Adjusted rate is the average of two rates based on calibration values in published literature. The rate was then reduced by about 25 percent to correct for differences between observed and modeled results.

Road erosion due to gullies, washouts, and small road-related landslides were not included in the SEDMOD model. Tables 3-8 and 3-9 show non-surface road erosion by geology and by watersheds in WAA. The Galice Formation and South Fork Mountain Schist had the highest rates of sediment delivery due to gullies, washouts, and landslides. The Galice Formation was dominated by road-related landslides, and the South Fork Mountain Schist was dominated by washouts. As would be expected, Hidden Valley watershed, which is underlain by the Galice and S.F. Mountain Schist, had much higher rates of road-related gullies, washouts, and landslides than Plummer Creek or Rattlesnake Creek watershed.

Table 3-8. Gullies, Washouts, and Landslides on Roads by Combined Geologic Unit for Watershed Analysis Area. Adapted from Raines (1998).

Combined Geologic Unit	Total Road Surveys (mi)	Total Washouts (yd^3)	Total Gullies (yd^3)	Total Landslides (yd^3)	Overall Total (yd^3)	Average (yd^3/ mi of Road)	Sediment Per Mile (tons/ mi)
Igneous & volcanics (DG)	30	75	223	0	298	10	15
Franciscan & affiliated (FR)	8	0	36	0	36	4	7
Galice Formation (JG)	18	67	337	2,350	2,753	154	231
Rattlesnake Ck. Terrane (RC)	29	0	473	0	473	16	24
S.F. Mountain Schist (SC)	5	475	13	0	488	98	146
Total	114				6,088	53	80

Streambank Erosion

Streambank erosion is a significant source of sediment in the WAA, contributing about 14 percent of the sediment to the watercourses (Figure 3-1). Four studies have been published that include streambank erosion results from different areas of the S.F. Trinity River basin. In 1972, the USDA Soil Conservation Service released a study that used aerial photographs and field checking of streams to report erosion rates throughout northern California. Raines and Kelsey (1991) examined streambank erosion as part of the detailed study of Grouse Creek watershed located north of the WAA. Llanos (1998) sampled 82 locations in geomorphically distinct areas within the S.F. Trinity River basin.

Table 3-9. Road Surveys in Watershed Analysis Area. Adapted from Raines (1998).

Watershed	Main Lithology	Road Surveys (mi)	Total Gullies, Washouts, & Landslides (yd^3)	Average Gullies, Washouts, & Landslides Per Mile of Road (yd^3)	Tons Per Mile of Road
Hidden Valley	JG, SC	7.2	655	91	136
Plummer Creek	DG	5.1	77	15	23
Rattlesnake Creek	DG	3.3	33	10	15

Based on past research, Raines (1998) estimated streambank erosion by stream order in tons per year (Table 3-10). These estimates are based on observed erosion rates for the particular geology, but since the only two factors used to estimate the erosion rate were stream order and geology, they were not site-specific and are very rough estimates. Raines (1998) also did not distinguish between management and non-management related streambank erosion because it was difficult to separate. Hidden Valley watershed, with the S.F. Trinity River running through the steep inner gorge composed of the Galice Formation, has the highest rate of streambank erosion.

Table 3-10. Stream Bank Erosion (tons per year) by Stream Order in the Watershed Analysis Area. Adapted from Raines (1998).

Watershed	Stream Order							Total
	1	2	3	4	5	6	7	(tons/yr)
Hidden Valley	1,900	6,500	10,100	1,700	0	0	40,200	60,400
Plummer Creek	1,200	3,200	2,500	3,500	400	0	1,500	12,200
Rattlesnake Creek	1,300	4,200	2,900	4,200	500	4,500	0	17,500

Hillslope Surface Erosion

This erosion category includes sediment that is delivered to the stream system by splash erosion, sheetwash, rilling, and gully erosion. This type of erosion accounts for about 4 percent of the erosion in the WAA, for both management- and non-management-related sources. Timber harvest and related activities are the dominant management-related activity in the WAA. Raines (1998) estimated the management-related surface erosion based on tree plantation data obtained from the Forest Service, erosion rate factors from published papers, and other factors including geology, slope, and sediment delivery potential. The limited amount of timber harvest history data hampered efforts at obtaining an accurate estimate of management-related surface erosion. Table 3-11 shows the amount of erosion from management and non-management related surface erosion over the study period from 1944 to 1990. Hidden Valley watershed has the highest levels of management-related surface erosion due to the amount of timber harvest that occurred earlier than in Plummer Creek or Rattlesnake Creek watershed, particularly on private lands.

According to the Forest Service plantation records and assumptions about private land timber harvest practices cited in Raines (1998), over one-quarter of Hidden Valley watershed had been harvested prior to 1960.

Non-management related erosion was attributed to areas that had burned from wildland fires. Areas with old-growth timber were assumed to have negligible levels of surface erosion. Of the three watersheds, Plummer Creek had the greatest area burned from wildland fire (approximately 18,753 acres) and the corresponding highest rate of fire-related erosion. Rattlesnake Creek and Hidden Valley watersheds had 4,995 and 2,748 acres burned from wildland fire, respectively.

For non-forested areas with grass, oak woodland, or chaparral, erosion rates were based on results obtained from the Grouse Creek study by Raines and Kelsey (1991). Plummer Creek has the greatest area in grasslands, oak woodland, and chaparral, and the corresponding highest rate of non-forested surface erosion of the three watersheds in the WAA.

Table 3-11. Surface Erosion from Management Activities (timber harvest), Fires, and Non-forested Areas in Watershed Analysis Area, 1944 to 1990. Adapted from Raines (1998).

Watershed	Management-related Sediment (tons)	Sediment from Fires (tons)	Sediment from Non-forested Areas (tons)	Overall Total
Hidden Valley	94,322	14,292	8,686	117,300
Plummer Creek	22,362	97,516	16,619	136,497
Rattlesnake Creek	27,307	25,976	903	54,186

Channel Geomorphology

The current channel conditions in the S.F. Trinity River and its tributaries are influenced by the flood event that occurred in December of 1964, which was the largest on record. Several gaging stations were established in the basin between a major flood in 1955 and the flood in 1964, which washed out most of the gages. Channel cross-section data was collected at these gaging stations during some of their years of operation, and some were re-surveyed in 1980 and 1998 and summarized in Matthews (1998). The cross-section at Forest Glen showed channel aggradation following the 1955 flood, channel degradation from 1960 to 1964, and between 2 and 3 feet of aggradation from the 1964 flood. From comparing photographs from that period to current conditions reveals that most of the gravel and finer material has flushed downstream leaving a coarse riffle of large cobbles and boulders. There is still considerable fill of gravel and fine sediment in the pool upstream of the abandoned gage site at Forest Glen (Matthews 1998).

At the gage site above Hyampom (the near Hympom site), the channel filled in between 2 and 3 feet from the 1955 flood, degraded back to pre-flood levels by 1960, and remained stable until the 1964 flood. The 1964 flood deposited between 2 and 7 feet of fill and eroded both stream banks substantially. The mean streambed elevation is still about 2 feet above the pre-1964 flood level, although floods in 1995 through 1998 could have deposited additional fill (Matthews 1998).

In the upper portions of the S.F. Trinity River basin (above the WAA), channel fill deposits have largely been removed (PWA 1994). Channel cross-sections have returned to pre-flood conditions, but alluvial terraces still exist that contribute sediment during high flow events. Below Forest Glen, there is still evidence of considerable alluvial fill and widening of the main channel causing thalweg meandering, channel migration, and increased flooding (PWA 1994).

Anecdotal observations of the effects of the 1964 flood are that both the number and depth of pools decreased after the flood. River surveys upstream of the WAA found only five pools deeper than six feet from Forest Glen to the East Fork in 1970, but a re-survey in 1989 found 28 pools greater than six feet deep. Further details of fish habitat surveys are presented in the Fisheries Section.

Most of the S.F. Trinity River channels can be classified as transport reaches according to the Montgomery and Buffington (1993) channel classification. These reaches have a high sediment transport capacity, and tend to have a plane bed morphology, tend to lack free-form bars, have subdued cross-section topography, and consist primarily of riffles (USFS 2000). Large woody debris is the primary source of roughness and complexity in these channels and is currently lacking due to the basin-wide past practice of wood removal from stream channels (USFS 2000). Incised low gradient transport channels occur in Rattlesnake Creek, and are characterized by channels with mixed-sized sediment, and floodplain incision. Incised channels are disconnected from the floodplain leading to increased bank erosion, susceptibility to scouring, and higher energy gradients.

Response reaches are generally low gradient reaches that have a lower sediment transport capacity. Portions of the S.F. Trinity River, particularly in the Hyampom Valley, are response reaches. The 1964 flood deposited millions of tons of sediment in the mainstem, resulting in filled pools, aggradation, and decreased channel complexity (USFS 2000).

Limited bedload measurements collected below Hyampom (outside the WAA), yielded unusual results in that bedload transport, which usually accounts for about 5 to 20 percent of the suspended sediment discharge, was larger than the suspended sediment discharge on average. At 3,000 cu ft/ sec (cfs), suspended sediment equations indicate about 700 tons per day would be discharged and that bedload transport would account for about 1,250 tons per day (Matthews 1998).

3.1.3 Soils

Soils data for the Shasta-Trinity National Forest and the WAA are compiled in the Soil Survey of Shasta-Trinity National Forest Area, California (SRI) based on field and aerial photo soil surveys completed in 1980 (USFS 1983). Most of the National Forest System lands were mapped to the third order, including the WAA. There are 86 soil mapping units represented in the WAA, out of 363 units found on the Shasta-Trinity National Forest. Map units are usually composed of two or more major soil types and inclusions of other soils that have similar parent material or temperature regime. Because soil characteristics are reported by soil type, each map unit may contain varying amounts of two to four different soil types.

This analysis used GIS layers to determine the extent of each soil map unit by watershed, and then the percentage of each major soil type was input from the SRI and the extent of the different soil characteristics was computed. Each watershed has about 20 percent of the soils classified in the minor inclusions category, which were labeled as residuals.

Table 3-12 shows the mineralogy of the soils for each watershed in the WAA. Serpentitic soils generally have a lower productivity than other soils. Rattlesnake Creek has the greatest extent of serpentinitic soils at 6.6 percent of the soils in the watershed. Table 3-13 shows the soil orders for each watershed in the WAA. The dominant soil orders in all three watersheds are Inceptisols, and followed by Entisols. These two orders make up about 70 percent of the soils in the WAA. Table 3-14 lists the five most extensive soil families for each watershed in the WAA.

Table 3-12. Mineralogy of Soils within the Watershed Analysis Area. Adapted from USFS (1983) and GIS coverage.

Soil Mineralogy	Hidden Valley		Plummer Creek		Rattlesnake Creek	
	Acres	% Area	Acres	% Area	Acres	% Area
Mixed	25,922	77.2	25,199	77.2	21,954	72.9
Oxidic	548	1.6	0	0.0	143	0.5
Serpentinitic	319	1.0	1,061	3.2	2,001	6.6
Total	26,788[1]	79.8	26,259[1]	80.4	24,098[1]	80.1

[1]Total acres of the watershed does not equal the actual total acreage because of the unclassified residual soils in each mapping unit.

Table 3-13. Soil Orders within the Watershed Analysis Area. Adapted from USFS (1983) and GIS coverage.

Soil Order	Hidden Valley		Plummer Creek		Rattlesnake Creek	
	Acres	% Area	Acres	% Area	Acres	% Area
Alfisols	10,352	30.8	5,849	17.9	9,797	32.5
Entisols	1,252	3.7	2,710	8.3	1,265	4.2
Inceptisols	14,874	44.3	17,043	52.2	12,318	40.9
Mollisols	260	0.8	657	2.0	719	2.4
Total	26,739[1]	79.6	26,259[1]	80.4	24,098[1]	80.1

[1]Total acres of the watershed does not equal the actual total acreage because of the unclassified residual soils in each mapping unit.

Table 3-14. Five Most Extensive Soil Types in the Watershed Analysis Area. Adapted from USFS (1983) and GIS coverage.

Hidden Valley			Plummer Creek			Rattlesnake Creek		
Soil Type	Acres	% Area	Soil Type	Acres	% Area	Soil Type	Acres	% Area
Hugo Family	9,565	28.5	Neuns Family	8,596	26.3	Neuns Family	7,443	24.7
Holland Family, deep	7,865	23.4	Residual[1]	6,328	19.4	Residual[1]	5,900	19.6
Residual [1]	5,704	17.0	Deadwood Family	4,209	12.9	Holland Family, deep	3,144	10.4
Neuns Family	3,292	9.8	Marpa Family	2,534	7.8	Holland Family	2,947	9.8
Holland Family	1,488	4.4	Rock Outcrop	1,804	5.5	Holland Family, granitic	2,330	7.7

[1]Residual is soils that were not assigned a percentage of the mapping unit, and cannot be quantified.

The Forest Soils goal in the Shasta-Trinity National Forest LRMP is to "maintain or improve soil productivity and prevent excessive surface erosion, mass wasting, and cumulative watershed impacts" (USFS 1994a). One of the principal agents of reduced soil productivity is soil erosion. Each soil type in the SRI has an erosion hazard rating (EHR) designed to appraise the relative risk of accelerated sheet and rill erosion (USFS 1983). It does not rate gully, dry ravel, wind, or mass wasting erosion. The EHR assumes there is little or no vegetative cover, and that the soil is subject to a 2-year, 6-hour storm event. Table 3-15 lists the EHR for the watersheds in the WAA. Plummer Creek watershed has the highest erosion hazard, with one-third of its soils in the high to very high erosion category. Hidden Valley and Rattlesnake Creek watersheds have only about 13 and 19 percent, respectively, in the high to very high erosion category.

Table 3-15. Erosion Hazard Ratings for Soils within the Watershed Analysis Area. Adapted from USFS (1983) and GIS Coverage.

Erosion Hazard Rating	Hidden Valley		Plummer Creek		Rattlesnake Creek	
	Acres	% Area	Acres	% Area	Acres	% Area
Low	14,923	44.4	6,971	21.3	7,826	26.0
Medium	8,841	26.3	8,164	25.0	10,674	35.5
High	4,281	12.7	10,335	31.7	3,729	12.4
Very High	0	0	790	2.4	1,953	6.5
Total	28,045[1]	83.5	26,259[1]	80.4	24,183[1]	80.3

[1]Total acres of the watershed does not equal the actual total acreage because of the unclassified residual soils in each mapping unit.

Other factors that effect soil productivity are the extent of soil compaction, which can be addressed through the cumulative effects analysis and the equivalent roaded acres model (see Cumulative Watershed Effects section), and fires. Fires can impact soil productivity by consuming the soil duff layer and changing the physical and chemical properties of the soil. Plummer Creek watershed has had the most area burned in the past century, although fire suppression has minimized extensive fire occurrences from about 1911 until the early 1980s. The Fire and Fuels section has more detail on the fire history of the WAA.

3.2 Hydrology, Stream Channel, and Water Quality

3.2.1 Hydrology and Stream Channel

The WAA includes three watershed planning units that contribute to the S.F. Trinity River and span an area of about 150 square miles or about 15 percent of the entire S.F. Trinity River basin. Elevations within the WAA range from over 5,800 feet in the headwaters of Rattlesnake Creek to below 1,300 feet in elevation where the S.F. Trinity River meets Hayfork Creek. The hydrologic cycle within the WAA is driven by the regional climate.

Climate

The WAA has a Mediterranean type climate where 90 percent of the precipitation falls between October and April (CDWR 1979). The climate is strongly influenced by the proximity of the Pacific Ocean, which brings winter moisture into the WAA. Average precipitation generally decreases across the WAA from west to east, with South Fork Mountain receiving an average of about 80 inches of precipitation and the lower eastern portions of Rattlesnake Creek receiving an average of about 40 inches per year. The precipitation gage at Hayfork is one of few operating in the area, and it has the longest record extending from 1945 to current.

Snow is common at elevations above 4,000 feet in the winter, and typically lasts through mid-June. The rain-on-snow zone (ROS) ranges from 2,000 to 6,000 feet in the WAA (J. Fitzgerald, personal communication 2001), which includes a majority of the WAA. ROS events occur when storms bring warm air and rain that melts a significant portion of a snowpack, which then contributes to flood runoff. For the USGS gage near Hyampom on the S.F. Trinity River, December through February have the highest number of peak flows suggesting that ROS events generate the highest flows for the WAA (Figure 3-5).

Stream Network

The S.F. Trinity River runs roughly north-northwest through the WAA, dividing Hidden Valley watershed from Plummer Creek watershed for most of the length of the WAA. At the Forest Glen USGS gage, the S.F. Trinity River enters the WAA at about 2,253 feet in elevation, and after 25 to 30 miles, it leaves the WAA at about 1,259 feet where the USGS gage near Hyampom is located. The drainage area at the gage above Hyampom is 342 square miles, and at Forest Glen the drainage area is 208 miles. The average gradient of the S.F. Trinity River between the gages is about 35 to 40 feet per mile. Major tributaries to the S.F. Trinity River include Rattlesnake Creek and Plummer Creek, which enter the S.F. Trinity from the east.

The drainage network is dendritic in the Rattlesnake and Plummer drainages. Most of Hidden Valley is a face drainage where numerous short streams empty into the S.F. Trinity River. Although most of the streams on South Fork Mountain are short, there are numerous perennial streams and most of those are potential anadromous fish habitat. Table 3-16 lists the length of streams by stream types, and stream densities for the three watersheds in the WAA. See Map 3-2, Stream Types within Watershed Analysis Area.

Table 3-16. Stream Types (by flow regimes of crenulated streams) in the Watershed Analysis Area.

	Hidden Valley[1]	Plummer Creek	Rattlesnake Creek
Stream Types	Length (mi)	Length (mi)	Length (mi)
Ephemeral	44.00	84.00	120.00
Intermittent	63.00	53.00	64.00
Perennial	52.00	51.00	46.00
Unclassified	10.00	-	-
Total Length	170.00	188.00	230.00
Stream Density (mi/mi^2)	3.24	3.68	4.89

[1]The S.F. Trinity River itself was not included in stream length and density calculations for either Hidden Valley or Plummer Creek watersheds since the S.F. Trinity River divides the two watersheds (J. Fitzgerald, personal communication 2001).

Protected Status of River

The S.F. Trinity River is the longest undammed river in California. The S.F. Trinity River from Forest Glenn to the mouth is designated as a Wild and Scenic River. The designations (for a total of 37.2 miles out of the total of 53 miles) for the S.F. Trinity River on Shasta-Trinity

National Forest are as follows: 19.3 miles as Wild, 11.8 miles as Scenic, and 6.1 miles as Recreational (USFS 1994b).

Gages and Streamflow Data Availability

Two USGS stream gages have actively collected data on the S.F. Trinity within the WAA. The gage above Hyampom called the "Sf Trinity R Nr Hyampom Ca" operated from about 1955 to 1965 collecting daily and peak flows. The gage at Forest Glen called the "Sf Trinity R A Forest Glen Ca" operated from 1959 to 1965. Neither of these gages offer a record long enough to analyze flood frequencies or to develop a statistically accurate picture of flows. The gage below Hyampom has operated from 1965 to present, but includes flows from the S.F. Trinity River's largest tributary, Hayfork Creek, which makes it of limited use for this analysis.

Two gages on smaller tributaries to the S.F. Trinity River also collected peak flow data for limited periods. A gage on Swift Creek operated from 1961 to 1964, and a gage on Post Creek operated from 1967 to 1974. Hydrologic parameters of interest are typically peak flows, low flows, water yield, and the timing of each. Data from the S.F. Trinity River gage near Hyampom were used due to its location downstream of the WAA.

Peak flows are of concern due to the potential for flooding damage to structures in the floodplain and changes in channel morphology. Although peak flows are important, channel form is typically determined by the more frequent bankfull discharges that occur every 1.5 to 3 years, depending on the system. Floods, however, have had a significant impact on the S.F. Trinity River system. The December 1964 flood was the largest on record, and probably for the last 150 years. The changes resulting from this massive flood are still working through the system. Other known large floods occurred historically in 1861, 1881, and 1890 after which there was a lull until 1955. Most of the largest floods in the last 150 years have occurred since 1950 (Matthews 1998). The highest peak flows recorded by the USGS gage below Hyampom (with a record from 1964 to 1998) occurred in 1964, 1974, 1983, 1986, and 1996. Peak flows for the USGS gage near Hyampom are presented in Figure 3-4.

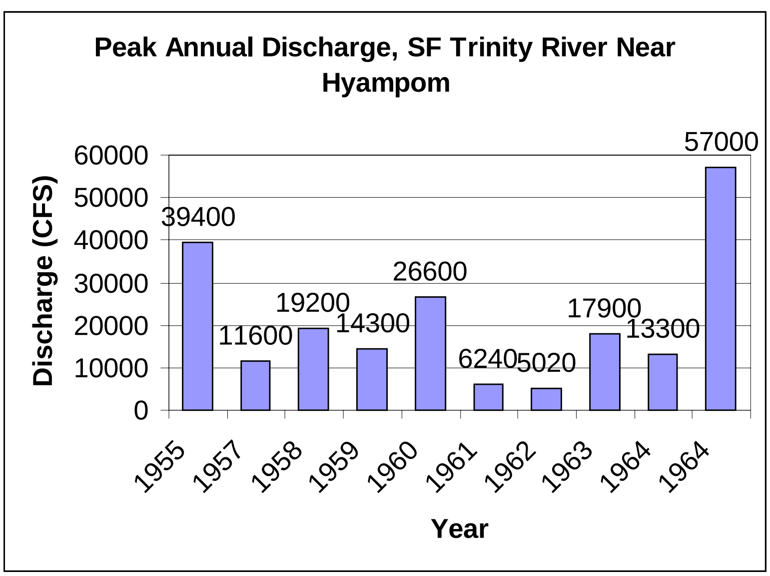


Figure 3-4. Peak Flows for the Period of Record from the USGS Gage near Hyampom.

The timing of peak flows is also important. Figure 3-5 illustrates which months that peak flows occurred. Most peak flows occur in the winter months, from December through February, indicating that they are likely rain-on-snow events. There are no peak flows in May or June, indicating that annual peak flows do not occur from spring snowmelt events. Even the more common bankfull flows occur during the winter months. Bankfull, or 1.5-year discharges, were computed by Matthews (1998) for the Forest Glen and near Hyampom USGS gages on the S.F. Trinity, and are 9,300 and 13,000 cfs, respectively.

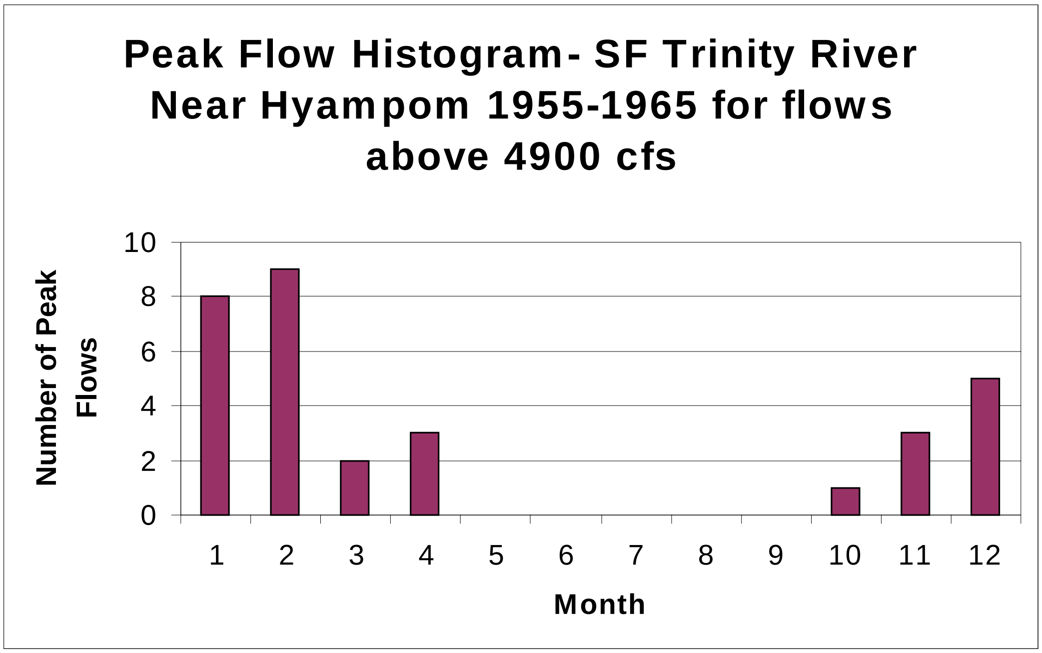


Figure 3-5. Distribution of Peak Flows for the USGS Gage near Hyampom.

Low flows are very important for fish. With ninety percent of the precipitation falling between October and April, the summers are long and dry. As Figure 3-6 shows, the summer low flows occur in September, and mean monthly flow is almost 60 times less than the mean monthly flow in February. In late September 1964, the near Hyampom gage recorded a 7-day mean flow of 25 cfs, the lowest in the record. In comparison, the average mean annual discharge for the period of record is 729 cfs.

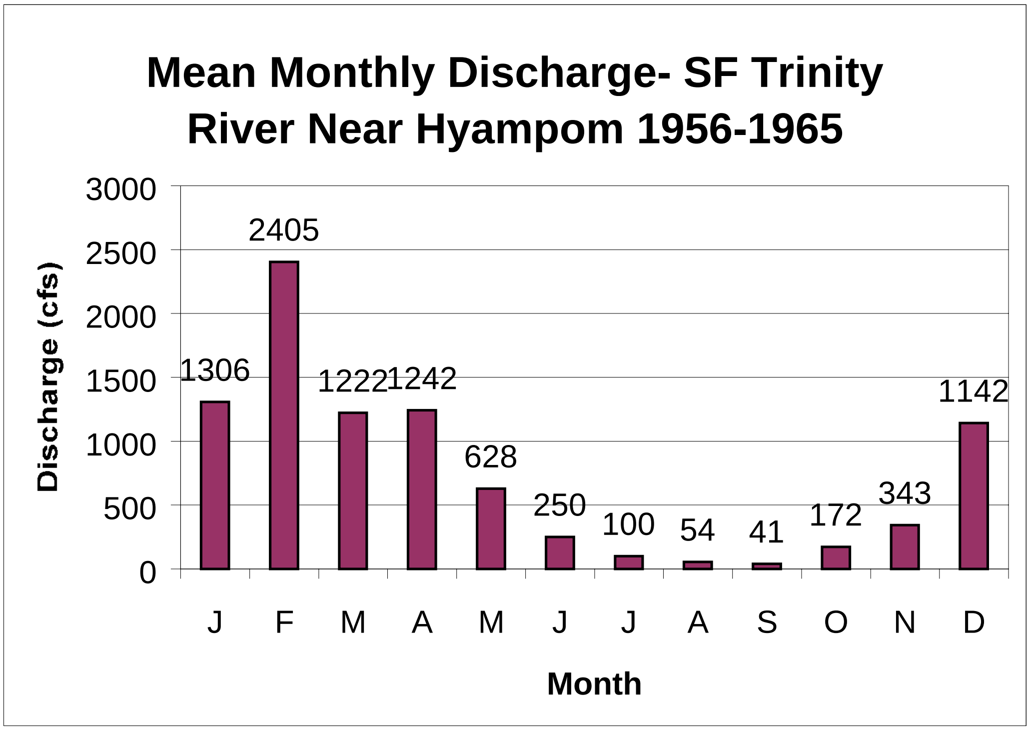


Figure 3-6. Mean Monthly Discharge of the S. F. Trinity River at the USGS Gage near Hyampom.

The mean monthly discharges displayed in Figure 3-6 show the strong seasonality of flows in the S.F. Trinity River. There is also considerable variation from year-to-year, as Figure 3-7 shows for the gage near Hyampom. The most runoff occurred in 1984, with an estimated 1,191,510 acre-feet of discharge in the S.F. Trinity River at the gage near Hyampom. The driest year was 1977, with 51,308 acre-feet. The graph also shows how severe the drought from 1987 to 1994 was, with a cumulative deficit of over two million acre-feet of water. It should be noted that all of these discharge values are estimates based on correlation analysis done by Matthews (1998).

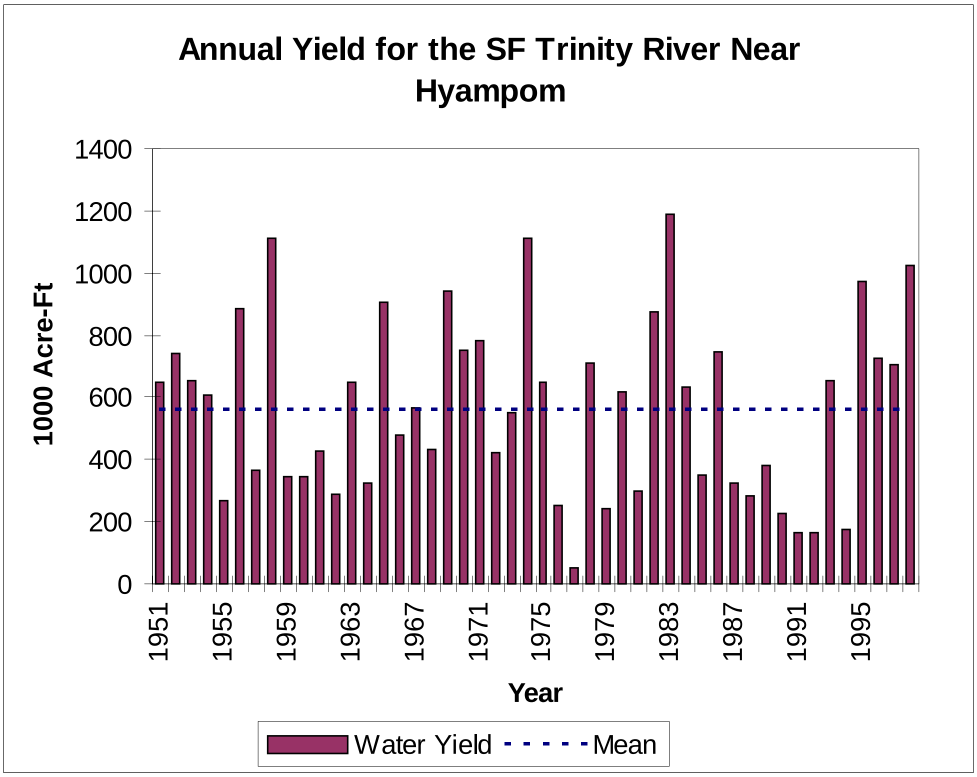


Figure 3-7. Annual Water Yield for the S.F. Trinity River at the USGS Gage near Hyampom[1].

[1]Figure is based on data from Matthews (1998) who used correlation analysis to estimate all the values except for the period of record from 1957 to 1964, which used USGS gage data.

Water Rights

Several private water rights claims exist in the WAA, around Forest Glen in particular. In addition, the Shasta-Trinity National Forest holds a few water rights in the WAA for management purposes. There are two watercourses in the WAA that are on the fully appropriated stream list; Cold Springs Creek, and the S.F. Trinity River from Highway 36 down to the confluence (SWRCB 1998).

3.2.2 Water Quality

Water quality data collected within the WAA is very limited. In general, the water quality within the basin is considered excellent, with a few exceptions, due to the limited development within the WAA. There have been a few exceedances of water quality standards for bacteria near Indian Valley Camp and Forest Glen, but more detailed water quality data were not available (J. Fitzgerald, personal communication 2001).

Section 303(d) of the Clean Water Act requires that "Each State shall identify those waters within its boundaries for which the effluent limitations….are not stringent enough to implement any water quality standard applicable to such waters" (EPA 1998). Every two years the State of California publishes a list of impaired waterbodies called the 303(d) list. The S.F. Trinity River was listed on the 1992 303(d) list for sediment, which triggered the development of a TMDL for sediment. In 1998, the S.F. Trinity River was also listed for temperature, for which a TMDL completion date has been set for 2008. Both limitations were judged to impair beneficial uses; cold water fisheries in particular. Stream temperatures are discussed in the Fisheries section.

As described in the Geomorphology section, about one-third of the sediment delivered to the S.F. Trinity River is estimated to be from management sources. The TMDL estimates that about two-thirds of the management-caused sediment loading is controllable, and sets specific indicators and targets to achieve water quality standards (EPA 1998).

Beneficial uses for the S.F. Trinity River listed in the Water Quality Control Plan for the North Coast Region (NCRWQCB 1993) include the existing beneficial uses of Municipal and Domestic Supply, Agricultural Supply, Freshwater Replenishment, Water Contact Recreation, Non-Contact Water Recreation, Commercial and Sport Fishing, Cold Freshwater Habitat, Wildlife Habitat, Migration of Aquatic Organisms, and Spawning, Reproduction, and/or Early Development of Fish. Potential beneficial uses are Industrial Service Supply and Industrial Process Supply.

3.3 Roads and Cumulative Watershed Effects

3.3.1 Roads

Road data for the WAA were compiled from GIS layers, and analyzed to give a description of where the roads are located and potential impacts to the ecosystem. The Forest Service GIS coverage does not contain all known roads, and the magnitude of the discrepancy is unknown. Map 3-3 shows the road network within the WAA by surface type.

As described above, roads contribute a significant amount to the total sediment budget for the basin, contributing about 17 percent of the total sediment for the whole 1944 to 1990 time period (Figure 3-1). Roads contributed 4 percent of the sediment yield through mass wasting, leaving 13 percent attributed to surface erosion, washouts, gullies, and slides too small to show up on the aerial photos.

One of the principle indicators of potential road issues is road density (Table 3-17). Roads impact watershed functions and characteristics in a variety of ways. As road densities increase, the potential for cumulative watershed effects, changes in hydrologic function, habitat fragmentation, and sedimentation increase. The Rattlesnake Creek watershed has the highest road density of all of the watersheds in the S.F. Trinity River basin at about 5.2 mi/ sq. mi. Hidden Valley and Plummer Creek watersheds have lower (but still relatively high) road densities at 3.8 and 2.6 mi/ sq. mi, respectively.

Different types of roads have different effects on an ecosystem. Native surfaced roads tend to have higher erosion rates than gravel or paved surfaces, and the erosion rate is a direct function of the amount of traffic on the road (Raines 1998). Roads constructed for higher speeds and levels of traffic generally have a large footprint on the landscape since they will usually be wider and have wider turns. Table 3-17 lists the length and density of each type of road for each watershed in the WAA.

Table 3-17. Length of Roads by Road Type, Private Lands Roads, and Road Density in the Watershed Analysis Area.

Road Code &Type	Hidden Valley (mi)	Plummer Creek (mi)	Rattlesnake Creek (mi)	Total (mi)
0 — Unknown	0.8	0.9		1.7
89 — 4WD Road	0.5			0.5
103 — Highway (Class 2)	6.8	0.9	8.0	15.8
105 — Light Duty, Outside FS	31.6	5.9	26.0	63.5
106 — Unimproved	5.4	12.1	25.4	43.0
107 — Trail	4.2	9.9	1.2	15.2
515 — FS Dirt (Class 3)	73.7	79.1	134.6	287.5
517 — FS Paved (3A)	28.5	0.3	4.8	33.6
518 — FS Gravel (3B)	12.1	16.8	45.9	74.9
Private Land Roads	35.2	4.1	0.5	39.9
Total Length	198.9	130.1	246.4	575.5
Road Density (mi/sq. mi)	3.8	2.6	5.2	

Riparian areas play an important role in the maintenance of healthy aquatic ecosystem. Roads in riparian areas and valley bottoms have more impacts to stream ecosystem due to their close proximity. Rattlesnake Creek watershed has double the road density in riparian areas compared to the other two watersheds in the WAA (Table 3-18). A road density above three miles per square mile for entire watersheds is considered high by some standards (e.g., greater than three miles is considered high for estimating watershed sensitivity in the Herger-Feinstein Quincy Library Group Forest Recovery Act FEIS, Appendix N, USFS 1999a).

Table 3-18. Length and Density of Roads within Riparian Areas in the Watershed Analysis Area.

Road Code &Type[1]	Hidden Valley (mi)	Plummer Creek (mi)	Rattlesnake Creek (mi)	Total (mi)
0 — Unknown		0.3		0.3
103 — Highway (Class 2)	1.1	0.2	4.1	5.4
105 — Light Duty, Outside FS	6.7	1.5	4.6	12.8
106 — Unimproved	0.7	0.7	6.6	8.1
107 — Trail	1.1	3.5		4.6
515 — FS Dirt (Class 3)	11.4	13.4	30.6	55.5
517 — FS Paved (3A)	1.7	0.3	0.6	2.6
518 — FS Gravel (3B)	1.7	5.0	11.1	17.8
Total Length	24.5	24.9	57.6	106.9
Riparian Road Density (mi/sq. mi)[2]	2.2	2.1	4.7	

[1]Does not include private land roads that were not part of the FS roads coverage.

[2]Riparian road densities calculated in miles of road per square mile of riparian area in the watershed. Riparian areas were buffered according to the management prescriptions for riparian reserves in the Shasta-Trinity National Forest LRMP (USFS 1994a).

Road-stream crossings are where roads can directly influence the aquatic ecosystem. The number and density of road-stream crossings can be used as an indicator of potential impacts to streams from roads (Table 3-19). The road-stream crossing densities shown in Table 3-19 are extremely high by most standards (greater than two is given a high rating for estimating watershed sensitivity in the Herger-Feinstein Quincy Library Group Forest Recovery Act FEIS, Appendix N, USFS 1999a).

Table 3-19. Number of Road-Stream Crossings by Stream Type and Road-Stream Crossing Density in Watershed Analysis Area[1].

Stream Type	Hidden Valley	Plummer Creek	Rattlesnake Creek	Total (#)
Ephemeral	71.0	102.0	350.0	523
Intermittent	109.0	69.0	150.0	328
Perennial	62.0	36.0	56.0	154
Total Crossings	242.0	207.0	556.0	1,005
Road-Stream Crossing Density (crossing/sq. mi)	4.6	4.1	11.8	

[1]Does not include private land roads that were not part of the FS roads coverage; and density of road-stream crossings based on sq. mile of watershed area.

Rattlesnake Creek watershed has the greatest length of roads on slopes greater than 35 percent (Table 3-20). Hidden Valley watershed, however, since it is composed almost entirely of South Fork Mountain Schist and the Galice Formation has the highest length of roads in erosive lithologies, and has a correspondingly high erosion rate (Table 3-9). It also has the most landslides of the three watersheds in the WAA (Table 3-2).

Table 3-20. Length of Roads on Slope Classes Greater than 35 Percent and/or Located in the Galice Formation or South Fork Mountain Schist within the Watershed Analysis Area[1].

Topography & Lithology	Hidden Valley (mi)	Plummer Creek (mi)	Rattlesnake Creek (mi)	Total Length (mi)
Slopes > 35%	38.8	21.8	57.1	117.7
S.F. Mtn. Schist (SC) or Galice Formation (JG)	128.7	21.5	25.5	175.8
Both Combined	30.4	10.0	11.5	51.8

[1]Does not include private land roads that were not part of the FS roads coverage.

3.3.2 Cumulative Watershed Effects

A cumulative impact, as defined in 40 CFR 1508.7 is …. *the impact on the environment which results from the incremental impact of the action when added to other past, present , and foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time* (CEQ 1971). With respect to watersheds, off-site cumulative watershed effects (CWE) is one manifestation of these impacts, and effects the beneficial uses of water away from the locations of actual land use activity, transmitted through the fluvial system. Effects can be either beneficial or adverse and result from the synergistic or additive effects of multiple management activities within a watershed (R-5 FSH2509.22, Ch.20 7/88).

Increasing the amount of disturbance within a watershed can lead to changes in sediment transport and hydrologic characteristics of watersheds, which can lead to changes in downstream resources and impact beneficial uses (see Hydrology section). Cumulative effects are a function of: the amount of sensitive ground and its hazard level within a watershed; the level and type of management activities; and the location of management activities relative to sensitive ground (Haskins 1983).

On the Shasta-Trinity National Forest, a watershed sensitivity and CWE analysis was conducted for the Shasta-Trinity National Forest LRMP FEIS (USFS 1994b). The sensitivity of Shasta-Trinity National Forest's fourth- and fifth-field watersheds was assessed by using the following factors: slope gradient, soil erodibility, mass wasting potential, and peak streamflow characteristics of each watershed (USFS 1994b). Based on the sensitivity index, watersheds were grouped into low, moderate, high, and extreme sensitivity classes.

Watersheds with a high natural sensitivity can tolerate less land disturbance and require greater care in planning land use activities than watersheds with a low sensitivity. As the amount of land use increases within a watershed, the susceptibility of that watershed to CWE increases. There is a point where additive or synergistic effects of the land use activities will cause the watershed to become highly susceptible to CWE. This estimated upper limit of the effects of land use activities is called the threshold of concern (TOC). The TOC does not represent the exact point at which cumulative effects will occur. Rather, it serves as a measure of probability that there is increasing susceptibility for significant adverse cumulative effects occurring within a watershed. TOC values were assigned to watersheds based on their sensitivity. The extremely sensitive Hidden Valley watershed was given a TOC rating of 12 percent, and Plummer Creek and Rattlesnake Creek watersheds, with a moderate sensitivity rating, were given a TOC rating of 16 percent.

The extent and impact of land use activities in watersheds is determined by using the equivalent roaded acres (ERA) method that normalizes disturbance from management activities. That is, all management activities are converted to equivalent roaded acres using disturbance coefficients. The coefficients are estimates of land disturbance as they relate to probable mechanisms for initiating CWE and resulting impacts to downstream beneficial uses. The development of the coefficients is left up to the individual practitioner to formulate, but there is general consistency across the region, and they are based on visual observations, field surveys, published studies, transects and aerial photo interpretation to estimate land disturbance coefficients (R-5 FSH 2509.22). In addition, it is assumed that disturbances other than roads such as harvested areas recover linearly over a 30-year period as the forest regrows.

Watershed condition can than be classified by comparing the percent ERA level to the TOC. Class 1 watersheds have an ERA less than 40 percent of the TOC and are generally in excellent condition. Class 2 watersheds have an ERA that is between 40 and 80 percent of the TOC and are generally in fair to good condition. Class 3 watersheds have ERA levels greater than 80 percent of the TOC and have the greatest risk of cumulative effects, but can vary in actual condition from poor to good (USFS 1994b). See the Shasta-Trinity National Forest LRMP FEIS (USFS 1994b), Appendix H for more details on watershed cumulative effects, and watershed condition classes.

The timber harvest history GIS coverage is currently under revision, and was not sufficient to calculate accurate ERA values for this watershed condition evaluation. A matrix showing the incomplete calculations and the analysis procedure used are in Appendix C. Map 3-4 summarizes the cumulative watershed effects assessment by illustrating subwatersheds and associated percent ERA and condition class in the WAA.

3.4 Fish Habitats and Species, and Riparian Habitat

3.4.1 Physiographic Setting

The Hidden Valley watershed drains a 33,580-acre area located from the mouth of Hayfork Creek to Rattlesnake Creek. Plummer Creek drains a 32,650-acre watershed area from the headwaters of Jim's and Naufus Creeks to the South Fork Trinity River. Rattlesnake Creek drains a 30,100-acre watershed from its headwaters on Post and South Dubakella Mountains to the South Fork Trinity River.

Dendritic channel networks drain the Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds. Major tributaries in the Hidden Valley watershed (not including Plummer and Rattlesnake Creeks) are Sulphur Glade Creek, Butter Creek, and Little Bear Wallow, along with numerous smaller watercourses. Tributaries to Plummer Creek include Jim's Creek, Bear Wallow Creek, and Naufus Creek. Tributaries to Rattlesnake Creek include North Rattlesnake Creek, Post Creek, and Little Rattlesnake Creek.

The watershed analysis area contains approximately 606 miles of streams. Table 3-21 displays stream miles and densities for the Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds. Map 3-2 illustrates stream types within the WAA.

Table 3-21. Stream Length by Steam Types, and Stream Densities in Watershed Analysis Area.

Watershed	Perennial Streams (mi)	Intermittent Streams (mi)	Ephemeral Streams (mi)	Stream Density (mi/mi^2)
Hidden Valley	76.5	64.0	47.4	3.6
Plummer Creek	50.9	53.3	84.0	3.7
Rattlesnake Creek	46.4	64.4	119.6	4.9

The WAA contains at least 40 miles of anadromous and resident trout streams. Table 3-22 displays stream miles utilized by anadromous and resident salmonids for the Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds. Map 3-5 illustrates fish bearing streams within the WAA.

Table 3-22. Length of Streams Utilized by Anadromous and Resident Salmonids in Watershed Analysis Area.

Watershed	Anadromous Streams (mi)[1]	Resident Trout Streams (mi)
Hidden Valley	27.0	50.4
Plummer Creek	5.8	47.5
Rattlesnake Creek	8.0	48.8

[1]Approximate number of miles based upon USFS stream survey information.

Water uses within the analysis area include withdrawals for mostly domestic, agricultural, and livestock purposes.

3.4.2 Riparian Conditions

The riparian zone provides the interface between terrestrial and aquatic habitats. Two direct functions of riparian vegetation are to provide shade for water temperature control and long-term input of large woody debris (LWD) to streams. Other benefits include screening input of fine sediments, maintenance of microclimates for temperature and humidity, and the input of energy in the form of organic debris that supports other biota, including invertebrates and non-salmonid vertebrates (Ligon et al. 1999). In many areas riparian zones are used as migration corridors for a variety of avian and terrestrial wildlife.

Forest vegetation and stream classification GIS coverages were used to assess current riparian conditions within the National Forest System lands in the analysis area. Riparian areas encompass approximately 17,559 acres of the 88,818 acres of vegetation classified for the WAA. The riparian areas are composed of a variety of vegetation types and size classes. Over 65 percent of the riparian areas are composed of conifer tree size class 3 or larger, with approximately 61 percent of those stands with moderate-dense (>40 percent) crown closure and 39 percent with sparse-open (0 to 39 percent) crown closure (Tables 3-23 and 3-24).

Table 3-23. Riparian Acreages by Strata (forest type/species, tree size and density classes) for Late-Successional Reserves (LSR) and Matrix Lands[1].

Stratum[2]	Hidden Valley LSR	Hidden Valley Matrix	Plummer Creek LSR	Plummer Creek Matrix	Rattlesnake Creek LSR	Rattlesnake Creek Matrix	Total Acreage
M2P	1	2	8	41	3	701	756
M2G	23	0	44	79	79	631	856
M3P	300	160	567	1183	100	2,045	4,355
M3G	474	108	356	902	69	2,129	4,038
M4G	1,487	78	505	218	205	492	2,985
M6G	11	0	0	41	0	0	52
XX1	10	20	29	191	38	281	569
XX2	121	12	5	57	50	199	444
XX3	78	4	5	23	3	22	135
HCO	4	1	0	0	0	0	5
HNC	60	16	153	124	0	17	370
NC	0	0	0	0	0	17	17
SX	261	4	72	149	3	5	494
GR	7	1	8	0	0	0	16
NF	96	3	58	0	0	0	157
Total USFS	2,933	410	1,812	3,008	552	6,540	15,255
Unclassified	279	15	276	231	3	956	1,760

[1]Acreages calculated by summing strata within 300-foot, 150- foot, and 100-foot riparian reserves around perennial, intermittent, and ephemeral streams, respectively. Acreages of intermittent and ephemeral watercourse riparian areas have been increased by 15 percent to account for unmapped watercourses.
[2]M stratum includes mixed conifer, red fir, and Douglas-fir.

Table 3-24. Riparian Acreages by Strata (forest type/species, tree size and density classes) for Administratively Withdrawn Area (AWA)[1].

Stratum[2]	Hidden Valley AWA	Plummer Creek AWA	Rattlesnake Creek AWA	Total Acreage
M2P	0	0	0	0
M2G	0	35	0	35
M3P	126	662	0	788
M3G	107	379	0	486
M4G	178	19	0	197
M6G	0	0	0	0
XX1	7	1	0	8
XX2	0	0	0	0
XX3	0	0	0	0
HCO	17	22	0	39
HNC	67	418	0	485
NC	0	0	0	0
SX	73	50	0	123
GR	2	10	0	17
NF	101	32	0	133
Total USFS	677	1,627	0	2,304
Unclassified	191	125	0	316

[1]Acreages were calculated by summing strata within 300-foot, 150- foot, and 100-foot riparian reserves around perennial, intermittent, and ephemeral streams, respectively. Acreages of intermittent and ephemeral watercourse riparian areas have been increased by 15 percent to account for unmapped watercourses.

[2]M stratum includes mixed conifer, red fir, and Douglas-fir.

3.4.3 Stream Channel and Fish Habitat

Stream channels in the headwaters of the watersheds are characterized as high energy, low order streams with stream gradients greater than 10 percent and sideslopes that can exceed 70 percent. These channels function largely as transport channels, delivering large woody debris (LWD), fine sediment, and organic material to downstream channels. This type of stream is considered an A type channel (Rosgen 1985). Anadromous fish habitat is limited in these channels due to the lack of fish access, intermittent flows, high gradients, absence of spawning gravels, and poor rearing habitat. Inner gorge slides can occur in these channels and are the primary disturbances associated with LWD and sediment delivery.

As streams progress downstream into higher order channels, channels are high to moderately entrenched, with low to moderate sinuosity, and have channel gradients between 0.5 and 10 percent. This type of stream is classified as a B or C type channel. Tables 3-25 and 3-26 describe channel characteristics of the Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds.

Current channel conditions within the watershed analysis area have been affected in the past century primarily by the 1964 flood, recent flood events, wildfires, grazing, road construction, and the extent and intensity of timber management activities in the past 30 years. Although some mining occurred, it was not nearly as extensive as that along the mainstem Trinity River. The river continues to erode alluvium deposited during the 1964 flood event.

Table 3-25. Channel Morphology Characteristics for Hidden Valley, Plummer Creek, and Rattlesnake Creek Watersheds.

Parameters	Watershed		
	Hidden Valley[1]	Plummer[2]	Rattlesnake[3]
Pools (% area)	15.6	21.4	26
Step Runs (% area)	13.9	43.9	37
Glides (% area)	34.4	10.2	24.7
Low Gradient Riffles (% area)	18.5	8	4.2
Average Max. Depth (feet)	3.4	1.0	1.3
Average Pool Max. Depth (feet)	4.1	1.3	2.1
Gradient (% slope)	1.3	1.8 - 14.5	3.5
Pool-Riffle-Run Ratio by Area	1:1.6:3.8	1:1.1:3.7	2.2:1:5.7

[1]USFS (1989a)
[2]USFS (1993)
[3]USFS (1989b)

Table 3-26. Channel Substrate Characteristics for Hidden Valley, Plummer Creek, and Rattlesnake Creek Watersheds

Substrate Composition & Embeddedness[1]	Watershed					
	Hidden Valley[2]		Plummer[3]		Rattlesnake[4]	
	Pools	Riffles	Pools	Riffles	Pools	Riffles
% Bedrock	9	2	9	6	9	9
% Boulder	14	25	32	39	23	39
% Cobble	13	35	19	31	23	27
% Gravel	25	28	28	18	27	20
% Sand	33	9	9	4.5	16	5
% Fines	6	1	3	1.5	2	-
% Embeddedness	42	23	38	38	27	5

[1]Measurements of substrate composition and embeddedness percentages are ocular qualitative estimates.
[2]USFS (1989a)
[3]USFS (1993)
[4]USFS (1989b)

Hidden Valley

A reach of South Fork from Eltapom Creek (5 miles downstream from Hayfork Creek) upstream to the East Fork Trinity River was habitat typed in 1989 (USFS 1989a). This reach encompasses the Hidden Valley portion of the South Fork. Flatwater habitat types (runs, glides, step runs, pocket waters, and edgewater) were the dominant habitat types, with 58 percent of the survey length. Riffles (low gradient riffles, high gradient riffles, and cascades) were the second most common, with 25 percent of survey length. Pools (backwater, scour, corner, and mid-channel pools) were the least common types, with 16.5 percent of the survey length. Log and rootwad scour pools accounted for only 8 of the 1,142 habitat units surveyed. Riffle embeddedness averaged 32 percent and pooltail embeddedness averaged 42 percent. Gravel comprised 28 percent of the substrate in all habitat types, with cobble (27 percent) and sand/fines (24 percent) in decreasing order. The Rosgen (1985) channel types varied between B2, C2, and C3. Instream cover was rated as moderate to good and it improved in an upstream direction. The dominant cover types were white water and vegetation.

The relative lack of LWD in the South Fork Trinity River may be due in large part to the size of the channel. Transport of wood by streamflow depends on piece length, and in general, highly mobile pieces are shorter than the width of the channel at bankfull (Benda and Sias 1998). As channel width increases downstream, an increasing proportion of all wood becomes mobile (Bilby and Ward 1989). Eventually only the largest pieces of wood entering the stream would be capable of remaining stable and those would need to be anchored to the bed or bank in some fashion.

Sulphur Glade Creek, a sub-watershed within Hidden Valley, was surveyed by the USFS (1979) to assess fisheries resources. The surveyors found it to be a small perennial stream with sideslopes in excess of 100 percent. Stream gradients ranged from 15 to 25 percent, with a short reach of three percent near its mouth. Fish habitat was described as poor. Rainbow trout were observed only in the lower 150 feet of the stream. The surveyors recommended the watershed be managed for water quality protection.

Glen Creek, a sub-watershed within Hidden Valley, was surveyed by the USFS (1973) to assess fisheries resources. The surveyors found salmon and steelhead spawning to be limited to the lower 150 yards. Above that a series of rock falls and logjams limited upstream movement. Few spawning areas were seen, and those present were in poor to fair condition. Channel stability was rated as poor, with exposed cutbanks and large slides common.

Plummer Creek

Approximately 2.75 miles of Plummer Creek was habitat typed by the USFS in 1990 (USFS 1993). The survey covered the entire anadromous fishery reach and stopped at a boulder slide that prevented upstream fish migration. Flatwaters (runs, glides, step runs, pocket waters, and edgewater) and riffles (low gradient riffles, high gradient riffles, and cascades) made up 71.8 percent of the survey area. Pools (backwater, scour, corner, and mid-channel pools) were the least common types, with 21.4 percent of the survey area. Log and rootwad scour pools accounted for six of the 167 habitat units surveyed. Riffle and pooltail embeddedness averaged 38 percent. Boulders were the dominant substrate (33 percent) in all habitat types, with gravel (26.4 percent) and cobble (22 percent) in decreasing order. The Rosgen (1985) channel types were A3, A2, B1, and A2A from the mouth to end of survey reach. Instream cover complexity was rated as low to medium. The dominant cover types were boulders and white water. A total of 1,428 square meters of spawning habitat was inventoried of which 40 percent was suitable for steelhead, 22 percent for salmon, and 38 percent for trout. Plummer Creek is considered as an important spring chinook spawning and rearing stream. The surveyors recommended future instream enhancement work should focus on creating pool and cover habitat, and controlling sediment input into the creek. Plummer Creek becomes intermittent above the confluence with Jim's Creek (USFS 1982b).

Bear Wallow Creek enters Plummer Creek approximately 1.5 miles upstream of the confluence with South Fork Trinity River. The USFS (1992) describes Bear Wallow as a small perennial Class II stream. Fish habitat is rated as fair, with steelhead/rainbow trout being observed in the lower one to two miles. Mass wasting and slides are common throughout the drainage. Jim's Creek enters Plummer Creek approximately two miles upstream of the confluence with South Fork Trinity River. The USFS (1980) describe Jim's Creek as a small perennial Class II stream that provides limited habitat for steelhead/rainbow trout. The stream gradient is seven percent at the mouth, 22 percent in the middle, and seven percent in the upper reach. Channel width ranges from 20 to 35 feet. The pool-riffle-run ratio is 2:3:0, with pools formed primarily by rocks and boulders. Fair spawning habitat for steelhead is located in the lower 0.8 miles. Anadromous migration is restricted by the high stream gradient approximately one mile upstream of the mouth.

Naufus Creek enters Plummer Creek approximately three miles upstream of the confluence with the South Fork Trinity River. An anadromous migration barrier exists approximately ¼ mile downstream of the mouth of Naufus Creek. This creek supports a resident population of rainbow trout. The USFS (1992) reported a barrier to resident trout approximately one and ¼ miles upstream of its confluence with Plummer Creek.

Rattlesnake Creek

Approximately 6.2 miles of Rattlesnake Creek was habitat typed by the USFS in 1989 (USFS 1989b), from the mouth upstream to the Road 30N30 crossing. Flatwater habitat types (runs, glides, step runs, pocket waters, and edgewater) were the dominant habitat types, with 68 percent of the survey area. Pools (backwater, scour, corner, and mid-channel pools) were the second most common types, with 26 percent of the area. Riffles (low gradient riffles, high gradient riffles, and cascades) were the least common, with 5.8 percent of survey area. Riffle and pooltail embeddedness averaged 5 percent and 27 percent, respectively. Log and rootwad scour pools accounted for only two of the 343 habitat units surveyed. Boulders were the dominant substrate (32 percent) in all habitat types, with cobble (26 percent) and gravel (23 percent) in decreasing order. The channel gradient averaged 3.5 percent. The channel was typed as a B2 (Rosgen 1985). This indicates that the channel is moderately entrenched and moderately confined with coarse substrates and stable terraces. Instream cover complexity was rated as moderate to good, with more cover in the lower reach. The dominant cover types were boulders, white waters, and aquatic vegetation. Spawning gravel for steelhead was common and relatively "clean." Salmon spawning gravel was considered very limited and of poor quality. In 1985, the USFS installed 12 cover structures in the creek to improve salmonid rearing habitat. A subsequent evaluation survey in 1986 revealed that 44 percent of them failed, although the causes were not reported.

The relatively high gradient combined with the confined channel and large substrates indicate high flushing flows are common in Rattlesnake Creek. These high velocity flows along with wildfire events may partially explain the relative scarcity of LWD in the channel.

Little Rattlesnake Creek enters Rattlesnake Creek approximately 0.75 miles upstream of the confluence with the South Fork Trinity River. NSR (1996) reported Little Rattlesnake Creek as being contained within a 4.7 square mile watershed area. It is a relatively short, steep gradient (average 6.6 percent) stream with many steep cascades and falls. Substrates were composed of large amounts of bedrock, boulders, and cobbles, which may have limited suitable spawning locations. The pool-riffle-run ratio was 1.5:1.0:1.6. Pooltail embeddedness averaged 54 percent. Only three out of 148 habitat units typed were either log or rootwad scour pools. However, the surveyors reported frequent observations of LWD and small woody debris.

Post Creek enters Rattlesnake Creek approximately 3.5 miles upstream of its confluence with the South Fork Trinity River. The creek was surveyed by the USFS in 1980 who characterized it as a small perennial stream containing rainbow trout and steelhead (USFS 1980). The stream gradient was three to five percent, with a pool-riffle-run ratio of 2:3:0. The stream reportedly becomes intermittent during the summer with water only in isolated pools.

3.4.4 Stream Temperature

Water temperatures vary depending on location. In general, the lower reaches tend to have higher water temperatures than the more confined upstream reaches. This may be due to the lower reaches generally having less riparian vegetation and shade canopy, higher air temperatures, wider stream channels being exposed to solar radiation, and less topographic shading.

The USFS collected water temperature data in the mainstem South Fork Trinity River below Butter Creek and Cave Creek in 1992. During the months of July and August 1992 the maximum water temperatures ranged from 65 to 78°F (18 to 26°C), with minimums of 57 to 70°F (14 to 21°C). These mainstem temperatures show stressful conditions exist for salmonids during the summer months. Rattlesnake Creek water temperatures, upstream of Flume Creek, were recorded in 1990 (USFS 1991). During the months of July and August 1990 the maximum water temperatures in Rattlesnake Creek ranged from 60 to 71°F (16 to 22°C), with minimums of 57 to 65°F (14 to 18°C). The mixing of tributary water into larger streams can affect water temperatures in the receiving water. Farber et al. (1998) determined that Rattlesnake Creek was able to cool the South Fork Trinity water temperature by 0.4°C and Cave Creek by 0.1°C, but these small temperature influences quickly diminish downstream. However, the mouths of these cooler tributaries provide very important cool water refugia for salmonids during periods of high water temperatures.

3.4.5 Fish Species

The watershed analysis area supports anadromous runs of summer and winter steelhead trout and spring chinook salmon. A few fall chinook and coho salmon may be able to enter the analysis area during years when fall streamflow are high enough to permit entry. Steelhead is present throughout the analysis area up to the limits of anadromy. Spring chinook spawn and rear primarily in the mainstem South Fork, but are also found in lower Plummer Creek. Other fish known to inhabit the analysis area include speckled dace (Rhinichthys osculus), Klamath small-scale sucker (Catostomus rimiculus), and Pacific lamprey (Lampetra tridentata). Green sturgeon (Acipenser medirostris) were once very numerous in the South Fork Trinity River up until the 1964 flood, which widened the channel and filled in the deep pools that this species requires (Moyle et al. 1995).

Steelhead Trout – Life History

Winter run steelhead enter the analysis area in the early fall through spring and begin spawning in December. Preferred water temperatures for spawning migration are 3.9 to 9.4°C (39 to 49ºF). Steelhead is capable of repeat spawning. Up to 30 percent can survive to spawn a second or third time, but in large drainages where fish migrate long distances, the proportion is much lower (Meehan and Bjorn 1991). Steelhead tend to construct redds (spawning nests) for egg deposition in gravels ranging in size from 0.6 to 10.2 cm (Bjornn and Reiser 1991). Egg development is temperature dependent and usually takes 31 days at 10°C (50ºF) (Flosi et al. 1998). Intergravel mortality of steelhead can occur when fine sediment (<0.85 mm) exceeds 13 percent of the substrate composition (Spence et al. 1996). Upon emerging from gravel, the fry rear in edgewater habitats and move gradually into pools and riffles, as they grow larger. Juvenile steelhead will spend one to three years in freshwater before migrating to the ocean (Busby et al. 1996). Preferred water temperatures for rearing are reported to be 10 to13°C (50 to 56ºF), with an upper lethal limit of 23.9°C (74ºF) (Bjornn and Reiser 1991). However, juvenile steelheads are known to utilize the lower Mad, Eel, and Van Duzen Rivers in Humboldt County (California), where maximum daily water temperatures frequently exceed 24°C (75ºF) for several weeks at a time (Halligan 1998, 1999). Most downstream smolting migration takes place in spring and early summer. Most steelhead will spend one to two years in the ocean before returning to spawn. For more information refer to Busby et al. (1996).

Status of Steelhead Trout in Analysis Area

The National Marine Fisheries Service (NMFS) stated, "While absolute abundance of steelhead within the ESU remains fairly high, since about 1970 trends in abundance have been downward in most steelhead populations for which we have data, and a number of populations are considered by various agencies and groups to be at some risk of extinction" (Busby et al. 1996). However, NMFS determined that listing steelhead under the ESA in the Klamath Mountain Province Evolutionarily Significant Unit (ESU) was not warranted.

The following information is taken in its entirety from the report by Pacific Watershed Associates (PWA 1994). Local anglers report that the abundance of winter steelhead has declined substantially since the 1964 flood. This observation is consistent with the findings of Rogers (1972, 1973) who compared redd counts from 1964 and 1972 for upper Trinity River tributaries and Hayfork Creek and its tributaries. In 1964, there were over 5,000 redds (spawning nests) counted in contrast to 352 in 1972. Anglers interviewed recalled resurgence in abundance of steelhead in the late 1970s, but a subsequent drop in the 1980s. Winter steelhead run sizes for the 1990 to 1991 and 1991 to 1992 South Fork Trinity's weir trapping seasons indicate populations of 2,356 and 3,500 fish, respectively (PWA 1994). KRIS (1997) reported a range of 0 to 7.94 steelhead redds per kilometer in Plummer Creek and 0.09 to 2.61 redds per kilometer in Rattlesnake Creek for the years 1990 through 1995.

Juvenile steelhead surveys have been conducted in Plummer and Rattlesnake Creeks. PWA (1994) reported age 0+, 1+, and 2+ steelhead densities of 0.136, 0.01, and 0.015 fish per square meter, respectively, in Plummer Creek. PWA (1994) also reported 0.20, 0.034, and 0.013 fish per square meter for the respective age groups in Rattlesnake Creek. No dates were associated with these fish densities. Jong and Mills (1992) reported a range of three to 91 summer steelhead adults have been observed during 10 surveys between the years of 1979 and 1991. In 1995, 24 and 30 summer steelhead were counted during two separate survey periods in the South Fork Trinity (Dean 1995). In 1999, 14 of the 20 summer steelhead observed during a South Fork Trinity River survey were located in the analysis area between Forest Glen and Hitchcock Creek (Moore 1999). However, turbid water from Hitchcock Creek precluded observations from being made downstream where historically 44 percent of the summer steelhead have been observed.

It is especially difficult to accurately estimate adult winter steelhead populations since peak runs occur during periods of highly turbid runoff, flooding, and snowmelt. Traditional counting techniques such as redd counts and weirs are fairly ineffective during these periods.

Chinook Salmon – Life History

Fall-run chinook salmon generally leave ocean waters and enter rivers in late August through late fall as long as sandbars do not block the stream mouths. Spring-run chinook migrates into the analysis area around May through July, where they hold in pools during the summer prior to spawning in the fall. Dean (1995) reported spring-run chinook spawning occurs between mid-September and mid-November. Fall chinook spawning usually occurs from October through January (Flosi et al. 1998), when water temperatures are between 5.6 to 13.9°C (41 to 57°F) (Bjornn and Reiser 1991). Chinooks are riffle spawners and tend to utilize gravel substrate at the head of riffles or pool tails ranging in size from 1.3 to 15 cm. Chinook die after spawning. The eggs develop in the gravel for 50 to 60 days before hatching, depending on water temperatures. Embryo survival rates begin to decrease when the amount of substrate smaller than 6.35 mm exceeds 20 percent (Bjornn and Reiser 1991). Young salmon emerge from gravel after the yolk sac is absorbed two to four weeks later. Juvenile chinook generally begins their downstream migration soon thereafter. Downstream migration is usually complete by late June, but some fish may remain in estuaries until fall and enter the ocean as yearlings. Chinook will remain in the ocean for three to five years before returning to freshwater to spawn.

Status of Chinook Salmon in Analysis Area

NMFS determined that ESA listing of chinook salmon in the Upper Klamath and Trinity Rivers ESU was not warranted (Myers et al. 1998). NMFS (in Myers et al. 1998) found that the fall-run populations are at relatively high abundance, near historical levels, and trends are generally stable. However, NMFS has substantial concern about the spring-run populations, which are at approximately 10 percent of their historical abundance due to dams blocking access to historical spawning and rearing habitat. Snyder (1931) reported the spring chinook run was once very pronounced and supported a commercial fishery, but by 1931 it was limited to individual fish and of little economic importance. Jong and Mills (1992) reported spring runs in the South Fork Trinity River exceeding 11,000 fish in 1964. Jong and Mills (1992) reported a range of seven to 342 spring chinook were observed in the South Fork Trinity during 10 surveys between the years of 1970 and 1992. Dean (1995) reported that current South Fork Trinity River spring runs appear stable at 400 to 1,000 fish. Dean (1995) counted 292 and 579 adult spring chinook during the early and late 1995 snorkel surveys, respectively. Dean (1995) also reported 21 holding pools in the mainstem South Fork and suggested that holding pools do not appear to be a limiting factor for spring chinook. Spring-run chinook redds were distributed upstream and downstream of Forest Glen with few below Hyampom. Dean (1995) believes that the reach between Forest Glen and Hitchcock Creek (in the Hidden Valley watershed analysis area) is critical to spring chinook for over-summering and spawning, especially in dry years. In normal to wet years the reach between Forest Glen and the East Fork is also important for spawning spring chinook. The Hyampom Gorge forms a barrier to fall chinook migration due to low flows coinciding with the fall migration run timing (M. Dean, personal communication 2001). However, it is possible that a few individual fall chinook could enter the analysis area during years when fall streamflows are high enough to permit passage.

Coho Salmon – Life History

Upstream adult spawning migration generally occurs from late October to mid-February (Weitkamp et al. 1995), when water temperatures are 4 to 14°C (40 to 58ºF). Coho migrate up and spawn in streams that flow directly into the ocean or tributaries of larger rivers (Moyle et al. 1995). Generally, coho spawn in smaller streams than those used by chinook. Preferred gravel sizes range from 1.3 to 10.2 cm. Adults die within 10 to 14 days following spawning. Studies summarized by Spence et al. (1996) stated that intergravel mortality of coho and steelhead occurs when fine sediment (<0.85 mm) exceed 13 percent of the substrate composition. Embryos hatch after eight to 12 weeks of incubation and emerge from the gravel several weeks later. Bjornn and Reiser (1991) reported that emergence rate for swim-up fry declined when the percentage of fines (2-6.4 mm) exceeded 20 percent. Young fry rear in edgewater habitats and move gradually to deep, well-shaded pools by summer. Highest densities are usually associated with pools greater than 3 feet in depth, with plenty of overhead cover, undercut banks, logs, and other woody debris and water temperatures not exceeding 22 to 25°C (72 to 77ºF) for extended periods of time (Moyle et al. 1995). Preferred water temperatures are in the 7.2 to 16.7°C (45 to 62ºF) range (Hassler 1987). Juveniles will spend the next year in these habitats. Downstream migration to the ocean starts around March when the coho are about one year old. The migration peaks around mid-May and continues until mid-June. Coho will spend two to three years at sea before migrating back to their natal streams to spawn. For more information refer to Weitkamp et al. (1995).

Status of Coho Salmon in Analysis Area

Coho salmon have been listed as "threatened" under the ESA in the Southern Oregon-Northern California Coast ESU. Coho have been reported to inhabit the South Fork Trinity River up to the Hyampom Gorge, downstream of the analysis area. The Hyampom Gorge forms a barrier to coho migration due to low flows inhibiting passage in the fall (M. Dean, personal communication 2001). However, it is possible that a few individuals could enter the analysis area during years when fall streamflows are high enough to permit passage. No information regarding coho presence in the analysis area was found during a search of CDFG and USFS records.

3.5 Vegetation and Fire/Fuels

3.5.1 Forest Vegetation and Timber

The current vegetative conditions are the result of past forest disturbances, both natural and human caused. Other than wildfire, the primary influence of change has been timber harvesting. The first major commercial timber harvests took place after World War II. Typical harvest entries consisted of selection cuts where some trees were cut and some retained. Replanting following these cuts was restricted to ponderosa pine. A shift to clearcutting was seen in the 1960s through the 1980s. Following these harvests, restocking was established by planting mixed species. Harvesting in the past decade has been limited to utilizing sanitation-salvage cuts. These harvests occurred in areas that appeared to have a higher than normal incidence of dwarf mistletoe infestation, which in turn exposed the weakened trees to attack by insects and other pathogens. Cytospora canker has been an endemic problem for at least 60 years in the red fir stands in the higher elevations of Hidden Valley watershed, and has recently been exacerbated by the last two drought cycles. These factors, along with the effects of a long drought period, which ended in the early 1990s, have driven the tree mortality rate in this area to higher than normal. Since the end of the 1986 to 1993 drought, the tree mortality rate appears to be falling, but is still higher than normal.

The Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds are dominated by forest cover type. Hidden Valley and Plummer Creek analysis area have less than 4 percent in National Forest System lands classified as non-forested, and Rattlesnake Creek analysis area has less than 1 percent in non-forested. There are 11,083 acres (or over 13 percent) of National Forest System lands in the three watersheds classified as plantations (Table 3-27). Plantations were grouped into three categories: 1 to 10 years old; 11 to 20 years old; and 21+ years old. These categories were assigned when the vegetative strata were typed in 1995, and each age class range is now six years older; thus, the existing age classes are 7 to 16 years, 17 to 26 years, and 27+ years old. The Hidden Valley watershed has 4,043 acres of plantations, with 20 percent being 7 to 16 years, 42 percent being 17 to 26 years, and 38 percent being 27+ years. The Rattlesnake Creek watershed has 3,927 acres of plantations, with 52 percent in 7 to 16 years old, 41 percent in 17 to 26 years old, and 7 percent in 27+ years old. The Plummer Creek watershed has 3,113 acres of plantations, with 75 percent being 7 to 16 years, 16 percent being 17 to 26 years, and 9 percent being 27+ years. There has been no significant change with new plantations being added in the last six years. There has been recent tree planting activity in these watersheds; however, these plantings were partial plantings and did not establish a new even-aged stand.

Current conditions were analyzed with the use of the forest inventory data collected for the Shasta-Trinity National Forest LRMP. Delineated stands were classified according to the LRMP vegetation stratification (forest type/species, tree size and density classes) (Table 3-27 and Map 3-6).

Table 3-27. Strata (forest type/species, tree size and density classes) Acreages on National Forest System (NFS) lands in the Watershed Analysis Area.

Strata	Hidden Valley (acres)	Rattlesnake Creek (acres)	Plummer Creek (acres)	Total Acreage
M2P	157	2,900	358	3,415
M2G	232	3,003	1,054	4,289
M3P	3,260	8,707	10,821	22,788
M3G	3,924	6,314	6,720	16,958
M4G	11,081	1,855	3,551	16,487
M6G	96		215	311
XX1[1]	799	2,028	2,330	5,157
XX2[1]	1,693	1,614	501	3,808
XX3[1]	1,551	285	282	2,118
HCO	84		56	140
HNC	511	19	3,209	3,739
NC		81		81
SX	546	97	872	1,515
GR	87		26	113
NF	237	2	108	347
Total NFS lands	24,258	26,905	30,103	81,266
Unclassified	1,981	3,187	2,384	7,552

[1]Plantation ages are as of 1995.

Due to exclusion of Late-Successional Reserves and Riparian Reserves, not all of the forested lands in the watershed analysis area are available as commercial timber base. Table 3-28 shows the available timber production acreages by strata for the watershed analysis area.

Table 3-28. Available Timber Production Acreages on National Forest System (NFS) lands in the Watershed Analysis Area[1].

Strata	Hidden Valley (acres)	Rattlesnake Creek (acres)	Plummer Creek (acres)	Total Acreage
M2P	51	2,141	270	2,462
M2G		1,902	473	2,375
M3P	1,106	6,346	3,542	10,994
M3G	709	3,892	2,150	6,751
M4G	491	818	462	1,771
M6G			174	174
XX1[2]	280	1,556	1,686	3,522
XX2[2]	174	1,129	304	1,607
XX3[2]	111	71	165	347
Total NFS lands	2,922	17,855	9,226	30,003

[1]Includes commercial forest-types within Matrix lands. Excludes grasslands, non-commercial forest-types, late-successional reserves, and riparian reserves. Acreages of intermittent and ephemeral watercourse riparian reserves have been increased by 15 percent to account for unmapped watercourses.

[2]Plantation ages are as of 1995.

Moderate to steep terrain that is dominated by mixed conifer communities characterizes the watershed analysis area. The conifer stands have moderate to dense canopy cover, with few openings. The predominant species are Douglas-fir and ponderosa pine. In the higher elevations there are almost pure stands of white and red firs. Sugar pine, incense-cedar, and Jeffrey pine are also found in lesser amounts.

3.5.2 Fire and Fuels

Within the watershed analysis area, fire has and will continue to play a major role in the forest ecosystem. Fire has been a significant disturbance factor within the analysis area. The recurrence of fire and the recovery from fire is an important mechanism for the health of the ecosystem, and has historically maintained a diverse landscape in the analysis area.

Fire intervals have varied greatly with the longest return interval of 24.5 years found during the suppression period of 1900 to 1992, and the shortest fire return interval occurring during the 1850 to 1900 settlement period (Skinner and Taylor 1998) (Table 3-29). This is an indicator that European settlement had impacted the fire return interval, both by increasing the return interval through suppression and decreasing the return interval because of settlement activities. It includes suppression in the form of animal grazing as well as active fire suppression.

The Skinner and Taylor (1998) study indicates that fire regimes were more frequent, generally less severe, and had short fire rotations during pre-settlement times. More frequent fires of low and moderate intensity killed some overstory trees and thinned or killed understory stems. The mixed severity fires created multi-aged stands. This frequency and high variability of the fires may be an important factor contributing to the overall diversity of the forest stands in the analysis area (Skinner and Taylor 1998).

Table 3-29. Fire Return Intervals in the Watershed Analysis Area.

Time Period	Fire Return Interval (years)
1626-1699	19.2
1700-1799	19.1
1800-1850	15.1
1850-1900	12.3
1900-1992	24.5

Vegetation types in this fire regime were dominated by fire adapted and fire resistant species. The exclusion of forest fires, along with other human caused disturbances, has initiated a transition to a fire regime characterized by less frequent, high intensity fire events that modify existing vegetation types by creating greater abundance of white fir.

Historically, the Hidden Valley, Rattlesnake Creek and Plummer Creek watersheds developed under a low severity fire regime. Through 90 years of fire suppression, the historic fire regime has been altered to one of infrequent, high intensity, stand replacing fires. Currently stand density, species composition, fire return intervals, fuel levels as well as tree mortality have contributed to the increase in fire size and intensity. The cumulative effects of altering the historic fire regime in the watershed will result in the occurrence of large, high intensity, stand replacement fires, that fall outside the natural range of variability (W. Clark, personal communication 1995).

Suppression Era 1911 to 1998

From 1911 to 1998 there have been 437 small fires (less than 100 acres) reported in the Hidden Valley, Plummer Creek and Rattlesnake Creek watersheds on the Hayfork Ranger District (Map 3-7). Large fires (greater than 100 acres) from recent history that have occurred in the analysis area are shown in Table 3-30 and Map 3-7; all of the 1987 fires were lightning caused fires.

Table 3-30. Fires (Greater than 100 Acres) in the Watershed Analysis Area.

Year	Cause	Acres	Fire	Watershed
1924	Unknown	105	Unknown	Hidden Valley
1924	Unknown	140	Unknown	Rattlesnake Creek
1938	Unknown	265	Unknown	Hidden Valley
1938	Unknown	1,600	Unknown	Plummer Creek
1987	Lightning	7,574	Cold	Plummer Creek
1987	Lightning	4993	Flume	Rattlesnake Creek
1987	Lightning	6,004	Flume	Plummer Creek
1987	Lightning	3,050	Wallow	Plummer Creek
1987	Lightning	2,844	Jessie	Hidden Valley
1987	Lightning	531	Friendly	Plummer Creek

An analysis of the 1985 to 1996 Hayfork Ranger District fire data shows that 240 out of the 436 fires were lightning caused. During a high lightning season the number of starts increases dramatically (Appendix E).

Resources available for fire suppression during the fire season from June through October include two engines in Hayfork (one USFS and one California Department of Forestry and Fire Protection), a 20-person hand crew, and a volunteer fire department. There is also a bull dozer that is scheduled to be stationed at Hayfork in the Fall of 2001. These are the closest fire-related resources to the watershed analysis area. There are wildland fire fighting resources in Junction City (with one engine), Harrison Gulch (with two engines), and Hyampom (with one engine). The USFS has recently re-opened its station at Forest Glen and placed one wildland fire engine there. There is a volunteer fire station at Trinity Pines, with one engine.

Fire Hazards and Risks

It is important to understand the meaning of fire hazard and fire risk. Fire risk is defined as fire cause such as lightning, a natural causes, and human caused which can include a variety of causes such as children playing with matches, equipment, powerlines, campfires, and escape debris burning and others. This analysis will use only lightning or human caused fires, and will not break the causes down any further. Hazard is a rating assigned to a fuel complex that reflects its susceptibility to ignition, the wildfire behavior, and fire severity and fire suppression difficulty. A fuel complex is defined by kind, arrangement, volume, condition, and location. Hazard ratings are generally subjective, ranging from very low (green grasses and conifer litter) to extreme (cured grass and heavy slash) (Deeming 1990). A fire protection program can include fire suppression, prevention or risk management, and fuels management or hazard management.

Fire risk refers to cause of fire. Human-caused fires are a consideration for the analysis area, although not the primary consideration. There are small communities located at Forest Glen, Post Creek, and Glade Gulch within the analysis area. Recreation is a major source of human impact, as well as private timber harvesting. Lightning fires are of primary concern in the WAA. Lightning caused fires or natural ignitions are impossible to prevent. In order to minimize the impacts from lightning caused fires, the fuel hazard needs to be mitigated or suppression resources increased or allow fire to return to a more natural cycle.

To assess fire hazard we would need to examine the fuel model and hazard ratings for the analysis area. A description of the fuel models can be found in Appendix E. The fuel models and hazard ratings in the watershed analysis area are displayed in Tables 3-31 and 3-32, and Maps 3-8 and 3-9, respectively.

Fuel models 4, 6, and 10 are fuel models that offer considerable resistance to control and are likely to result in severe damage on high fire danger days.

Table 3-31. Fuel Models for National Forest System Lands in the Watershed Analysis Area.

Fuel Model	Acres by Fuel Model	Cover Type
2	15,148	Grass
4	5,593	Brush
6	22,834	Brush or Plantations
9	3,650	Timber
10	33,218	Timber
99	823	Barren
Total Acreage	81,266	

Table 3-32. Fire Hazard Ratings for National Forest System Lands in the Watershed Analysis Area.

Hazard Category	Acres by Hazard Rating
Barren	823
Low	240
Medium	63,665
High	16,538
Total Acreage	81,266

Fire Exclusion Effects

All the fire history studies for the Klamath Mountains indicate that the fire regime for the analysis area was frequent fires of generally less severity and with shorter fire return intervals. Frequent fires of mixed low and moderate severity killed some overstory trees, initiated recruitment, and thinned or killed understory stems.

The persistence of species in Pacific Northwest forests through time is attributed to vegetation adaptations to fire. Adaptations to fire survival are, in reality, adaptations to a particular ecosystem and its specific fire regime. If fire regime is altered, then the capacity for that species to survive in an environment may be eliminated (Pyne 1984).

In ecosystems where fire has been frequent the absence of periodic low intensity surface fire allows relatively rapid changes in species composition and structure. These will often become predisposing factors to epidemic insect and disease outbreaks, increasing dead and down fuel loading, shade tolerant species in the understory, and severe stand replacement fires. Sustainability becomes difficult to achieve in these ecosystems when periodic low intensity fire is changed to infrequent high intensity fire, much like the existing condition (W. Clark, personal communication 1995). Continuing to suppress low to moderate severity fires insures that the fires that will affect most of the landscape are the high severity, stand replacement fires (Skinner and Taylor 1998).

Few forested regions have experienced fires as frequently and with such high variability in fire severity as those in the Klamath Mountains. This highly variable fire regime may be an important factor contributing to overall diversity in the Klamath Mountains (Martin and Sapsis 1992).

Fire and Tree Plantations

Plantations comprise the following acreages in the analysis area: Hidden Valley with 4,043 acres, Rattlesnake Creek with 3,927 acres, and Plummer Creek with 3,113 acres. Plantations make up 14 percent of the Forest Service's timber base on the analysis area. Although the acreage is relatively small, the investment in money and time into the plantations is high and the loss of these plantations to wildfire would represent starting over at year 0. These plantations average 7 to 27+ years of age, and over half are more than 17 years of age.

Tree plantations are costly to establish. Current cost estimates are from US$1,000 to US$1,500 per acre (J. Paulo, personal communication 2001). A study by Skinner and Weatherspoon (1995) assessed the damage fires caused to plantations during the 1987 fires on the Hayfork District. The large scale study was undertaken to determine relationships between (1) degree of damage caused by the 1987 wildfires, and (2) prior management activities, fuelbed characteristics, and site/stand factors that might be expected to influence fire behavior and associated fire effects. Several interesting findings came to the surface as a result of the study that are relevant to this watershed analysis area. The study provided the following results that are important in evaluating the potential for fuels treatment:

- Fire damage to plantations was strongly associated with damage to the adjacent stand in the direction which the fire apparently came. The greater the damage in the adjacent stands, the greater the damage to the plantation.
- Site preparation method was the only factor related to uniformity of damage and it was highly significant. Untreated plantations burned quite uniformly (Skinner and Weatherspoon 1995).

The study goes on to present other factors affecting or damaging the timber resource as follows:

- Stand treatment: uncut stands suffered the least fire damage and followed by partial cut stands with fuel treatment, and the most damage was found in partial cut stands with no fuel treatment.
- Tree species: stands with ponderosa pine as the primary species sustained more damage than stands dominated by Douglas-fir.
- Aspect: the north aspects had the least damage, and south and flat the greatest damage.

The study concludes that for the short interval, for low to moderate severity fire regimes studied here, if fuels are left untreated, damage from wildfires could increase significantly.

3.6 Plant Species and Habitats, and Noxious Weeds

3.6.1 Vegetation/ Plant Communities

The watershed analysis area is distributed over two ecological sections of California; the Northern California Coast Ranges and Klamath Mountains, with three subsections that include the Eastern Franciscan, Pelletreau Ridge, and Rattlesnake Creek subsections (Goudey and Smith 1994). These mountainous areas have long, broad ridges, steep slopes, and narrow canyons ranging from 1,000 to 6,000 feet in elevation. Common in this area are extensive ridges with serpentine substrates. The area is characterized by cold and wet winters (precipitation in the form of snow and rain) and hot, dry summers. The geologic substrates are Paleozoic sedimentary and volcanic rocks, Mesozoic ultramafic, granitic, sedimentary and volcanic rocks in the Klamath Mountains section; and late Mesozoic eugeosynclinal rocks of the Franciscan Formation, Mesozoic ultramafic rocks, and Cenozoic rocks in the Northern California Coast Ranges section (Miles and Goudey 1998). Serpentine and granitic substrates, and their plant associations, are concentrated in the Plummer Creek and Rattlesnake Creek watersheds (Strand 1962). The physical attributes of the analysis area support the following California vegetation/habitat types (Sawyer and Wolf 1995) for plants and fungi:

Series Dominated by Trees

- Douglas-fir series
- Douglas-fir-tan oak series
- Douglas-fir-ponderosa pine series
- Jeffrey pine series
- White alder series
- Mixed willow series (with cottonwood component)
- Mixed conifer series
- Oregon white oak series
- White fir series
- Red fir series

Series Dominated by Shrubs

- Interior live oak – chaparral whitethorn shrub series
- Mixed scrub oak series
- Manzanita series

Series Dominated by Herbaceous Plants

- Fescue series
- Wet meadow series

Significant habitat types in the analysis area are serpentine substrates (derived from ultramafic rocks), rock outcrops, wetlands and meadows, and disturbed sites where invasive weeds are displacing natural plant populations. The analysis area also contains substrates that frequently have rare taxa associated with them, these being serpentine, granitic, limestone, and volcanic. The serpentine substrates of the analysis area supports vascular plant species of concern and are associated with scattered ultramafic rock intrusions in western portions of Plummer Creek watershed and throughout Rattlesnake Creek watershed. The Dubakella Mountain area is especially known for its floristic diversity and high number of rare and endemic serpentine plants (Jimerson et al. 1995). Many of the known occurrences of the vascular plant species of concern are associated with serpentine substrates in this analysis area. The serpentine habitat is both naturally fragmented (scattered intrusions), as well as fragmented from human activities such as roads, skid trails and log landings, especially in the Rattlesnake Creek watershed and eastern portions of Plummer Creek watershed. Moist to wet meadows also support rare and endemic taxa in the area, especially in the most southern portion of Hidden Valley watershed and within Jeffrey pine/ incense cedar forest type.

Overall, fragmentation of plant and fungi habitats has occurred throughout the analysis area due to past rural development and grazing, logging of the hillslopes and riparian corridors, mining, and road building activities.

3.6.2 Plant Species of Special Concern

Federally Threatened or Endangered Plants

There are no known occurrences of any federally threatened or endangered plant species in the analysis area. There is potential habitat for two federally and state listed endangered plant species, McDonald's rock cress (*Arabis macdonaldiana*) and water howellia (*Howellia aquatilis*) (Table 3-33).

There is potential habitat for McDonald's rock cress in high elevation and rocky areas with serpentine substrates. The potential for occurrence is low due to its known distribution of this species being linked with specific serpentine intrusions south and north of the analysis area (i.e., Red Mountain in Mendocino County, and Salmon Mountain in Trinity County, CA).

There is potential habitat for water howellia in ponding wetlands, which are scattered throughout the analysis area. This species has known occurrence south of the analysis area, in seasonal ponds on the Mendocino National Forest. Water howellia has not been identified on the Shasta-Trinity National Forest, despite numerous informal surveys in available suitable habitat.

Table 3-33. Federally Endangered or Threatened Species with Potential Habitat or Known Occurrence in the Watershed Analysis Area.

Common Name (Scientific Name) [Code][2]	Status[1]	Species/ Habitat Occurrences	Species-Habitat Associations
McDonald's rock cress (*Arabis macdonaldiana*) [ARMA33]	FE/SE	No	Dry gravelly to bouldery, moderate to steep, semi-stabilized slopes of serpentine or peridotite origin, typically on ridges. Often on rocky sites in Jeffrey pine woodlands. Elevation range 3,950 to 5,000 feet. (Jimerson et al. 1995)
water howellia (*Howellia aquatilis*) [HOAQ]	FT	No	Lakes, marshes, swamps, and ponds, often seasonal. California (Mendocino County), western Oregon, western Washington and northern Idaho.

[1]FT–Federal Threatened; FE–Federal Endangered; SE–State Endangered.
[2]USDA Plant Database ID Code.

Forest Service Sensitive (FSS) and Endemic (FSE) Plants

There are four FSS vascular plant species with known occurrences and potential habitat for ten additional plant species in the analysis area (Table 3-34). The majority of these plant species are associated with rock outcrops, wetlands, and serpentine substrates.

There are two FSE vascular plant species known to be present, and one species potentially present in the analysis area (Table 3-34). Serpentine goldenbush (*Ericameria ophitidus*) and Dubakella Mountain buckwheat (*Eriogonum libertini*) are both known endemics of the Rattlesnake Creek Terrane. Veiny arnica (*Arnica venosa*) has not been observed in the analysis area, but is found locally (Trinity and Shasta Counties, CA.) in mixed conifer or conifer/oak forest type, on ridges and old road cuts.

Elmer's lupine (*Lupinus elmerii*) is thought to exist within the Hidden Valley watershed on the South Fork Mountain ridgeline, but the taxonomy is unclear at this time. There is a large population (occupying 50 to 100 acres) along the ridgetop and extending south to Pickett Peak. The species is associated with disturbed areas in gravel or clay soils. Species verification is currently underway.

Table 3-35 presents habitat associations of sensitive plant species known or having potential to occur in the watershed analysis area.

Table 3-34. Forest Service Sensitive and Endemic Plant Species of Known Occurrence in the Watershed Analysis Area.

Common Name (*Scientific Name*)	Watershed[1]	Number of Known Occurrences
Forest Service Sensitive Species		
mountain lady's slipper (*Cypripedium montanum*)	PC	1
Nile's madia (*Madia doris-nilesiae*)	PC, RC	4
Peanut sandwort (*Minuartia rosei*)	RC	3
Umpqua green gentian (*Frasera umpquaensis*)	HV	5
Forest Service Endemic Species		
serpentine goldenbush (*Ericameria ophitidus*)	RC	8
Dubakella Mountain buckwheat (*Eriogonum libertini*)	PC, RC	9

[1]HV–Hidden Valley; PC–Plummer Creek; RC–Rattlesnake Creek.

It should be noted that one vascular plant species of the analysis area, the roseflower (or pale yellow) stonecrop (*Sedum laxum* ssp *flavidum*) has recently been dropped from the FSS species list. This species is currently on the CNPS List 4 (limited distribution), and has no state or federal rare plant listing.

Survey and Manage (SM) Plants and Fungi

The Survey and Manage plants and fungi are of recent concern (since 1994), particularly the non-vascular plants and fungi. There were certain SM plant and fungi species that were identified in the *Presidential Northwest Forest Plan Record of Decision (NFP ROD)– Standards and Guidelines* (April 1994) as requiring field surveys prior to implementing ground-disturbing activities. These SM plants and fungi were termed *Survey Strategy* 2 (SS2) and *Protection Buffer* (PB) species. Under the current Amendment of the Presidential NFP ROD (signed January 2001), these taxa were removed or reassigned to one of six categories (A through F)– two of which require field surveys prior to implementation of ground-disturbing activities (Category A: rare, pre-disturbance surveys practical, and Category C: uncommon, pre-disturbance surveys practical).

Table 3-35. Habitat Associations of Sensitive Plant Species of Known/Suspected Occurrence in the Watershed Analysis Area.

Common Name (*Scientific Name*)	**Code[1]**	**Status[2]**
Non-Serpentine Upland Forest		
Brownie lady's-slipper (*Cypripedium fasciculatum*)	CYFA	FSS/SM (C)
Mountain lady's-slipper (*Cypripedium montanum*)	CYMO2	FSS/SM (C)
Elmer's lupine (*Lupinus elmeri*)	LUEL2	FSS
Red Mountain catchfly (*Silene campanulata* ssp. *campanulata*)	SICAC	FSS/CE
Clustered green gentian (*Frasera umpquaensis*)	FRUM2	FSS
Canyon Creek stonecrop (*Sedum paradisum* [= *Sedum obtusum* ssp. *Paradisum*])	SEPA15	FSS
Pacific fuzzwort (bryophyte) (*Ptilidium californicum*)	PTCA	SM (A)
goblin's gold (bryophyte) (*Schistostegia pennata*)	-	SM (A)
bent-kneed four-toothed moss (bryophyte) (*Tetraphis geniculata*)	TEGE	SM (A)
Non-Serpentine Wet Meadows and Openings		
coast checkerbloom (*Sidalcea oregana*)	SIOR	FSS
Clustered green gentian (*Frasera umpquaensis*)	FRUM2	FSS
Mingan moonwort (*Botrychium minganense*)	BOMI	SM (A)
Western goblin (*Botrychium montanum*)	BOMO	SM (A)
Serpentine Meadows		
Oregon willow herb (*Epilobium oreganum*)	EPOR	FSS
Chaparral Openings and Closed-Cone Forest		
Brandegee's woolly-stars (*Eriastrum brandegeae*)	ERBR3	FSS
Streamside Riparian		
Brownie lady's-slipper (*Cypripedium fasciculatum*)	CYFA	FSS/SM (C)
mountain lady's-slipper (*Cypripedium montanum*)	CYMO2	FSS/SM (C)
Shasta pincushion *(Chaenactis suffrutescens)*	CHSU	FSS
Vernally Wet Soils or Vernal Pools		
water howellia	HOAQ	FT

(*Howellia aquatilis*)		
Howell's montia (*Montia howellii*)	MOHO	FSS
Serpentine Forest		
serpentine goldenbush (*Ericameria ophitidus* [= *Haplopappus ophitidus*])	EROP2	FSE
Dubakella Mountain buckwheat (*Eriogonum libertini*)	ERLI4	FSE
Red Mountain catchfly (*Silene campanulata* ssp. *campanulata*)	SICAC	FSS/CE
Peanut sandwort (*Minuartia rosei*)	MIRO3	FSS
Serpentine Openings		
Serpentine goldenbush (*Ericameria ophitidus*)	EROP2	FSE
Dubakella Mountain buckwheat (*Eriogonum libertini*)	ERLI4	FSE
Nile's harmonia (*Madia doris-nilesiae*)	MADO3	FSS
Stebbin's harmonia (*Madia stebbinsii*)	MAST3	FSS
Peanut sandwort (*Minuartia rosei*)	MIRO3	FSS
Dry, Serpentine Slopes and Ridges		
McDonald's rock-cress (*Arabis macdonaldiana*)	ARMA33	FE
Shasta chaenactis (*Chaenactis suffrutescens*)	CHSU	FSS

[1]USDA Database Species Code.

[2]FE–Federal Endangered; FT–Federal Threatened; CE–California State Endangered; FSS–Forest Service Sensitive; FSE–Forest Service Endemic; SM–Survey and Manage, A–Current Survey and Manage in Alternative A (rare, pre-disturbance surveys practical), C–Current Survey and Manage in Alternative C (uncommon, pre-disturbance surveys practical).

Surveys for the non-vascular plant and fungi species have been initiated in the Shasta-Trinity National Forest, and some data is currently available. Although overlooked in the past, the non-vascular plant and fungi species are an integral component of the forest ecosystem that serve a variety of functions and occupying a diverse array of habitats. Strategic surveys for other fungi, lichen, and bryophyte species are being performed in 2001 and 2002 on the Shasta-Trinity National Forest to help refine species habitat descriptions and locate new populations. There is only one known occurrence of a Survey and Manage vascular plant species, *Cypripedium montanum* in the watershed analysis area (located in Plummer Creek watershed).

Other Species of Concern

There are no additional rare vascular plants (CNPS Lists 1, 2, and 3) which are known to occur within the watershed analysis area. However, the following uncommon vascular plants (CNPS List 4) have been documented: Beegum onion (*Allium hoffmanii*; ALHO), Siskiyou onion (*Allium siskiyouense*; ALSI2), serpentine milkweed (*Asclepias solanoanum*; ASSO), redwood lily (*Lilium rubescens*; LIRU), Tracy's desert parsley (*Lomatium tracyi*; LOTR), Snow Mountain beardtongue (*Penstemon purpusii*; PEPU4), and whiteflower rein orchid (*Piperia candida*; PICA13) (see Map 3-10, Rare Plant Occurrences within WAA).

Additional rare vascular plants (CNPS Lists 1 and 2) that could potentially have presence in the analysis area include: small ground cone (*Boschniakia hookeri*; BOHO), Indian pipe (*Monotropa uniflora*; MOUN3), white beaked-rush (*Rhynchospora alba*; RHAL3), and coast checkerbloom (*Sidalcea oregana*; SIOR). Showy stickweed (*Hackelia venusta*) and brook lobelia (*Lobelia kalmii*) are vascular plants known to occur in Oregon, with possible occurrences within the analysis area. Tracy's collomia (*Collomia tracyi*; COTR), an uncommon vascular plant (CNPS List 4), potentially could occur in the analysis area.

3.6.3 Noxious Weeds

Noxious weed infestation occurs adjacent to private lands, along main travel routes, and in areas of frequent ground disturbance in portions of the analysis area. Invasive weed presence in well-developed forest vegetation communities is at a low level. Of primary concern is the diffuse knapweed (*Centaurea diffusa*; CEDI3) on South Fork Mountain roadsides and disturbed sites, which is spreading from adjacent private inholdings where the diffuse knapweed population has been allowed to grow uncontrolled for some time. The following noxious weeds are known to exist in the watershed analysis area (S. Erwin, personal communication 2001):

- diffuse knapweed (*Centaurea diffusa*; CEDI3)
- spotted knapweed (*Centaurea maculosa*; CEBI2)
- yellow star thistle (*Centaurea solistitalis*)
- St. John's-wort (*Hypericum perforatum*)
- plumeless thistle (*Carduus acanthoides*; CAAC)
- Scotch broom (*Cytisus scoparius*; CYSC4)
- French broom (*Genista monspessulana*; GEMO2)
- Dalmatian toad flax (*Linaria genistifolia* ssp. *dalmatica*)
- Canada thistle (*Cirsium arvense*)

There are two significant invasive weeds within the watershed analysis area; namely diffuse knapweed and spotted knapweed. Both species are currently known to occur on the Shasta-Trinity National Forest from only two populations within the analysis area, although larger populations exist on the Klamath National Forest. Their limited extent make control efforts on the National Forest System lands feasible, but control on adjacent private lands is more difficult.

Diffuse knapweed occupies approximately 100 acres of roadsides and openings along Forest Road 1 on the South Fork Mountain ridgetop and several feeder routes to this road (located in Hidden Valley watershed). This very serious noxious weed has been common on the Shasta-Trinity National Forest, but is expanding from South Fork Mountain into Humboldt County, CA. It is currently restricted enough in size and extent to make control efforts feasible; but is in danger of moving beyond that distribution in the near future.

There is a five to ten-acre population of spotted knapweed near Hackney Spring within the Rattlesnake Creek watershed. This population has grown in the two years since its discovery, despite annual efforts to remove it. It is currently within a size that can be managed effectively, but could expand aggressively without control efforts.

3.6.4 Effects of Grazing

The number of grazing animals on each allotment within the Trinity National Forest has not changed significantly since the 1980s. The most important factors of change on these grazing allotments are wildland fires and timber harvesting. It is unlikely that grazing impacts sensitive and endemic plant populations in ultramafic/ serpentine areas because the forage quality is generally so low that cattle are not drawn to these areas (URS Greiner Woodward Clyde 2000).

There are no sensitive vascular plant species known to occur on the Lamb Gap Allotment (including portions of the Hidden Valley watershed). Clustered green gentian (*Frasera umpquaensis*; FRFA) is the only rare plant known to occur in the South Fork Mountain Allotment (including southern portions of the Hidden Valley watershed). Serpentine goldenbush (*Ericameria ophitidus*), Dubakella Mountain buckwheat (*Eriogonum libertini*), Nile's madia (*Madia doris-nilesiae*), and Peanut sandwort (*Minuartia rosei*) are known to occur in the Post Creek Allotment (including portions of the Rattlesnake Creek watershed) (URS Greiner Woodward Clyde 2000).

Sensitive plant species on the National Forest System lands in the analysis area are not likely to be adversely affected by cattle grazing, except for Oregon willow herb (*Epilobium oreganum*) which is highly at risk of cattle grazing. Moderate to heavy trampling is occurring where cattle are attracted to serpentine fens and wet seeps within the dry forest types. Plant losses may contribute to the federal listing of Oregon willow herb as a threatened species under ESA (USFS 1995). Other Forest Service (Region 5) sensitive plant species known or suspected to occur within the analysis area are at low risk of being impacted by grazing (URS Greiner Woodward Clyde 2000).

Water howellia (*Howellia aquatilis*) is a federally listed plant species which has been found in seasonal ponds and vernal ponds on the Mendocino National Forest, and it may occur on the Trinity National Forest. Although water howellia has not been found in the analysis area, a focused field survey has not been conducted (S. Erwin, personal communication 2001). There is a high risk of interaction between cattle and water howellia because the cattle tend to congregate in wet areas where this plant grows. Impacts to water howellia populations have been observed on the Mendocino National Forest (URS Greiner Woodward Clyde 2000).

Nearly all riparian zones within the analysis area maintain a non-native grass component due to riparian seeding practices over the past 100 years. In this sense, grazing may be contributing to the displacement of native grasses, as exotic species may be more adaptable to disturbance. A minor amount of cattle crossing and streambank tramplings has been observed in Rattlesnake Creek watershed. Generally, cattle have not suppressed hardwood species establishment, but rather feed almost exclusively on grasses and forbs. Most disturbances have been isolated, and have not affected channel processes or watershed functions (URS Greiner Woodward Clyde 2000).

3.7 Wildlife Habitats and Species

This section describes the existing conditions of wildlife habitats and species for the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area. The Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds encompass approximately 33,580 acres, 32,652 acres, and 30,103 acres, respectively. Combined watershed analysis area encompasses approximately 96,335 acres, with 81,250 acres in National Forest System lands and the remaining areas in private lands (approximately 9,330 acres in Hidden Valley, 2,592 acres in Plummer Creek, and 3,163 acres in Rattlesnake Creek watersheds). The Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds are 5th field watersheds located within the South Fork Trinity River basin in northwestern California.

Overall approach for the wildlife resources analysis was to describe the existing wildlife habitats and species in the watershed analysis area. Dependent upon best available information, quantitative descriptions are preferred over qualitative ones. Area of emphasis will be on the National Forest System lands in Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds. Private lands are excluded from the wildlife resources analysis because of constraints or limitations associated to data availability. Descriptions of existing vegetation for terrestrial wildlife habitats used the forest inventory strata information developed by the Forest Service in 1995. For the watershed analysis area, only approximately 88,845 acres had vegetation classification with delineated forest inventory strata. Other Forest Service's GIS-based data layers were queried to obtain relevant information to describe wildlife habitats. Wildlife species occurrences for the watershed analysis area were described using available data (including GIS-based) that were provided by the Forest Service.

3.7.1 Upland Forest Habitats

Habitat conditions in the analysis area could be described using vegetation pattern that includes vegetation type and successional stages. Most wildlife species-habitat relationships matrices use habitat stages that include vegetation cover types, successional or structural stages, and crown canopy closure to describe habitat stages and potential suitability for any given species (Verner and Boss 1980; Mayer and Laudenslayer 1988). The species-habitat matrix does not account for patch size of any given habitat stage, and landscape pattern of the habitat stages and associated habitat fragmentation. Elevation, climate, soil, topography, and disturbances or management activities influence vegetation cover type. Vegetation pattern (include composition and structure) would influence the availability of potential habitat for various wildlife assemblages that occur on terrestrial habitats.

Vegetation Composition

Vegetation composition describes the existing forest cover types or habitat types based on selected vegetation classification system commonly used on National Forest System lands of California. The existing vegetation classification used has an inherent emphasis for tree dominated habitats. The California Wildlife Habitat Relationships system (Mayer and Laudenslayer 1988) would classify the watershed analysis area to consist of Douglas-fir (or Mixed Evergreen), Klamath Mixed Conifer, Montane Hardwood-Conifer, and Montane Riparian. Other associates of vegetation/habitat types, with varied distribution, in the analysis area include ponderosa pine, white fire, and red fir.

Vegetative cover types are named for the dominant species within a site and indicate the existing species composition of the area. Map 3-6 illustrates the vegetation types distribution in Hidden Valley, Plummer Creek, and Rattlesnake Creek analysis area. In the combined watershed analysis area, Douglas-fir forest is the predominant vegetation cover type, and followed by ponderosa pine (Table 3-36). Douglas-fir forest is the dominant cover type in Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds even when they are considered individually. Ponderosa pine occurs in greater extent in Rattlesnake Creek in comparison to Hidden Valley and Plummer Creek watersheds. Red fir forest cover type only occurred in Rattlesnake Creek analysis area. Broad-leaved species or hardwoods were documented for Hidden Valley and Plummer Creek, and only limited hardwood areas were located in Rattlesnake Creek analysis area (Table 3-36). The differences in vegetation types distribution between the watershed analysis area could be an artifact of the variability in physiographic factors (including elevation and topography), and natural and human-induced disturbances. In general, the watershed analysis area is dominated by coniferous forest cover type with a preponderance of Douglas-fir and ponderosa pine.

Table 3-36. Vegetation Composition in Hidden Valley, Plummer Creek, and Rattlesnake Creek Watershed Analysis Area.

Vegetation Type	Hidden Valley (acres)	Plummer Creek (acres)	Rattlesnake Creek (acres)	Total Acreage
CX		134.1	75.7	209.8
DF	17651.3	19713.6	13215.6	50580.5
DP			81.3	81.3
GH	44.3			44.3
GL	42.5	25.5		68.0
HB	76.7	38.3		115.0
HC	7.7	17.6		25.3
HL	284.0	3207.7	19.4	3511.1
HW	227.6	2.3		229.9
NB	175.8	101.8	2.2	279.8
ND	9.9			9.9
NW	51.6	5.9		57.6
PP	111.8	2961.9	9261.4	12335.1
RF			25.5	25.5
SA	78.6	4.5	27.2	110.3
SM	97.1	692.9	69.0	859.0
SP		15.9	181.9	197.7
SR	370.3	113.9	0.4	484.5
SX		61.2		61.2
UX	3268.6	2977.1	3844.4	10090.0
WF	1762.2	40.4	111.3	1913.9
Unclassified	1981.6	2384.9	3188.2	7554.8
Total Acreage	26241.7	32499.5	30103.6	88844.7

*See Appendix D for Vegetation Type Descriptions.

Stand Structure and Seral Stages

In commonly used stand structure classification for tree dominated habitat types, tree size (based on diameter-at-breast height or average crown diameter) and density (crown closure, basal area or trees per unit area) classes are used. The descriptions of vegetation structure and densities would define the existing successional or seral stages that could be potential habitats for any target wildlife species. Tree canopy structure in forest stands would provide habitat layers. Horizontal and vertical structural diversity and complexity are important habitat functions for terrestrial wildlife species. Wildlife species occurrence is a function of available habitat types and stages (including both vegetation composition and structure) and landscape patterns of the potential habitats. There are intrinsic differences in wildlife assemblages that are associated to shrub and early successional habitat, late-successional/old-growth forests, open and closed canopy forests, riparian/meadow habitat, and ecotone/mosaic habitat. Vegetation succession would change the existing successional or seral stages by following multiple pathways in forest development.

Table 3-37 illustrates the vegetation structural stages in the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area. In the combined watershed analysis area, the predominant vegetation structural stage is the tree-dominated M3P, and followed by the tree-dominated M3G. Both these tree-dominated habitats are mixed conifer forest stands, and the vegetation structural stages for Douglas-fir and red fir are reported separately in Table 3-37. In comparison to Hidden Valley and Rattlesnake Creek analysis areas, the Plummer Creek area has the highest acreage of tree-dominated M3P (Table 3-37). The Rattlesnake Creek and Plummer Creek analysis areas have relatively similar acreage in tree-dominated M3G. The Hidden Valley analysis area has relatively more areas in tree plantations in comparison to Plummer Creek and Rattlesnake Creek (Table 3-37).

Table 3-38 describes the habitat stages available, based on seral stages (late-older mature, mid-late seral, and early-mid seral), in the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area. The combined watershed analysis area contained approximately 13,851 acres of late seral old-growth, with Hidden Valley analysis area having the greatest extent of this tree-dominated habitat type (Table 3-38). In addition, approximately 7,806 acres of potential late seral old-growth are available in the combined watershed analysis area (Table 3-38). The Rattlesnake Creek analysis area has the highest acreage of potential late seral old-growth. Overall, the combined watershed analysis area has approximately 21,657 acres of late seral old-growth. Late seral stage associated species such as the northern spotted owl, northern goshawk, and forest carnivores would benefit from the availability of this habitat stage.

The combined watershed analysis area has approximately 29,334 acres of mid-late seral stage, and 30,844 acres of early-mid seral stage habitats (Table 3-38). The Rattlesnake Creek analysis area has the largest area of mid-late seral stage, and Plummer Creek analysis area with the greatest extent of early-mid seral stage habitat. Wildlife assemblages associated to openings and early successional habitat, and wildlife species that utilize multiple habitats would benefit from this forest condition.

Table 3-37. Vegetation Structural Stages in Hidden Valley, Plummer Creek, and Rattlesnake Creek Watershed Analysis Area.

Vegetation Structural Stage	Hidden Valley (acres)	Plummer Creek (acres)	Rattlesnake Creek (acres)	Total Acreage
D3G	2371.4	557.3		2928.7
D3P	1485.1	273.3		1758.3
D4G	7930.4			7930.4
GR	86.8	25.5		112.3
HCO	84.5	55.9		140.3
HNC	511.6	3210.0	19.4	3740.9
M2G	231.7	1053.9	3004.2	4289.8
M2P	157.3	358.6	2901.4	3417.3
M3G	1549.8	6165.5	6290.2	14005.4
M3P	1773.8	10551.4	8710.3	21035.6
M4G	3154.5	3552.7	1855.2	8562.4
M6G	95.9	215.5		311.4
NC			81.3	81.3
NF	237.3	107.8	2.2	347.3
R3G			25.5	25.5
SX	546.0	872.5	96.6	1515.1
XX1	798.4	2331.2	2028.6	5158.2
XX2	1694.0	501.3	1614.9	3810.1
XX3	1551.5	282.1	285.6	2119.2
Unclassified	1981.6	2384.9	3188.2	7554.8
Total Acreage	26241.7	32499.5	30103.6	88844.7

*See Appendix D for Vegetation/Timber Strata Descriptions.

Table 3-38. Habitat Stages Available in Hidden Valley, Plummer Creek, and Rattlesnake Creek Watershed Analysis Area.

Seral Stages	Late Seral Habitat[1]		Mid-Seral Habitat[2] (acres)	Early Seral Habitat[3] (acres)
	Old-Growth (acres)	Potential Old-Growth (acres)		
Hidden Valley	10,458	2,070	7,036	4,718
Plummer Creek	1,800	2,216	7,864	18,863
Rattlesnake Creek	1,593	3,520	14,434	7,263
Total Acreage	13,851	7,806	29,334	30,844

[Source: Watershed Analysis of the South Fork Trinity River Watershed, Tetra Tech Inc, May 2000].

[1]Late-Older Mature includes two subcategories: (a) old-growth stands which are composed of commercial conifer stands in the 4-6 size classes; (b) potential old-growth which are composed of 20 percent of the commercial conifer stands in size class 3 with crown closure class P and 40 percent of the size class 3 stands with crown closure class G.

[2]Mid-late seral includes three subcategories: (a) HCO and HNC vegetation strata which are hardwood stands; (b) KPX and NC vegetation strata which are non-commercial conifers; (c) commercial conifer vegetation strata with the following characteristics: plantations and burns older than 20 years, size class 2 stands, 80 percent of size class 3 stands with crown closure class P and 60 percent of size class 3 stands with crown closure class G.

[3]Early-mid seral includes: plantations and burns <20 years old, GR and SX vegetation strata which are grasslands and shrubs.

3.7.2 Aquatic and Riparian Habitats

Aquatic wildlife assemblage is dependent upon water quality and quantity, riparian cover, fish and/or aquatic invertebrates, and in-stream large woody debris. Riparian communities are considered important for wildlife, as productive habitat for many species and as critical habitat for some species (Thomas et al. 1979; Oakley et al. 1985). A riparian ecosystem is the interface between terrestrial and aquatic ecosystems. Riparian communities are reported to support more species than the surrounding upslope forest habitat.

Table 3-21 (see Fish Habitats and Species, and Riparian Habitat section) reports that there are approximately 607 miles of streams (include 173.8 miles of perennial, 181.7 miles of intermittent, and 251.0 miles of ephemeral streams) in the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area. The Rattlesnake Creek analysis area has the highest stream density with 4.9 mi/mi2, and Hidden Valley and Plummer Creek analysis areas have 3.6 mi/mi2 and 3.7 mi/mi2, respectively. The Hidden Valley analysis area has the greatest length (76.5 mi) of perennial streams, whereas the Rattlesnake Creek analysis area has the greatest length (119.6 mi) of ephemeral streams. Fish habitat surveys for assessing stream conditions have been conducted by the Forest Service; however, the suitability of the stream habitat for aquatic amphibians and reptiles are currently undetermined. Incidental sightings of aquatic herptofauna have been documented during stream surveys. Certain terrestrial wildlife species are dependent upon aquatic wildlife species or fish for their diet.

Tables 3-23 and 3-24 (see Fish Habitats and Species, and Riparian Habitat section) describe the riparian conditions in the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area. Riparian areas encompass approximately 17,559 acres of vegetation classified for the watershed analysis area. The riparian areas are composed of a range of vegetation types, and tree size and density classes. Over 65 percent of the riparian areas are composed of conifer tree size class 3 or larger, with approximately 61 percent of the forest stands with moderate-dense (>40 percent) crown closure and 39 percent with sparse-open (10 to 39 percent) closure.

Silvicultural practices, grazing, and wildfires in riparian areas could have potential impacts to riparian and aquatic systems. Current management direction, under the Aquatic Conservation Strategy, is to manage riparian reserves of a minimum of 150 feet along perennial streams and lakes, a minimum of 300 feet along all perennial fish-bearing streams, and a minimum of 100 feet along all seasonally flowing or intermittent streams, wetlands less than one acre, and unstable and potentially unstable areas (USFS 1994a). The riparian reserves over the forested landscape provide habitat connectivity, especially in lower two-third slope position, for selected terrestrial wildlife.

3.7.3 Spotted Owl Habitat

A suitable habitat analysis for the northern spotted owl (*Strix occidentalis caurina*), a federally threatened species, was conducted for the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area. The habitat analysis used the data provided by the Forest Service, and habitat suitability definitions followed the guidelines provided by the U.S. Fish and Wildlife Service for the Shasta-Trinity Land and Resource Management Plan. Table 3-39 illustrates the potential habitat that is available in the watershed analysis area. The combined watershed analysis area contained approximately 24,895 acres classified as nesting/roosting habitat capability, and approximately 15,680 acres as foraging habitat capability (Table 3-39). The Hidden Valley analysis area has the highest acreage of tree-dominated forest stands with nesting/roosting habitat capability for spotted owls. The Plummer Creek analysis area has the highest acreage classified as unsuitable habitat with no potential use by spotted owls.

The U.S. Fish and Wildlife Service (1991) designation of critical habitat for the northern spotted owl overlaps the Hidden Valley watershed analysis area. The critical habitat unit (CA-38) that overlaps National Forest System lands in the Hidden Valley analysis area is located in the South Fork Mountain area. According to federal standards and guidelines, the physical and biological features referred to as primary constituent elements must be maintained and/or enhanced in the critical habitat units for the conservation of this species. The Northwest Forest Plan's management strategies are designed to provide protection of critical habitats for the northern spotted owls.

Table 3-39. Northern Spotted Owl Habitat Available in Hidden Valley, Plummer Creek, and Rattlesnake Creek Watershed Analysis Area.

Habitat Capability	Hidden Valley (acres)	Plummer Creek (acres)	Rattlesnake Creek (acres)	Total Acreage
Nesting/Roosting	12827.7	6885.7	5181.7	24895.2
Foraging	3323.8	6332.0	6025.1	15680.8
Capable (in Plantations)	4750.9	4340.3	10005.3	19096.4
Non-Capable (in Trees)	2484.8	11550.9	5604.6	19640.3
Non-forested	869.9	1005.9	98.8	1974.5
Unknown (Outside FS lands)	1981.6	2384.9	3188.2	7554.7
Total Acreage	26238.6	32499.7	30103.6	88842.0

[Source: Shasta-Trinity National Forests GIS layer- owl_baseline].

3.7.4 Snags and Downed Wood

Snags (standing dead trees) and downed wood are components of stand decadence, and a structural diversity requirement for certain wildlife assemblage. Snags provide nesting/ roosting habitats for raptors and woodpeckers, and denning/resting habitats for forest carnivores (Neitro et al. 1985). Downed wood or logs provide habitat for ground-dwelling wildlife assemblage by creating favorable microclimate conditions and provide cover for amphibians and small mammals (Bartels et al. 1985). Snags and downed wood are naturally found in conifer and hardwood forests, particularly in old-growth conifer forest. Many wildlife species associated with late-successional/old-growth are recognized to be closely associated to snags and coarse woody debris or dead trees on the ground (Thomas et al. 1993). Even-aged plantations and early successional habitats are usually deficient in snags and downed logs, and therefore do not provide adequate habitat for wildlife species that are dependent on these special habitat components. Current management practices in National Forest System lands provide for the maintenance of sufficient large snags and downed logs for wildlife assemblage requiring these special habitat elements.

Data are lacking for snags and downed wood distribution in the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area. However, there is data available for typical forest stands and old-growth stands, based on forest inventory plots, on the Shasta-Trinity

National Forest. Table 3-40 illustrates the distribution of snags and coarse woody debris by vegetation type and seral stage in typical forest stands, and Table 3-41 shows the distribution of coarse woody debris by vegetation type and seral stage in old-growth stands. The highest occurrences of snags and coarse woody debris tend to be in the true fir forest stands. The higher tree density in true fir stands in comparison to mixed conifer or Douglas-fir may explain this situation. The potential recruitment of snags and downed wood would vary by stand density-related tree mortality, and disturbances by wind, fire, insect and disease.

Table 3-40. Snags and Coarse Woody Debris (CWD) in Typical Forest Stands, Using Forest Inventory Plot Data, on the Shasta-Trinity National Forest.

Vegetation Type & Seral Stage	Snags 9-15 inch	Snags 15-21 inch	Snags >21 inches	CWD 15-21 inch	CWD >21 inch
WF/ RF mid-dense	7.2	2.4	2.6	4.6	5.8
WF/ RF late-dense	4.1	2.8	2.5	7.1	7.9
WF/ RF mid/ late-open	2.6	1.5	2.0	3.3	3.5
DF mid-dense	2.0	1.0	2.4	4.7	7.9
DF late-dense	2.9	1.6	2.8	6.0	9.1
DF mid/ late-open	4.3	1.0	2.0	4.8	8.3
MC mid-dense	3.3	1.6	1.9	4.9	4.8
MC late-dense	1.6	0.6	1.9	4.2	6.0
MC mid/ late-open	1.7	0.9	1.6	3.8	4.8

[Source: Forest-wide LSR Assessment, Online at www.r5.fs.fed.us/shastatrinity/lsr/].

Table 3-41. Distribution of Coarse Woody Debris (CWD) in Old-Growth Forest Stands, Using Old-Growth Inventory Plot Data, on the Shasta-Trinity National Forest.

Vegetation Type & Seral Stage	pieces/ acre <21 inch	pieces/ acre >21 inch	tons/ acre 9-21 inch	tons/ acre >21 inch	tons/ acre total
WF/ RF mid-dense	12.3	5.1	2.1	3.3	5.4
WF/ RF late-dense	13.0	7.7	2.5	7.1	9.6
WF/ RF mid/ late-open	7.2	3.5	1.1	3.2	4.3
DF mid-dense	10.0	7.9	2.4	13.1	15.5
DF late-dense	14.2	9.1	3.4	13.8	17.2
DF mid/ late-open	12.5	8.3	2.8	11.4	14.2
MC mid-dense	11.7	5.2	2.0	6.5	8.5
MC late-dense	10.1	5.7	2.1	7.8	9.1
MC mid/ late-open	8.9	4.8	1.9	5.7	7.6

[Source: Forest-wide LSR Assessment, Online at www.r5.fs.fed.us/shastatrinity/lsr/].

3.7.5 Land Allocations and Habitat Stages

Tables 3-42, 3-43, and 3-44 illustrate the strata (forest type/species, tree size and density classes) by land allocations and management prescriptions for the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis areas, respectively. For the combined watershed analysis area, late seral stage forest stands, with conifer 4-6 size classes and limited exceptions for conifer stands in 3P and 3G strata, are under Late-Successional Reserves (LSRs). The objective of LSRs is to protect and enhance conditions of late-successional/old-growth forest ecosystems which serve as habitat for late-successional/old-growth associated species (USDA and USDI 1994a,b).

The Hidden Valley analysis area has the highest acreage delineated as LSRs that are dominated by late successional/old-growth forest stands. The Rattlesnake Creek analysis area has the highest acreage delineated as Matrix lands; least amount of area delineated as LSRs; highest acreage delineated for timber management; and highest level of roaded recreation in Matrix lands. The Hidden Valley analysis area has the highest acreage delineated as LSRs that are in tree plantations. The Rattlesnake Creek analysis area has the highest acreage in larger tree size class that is delineated for timber management, and it is followed closely by the Plummer Creek analysis area. The Plummer Creek analysis area has the largest area delineated as Administratively Withdrawn Area (AWA) in comparison to Hidden Valley and Rattlesnake Creek analysis areas. The AWA in Plummer Creek analysis area composes of mixed conifer of size class 3 and non-commercial hardwoods.

Table 3-42. Strata (Forest Type/Species, Tree Size and Density Classes) by Land Allocations/Management Prescriptions for Hidden Valley Analysis Area.

Strata	Land Allocations/ Management Prescriptions[a] (acres)						Total Acreage
	1	2	3	6	7L	8	
D3G	154.4	205.9	19.5		1930.0	61.6	2371.4
D3P	23.1	300.4			1081.2	80.5	1485.1
D4G	52.5	729.1			6947.7	201.1	7930.4
GR	2.0		31.0		53.7		86.8
HCO	35.8	11.5			16.3	20.9	84.5
HNC	34.8	140.7		50.9	202.5	82.7	511.6
M2G	0.2				231.5		231.7
M2P		40.9			62.8	53.5	157.3
M3G	52.3	79.9	239.5	88.5	685.6	403.9	1549.8
M3P	33.8	308.6	193.5	95.4	248.3	894.1	1773.8
M4G	26.8	107.2	261.3		2653.0	106.2	3154.5
M6G					95.9		95.9
NF	52.2	48.6	13.5		118.3		237.3
SX	75.2		3.0	4.8	427.0	36.0	546.0
XX1		191.2	48.3	4.1	308.4	246.4	798.4
XX2		15.4	28.0		1485.4	165.1	1694.0
XX3			8.7		1436.3	106.6	1551.5
Unclassified	57.7	344.7		3.9	1285.0	111.0	1981.6
Total Acreage	600.8	2524.1	846.4	247.6	19269.1	2569.7	26241.7

[a]1-Administratively Withdrawn Area (AWA) Rx I: Unroaded Recreation; 2-AWA Rx II: Limited Roaded Recreation; 3-Matrix Rx III: Roaded Recreation; 6-Matrix Rx VI: Wildlife Habitat Management; 7F-Late-Successional Reserve (LSR) Rx VII: TES Species; 7L-LSR Rx VII: Late-Successional Reserve; 8- Matrix Rx VIII: Timber Management.

See Appendix D for Vegetation/Timber Strata Descriptions.

Table 3-43. Strata (Forest Type/Species, Tree Size and Density Classes) by Land Allocations/Management Prescriptions for Plummer Creek Analysis Area.

Strata	Land Allocations/ Management Prescriptions[a] (acres)							Total Acreage
	1	2	3	6	7F	7L	8	
D3G	111.6			10.5		410.5	24.6	557.3
D3P	177.6			12.7		83.0		273.3
GR	10.0					15.5		25.5
HCO	55.9							55.9
HNC	2287.6	0.1	158.7	56.8		534.7	172.0	3210.0
M2G	186.6		162.0	9.6	24.6	290.5	380.6	1053.9
M2P			90.7	5.5	17.5	30.1	214.8	358.6
M3G	1877.4	0.6	363.6	189.9	97.2	1172.2	2464.5	6165.5
M3P	3346.6	8.0	430.8	628.2	379.8	2102.7	3655.3	10551.5
M4G	108.9		48.1	87.6	12.7	2750.5	544.9	3552.8
M6G							215.6	215.6
NF	45.0	2.1				60.7		107.8
SX	80.1		5.4			166.7	620.3	872.5
XX1	38.8		53.6	23.7	62.2	353.0	1800.0	2331.3
XX2			0.1	0.6	27.6	112.7	360.4	501.3
XX3						93.6	188.5	282.1
Unclassified	174.7	231.6		188.4		982.0	808.3	2385.0
Total Acreage	8501.0	242.4	1313.0	1213.4	621.5	9158.2	11450.0	32499.5

[a]1-Administratively Withdrawn Area (AWA) Rx I: Unroaded Recreation; 2-AWA Rx II: Limited Roaded Recreation; 3-Matrix Rx III: Roaded Recreation; 6-Matrix Rx VI: Wildlife Habitat Management; 7F-Late-Successional Reserve (LSR) Rx VII: TES Species; 7L-LSR Rx VII: Late-Successional Reserve; 8-Matrix Rx VIII: Timber Management.

See Appendix D for Vegetation/Timber Strata Descriptions.

3.7.6 Landscape Pattern and Habitat Fragmentation

Landscapes are characterized by their spatial heterogeneity (i.e., patchiness) at a variety of scales, and landscape ecology focuses on the structure, function, and change of the landscapes (Forman and Gordan 1986). It is generally accepted that wildlife ecology and behavior may be strongly dependent on the nature and pattern of landscape elements (patches). Properties of forested landscapes such as patch size, the amount of edge, the distance between habitat areas, and the connectedness of habitat patches have a direct influence on the flora and fauna interactions (Harris 1984; Franklin and Forman 1987). Spatial patterning, or fragmentation, of habitat has been suggested to influence the quality of wildlife habitat through a variety of processes such as isolation of habitat patches and edge effects (Harris 1984; Wilcove et al. 1986; Franklin and Forman 1987; Lehmkuhl and Ruggiero 1991). Habitat fragmentation alters the spatial configuration of habitats, and occurs along a continuum, from landscapes dominated by the original cover type to landscapes where the original cover type is reduced to remnant patches.

For the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area, landscape statistics were not computed to determine the degree of fragmentation sustained by the forested areas, especially Matrix lands, as a result of past land management practices.

Table 3-44. Strata (Forest Type/Species, Tree Size and Density Classes) by Land Allocations/Management Prescriptions for Rattlesnake Creek Analysis Area.

Strata	Land Allocations/ Management Prescriptions[a] (acres)				Total Acreage
	3	7F	7L	8	
HNC				19.4	19.4
M2G	883.6	1.7	468.8	1650.1	3004.0
M2P	947.5	4.8	53.4	1895.7	2901.4
M3G	2769.1	28.9	263.8	3228.4	6290.2
M3P	4130.9	12.0	304.5	4262.9	8710.3
M4G	855.8		544.7	454.6	1855.2
NC	37.2			44.1	81.3
NF	2.2				2.2
R3G				25.5	25.5
SX			20.2	76.5	96.6
XX1	710.2	163.0	27.8	1127.6	2028.6
XX2	472.5	19.4	267.5	855.5	1614.9
XX3	66.2		192.3	27.0	285.6
Unclassified	552.3		17.2	2618.7	3188.2
Total Acreage	11427.6	229.7	2160.2	16286.0	30103.6

[a]1-Administratively Withdrawn Area (AWA) Rx I: Unroaded Recreation; 2-AWA Rx II: Limited Roaded Recreation; 3-Matrix Rx III: Roaded Recreation; 6-Matrix Rx VI: Wildlife Habitat Management; 7F-Late-Successional Reserve (LSR) Rx VII: TES Species; 7L-LSR Rx VII: Late-Successional Reserve; 8-Matrix Rx VIII: Timber Management.

See Appendix D for Vegetation/Timber Strata Descriptions.

Nevertheless, a mandate to minimize habitat fragmentation for maintaining biological diversity on National Forest System lands would be implemented through appropriate land allocations and management prescriptions. The amount of tree plantations in the analysis area could be used to evaluate the degree of habitat fragmentation in the forested landscape. Riparian reserves in the watershed analysis area would provide habitat connectivity and migration corridors between late seral stage habitat and others. With the growing interest in late-successional/old-growth associated species, more areas with this habitat stage would be protected for the conservation of these species. Overall, with the protection of relatively large areas of late seral stage habitat and reduced level of timber management activities, the landscape in the analysis area is not expected to undergo further human-induced habitat fragmentation. However, natural disturbances such as wildfires and floods could possibly fragment the forested upslope and riparian habitats in the analysis area.

3.7.7 Wildlife Species

Wildlife species of special status or concern that were considered for the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area are as follows:

- *Federally Threatened or Endangered Species* — bald eagle and northern spotted owl.

- *Forest Service Sensitive Species and/or Species of Concern* — American peregrine falcon, northern goshawk, willow flycatcher, Pacific fisher, American marten, California wolverine, pallid bat, Townsend's big-eared bat, western red bat, northwestern pond turtle, foothill yellow-legged frog, southern torrent salamander, and northern red-legged frog.

- *Northwest Forest Plan's Survey and Manage* — flammulated owl, white-headed woodpecker, pygmy nuthatch, red tree vole, Church's sideband snail, Klamath shoulderband snail, Oregon shoulderband snail, Pressley hesperian snail, and Hooded lancetooth snail.

Information on sightings of wildlife species of special status or concern that is currently available for the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area include bald eagle, northern spotted owl, peregrine falcon, northern goshawk, Pacific fisher, American marten, western pond turtle, and California wolverine. Focused field surveys have only been conducted on a limited number of wildlife species of special status or concern. The GIS-based wildlife sighting information was compiled and provided by the Forest Service.

Wildlife species occurrences within the watershed analysis area are presented in Map 3-11. The bald eagle has the longest sighting record available that dates back to 1973, and this species seems to occur mostly along the South Fork Trinity River, especially wintering birds. There is a known bald eagle nest site located on the boundary of Hidden Valley and Plummer Creek analysis areas. Also, there are two known peregrine falcon nest eyries located in the Plummer Creek analysis area. The only historic sighting of California wolverine was documented for the Hidden Valley watershed analysis area. Northern spotted owl, northern goshawk, Pacific fisher, and American marten have been documented in all three of the watershed analysis areas. There is a northern spotted owl core area delineated for the Hidden Valley analysis area, three core areas delineated for Plummer Creek analysis area, and four core areas delineated for Rattlesnake Creek analysis area. The western pond turtle occurrences illustrated in Map 3-11 does not include the information from fish and stream habitat surveys that was not available for this analysis.

The Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area has a wide range of potential habitats to support wildlife assemblages associated to late, mid-, and early seral stages; openings and multiple habitats; snags and downed wood; aquatic, riparian, and meadows; hardwoods and grasslands; and special habitat components (including seeps and springs, cliffs, cave, talus, and rock outcrops). Due to lack of available information on potential habitat distribution and wildlife species occurrences, descriptions of species-habitat associations in the analysis area are limited. Overall, more information is available for the threatened, endangered, and/or sensitive species in comparison to the Northwest Forest Plan's survey and manage and/or protection buffer species. The Northwest Forest Plan categories of wildlife species have only been an area of emphasis in recent years; thus, data capture from focused surveys has not been a priority historically. Very little is known on the wildlife species not listed as threatened, endangered, or sensitive species. Field survey efforts to gather more data on wildlife species of special status or concern are underway for the watershed analysis area and elsewhere on the Shasta-Trinity National Forest.

3.8 Cultural Heritage and Human Uses

The Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area is within a medium to high sensitivity zone for heritage resources. Archaeological sites in the analysis area include prehistoric, historic, and ethnographic sites.

South Fork Mountain is the most important archaeological zone in the analysis area and has been determined eligible to the National Register of Historic Places (M. Arnold, personal communication, 2001). Humans have used the long, continuous ridgeline and abundant natural resources for centuries. The Horse Pasture area, in the southeastern corner of the South Fork Mountain allotment, is particularly rich in Native American artifacts and was damaged by overgrazing, logging and gulling in the past. Along South Fork Mountain, logging has impacted many archaeological sites, but illicit collecting by the public may be causing even more damage (USFS 2000). The extensive road network along South Fork Mountain provides access and has made theft very easy.

Several thousand acres of land within the WAA have been extensively surveyed for archaeological resources. Archaeological and ethnographic survey coverage for the Hidden Valley watershed is approximately 12,000 acres, and coverage for the Plummer Creek and Rattlesnake Creek watershed is approximately 8,000 acres each. Fifty-three archaeological sites have been formally recorded within the WAA. Site types consist of forty-five prehistoric, four historic, and four multicomponent (both prehistoric and historic). Seventeen of these sites have been determined eligible for the inclusion on the National Register of Historic Places (NRHP), five have been found not eligible, and the remaining thirty-one sites have not been evaluated.

Selected cultural resource properties within the analysis area are managed and protected because of their significance. The Shasta-Trinity National Forest LRMP sets forth a list of attributes that are applied to specific heritage resource properties for consideration of significance. Such properties include:

- Sites that have been determined eligible for the NRHP
- Sites that have known scientific values that are highly important or unique and are conducive to long-term study
- Sites that have potential for interpretation of cultural resource values to National Forest visitors
- Sites that have cultural importance to Native Americans

There are eight archaeological sites within the WAA that have not been evaluated for the NRHP, however, they do exhibit one or more of the above attributes and are also considered significant.

4. REFERENCE CONDITIONS

The purpose of the chapter is to explain how watershed/landscape ecological conditions have changed over time as a result of human influences and natural disturbances. A reference is developed to describe the basic condition trends (comparison of current and reference conditions) over the timeframe that the system evolved, and comparison with existing key management plan objectives.

4.1 Geology

The physiography and geology in the WAA is the result of millions of years of geologic activity and has not changed significantly since Euro-American settlement. Some rates of erosion and mass wasting have increased due to management activities over the last 150 years, and those will be described in more detail in the Geomorphology section. Historically there was no significant mining in the analysis area, and impact from humans was minimal. It is likely that inner gorge areas of the S.F. Trinity River and some of its tributaries were less steep, and rock outcrops exposed by road cuts and patches of eroded soils were much less common.

4.2 Geomorphology

Prior to Euro-American settlement, the rate of sediment to delivery to streams in the WAA would have been lower than current rates. Geomorphic processes related to geologic planes of weakness such as deep-seated landslides on South Fork Mountain Schist and inner-gorge mass wasting in the Galice Formation along the S.F. Trinity River would have occurred, particularly during extreme rainfall events. However, sedimentation due to management activities as shown in Figure 3-1 would not have occurred prior to settlement, road building, and timber harvest. Approximately 34 percent of the current sediment sources in the WAA are attributed to management-related activities according to Raines (1998), which would not have occurred prior to Euro-American land management although there is considerable uncertainty with this estimate.

The healthy anadromous fish population that existed in the S.F. Trinity River basin prior to the 1964 floods indicates that sedimentation rates and geomorphic processes in the past were more favorable to those populations. While there have likely been flood events of equivalent or greater magnitude in the past, they likely delivered less sediment to the stream systems due to mature vegetation coverage, uncompacted soils, lack of roads, and undisturbed conditions in general. Wildfires would have cause brief periods of higher sedimentation rates, and the fire history of the area indicates that fires historically were of mixed severity with a return interval of 15 to 20 years (URS Greiner Woodward Clyde 2000).

4.3 Soils

Soils change very slowly through time. Soils prior to Euro-American settlement and land management would have had a different disturbance regime. Major disturbances to soils would have been periodic fires, high-intensity storm events, and landslides. Since Euro-American settlement, the soils have been subject to increased compaction across large areas due to road construction, trails, timber harvest activities, and other land uses. In addition, most land management activities can cause erosion, which would strip the surface layers of the soil to various depths. The hillslope and road erosion rates due to management discussed in the Geomorphology section represent erosion rates that are much higher than would have existed prior to Euro-American settlement.

4.4 Hydrology and Water Quality

Hydrologic characteristics of the WAA prior to Euro-American settlement were controlled by long-term climate trends, annual weather variations, and fire regime (which was partially influenced by Native Americans). Periodic fires influenced the water cycle in the WAA by removing vegetation, which reduces evapotranspiration, increases water yields and local sedimentation rates. The extent of these changes depends on the extent and severity of the fires, which were characterized as frequent, not very severe, and typically confined to the understory (URS Greiner Woodward Clyde 2000). This type of fire regime would have less of an impact than would be associated with the larger-scale stand-replacement fires.

Since settlement, the major influences on hydrologic characteristics of the WAA have been road building, timber harvest, grazing, and to a lesser extent than surrounding watersheds, mining. Road building influences the hydrologic characteristics of watersheds in various ways which is discussed in greater detail in the Roads section. Timber harvest also effects water yields by reducing evapotranspiration. Overgrazing can strip the land surface of vegetation and also directly alter the riparian function. All of these landscape-scale changes have likely changed how the watershed routes, stores, and releases water. Streams and rivers within the watershed likely had lower peak flows for floods below the about 25-year return interval, potentially lower water yields due to mature forest condition, and higher summer low flows due to greater infiltration rates into undisturbed soils.

Water quality was likely to be better prior to watershed-scale disturbance. The sedimentation rates discussed in the reference conditions for the Geomorphology section would have been lower prior to Euro-American settlement. Stream temperatures would also have been lower due to healthy and mature riparian vegetation established along streams and rivers. Other water quality parameters would have been within the natural range of variability, and pollutants commonly associated with modern civilization would have been non-existent.

4.5 Roads

No roads existed in the WAA prior to Euro-American settlement. Trails used by animals and Native Americans existed to an unquantifiable degree, but would not have had a significant impact on the watersheds compared to the current road network.

4.6 Riparian Habitat

Prior to the arrival of European settlers natural disturbances such as floods, landslides and debris flows, and fires were the dominant processes that influenced riparian conditions. A mosaic of riparian vegetative conditions existed due to the spatial and temporal separation between these natural events. It is likely that a higher percentage of large old trees existed in the riparian areas than upslope due to the generally higher humidity and cooler air temperatures that reduced the stand replacement influence of fire.

Riparian vegetation suffered as a result of timber harvesting and utilization of stream channels and floodplains as skid and haul roads during the 1950s and 1960s. The 1964 rainstorm and flood had a devastating effect on the riparian areas. Extensive landsliding and hillslope erosion caused severe damage to riparian vegetation. The sediment deposited in the channels elevated and widened the streambed. Flood flows eroded and destabilized newly unprotected inner gorge slopes which triggered shallow-seated slides and bank wasting. This resulted in further loss of riparian vegetation and soil productivity.

Non-timber riparian vegetation around wet meadows likely had higher species diversity and abundance than today. This may be due to the effects of livestock grazing, introduction of non-native plant species, and soil compaction. Logging has affected wetlands and riparian corridors through sediment delivery by the removal of trees and road construction. Forest canopy removal reduced shading, increased solar exposure and water evaporation.

4.7 Fish Habitats

Prior to the arrival of European miners and settlers in the South Fork Trinity River, aquatic habitat conditions and fish populations evolved almost entirely in response to natural events such as forest fires, landslides, floods, and drought. These episodes were of a periodic nature and varied in intensity across the landscape. These events introduced variability in habitat types and conditions that healthy fish populations depended upon. With the arrival of European settlers in the basin, came an accelerated level of disturbance that was more of a chronic rather than periodic nature. New disturbance regimes resulting from the effects of road construction, land clearing, mining, timber harvesting, water diversions, and residential development overlaid those already present from natural events. As development and resource extraction increased the ability of the watershed to recover from impacts decreased (URS Greiner Woodward Clyde 2000).

Native fish populations in the Klamath River basin sustained themselves in numbers sufficient to provide for lucrative fishing enterprises in the mid-1800s to early 1900s (URS Greiner Woodward Clyde 2000). Snyder (1931) reported commercial catches of chinook salmon in the Klamath River between 1913 and 1926 that ranged from 7,200 to 72,400 fish annually. The USFS (1999b) reported that declining fish populations were noted on the Trinity River as early as 1850, and were linked predominantly to mining-related sedimentation. An observer in Hoopa Valley noted in 1865 that the Klamath and Trinity Rivers were very muddy and almost deserted by salmon (Klamath River Basin Fisheries Task Force 1991). From 1860 to 1900 “hidehunters” were able to establish a lucrative business by selling fish and game from the South Fork to miners on the Trinity River (USFS 1998). Due to the absence of large scale mining and other land management practices, it can be theorized that the South Fork may have supported large populations of anadromous salmonids, and may have played an important role in the recovery and recolonization of these species on the Trinity River during the early 1900s (USFS 1999b).

Hidden Valley

The USFS (1999b) reported, “Recent history indicates the 1964 flood was the most significant event that affected fish populations and habitat conditions on the South Fork. Prior to 1963, spring chinook salmon runs were estimated to be between 10,000 and 12,000 fish, and steelhead populations were thought to be large and well distributed throughout the South Fork basin.

Dramatic declines in spring chinook populations were observed in the years following the 1964 flood, with fewer than 50 observed in the South Fork during some years in the 1970s and 1980s. A trend of increasing returns has been observed in the 1990s, although these fall far below the pre-1964 estimates." South Fork spring chinook populations are estimated to be between 400 and 1,000 fish (URS Greiner Woodward Clyde 2000).

The reason behind the decline in fish populations was thought to have resulted primarily from the deposition of sediment into the South Fork channel from landslides triggered by the 1964 rainfall and flood event. Depending on location, the channel experienced aggradation from 2.2 to 25 feet deep that filled in pools and widened the channel (PWA 1994). In some sections of the upper South Fork, where gradients were relatively high or the channel is naturally constricted, deep channel filling apparently never occurred. For example, at the Forest Glen gaging station the 1965 thalweg elevations were 2.2 feet above the pre-1964 elevation (PWA 1994). By contrast, Hyampom Valley exhibited fill deposits over 25 feet and channel widening of more than 65 feet (PWA 1994). The USFS (1999b) reported, "Healy (unpublished) noted signs of recovery beginning in 1969 as pools begin to deepen and fines begin to diminish in gravel bars. Rogers (unpublished) stated that only five pools exceeded six feet in depth between the East Fork Trinity River and Forest Glen during a 1970 survey. LaFuance (unpublished) indicated that recovery seemed to be progressing in a downstream direction with the best pool habitat observed above Silver Creek. Stream surveys in 1989 seem to substantiate this observation, revealing that the number of pools exceeding six feet in depth between the East Fork confluence and Forest Glen had increased to 28 (USFS 1989); and following a 1997 survey pools had increased again to 48 (USFS 1997)."

Rattlesnake Creek

Limited information was found concerning historical fish habitat conditions within the Rattlesnake Creek watershed. The earliest citation was from the USFS (1954), which reported that the area had an abundance of mink, bear, and deer. The stream was composed of large boulders along its entire length. The water level increased rapidly to a height of 6 or 7 feet during runoff periods. The caretaker of a lodge said that mostly salmon use the creek with a few steelhead. The gravel composition, exclusive of boulders, was 40 percent large, 15 percent medium, 15 percent small, 25 percent fines, and 5 percent sand and silt.

The USFS (1967) reported extensive mining from the mouth to Brown's Mine. Most of the mining was by ground sluicing and suction dredge, but hydraulic mining occurred at Brown's Mine. The stream was characterized as having many long riffle sections with small pools. A large amount of bedrock was exposed in the mined sections.

The USFS (1972) reported Rattlesnake Creek had a pool-riffle ratio of 1:1. Pools were formed by boulders. Watershed soil and channel were described as being stable. Substrate composition in pools and riffles averaged 10 percent boulders, 40 percent rocks, 19 percent rubble, 10 percent gravel, 20 percent sand, and one percent silt within the mouth to Post Creek reach.

As stated in Chapter 3 (Current Conditions), the USFS (1989b) reported Rattlesnake Creek to have a pool-riffle ratio of roughly 1:3. The average substrate composition was composed of 9 percent bedrock, 31 percent boulders, 25 percent cobble, 23 percent gravel, 11 percent sand, and one percent fines. It appears that there was a loss of pool habitat between 1972 and 1989, along with a coarsening of the streambed and winnowing out of sand and fine sediments. No USFS stream survey information was available for the years 1990 to 2000.

Plummer Creek

There is very little historic stream survey information available for Plummer Creek. The earliest reference on Plummer Creek in the USFS files was a stream survey conducted in 1982. The survey report rated the fish habitat as fair. The pool-riffle-run ratio was 40:50:10 in the lower section and 50:50:0 in the upper section. The USFS (1993) gave Plummer Creek a ratio of 1:1.7:3.7, reflecting a major change in habitat type composition. The USFS (1982b) survey had pool depths ranging up to 6 feet deep, whereas USFS (1993) reported a maximum depth of 2.1 feet. It is apparent that aggradation of the channel occurred that resulted in loss of pool volume and frequency. The USFS (1982b) report mentioned measures to decrease sediment inputs to the stream were appropriate. No USFS stream survey information was available for the years 1993 to 2000.

4.8 Forest Vegetation and Fire Disturbance

Prior to 1850 the major force which shaped the vegetation on a landscape level was fire. There were lightning caused fires, and there was also burning by Native Americans until the discovery of gold and the influx of settlers. An unpublished 1996 fire scar analysis in the Rusch Creek and Judd Creek watersheds, approximately five miles to the northeast of the subject watersheds, found that during the presettlement and settlement periods (prior to 1905) fire occurred somewhere in the approximately 7,000 acre study area on average once every two years, during the fire suppression period (1905 to 1995) this return interval decreased to less than once every four years. The study also found that, prior to 1905, fire returned to burn any one area once every 15 to 20 years; after 1905, this interval increased more than ten fold to greater than 200 years (C. Skinner, personal communication, 2001). The oldest conifers in the analysis area have large fire scars. The size and species distribution of these trees indicates a stand structure prior to 1850 which was generally an open stand consisting of large diameter ponderosa pine, sugar pine, and Douglas-fir. During the period between fires, a woody understory of brush, conifer seedlings and sprouts of hardwoods such as madrone, California black oak, and Oregon white oak would grow.

The serpentine areas are generally so unproductive that they rarely accumulate enough litter to carry a ground fire over a large area. Many of the open conifer stands on serpentine would have looked similar in 1850 to their current appearance. Large fires in adjacent stands on more productive soils will occasionally promote a stand replacing crown fire in a stand on serpentine. Some of the younger conifer aggregations on serpentine soils could have originated from a recent burn of brushfield.

The true fir stands in the higher elevations of the analysis area tend to have irregular periods between fires. Large diameter fir trees have a corky bark which helps to insulate them from a ground fire. Large fir trees will survive ground fires as well, or better than ponderosa pine. When there are long intervals between fires, the fir stands will slowly accumulate biomass and tree mortality will increase. A large accumulation of dead material will set the stage for a stand replacing crown fire. In 1850, the fir stands would have been a mosaic of different ages ranging from recently burned openings to patches with large diameter older fir trees.

Fire is the most important natural disturbance that has affected vegetation in the analysis area. Fire scar tree-ring studies from the Klamath Mountains indicate a pre-1850 fire return interval of having a median of 14.5 years; settlement period of 1850 to 1904 with 12.5 years; and the suppression period of 1905 to 1992 with 21.5 years. Initial data samples from a study by Skinner and Taylor (1998) on the Hayfork Ranger District indicates a similar fire return interval, but a larger number of fire starts. This is also a likely occurrence of the analysis area.

Fire regime studies in the Sierra Nevada suggest that forest ecosystems are outside their historical range of variability as to fire frequency and severity and associated stand structures (Skinner and Chang 1996). This is primarily the result of fire exclusion due to suppression efforts since the early 1900s. The exclusion of fire has been successful in minimizing low severity fires and most moderate severity fires which were characteristic of the pre-1850s. This fire exclusion has resulted in an increase in shrubs and understory trees. It has also increased the ingrowth of fire intolerant species and created more competition for moisture. These denser areas of understory have become ladder fuels, which can enable a fire to reach the overstory canopy resulting in stand replacement fires. This scenario in the Sierra Nevada is also likely to be characteristic of this analysis area.

It was common for Native Americans to set fires for cultural purposes. It is likely that the forests at that time were composed of a relatively open overstory of large mixed conifers, with a sparse conifer and hardwood understory and light shrub layer. There were probably fewer dead and down ground fuels and fewer ladder fuels composed of shade intolerant understory trees. Before fire suppression occurred in the early 1900's, it is likely that there were more annual fires that were generally of low severity and stayed on the ground.

Fire history records (1985 to 1995) for the Hayfork Ranger District show that 55 percent of the fires are lightning caused, and 45 percent are human caused (see Appendix E, Fire Family Plus-related data). The largest recent fire in the watershed analysis area was in 1987 during a series of lightning fires that struck the Shasta-Trinity National Forest. The Peanut Fire burned 6,260 acres, the Friendly Fire burned 3,463 acres, and the Tule Fire burned 994 acres, all were lightning caused.

The fire history also shows that suppression success during the first half of the 20th century was good, but as the fuels began to build up suppression success began to decrease. The larger fires became larger and more difficult for the modern suppression resources to keep below 100 acres. The fires also became more damaging to existing resources.

4.9 Commercial Timber

Commercial timber harvesting in the past decade has been very limited, especially compared to the previous decades going back to post World War II when commercial timber harvesting started on a significant scale. The only recent harvesting has been sanitation-salvage timber sales. Sanitation-salvage timber sales target dead, dying, and diseased trees. The absence of relatively frequent, low intensity fires in the analysis area has most likely contributed to a higher than normal incidence of dwarf mistletoe infestations, which in turn exposes the weakened trees to attack by insects and other pathogens.

4.10 Plants of Special Concern

The diversity of life forms and habitats involved makes it difficult to generalize reference conditions for species of concern. However, old-growth forest and natural lowland habitats were more widespread and all habitats were less fragmented than those existing currently. Plant and fungi species of concern evolved in response to natural disturbance cycles, which varied in intensity and recurrence depending upon climatic events and geologic processes. Currently these species are affected by natural events, but anthropogenic impacts have become significant influences on the species of concern. Anthropogenic impacts from a variety of activities such as grazing, logging road construction, rural development, fire suppression, mining and recreation have changed the natural vegetation dynamics of the watershed analysis area. These impacts have resulted in habitat fragmentation and loss, and the introduction of exotic species (i.e., domestic animals and noxious weeds).

The habitats associated with many of the species of concern are serpentine substrates, meadows, rock outcrops, and wetlands for the vascular plant species, and mature forests and large woody debris for many of the non-vascular plant and fungi species (Table 3-35). The habitat quality and population levels of serpentine-associated species fluctuated according to broad climatic patterns and geologic processes. Succession is very slow on these substrates and is dictated by long-term soil weathering and erosion processes. Wildland fire impacts were limited, as fuel levels in these open woodlands were too low to carry a high intensity wildfire. Though recent activities such as road building have caused fragmentation and loss of serpentine habitat, serpentine substrate distribution was relatively unchanged from pre-European times. Naturally occurring islands of ultramafic rock intrusions that support serpentine substrates exist primarily in western Plummer Creek, southern Plummer Creek and Hidden Valley, and all of Rattlesnake Creek watersheds.

In pre-European times, changes in the vegetation on rock outcrops were influenced by fluctuations in climatic patterns and geologic processes and to a lesser extent with periodic wildfires. Although rock outcrops are relatively impervious to fire, the heat and flames could have resulted in a loss of rock-dwelling species and the destruction of adjacent trees. The loss of adjacent trees may have resulted in a temporal alteration of shade and moisture on a rock outcrop. Since European settlement, rock outcrops and associated plant species were further impacted with logging, road building, and excavation activities. A loss and degradation of habitat for rock-dwelling species resulted from these activities; however, the distribution of rock outcrops on the landscape has not changed significantly since pre-European times.

The distribution of wetlands have naturally evolved and changed significantly throughout time with geologic processes and changes in hydrologic regimes. In pre-European times, the habitat and population levels for wetland species fluctuated with the availability and extent of water, temperature and light. Periods of drought and flooding as well as events that restructured topography such as erosion and earthquakes have influenced wetland distribution. After European settlement, wetland species were further impacted with alteration or elimination of habitat. Activities such as road building, mining, logging, and grazing affected wetland conditions. Road building had significant aquatic/riparian habitat impacts. Roads constructed through wetlands resulted in the concentration or diversion of water. This could have dewatered wetlands or created new wetlands. Mining also diverted water and altered topography, and had similar effects as roads. Logging has affected wetlands and stream-riparian corridors. Forest canopy removal eliminated shade and increased exposure and water evaporation.

Grazing has had impacts on wetland species and habitat. Wetlands often focus grazing impacts due to availability of water and moist vegetation, especially in summer months. This has lead to the consumption of wetland vegetation, the trampling of vegetation, and the structural degradation of the wetlands. Several serpentine fens are present in the analysis area, particularly in Rattlesnake Creek and Plummer Creek watersheds. Cattle and wildlife are naturally attracted to these localized areas of water and lush foliage surrounded by dry forest which often provides only minimal forage, and trampling impacts to these areas are obvious. Pre-European wildlife grazing impacts were likely less degrading than those from cattle, despite low numbers being grazed in allotments currently. A fence has been constructed around Seven-up Cedars to reduce cattle impacts. Bull thistle and other non-native plants have been introduced through cattle waste.

Lastly, there are several non-vascular plant and fungi species of concern that are associated with mature forests and large woody debris, a common component of late-successional/old-growth forests. This habitat stage was more widely available in pre-European forest conditions. The absence of high fuel loading yielded lower intensity wildfires that were less destructive to this habitat. Fire suppression and logging have reduced the available habitat through the introduction of higher intensity fires and removal of mature forests and associated components.

4.11 Noxious Weeds

Noxious weeds have become naturalized with European settlement. Importation of noxious weed seeds and disturbance of natural vegetation associated with European settlement (i.e., development, logging, road building, mining, and grazing) has provided opportunities for noxious weeds to obtain a foothold and proliferate in the watershed analysis area. Road building and transportation use has further assisted the dispersal of noxious weed seeds. Currently, all the species of noxious weeds present and the extent of infestation in the analysis area are not known.

The noxious weeds were not part of the vegetation component or not a problem in pre-European times. Nearly all of the noxious weeds have become naturalized since 1769 when the Spanish colonists arrived in California (USFWS 1999). With European settlement, many non-native plant species were purposefully or incidentally introduced to provide forage for livestock or landscaping for homesteads. The disturbance pattern in the watershed analysis area associated with development, road building, logging, mining, and grazing have assisted in the introduction and spread of noxious or invasive exotic weeds.

4.12 Land Use for Grazing

The grazing history of the watershed analysis area as a whole is thoroughly presented elsewhere (USFS 2000), and it is only summarized here.

The forested lands surrounding the valleys were public domain used as open grazing from around 1860. Stockmen established a pattern of burning the underbrush when the stock was removed to increase accessibility and promote new plant growth. Subsequently, stock raising and mining were the primary industries in the Shasta-Trinity National Forests. Burning on the grazing allotments ceased by around 1920, under Forest Service management directions. Grazing reached a peak just prior to World War II, with sheep being a significant factor. In the 1940s through 1990s grazing on National Forest System lands continued at a much-reduced level of intensity in the Lamb Gap, South Fork Mountain, and Post Creek allotments, with an emphasis on horses and cows.

Currently, 152 animals per year graze on the Lamb Gap, South Fork Mountain, and Post Creek Allotments- less than 25 percent of the permitted numbers. Impacts from grazing are light, except for within wet seeps and meadows where cattle tend to congregate because of lack of water and limited forage in the uplands.

4.13 Wildlife Habitats and Species

The reference conditions would be discussed in three timeframes that include: pre-European settlement (pre-1850), 1850 to Federal ownership (1905), and 1905 to present. Within these different timeframes, human population, land use, vegetation, and land management have changed significantly. Disturbance would be the focus of the discussion here, since disturbance, recovery, and stability is the process that shape ecosystems (Perry and Amaranthus 1997).

Vegetation in the watershed analysis area has changed over time as regional climate changed. The vegetation patterns would shift with long-term climate changes, and vegetation communities respond to short-term climate fluctuations. Historically, climate has changed alternating between warm and dry to cool and wet periods. Prior to 1850, the disturbances in the analysis area could have been wildland fires, flooding, and wind. These natural disturbance agents would have been acting on pristine terrestrial, riparian, and aquatic ecosystems. The fire regime that existed prior to 1850 resulted from the interaction of the cooler climate and fires caused by lightening and by the burning practices of American Indians. Prior to 1850, fires were generally frequent and most were low to moderate in intensity. Fires were the major mechanism for reducing fuel, although the harvest of firewood by American Indians may have been a contributing factor in areas near settlements. Changes in fire regimes, which are related to climate change as well as land use patterns, would directly affect vegetation composition and structure. Prior to 1850, the overall impact to wildlife species was related to subsistence hunting and domestication of animals.

Migration of European settlers to the west began during the period of 1850 to 1905, especially during the California gold rush. The regional population began to see an increase, and forestlands were cleared for homesteads. Early settlers began ranches for livestock and farming in lowlands of the region. Fire was used to clear forestlands and improve pasturelands. The early mining operations caused damage to the riparian and aquatic ecosystems. Despite this situation, wildlife species associated to terrestrial, riparian, and aquatic ecosystems had relatively high population levels during this timeframe.

From 1905 to present, the forested landscape in the analysis area had changed significantly. Vegetation composition and structure have changed as a result of timber harvesting and wildland fires. Fire regimes changed from frequent, low to moderate intensity to less frequent, high intensity fires. Fire suppression effort has modified the fire regime in the analysis area. Timber harvesting since after World War II has altered the landscape-level habitat pattern that existed for terrestrial, riparian, and aquatic wildlife species. Forest stand conditions changed during this timeframe, with higher stocking levels as a result of fire suppression. Wildlife species management emphasis has changed during this time frame, with moving from game species to non-game species emphasis. Earlier management directions for game species management that promoted more ecotone/edges had to be changed to develop more forest interior and late-successional/old-growth habitats.

Prior to relatively effective fire suppression starting around the turn of the century, late-successional/old-growth habitat was likely restricted to northeasterly slope aspects and the bottom third of slopes on other aspects. The upper two-thirds of southwesterly slope aspects were likely dominated by much more open (sparse canopy cover) ponderosa pine rather than Douglas-fir forest. Relatively frequent low intensity fires maintained this general pattern, as intense stand-replacing fires were rare. Overall, late-successional/old-growth stands were probably more resistant and resilient to disturbance such as fire than they are today. No reliable information is available to characterize the historic levels of late-successional/old-growth habitat-related species occurrence or relative abundance.

Overall, the forest conditions have changed overtime as a result of human-induced and natural disturbances. The human-induced disturbances are expected to increase as human population increases. Conflicts between land use and wildlife resources protection tend to have increased in recent years. Loss of vulnerable habitats such as late successional/old-growth forest, riparian and wetland, and aquatic habitats are of overall concern.

4.14 Cultural Heritage and Human Uses

Archaeological research has focused on cultural resource management activity associated with various Forest Service projects, with most of the archaeological inventories occurring in areas managed for multiple-use. Archaeological and ethnographic evidence associated with prehistoric land use includes sites at locations along the Trinity River, South Fork of the Trinity River, and South Fork Mountain. Evidence from archaeological investigations suggests early human occupation of the Hidden Valley, Plummer Creek, and Rattlesnake Creek watershed analysis area occurred between 5,000 to 10,000 years ago.

The earliest Native American group to inhabit the analysis area was the Chimariko, however, by late prehistoric time the Chimariko territory and population had been reduced significantly by encroaching neighboring Native American groups. Precedent groups who occupied portions of the analysis area include the Hupa, Chilula, Whilkut, and Wintu.

Settlement patterns within the analysis area were focused around seasonal resource availability along streams and upland ridgelines. Subsistence included riverine resources, seed and nut gathering, hunting, and collection of plant material for utilitarian use. Controlled burns of their resource areas were utilized to promote forage for deer and other game animals, growth of desired plants, and increase edible seed yield.

The prehistoric groups of the analysis area also utilized a network of established trails for travel between villages, seasonal localities, and the distribution of trade goods. Along the trails were traditional stopping places or spots which held special religious or eventful meanings (Moratto 1984; Silver 1978). Euro-American explorers and trappers were among the first to benefit from the established routes, followed by the influx of settlers. Some of these trails evolved into roads and are still used for travel.

Human presence and use of the analysis area began between 5,000 to 10,000 years before present. Prehistoric occupation or activity is evident in the form of physical remains such as lithic scatters (chipped tools and ground stone).

1830 – 1840

Early Euro-American explorers and trappers traveled through the present Trinity Forest.

1850 – 1905

Early settlement by Euro-Americans was focused around farming and ranching in the Hyampom Valley, and mining along the South Fork of the Trinity River and Hayfork Creek.

Gold mining was introduced in mid-1850 along the Trinity River and its tributaries. The large influx of miners (Euro-American and Chinese) encouraged settlements for services and supplies. Placer mining was initiated in 1857, and hydraulic mining began in the 1870s. Evidence of the mining history is preserved in a number of recorded mining sites and settlements, ditches, and tailing piles.

The increase in population encouraged ranchers to homestead in the area and pursue grazing and agricultural production. Domesticated stock that grazed included cattle, sheep, and horses. Hay, wheat, onions, and potatoes were exported to mining camps and outlying areas.

Sawmills arose in outlying areas to supply wood products for the ranchers and miners.

1905 – 1945

The Trinity Forest Reserve was established on April 26, 1905 and the management of public forestlands transferred to the Department of Agriculture- Bureau of Forestry, which became known as the Forest Service. Early Forest Rangers spent much of their time administering grazing allotments, examining homestead claims, building trails, and patrolling and fighting fires. Early Ranger Stations were often private homes of the Rangers. The 1907 Trinity National Forest Atlas shows Ranger Stations on Carr Creek and the East Fork. The Hayfork Ranger Station was established in 1913 on land donated by Jake Kelly.

Mining and stock raising were the primary industries on the Trinity National Forest in the early years, although timber production increased with time. The important commercial woods were red fir, sugar pine, yellow pine, incense cedar, and white fir. A number of hard rock gold mines, located in quartz veins along the edges of the valley and canyon, continued operations in the decades after 1900. Grazing reached a peak just prior to World War II, with sheep being a significant factor. Burning on the allotments ceased by around 1920 under Forest Service regulations.

1945 – 1990

Timber production became a major economic interest after World War II, with lumber products headed for national and international markets. The percentage of the population of Trinity County that was employed in lumber and wood products rose from 2 percent in 1940 to 36 percent in 1950. Grazing of public lands continued with an emphasis on horses and cows.

Environmental concerns of the 1970s gradually changed Forest Service management policies from a focus on timber commodity production to one of ecosystem management for ecological sustainability.

5. SYNTHESIS AND INTERPRETATION

The purpose of this chapter is to compare current and reference conditions of specific ecosystem elements and to explain significant differences, similarities, or trends and their causes. The capability of the system to achieve key management plan objectives is also evaluated. Basically, this 5th step of the six-step ecosystem analysis process is intended to bridge Step 3 (Current Conditions) and Step 4 (Reference Conditions) by conditions comparison and trend evaluation. Current and reference conditions are discussed here in the context of the core issues and related key questions identified in Chapter 2.

5.1 Erosion Processes

What are the natural and human causes of change between the historical and current erosion processes in the watershed? What are the influences and relationships between erosion processes and other ecosystem processes?

5.1.1 Erosion/Sedimentation – General Trends

The geomorphic response of an entire river basin is difficult to predict. This is especially true in the S.F. Trinity River watershed because the geology and geomorphologic characteristics are complex and subject to a variety of interrelated processes.

Figure 5-1 shows the sediment delivery trends for the three time periods studied by Raines (1998). Management and non-management sediment sources within the entire upper S.F. Trinity River basin, which includes the WAA, were tracked for the study period. There had been some timber harvest in Hidden Valley watershed prior to the study, but not in Plummer or Rattlesnake Creek watershed. Therefore, this study represents the period of major change within the WAA, but does not extend back to pre-settlement times.

5.1.2 Mass Wasting

Mass wasting is a naturally occurring process in the WAA. As depicted in Figure 3-1, non-management related mass wasting contributed 50 percent of the total sediment load in the S.F. Trinity River basin during the study period of 1944 to 1990 (Raines 1998). Although Figure 3-1 is averaged over the entire time period and includes road construction, land management, fires, and flood events, the high level of non-management related mass wasting indicates the inherent instability of the terrain. Table 5-1 lists the upper 10 percent of the subwatersheds with the most landslides per square mile that were visible on aerial photos from 1944 to 1990. Inactive landslides are abundant throughout the South Fork Mountain Schist and Rattlesnake Creek Terrane. However, little data are available on the processes and extent of sedimentation from landsliding prior to settlement and land management within the WAA (and prior to the first set of aerial photos in particular).

The majority of landslides occur during the 1960 to1975 time period, which included the historic 1964 flood (Raines 1998). About 11 percent of all existing landslides also enlarged during this, or the subsequent, time period and contributed about 40 percent of the sediment delivered during that time period. Mass wasting sediment loads decreased significantly in the 1975 to 1990 period, which Raines (1998) attributes to the lack of intense storms and flood events.

The ratio of management to non-management related landslides within the whole basin has increased over time from 0.41 in 1960 to 0.64 in 1975 to 1.4 in 1990. Raines (1998) attributes this trend to the cumulative increase in road building and harvest activities within the basin. For the WAA in particular, this relationship is reflected in the management to non-management mass wasting ratio for the three watersheds: 0.13 in Hidden Valley, 0.08 in Plummer Creek, and 1.69 in Rattlesnake Creek. Rattlesnake Creek has double the road density of Plummer Creek watershed.

Management activities have clearly contributed to the mass wasting sediment contribution within the WAA. Landsliding peaked during the 1960 to 1975 time period, coinciding with dramatic increases in road building and harvest and with more frequent intense flood events. Since that time, management practices have improved and the amount of road building and harvest has decreased considerably since the late 1980s.

The effects of the 1987 fires are of concern for mass wasting and erosion. Tree roots contribute to soil cohesion in soils on forested hillslopes, and as root systems decay following fire, the likelihood of mass wasting increases. A study cited by Sidle (1992) in a Douglas-fir forest in the Oregon Coast Range determined that soil cohesion decreases for the first five to seven years following clearcutting and then slowly increases over the next twenty years as the forest regenerates. In the WAA, areas where trees were killed by the 1987 fires will be at higher risk for mass wasting until the forest fully regenerates in another 10 to 15 years, particularly along the inner gorge of the S.F. Trinity River underlain by the Galice Formation.

5.1.3 Road-related Erosion

Roads serve numerous beneficial purposes, but problems associated with roads have received increased attention in the past decade. This increased focus on the costs and benefits of forest roads has led to policy changes and roads related research published by the Forest Service. A roads analysis procedure has been developed in "Roads Analysis: Informing Decisions About Managing the National Forest Transportation System" (USFS 1999c), and a comprehensive literature review of the impacts of roads has been published in "Forest Roads: a Synthesis of Scientific Information" (Gucinski et al. 2001).

Roads have both direct and indirect effects on watersheds. Any erosion or sedimentation caused by roads represents a human caused change from natural or historic erosion processes. Roads contribute a significant amount to the total sediment budget for the basin, accounting for 17 percent of the total sediment for the 1944 to 1990 time period (Figure 3-1). Roads contributed 4 percent of the sediment yield through mass wasting, leaving 13 percent attributed to surface erosion, washouts, gullies, and landslides too small to show up on the aerial photos.

As Figure 5-2 shows, road erosion rates increased substantially from the 1944 to 1960 time period to the 1960 to 1975 time period due to the increased road construction in most of the WAA. From 1975 to 1990, road-related mass wasting declined (see Mass Wasting section above), and surface erosion, gullies, washouts, and small landslides decreased slightly.

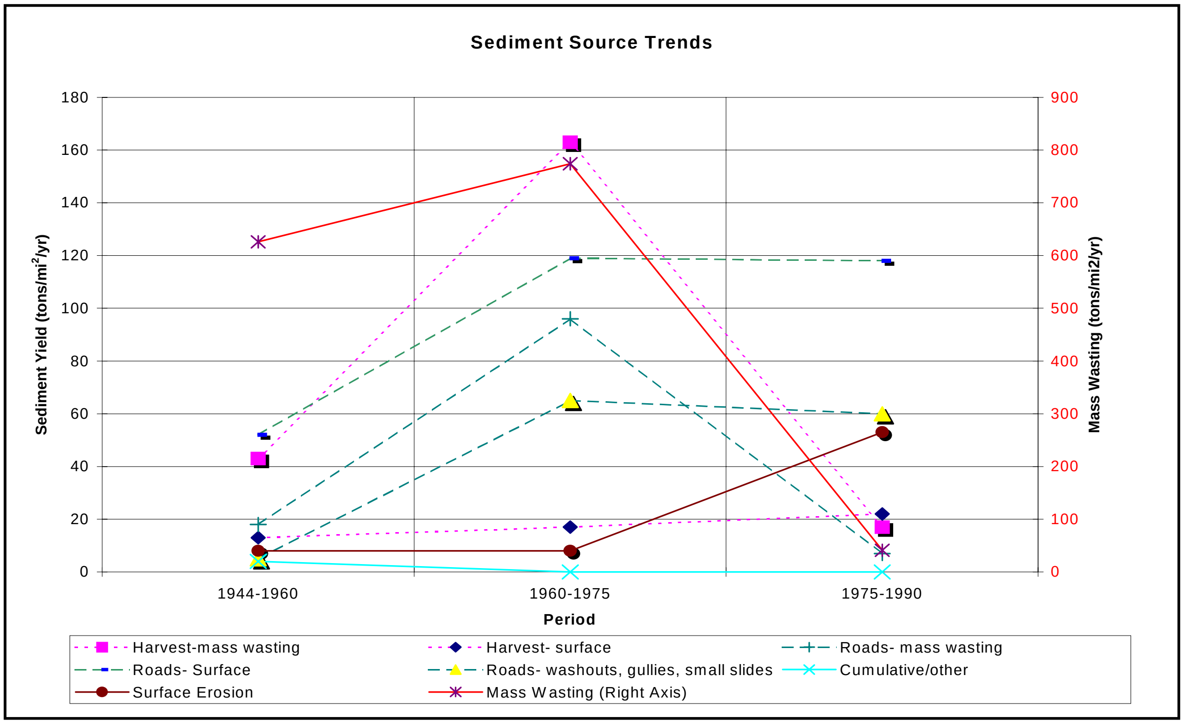


Figure 5-1. Sediment Source Trends for the S.F. Trinity River Basin. Adapted from Raines (1998).

Table 5-1. Upper 10 Percent of Subwatersheds in WAA with Highest Landslide Density. (Overall Ranking Matrix is in Appendix F).

Subwatershed[1]	Square Miles (acres)	NFS lands (% area)	Number of Landslides	Landslide Density (#/sq. mi)
HV – 9	0.8 (519.9)	19.8	3	3.7
HV – 37	0.1 (61.7)	100.0	1	10.4
HV – 43	0.3 (209.5)	93.5	2	6.1
HV – 92	0.9 (563.0)	59.6	4	4.5
PC – 96	0.2 (154.1)	66.0	5	20.8
HV – 119	0.6 (384.3)	93.1	4	6.7
PC – 123	1.7 (1110.9)	51.7	7	4.0
HV – 127	0.1 (49.8)	78.6	1	12.9
HV – 131	0.5 (319.2)	43.8	3	6.0
PC – 133	0.7 (471.3)	100.0	4	5.4
PC – 135	0.3 (163.4)	80.6	1	3.9
PC – 220	1.8 (1167.5)	86.1	10	5.5
HV – 228	1.7 (1099.4)	48.9	9	5.2

[1]HV - Hidden Valley; PC - Plummer Creek; and RC - Rattlesnake Creek.

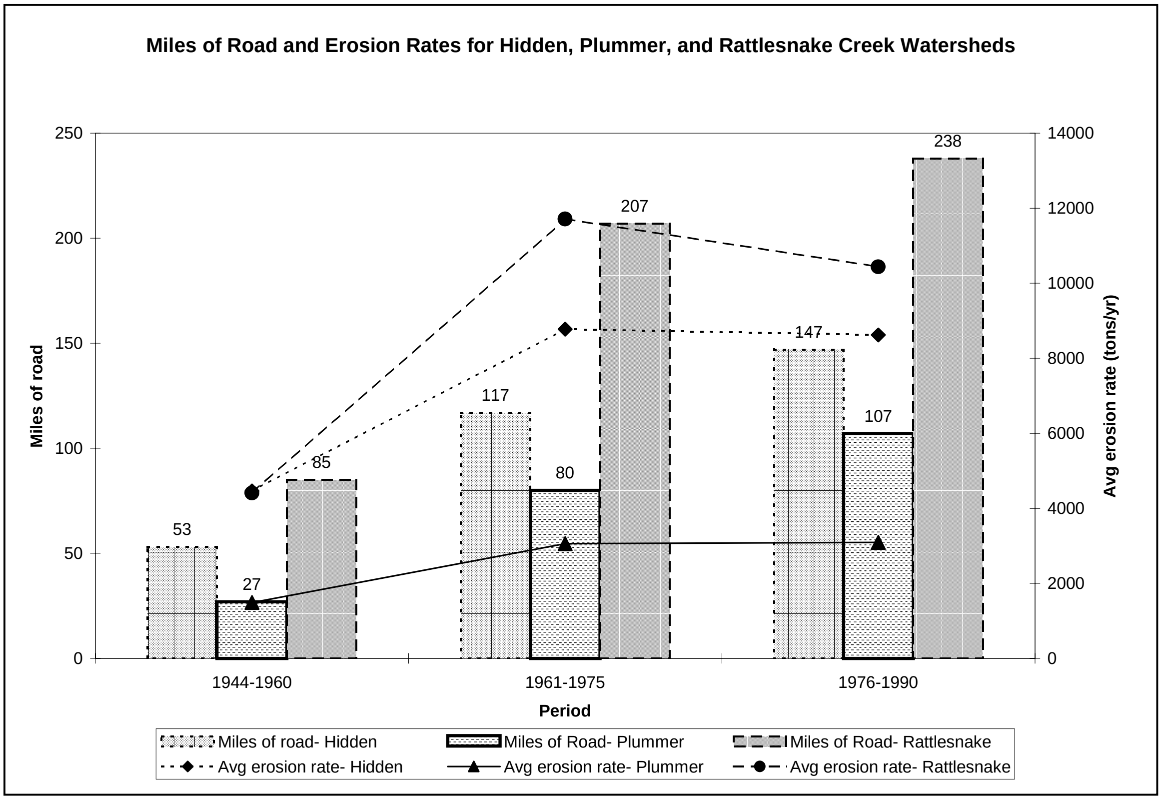


Figure 5-2. Miles of Road and Average Erosion Rates for Hidden Valley, Plummer Creek, and Rattlesnake Creek Watersheds for Three Time Periods. Adapted from Raines (1998).

Decreased road construction, improved engineering methods, and fewer major storms resulted in less road-related erosion during this period.

Since 1990, road construction and most timber harvest activity have ceased within the WAA, and traffic levels have declined as well. Raines (1998) noted that traffic levels on unpaved roads was the most significant factor in surface erosion rates and predicted that with reduced traffic volumes the surface erosion rate would drop by a factor of 4 or 5 from 1975 to 1990 levels. If data were available, the erosion rates displayed in Figure 5-2 would likely exhibit a downward trend over the next time period, but would level off as traffic levels reached a base level. Table 5-2 lists the upper 10 percent of subwatersheds that have the highest densities of sediment delivering road segments based on the SEDMOD model results by Raines (1998).

As described briefly in the Hydrology section in Chapter 3, roads can affect the hydrologic characteristics of a watershed by intercepting rainfall and overland flow, concentrating flows, and diverting or re-routing surface or subsurface flow (Gucinski et al. 2001). Roads can reduce site productivity by compacting soils, causing erosion, and removing soils from production. Ecological changes include habitat fragmentation, changes in habitat type, providing a route for biological invasion, and indirect changes to aquatic habitats and water quality (Gucinski et al. 2001).

The extent of these changes on the landscape depends on how the road is constructed, where in the landscape it is located, the density of roads, the number of times it crosses stream channels, the level and type of use, and other factors. The Rattlesnake Creek watershed has the highest road density of all of the watersheds in the S.F. Trinity River basin at about 5.2 miles per square mile. Hidden Valley and Plummer Creek watersheds have lower road densities at 3.8 and 2.6 miles per square mile, respectively (Table 3-17). A road density above three miles per square

Table 5-2. Upper 10 Percent of Subwatersheds in WAA with Highest Density Sediment Delivering Road Segments. (Overall Ranking Matrix is in Appendix F).

Subwatershed[1]	Square Miles (acres)	NFS lands (% area)	Length of Sediment Delivering Roads (mi)	Density of Sediment Delivering Roads (mi/ sq. mi)
HV – 10	0.9 (591.1)	50.6	2.7	2.9
PC – 107	1.7 (1062.8)	100.0	4.9	2.9
RC – 146	1.1 (687.2)	100.0	3.3	3.1
RC – 153	1.7 (1116.2)	100.0	5.0	2.9
RC – 156	2.4 (1508.0)	55.5	8.2	3.5
RC – 157	0.5 (328.1)	100.0	1.8	3.5
RC – 161	0.9 (564.3)	9.3	3.9	4.4
RC – 164	2.0 (1307.7)	58.0	7.8	3.8
RC – 173	0.6 (387.4)	30.9	1.8	3.0
RC – 177	0.7 (435.2)	10.9	2.3	3.3
RC – 178	1.7 (1119.9)	100.0	5.8	3.3
RC – 195	0.7 (474.6)	100.0	3.2	4.4
RC – 208	0.3 (192.8)	89.5	1.1	3.7

[1] HV- Hidden Valley; PC- Plummer Creek; and RC- Rattlesnake Creek.

Table 5-3. Upper 10 Percent of Subwatersheds in WAA with Highest Road Density. (Overall Ranking Matrix is in Appendix F).

Subwatershed[1]	Square Miles (acres)	NFS Lands (% area)	Length of Road (mi)	Road Density (mi/sq. mi)
HV – 8	0.1 (53.9)	0.4	0.7	7.9
RC – 146	1.1 (687.2)	100.0	7.5	7.0
RC – 153	1.7 (1116.2)	100.0	10.6	6.0
RC – 156	2.4 (1508.0)	55.5	17.3	7.3
RC – 158	1.2 (759.7)	100.0	7.7	6.5
RC – 161	0.9 (564.3)	9.3	5.2	5.9
RC – 164	2.0 (1307.7)	58.0	12.4	6.1
RC – 173	0.6 (387.4)	30.9	3.6	5.9
RC – 177	0.7 (435.2)	10.9	4.8	7.1
RC – 178	1.7 (1119.9)	100.0	10.1	5.8
RC – 195	0.7 (474.6)	100.0	4.6	6.2
RC – 208	0.3 (192.8)	89.5	2.3	7.6
RC – 217	0.9 (581.5)	99.7	5.4	6.0

[1] HV- Hidden Valley; PC- Plummer Creek; and RC- Rattlesnake Creek.

mile is considered high by some standards (e.g., greater than three is considered high for estimating watershed sensitivity in the Herger-Feinstein Quincy Library Group Forest Recovery Act FEIS, Appendix N, USFS 1999a). Table 5-3 lists the upper 10 percent of subwatersheds within the WAA with the highest road density.

Riparian areas play an important role in the maintenance of healthy aquatic ecosystems. Roads in riparian zones and valley bottoms can have more impacts to stream ecosystems due to their close proximity. Effects include delivery of sediment to watercourses, removal of riparian vegetation that provides shade and allochthonous material, destabilization of hillslope toes, confinement of stream channels, filling of the floodplain, and others. McGurk and Fong (1995) noted a decrease in biotic diversity in streams where equivalent roaded acres (ERA) exceeded 5 percent within 328 feet of a stream. While roads are not the only factor that contributes to the ERA, they are a permanent and significant contributors to landscape change. In examining cumulative watershed effects in the Sierra Nevada, Menning et al. (1996) also emphasized the importance of activity in the riparian zones and recommended higher disturbance coefficients for modeling roads and management within the riparian zone. Rattlesnake Creek watershed has double the road density in riparian zones in comparison to the other two watersheds in the WAA (Table 3-18). Table 5-4 lists the upper 10 percent of subwatersheds in WAA with the highest riparian road densities.

Table 5-4. Upper 10 Percent of Subwatersheds in WAA with Highest Riparian Road Density. (Overall Ranking Matrix is in Appendix F).

Subwatershed[1]	Square Miles (acres)	NFS Lands (% area)	Length of Road in Riparian Reserves [2]	Riparian Road Density [2] (mi/sq. mi)
HV – 10	0.9 (591.1)	50.6	5.8	6.3
PC – 96	0.2 (154.1)	66.0	1.5	6.2
PC – 107	1.7 (1062.8)	100.0	10.1	6.1
RC – 146	1.1 (687.2)	100.0	7.8	7.3
RC – 158	1.2 (759.7)	100.0	18.2	15.4
RC – 161	0.9 (564.3)	9.3	6.4	7.3
RC – 164	2.0 (1307.7)	58.0	16.1	7.9
RC – 173	0.6 (387.4)	30.9	4.0	6.6
RC – 176	1.3 (850.2)	96.0	8.8	6.6
RC – 178	1.7 (1119.9)	100.0	12.1	6.9
PC – 194	0.8 (540.8)	89.0	5.4	6.4
RC – 195	0.7 (474.6)	100.0	6.1	8.2
RC – 208	0.3 (192.8)	89.5	3.7	12.4

[1] HV- Hidden Valley; PC- Plummer Creek; and RC- Rattlesnake Creek.

[2] Area in Riparian Reserves was calculated by applying the Shasta-Trinity National Forest LRMP (USFS 1994a) guidelines of 300 feet on each side of fish bearing streams, 150 feet on each side of permanently flowing non-fish bearing streams, and 100 feet on each side of seasonally flowing or intermittent streams.

The most critical area for road-water interactions is where the road meets a stream channel. The number and density of stream crossings can be used as an indicator of potential impacts to streams from roads (Tables 3-19 and 5-5). The road-stream crossing densities shown in Table 3-19 are extremely high by most standards (greater than two is given a high rating for estimating watershed sensitivity in the Herger-Feinstein Quincy Library Group Forest Recovery Act FEIS, Appendix N, USFS 1999a). The majority of the crossings are in the smaller ephemeral streams, which may not be as accurate in the GIS stream layer. Rattlesnake Creek, with its high road and stream densities, has a large number of both ephemeral and intermittent stream crossings. There is an ongoing discussion about the importance of impacts in smaller ephemeral draws. However, even with ephemeral stream crossings removed from the density calculation, the densities are still high at 3.3, 2.1, and 4.4 crossings per square mile for Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds, respectively.

Table 5-5. Upper 10 Percent of Subwatersheds in WAA with Highest Road-Stream Intersections Density. (Overall Ranking Matrix is in Appendix F).

Subwatershed[1]	Square Miles (acres)	NFS Lands (% area)	Number of Road-Stream Crossings	Road-Stream Crossing Density (#/sq. mi)
RC – 144	0.7 (457.7)	100.0	11	15.4
RC – 146	1.1 (687.2)	100.0	26	24.2
RC – 147	2.3 (1451.9)	60.3	36	15.9
RC – 153	1.7 (1116.2)	100.0	42	24.1
RC – 158	1.2 (759.7)	100.0	23	19.4
RC – 164	2.0 (1307.7)	58.0	38	18.6
RC – 168	0.6 (391.0)	100.0	10	16.4
RC – 171	0.9 (581.5)	100.0	16	17.6
RC – 178	1.7 (1119.9)	100.0	28	16.0
RC – 183	0.6 (371.7)	93.6	9	15.5
HV – 189	1.0 (665.4)	100.0	17	16.4
RC – 195	0.7 (474.6)	100.0	14	18.9
RC – 208	0.3 (192.8)	89.5	7	23.2

[1] HV- Hidden Valley; PC- Plummer Creek; and RC- Rattlesnake Creek.

Other factors that could potentially indicate whether a road is in a sensitive location include slope and the underlying geology. As described in Chapter 3, roads located in the South Fork Mountain Schist have higher observed erosion rates. In addition, the Galice Formation is extremely unstable and roads built on this geologic formation could have higher failure rates. Slope is a factor identified in Menning et al. (1996) as having an increased impact for ERA analysis when slopes exceed 40 percent. Table 5-6 lists the upper 10 percent of subwatersheds in WAA with the highest road densities on both sensitive geology types (Galice Formation and South Fork Mountain Schist) and slopes greater than 35 percent (slopes greater than 30 percent are considered moderately steep to steep and potentially unstable [R-5 FSH 2509.22, 31.1.4, 1987]).

5.1.4 Streambank Erosion

Raines (1998) estimated that streambank erosion accounted for about 14 percent of the sediment supply in the S.F. Trinity River basin (Figure 3-1). Raines (1998) did not differentiate management from non-management caused streambank erosion due the difficulty in determining the cause. Several factors that influence streambank erosion rates include the substrate geology, riparian conditions, sediment storage in streambanks, stream stability, landslides ending in the floodplain, sediment loads, undercut banks, and other factors. The relationships between these factors are complex and difficult to predict.

Table 5-6. Upper 10 Percent of Subwatersheds in WAA with Highest Road Density in Galice Formation or South Fork Mountain Schist and on Slopes Greater than 35 Percent. (Overall Ranking Matrix is in Appendix F).

Subwatershed[1]	Square Miles (acres)	NFS Lands (% area)	Length of Road on both Slope and Geology (mi)	Road Density on both Slope and Geology (mi/sq. mi)
HV – 12	0.7 (479.9)	69.5	2.3	3.0
HV – 23	2.1 (1365.2)	84.8	4.3	2.0
PC – 52	1.3 (823.4)	95.4	1.6	1.2
HV – 92	0.9 (563.0)	59.6	1.3	1.5
PC – 133	0.7 (471.3)	100.0	1.5	2.0
HV – 162	0.4 (267.2)	59.3	0.9	2.2
HV – 172	0.8 (494.4)	100.0	1.4	1.9
HV – 185	0.3 (180.9)	100.0	0.3	1.2
HV – 205	0.1 (95.0)	99.9	0.3	1.8
RC – 211	0.7 (440.3)	100.0	1.0	1.5
RC – 212	1.1 (710.3)	100.0	1.9	1.7
RC – 215	0.8 (538.1)	100.0	1.4	1.7
RC – 217	0.9 (581.5)	99.7	2.3	2.5

[1] HV- Hidden Valley; PC- Plummer Creek; and RC- Rattlesnake Creek.

There is likely more streambank erosion now than would have occurred prior to Euro-American settlement. Since the 1964 flood event, when the system was swamped with sediment, the stream channels have been transporting excess sediment out of the system. The excess sediment storage in river bars, landslide toes, terraces, and riverbanks has provided a ready supply of sediment to the river (see Stream Channel section below). In addition to extra sediment stored in the river system (mostly in tributaries to the S.F. Trinity River), streams have aggraded and widened in response to the sediment load causing bank undercutting and bank erosion in areas not confined by bedrock walls. However, riparian areas along tributaries to the S.F. Trinity River appear to be revegetating, which will stabilize sediments and contribute to large woody debris recruitment (Llanos and Cook 2001).

5.1.5 Hillslope Surface Erosion

Management activities (timber harvest but not roads) and non-management sources of surface erosion each accounted for two percent of the total sediment load for the study period (Figure 3-1). Table 5-7 lists the upper 10 percent of subwatersheds in WAA with high or very high soil erosion hazard ratings (EHR). Non-management surface erosion was attributed to burned areas and non-forested areas (Table 3-11). Raines (1998) assumed that old-growth forest had negligible levels of surface erosion. Changes in surface erosion not related to timber harvest are primarily from areas that have burned under severe conditions due to high fuel loads and vegetation densities (Table 5-8). As discussed below in the Water Quality section, policies of fire suppression have changed the fire regime within the WAA leading to infrequent high severity fires. Increases in surface erosion rates in the 1975 to 1990 period are mainly due to the fires that took place within Plummer and Rattlesnake Creeks watersheds (Figure 5-1; Raines 1998).

Table 5-7. Upper 10 Percent of Subwatersheds in WAA with High or Very High Soil Erosion Hazard Ratings (EHR). (Overall Ranking Matrix is in Appendix F).

Subwatershed[1]	Square Miles (acres)	NFS Lands (% area)	Area of High or Very High EHR (acres)	High or Very High EHR [2] (% area)
PC – 123	1.7 (1110.9)	51.7	710.4	63.9
PC – 132	0.4 (236.5)	96.4	174.4	73.7
PC – 137	0.5 (319.9)	100.0	237.9	74.4
PC – 143	0.4 (271.8)	100.0	201.9	74.3
RC – 156	2.4 (1508.0)	55.5	933.7	61.9
RC – 157	0.5 (328.1)	100.0	223.9	68.3
PC – 163	1.0 (666.1)	97.8	451.2	67.7
PC – 170	0.6 (364.4)	100.0	262.9	72.1
PC – 179	0.4 (270.8)	100.0	185.3	68.4
PC – 181	0.6 (357.4)	100.0	251.7	70.4
PC – 182	0.2 (112.7)	100.0	100.3	88.9
PC – 187	0.2 (97.9)	100.0	85.2	87.1
PC – 190	1.0 (625.3)	100.0	437.7	70.0

[1] HV- Hidden Valley; PC- Plummer Creek; and RC- Rattlesnake Creek.

[2] Percentage does not include residual soils that make up approximately 20 percent of each watershed.

Table 5-8. Upper 10 Percent of Subwatersheds in WAA with Highest Amount of Burned Areas in the 1987 Fires. (Overall Ranking Matrix is in Appendix F).

Subwatershed[1]	Square Miles (acres)	NFS lands (% area)	Area Burned in 1987 Fires (acres)	Area Burned in 1987 Fires (%)
PC – 55	0.6 (369.0)	100.0	369.0	100.0
PC – 64	0.7 (431.4)	100.0	431.1	99.9
PC – 66	1.4 (871.2)	100.0	871.2	100.0
PC – 74	1.0 (651.0)	100.0	648.4	99.6
PC – 84	1.3 (812.0)	94.3	809.9	99.7
PC – 132	0.4 (236.5)	96.4	236.2	99.9
PC – 143	0.4 (271.8)	100.0	271.3	99.8
PC – 165	0.8 (500.1)	100.0	500.1	100.0
PC – 167	1.9 (1237.4)	100.0	1232.7	99.6
RC – 168	0.6 (391.0)	100.0	391.0	100.0
RC – 171	0.9 (581.5)	100.0	581.5	100.0
RC – 174	1.4 (889.4)	100.0	887.3	99.8
PC – 181	0.6 (357.4)	100.0	356.5	99.7

[1] HV- Hidden Valley; PC- Plummer Creek; and RC- Rattlesnake Creek.

Timber harvest-related erosion would not have occurred prior to Euro-American settlement. Erosion levels increased for Plummer Creek and Rattlesnake Creek watersheds, and decreased for Hidden Valley watershed during the study period (Table 5-9). Greater erosion between 1975 and 1990 is due to the high levels of timber harvest in Hidden Valley watershed prior to 1960 and before best management practices, particularly on private lands (Table 5-9). Since about 1990, timber harvest has essentially ceased within the WAA, and erosion from harvest activity has likely decreased to background levels.

Table 5-9. Estimates of Sediment Yield from Timber Harvest. Adapted from Raines (1998).

	Tons			
Watershed	**1944–1959**	**1960–1974**	**1975–1990**	**Total 1944-1990**
Hidden Valley	55,466	26,747	12,110	94,322
Plummer Creek	0	5,318	17,044	22,362
Rattlesnake Creek	0	4,722	22,586	27,307

5.2 Hydrology, Stream Channel, and Water Quality

5.2.1 Hydrology

What are the natural and human causes of change between historical and current hydrologic conditions? What are the influences and relationships between hydrological processes and other ecosystem processes?

Hydrologic characteristics of the WAA have likely changed since the arrival of Euro-Americans, but the extent is difficult to quantify without accurate flow records. The four main management factors contributing to hydrologic changes are the building of roads, timber harvest, fire suppression, and flow diversions.

Roads influence hydrologic flows through a watershed (Table 5-3). Road cuts on hillslopes intercept surface runoff and subsurface flow and route it more quickly to streams (Table 5-5). Roads, skid trails, and landings also compact soils, reducing infiltration for potentially long periods of time. This can result in increases in peak flows for floods with frequent return intervals and decreases in summer low flows by routing water out of the watershed more efficiently and decreasing the amount that infiltrates. Increases in peak flows from roads are related to the connection of road ditches to streams (i.e., they drain hillslopes directly to streams) or long inside ditches that drain through culverts to eroded gullies that connect to streams. Beschta et al. (2000) reported a 13 to 16 percent increase in flow for one-year recurrence interval events, and a six to nine percent increase in peak flow for 5-year recurrence interval events after timber harvest and road construction in a western Cascade forest.

Land management practices can also affect the water yield from watersheds. One study of runoff response to timber harvest in 31 watershed-scale studies in the western United States concluded that there could be up to a one-inch increase in annual runoff from a ten percent increase in timber harvest averaged across the Sierra Nevada (Marvin 1996). Increases in runoff would be greater in years of above average precipitation, and would most likely occur during winter storm events or during spring snowmelt peaks. Soil compaction from timber harvest activities can reduce infiltration rates and increase runoff. However, dense vegetation growth following timber harvest and dense vegetation resulting from fire suppression practices in the past 100 years often offset water yield increases caused by timber harvest (Marvin 1996).

Fire suppression has two consequences that affect hydrologic characteristics of watersheds; higher vegetation densities and infrequent but more severe fires. Dense second-growth forests under a fire-suppression policy have higher vegetation densities, potentially increasing the evapotranspiration rate over natural conditions. This reduces the amount of water that infiltrates into the soil to recharge aquifers and contribute to baseflow in streams. The extent that water yields and timing are changed are site specific and difficult to predict in the WAA due to a lack of local data.

Due to the high fuel loads and dense vegetation in the fire-suppressed system, fires that occur tend to be more severe and extensive than those that occurred under historic conditions. In comparison to more frequent, lower severity historic fires, severe stand-replacing fires result in greater changes to hydrologic characteristics and sedimentation rates. Severe fires have been observed to increase water yield and peak flows immediately following burns in western forests (Kattleman 1996).

Detailed water rights data were not available in time to include in this watershed analysis. The list of fully appropriated streams was available, and indicated that two watercourses in the WAA are fully-appropriated. The S.F. Trinity River from Highway 36 to the confluence and Cold Springs Creek are both fully appropriated (SWRCB 1998). Other water right claims allow for diversions from the WAA streams, and likely influence low flows and water temperatures. Significant diversions of water from WAA streams did not occur prior to Euro-American settlement.

The result of all of these factors on hydrologic characteristics is difficult to quantify. Potential changes include lower water yields and summer low flows, which, combined with wider than historic stream widths, could be detrimental to fish habitat. Lower summer flow levels could also stress riparian vegetation, especially since the late summer receives little precipitation. Peak flows may also be higher for higher frequency events, which could cause increased streambank erosion, but would also tend to flush in-stream sediments and large woody debris downstream.

5.2.2 Stream Channel

What are the natural and human causes of change between historical and current stream channel conditions? What are the influences and relationships between channel conditions and other ecosystem processes?

The turning point for the S.F. Trinity River was the 1964 flood event. It was a doozy, rated at about a 100- to 150-year flood for the S.F. Trinity River. This event triggered massive landslides and debris flows, eroded several steeper lower order streams to bedrock along South Fork Mountain (particularly on private lands), filled most of the deep pools along the mainstem S.F. Trinity, and caused extensive aggradation throughout the lower basin. The extent to which these effects can be attributed to management activity is still being debated (PWA 1994; Raines 1998;

and others). What is certain is that the S.F. Trinity River changed significantly after the 1964 flood, and that the once abundant anadromous fishery significantly declined.

Regardless of whether the changes wrought by the 1964 flood were human-caused or not, the system, and people living in and managing the watershed, are still dealing with the results of the flood. Many of the S.F. Trinity River tributaries have high levels of sediment storage and production. About 70 percent of the total sediment storage in the S.F. Trinity River basin is in the tributary channels, with a majority lying within the active channel (Llanos and Cook 2001). Because most of the sediment is stored within the active channel, Llanos and Cook (2001) suggest that recent events, and not the 1964 flood, likely produced the deposits. The source of this material could be the large supply of sediment stored in terraces from the 1964 flood. A modern flood event could re-mobilize large amounts of the sediment stored in river and tributary banks.

The aggradation that took place after the 1964 flood event filled pools and caused the stream channel to rise and widen, eroding into terraces and toe slopes triggering landslides and increasing the sediment load. As the system destabilized, functioning floodplains were swamped with sediment or eroded. This deposition had a negative impact on fish habitat by filling pools, decreasing the habitat complexity, and exposing a greater surface area of the river to solar radiation.

Another factor influencing sediment transport and storage and fish habitat is large woody debris. Llanos and Cook (2001) found very little (5 percent) sediment storage behind large wood. Most of the wood in the system was flushed out by the 1964 flood, and following the flood, land management policy directed that wood be aggressively removed from stream channels (Llanos and Cook 2001). The riparian areas have revegetated since the 1964 flood, but the dominant species appears to be alders, which break down quickly in the channel (Llanos and Cook 2001).

Stream channels are also influenced by roads. A common practice in road construction prior to the 1980s was to build the roads in flatter valley bottoms in the riparian areas (Table 5-4). This design constricts the stream, reduces sinuosity, and partially fills the floodplain. Roads constructed in riparian areas also affect large woody debris recruitment, are more likely to deliver sediment to the stream and disrupt the sediment balance, and disrupt hydrologic flows above and below the surface of the floodplain (Table 5-4).

Stream crossings by roads also affect channel function (Table 5-5). Fill is often placed in the floodplain and streambanks above and below crossings that are hardened to prevent bank erosion. Past road engineering practices generally did not design crossings to pass floods larger than the 25-year to 50-year event, which lead to extensive road failures during larger storm events. Current engineering standards design crossings to accommodate a 100-year flood event.

5.2.3 Water Quality

What are the natural and human causes of change between historical and current water quality conditions? What are the influences and relationships between water quality and other ecosystem processes?

The principal water quality issues within the WAA are sedimentation and temperature. Both are tied to the beneficial use of the S.F. Trinity River and its tributaries as cold-water fish habitat. There may be other localized areas of water quality degradation, such as nutrient loading from malfunctioning septic systems, areas with elevated bacteria counts, or release of gasoline, oil, or domestic chemicals into the watershed in areas of high intensity use such as private inholdings and recreational sites. These impacts would not have occurred prior to Euro-American settlement. There has been minimal water quality monitoring in the WAA.

Due to increased levels of sedimentation within the watershed (see Chapter 3, Geomorphology; and Chapter 5, Erosion Processes), sedimentation and turbidity in the WAA are higher than would have occurred historically. There would have been spikes of sediment input into the aquatic habitats following severe storms in the past, but equivalent storms under the current watershed conditions would like result in much higher sedimentation, turbidity, and sediment transport. There are still large amounts of sediment stored in S.F. Trinity River tributaries that could contribute to aggradation under high flow conditions (see Chapter 5, Stream Channel). This condition is likely to persist until upland sediment sources are reduced, and the river system adjusts to the to its current sediment load.

Other factors influencing surface erosion rates are frequency and intensity of wildfires. Prior to Euro-American settlement, fires were more frequent but less severe. They were typically not large stand-replacing fires, but would have contributed localized pulses of sediment to watercourses. Since about 1911, fires have been suppressed on National Forest System lands reducing the frequency of fires and increasing the severity of fires that do occur. In 1987, about 25,000 acres of the WAA burned, primarily in Plummer Creek watershed. Stabilization and erosion control efforts began soon after the fires, but there were significant amounts of erosion associated with these stand-replacement fires. Until fire is re-introduced into the ecosystem, the effects of large-stand replacement fires will fall outside the natural range of variability.

Water temperatures are controlled by a variety of factors, but two factors affected by human activity are riparian vegetation and, indirectly, channel width and structure. Management activities within the WAA such as timber harvesting within riparian areas (a common practice prior to 1980), and geomorphic changes triggered by management activities have affected the S.F. Trinity River and its tributaries. The current water temperature and riparian conditions are described in Chapter 3, Fish Habitats and Species, and Riparian Habitat section. Due to changes in riparian vegetation (currently 39 percent of riparian stands have sparse-open canopy closure) and stream widths, current water temperatures may be higher than would have occurred prior to Euro-American settlement along tributaries to the SF Trinity River (see Section 5.3). The S.F. Trinity River is on the 1998 impaired waterbody list, pursuant to CWA §303(d), for water temperature and is scheduled to have a TMDL completed by 2008.

Erosion Processes, Hydrology, Stream Channel, and Water Quality-Related Key Questions

- *What erosional processes are dominant within the watershed?* Mass wasting is the dominant erosional process in the watershed. See Sections 3.1 and 5.1 on Erosion Processes.

- *What erosional processes have been accelerated by natural and human induced disturbances?* Human activities in the WAA have accelerated all types of erosional processes. About one-third of the erosion is management-related (Figure 3-1). See Sections 3.1 and 5.1 on Erosion Processes.
- *What role do forest roads play in erosion processes and sediment contribution to stream channels?* Roads contribute about 17 percent of the total sediment supply (Figure 3-1). See Sections 3.1 and 5.1, and Tables 3-7, 3-8, and 3-9 on Road-related Erosion.
- *Where do erosion processes deliver sediment to stream channels?* Section 5.1 (Erosion Processes) lists subwatersheds that have high likelihood of delivering sediment to streams based on road density, riparian road density, road substrate and slope, landslide activity, and other indicators. See Sections 3.1 and 5.1, and Tables 5-3 and 5-4 on Erosion Processes.
- *What measures can be implemented to reduce delivery of sediment to stream channels?* Implementing the roads analysis procedure would assess the benefits and costs associated with roads, which is a significant management related source of sediment. Best management practices and the recommendations in Section 6.1 would also reduce sediment loads. See Section 5.1 on Erosion Processes.
- *Which stream channels would benefit from the implementation of channel stabilization or restoration measures?* Streams in areas with high riparian road densities, high numbers of stream crossings, or watersheds that were burned in the 1987 fires are at higher risk. See Section 5.1, Erosion Processes; and Section 5.2, Stream Channels.
- *What effects did the 1987 fires have on erosion processes and stream channels?* The 1987 fires accelerated surface erosion within Plummer Creek and Rattlesnake Creek, and contributed higher levels of sediment to stream channels than would have occurred from historic fires of lower severity (Figure 5-1). See Sections 3.1 and 5.1 on Erosion Processes.
- *What areas of Hidden Valley, Rattlesnake Creek, and Plummer Creek watersheds are of high soil erodibility and require special management emphasis?* Table 5-7 lists subwatersheds with high or very high erosion hazard ratings where special emphasis should be placed on erosion potential. See Section 3.1, Soils.
- *What are the dominant hydrologic characteristics and other notable hydrologic features and processes in the watershed*? See Sections 3.2 and 5.2, Hydrology.
- *What beneficial uses dependent on aquatic resources occur in the watershed?* The principal beneficial use is cold water fishery. See Section 3.2, Hydrology.
- *Which water quality parameters are critical to these uses?* Water temperature and sedimentation are the two critical parameters. A TMDL has been established for sediment, and a TMDL is to be completed for water temperature by 2008. See Sections 3.2 and 5.2, Water Quality.

Roads Assessment-related Key Questions

- *How and where does the road system modify the surface and subsurface hydrology of the area?* See Section 5.1, Road-related Erosion; and Section 5.2, Hydrology and Stream

Channel. Table 5-4 lists subwatersheds with the highest riparian road density, and Table 5-5 lists subwatersheds with the highest road-stream crossing densities.

- *How and where does the road system generate surface erosion?* Section 5.1, Road-related Erosion, describes how roads generate sediment in the WAA. Figure 5-1 shows sediment sources and Figure 5-2 shows erosion trends within the three watersheds in the analysis area. Table 5-2 lists the subwatersheds with the highest density of road segments delivering sediment to streams.
- *How and where does the road system affect mass wasting?* Section 5.1, Mass Wasting and Road-related Erosion, describes road influences on mass wasting. Figure 5-1 and Table 5-6 show the contribution to mass wasting by roads and subwatersheds with roads constructed on steeper slopes and unstable geology, respectively.
- *How and where do road-stream crossings influence local stream channels and water quality?* Section 5.1 (Erosion Processes) and Section 5.2 (Stream Channels and Water Quality) describe road interactions with streams. Table 5-5 lists the subwatersheds with the highest density of road-stream crossings.
- *How and where does the road system create the potential for pollutants, such as chemical spills, oils, de-icing salts, or herbicides to enter surface water?* There are about 16 miles of non-Forest Service highway (Class 2) in the WAA. Highway 36 is the only major road in the WAA and receives the bulk of the through-traffic in the area. Although it is not a major highway, it is the only main road in the area and receives a moderate level of traffic. It follows Rattlesnake Creek for about six miles, and crosses the S.F. Trinity River about a mile below the confluence with Rattlesnake Creek. This stretch of Highway 36 represents the greatest risk of accidental spills into a major waterway in the WAA.

5.3 Fish Habitats and Species, and Riparian Habitat

5.3.1 Riparian Reserves – General Trends

What are the natural and human causes of change between the historical and current vegetative conditions? What are the influences and relationships between riparian vegetation and seral stage patterns and other ecosystem processes in the watershed?

Prior to the arrival of European settlers natural disturbances such as fires, floods, landslides, and debris flows were the dominant processes that influenced timber/vegetation conditions. Historic forest stands may have been composed primarily of large diameter conifer and hardwood trees. The largest of these trees may have been in the riparian areas where an abundance of water and more fertile soil conditions exist. In addition, the higher humidity and cooler temperatures next to watercourses may have reduced the potential for stand replacing fires. However, the 1987 fires did result in extensive loss of riparian vegetation within the Plummer Creek and Rattlesnake Creek watersheds. The loss of vegetation and its associated root strength contributed to increased sediment delivery to stream channels and reduction in instream habitat quality.

Logging on private lands, earlier logging on National Forest System lands, and the fires of 1987, have removed mature coniferous and/or deciduous riparian vegetation along many tributary streams throughout the S.F. Trinity River watershed (PWA 1994). Loss of riparian vegetation has resulted in a loss of shading and a diminished input of LWD to tributary stream channels. These effects resulted in increased summer water temperatures, reduced channel structure and instream habitat complexity, and fewer and smaller pools for rearing salmonids. Loss of riparian vegetation, and its slow recovery in many areas, is thought to be one factor limiting fisheries recovery (PWA 1994). Timber harvesting impacts occurred throughout the analysis area beginning in the 1940s, with the exception of the lower reaches in the Plummer Creek watershed analysis unit.

The decrease of LWD recruitment and its effect on instream habitat is felt primarily in the Plummer Creek and Rattlesnake Creek watersheds as well as the smaller tributaries flowing into the S.F. Trinity River. The stream channels in these systems are small enough that LWD could remain stable and form habitat features. By contrast, the S.F. Trinity River is contained in a sixth order or larger channel where all but the largest LWD is transported during high flows. As a consequence, pool and associated habitat formation is generally a result of bedrock controls and other channel morphological features. However, the sediment storage capacity of LWD in smaller channels affects substrate quality and quantity in the S.F. Trinity River.

Riparian conditions have been recovering from the effects of historic land-use practices and natural fire and flood events. The Aquatic Conservation Strategy (ACS) goal is to maintain and restore the ecological health of watersheds and aquatic ecosystems contained within them on public lands. One of the ways to accomplish this is to maintain and restore the species composition and structural diversity of forest vegetation in the riparian areas. As described in Chapter 3, nearly 36 percent of the riparian forest vegetation is composed of strata M2G or M3G or 15 to 30-year old plantations. Approximately 87 percent of these forest stands in riparian areas are located in the Rattlesnake Creek and Plummer Creek watersheds. These young stands would respond well to thinning treatments, with the remaining trees reaching large size at a significantly faster rate then if left untreated. The desired future condition includes developing forest stands that include restoring riparian areas containing large diameter conifer and hardwood trees that can eventually function and develop in response to natural disturbance regimes.

Riparian Reserves Management-related Key Questions

- *What management activities have occurred in riparian areas?* See Section 4.6, Riparian Habitat.
- *What are the current conditions of the riparian reserves?* See Section 3.4, Riparian Conditions.
- *What is the desired future condition for the riparian vegetation?* See Section 5.3, Riparian Reserves.
- *What vegetation treatments can be used to enhance riparian reserves and associated benefits to terrestrial and aquatic species within stream corridors?* See Section 6.2, Riparian Habitat.

5.3.2 Stream Channel and Aquatic Habitat – General Trends

What are the natural and human causes of change between the historical and current stream channel and aquatic habitat conditions? What are the influences and relationships between stream channel and aquatic habitat conditions and other ecosystem processes in the watershed?

Stream channel and instream habitat conditions have changed from the reference condition due to natural and human influenced causes. Logging activities commenced in the 1940s in the watershed analysis area. During this time period roads and skid trails were constructed in streams and inner gorges for tractor yarding and log hauling. The 1964 rain-on-snow flood resulted in massive amounts of sediment being deposited in streams, filling pools, and widening channels. This sediment source was from both natural landscapes as well as those altered by land management practices. The S.F. Trinity River has been on a recovery trajectory since at least 1969, with steadily increasing numbers of deep pools.

Farber et al. (1998) reported that prior to the 1964 flood instantaneous maximum water temperatures in the South Fork Trinity River near Hyampom ranged from 20 to 25ºC (68.4 to 77.5ºF). Water temperatures increased to 28 to 29ºC (82.9 to 84.8ºF) in the three years following the flood. More recently (1990 and 1996) maximum water temperatures have ranged from 23.2 to 26.7ºC (74.2 to 80.6ºF).

Water temperatures in tributary streams tend to respond relatively quickly to the removal of riparian canopy. This is due to vegetative shading having a greater influence in smaller streams than mainstem rivers, which tend to be heavily influenced by air temperatures. Although there are very little historic data for Rattlesnake Creek and Plummer Creek it can be expected that riparian vegetation removal from fires and historic logging activities had an adverse impact on water temperatures. The 1987 fires in Plummer Creek and Rattlesnake Creek appeared to result in additional deposition of sediment to those watercourses, and setting back their recovery. In addition, historic mining activities in Rattlesnake Creek contributed to the degradation of instream habitat. Pool frequency has decreased in Plummer and Rattlesnake Creeks over the last 20 years.

Stream channels and aquatic habitats are recipients of watershed inputs of sediment, wood, and water. Channel conditions respond to these inputs in various ways. Excessive road or landslide-related erosion can overwhelm a stream's sediment transport capability and result in aggradation and reductions in pool frequency and volume. Too little sediment could cause coarsening of the stream substrate and decrease salmonid spawning habitat abundance and quality. Unrestrained riparian area logging decreases the amount of LWD recruitment, which can reduce pool formation and instream habitat complexity. In addition, LWD functions as gradient control and sediment storage sites in smaller streams. Construction of roads and other compacted surfaces in a watershed can increase peak flows in watercourses, especially during the early part of the winter period when saturated soil conditions have not been achieved. Increased peak flows can cause flooding or channel and streambank erosion. By contrast, summer flows could increase in areas where vegetation removal has occurred and resulting in reductions in evapotranspiration rates.

The ACS goal is to maintain and restore the ecological health of watersheds and aquatic ecosystems contained within them on public lands. If the ACS is fully implemented, it is expected that stream channel and instream habitat conditions will return in large part to that which developed during natural events. There would be an increased amount of LWD in the channels, more frequent deep pools, better quality spawning and rearing habitat, and subsequently more fish. Rattlesnake Creek and Plummer Creek appear to have the greatest potential for channel and habitat improvements.

Stream Channel and Aquatic Habitat-related Key Questions

- *What are the processes that create and maintain instream habitat over long periods of time?* See Section 4.7, Fish Habitats; and Section 5.3, Stream Channel and Aquatic Habitat.
- *Have these processes been altered?* See Section 4.7, Fish Habitats.
- *If the natural processes have been altered, how have they affected anadromous fish habitat, especially in relation to sediment yield, transport, and deposition?* See Section 4.7, Fish Habitats; and Section 5.3, Stream Channel and Aquatic Habitat.
- *How have human induced disturbances altered these processes?* See Section 5.3, Stream Channel and Aquatic Habitat.
- *What watershed processes have deviated from equilibrium, and which streams would benefit most from channel stabilization and restoration efforts?* It appears that Plummer Creek and Rattlesnake Creek have deviated from equilibrium due to excessive sediment inputs and loss of riparian vegetation. These watersheds would benefit more from riparian restoration treatments than would the S.F. Trinity River in the Hidden Valley analysis area. However, the entire watershed analysis area would benefit from sediment reduction and erosion control efforts.
- *What is the predicted future condition for aquatic habitat (especially anadromous fish habitat) if the ACS is implemented?* In-channel aquatic habitat conditions should improve.

5.4 Vegetation and Fire/Fuels

5.4.1 Fire and Fuels – General Trends

During the fire suppression era, from 1911 to 1998, there were 446 fires reported in the watershed analysis area. Nine of the fires were larger than 100 acres, and 437 fires were less than 100 acres. Five of the nine larger fires occurred in 1987 and they were all lightning caused. The four earlier larger fires occurred 49 and 63 years before the 1987 fires and they were of unknown causes. More recently, from 1985 to 1996, there were 436 fires reported on the entire Hayfork Ranger District. Fifty-five percent of these fires were lightning caused, and the remainder were human caused. As indicated by the fire history studies mentioned in the earlier sections of this watershed analysis, the number of lightning caused fires has, in prehistoric times, played an important role in the disturbance history of the analysis area and will continue to play a major role in disturbance into the future. Human caused fires is also a concern, especially in wildland/community interface areas. Areas of concern in the watershed analysis area are the corridor along Highway 36, including Forest Glen, and the community of Trinity Pines near Post Mountain.

Fire management programs were effective in containing and controlling the majority of wildland fire ignitions within the watershed analysis area up until 1987. Prior to 1987 there had not been any large fires for almost half a century. However, the 1987 fires burned approximately 24,996 acres, or more than 30 percent, of the National Forest System lands within the analysis area. Since 1987 there have been no large fires in the analysis area. A primary factor that made the 1987 fires as intense as they were was the success in fire prevention in the prior 50 years.

Even though fire suppression resources increased up to 1980, and the technology of fire suppression has improved, the ability to suppress fuel driven fires has reduced. The early success of fire suppression during the last 75 years of the 20th century has also increased the fuel accumulation in the forest. Fire intensities of the historic fire regime were characterized by low intensity, frequent fires that burned over large areas throughout the dry months, removing fuel accumulations and keeping the stands healthy. This situation has changed since settlement times to less frequent and more intense fires, particularly during the last 25 years of the 20th century. This has been a direct result of early fire suppression success and an increase in the accumulation of burnable biomass and dead fuel loads. Currently when a large number of lightning fire starts or a single start exceeds the capabilities of the initial attack forces the fires get larger. The increase in fire intensities is a direct result of increases in fuel loading, which allows for higher intensity and larger fires when compared to the fire intensities and sizes of historic times.

The fuel hazard rating model used to assess the fuel hazards in this analysis is based on vegetation types, slope, elevation, and aspect. This model assigns broad scale hazard ratings. The fuel hazard rating within the watershed analysis area at present is moderate to high. The high fuel hazard areas are concentrated in short, steep subwatershed in the Plummer Creek and Rattlesnake Creek watersheds.

With diminishing fire management budgets and the reduction in the work force (starting in 1980) available to suppress fires, as well as an increase in the fuel loading, the risk of large catastrophic fires will increase. Even with recent increases of fire fighting resources emphasis on fuels treatment is important.

In landscape such as the Hidden Valley, Rattlesnake Creek, and Plummer Creek watersheds historic fire regimes had, prior to European settlement, been characterized by low intensity and frequent fires. Since settlement that changed to a less frequent and high intensity fire regime can have catastrophic impacts to the watershed. The absence of low intensity fires to reduce the fuel loading and the reduction of the timber salvage program has caused an increase in the vegetation and dead fuel component in much of the assessment area. Fire exclusion has also allowed an increase in the growth of fire intolerant vegetative species, and an increase in other biomass growth that adds to the buildup of flammable fuels that can add to the fires’ intensity and difficulty of control. The cause and effect of not allowing fires to burn under low intensities either naturally or under prescribed conditions of control, or not trying to reduce the fuel accumulation through mechanical treatment, has increased the probability that stand replacing fires will occur in the future. Stand replacing fires will increase the loss of, or alteration of late seral stage and instream fish habitats, water quality, commercial timber, and lives and property within the analysis area.

Fire and Fuels-related Key Questions

- *What are the current fire regimes and major causes of fires?* See Section 3.5, Fire Suppression Era 1911 to 1998; and Section 5.4, Fire and Fuels.
- *What is the existing fire hazard pattern? What is the risk of catastrophic fire associated with Late-Successional and Riparian Reserves?* See Section 3.5, Fire Hazards and Risk; and Section 5.4, Fire and Fuels. In Late-Successional and Riparian Reserves, where fire has been actively excluded, the buildup of fuels can accumulate to levels that are of high risk for catastrophic loss to fire.
- *What are the areas of concern with respect to wildland/urban interface, rural communities, and high value resources at risk in terms of catastrophic wildland fires? Which of these areas are of highest priority for fuels reduction treatments and assistance for adjacent communities?* See Sections 5.4 and 6.3, Fire and Fuels.
- *What vegetation treatments are needed to reduce the risk of catastrophic fires? Which areas would benefit most by prescribed fires for fuel hazard reduction and terrestrial habitat improvement? What silvicultural treatments are needed to reduce fuel ladders prior to prescribed fires to provide for post-fire stands that are healthier?* The reintroduction of lower level, more frequent fires that more closely mimic the natural occurring fire regime would greatly reduce the risk of catastrophic loss to fires. Prescribed burns must be carefully planned, and in some cases the stands must be pretreated to reduce risk of fires getting out of control. Thinning from below is an important silvicultural tool to reduce risk prior to prescribed burning in those stands that have heavier than usual fuel loading and with mid-story shade-tolerant vegetation. Biomass removal is also a key tool that may be used in preparation for prescribed burning to reduce risk of fires burning out of control. The planning, construction and maintenance of strategic fuel beak systems is also key to the protection of forest resources and private property. Fuel break planning should be an effort that includes all landowners in the watersheds.

5.4.2 Forest Vegetation and Commercial Wood Production – General Trends

Historic forest vegetation condition within the watershed analysis area was primarily dominated by larger diameter pine, Douglas-fir, and true fir stands. Late seral stands probably dominated most of the watershed areas, with patches of younger stands established following fire events or landslides. Periodic lighter burn fires would have burned the understory of many stands, thinning out some stems and clearing accumulating fuel, thus preventing a large fuels buildup.

Current forest vegetation condition tends toward mid-seral stage stands. Stands with tree diameters in the 11 to 24-inch range occupy approximately half of these watershed acreages. These stands are interspersed with somewhat larger diameter trees of mid- to late-seral stands, and early seral stage plantations. Many of the plantations are overstocked and are therefore susceptible to insect attack, especially during periods of drought that may weaken individual trees. These stands are prime candidate areas for intermediate silvicultural treatments including precommercial and commercial thinnings. Some of the larger diameter timber stands which lie outside of the Late-Successional and Riparian Reserves exhibit reduced growth characteristics, having achieved culmination of mean annual increment (CMAI) and are no longer efficiently contributing to commercial wood production. These areas may provide opportunities for regeneration treatments to reestablish more vigorous timber stands.

Changes to structure of the vegetation in the analysis areas can be attributed to two main factors: timber harvesting, and large, high intensity stand replacing fires. About 100 years ago, the policy toward fire suppression began to change forest conditions by allowing development of an understory of smaller trees and brush to become established in many areas due to the absence of the periodic fires that had previously kept such growth in check. This allowed the buildup of smaller understory fuels, setting the stage for the larger and higher intensity fires that have taken place over the last half-century. Some higher intensity burn areas suitable to support conifer stands are now dominated by brush. Fire suppression efforts also arrested the culling of weaker, damaged, and insect kill trees that the periodic fires would have helped eliminate.

The initial timber harvest entries into these watersheds were selection harvests that targeted only the biggest and most valuable trees. Later timber harvests, starting in the 1960s, were clearcuts that created entire new replacement stands of early seral stage. The clearcutting continued through the 1970s and into the 1980s. Also, the 1987 fires and subsequent rehabilitation created more early seral stage stands. The more recent timber harvests have all been sanitation salvage silviculture undertaken to improve forest health and stand vigor.

"Silviculture consists of the techniques for manipulating the establishments, composition, structure, and rates of development of forest stands, including both trees and associated other vegetation. These techniques are the product of a long history of accumulated research and experience. Although many of these techniques were originally developed to enhance wood production, they can easily be extended to the broader problems of developing forests, stands, and trees with the characteristics desired for multiple forest objectives. In young stands particularly, stand characteristics can be markedly modified and development rates sharply accelerated within relatively short periods. Details of application must of course be worked out for any specific set of conditions and objectives." (Curtis et al. 1998)

Matrix lands in the analysis area include 2,922 acres in the Hidden Valley watershed, 17,855 acres in the Rattlesnake Creek watershed, and 9,226 acres in the Plummer Creek watershed that are capable, available, and suitable (CAS) for timber production. Timber harvesting on these Matrix lands will establish a more diversified landscape condition. Silvicultural treatments can also contribute to fire prevention. Under a fully regulated basis, using a rotation age of 130 years, there would be regeneration harvesting on 2,308 acres (net) per decade in the three watersheds combined. Recent timber harvesting activity, however, has been well below this level. As this land base progresses toward a fully regulated condition, it is anticipated that a well-distributed range of seral stages will occur. Increasing emphasis will be placed on intermediate harvesting (thinning) and on single-tree and group selection harvest methods to meet regulated forest objectives. Intermediate and partial harvests can accelerate the growth of the remaining tree stand and thereby accelerate that stand's progression toward more advanced seral stages. These treatments could also benefit other biological resources dependent on riparian areas. Thinning in riparian reserves can restore a desired condition of large diameter trees that would increase large woody debris recruitment and improve instream habitat conditions. Thinning treatments also can be utilized to increase habitat quality for wildlife species of concern.

Forest Vegetation and Commercial Wood Production-related Key Questions

- *What are the past and current vegetation conditions (structure and composition) and patterns?* See Section 3.5, Forest Vegetation and Timber; and Section 4.8, Forest Vegetation.
- *Are there any known threats to forest health? What treatments can be employed to maintain or improve the health of the existing forests?* See Section 3.5, Forest Vegetation and Timber, and Fire Exclusion Effects; and Section 4.8, Forest Vegetation and Fire Disturbance. The reintroduction of lower level, more frequent fires that more closely mimic the naturally occurring fire regime could benefit the health of existing forest by culling out weakened or diseased trees and reducing moisture competition in overcrowded stands. This can also be accomplished through prescribed burning or through thinning and sanitation-salvage timber harvests in areas where wildfire risks are high or where commercial timber can be successfully harvested in the operation.
- *Are designated Matrix lands currently being regulated to provide predicted timber outputs? What regeneration harvesting opportunities are available to move the Matrix lands toward a fully regulated timber land-base? What intermediate cutting opportunities are available to maintain tree-stocking levels that will reduce susceptibility to insect or disease attacks and maintain stand growth and vigor?* See Sections 5.4 and 6.3, Forest Vegetation and Commercial Wood Production.
- *What silvicultural treatments, besides for commodity production, could be implemented that would improve existing conditions for biological diversity and other non-consumptive uses of the forests?* See Section 5.4, Forest Vegetation and Commercial Wood Production. Some of the plantation tree plantings in the analysis area have been very successful to the extent that they are currently overstocked. These areas would benefit from thinnings to open the crown closure and in turn encourage forest understory development for forest structure diversity. Many of the mid-seral forest areas are comprised of a single story canopy. Intermediate timber harvests and group selection harvesting will speed the development of multistoried stands that provide a more diversified habitat. Prescribed burning can also be used to promote biological diversity through disturbance. Some areas that have understory growth and accumulated high quantities of fuel may need pretreatment before prescribed burning. In these areas thinning or biomass removal may be required.
- *Are there potential fuelwood cutting opportunities in selected Late-Successional Reserves that could reduce risk of loss of forest stands with overstocked conditions to catastrophic fires, and/or accelerate the trend towards desired late-successional forest conditions?* There are areas in both Late-Successional and Riparian Reserves that are overstocked and would benefit from reduction of moisture competition and stand structural diversity by creating openings in the canopy through selectively harvesting individual trees for fuelwood. Careful direction of such fuelwood cutting can accelerate the development of

these areas toward the desired condition of late seral stage. See Section 5.4, Forest Vegetation and Commercial Wood Production.

5.5 Plant Species of Concern and Noxious Weeds

5.5.1 Threatened or Endangered, Sensitive and Endemic, Survey and Manage Plant Species – General Trends

What are the natural and human causes of change between historical and current distribution of species and habitat for species of concern in the watershed?

Overall, historical changes in the habitat and population of plant species of concern were regulated primarily by natural systems, such as climatic and geological processes, and natural low intensity fires. Indigenous people had secondary impacts such as periodic burns and collection of plant material for food, clothing, and shelter. Populations of the vascular plant species of concern associated with rock outcrops, serpentine substrates, and wetlands were naturally fragmented by the scattered geologic occurrences of intrusions of rock, ultramafic rock, and the often scattered geologic occurrence of wetlands. However, wetlands associated with riparian corridors were a connected feature throughout the analysis area. Populations of non-vascular species of concern associated with mature forest components (large trees and large down woody debris) had a widespread and available habitat throughout the analysis area.

The European anthropogenic factors have significantly impacted and changed population levels and habitats of the species of concern. These factors include land development, logging, road building, mining, grazing, and fire suppression. Past logging has fragmented and reduced mature forest habitats as well as changed the qualities of adjacent habitats such as wetlands, rock outcrops, and serpentine substrates. These effects occur through the loss of shade canopy, resulting in increased exposure and evaporation. Road building throughout the analysis area has diverted or concentrated water that potentially affect wetland species of concern. Additionally, road building has fragmented habitat and suitable habitat has been lost for most of the species of concern. Mining has had similar effects as road building, in addition to physically removing substrate for plant growth. Grazing has impacted population levels of some plants, and the suitable habitat particularly has been impacted. Fire suppression has interrupted the historical fire ecology in the region and resulted in increased fuel loading and the potential for high-intensity fires. This could cause the loss of potential habitat and reduce population levels of many of the plant species of concern, as well as alter the rate and direction of successional processes.

Logging has occurred within the WAA since the early part of the 20th century, and most forested stands are second-growth. Fire ecology records indicate much greater stand densities presently due to fire exclusion practices despite widespread logging. It is unknown whether populations of species occupying upland forests covered a broader or smaller range, as many of the sensitive species can be found to some degree. As stand densities have increased with fire exclusion, habitat for shade-tolerant forest species such as the lady's-slippers and all bryophytes, has increased. Habitat for those species requiring openings (i.e., Elmer's lupine, Red Mountain catchfly, and clustered green gentian) has presumably decreased. Timber harvest has had a lesser impact on serpentine openings and Jeffrey pine/ incense cedar forest type. Lesser timber volumes in these areas have discouraged logging as compared with more mesic forests.

The sensitive habitats (i.e., rock outcrops, serpentine substrates, and wetlands) that support many of the plant species of concern are highly susceptible to habitat degradation and loss due to their often-isolated and limited occurrence in the analysis area. In addition, harsh sites such as serpentine substrates and rock outcrops are slow to recover from disturbances.

Serpentine openings have been greatly impacted by mining and road building which took place in the mid-19th century. The apparent absence of vegetation, naturally gentle slopes, and lack of knowledge of these fragile habitats has led to fragmentation. Rates of recovery are slow in these barrens, and full restoration is unlikely to occur without assistance where soil disturbance has been moderate to heavy.

A conservation strategy to develop management recommendations for serpentine endemic plant species is currently being developed. The Multi-Species Conservation Strategy for the Serpentine Endemics of the Rattlesnake Creek Terrane would develop standards and guidelines for the conservation of several serpentine species, as well as suggesting reserve areas and restoration projects.

Plant Species of Concern-related Key Questions

- *What are the distribution status and trends of special-status plant species (i.e., federally threatened or endangered, Forest Service sensitive and endemic, and Northwest Forest Plan survey and manage) and associated habitats? Are there management opportunities to protect and/or enhance the existing habitat conditions?* See Sections 3.6, 4.10, 5.5, and 6.4 on Plant Species of Concern. Comprehensive rare plant surveys of the watershed analysis area are currently underway by the USDA Forest Service.
- *What natural plant communities and associated special habitats (i.e., plant species with special adaptation to mineralized soils) of concern exist?* Are there management opportunities to enhance and/or protect the exiting special habitat components and associated plant communities? See Sections 3.6, 4.10, 5.5, and 6.4 on Plant Species of Concern.

5.5.2 Noxious/Invasive Weeds – General Trends

What are the natural and human factors contributing to changes in the historical and current populations and habitats of the noxious weeds present on the analysis area? What are the influences and relationships between noxious weeds and other ecosystem processes in the watershed?

Noxious weeds overrun and alter native ecosystems and form large and aggressive monocultures that displace native plants and alter long established native flora and fauna relationships (food, habitat, and genetic), soil chemistry, fire frequency, and water table levels. Without combined native plant revegetation and weed abatement programs in the analysis area, habitat quality will decline and habitat loss will rapidly accelerate for both flora and fauna. Main routes of travel enable introduction of weeds and distribution of weeds throughout the analysis area. Fire suppression activities can introduce weeds as equipment moves between forestlands carrying weed propagules.

Potential effects of the establishment of invasive and noxious weeds include increased fire hazard, loss of native plant species diversity, loss of income from agricultural uses (reduced crop and livestock yields), and loss of habitat for livestock. A large portion of the analysis area is privately owned, making management and control of invasive and noxious weeds more complex. However, public access areas adjacent to the ridge road the length of South Fork Mountain are seriously infested by diffuse knapweed. Focused weed abatement here should be feasible.

Yellow star thistle and St. John's-wort are found throughout the watershed analysis area, while scotchbroom, Canada thistle, and dalmation toadflax tend to be found in more dispersed, isolated populations. Only one known population each of diffuse and spotted knapweed (Hidden Valley and Rattlesnake Creek watersheds, respectively) are known from the WAA and the Trinity National Forest. All weed populations can be expected to expand more or less due to restrictions on use of chemical controls in Trinity County and shortages of funding for manual control. With time, and the establishment of new invasive weed populations, control becomes increasingly difficult because of increased proximity of seed sources. The best control and management strategy for the analysis area is removal when populations are small and contained, as are the existing knapweed populations. A large part of the Hidden Valley watershed encompasses private inholdings, increasing the complexity of invasive weed control. The origin and concentration of the South Fork Mountain diffuse knapweed population is on private land adjacent to the ridgetop. Effective management of this population depends on cooperation from the private landowners.

Noxious Weeds-related Key Questions

- *What are the distribution status and trends related to noxious weed (or invasive exotic plants)? Are there opportunities to identify and control spread of the noxious weeds?* See Sections 3.6, 4.11, 5.5, and 6.4.

5.5.3 Grazing – General Trends

What are the significant trends which have occurred from historic to present times concerning livestock grazing activity and its impact upon the physical condition of the watershed analysis area?

Grazing in the WAA by sheep, cattle, horses, goats, and swine began during the mid-1800s, when settlers first arrived to the region. Livestock were grazed on private and public lands with little or no governmental regulation until the late 1800s, when the U.S. government established Lands of the Public Domain. In 1905 limits on numbers of animals and seasons of use were first established. Prior to this the number of animals grazed on the forestland were as high as 60,000 head. The greatest grazing impacts occurred before the establishment of the National Forest System in 1906, and again during World War I, when sheep production was increased for meat and wool production. In addition to overgrazing, the periodic burning of rangelands and the introduction of invasive and non-native plant species resulted in changes to the landscape ranging from short-term to permanent.

Historic concentrated use of riparian areas and wet meadows by livestock caused the greatest impact from trampling by animals. The introduction of invasive weeds into wet sites has resulted in some displacement of endemic plant species, while soil compaction and erosion have directly affected the physical habitat. Even though livestock numbers have dramatically decreased in recent times, livestock continue to converge at wet sites where water is available and the vegetation is most lush. These wet sites are especially susceptible to disturbances. On upslope drier sites, the early practice of deliberately burning grazed lands had encouraged the development of open grassy areas. Subsequent fire suppression has encouraged the recovery of trees and brush into these open areas, while reduced grazing pressure has encouraged understory vegetation to increase in many areas. Invasive weeds continue to be an issue within parts of the analysis area, especially in wet sites, along roads and in proximity to private inholdings.

Grazing-related Key Questions

- *What sensitive habitats for plant species are potentially affected by existing livestock grazing activities? What are the status and trends for livestock grazing allotments? Are there opportunities to redirect livestock grazing away from, or exclude them from, sensitive areas?* See Sections 3.6, 4.10, 4.12, and 5.5 on Grazing. Management recommendations are discussed in Section 6.4. Also, see the Watershed Analysis of the South Fork Trinity River (USFS 2000) for detailed discussion on grazing-related issues and grazing allotments within the watersheds.

5.6 Wildlife Habitats and Species

What are the natural and human causes of change between the historical and current forest vegetation/habitat conditions and wildlife species distribution? What are the influences and relationships between forest vegetation/habitats and species distribution and other ecosystem processes in the watershed?

5.6.1 Forest Vegetation/ Habitats – General Trends

The current forest cover types have changed in comparison to the reference forest condition. Vegetative conditions changed over time as a result of forest development pathways, fire disturbance and suppression, and land use activities. A mosaic of forest stands with varying species, ages, and tree sizes and densities would characterize current vegetation and landscape condition.

Historically the WAA could be characterized by a fire regime with frequent, low-severity understory fires. With extensive fire suppression, the historic fire regime has been altered to infrequent, high-severity stand-replacement fires. The change in fire regime over time falls outside the natural range of variability. Fire is a natural disturbance that initiates change and affects the vegetation composition, structure, and landscape pattern. Wildland fire effects on flora include plant mortality, vegetative regeneration, seedling establishment, and others (Brown and Smith 2000). The change in fire regimes within the WAA is evidenced by the response by white fir and incense cedar (both fire intolerant species), and hardwood species in the lower elevations. Current stand density from natural regeneration of all species is higher than historical levels due to change in fire regimes within the analysis area. Changes in historical fire regime would create situations in the analysis area where there may be encroachment by conifers into meadows or grasslands, and oak-woodlands. Infrequent fire regimes tend to favor trees over grasses and shrubs in this open plant community/forest interface areas. Wildland fires in terrestrial ecosystems have varying effects on animal populations and communities, wildlife foods, and fauna-interactions (Smith 2000).

Timber harvest, both clearcutting (removing all trees from an area) and high grading (removing only the largest and most valuable trees), grazing, fire suppression and catastrophic fires of recent years have changed the forest vegetation structure in the WAA. Today's forest conditions differ from pre-settlement forests in a number of ways that may include: (1) reduction of large trees and vegetation structure (fewer tree size classes within a stand), (2) loss of diversity between forest stands or patches (larger area of homogeneous forests), (3) larger accumulation of fuels that increase the risk of catastrophic fire, and (4) introduction of pests (i.e., insects and pathogens) and exotic plants significantly influenced vegetation structure and composition. Pre-settlement forest vegetation and landscape condition is hypothesized to be exceptionally patchy, and containing a complex mosaic of age, size, and structure. Forest stands in the analysis area initially cleared for grazing activities during the settlement period later reestablish as forestlands, especially in Douglas-fir cover type.

As a result of catastrophic fires such as the 1987 fires and intensive timber harvesting until late 1980s, the distribution and abundance of late-successional and old-growth forests in the WAA may have declined from historical forest conditions. In comparison to historical forest landscape, more mid- and early-seral stage than late-seral/old-growth habitat type exists currently. The decline in the distribution of late-successional/old-growth habitat is especially significant in the upslope forests. The mesic condition associated with riparian area forests can provide a barrier from wildland fires. The microclimate, vegetation type, and topographic position of riparian areas would reduce the fire intensities and damage severity to the terrestrial/aquatic ecosystem interface. Stand-replacement fires do occur within riparian areas resulting in catastrophic effects on riparian vegetation and subsequently affecting stream channels or aquatic systems.

Catastrophic fires, timber harvesting, road building, grazing, mining, and other human activities tend to modify watershed hydrology and accelerate erosion/sedimentation that have potential impacts on water quantity and quality. In comparison to the reference condition, the recent disturbance regimes on the forest landscape tend to be more intense and widespread. Implementation of best management practices at various spatial scales is important for avoidance or minimization of potential impacts to riparian and aquatic wildlife resources.

Wildland fires continue to play an important role in the creation and removal of snags and downed logs. Historic timber harvesting, especially clearcutting, contributed to the decline in the abundance of snags and downed wood in previously entered forest stands located in the WAA. Snags and downed wood are components of stand decadence, and are prevalent habitat elements in late-successional and old-growth forests in the analysis areas. Early and mid-seral stage habitat types have limited abundance of snags and coarse woody debris as a result of historic fires and timber harvest. Tree plantations are devoid of larger diameter snags and downed wood. Residual woody material in tree-dominated habitats is important habitat structural component for terrestrial wildlife.

5.6.2 Landscape Pattern and Habitat Connectivity

Wildlife species are adapted to specific abundance and spatial arrangement of suitable habitat components. Stand-replacement fires, timber harvesting and reforestation, and road building can alter forest landscape pattern by increasing similarity or fragmentation as a result of disturbance or succession. The current landscape vegetation pattern in the WAA has been significant altered from the historic landscape condition. The 1987 fires that burned significant portions of the WAA and have altered the forest landscape pattern, especially in Plummer Creek watershed. The fires in 1987 to a lesser extent impacted the landscape pattern in Rattlesnake Creek and Hidden Valley watersheds. To a large extent, the 1987 fires burned late-successional reserve and unroaded recreation land allocation in the Plummer Creek watershed. The 1987 fires fragmented the forest landscape and potentially limited habitat connectivity between the late-successional reserve areas located in Plummer Creek and Hidden Valley watersheds. Existing forest road density may contribute to landscape fragmentation in the Rattlesnake Creek watershed. The land allocation in Rattlesnake Creek is mostly matrix lands, with historic timber harvesting and road building activities.

Riparian reserves and spotted owl dispersal habitat will contribute to improved landscape-level habitat connectivity, especially for closed-canopy, late-successional/old-growth forests associated species. Riparian reserves for perennial, intermittent, and ephemeral streams as outlined in the Aquatic Conservation Strategy will provide dispersal or travel corridor for terrestrial vertebrate species. However, upslope corridors or linkages for habitat connectivity between watersheds are limited due to existing vegetation condition and landscape pattern. The spotted owl habitat conservation strategies will contribute towards a mosaic landscape structure of closed- and open-canopy forests that facilitate dispersal for late-successional/old-growth associated wildlife species. Reforestation of burned areas (both upslope and riparian) and past timber harvest areas would accelerate the rate of reestablishing habitat connectivity in the WAA. Structure similarity instead of fragmentation would the outcome of extensive reforestation over the forest landscape in the analysis area.

Existing access roads could contribute towards landscape fragmentation of upslope forests for terrestrial and aquatic species. Road-stream crossings can create species movement barriers that will have potential adverse effects to aquatic herptofauna and fish species. Excessive forest roads contribute negatively through access-related disturbances and limiting habitat connectivity, especially for late-successional/old-growth forests associated species (i.e., northern spotted owl, northern goshawk, fisher, and marten).

5.6.3 Terrestrial and Aquatic Species

Comparative analysis of current and historical distribution of wildlife species was proven to be difficult for the WAA. For the reference condition timeframe, the overall emphasis for wildlife management was on game species in comparison to non-game, sensitive species that is being emphasized today. The information available to evaluate trends (including species distribution and population status) is limited due to lack of past focused field surveys for the species of concern. Wildlife species of special status or concern occurrences that are currently available for the WAA include bald eagle, northern spotted owl, peregrine falcon, northern goshawk, Pacific fisher, American marten, western pond turtle, and California wolverine. Information to evaluate population trends is generally not available for most species; however, habitat condition trends can be assessed using species-habitat associations. Species diversity cannot be evaluated since there are no comprehensive biological field surveys that exist for the WAA. Landscape diversity can be assessed using spatial pattern analysis for the characterization of tree-dominated habitat landscape structure.

5.6.4 Desired Forest Landscape Conditions

Since 1993 there has been a shift in forest planning for the National Forest System lands under the Northwest Forest Plan. The Northwest Forest Plan's three conservation strategies included terrestrial (i.e., late-successional and old-growth forest ecosystems), aquatic (i.e., aquatic conservation strategy), and social. The primary goal for the terrestrial strategy is "to protect and enhance habitat for late-successional and old-growth forests related species," and the primary goal for the aquatic conservation strategy is "to restore and maintain ecological integrity of watershed and aquatic ecosystems" (FEMAT 1993, USDA and USDI 1994a,b). The terrestrial strategy is northern spotted owl and marbled murrelet emphasis; the aquatic conservation strategy is fish species emphasis; and the combined terrestrial and aquatic strategies is survey-manage biodiversity emphasis. These ecological resources conservation assume overall positive outcomes through the implementation of standards and guidelines that reflect the new management directions. The overall management strategy is to allocate large reserves areas for species-habitat conservation.

In general, the current and future trend line for forest vegetation and terrestrial wildlife habitats on National Forest System lands in the WAA is for the maintenance and/or enhancement of late-successional and old-growth forests in upslope and riparian areas. Biological diversity will be maintained or restored through the maintenance of long-term site productivity of forest ecosystems.

Forest Vegetation/ Habitats and Species-related Key Questions

- *What is the existing vegetation distribution by composition and structure? What is the current landscape pattern of the vegetation mosaic, with special emphasis on habitat connectivity related to Late-Successional and Riparian Reserves?* See Section 3.7, Wildlife Habitats and Species.
- *What are the distribution status and trends related to special-status fish and wildlife species (i.e., federally threatened or endangered, federal candidate for listing, federal species of concern, Forest Service sensitive, and Northwest Forest Plan survey and manage) and associated habitats?* See Sections 3.7, 4.13, and 5.6 on Wildlife Habitats and Species.
- What management opportunities exist to improve habitat capability for special-status species, and also to maintain and/or enhance species-habitat diversity? See Sections 5.6 and 6.5 on Wildlife Habitats and Species.

6. RECOMMENDATIONS

The purpose of this chapter is to bring the results of the previous landscape ecosystem analysis steps to conclusion, focusing on management recommendations that are responsive to watershed/ landscape process identified in the analysis. Prioritization of management actions will be identified, where possible. Adaptive management and monitoring activities will be identified, and data gaps and limitations will be documented.

6.1 Erosion Processes, Hydrology, Stream Channel, and Water Quality

Table 6-1 is a composite table that lists all of the subwatersheds in the WAA that has more than one indicator in the upper 10 percent cluster. The table also lists the percentage of National Forest System lands and land allocations/ management prescriptions.

Recommendations related to physical components (land and water) include the following:

- Conduct detailed road inventories in areas of the WAA that have not been inventoried. Use the new roads analysis procedure (USFS 1999c) to determine benefits and liabilities associated with the road system within the WAA. Collect data on road traffic levels and type of use.
- Consistent with the results of the roads analysis procedure and other management objectives, reduce road densities with the goal of achieving densities less than three miles per square mile. Rattlesnake Creek watershed in particular has a high average road density. Table 5-3 and Map 6-1 show the subwatersheds with the highest road densities in the WAA. Roads in areas of sensitive geology, steeper slopes, and high EHR should be given a priority.
- Reduce road densities within riparian reserves and restore riparian reserves to properly functioning conditions consistent with ACS objectives. Evaluate opportunities to reconnect stream channels to the floodplain to reduce instream sediment storage, reduce channel widths, increase habitat complexity, and reduce impacts from flood events. Table 5-4 and Map 6-2 list the subwatersheds with the highest riparian road densities. Table 5-5 and Map 6-2 show subwatersheds with the highest road-stream crossing densities.
- Reduce road-related erosion and sediment delivery to streams by:
    - Closing unnecessary roads within the riparian reserves (target subwatersheds with high density of riparian roads).
    - Upgrading segments of roads that have been identified as potentially delivering sediment to streams. Table 5-2 and Map 6-2 show subwatersheds with highest density of sediment delivering road segments.
    - Eliminate or upgrade stream crossings in areas with high road-stream crossing densities. Table 5-5 and Map 6-2 show subwatersheds with highest densities of stream crossings.

  - Evaluate the stability of roads on Galice Formation or South Fork Mountain Schist on slopes greater than 35 percent. Table 5-6 and Map 6-1 show the subwatersheds with highest densities of roads in these sensitive areas.
  - Road improvement considerations include:
    - Convert native surfaced roads to gravel.
    - Increase the frequency of drainage structures.
    - Design roads to minimize interception, concentration, and diversion potential, including measures to reintroduce intercepted water back into slow (subsurface) pathways by using outsloping and drainage structures rather than attempting to concentrate and move water directly to channels.
    - Evaluate and eliminate diversion potential at stream crossings.
    - Design road-stream crossings to pass all likely watershed products, including woody debris, sediment, and fish—not just water. Current design specifications require stream-road crossings to accommodate a 100-year flood event.
    - Consider landscape location, hillslope vulnerability, and orientation of roads when designing, redesigning, or removing roads.
    - Design with failure in mind. Anticipate and explicitly acknowledge the risk from existing roads and from building any new roads, including the probability of road failure and damage to local and downstream resources that would result.
- In areas burned in the 1987 fires:
  - Monitor, identify, and restore areas that are delivering sediment to streams.
  - Target areas with roads in sensitive geology and high erosion hazard ratings (see Map 6-1).
  - Focus on subwatersheds 12, 23, 52, 132, 137, 143, 195, 190, 181, 187, 178, 168, 171, and 179.
- Design and implement water quality monitoring plan to gather baseline data on water temperatures, flow, turbidity, nutrients, and pollutants. Sample locations on the S.F. Trinity River such as the USGS gage sites, and the bridge at Highway 36. Also monitor tributaries including Rattlesnake and Plummer Creeks and downstream of burned areas such as Little Bear Wallow Creek, Jim's Creek, and North Rattlesnake Creek. Monitoring for specific parameters such as fecal coliform should be conducted near areas of high recreational use such as campgrounds and stock holding areas.
- Restore the historic hydrologic and sediment regimes of fish-bearing streams by implementing a fuels reduction and prescribed fire program to reduce the occurrence of high intensity fires and water utilization by overstocked forest stands. This will increase stream discharge during the low flow period, reduce low flow water temperatures, and provide increased channel substrate diversity. Focus these activities in Rattlesnake Creek and Hidden Valley watersheds.

Table 6-1. Subwatersheds in WAA with Multiple Indicators in Upper 10 Percent Cluster. (Overall Ranking is in Appendix F).

							Miles per square mile				# per square mile		Percent of Area		
Sub-watershed	Square Miles (acres)	NFS lands (% area)	AMA (%)	AWA (%)	LSR (%)	Matrix (%)	Road Density	Riparian Road Density	Density of Sediment Delivering Roads	Road Density on both Slope and Geology	Road-Stream Crossing Density	Landslide Density	Burned in 1987 Fires	High or Very High EHR	Watershed Indicators Tally (Top 10%)
HV-10	0.9 (591.1)	50.6	0.2	50.4	0	0	4.2	***6.3***	***2.9***	0.5	2.2	2.2	7.7	45.3	2
HV-92	0.9 (563.0)	59.6	0	8.7	50.9	0	5.7	2.8	0.5	***1.5***	4.5	***4.5***	0	0.3	2
PC-96	0.2 (154.1)	66.0	0	66.0	0	0	1.8	***6.2***	0	0	8.3	***20.8***	70.2	24.2	2
PC-107	1.7 (1062.8)	100.0	1.9	0	0	98.1	5.5	***6.1***	***2.9***	0	10.2	0	7.1	23.0	2
PC-123	1.7 (1110.9)	51.7	0	0	51.7	0	0.9	0.7	0	0.5	1.7	***4.0***	85.8	***63.9***	2
PC-132	0.4 (236.5)	96.4	0	0	96.4	0	0.7	0	0	0	0	0	***99.9***	***73.7***	2
PC-133	0.7 (471.3)	100.0	0	1.2	87.9	10.9	3.3	5.3	0	***2.0***	9.5	***5.4***	33.2	61.9	2
PC-143	0.4 (271.8)	100.0	0	77.5	22.4	0.1	1.2	0	0	0.1	0	0	***99.8***	***74.3***	2
RC-146	1.1 (687.2)	100.0	0	0	0	100.0	***7.0***	***7.3***	***3.1***	0	***24.2***	0	7.8	0	4
RC-153	1.7 (1116.2)	100.0	0	0	0	100.0	***6.0***	5.9	***2.9***	0	***24.1***	0	22.9	8.2	3
RC-156	2.4 (1508.0)	55.5	5.9	0.0	0	49.6	***7.3***	5.2	***3.5***	0	10.2	0	0	***61.9***	3
RC-157	0.5 (328.1)	100.0	0.1	0	0	99.9	4.6	2.2	***3.5***	0	5.9	0	0	***68.3***	2
RC-158	1.2 (759.7)	100.0	0	0	0	100.0	***6.5***	***15.4***	2.7	0	*19.4*	0	27.1	21.6	3
RC-161	0.9 (564.3)	9.3	0	0	0	9.3	***5.9***	***7.3***	***4.4***	0	13.6	0	0	52.2	3
RC-164	2.0 (1307.7)	58.0	1.3	0	0	56.7	***6.1***	***7.9***	***3.8***	0	***18.6***	0	0	35.6	4
RC-168	0.6 (391.0)	100.0	0	0	0	100.0	4.6	3.3	2.1	0	***16.4***	0	***100.0***	16.3	2
RC-171	0.9 (581.5)	100.0	0	0	0	100.0	4.6	2.8	1.5	0	***17.6***	0	***100.0***	7.3	2
RC-173	0.6 (387.4)	30.9	0	0	0	30.9	***5.9***	***6.6***	***3.0***	0	13.2	0	0	15.9	3
RC-177	0.7 (435.2)	10.9	0	0	0	10.9	***7.1***	4.5	*3.3*	0	10.3	0	0	29.1	2
RC-178	1.7 (1119.9)	100.0	0	0	1.0	99.0	***5.8***	***6.9***	***3.3***	0.1	***16.0***	0	55.3	6.6	4
PC-181	0.6 (357.4)	100.0	0	95.2	0	4.8	0	0	0	0	0	0	***99.7***	***70.4***	2
RC-195	0.7 (474.6)	100.0	0	0	0	100.0	***6.2***	***8.2***	***4.4***	0	***18.9***	0	76.3	11.1	4
RC-208	0.3 (192.8)	89.5	0	0	39.4	50.1	***7.6***	***12.4***	***3.7***	0.2	***23.2***	0	30.4	3.8	4
RC-217	0.9 (581.5)	99.7	0	0	98.4	1.4	***6.0***	2.1	1.0	***2.5***	4.4	0	0	2.6	2

[Values in ***bold italics*** have more than one indicator in the upper 10 percent cluster].
[Include National Forest System Lands and Land Allocation/Management Prescriptions].

- Update the SRS harvest history GIS coverage, and complete the cumulative watershed effects analysis for all subwatersheds within the WAA.
- Inventory water rights claims and other diversions within the analysis area.

6.2 Fish Habitats and Species, and Riparian Habitat

Riparian Habitat

- The 1987 fire burned riparian forest stands throughout the Plummer Creek and Rattlesnake Creek watersheds. The current riparian condition includes a significant amount of young, dense-conifers that contributes only small-sized LWD to the streams. Thinning of the M2G and M3G strata will release the remaining trees and help achieve late-successional stage condition at a faster rate than if left unmanaged. The larger trees could have a significant beneficial effect on instream habitat conditions when they fall into the streams. In addition, wildlife species dependent on stands containing old-growth characteristics could also benefit from the accelerated development of these stands. These thinning projects could also be used to decrease the risk of catastrophic stand-replacement fires by reducing the fuel load accumulation. Plummer Creek and Rattlesnake Creek watersheds could benefit from these management actions.
- Explore opportunities to test the reintroduction of low intensity prescribed fire in riparian areas to reduce fuel loading in M4G stands in the Adaptive Management Area.
- Some riparian areas contain sparse to patchy (<20 to 39 percent) tree crown cover. These areas account for approximately 33 percent of the riparian acreage within the watershed analysis area. Interplanting conifers in these locations following site preparation could increase crown closure over time and reduce water temperatures, and eventually supply LWD to the channels. Forest stands of these types are located primarily in the Rattlesnake Creek and Plummer Creek watersheds.
- Thinning of overstocked stands in riparian reserves to accelerate development of late-successional/old-growth forest characteristics should be a priority to provide habitat connectivity and refugia for terrestrial, riparian, or riparian-aquatic species.

Fish Habitat

- Sediment inputs from natural and anthropogenic influences have resulted in pool filling and reductions in fish habitat quality in the Plummer Creek and Rattlesnake Creek watersheds. Road-related sediment delivery is a contributing factor to impacts to fisheries resources. Reduce road-related impacts to stream channels by rocking native surfaced roads, upgrading culverts to withstand 100-year runoff events, installing more frequent cross-ditch drains, outsloping roads where appropriate, and stabilizing cut and fill slopes. Implement these operations, where appropriate, according to the results of the road analysis procedures.
- Conduct surveys for LWD loads in Plummer Creek and Rattlesnake Creek watersheds to determine opportunities for instream LWD structure placement. These surveys should include a determination of channel type and stream gradient to help identify appropriate stream improvement locations. Channels adjacent to and downstream of M2G, M2P, M3P, M3G, XX2, and XX3 stands may benefit from instream LWD structure

construction. Instream structures could improve habitat complexity and functionality while the adjacent forest stands develop to the point they can contribute adequate supplies of wood to the stream.

- Water temperature information presented in Chapter 3 indicates stressful rearing conditions for salmonids exist in the watershed analysis area. An evaluation of riparian reserves' strata could help determine where tree-planting operations may increase conifer and hardwood production, improve canopy closure, and eventually decrease water temperatures. These types of projects would have the most benefit in forest stands with S or P tree density code.
- Implement an instream habitat, geomorphic, water flow, and water temperature monitoring program to assess the effectiveness of upslope, riparian, and instream restoration projects.

6.3 Vegetation and Fire/Fuels

Fire and Fuels

- Fuel hazard reduction treatments should be guided by the following criteria from the Shasta-Trinity National Forest's LRMP and National Fire Plan: (1) public safety, (2) high investment areas (i.e., structural improvements, plantations, private property adjacent to forest land, and others), (3) known areas of high fire occurrence, and (4) resource benefits, such as improvement to stand health through the reintroduction of fire into the ecosystem.
- For all land allocations, use prescribed fires to reintroduce low intensity fires back into the analysis area, especially areas that are deemed appropriate based on getting the most out of the use of prescribed fires and have the least impact on forest resources. Use available natural barriers, existing road systems, existing fuel breaks, natural openings or changes in the fuel type as boundaries for prescribed fires. It is very important to consider the use of thinning or biomass removal prior to doing prescribed fires. The growth of understory fuels may be too great to just use prescribed fire as the tool of choice. Focus hazard reduction activities in the areas around Trinity Pines near Post Mountain, along the California State Highway 36 corridor where human activities are concentrated, in areas where Fuel Model 10 is present, and in timber stands adjacent to plantations.
- Biomass reduction to reduce understory fuels should be allowed in all forestlands to assist in removing excess levels of windthrow, insect or pathogen infested, or mortality timber that will otherwise become a fire hazard if left. Treat all activity generated fuels with removal or prescribed burning. An area of primary concern is the Trinity Pines area near Post Mountain. Location of fire suppression water sources is an indispensable tool in the immediate response to wildland fire suppression. All locations and estimated capacities of existing sources within these watersheds should be identified and mapped.
- Identify strategic access roads and water sources for fire fighting needs in the WAA.

Forest Vegetation and Commercial Wood Production

- *Matrix Outputs:* There are an estimated 30,003 acres (net) of capable, available, and suitable (CAS) for commercial timber production in the Hidden Valley, Rattlesnake Creek, and Plummer Creek watershed anlaysis area. Of this CAS lands, there are 1,945 acres in the 4G and 6G strata. Assuming a 130-year rotation and a 10-year entry cycle, approximately 150 acres per entry cycle would be available for regeneration harvesting in the future. The primary harvest activities should be intermediate treatments to thin approximately 9,126 acres of 2G and 3G strata to move these stands toward a regulated condition, as provided for on Matrix and AMA lands within the Shasta-Trinity National Forest's LRMP. Once the thinning treatments are completed on these stands, a total of 30,003 acres would eventually be rotated into regeneration harvesting cycles. Assuming a 130-year rotation age, and a 10-year entry cycle, approximately 2,308 acres (net) would be available for regeneration harvesting per entry in the future. Other threshold factors, including habitat connectivity/fragmentation, cumulative watershed effects, unmapped riparian reserves, and regeneration potential must be considered during a site-specific analysis prior to proposing specific regeneration harvest treatment units within the analysis area.
- *Late-Successional and Riparian Reserves:* Limited harvest opportunities are available within the LSR and Riparian Reserve areas. Harvest activities within these areas have two principal objectives: (1) development of old-growth forest characteristics including snags, logs on the forest floor, large trees, and canopy gaps that enable establishment of multiple tree layers and diverse species composition; and (2) prevention of large scale disturbances by fire, wind, insects, and diseases that would destroy or limit the ability of the reserves to sustain forest species- populations. Harvests in these reserve areas could be non-commercial (biomass removal or precommercial thinnings), commercial thinnings, commercial harvests, or firewood cutting. Several plantations exist within the designated LSR and Riparian Reserve areas that would provide thinning opportunities which would meet both of the objectives listed above.
- *Regeneration Opportunities on Understocked Sites:* There are approximately 10,994 acres of CAS lands classified as 3P strata in the watershed analysis area. Since the forest was last stratified and classifications assigned, some of these stands may have grown into size class 4 stands. Conduct site-specific analysis of understocked stands on commercially suitable and available Matrix lands which may be suitable for regeneration harvest through the development of silvicultural prescriptions. Indicators of stand conditions which may be candidates include: size/density stands of 3S or P, or 4S or P. Watersheds currently deficient in habitat connectivity may be priority for treatment. Concentrations of these types occur in the headwaters of Rattlesnake Creek, Post Glade Creek, and Jim's Creek sub-watersheds.
- *Plantation Thinning Opportunities:* Conduct site-specific analysis of plantations that may be suitable for stocking control (thinning) through the development of silvicultural prescriptions. There are 5,476 acres of plantations on CAS Matrix lands on the watershed analysis area. Only about 6 percent of these acres are in plantations that are 27 years or older, therefore, commercial harvesting opportunities from the plantation areas are limited. However, precommercial thinning operations can be combined with fuel

reduction efforts in stands adjacent to older timber stands, and for pathogen control in mistletoe and cytospora infested areas.

- *Thinning Opportunities on Overstocked Young-Growth Sites:* Conduct site-specific analysis of well stocked stands which may be suitable for intermediate harvest (thinning) on suitable commercial Matrix lands, and within Late-Successional and Riparian Reserves through the development of silvicultural prescriptions. There are approximately 22,582 acres of size class 2 and 3 stands within Matrix lands available for commercial harvest. These stands should be evaluated for opportunities to thin overstocked stands and to restore vigor and capture expected mortality. Some mature stands in the watershed are beyond the natural range of variability in carrying capacity due to fire suppression and the subsequent encroachment of a shade-tolerant understory. This has led to conditions of low vigor and excessive mortality. Many of these types of stands occur in LSR areas, but also occur in the headwaters of Rattlesnake Creek and North Post Creek. Stands in LSR areas should be analyzed for suitability for thinning treatments that would enhance the overall structure of these stands and accelerate their advance toward late seral stage.
- *Regeneration Opportunities in CMAI Sites:* Conduct site-specific analysis of stands on CAS Matrix lands that may have culminated mean annual increment (CMAI). Such stands are no longer producing at their maximum potential and may be suitable for regeneration harvest through the development of silvicultural prescriptions. Indicators of stand conditions that may be candidates include size/density stands of 3N or G, 4N or G, or 6N or G. Most of these stand types occur in the LSR areas of the Hidden Valley and Plummer Creek watersheds. However, there are stands in Jim’s Creek, upper Plummer Creek, North Post Creek, North Rattlesnake Creek, and other areas outside of Late-Successional and Riparian Reserves that should be reviewed for potential treatment.
- *Salvage Opportunities:* Episodic events, both natural and human-caused, occasionally present opportunities for salvage of recently killed trees or to capture expected mortality. Such events include fires, insect infestations, landslides, and windthrow. When such events are known and are significant in size, they should be investigated for opportunities for salvage. Considerations in deciding which course of action should be taken, including taking no action, should include effects on wildlife, fire risk, site disturbance, erosion, site occupancy, site productivity, regeneration opportunities, and overall forest health. One known area that should be reviewed for salvage opportunities is in the Hidden Valley watershed. An endemic infestation of mistletoe and cytospora in the higher elevation red fir stands has been exacerbated by stress brought on by recent droughts. Trees showing signs of infection should be removed and slash treated by removal or prescription burning to make room for healthy trees to replace them.

6.4 Plants Species of Concern and Noxious Weeds

Federally Threatened or Endangered, Forest Service Sensitive and Endemic, and Survey and Manage Plant Species

- Inventory and map serpentine soils and populations of serpentine endemic plant species. Identify populations which have experienced the greatest fragmentation from past activities, and determine appropriate restoration treatments, including reducing road density.

- Continue development of Multi-Species Conservation Strategy for Serpentine Endemics in the Rattlesnake Creek Terrane.
- Identify wetlands which have experienced localized degradation from grazing activities. Consider following the management guidelines developed in the Watershed Analysis of the South Fork Trinity River (USDA Forest Service 2000). Establish measures to control impacts from grazing and trampling in localized wet meadows, including fencing, where necessary.

Noxious/ Invasive Weeds

- Inventory and map concentrations of invasive and noxious weeds. Identify specific areas of the National Forest where invasive weeds especially pose a threat to native vegetation. Emphasize surveys in areas of high risk, such as boundaries between the National Forest System lands and private inholdings, along roads, and within grazing allotments.
- Develop a focused and systematic weed eradication and endemic plant rehabilitation program for the National Forest System lands in the analysis area.
- Develop partnerships with private landowners in the South Fork Mountain area to control diffuse knapweed. Continue manual removal of diffuse knapweed.
- Manually remove spotted knapweed in the Hackney Spring area until population is managed, or more effective control methods become available.

Grazing

- Focus management for protection and rehabilitation of identified wet meadows and riparian areas with degraded native and sensitive plant habitat.
- Establish a monitoring and mitigation plan to protect the sensitive plant species of concern within the grazing allotments on the analysis area.

6.5 Wildlife Habitats and Species

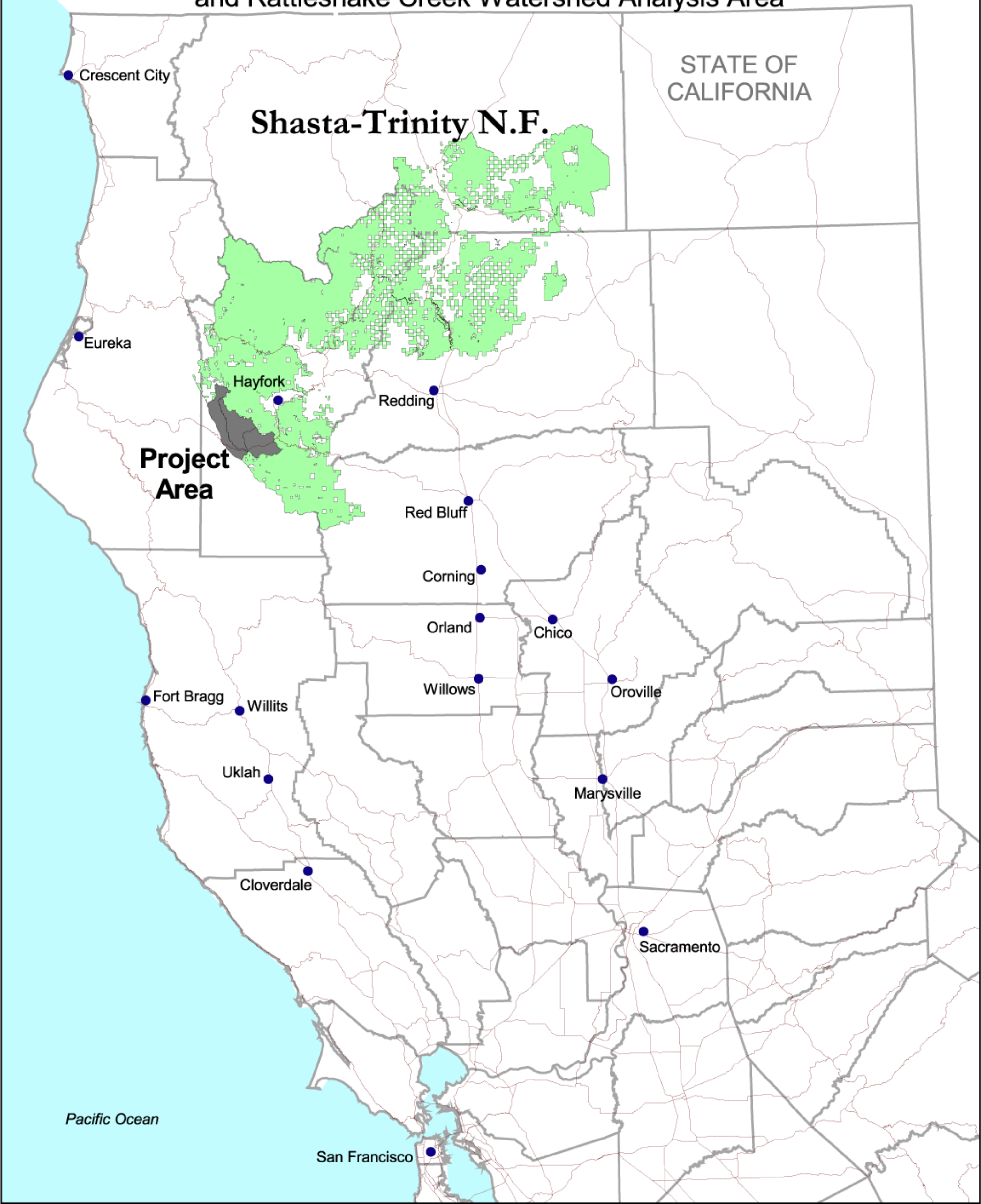
- *Stand Structure-Composition:* Restore upslope and riparian forest vegetation structure and composition within areas burned by the 1987 fires in Plummer and Rattlesnake Creeks. Existing stands with relatively high stocking levels should be thinned to reduce tree density and to achieve late-successional/old-growth forest conditions in the shortest possible time period. Stand thinning for this purpose should be of high priority. Vegetation management considerations should be given to strata M2G and M3G in Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds. In addition, strata D3G in Hidden Valley and Plummer Creek should be considered. Priority for stand treatment will be those upslope and riparian areas that overlap areas burned by the 1987 fires. Thinning should be conducted in plantations with high stocking levels. Reforestation of upslope and riparian areas impacted by the 1987 fires should be a priority. Erosion/sedimentation risk and potential impacts to water quality will be considered prior to implementation of stand vegetation management.

- *Landscape Structure-Composition:* Landscape-level patterns of forest cover, and forest stand or patch arrangements should be considered when implementing stand vegetation management. Landscape attributes are important for the distribution and occurrences of wildlife species sensitive to spatial pattern of potentially suitable habitats. Late-successional and old-growth forests that are highly fragmented has diminished habitat quality of habitat associated to these habitat stages. Stand treatments should consider post-harvest tree retention with an average diameter (at breast height) of 11-inch and at least 40 percent canopy cover, where possible, to maintain habitat connectivity across the forest landscape. Riparian areas in the upper third slope position are important habitat connectors to adjacent watershed/landscape; thus, stand treatment in these areas should be a priority, especially those stands burned in the 1987 fires. Forest vegetation pattern manipulation should consider landscape vulnerability to potential fire disturbances.
- *Adaptive Management and Monitoring:* Implement thinning from below, on experimental basis, in mid-seral stage stands within spotted owl home range core areas and riparian areas on Matrix lands in Plummer and Rattlesnake Creeks watersheds. Thinning priority will be give to stands with existing dense understory tree density. The stand thinning would accelerate development of tree-dominated habitats for multi-layered late-seral stage associated wildlife species, and provides canopy structure lift for forest raptors such as spotted owls and goshawks. Stand thinnings can be used in combination with low intensity prescribed fires, on an experimental basis, to reduce fuels hazard and potential landscape vulnerability to catastrophic fire disturbances. Snags and downed wood recruitment in upslope and riparian forests under various management scenarios should be monitored to characterize trends in wildlife habitat elements. Design and implement landscape-level monitoring for forest vegetation/habitats to determine effectiveness of management actions and resource trends.
- *Data Gaps and Limitations:* To improve the trend predictions for ecological resources, additional data is needed on forest vegetation structure, special habitat components, and wildlife species distribution and occurrences. Lack of adequate information will preclude effectiveness monitoring to evaluate meeting the ecological goals and objectives of the Northwest Forest Plan. Prioritization for species-population data collection should be as follows: (1) species distribution and species-habitat associations, (2) species-habitat predictive trend modeling, and (3) population persistence. Data capture priority for species-population should be as follows: (1) late-successional/old-growth forests, and (2) aquatic and riparian ecosystems associated species. The emphasis species may include federally threatened or endangered, federal species of concern, Forest Service sensitive, Forest Service survey and manage or protection buffer species. Overall, the existing species-population information is limited or lacking and it can only be utilized for preliminary evaluation. No detailed analysis of species/population status and trends can be conducted from the existing data.

Appendix A

Maps

Map 1-1: Location of Hidden Valley, Plummer Creek, and Rattlesnake Creek Watershed Analysis Area



Appendix B

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Appendix C

Cumulative Watershed Effects

Cumulative Watershed Effects Analysis Methods

GIS Data Analysis

1. Merged watershed themes: Hid_face 1,2,3,4, rattlesnake, plummer, lbearwallow.
2. Adjusted watersheds- divided watersheds > 2,000 acres in size, merged a few smaller ones.
3. Clipped HV_SRS layer to Hidplrat_bnd.
4. Assigned subwatershed numbers to layers HV_SRS, HPR_roads, and the private land layers, newroads, ratcover, plumcover, hiddencover using Identity.
5. Exported tables to dbf files and edited so that only the relevant information remained- subwatershed numbers, SRS codes, miles of roads, etc. depending on the database.
6. Exported dbf tables to MS Access.
7. Created table of treatment coefficients based on act_ext in the hv_activity database (Table ERA-1). Coefficients were taken from Haskins (1983), and from other coefficient lists used in California. Each code used in the SRS database was looked up in the SRS data dictionary and assigned a code. Most codes were not harvest-related and assigned a coefficient of zero.
8. Created table of treatment method coefficients based on METHOD_CAU attribute in the hv_activity database. Each code was looked up in the SRS data dictionary and assigned a modifier code. This coefficient modifies the treatment coefficient based on the method used- cable logging has about 2/3 the impact of tractor logging and was assigned a coefficient of .66. Helicopter logging has about ¼ the impact of tractor logging and was assigned a value of .25. (Table ERA-2).
9. Assigned coefficients to veg classes in private land coverage (Table ERA-3).
10. The recovery coefficient was calculated based on the year value in CY_accomp using the following equation and setting negative values to zero: Recovery Coefficient = (30-(2001-CY_accomp))/30.
11. Roads were assigned widths based on the CFF code or whether they were on private land. (Table ERA-4).
12. The five tables (four derived from GIS layers: SRS lands, private lands vegetation, FS roads layer, private lands roads, and one SRS activity table keyed to the SRS code) were sent to our database specialist along with the appropriate equations and unit conversion factors.
13. One watershed (Subwatershed number 5) that had all data from all four databases was selected and calculated in a spreadsheet to double-check the database results. See CWE Method Table.xls spreadsheet for the calculations.
14. The database specialist produced the raw output for the ERA table using relational databases and the method that he describes below. See CWE Method Table.xls for the output table.

[Database Methods by Matt Kozleski, Database Specialist]

ERA Analysis Procedure

This is a method to calculate a value for total Equivalent Roaded Acres (ERA) in the Hidden Valley, Plummer Creek, and Rattlesnake Creek watersheds. There are four factors that contribute to the calculation, and each is handled separately in the first stage, with the ERA totals summed together in the second stage.

The first factor is Forest Service roads. Each road length converts to ERA through multiplication by a CFF value. I received a table with the subwatershed ID, road length and CFF code (call the table ROADS). There were multiple entries in the table for each subwatershed. There was also a lookup table of CFF codes and their related multipliers. To calculate the ERA from Forest Service roads, I queried the CFF code multiplier into the ROADS table based on the relationship to the CFF code lookup table then updated each record in the ROADS table with a calculated field of the length multiplied by the multiplier, which included the width from the lookup table and a unit conversion factor.

Another ERA factor was roads on private lands. The working table included fields for road length and subwatershed number (call the table NEWROADS). This ERA calculation did not need a converting factor, so the calculation was done by multiplying the road length by a consistent width of 25 feet, and converting to acres. The only step necessary here was to update NEWROADS with this calculation.

Some of the watershed includes privately owned land. The table (PRIVVEG) had fields for the subwatershed ID, crown closure, size class, and acreage of each stand. I also had a lookup table of the treatment coefficient and recovery coefficient to be applied for each combination of crown closure and size class. First, I queried the coefficients into the PRIVVEG table through the relation between the size class and crown closure in each table. Then I multiplied the acreage of each stand by the coefficients to get ERA, and updated that value in PRIVVEG.

The last factor was ERA due to USFS management as recorded in the SRS database. Each activity had an SRS code, which identified the location, and an activity code that identified the type of activity and the coefficients, which I multiplied to calculate the ERA. Another factor was how long ago the activity took place. I calculated an age coefficient that ranged from 1 for something that took place this year to 0 for an activity that took place 30 years ago. Activities that occurred before 30 years ago, or those for which a date was not given, were assigned a coefficient of zero. There were two tables of data relating to this factor. The first had fields for SRS code, subwatershed ID, and acres affected (SRS). There were multiple listings for each code in each watershed. The second table was a lookup table of SRS code, activity code, year performed and a method code (ACT). Additional lookup tables included coefficients for each activity code and method code. In the first step, I added coefficient values to ACT through relationships to the lookup tables. Then I calculated the age coefficient. The next step was to query matching results from SRS and ACT into a new table that listed each activity performed in each subwatershed, the acreage, and the coefficients. From this I was able to calculate the ERA for each record in this table.

The next step was to summarize the information into one table. I created a master summary table that had a field for subwatershed, and fields for total acreage, and ERA acreage for each factor, and total ERA acreage. In this table, subwatershed ID would be a unique identifier, so there would be one record per subwatershed. I used a separate table, which had all the subwatersheds and their total acreage, to populate the main summary table with basic information. Next, I created summary queries for each factor, which summed the acreage, and ERA acreage for each subwatershed. Then I used the summary queries to update the main summary table with the appropriate information for each factor. For example, I ran an update query for new roads, which populated the NewRoadsTotalAcreage and NewRoadsTotalERA Acreage in the main summary table for each subwatershed that had new roads. I did similar update queries for each factor. The last step was updating the total ERA acreage field in the main summary field, which was a simple addition of the NewRoadsTotalERA, FSRoadsERA, ActivityERA, and PrivVegERA fields. This calculated a total ERA value for each subwatershed.

Issues, problems, and concerns with the ERA calculations:

- TOC values are set for the watershed as whole, not by subwatershed, so local areas that may be more sensitive are not represented.
- The SRS database seems to be the most problematic data layer.
- There are two components of the SRS database- the HV_SRS, which represents actual acres on the ground as calculated by GIS, and the HV_activity table, which lists one or more activities that have occurred on each parcel of land that has a unique SRS key.
    - The HV_SRS database was assigned subwatershed numbers using an identity function, creating a layer called SRS_ID2. If an SRS polygon straddled two subwatersheds, the polygon was split into two polygons (and records) with the same SRS key, but with proportional acreage in each subwatershed.
- Of the 1,276 records in the SRS_ID2 GIS layer database:
    - 710 SRS_ID2 records had a matching SRS code in HV-activity for a total of 6,409 on-the-ground acres.
        - The SRS code from these 710 records matched SRS codes with 6,409 records in the HV_activity table, totaling 63,352 acres.
        - Of these 6,409 records with matching SRS codes, 612 records did not have CY_accomp (year of activity codes) totaling 5,608 acres that were not used in the ERA calculation.
- 566 records did not have an SRS key that matched an SRS code in the HV_activity table for a total of 5,401 on-the-ground acres that had an unknown activity and were not used in the ERA calculation (45 of the total acreage). See CWE Method Tables.xls spreadsheet for the list of records that did not match.
- 179 HV_SRS records were not assigned to subwatersheds and dropped because they fell in the gaps between the subwatershed boundaries and the Hidplrat_bnd watershed boundary layer. This represented only 2.78 acres.

ERA values were calculated for all subwatersheds delineated in the Cumulative Watershed Effects map (Map 3-4). Subwatersheds below 300 acres in size were eliminated from the analysis (but included on the map) since most were face drainages or too small for meaningful analysis. The matrix below (in Appendix B) presents the results of the CWE analysis, which only includes about 55 percent of the harvest activity known to have occurred on the Shasta-Trinity National Forest lands within the WAA.

Matrix of Subwatershed-related Threshold of Concern (TOC) and Equivalent Roaded Acres (ERA) Calculations based on Incomplete Harvest Data

Sub-watershed ID	Watershed	TOC	Total Area (ac)	SRS Area (ac)	SRS ERA (ac)	Private Veg. Area (ac)	Private Veg. ERA (ac)	Length of FS Roads (mi)	FS Roads ERA (ac)	Length of Private Roads (mi)	Private Roads ERA (ac)	Total ERA	ERA (%)	TOC (%)	Condition Class
3	Hidden Valley	12	624.7	261.4	6.0	417.4	47.7	4.1	17.2	0.9	2.8	73.8	11.8	98.4	3
12	Hidden Valley	12	479.9	1245.8	21.5	146.2	14.8	3.6	15.5	0		51.8	10.8	89.9	3
94	Hidden Valley	12	809.7			497.5	50.4	6.3	26.9	1.8	5.5	82.8	10.2	85.2	3
9	Hidden Valley	12	519.9			416.8	38.3	1.1	4.7	1.8	5.6	48.6	9.4	77.9	2
36	Hidden Valley	12	957.2	441.4	7.0	685.9	63.4	4.1	17.2	0		87.6	9.1	76.2	2
118	Hidden Valley	12	466.0			290.1	27.6	2.0	8.2	1.7	5.1	40.8	8.8	72.9	2
69	Hidden Valley	12	1775.5	153.9	3.3	1140.3	105.3	7.4	31.4	4.5	13.7	153.8	8.7	72.2	2
207	Hidden Valley	12	534.4			276.1	24.3	1.3	5.7	4.0	12.0	41.9	7.8	65.4	2
49	Hidden Valley	12	875.0	107.8	3.1	385.1	43.6	2.9	12.3	2.4	7.4	66.4	7.6	63.2	2
228	Hidden Valley	12	1099.4	40.3	1.0	561.6	53.9	4.2	17.8	1.0	3.0	75.6	6.9	57.3	2
23	Hidden Valley	12	1365.2	2671.5	41.1	207.4	23.4	6.7	28.3	0		92.8	6.8	56.7	2
121	Hidden Valley	12	550.6			237.6	22.8	2.3	9.3	1.4	4.2	36.4	6.6	55.1	2
42	Hidden Valley	12	1813.3	119.2	2.7	840.7	76.4	6.5	23.7	2.8	8.4	111.3	6.1	51.1	2
92	Hidden Valley	12	563.0			227.4	11.1	5.0	17.1	0.5	1.6	29.9	5.3	44.2	2
10	Hidden Valley	12	591.1			291.9	20.3	3.8	10.0	0.3	0.8	31.1	5.3	43.9	2
209	Hidden Valley	12	1522.5	507.8	8.4	297.3	28.7	6.6	27.3	4.6	13.9	78.3	5.1	42.8	2
152	Hidden Valley	12	333.0	5.0	0.1	111.7	12.7	1.0	4.2	0		17.0	5.1	42.5	2
5	Hidden Valley	12	1552.0	806.8	12.9	339.0	31.5	6.7	28.6	0.1	0.3	73.3	4.7	39.4	1
77	Hidden Valley	12	1760.1	29.1	0.6	370.3	46.3	7.3	30.2	1.5	4.6	81.7	4.6	38.7	1
128	Hidden Valley	12	1659.0	1432.5	9.2	152.9	12.6	11.4	48.2	1.1	3.4	73.5	4.4	36.9	1
166	Hidden Valley	12	1789.4	337.4	2.8	333.4	30.2	9.2	39.8	1.1	3.3	76.1	4.3	35.4	1
206	Hidden Valley	12	710.2			53.1	5.1	4.7	19.5	0.6	1.9	26.5	3.7	31.1	1
172	Hidden Valley	12	494.4	150.7	5.9			2.9	12.2	0		18.1	3.7	30.6	1
160	Hidden Valley	12	625.7	710.7	9.3	20.7	0.3	2.7	11.6	0		21.2	3.4	28.3	1
138	Hidden Valley	12	1193.4	869.2	11.0	3.5	0	7.0	29.4	0		40.4	3.4	28.2	1
131	Hidden Valley	12	319.2	236.0	1.2	179.5	4.6	0.6	2.4	0.8	2.4	10.7	3.3	27.8	1
184	Hidden Valley	12	1044.2	139.8	0.1			7.5	33.4	0		33.6	3.2	26.8	1
204	Hidden Valley	12	486.4	21.2	0			3.3	15.6	0		15.6	3.2	26.7	1
150	Hidden Valley	12	465.1	314.8	4.9			2.3	9.8	0		14.7	3.2	26.4	1
189	Hidden Valley	12	665.4					4.7	20.5	0		20.5	3.1	25.7	1
47	Hidden Valley	12	1090.6			357.2	20.3	2.0	8.6	0.3	0.9	29.8	2.7	22.8	1

Sub-watershed ID	Watershed	TOC	Total Area (ac)	SRS Area (ac)	SRS ERA (ac)	Private Veg. Area (ac)	Private Veg. ERA (ac)	Length of FS Roads (mi)	FS Roads ERA (ac)	Length of Private Roads (mi)	Private Roads ERA (ac)	Total ERA	ERA (%)	TOC (%)	Condition Class
227	Hidden Valley	12	1026.5	230.2	3.6	107.2	9.4	3.5	15.0	0		28.0	2.7	22.7	1
198	Hidden Valley	12	554.6					3.2	13.7	0		13.7	2.5	20.7	1
199	Hidden Valley	12	621.6	140.0	2.4	69.2	0	3.0	11.9	0		14.3	2.3	19.1	1
119	Hidden Valley	12	384.3			26.6	3.2	1.6	4.6	0.3	0.9	8.6	2.2	18.7	1
188	Hidden Valley	12	702.9	0.7	0	90.3	0	3.2	13.8	0		13.8	2.0	16.4	1
226	Hidden Valley	12	453.7					1.7	7.0	0		7.0	1.5	12.8	1
113	Plummer	16	1262.5	2463.5	45.4	281.2	34.8	8.2	34.9	1.3	3.9	119.0	9.4	58.9	2
165	Plummer	16	500.1	1255.2	34.0			2.1	9.1	0		43.1	8.6	53.8	2
93	Plummer	16	328.3			221.7	17.0	1.9	8.0	1.0	2.9	27.9	8.5	53.1	2
66	Plummer	16	871.2	2500.5	39.2			6.4	26.9	0		66.2	7.6	47.5	2
116	Plummer	16	403.4	58.0	0.3	149.5	18.7	2.1	9.0	0.6	1.8	29.8	7.4	46.2	2
167	Plummer	16	1237.4	3056.6	59.5			7.7	30.5	0		90.0	7.3	45.5	2
107	Plummer	16	1062.8	1171.0	29.6			9.0	35.5	0		65.2	6.1	38.3	1
130	Plummer	16	1329.8	1262.2	25.3	162.5	15.7	9.0	36.5	0		77.4	5.8	36.4	1
124	Plummer	16	968.8	944.7	20.0			8.5	35.4	0		55.5	5.7	35.8	1
123	Plummer	16	1110.9			536.0	55.2	1.5	5.2	0		60.4	5.4	34.0	1
120	Plummer	16	1611.9	2708.9	43.0	16.0	2.0	9.9	41.5	0.3	0.9	87.4	5.4	33.9	1
129	Plummer	16	1685.0	1291.6	23.7			14.5	61.3	0		85.0	5.0	31.5	1
145	Plummer	16	1325.8	1270.1	32.7			8.0	33.8	0		66.4	5.0	31.3	1
154	Plummer	16	324.5			129.4	16.2	0		0		16.2	5.0	31.2	1
194	Plummer	16	540.8	62.5	1.2	59.6	6.0	3.6	10.6	0.2	0.6	18.3	3.4	21.2	1
225	Plummer	16	1430.1	302.1	5.7	220.3	22.6	5.8	19.8	0		48.1	3.4	21.0	1
134	Plummer	16	525.1	61.8	1.2			3.5	14.1	0		15.4	2.9	18.3	1
30	Plummer	16	1496.5			278.0	14.5	5.9	20.9	0.4	1.2	36.6	2.4	15.3	1
219	Plummer	16	1660.6	869.9	17.5	52.5	5.0	4.6	16.9	0		39.4	2.4	14.8	1
115	Plummer	16	342.7			60.0	6.5	0.6	0.7	0		7.3	2.1	13.2	1
133	Plummer	16	471.3	0.1	0			2.5	9.1	0		9.1	1.9	12.1	1
220	Plummer	16	1167.5			162.4	18.1	2.2	3.4	0		21.5	1.8	11.5	1
175	Plummer	16	927.0	247.4	5.2			1.6	6.6	0		11.8	1.3	8.0	1
84	Plummer	16	812.0	114.2	1.4	46.1	4.3	0.1	0.4	0.1	0.4	6.4	0.8	5.0	1
148	Plummer	16	591.5	16.7	0.7			1.1	3.6	0		4.3	0.7	4.5	1
52	Plummer	16	823.4	0.6	0	37.8	2.9	1.9	2.3	0		5.2	0.6	3.9	1
55	Plummer	16	369.0	72.7	1.7			0.2	0.3	0		2.0	0.6	3.5	1
155	Plummer	16	1545.7	120.3	4.7	6.3	0.8	0.5	2.1	0		7.5	0.5	3.0	1

Sub-watershed ID	Watershed	TOC	Total Area (ac)	SRS Area (ac)	SRS ERA (ac)	Private Veg. Area (ac)	Private Veg. ERA (ac)	Length of FS Roads (mi)	FS Roads ERA (ac)	Length of Private Roads (mi)	Private Roads ERA (ac)	Total ERA	ERA (%)	TOC (%)	Condition Class
163	Plummer	16	666.1			14.9	1.9	0		0		1.9	0.3	1.8	1
64	Plummer	16	431.4	1.5	0			0.2	1.0	0		1.0	0.2	1.4	1
74	Plummer	16	651.0	3.7	0.1			0.2	0.8	0		0.9	0.1	0.8	1
46	Plummer	16	579.4	10.8	0.3			0.3	0.4	0		0.7	0.1	0.7	1
181	Plummer	16	357.4	18.9	0.4			0		0		0.4	0.1	0.7	1
137	Plummer	16	319.9					0	0.1	0		0.1	0	0.2	1
170	Plummer	16	364.4					0		0		0	0	0	1
190	Plummer	16	625.3					0		0		0	0	0	1
177	Rattlesnake	16	435.2			387.7	42.9	4.8	20.2	0.1	0.2	63.2	14.5	90.8	3
171	Rattlesnake	16	581.5	2833.6	63.7			4.1	16.6	0		80.3	13.8	86.3	3
174	Rattlesnake	16	889.4	5276.0	84.3			7.8	29.6	0		113.9	12.8	80.1	3
161	Rattlesnake	16	564.3			511.7	45.1	5.2	22.1	0	0.1	67.3	11.9	74.6	2
169	Rattlesnake	16	1017.1	3172.8	69.4			8.5	33.5	0		102.9	10.1	63.3	2
168	Rattlesnake	16	391.0	1542.0	26.7			2.8	11.0	0		37.6	9.6	60.2	2
195	Rattlesnake	16	474.6	1203.0	25.1			4.6	20.5	0		45.7	9.6	60.2	2
173	Rattlesnake	16	387.4	19.8	0.3	267.9	21.5	3.6	15.1	0		37.0	9.5	59.6	2
164	Rattlesnake	16	1307.7	25.8	0	549.1	53.1	12.4	52.0	0.4	1.3	106.4	8.1	50.9	2
156	Rattlesnake	16	1508.0	345.7	3.7	670.4	39.5	17.3	72.1	0	0	115.3	7.6	47.8	2
146	Rattlesnake	16	687.2	1311.4	21.3			7.5	29.9	0		51.3	7.5	46.6	2
147	Rattlesnake	16	1451.9	104.0	1.7	576.6	50.8	13.0	55.3	0		107.8	7.4	46.4	2
217	Rattlesnake	16	581.5	1051.2	17.6	1.5	0	5.4	23.0	0		40.6	7.0	43.6	2
158	Rattlesnake	16	759.7	1193.7	22.6			7.7	28.3	0		50.8	6.7	41.8	2
197	Rattlesnake	16	815.4	1347.4	25.1			6.6	27.7	0		52.8	6.5	40.5	2
153	Rattlesnake	16	1116.2	1325.0	24.2			10.6	43.5	0		67.8	6.1	37.9	1
159	Rattlesnake	16	421.2	581.8	10.8			3.4	14.3	0		25.1	6.0	37.3	1
192	Rattlesnake	16	452.6	581.6	9.9			3.1	13.3	0		23.2	5.1	32.0	1
178	Rattlesnake	16	1119.9	1034.0	17.9			10.2	39.2	0		57.2	5.1	31.9	1
136	Rattlesnake	16	2037.7	1433.2	32.2	0.1	0	16.2	67.1	0		99.3	4.9	30.5	1
141	Rattlesnake	16	727.9	597.9	11.2			5.6	21.3	0		32.5	4.5	27.9	1
212	Rattlesnake	16	710.3	689.3	8.2			5.5	23.1	0		31.3	4.4	27.5	1
193	Rattlesnake	16	674.9	386.7	6.2			5.5	23.3	0		29.6	4.4	27.4	1
180	Rattlesnake	16	772.2	443.7	7.6	38.3	4.6	4.5	20.2	0		32.4	4.2	26.2	1
215	Rattlesnake	16	538.1	178.6	2.7			4.8	19.8	0		22.6	4.2	26.2	1
224	Rattlesnake	16	1395.1	620.3	9.8	9.3	1.2	11.3	47.0	0		58.0	4.2	26.0	1

Sub-watershed ID	Watershed	TOC	Total Area (ac)	SRS Area (ac)	SRS ERA (ac)	Private Veg. Area (ac)	Private Veg. ERA (ac)	Length of FS Roads (mi)	FS Roads ERA (ac)	Length of Private Roads (mi)	Private Roads ERA (ac)	Total ERA	ERA (%)	TOC (%)	Condition Class
203	Rattlesnake	16	1009.9	298.2	4.2			8.6	36.6	0		40.8	4.0	25.3	1
218	Rattlesnake	16	1399.7	587.0	9.2	65.6	8.2	8.6	38.5	0		56.0	4.0	25.0	1
144	Rattlesnake	16	457.7	209.8	4.4			3.1	13.1	0		17.5	3.8	23.8	1
183	Rattlesnake	16	371.7	115.5	2.1	23.6	2.1	2.6	9.8	0		13.9	3.7	23.4	1
186	Rattlesnake	16	1830.9	1180.0	18.2	7.4	0.9	10.9	48.9	0		68.0	3.7	23.2	1
191	Rattlesnake	16	1404.6	717.0	11.9			8.6	35.7	0		47.6	3.4	21.2	1
157	Rattlesnake	16	328.1	46.0	1.2			2.3	9.5	0		10.6	3.2	20.2	1
211	Rattlesnake	16	440.3	268.2	5.1			2.1	8.6	0		13.6	3.1	19.3	1
176	Rattlesnake	16	850.2	248.3	5.8	33.6	2.0	4.4	17.8	0		25.6	3.0	18.8	1

Appendix D

Vegetation/Timber Strata Descriptions

VEGETATION/ STRATA TYPE		
• CX – Mixed Conifer	• NW – Water (lakes, etc.)	• D – Douglas-fir
• DF – Douglas-fir	• PP – Jeffrey Pine or Ponderosa Pine	• GR – Grass
• DP – Digger Pine	• RF – Red Fir	• HCO – Commercial Hardwoods
• GH – Herbaceous Cover	• SA – Chaparral	• HNC – Non-Commercial Hardwoods
• GL – Grass	• SM – Montane (buckbrush, whitethorn, etc.)	• M – Mixed Conifer
• HB – Black Oak	• SP – Sugar Pine	• NC – Forest, Commercial Conifers
• HC – Mixed Commercial Hardwoods	• SR – Streamside (meadow, alter, etc)	• NF – Non-Vegetated
• HL – Live Oak	• SX – Misc. Shrubs	• R – Red Fir
• HW – Oregon White Oak	• UX – Clearcuts/Type Conversions	• SX – Non-Forest, Shrubs & Brush
• NB – Barren (rocks)	• WF – White Fir	• XX – Plantations or Recent Cutover Land
• ND – Urban Developed (roads, etc)		

VEGETATION SIZE		
Size Class	**Size Class Code**	**Crown Diameter**
Seedlings and Saplings	1	0-5 feet
Poles	2	6-12 feet
Small to Medium Timber	3	13-24 feet
Large Sawtimber	4	25-40 feet
Large Sawtimber	5	Over 40 feet
Two-Storied (Understory Size 1 or 2)	6	
*Based on predominant crown size of commercial species stands or components of stands.		

VEGETATION DENSITY		
Density Group	**Density Codes**	**Crown Cover**
Sparse	S	<20%
Light	P	20-39%
Medium	N	40-69%
Heavy	G	≥70%
*Applies only to commercial component of total stand density.		

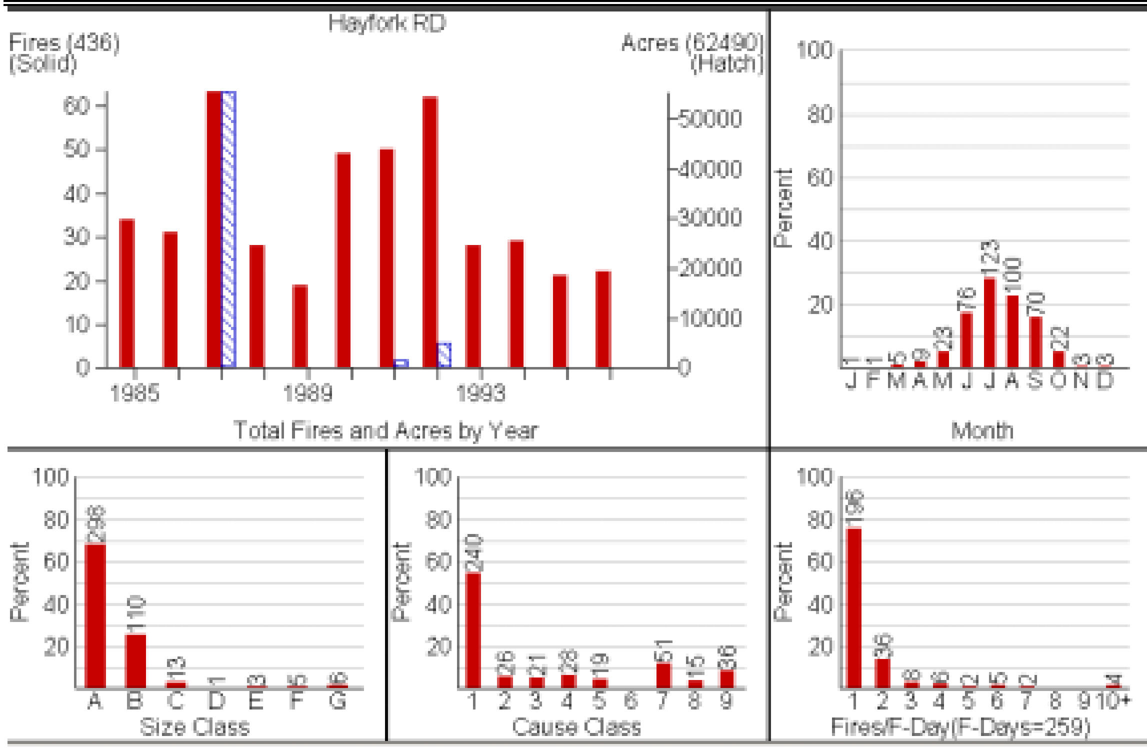
Appendix E

Fire and Fuels

Fire Family Plus

Fire Family Plus is a software system for summarizing and analyzing daily weather observations and computing fire danger indices based on the National Fire Danger Rating System (NFDRS). Fire occurrence data can also be analyzed and cross-referenced with the weather data to help determine the critical levels for staffing and fire danger for the area.

Fire Occurrence Data



Fire Size Class	Fire Cause Class
A- ¼ acre or less	1- Lightning
B- ¼ to 10 Acres	2 through 9- Human caused
C- 10 to 100 acres	
D- 100 to 300 acres	
E- 300 to 1000 acres	
F- 1000 to 5000 acres	
G- Over 5000 acres	

Definitions of Fuel Models

The prediction of fire behavior is valuable for assessing potential fire damage to land resources. A quantitative basis for rating fire danger and predicting fire behavior became possible with the development of mathematical fire behavior fuel models. Fuels have been classified into four groups– grasses, brush, timber, and slash. The differences in these groups are related to the fuel load and the distribution of the fuel among size classes. Size classes are: 0 to ¼ inch (1 hour fuels), ¼ to 1 inch (10 hour fuels), 1 to 3 inches (100 hour fuels), and larger size classes (1,000 hour fuels).

Descriptions of fuel models used in fire behavior, as documented by Albini (1976), are as follows:

FUEL MODEL (Typical Fuel Complex)	FUEL LOADING (tons/ acre)				Fuel Bed Depth (feet)
	1 hr	10 hr	100 hr	Live	
GRASS AND GRASS-DOMINATED					
1- Short Grass (1 foot)	0.74	0.00	0.00	0.00	1.0
2- Timber (Grass and Understory)	2.00	1.00	0.50	0.50	1.0
3- Tall Grass (2.5 feet)	3.01	0.00	0.00	0.00	-
CHAPARRAL AND SHRUB FIELDS					
4- Chaparral (6 feet)	5.01	4.01	2.00	5.01	6.0
5- Brush (2 feet)	1.00	0.50	0.00	2.00	2.0
6- Dormant Shrub/Hardwood Slash	1.50	2.50	2.00	0.00	2.5
7- Southern Rough	1.13	1.78	1.50	0.37	2.5
TIMBER LITTER					
8- Closed Timber Litter	1.50	1.00	2.50	0.00	0.2
9- Hardwood Litter	2.92	0.41	0.15	0.00	0.2
10- Timber (Litter and Understory)	3.01	2.00	5.01	2.00	1.0
SLASH					
11- Light Logging Slash	1.50	4.51	5.51	0.00	1.0
12- Medium Logging Slash	4.01	14.03	16.53	0.00	2.3
13- Heavy Logging Slash	7.01	23.04	28.05	0.00	3.0

The criteria for choosing a fuel model (Anderson 1982) include the fact that the fire burns in the fuel stratum best conditioned to support the fire. Fuel models are simply tools to help the user realistically estimate fire behavior. The 13 fire behavior predictive fuel models mimic fire behavior during the severe period of the fire season when wildfire pose greater control problems and impact on land resources.

Fuel Model Descriptions

Fuel Model 1 Grass– Fire spread is governed by the very fine, porous, and continuous herbaceous fuels that have cured or are nearly cured. Fires are surface fires that move rapidly through cured grass. Very little timber or shrubs is present.

Fuel Model 2 Grass– Fire spread is primarily through the fine herbaceous fuels. These are surface fires that may burn through pockets of litter and slash. Open shrub lands and pine stands that cover 1/3 to 2/3 of the area.

Fuel Model 3 Grass– Fire in this grass group display the highest rate of spread and fire intensity under the influence of wind.

Fuel Model 4 Shrub– Fire intensity and fast spreading fires involve the foliage and live and dead fine woody fuels with continuous secondary overstory involvement. Stands are nearly mature shrubs six feet tall or more. Conifer plantations can be included in this fuel model.

Fuel Model 5 Shrub– Fire is generally carried by the surface fuels that are made up of litter cast by the shrubs and grasses in the understory. Fires are generally not very intense because the fuels are light.

Fuel Model 6 Shrub– Fires carry through the shrub layer were the foliage is more flammable than fuel model 5 but requires moderate winds, greater than eight miles per hour.

Fuel Model 7 Shrub– Fires burn through the shrub strata and surface with equal ease and can occur at higher dead fuel moisture because of the flammability of live foliage and other live material.

Fuel Model 8 Timber– Slow burning ground fuels with low flame lengths are generally the case, although the fire may encounter small jackpots of heavier concentrations of fuels that can flare up. Only under severe weather conditions do the fuels pose a threat. Closed-canopy stands of short-needled conifers or hardwoods that have leafed out support fire in the compact litter layer.

Fuel Model 9 Timber– Fires run through the surface faster than in fuel model 8 and have a longer flame length. Both long-needle pine and hardwood stands are typical. Concentrations of dead down woody material will cause possible torching, spotting, and crowning of trees.

Fuel Model 10 Timber– Fires burn in the surface and ground fuels with greater intensity than the other timber liter types. A result of over maturing and natural events creates a large load of heavy down, dead material on the forest floor. Crowning out spotting and torching of individual tress is more likely to occur, leading to potential fire control difficulties.

Fuel Model 11 Slash– Fire are fairly active in the slash and herbaceous material. Fuel loads are light and of the shaded. Light partial cuts or thinning operations in conifer stand are representative of the model.

Fuel Model 12 Slash– Rapidly spreading fire with high intensities capable of generating firebrands can occur. When fire starts it is generally sustained until a change in conditions or fuel occurs. Fuels generally total less than 35 tons per acre and are well distributed. Heavily thinned conifer stands, clearcuts, and medium to heavy partial cut are this model.

Fuel Model 13 Slash– A continuous layer of slash generally carries fire. Large quantities of material three inches and greater are present. Fires spread quickly. Active flaming is present for a sustained period of time and firebrands may be generated. This contributes to spotting.

Fuel Model 99– Barren.

[Detailed descriptions of fuel models can be found in *How to Predict the Spread and Intensity of Forest and Range Fires* by R. C. Rothermel (USDA Forest Service, General Technical Report INT-143, June 1983)].

Appendix F

Watershed Indicators and Prioritization

Subwatersheds in Watershed Analysis Area and Watershed Indicators Ranking (upper 10 percent) for Prioritization of Management Actions. (Highlighted in *bold italics* are values in the upper 10 percent cluster)

Sub-watershed	Square Miles (acres)	NFS Lands (% area)	AMA (%)	AWA (%)	LSR (%)	Matrix (%)	Length of Road (mi)	Road Density (mi/sq. mi)	Length of Riparian Road (mi)	Riparian Road Density (mi/sq. mi)	Length of Sediment Delivering Roads (mi)	Density of Sediment Delivering Roads (mi/sq. mi)	Length of Road on both Slope and Geology (mi)	Road Density on both Slope and Geology (mi/sq. mi)	Number of Road-Stream Crossings	Road-Stream Crossing Density (#/sq. mi)	Number of Land-slides	Land-slide Density (#/sq. mi)	Burned in 1987 Fires (ac)	Burned in 1987 Fires (% area)	High or Very High HER (ac)	High or Very High EHR (% area)
HV-3	1.0 (624.7)	33.2	0	33.2	0	0	4.1	4.2	3.6	3.7	0.8	0.8	0	0	2	2.0	0	0	109.9	17.6	51.8	8.3
HV-5	2.4 (1552.0)	78.2	69.8	8.3	0	0	6.7	2.8	7.4	3.0	1.2	0.5	0	0	12	4.9	0	0	0	0	6.7	0.4
HV-8	0.1 (53.9)	0.4	0.4	0	0	0	0.7	***7.9***	0.1	1.6	0.1	0.9	0	0	0	0	0	0	0	0	0	0
HV-9	0.8 (519.9)	19.8	0.7	19.2	0	0	1.1	1.4	1.3	1.6	0.7	0.9	0	0	3	3.7	3	***3.7***	330.3	63.5	144.8	27.9
HV-10	0.9 (591.1)	50.6	0.2	50.4	0	0	3.8	4.2	5.8	***6.3***	2.7	***2.9***	0.4	0.5	2	2.2	2	2.2	45.5	7.7	267.9	45.3
HV-12	0.7 (479.9)	69.5	29.2	40.3	0	0	3.6	4.9	2.4	3.2	2.1	2.8	2.3	***3.0***	5	6.7	2	2.7	459.3	95.7	239.2	49.8
HV-23	2.1 (1365.2)	84.8	43.9	40.9	0	0	6.7	3.1	4.7	2.2	1.3	0.6	4.3	***2.0***	9	4.2	2	0.9	1168.9	85.6	672.7	49.3
PC-30	2.3 (1496.5)	81.4	0	0.7	80.8	0	5.9	2.5	8.6	3.7	0.9	0.4	2.1	0.9	14	6.0	5	2.1	58.4	3.9	705.7	47.2
HV-36	1.5 (957.2)	28.3	4.0	24.3	0	0	4.1	2.8	1.5	1.0	0.6	0.4	0.9	0.6	5	3.3	1	0.7	497.5	52.0	155.3	16.2
HV-37	0.1 (61.7)	100.0	0	98.6	1.4	0	0	0	0	0	0	0	0	0	0	0	1	***10.4***	61.0	98.9	19.2	31.0
HV-42	2.8 (1813.3)	53.6	0	16.5	25.0	12.1	6.5	2.3	2.7	0.9	1.9	0.7	0.6	0.2	7	2.5	2	0.7	171.5	9.5	134.5	7.4
HV-43	0.3 (209.5)	93.5	0	27.1	66.3	0	0	0	0	0	0	0	0	0	0	0	2	***6.1***	0.3	0.2	21.6	10.3
PC-46	0.9 (579.4)	100.0	0	0	100.0	0	0.3	0.4	0.8	0.9	0	0	0.1	0.1	1	1.1	0	0	559.0	96.5	279.3	48.2
HV-47	1.7 (1090.6)	67.3	0	0.9	66.4	0	2.0	1.2	1.8	1.1	0.6	0.3	0.3	0.2	4	2.3	5	2.9	9.7	0.9	287.0	26.3
HV-49	1.4 (875.0)	56.0	0	0.5	41.6	13.9	2.9	2.2	1.3	1.0	1.3	1.0	0.4	0.3	5	3.7	1	0.7	0	0	88.0	10.1
PC-52	1.3 (823.4)	95.4	0	84.5	10.9	0	1.9	1.4	1.1	0.9	0	0	1.6	***1.2***	5	3.9	1	0.8	777.5	94.4	312.7	38.0
PC-55	0.6 (369.0)	100.0	0	62.9	37.1	0	0.2	0.4	0.9	1.6	0	0	0.2	0.4	1	1.7	0	0	369.0	***100.0***	165.6	44.9
PC-64	0.7 (431.4)	100.0	0	97.4	2.6	0	0.2	0.3	0	0	0	0	0	0	0	0	0	0	431.1	***99.9***	183.9	42.6
PC-66	1.4 (871.2)	100.0	0	8.4	0.1	91.5	6.4	4.7	3.4	2.5	1.5	1.1	0	0	9	6.6	0	0	871.2	***100.0***	17.0	1.9
HV-69	2.8 (1775.5)	35.8	0	0	24.1	11.7	7.4	2.7	5.5	2.0	2.0	0.7	0.8	0.3	16	5.8	2	0.7	0	0	229.4	12.9
PC-74	1.0 (651.0)	100.0	0	100.0	0	0	0.2	0.2	0	0	0	0	0	0	0	0	0	0	648.4	***99.6***	278.8	42.8
HV-77	2.8 (1760.1)	79.0	0	3.2	74.5	1.3	7.3	2.6	6.6	2.4	2.1	0.8	2.0	0.7	16	5.8	8	2.9	1.5	0.1	165.6	9.4
PC-84	1.3 (812.0)	94.3	0	94.3	0	0	0.1	0.1	0.3	0.2	0	0	0	0	1	0.8	0	0	809.9	***99.7***	334.4	41.2
PC-87	0.2 (118.2)	100.0	0	100.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	105.3	89.0	34.7	29.4
HV-92	0.9 (563.0)	59.6	0	8.7	50.9	0	5.0	5.7	2.5	2.8	0.4	0.5	1.3	***1.5***	4	4.5	4	***4.5***	0	0	1.8	0.3
PC-93	0.5 (328.3)	32.5	0	0	0	32.5	1.9	3.7	1.8	3.4	0.4	0.8	0	0	1	1.9	0	0	85.4	26.0	5.1	1.5
HV-94	1.3 (809.7)	38.6	0	1.2	27.5	9.8	6.3	5.0	3.5	2.7	1.4	1.1	0.3	0.3	11	8.7	1	0.8	0	0	10.2	1.3
PC-96	0.2 (154.1)	66.0	0	66.0	0	0	0.4	1.8	1.5	***6.2***	0	0	0	0	2	8.3	5	***20.8***	108.3	70.2	37.3	24.2
PC-107	1.7 (1062.8)	100.0	1.9	0	0	98.1	9.1	5.5	10.1	***6.1***	4.9	***2.9***	0	0	17	10.2	0	0	75.0	7.1	244.8	23.0
PC-113	2.0 (1262.5)	77.7	0	0	0	77.7	8.2	4.2	10.8	5.5	4.0	2.0	0	0	11	5.6	0	0	368.4	29.2	0	0
PC-115	0.5 (342.7)	82.5	0	75.3	7.2	0	0.6	1.1	1.0	1.8	0	0	0.2	0.3	1	1.9	0	0	319.3	93.2	102.3	29.9
PC-116	0.6 (403.4)	62.9	0	0	0	62.9	2.1	3.4	1.5	2.4	0.5	0.7	0	0	5	7.9	0	0	0	0	5.7	1.4
HV-118	0.7 (466.0)	37.7	0	0	23.1	14.7	2.0	2.8	1.6	2.2	0.6	0.8	0.2	0.3	7	9.6	2	2.7	0	0	0	0
HV-119	0.6 (384.3)	93.1	0	0	93.1	0	1.6	2.6	0.3	0.4	0.2	0.3	0	0	1	1.7	4	***6.7***	0	0	2.1	0.6
PC-120	2.5 (1611.9)	99.0	0	0	38.6	60.4	9.9	3.9	4.2	1.7	2.8	1.1	0	0	16	6.4	9	3.6	0	0	473.2	29.4
HV-121	0.9 (550.6)	56.8	0	0	43.3	13.6	2.3	2.7	2.3	2.7	0.2	0.2	0.1	0.1	3	3.5	1	1.2	0	0	5.7	1.0

Sub-watershed	Square Miles (acres)	NFS Lands (% area)	AMA (%)	AWA (%)	LSR (%)	Matrix (%)	Length of Road (mi)	Road Density (mi/sq. mi)	Length of Riparian Road (mi)	Riparian Road Density (mi/sq. mi)	Length of Sediment Delivering Roads (mi)	Density of Sediment Delivering Roads (mi/sq. mi)	Length of Road on both Slope and Geology (mi)	Road Density on both Slope and Geology (mi/sq. mi)	Number of Road-Stream Crossings	Road-Stream Crossing Density (#/sq. mi)	Number of Land-slides	Land-slide Density (#/sq. mi)	Burned in 1987 Fires (ac)	Burned in 1987 Fires (% area)	High or Very High HER (ac)	High or Very High EHR (% area)
PC-122	0.4 (229.1)	72.3	0	0	72.3	0	0	0	0	0	0	0	0	0	0	0	1	2.8	175.0	76.4	112.0	48.9
PC-123	1.7 (1110.9)	51.7	0	0	51.7	0	1.5	0.9	1.1	0.7	0	0	0.9	0.5	3	1.7	7	***4.0***	953.0	85.8	710.4	***63.9***
PC-124	1.5 (968.8)	100.0	1.4	0	0	98.6	8.5	5.6	8.1	5.4	3.6	2.4	0	0	19	12.6	0	0	0	0	215.3	22.2
HV-127	0.1 (49.8)	78.6	0	0	78.6	0	0.1	1.3	0	0	0	0	0	0	0	0	1	***12.9***	0	0	5.9	11.9
HV-128	2.6 (1659.0)	90.8	0	0	89.6	1.2	11.4	4.4	8.3	3.2	1.4	0.6	1.9	0.8	17	6.6	3	1.2	0	0	34.9	2.1
PC-129	2.6 (1685.0)	100.0	0	0	0	100.0	14.5	5.5	14.9	5.6	6.6	2.5	0	0	34	12.9	0	0	0	0	195.5	11.6
PC-130	2.1 (1329.8)	87.8	0	0	77.0	10.8	9.0	4.3	6.5	3.1	1.7	0.8	0.3	0.2	12	5.8	0	0	0.5	0	707.6	53.2
HV-131	0.5 (319.2)	43.8	0	0	43.8	0	0.6	1.1	0	0	0.2	0.4	0.3	0.6	0	0	3	***6.0***	0	0	36.1	11.3
PC-132	0.4 (236.5)	96.4	0	0	96.4	0	0.2	0.7	0	0	0	0	0	0	0	0	0	0	236.2	***99.9***	174.4	***73.7***
PC-133	0.7 (471.3)	100.0	0	1.2	87.9	10.9	2.5	3.3	3.9	5.3	0	0	1.5	***2.0***	7	9.5	4	***5.4***	156.3	33.2	291.6	61.9
PC-134	0.8 (525.1)	100.0	0	0	0	100.0	3.5	4.3	3.2	3.9	1.6	2.0	0	0	8	9.8	0	0	0	0	0	0
PC-135	0.3 (163.4)	80.6	0	0	80.6	0	0	0	0	0	0	0	0	0	0	0	1	***3.9***	64.6	39.5	69.6	42.6
RC-136	3.2 (2037.7)	100.0	0.6	0	0	99.4	16.2	5.1	13.2	4.1	7.9	2.5	0	0	42	13.2	0	0	0	0	421.3	20.7
PC-137	0.5 (319.9)	100.0	0	0	100.0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	302.2	94.5	237.9	***74.4***
HV-138	1.9 (1193.4)	99.7	0	0	99.7	0	7.0	3.8	5.1	2.7	1.5	0.8	1.0	0.5	10	5.4	0	0	0	0	14.3	1.2
HV-140	0.2 (107.5)	100.0	0	0	100.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.5	12.5
RC-141	1.1 (727.9)	100.0	0	0	0	100.0	5.6	4.9	6.0	5.2	3.0	2.6	0	0	17	14.9	0	0	153.8	21.1	46.2	6.3
PC-142	0.4 (225.2)	100.0	0	32.5	67.5	0	0	0	0	0	0	0	0	0	0	0	0	0	146.4	65.0	110.4	49.0
PC-143	0.4 (271.8)	100.0	0	77.5	22.4	0.1	0.5	1.2	0	0	0	0	0	0.1	0	0	0	0	271.3	***99.8***	201.9	***74.3***
RC-144	0.7 (457.7)	100.0	2.0	0	0	98.0	3.1	4.3	2.1	3.0	1.3	1.8	0	0	11	***15.4***	0	0	0	0	267.3	58.4
PC-145	2.1 (1325.8)	100.0	0	0	86.7	13.3	8.0	3.8	4.4	2.1	1.7	0.8	0	0	8	3.9	0	0	1111.2	83.8	455.9	34.4
RC-146	1.1 (687.2)	100.0	0	0	0	100.0	7.5	***7.0***	7.8	***7.3***	3.3	***3.1***	0	0	26	***24.2***	0	0	53.4	7.8	0	0
RC-147	2.3 (1451.9)	60.3	6.0	0	0	54.3	13.1	5.8	12.9	5.7	5.6	2.5	0	0	36	***15.9***	0	0	0	0	205.3	14.1
PC-148	0.9 (591.5)	100.0	0	76.8	0	23.2	1.1	1.2	0	0	0	0	0.2	0.2	0	0	0	0	343.8	58.1	216.2	36.6
HV-150	0.7 (465.1)	100.0	0	0	100.0	0	2.3	3.2	0.4	0.6	0.1	0.1	0.2	0.3	0	0	0	0	0	0	3.3	0.7
HV-152	0.5 (333.0)	66.4	0	3.3	63.2	0	1.0	1.9	3.1	5.9	0.3	0.6	0.2	0.4	0	0	0	0	0	0	9.5	2.8
RC-153	1.7 (1116.2)	100.0	0	0	0	100.0	10.6	***6.0***	10.3	5.9	5.0	***2.9***	0	0	42	***24.1***	0	0	255.4	22.9	91.2	8.2
PC-154	0.5 (324.5)	60.1	0	60.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	225.4	69.5	169.8	52.3
PC-155	2.4 (1545.7)	99.6	0	71.7	0	27.9	0.5	0.2	0	0	0	0	0.1	0	0	0	0	0	1013.3	65.6	296.5	19.2
RC-156	2.4 (1508.0)	55.5	5.9	0	0	49.6	17.3	***7.3***	12.2	5.2	8.2	***3.5***	0	0	24	10.2	0	0	0	0	933.7	***61.9***
RC-157	0.5 (328.1)	100.0	0.1	0	0	99.9	2.3	4.6	1.1	2.2	1.8	***3.5***	0	0	3	5.9	0	0	0	0	223.9	***68.3***
RC-158	1.2 (759.7)	100.0	0	0	0	100.0	7.7	***6.5***	18.2	***15.4***	3.2	2.7	0	0	23	***19.4***	0	0	206.0	27.1	164.2	21.6
RC-159	0.7 (421.2)	100.0	0	0	0	100.0	3.4	5.2	1.3	1.9	1.5	2.3	0	0	8	12.2	0	0	368.6	87.5	34.3	8.1
HV-160	1.0 (625.7)	96.7	0	0	96.7	0	2.7	2.8	2.4	2.4	0.9	0.9	0.6	0.7	8	8.2	0	0	0	0	0	0
RC-161	0.9 (564.3)	9.3	0	0	0	9.3	5.2	***5.9***	6.4	***7.3***	3.9	***4.4***	0	0	12	13.6	0	0	0	0	294.7	52.2
HV-162	0.4 (267.2)	59.3	0	12.0	47.3	0	2.1	5.1	2.2	5.3	0.5	1.2	0.9	***2.2***	1	2.4	0	0	0	0	0	0
PC-163	1.0 (666.1)	97.8	0	96.6	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	29.3	4.4	451.2	***67.7***
RC-164	2.0 (1307.7)	58.0	1.3	0	0	56.7	12.4	***6.1***	16.1	***7.9***	7.8	***3.8***	0	0	38	***18.6***	0	0	0	0	465.4	35.6

Sub-watershed	Square Miles (acres)	NFS Lands (% area)	AMA (%)	AWA (%)	LSR (%)	Matrix (%)	Length of Road (mi)	Road Density (mi/sq. mi)	Length of Riparian Road (mi)	Riparian Road Density (mi/sq. mi)	Length of Sediment Delivering Roads (mi)	Density of Sediment Delivering Roads (mi/sq. mi)	Length of Road on both Slope and Geology (mi)	Road Density on both Slope and Geology (mi/sq. mi)	Number of Road-Stream Crossings	Road-Stream Crossing Density (#/sq. mi)	Number of Land-slides	Land-slide Density (#/sq. mi)	Burned in 1987 Fires (ac)	Burned in 1987 Fires (% area)	High or Very High HER (ac)	High or Very High EHR (% area)
PC-165	0.8 (500.1)	100.0	0	0	10.2	89.8	2.1	2.7	1.2	1.5	0.4	0.5	0	0	1	1.3	0	0	500.1	***100.0***	56.5	11.3
HV-166	2.8 (1789.4)	81.4	0	0	81.4	0	9.2	3.3	1.5	0.5	0.7	0.2	2.4	0.9	3	1.1	0	0	0	0	130.9	7.3
PC-167	1.9 (1237.4)	100.0	0	5.3	14.0	80.7	7.7	4.0	4.0	2.1	2.7	1.4	0	0	13	6.7	0	0	1232.7	***99.6***	206.2	16.7
RC-168	0.6 (391.0)	100.0	0	0	0	100.0	2.8	4.6	2.0	3.3	1.3	2.1	0	0	10	***16.4***	0	0	391.0	***100.0***	63.6	16.3
RC-169	1.6 (1017.1)	100.0	0	0	0	100.0	8.5	5.3	5.6	3.5	3.7	2.3	0	0	23	14.5	0	0	950.7	93.5	144.9	14.2
PC-170	0.6 (364.4)	100.0	0	98.5	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	262.9	***72.1***
RC-171	0.9 (581.5)	100.0	0	0	0	100.0	4.1	4.6	2.5	2.8	1.4	1.5	0	0	16	***17.6***	0	0	581.5	***100.0***	42.3	7.3
HV-172	0.8 (494.4)	100.0	0	4.9	95.1	0	2.9	3.7	1.9	2.5	0.1	0.1	1.4	***1.9***	1	1.3	0	0	0	0	41.5	8.4
RC-173	0.6 (387.4)	30.9	0	0	0	30.9	3.6	***5.9***	4.0	***6.6***	1.8	***3.0***	0	0	8	13.2	0	0	0	0	61.7	15.9
RC-174	1.4 (889.4)	100.0	0	0	25.8	74.2	7.8	5.6	4.8	3.5	2.2	1.6	0	0	17	12.2	0	0	887.3	***99.8***	131.1	14.7
PC-175	1.4 (927.0)	100.0	0	15.0	0	85.0	1.6	1.1	0.2	0.2	0.5	0.3	0.7	0.5	2	1.4	0	0	922.2	99.5	378.3	40.8
RC-176	1.3 (850.2)	96.0	0	0	0	96.0	4.4	3.3	8.8	***6.6***	3.4	2.6	0	0	19	14.3	0	0	3.8	0.4	93.5	11.0
RC-177	0.7 (435.2)	10.9	0	0	0	10.9	4.8	***7.1***	3.0	4.5	2.3	***3.3***	0	0	7	10.3	0	0	0	0	126.9	29.1
RC-178	1.7 (1119.9)	100.0	0	0	1.0	99.0	10.1	***5.8***	12.1	***6.9***	5.8	***3.3***	0.1	0.1	28	***16.0***	0	0	619.7	55.3	74.1	6.6
PC-179	0.4 (270.8)	100.0	0	89.7	0.2	10.2	0.2	0.4	0	0	0	0	0	0	0	0	0	0	133.8	49.4	185.3	***68.4***
RC-180	1.2 (772.2)	95.0	1.7	0	0	93.3	4.5	3.8	1.8	1.5	1.0	0.9	0	0	6	5.0	0	0	0	0	61.3	7.9
PC-181	0.6 (357.4)	100.0	0	95.2	0	4.8	0	0	0	0	0	0	0	0	0	0	0	0	356.5	***99.7***	251.7	***70.4***
PC-182	0.2 (112.7)	100.0	0	63.3	36.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	100.3	***88.9***
RC-183	0.6 (371.7)	93.6	0	0	0	93.6	2.6	4.6	3.2	5.6	1.1	1.9	0	0	9	***15.5***	0	0	0	0	37.6	10.1
HV-184	1.6 (1044.2)	100.0	0	0	100.0	0	7.5	4.6	6.8	4.1	2.6	1.6	1.9	1.2	17	10.4	0	0	0	0	106.9	10.2
HV-185	0.3 (180.9)	100.0	0	0	100.0	0	0.9	3.3	0	0	0.3	1.1	0.3	***1.2***	0	0	0	0	0	0	50.7	28.0
RC-186	2.9 (1830.9)	99.6	0	0	0	99.6	10.9	3.8	9.4	3.3	5.1	1.8	1.2	0.4	21	7.3	0	0	23.3	1.3	285.2	15.6
PC-187	0.2 (97.9)	100.0	0	95.4	4.6	0	0	0	0	0	0	0	0	0	0	0	0	0	96.4	98.5	85.2	***87.1***
HV-188	1.1 (702.9)	87.2	0	0.2	86.9	0	3.2	2.9	3.2	3.0	1.3	1.2	0.6	0.6	9	8.2	0	0	0	0	87.1	12.4
HV-189	1.0 (665.4)	100.0	0	0	100.0	0	4.7	4.5	4.3	4.2	2.1	2.0	0.5	0.5	17	***16.4***	0	0	0	0	11.1	1.7
PC-190	1.0 (625.3)	100.0	0	74.2	25.8	0	0	0	0	0	0	0	0	0	0	0	0	0	513.9	82.2	437.7	***70.0***
RC-191	2.2 (1404.6)	100.0	10.4	0	0	89.6	8.6	3.9	8.4	3.8	1.6	0.7	0	0	11	5.0	0	0	0	0	169.5	12.1
RC-192	0.7 (452.6)	100.0	0	0	1.5	98.5	3.1	4.4	3.5	5.0	1.5	2.1	0.6	0.8	7	9.9	0	0	74.2	16.4	43.1	9.5
RC-193	1.1 (674.9)	100.0	0	0	0	100.0	5.5	5.2	4.1	3.9	1.2	1.1	0	0	4	3.8	0	0	0	0	20.5	3.0
PC-194	0.8 (540.8)	89.0	0	16.0	6.0	67.0	3.6	4.3	5.4	***6.4***	0.4	0.4	0.9	1.0	4	4.7	0	0	361.5	66.8	0	0
RC-195	0.7 (474.6)	100.0	0	0	0	100.0	4.6	***6.2***	6.1	***8.2***	3.2	***4.4***	0	0	14	***18.9***	0	0	362.1	76.3	52.6	11.1
RC-197	1.3 (815.4)	100.0	0	0	0	100.0	6.7	5.2	5.5	4.3	2.5	2.0	0	0	10	7.8	0	0	0	0	12.4	1.5
HV-198	0.9 (554.6)	100.0	0	0	100.0	0	3.2	3.7	2.0	2.3	1.2	1.4	0.3	0.3	9	10.4	0	0	0	0	41.8	7.5
HV-199	1.0 (621.6)	88.9	0	0	88.9	0	3.0	3.1	3.1	3.2	1.6	1.7	0.5	0.5	8	8.2	0	0	0	0	11.7	1.9
PC-201	0 (11.5)	100.0	0	100.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.0	25.7	0	0
RC-203	1.6 (1009.9)	100.0	0	0	0	100.0	8.6	5.5	5.6	3.5	3.6	2.3	1.3	0.8	14	8.9	0	0	0	0	392.5	38.9
HV-204	0.8 (486.4)	100.0	0	7.4	92.4	0.2	3.3	4.3	2.0	2.7	0.3	0.4	0.2	0.3	3	3.9	0	0	0	0	90.6	18.6
HV-205	0.1 (95.0)	99.9	0	0	99.9	0	0.5	3.6	0	0.2	0.2	1.6	0.3	***1.8***	0	0	0	0	0	0	37.2	39.2

Sub-watershed	Square Miles (acres)	NFS Lands (% area)	AMA (%)	AWA (%)	LSR (%)	Matrix (%)	Length of Road (mi)	Road Density (mi/sq. mi)	Length of Riparian Road (mi)	Riparian Road Density (mi/sq. mi)	Length of Sediment Delivering Roads (mi)	Density of Sediment Delivering Roads (mi/sq. mi)	Length of Road on both Slope and Geology (mi)	Road Density on both Slope and Geology (mi/sq. mi)	Number of Road-Stream Crossings	Road-Stream Crossing Density (#/sq. mi)	Number of Land-slides	Land-slide Density (#/sq. mi)	Burned in 1987 Fires (ac)	Burned in 1987 Fires (% area)	High or Very High HER (ac)	High or Very High EHR (% area)
HV-206	1.1 (710.2)	92.5	0	0	92.5	0	4.7	4.3	2.3	2.0	1.5	1.3	0.5	0.4	10	9.0	0	0	0	0	33.9	4.8
HV-207	0.8 (534.4)	48.3	0	0	48.3	0	1.3	1.5	1.3	1.6	0.5	0.5	0.5	0.6	2	2.4	0	0	0	0	122.1	22.8
RC-208	0.3 (192.8)	89.5	0	0	39.4	50.1	2.3	***7.6***	3.7	***12.4***	1.1	***3.7***	0	0.2	7	***23.2***	0	0	58.6	30.4	7.4	3.8
HV-209	2.4 (1522.5)	80.5	0	0	80.5	0	6.6	2.8	3.6	1.5	1.7	0.7	1.1	0.5	10	4.2	0	0	0	0	240.6	15.8
RC-211	0.7 (440.3)	100.0	0	0	89.0	11.0	2.1	3.1	1.2	1.7	0.7	1.0	1.0	***1.5***	6	8.7	0	0	6.2	1.4	0.1	0
RC-212	1.1 (710.3)	100.0	0	0	77.2	22.8	5.5	5.0	1.7	1.5	0.7	0.6	1.9	***1.7***	3	2.7	0	0	0	0	261.4	36.8
RC-215	0.8 (538.1)	100.0	0	0	100.0	0	4.8	5.7	4.1	4.9	1.3	1.5	1.4	***1.7***	5	5.9	0	0	0	0	0	0
RC-217	0.9 (581.5)	99.7	0	0	98.4	1.4	5.4	***6.0***	1.9	2.1	0.9	1.0	2.3	***2.5***	4	4.4	0	0	0	0	15.2	2.6
RC-218	2.2 (1399.7)	95.3	0	0	0	95.3	8.6	3.9	7.8	3.6	4.2	1.9	0.9	0.4	20	9.1	0	0	0	0	53.3	3.8
PC-219	2.6 (1660.6)	96.8	0	4.2	22.3	70.3	4.6	1.8	1.9	0.7	0.8	0.3	0.2	0.1	6	2.3	1	0.4	1247.6	75.1	498.1	30.0
PC-220	1.8 (1167.5)	86.1	0	32.8	48.4	4.9	2.2	1.2	4.3	2.4	0	0	1.0	0.6	4	2.2	10	***5.5***	1155.4	99.0	450.1	38.6
RC-224	2.2 (1395.1)	99.3	0	0	0	99.3	11.3	5.2	9.5	4.4	5.0	2.3	0.7	0.3	31	14.2	0	0	0	0	384.8	27.6
PC-225	2.2 (1430.1)	84.6	0	0	34.6	50.0	5.8	2.6	2.3	1.0	1.0	0.5	0.1	0	9	4.0	7	3.1	9.5	0.7	420.6	29.4
HV-226	0.7 (453.7)	100.0	0	0	99.6	0.4	1.7	2.4	2.8	3.9	0.6	0.8	0.5	0.7	3	4.2	0	0	0	0	277.7	61.2
HV-227	1.6 (1026.5)	89.6	53.3	36.3	0	0	3.5	2.2	2.0	1.3	0.7	0.5	0	0	4	2.5	2	1.2	0.2	0	269.9	26.3
HV-228	1.7 (1099.4)	48.9	0	0	25.0	23.9	4.2	2.4	2.1	1.2	0.8	0.5	0.1	0.1	5	2.9	9	***5.2***	0	0	95.9	8.7