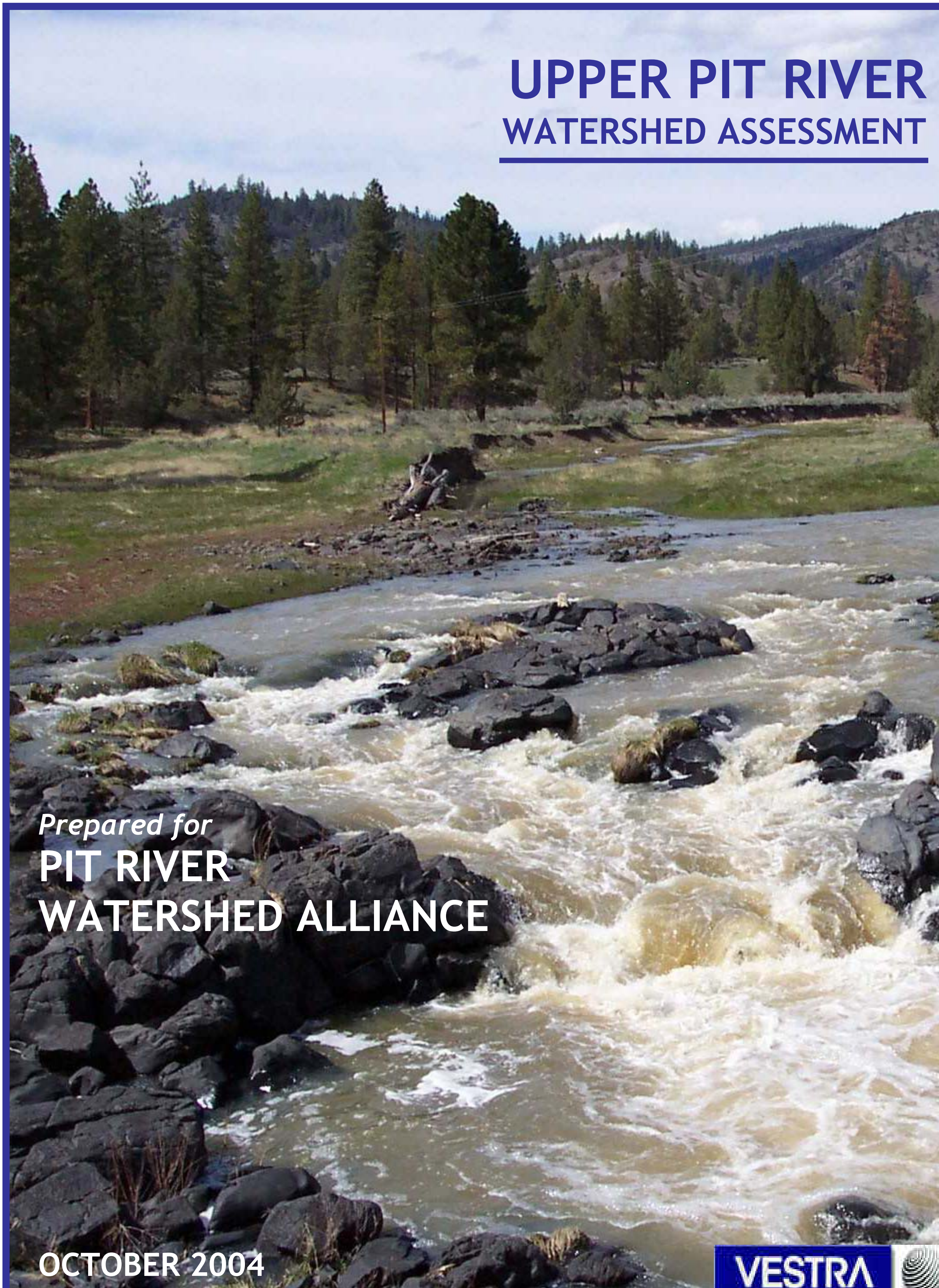
UPPER PIT RIVER
WATERSHED ASSESSMENT



Prepared for

PIT RIVER WATERSHED ALLIANCE

OCTOBER 2004

VESTRA

UPPER PIT RIVER
WATERSHED ASSESSMENT

Prepared for

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ACRONYMS AND ABBREVIATIONS

AGR	Agricultural Supply
BA	Biological Assessment
BE	Biological Evaluation
BLM	Bureau of Land Management
BO	Biological Option
BOR	Bureau of Reclamation
BSFMU	Big Sage Fire Management Unit
CCC	Civilian Conservation Corps
CDF	California Department of Forestry and Fire Protection
CDFA	California Department of Food and Agriculture
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	Cubic Feet per Second
CIMIS	California Irrigation Management Information Systems
CNDDB	California Natural Diversity Data Base
CNPS	California Native Plant Society
COLD	Cold Freshwater Habitat
CVMP	California Vegetation Management Plan
CWA	Clean Water Act
CWHR	California Wildlife Habitat Relationships
DAU	Cascade-North Sierra Nevada Deer Assessment Unit
dbh	Diameter Breast Height
DEM	Digital Elevation Model
DFPZ	Defensible Fuel Profile Zone
DNR	Department of Natural Resources
DO	Dissolved Oxygen
DOI	Department of the Interior
DOQQ	Digital Ortho Quad
DWR	California Department of Water Resources
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESP	Experimental Stewardship Program
ET	Evapotransporation
Eto and Rto	Reference Evaporation Rates
FERC	Federal Energy Regulatory Commission
FRAP	California Department of Forestry and Fire Protection, Fire and Resource Assessment Program
GIS	Geographic Information Systems
GPRA	Government Performance and Results Act
HCP	Habitat Conservation Plan
HMA	Herd Management Area
I	Electrical Current
LBNM	Lava Beds National Monument

mg	Milligrams
mg/l	Milligrams of Oxygen per Liter of Water
MIS	Management Indicator Species
mm/yr	Millimeters Per Year
Mmax	Maximum Moment Magnitude
MOU	Memorandum of Understanding
MPN	Most Probably Number
msl	Mean Sea Level
MUN	Municipal and Domestic Supply
N	Nitrogen
NH_3	Ammonia
NO_2	Nitrite
NO_3	Nitrate
NAAQS	National Ambient Air Quality Standards
NCCP	Natural Community Conservation Plan
NEPA	National Environmental Policy Act
NFMA	National Forest Management Act
NFP	National Fire Plan
NMFS	National Marine Fisheries Service
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NTUs	Nephelometric Turbidity Units
NWS	National Weather Service
OHV	Off-Highway Vehicle
PFC	Proper Functioning Condition
PLM	Private Lands Habitat Enhancement and Management Area Program
PM	Particulate Matter
POW	Hydropower Generation
PPM	Parts Per Million
PRIA	Public Rangelands Improvement Act
RC&D	Resource Conservation and Development Council
RCD	Resource Conservation District
REC-1	Water Contact Recreation
REC-2	Non-Contact Water Recreation
ROD	Record of Decision
RPA	Forest and Rangeland Renewable Resources Planning Act
RVD	Recreational Visitor Day
RWPCB	Regional Water Pollution Control Board
RWQCB	Regional Water Quality Control Board
SCS	Soil Conservation Service
SFID	South Fork Irrigation District
SNEP	Sierra Nevada Ecosystem Project
SNFPA	Sierra Nevada Forest Plan Amendment
SPLAT	Strategically Placed Area Treatments
SPWN	Spawning, Reproduction, and/or Early Development
SSURGO	NRCS Soil Survey Geographic
SWRCB	State Water Resources Control Board
STATSGO	State Soil Geographic

T&E	Threatened and Endangered
TMDL	Total Maximum Daily Loading
TSP	Total Suspended Solids
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
USEPA	U.S. Environmental Protection Agency
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
uS/cm	microSiemen per centimeter
UWIZ	Urban Wildland Intermix Zone
V	Voltage
WARM	Warm Freshwater Habitat
WFUDS	Wildlife and Fish User Days
WHR	California Wildlife Habitat Relationships
WILD	Wildlife Habitat
WMA(s)	Weed Management Areas

Section 1

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INTRODUCTION

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INTRODUCTION

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PROJECT GOALS

The mission of the Upper Pit River Watershed Assessment is to gather and integrate existing information on the physical, cultural, and demographic variables that characterize the Upper Pit River Watershed at the present and in the past. Some key areas lack information and may require further evaluation. The goal of the watershed assessment is to prepare a balanced document that will serve as an educational tool; provide available information to stakeholders; build consensus within the watershed; and provide a baseline for future action. The watershed assessment will include a historical perspective and summary of physical and ecological conditions within the watershed.

Individuals, as well as public and private groups, need good data for informed assessment of the effects of management decisions on the physical, ecological, economic, and cultural environment of the Upper Pit River Watershed. The watershed assessment will provide the beginning of a broad landscape-scale description that will set the foundation for future decisions and additional studies. The watershed assessment is only the initial step in developing our knowledge of the watershed ecosystem. It will be amended and extended as new information becomes available.

BACKGROUND

The Pit River Alliance is a cooperative, non-regulatory, working group of public and private land managers who are working together to address ecosystem and watershed issues in the Upper Pit River Watershed. The Alliance was originally formed in October 2000. In July 2002 the Alliance was awarded a grant from the State of California to conduct the initial phase of planned work—a watershed assessment of the Upper Pit River.

FUNDING SOURCES

The watershed assessment project is funded primarily through a grant from the CalFed Program and the voluntary efforts of hundreds of stakeholders. Many other contributions from state, federal, and private sources made this assessment possible.

ACKNOWLEDGEMENTS

Watershed Advisory Committee

Thank you to the Watershed Advisory Committee who's input and review was exceptionally valuable to this document. The committee members included:

Mark Steffek, North Cal-Neva Resource Conservation and Development District Inc.
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Jane Vorpagel, California Department of Fish and Game
James Rickert, Pit River Alliance Coordinator 2001–present

Pit River Watershed Alliance

The Pit River Watershed Alliance Memorandum of Understanding (MOU) now includes signatories, some of who are briefly described below. The Alliance is open to new members.

Big Valley Water Users Group
Big Valley Water Users Group is a agricultural group promoting water use efficiency to maximize the water resources in the Big Valley area. Originally started as the Modoc/Lassen Flood Control Group in the 1930s, the group's main goal has been to build the Allen Camp Dam. The Allen Camp Dam would be located north of Lookout on the main stem of the Pit River, and provide essential water for agricultural users in Big Valley.

California Department of Water Resources (DWR)
The DWR is responsible for managing the water resources of California in cooperation with other agencies, to benefit the State's people, and to protect, restore, and enhance the natural and human environments.

California Trout
California Trout is a membership-based organization of approximately 5,300 citizens throughout California. California Trout's mission is to protect and restore wild trout and native steelhead throughout California and to create high-quality fishing opportunities by improving the state's watersheds, rivers, and lakes.

California Farm Bureau
The California Farm Bureau is California's largest farm organization with more than 95,000 member families in 53 county farm bureaus. It is a voluntary, nongovernmental, nonpartisan organization of farm and ranch families seeking solutions to problems that affect their lives, both socially and economically. Some of the services provided through the bureau are farm and food news, weather, publications, upcoming legislation, health and safety, and agricultural crime prevention. County Farm Bureaus included in the MOU are:

- Shasta County Farm Bureau
- Modoc County Farm Bureau
- Lassen County Farm Bureau

California Waterfowl Association
The California Waterfowl Association is a membership-based group, formerly known as the Duck Hunters Association of California. The primary focus of this group is to conserve California's waterfowl, wetlands, and waterfowling heritage.

Central Valley Regional Water Quality Control Board (RWQCB)
The RWQCB is one of nine regional boards, which work in conjunction with the State Water Quality Control Board. One of the most important tasks of the RWQCB is preparing and periodically updating Basin Plans, which are water quality control plans. Regional boards also regulate all pollutant or nuisance discharges that may affect either surface water or groundwater.

Fall River Wild Rice Growers Association
Fall River Wild Rice is a grower-owned cooperative located in the Fall River Valley. With over twenty producers, Fall River Wild Rice strives to produce high-quality wild rice grown in the unique climate of the Intermountain region. This wildlife-friendly crop provides thousands of acres of flooded paddies in the winter months, providing an essential stop for migratory waterfowl on the Pacific Flyway.

High Mountain Hay Growers Association
The High Mountain Hay Growers is agricultural producer cooperative specializing in premium quality hay grown in the Intermountain region. The High Mountain Hay Growers promotes wise use of resources to maximize agricultural production.

Modoc County Board of Supervisors
The Modoc County Board of Supervisors consists of five elected members. The Board of Supervisors is responsible for the enactment of ordinances and resolutions, the adoption of the annual budget for county departments, approval of new programs and grants, and the adoption of land use and zoning plans. The Board of Supervisors is the policy-making body within the county, not including schools and independent special districts.

Modoc National Forest
The Modoc National Forest is one of many forests managed by U.S. Forest Service (USFS). The USFS is a federal agency with the U.S. Department of Agriculture (USDA) that manages public lands in national forests and grasslands. The USFS is also the largest forestry research organization in the world and provides technical and financial assistance to state and private forestry agencies.

Modoc National Wildlife Refuge
The U.S. Fish and Wildlife Service oversees the Modoc National Wildlife Refuge. The 1,500+-acre wetland refuge was established in 1961 to manage and protect migratory waterfowl.

Modoc/Washoe Experimental Stewardship Program (ESP)
The ESP is one of three unique federal land management collaborative programs in the nation. A 24-member committee representing diverse interests throughout the local geographic area guides the program. The ESP focuses on resolving land management conflicts through consensus and involvement of all stakeholders. ESP sprang from the 1978 Public Rangelands Improvement Act.

Modoc County Noxious Weed Management Working Group
The Modoc County Weed Management Working Group is part of a statewide program overseen by the California Department of Food and Agriculture. The group is one of many weed management areas (WMAs) that organize local landowners and managers (private, city, county, State, and Federal) in a county, multi-county, or other geographical area to coordinate efforts and expertise against common invasive weed species.

Natural Resource Conservation Service, Redding, Susanville, and Alturas
The National Resource Conservation Service, formerly known as the Soil Conservation Service, assists owners of America's private lands with conserving their soil, water, and other natural resources. Local, state, and federal agencies also rely on their expertise.

North Cal-Neva Resource Conservation and Development Council (RC&D)
The RC&D is a program initiated by the U.S. Department of Agriculture to help people care for and protect their natural resources; and improve their area's economy, environment, and living standards. Programs in the Upper Pit River Watershed include: Fire Safe Council, American Indian Education Program, Agricultural Cooperation, and Noxious Weed Control.

Resource Conservation Districts (RCD)
RCDs are intended to be independent liaisons between the federal government and landowners. The primary conservation issues addressed by RCDs are forest fuel management, water and air quality, wildlife restoration, soil erosion control, and conservation education. RCDs within the watershed are:

- Central Modoc RCD
- Fall River RCD
- Goose Lake RCD
- Pit RCD

Sierra Pacific Industries
Sierra Pacific Industries is one of the largest landowners and private timber firms in the Western United States. As a third-generation, family owned and operated forest products' company; Sierra Pacific Industries promotes healthy trees, good water quality, and enduring wildlife habitat as the result of sound forest management.

U.S. Bureau of Land Management (BLM)
The BLM is an agency of the U.S. Department of the Interior. Its primary duties are administrating the 262 million acres of America's public lands, located mostly in the 12 western states. The BLM is

charged with sustaining the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.

LOCATION

The Upper Pit River Watershed is located in northeastern California at the eastern edge of the Great Basin Province. The general vicinity of the watershed is shown in Figure 1-1. The north and south forks of the Pit River drain the northern portion of the watershed. The North Fork of the Pit River originates at Goose Lake, an enclosed basin except during rare events when it spills over into the Pit River. The North Fork headwaters include a number of tributaries in the Warner Mountains. The South Fork of the Pit River originates in the south Warner Mountains at Moon Lake in Lassen County. The north and south forks of the Pit River converge in the town of Alturas flows in a southwesterly direction into Shasta Lake in Shasta County into the Sacramento River. The southern limit of the Upper Pit River Watershed is marked by the confluence of the Pit River and Fall River in eastern Shasta County. The watershed boundary, its major tributaries, and general layout are included in Figure 1-2. The Upper Pit River Watershed includes approximately 3,415 square miles, or 2,767,000 acres, 21 named tributaries totaling about 1,050 miles of perennial stream, and 4,054 river miles.

Rural lifestyles and a population density of less than 10 persons per square mile characterize the Upper Pit River Watershed. The largest city in the watershed is Alturas with a current population of 2,840. Ranching, farming, and timber are the primary resource activities throughout the watershed area.

LAND OWNERSHIP

General ownership within the watershed is shown in Figure 1-3. Land ownership in the Upper Pit River Watershed is approximately 60 percent public and 40 percent private. The number of acres in each ownership classification is shown in Table 1-1. Land ownership and other administrative boundaries are discussed in more detail in Section 3, "Land Use and Demographics."

Table 1-1
LAND OWNERSHIP ACREAGE
IN THE UPPER PIT RIVER WATERSHED STUDY AREA

Ownership	Total Acres	Percent
Bureau of Land Management	338,819.18	16
U.S. Fish and Wildlife Service	7,581.54	0
USFS	983,982.84	45
Subtotal Federal Acres	**1,330,383.56**	**61**
Department of Fish and Game	17,111.24	1
Department of Parks and Recreation	4,309.400	0
State Lands Commission	6,019.76	0
Subtotal State Acres	**27,440.400**	**1**
Tribal Ownership	10,492.77	0
Subtotal Tribal Acres	**10,492.77**	**0**
Unclassified Private Ownership	580,269.27	27
Industrial Timber Companies	236,917.49	11
Subtotal Other Acres	**817,186.76**	**38**
Total	**2,185,503.49**	**100%**

TOPOGRAPHY

The Upper Pit River Watershed encompasses approximately 3,415 square miles, or more than 2.7 million acres. General watershed topography is included as Figure 1-4. A summary of the U.S. Geological Survey (USGS) quadrangle maps within the watershed is included as Figure 1-5. The slope gradient and aspect of the watershed vary significantly.

Elevation within the watershed varies from 9,833 feet above mean sea level (msl) at the Eagle Peak summit, located in the southeast portion of the Warner Mountains, to the Fall River Valley floor, elevation 3,200 feet msl. The largely volcanic history of the region has done much to shape the topography and landforms present today.

The low gradient of valley floors throughout the watershed is attributed to the deposition of large amounts of volcanics. Abundant volcanic flows were often channeled into the relatively narrow valleys, which confined the flows. This confinement along with the inherent viscosity of the magma combined to form nearly flat valley floors throughout the watershed. The overall flat topography of the Upper Pit River Valley plays a significant role in the ecological and physical characteristics of the river.

Many of the numerous flat or gently sloping plateaus throughout the watershed were formed by more recent lava flows. Faulting subsequently broke up the plateaus, creating many uplifted sections that form the dominant ridges of the watershed. The uplifted sections are seen as mountain blocks, typically steep on one side and gently to steeply sloping on the other. General elevation bands and general slope classes are included as Figures 1-6 and 1-7.

GEOLOGY

The Upper Pit River Watershed sits among one of the most unique volcanic regions in North America. Development of the region is thought to be in large part due to the subduction of the Juan de Fuca Plate beneath the continental North American Plate. Subduction of the denser Juan de Fuca Plate generates friction, which at depth is combined with extreme pressures causing the rock to melt (magma). The magma, being less dense than the surrounding rock, then rises toward the surface of the earth and is expelled as volcanic eruptions. The Cascade Range is thought to be a direct result of the Juan de Fuca Plate subducting beneath the North American Plate.

The region consists primarily of Cenozoic (younger than 65 million years ago volcanics overlain by Quaternary (less than 1.8 Ma) volcanic, alluvial, and lacustrine deposits. The western portion of the region contains many Pliocene and recent Holocene (less than 0.01 Ma) volcanics. Central and eastern portions of the watershed consist of heavily faulted late Cenozoic volcanics and more recent Tertiary (1.8 to 65 Ma) volcanics of the Warner Mountains. Each of the regions is discussed in more detail in "Geomorphic Provinces".

Many of the volcanic deposits are broken by normal faults, generally trending north-northwest, and exhibit offset from tens of feet to at least 1,000 feet.

The Cedarville Series, a primary volcanic unit within the watershed that consists of alternating volcanic tuffs and flows, began building up the plateau approximately 60 million years ago. Much of the alluvial deposits consist of sandstone, shale, and gravels. The alluvium is associated with the lakes and rivers that filled the valley floors during the Pliocene and Pleistocene Epochs when the climate in the area was much wetter. Lacustrine (lake) deposits consist primarily of diatomite (diatomaceous earth) interbedded with the aforementioned alluvial deposits.

Due to the change in the climate the last 11,000 years (Orr and Orr, 2000), most of the large lakes in the area have dried up or become much smaller; erosion rates have become extremely slow; and soil production has dropped dramatically.

Most erosion and soil production in the watershed comes from the chemical weathering of feldspar minerals found in the andesitic basalts throughout the watershed. Many continental volcanic rocks contain the mineral feldspar that weathers into clays, which make up a large percentage of the soil throughout the watershed.

A geologic time scale summarizing formations, series, and known deposits is included as Figure 1-9. A schematic of the general geology of the Upper Pit River Watershed is shown on Figure 1-10. A summary of the geologic formations exposed in the watershed, totaled by management unit, is provided in Table 1-2.

Table 1-2
ACRES OF PRINCIPAL ROCK TYPES

Principal Rock Type	Map Symbol	Description	Total Acres	% Total
Conglomerates and sandstones	Mc	Undivided Miocene Nonmarine	338.5	0
Rhyolite, andesite, basalt, and pyroclastic rocks	Mv	Miocene Volcanic	375,183.66	17
Semi-consolidated gravel and sand	Pc	Undivided Pliocene Nonmarine	162,031.65	8
Rhyolite, andesite, basalt, and pyroclastic rocks	Pv	Pliocene Volcanic	458,002.43	21
Gavel, sand, silt, and clay	Qal	Alluvium	95,699.05	4
Nonconsolidated talus and slope debris	Qc	Pleistocene Nonmarine	49,663.45	2
Sedimentary rock	Qg	Glacial Deposits	1,532.2	0
Sedimentary rock	Ql	Quaternary Lake Deposits	82,083.73	4
Rhyolite, andesite, basalt, and pyroclastic rocks	Qpv	Pleistocene Volcanic	419,985.51	19
Rhyolite, andesite, basalt, and pyroclastic rocks	Qrv	Recent Volcanic	184,859.23	8
Rhyolite, andesite, and basalt	Ti	Tertiary Intrusive	6,765.35	0
Rhyolite, andesite, basalt, and pyroclastic rocks	Tv	Tertiary Volcanic	317,571.8	15
	H2O	Water	31,786.9	2
Total			**2,185,503.49**	**100**

Geomorphic Provinces

The California Division of Mines and Geology has subdivided California into 12 geologic provinces, each with unique geology, topographic relief, and climate. Those provinces located within the Upper Pit River Watershed include the Cascade Range Geomorphic Province to the west, the centrally located Modoc Plateau Geomorphic Province, and the Basin and Range Geomorphic Province located throughout the eastern portion of the watershed. The province boundaries of Northern California, including the Upper Pit River Watershed, are included as Figure 1-8.

Cascade Range Geomorphic Province

The Cascade Range is present throughout the central portions of Washington, Oregon, and Northern California. Reaching as far south as the Sutter Buttes, the Cascade Range contains many of the highest peaks of Northern California such the Medicine Lake Highlands, Mt. Shasta, and Mt. Lassen.

The Medicine Lake Highlands are an easily recognized and highly studied feature of the Cascade Range located northwest of Canby. Originally, the Medicine Lake Highlands, the largest volcano in California, was composed of a single shield volcano approximately 20 miles across and 2,500 feet above msl, which collapsed to form a basin. This volcanic collapse or caldera develops from a specialized violent volcanic eruption where hot gasses and magma escape in a vertical funnel of pyroclastic lava within the existing cone. A subsequent ring of voids created by the explosive eruption allows the volcano to collapse, often developing a central circular depression. The ring of voids often facilitates smaller secondary eruptions as is evidenced by eight separate rim cones identified as Glass Mountain, Medicine Mountain, Mount Hoffman, Little Mount Hoffman, Red Shale Butte, and Lyons Peak, which surround the primary depression of Medicine Lake.

The Medicine Lake area has been described as representing an evolution in Cascade-type magmas under different geologic conditions (MacDonald, 1966). This means that the closer you get to the Modoc Plateau, the thinner the earth's crust. The increased thinning facilitates an eruption of more basaltic type volcanics, although the Medicine Lake Highlands is best known for its rhyolitic obsidian and pumice found at Glass Mountain and Little Glass Mountain.

Modoc Plateau Geomorphic Province

The largest portion of the Upper Pit River Watershed is part of the Modoc Plateau Geomorphic Province. The Modoc Plateau is a flat-topped upland area built up of irregular masses of a variety of volcanic materials, although it consists predominantly of basalt (Oakeshott, 1971). This area is characterized by attenuation, or stretching and thinning of the earth's crust, which results in the high-angle normal faults found throughout the region. At a distance, the region resembles a relatively smooth *plateau*; close up, the region is far from flat.

The Modoc Plateau is transected by multiple high-angle faults that give the region its unique topographic features of north-northwest trending steep-sided ridges and flat rectangular-shaped valleys. Due to the continued thinning of the earth's crust and widespread faulting, magma in the earth's upper mantle can more readily reach the surface, which manifests as basalt flows. It is thought that faulting throughout the Plateau has weakened the crustal zone facilitating fractures, which allows magma to easily reach the surface as evidenced by the numerous cinder cones that reside along the fault traces. As with the Cascade Range Geomorphic Province, volcanism is also a major characteristic of the Modoc Plateau.

Volcanic activity throughout the area began in the late Miocene or Pliocene (approximately 11 million years ago) and has continued into the early twentieth century (MacDonald, 1966). Evidence of volcanic activity can be seen throughout the watershed and plays a significant role in the present-day ecology and physical characteristics of the Pit River region, as seen in both the Miocene Cedarville Series and the Tertiary Warner Basalts, which flank both sides of the Fall River Valley.

The province is commonly known for its recent volcanic activity. Many of the landforms consist of alluvial, colluvial, and lacustrine sediments such as volcanic sandstones, mud flow breccias, and diatomite.

Basin and Range Geomorphic Province
The Basin and Range Geomorphic Province is located in the far northeastern portion of the watershed. The western boundary of the province extends southward from the California-Oregon border along the western shores of Goose Lake. From Goose Lake the boundary continues southward crossing the intersection of Highways 299 and 395 to the Modoc and Lassen County lines where the southernmost boundary of the province turns east until it intercepts the eastern watershed boundary.

The Basin and Range is characterized by semi-parallel, alternating valleys and mountainous ridges, for this reason named the Basin and Range Geomorphic Province. The alternating ridges and valleys are a result of normal faulting where the valley (once at the same elevation as the ridge tops) is relatively down-dropped to the ridges. Faulting within the province is similar to that of the Modoc Plateau. What sets the Basin and Range apart from the Modoc Plateau is the magnitude of the vertical offset of the faults.

Surprise Valley is an example of the Basin and Range system located within the Upper Pit River Watershed. Surprise Valley has been down-dropped in relation to the Warner Range. The Warner Range and Surprise Valley are separated by a normal fault (Surprise Valley Fault) approximately parallel to the eastern face of the Warner Range. Offset of the Surprise Valley Fault has been estimated at approximately 12,000 feet since its origin approximately 10,000 years ago (Hedel, 1981; McKee et al., 1983). Because of the drastic offset of the fault, it is included in the Basin and Range Geomorphic Province.

Faults

Faults are responsible for many of the landforms throughout the watershed. Some of the major faults in the area include the Surprise Valley Fault, Likely Fault, and the Goose Lake Fault. These faults are shown in Figure 1-11.

Surprise Valley Fault
The Surprise Valley Fault is identified as Holocene (younger than 10,000 years) based on a slip rate of 1.3 millimeters per year (mm/yr) and its association with the vertical offsets of Holocene alluvial fans. Tracing an estimated 54 miles of the border between Surprise Valley and Warner Mountains, this normal fault generally trends north south. The Surprise Valley fault is estimated to be approximately 7.5 miles wide with a dip of approximately 60 degrees to the east. The Maximum Moment Magnitude (Mmax), a measure of earthquake intensity based on the physical size and displacement of this fault, is calculated to be 7.0 on the Richter scale (Wells and Coppersmith, 1994).

Likely Fault
The Likely Fault is a Mid- to Late Pleistocene (beginning approximately 1.5 million years ago), right-lateral, strike-slip fault that lies approximately 12 miles southwest of the Alturas Landfill site. The general trend of this fault is northwest southeast for its entire length of approximately 40 miles.

Goose Lake Fault
The northern portion of the Goose Lake Fault trends north south and lies between the eastern shore of Goose Lake and the Warner Mountains. The southern portion of the fault trends northwest southeast and traces the border between the eastern edge of Fandango Valley and the western foothills of the Warner Mountains. This Late Pleistocene normal fault lays approximately 30 miles north-northeast of the Alturas Landfill and has an estimated length of 35 miles. The Mmax of the Goose Lake Fault is estimated at 6.8 on the Richter scale (Wells and Coppersmith, 1994).

Mineral and Hydrologic Resources

Mineral resources of the Upper Pit River Watershed are limited due to limited variety in the composition of rock types, a low population density creating minute local market demand, and a lack of known commercial grade deposits other than volcanic cinders, pumice, and lightweight and alluvial aggregate materials. Current mining operations consist primarily of volcanic based cinder, sand, and gravel excavation pits. These products are used for roadways, railroad beds, and decorative stone. Diatomaceous lake deposits have the potential to be mined for chalk products, but commercial operations have yet to begin.

Ore products are also limited throughout the region. Three gold districts in Modoc County produced approximately $5 million in gold during the early part of the twentieth century but have been inactive since 1934 (Gay, 1966). Currently, the Hayden Hill Gold Mine, located twelve miles south of Adin, is still active. Mining was completed in 1997, although residual production from the heap leach pad still continues (Kinross Gold Corporation Operations, 2002).

Development of new mineral resources within the watershed is restricted. Minimal development opportunities are the result of extent of exploration, market conditions, new technologies or uses, and distance from markets (Mintier Harnish and Assoc, 1988). Although mineral resource development may be limited and somewhat cost prohibitive, recent developments in geothermal production have been explored.

The watershed is home to abundant geothermal resources. A massive reserve of 450ºF water lies approximately 5,000 feet below Medicine Lake, a dormant volcano located in the extreme northwestern portion of the watershed. The water, heated by a large body of cooling magma, is stored in the pore space of the surrounding volcanic rock. The thin crust and close proximity to the earth's outer mantle produces a higher heat gradient throughout the region. The resulting heat gradient produces higher than normal subsurface temperatures. Isolated hot springs are common throughout the watershed and have been used for a variety of economic endeavors. General locations of surface geothermal activity are shown in Figure 1-12.

Modoc Unified School District has successfully used hot water generated from a geothermal well to heat its school since 1990. Recent proposals to use geothermal reservoirs for power generation have met significant opposition by both local residents and tribal governments.

The mineral and hydrologic resources of the region are summarized in Table 1-3.

Table 1-3
MINERAL RESOURCES

Map Symbol	Geologic Province			Principal Rock Type	Potential and Actual Mineral Resources
	Cascade Range	Modoc Plateau	Great Basin		
Mc			✓	Undivided Miocene nonmarine: conglomerates and sandstones	Sand and gravel
Mv		✓	✓	Miocene volcanic: rhyolite, andesite, basalt, and pyroclastic rocks	Volcanic cinder, obsidian, perlite
Pc		✓	✓	Undivided Pliocene nonmarine: semi-consolidated gravel and sand	Sand, gravel, and diatomite
Pv	✓	✓	✓	Pliocene volcanic: rhyolite, andesite, basalt, and pyroclastic rocks	Volcanic cinder, obsidian, perlite
Qal	✓	✓	✓	Alluvium	Sand and gravel
Qc		✓	✓	Pleistocene nonmarine: non-consolidated talus and slope debris	Sand and gravel
Qg	✓		✓	Glacial deposits: sedimentary rock	Sand and gravel
Ql		✓	✓	Quaternary lake deposits: sedimentary rock	Diatomite, salt
Qpv	✓	✓	✓	Pleistocene volcanic: rhyolite, andesite, basalt, and pyroclastic rocks	Volcanic cinder, obsidian, perlite
Qrv	✓	✓		Recent volcanic: rhyolite, andesite, basalt, and pyroclastic rocks	Volcanic cinder, obsidian, perlite
Ti		✓	✓	Tertiary intrusive: rhyolite, andesite, and basalt	Gold, mercury, volcanic cinder, obsidian, perlite
Tv		✓	✓	Tertiary volcanic: rhyolite, andesite, basalt, and pyroclastic rocks	Gold, mercury, volcanic cinder, obsidian, perlite

Geologic Issues

Geology and hydrogeology are foundations for much of what occurs in the watershed today and what will occur in the future. Geologic issues that could affect restoration, future land uses, and general watershed health include:

- Seismic activity resulting in diverted or restricted aquifer flow
- Weathering products of volcanic rocks (i.e., clays) resulting in poor water quality
- Heavy clay soils possessing high shrink-swell potential and inhibiting infiltration causing standing water
- Geologic composition, volcanic rock prohibitive to timber production, cattle grazing, and some agricultural crops
- Permeability of weathered volcanics inhibiting surface run-off throughout the watershed
- Slow soil production due to low humidity and precipitation

SOILS AND PRIMARY VEGETATION TYPES

The Upper Pit River Watershed contains a diverse assemblage of soil types essential to farming, ranching, timber, and wildlife resources. Soils within the watershed vary from prime farmland to woodland as identified by detailed soil surveys published by the USFS and the Natural Resources Conservation Service (NRCS) in 1994. Although the surveys are detailed, the soil groups described in the surveys vary.

For the purpose of this assessment, soils data are based on NRCS Soil Survey Geographic (SSURGO) database, which contains complete coverage of the Upper Pit River Watershed. The SSURGO database contains detailed soil information pertinent to residents of the watershed including farmers, ranchers, timber harvesters, and wildlife management personnel. The NRCS has also created a State Soil Geographic (STATSGO) database, which contains complete coverage of the watershed. The STATSGO database was not used in this assessment as it contains information more pertinent to regional planners. The soil data availability summary is included in Table 1-4. Areas of more detailed information are provided in Figure 1-14.

Grouping them into valley, plateau-foothill, and mountain associations summarizes soils within the watershed. A soil association is a landscape that has a distinctive proportional pattern of soils. An association typically consists of one or more dominant soil types and at least one minor soil type. The association is named after the dominant soil type. Grouped by physiographic features, parent rock material, slope, aspect precipitation, and vegetation potential define soil associations.

In general, valley soils contain soils appropriate to farmland; plateau-foothill soils contain soils found in rangeland; and mountain soils contain soils suitable for timber production. Dominant associations and associated soil series are shown in Figure 1-13 and summarized in Table 1-5.

Valley Soils

Modoc-Oxendine-Bieber
Found predominantly in the Big Valley area, the soils of this group are usually found in higher positions such as stream terraces and basins. Part of the surface layer has little identifiable ash from past volcanic events. Areas of this unit are used primarily for irrigated crops or for pasture. Most of

the soils of this group have both hardpan and clay pan, which limit the production of crops to rice, wild rice, and other wetland crops. These soils are formed in alluvium derived from extrusive igneous rocks, lake sediments, and sedimentary rocks. Elevation ranges from 4,000 to 4,800 feet above msl. The average annual precipitation is 12 to 16 inches and the average annual temperature is 48–50ºF. The average frost-free period is 80 to 120 days. Slopes range from 0 to 9 percent.

Table 1-4
SOIL DATA AVAILABILITY

Organization	Geographic Area	Reference Material	Scale	Published Date
NRCS	Alturas to Fall River Mills	Soil Survey Geographic (SSURGO) Data Base	1:12,000 1:63,360	1994
NRCS	Upper Pit River Watershed	State Soil Geographic (STATSGO) Data Base	1:250,000	1994
NRCS	Westernmost reaches of McArthur/Fall River Mills area	Soil Survey of Shasta County area, California	1:20,000	1974
NRCS	Upper Pit River Watershed	Soil Survey of Intermountain area, California.	1:24,000	1994
NRCS	Modoc County	Soil Survey of Modoc County	--	1980
NRCS	Alturas area	Soil Survey of Alturas area, California	--	1936
NRCS	Surprise Valley	Soil Survey: Surprise Valley – Home Camp area, Calif.-Nev.	--	1974
NRCS	Big Valley	Soil Survey of Big Valley, California	--	1924
USFS*	Medicine Lake, Warner Mountains	Soil Survey of Modoc National Forest area, California	1 inch = 62,500 feet	1983
USFS	Southwestern portion of the watershed	Soil Survey of Lassen National Forest area, California		1984

* Data not shown on the map are available through the USFS in paper form but were unavailable in digital form at the time of publication.

Occurring primarily on stream terraces, Modoc soils are moderately deep and well drained. Slopes range from 0 to 5 percent. The surface layer is sandy loam. The upper part of the subsoil is sandy clay loam, and the lower part is sandy clay. Soil thickness is up to 32 inches. A thick hardpan exists from 32 to 60 inches below ground surface. Parent material consists of mixed alluvium from sedimentary and extrusive igneous rock. Common plants associated with the Modoc soil are mountain big sagebrush, rubber rabbitbrush, basin wild rye, and lemon needle grass.

Table 1-5
DOMINANT TYPE SOIL

Soil Series	Acres	Coverage Type	Description	Content
Valley Soils				
Modoc-Oxendine-Bieber		Sagebrush, grasses, juniper	Shallow to moderately deep, level to moderately sloping, moderately well drained to well-drained soils	Gravelly sandy clay
Pittville-Dudgen-Esperanza		Grasses and sagebrush	Deep to very deep, gently sloping to moderately steep, moderately well drained to well-drained soils	Clay and sand
Aikman-Cardon		Sedges and grasses	Deep to very deep, poorly drained soils formed in clayey alluvium derived from basalt, andesite, or tuff	Clay, silty clay, and clay loam
Deven-Bieber-Pass Canyon		Sagebrush, juniper, Idaho fescue, and grasses	Moderately deep, well drained, with moderately slow permeability	Clay and cobbly clay loam
Plateau and Foothill Soils				
Jellycamp-Jellico-Adinot		Low sagebrush, grasses, juniper, conifers, oak, shrubs	Shallow and moderately deep, gently sloping to steep, moderately well drained to well-drained soils	Gravelly sandy clay
Alcot-Sadie-Germany		Ponderosa pine, incense cedar, and sugar pine	Very well drained, and moderately rapid permeability	Loam, clay loam, and cobbly clay loam
Loveness-Hunsinger-Lava Flows		Ponderosa pine, shrubs, grasses	Lava flows, deep to very deep, gently sloping to steep, well drained soils	Gravelly clayey sand
Jimmerson-Gasper-Scarface		Mixed conifers and shrubs	Very deep, gently sloping to steep, well-drained soils on volcanic plateaus and hills	Equal parts sand, silt, and clay
Mountain Soils				
Gosch-Witcher-Trojan		Juniper, Jeffrey pine, white fir	Deep, gently sloping to steep, well drained soils	Gravelly sandy clay
Divers-Lapine-Kinzel		Mixed conifer forests and mountain hemlock, prostate manzanita, and mint.	Moderately deep and very well drained with rapid permeability	Gravelly coarse sand and very gravelly sandy loam
Rivalier-Tionesta-Blankout		Oaks, fir, sugar pine, shrubs	Moderately deep to very deep, gently sloping to very steep, well drained soils	Equal parts sand, silt, and clay
Anatone-Bearskin-Merlin		Western juniper, low sagebrush, rabbitbrush, mountain mahogany, Idaho fescue, and cheatgrass	Shallow and well drained with moderately rapid permeability	Gravelly clay and cobbly silty clay loam
Cheadle-Superior-Behanin		White bark pine, sagebrush, mulesear, and Idaho fescue	Well drained with moderate permeability and derived from andesite, tuff, or obsidian	Gravelly sandy loam and cobbly clay loam
Canyoncreek-Hermit		White fir, ponderosa pine	Deep, gently sloping to steep, well-drained soils	Clayey silty sand

NOTE: Total acreage will vary, because this table includes only dominant soil types.

Oxendine soils are shallow and moderately well drained, materializing primarily on stream terraces. Slopes range from 0 to 9 percent. Elevation ranges from 4,200 to 4,400 feet above msl. The surface layer is extremely gravelly to sandy loam. The subsoil is sandy clay loam, commonly underlain by a thick hardpan. Thickness of this soil is up to 12 inches. Common vegetation found on this soil includes sagebrush, grasses, and scattered juniper.

Bieber soils are shallow and moderately well drained and also occur on stream terraces. Slopes range from 0 to 5 percent. Elevation ranges from 4,100 to 4,500 feet above msl. The surface layer is gravelly to sandy loam. The subsurface layer is loam. The subsoil is clay loam and clay. Soil thickness is up to 19 inches and underlain by a thick hardpan at a depth of 19 to 60 inches. Parent materials contain alluvium derived from extrusive igneous rock and lacustrine sediments. Common plants on Bieber soil are Wright buckwheat, bottlebrush squirreltail, Sandberg bluegrass, and low sagebrush.

Soil Type	Sustainable Uses	Common Crops
Modoc-Oxendine-Bieber	Irrigated crops and livestock grazing	Alfalfa, grass-legume hay, barley, wheat, potatoes, wild rice, strawberries

Pittville-Dudgen-Esperanza

These soils form in alluvium derived from extrusive igneous rock and, in some areas, from diatomite. Elevation ranges from 2,700 feet in the Fall River Valley area to 5,500 feet west of the Fall River Valley. Areas of this unit are used primarily for irrigated crops or for pasture. Common crops planted in these soils are alfalfa, grass-legume hay, barley, wheat, strawberries, potatoes, peppermint, wild rice, and vegetable seed. The average annual precipitation is 12 to 50 inches, and the average annual temperature is 45–52ºF. The average frost-free period is 80 to 130 days. Slopes range from 0 to 30 percent.

Pittville soils are very deep and well drained, and are found primarily on stream terraces. Slopes range from 0 to 30 percent. Elevation ranges from 3,250 to 3,550 feet above msl. The surface layer is sandy loam. The subsoil is sandy clay loam underlain by stratified sand to sandy loam. A hardpan layer up to 84 inches thick is commonly found below the stratified sandy loams. Common vegetation associated with the Pittville soils is grasses and big sagebrush.

Dudgen soils are shallow and moderately well drained and are found primarily on stream terraces with slopes ranging from 0 to 2 percent. Elevations range from 3,310 to 3,320 feet above msl. The surface layer is loam. The subsoil is clay loam and clay underlain by a thin hardpan at a depth of about 15 inches. Below the hardpan is stratified, very fine, sandy loam to loamy sand. Depth to bedrock can be more than 60 inches below ground surface. Vegetation found on these soils commonly includes grasses, low sagebrush, bottlebrush, squirreltail, and bluegrass.

Esperanza soils are deep and well drained. Slopes range from 0 to 5 percent. Elevation ranges from 3,500 to 5,000 feet above msl. The surface layer is sandy loam and the upper part of the subsoil is loam commonly over clay. The lower part of the subsoil contains sandy clay loam underlain by sandy loam and subsequently hardpan. Soil thickness is up to 84 inches. Common plants are low sagebrush, beardless wildrye, rubber rabbitbrush, antelope bitterbrush, and lemon needlegrass.

Soil Type	Sustainable Uses	Common Crops
Pittville-Dudgen-Esperanza	Irrigated crops and livestock grazing	Alfalfa, grass-legume hay, barley, wheat, potatoes, strawberries, wild rice

Aikman-Cardon

This soil association is primarily in the alluvial plains surrounding the town of Canby. The Aikman-Cardon soils are found at elevations ranging from 4,300 to 6,200 feet above msl. The average annual precipitation is 14 to 18 inches and the mean annual temperature ranges from 44 to 49ºF. The average frost-free season ranges from 80 to 110 days. Slopes generally range from 0 to 15 percent. The association consists of deep, somewhat poorly drained soils formed in clayey alluvium derived from basalt, andesite, or tuff. This soil is found on flood plains, alluvial basins, and drainages on the lower side slopes of mountain uplands and basalt plateaus.

Aikman soils are moderately deep and well drained. Slope ranges from 0 to 2 percent. Elevation ranges from 4,300 to 6,200 feet above msl. The surface layer is a very hard, dark gray to dark grayish brown silty clay. The subsoil consists of very to extremely hard, grayish brown silty clay. Soil thickness is up to 60 inches. Common vegetation found in this soil association is silver sagebrush, sedges, forges, and grasses.

Cardon soils are deep, but poorly drained. Slope ranges from 0 to 15 percent. Elevation ranges from 4,600 to 6,200 feet above msl. The surface layer consists of very dark gray clay. The subsurface is dark gray clays and clay loam. Soil thickness is up to 60 inches. Due to the soils' low permeability, spring flooding is common. Customary vegetation found in this soil is sedges, forbes, and grasses.

Soil Type	Sustainable Uses	Common Crops
Aikman-Cardon	Wetlands and livestock grazing	N/A

Deven-Bieber-Pass Canyon

This soil association occurs on basalt plateaus throughout the area but is most prominate in the north-central portion. About half of this unit is directly over basalt bedrock and the other is strongly cemented to indurated silica duripan. Slope ranges from 0 to 20 percent and elevation ranges from 4,300 to 6,000 feet above msl. Annual precipitation ranges from 14 to 20 inches and the frost-free season ranges from 80 to 110 days. The soils in this unit are used mainly for rangeland.

Deven soils are 10 to 20 inches deep, well drained, and over hard basalt bedrock. Slope ranges from 1 to 15 percent. Elevation ranges from 4,600 to 6,000 feet above msl. The surface layer consists of cobbly loam. The subsurface consists of clay loam and clay with depth. Common vegetations found on this soil are western juniper, low sagebrush, high sagebrush, Idaho fescue, Sandberg bluegrass, and bottlebrush.

Bieber soils are 7 to 20 inches deep to a relatively thin silica duripan. Slope ranges from 1 to 10 percent. Elevation ranges from 4,600 to 6,000 feet above msl. These soils are well drained and permeability is very slow. The surface consists of a thin brown very cobbly loan with a subsurface of clay. Common vegetations found in this soil are low sagebrush, Sandberg bluegrass, Idaho fescue, bottlebrush, and cheatgrass.

Pass Canyon soils are 8 to 20 inches deep, well drained, with moderately slow permeability. Slope ranges from 2 to 15 percent. Elevation ranges from 4,300 to 6,000 feet above msl. The surface consists of very cobbly loam with a subsurface of loam, clay loam, and cobbly clay loam. Common vegetations found in this soil are western juniper, ponderosa pine, low sagebrush, big sagebrush, bitterbrush, rabbitbrush, Sandberg bluegrass, Idaho fescue, and cheatgrass.

Soil Type	Sustainable Uses	Common Crops
Deven-Bieber-Pass Canyon	Irrigated crops, livestock grazing, and some timber products	Alfalfa, grass-legume hay, barley, wheat Timber: western juniper

Plateau and Foothill Soils

Jellycamp-Jellico-Adinot

Found primarily on lava plateaus surrounding Big Valley and Fall River Valley. The Jellycamp-Jellico-Adinot soils are formed from extrusive igneous rock parent material. Elevation ranges from about 3,200 feet surrounding the Fall River Valley area to about 5,800 feet above msl in the Silva Flat area. The average annual precipitation is 12 to 20 inches. The average annual temperature is 45–50ºF. The average frost-free season ranges from about 50 days in the Silva Flat area to about 120 days near the Fall River and Big Valley area. Slopes generally range from 2 to 50 percent. The soils in this unit are used mainly for livestock grazing or wood products, mainly western juniper. Timber is a viable resource in areas receiving larger amounts of precipitation. Vegetations associated with the Jellycamp-Jellico-Adinot soils are juniper, conifers, oak, and shrubs.

Jellycamp soils are generally shallow and moderately well drained. They are found primarily on volcanic plateaus. Slopes range from 2 to 15 percent. Elevation ranges from 4,600 to 5,800 feet above msl. The surface layer is very cobbly loam. The clay subsoil is underlain by hardpan at a depth of about 11 inches further underlain by basalt. Vegetation commonly found on Jellycamp soils is low sagebrush, Thurber needlegrass, bluebunch wheatgrass, and Idaho fescue.

Jellico soils are moderately deep and well drained. These soils are present on volcanic plateaus and hills. Slopes range from 5 to 50 percent. Elevation ranges from 3,200 to 4,500 feet above msl. The surface layer is very cobbly silt loam and the subsoil is very cobbly silty loam underlain by basalt. Depth to bedrock ranges from 20 to 40 inches. The primary woodland species found on the Jellico soils are Oregon white oak, ponderosa pine, California black oak, gray pine, and western juniper. Common understory plants are bluebunch wheatgrass, antelope bitterbrush, bottlebrush squirreltail, Columbia needlegrass, and mountain mahogany.

Adinot soils are shallow and moderately well drained. These soils are found on pediments and hills. Elevation ranges from 4,200 to 4,400 feet above msl. Slopes range from 2 to 30 percent. The surface layer is very gravelly sandy loam; the subsoil is gravelly loam in the upper portion and gravelly and very gravelly clay loam in the lower portion of the subsoil underlain by volcanic tuff. Depth to bedrock ranges from 14 to 20 inches. Common vegetation found on Adinot soils is low sagebrush and grasses.

Soil Type	Sustainable Uses	Timber Harvested
Jellycamp-Jellico-Adinot	Livestock grazing and timber products	Western juniper, ponderosa pine, gray pine, Oregon white oak, and California black oak

Alcot-Sadie-Germany

This soil association is found predominately in the western portion of the watershed, west of the town of Scarface in the Burnt Lava Flow Virgin Area. The soils are found on basalt plateaus and lower side slopes of cinder cones from elevations ranging from 4,350 to 5,500 feet above msl. Slope ranges from 1 to 20 percent. The average annual precipitation is 16 to 25 inches, and the average annual temperature is 44–49ºF. Annual precipitation ranges from 20 to 30 inches, and the frost-free growing season ranges from 60 to 110 days. These soils support a mixed conifer forest of ponderosa pine, incense cedar, and sugar pine.

Alcot soils are very well drained, and permeability is moderately rapid. The soils are found primarily on undulating basalt plateaus and sideslopes of cinder cones. Slope ranges from 1 to 20 percent. Elevation ranges from 4,400 to 5,500 feet above msl. The surface consists of gravelly sandy loam with a subsurface of very gravelly sandy loam. Soil thickness is up to 60 inches. Common vegetation found on Alcot soils are ponderosa pine, white fir, incense cedar, sugar pine, greenleaf manzanita, snowberry, ceanothus, Ross's sedge, and grasses.

Sadie soils are well drained with moderately rapid permeability. Sadie soils are found primarily on recent ash, cinders, and pumice, which cap older basalt. Slope ranges from 1 to 20 percent. Elevation ranges from 4,350 to 5,500 feet above msl. The surface consists of gravelly sandy loan with a subsurface of gravelly coarse sandy loam. Soil thickness can be up to 50 inches. Common vegetation found on Sadie soils are ponderosa pine, white fir, incense cedar, sugar pine, greenleaf manzanita, snowberry, ceanothus, Ross's sedge, and grasses.

Germany soils are well drained with moderately rapid permeability. These soils are found on undulating basalt plateaus with a slope ranging from 1 to 5 percent. Elevation ranges from 4,350 to 4,500 feet above msl. The soil consists of fine sandy loam, cobbly fine sandy loam, and very cobbly sandy loam. Soil thickness is up to 60 inches. Common vegetation found on Germany soils are ponderosa pine, white fir, Jeffrey pine, greenleaf manzanita, rabbitbrush, ceanothus, Ross's sedge, and grasses.

Soil Type	Sustainable Uses	Timber Harvested
Alcot-Sadie-Germany	Livestock grazing and timber products	Ponderosa pine, sugar pine, incense cedar, and white fir

Loveness-Hunsinger-Lava Flows

In areas of lower rainfall, this soil association is dominant in the lower forested areas surrounding the valleys. The Loveness-Hunsinger-Lava Flow soils formed in material derived from extrusive igneous rock and tephra. Elevation ranges from 3,100 feet in the Fall River Valley area to 5,000 feet above msl in the Loveness area. The average annual precipitation is 16 to 25 inches, and the average annual temperature is 45-48ºF. The average frost-free period is 80 to 120 days. Slopes range from 2 to 50 percent. Loveness-Hunsinger-Lava Flow soils are used mainly for timber production or home site development. Lava Flows provide wildlife habitat but are not suited for timber production and cause access problems for forest management. Common vegetation associated with this soil group is ponderosa pine, shrubs, and grasses.

Loveness soils are very deep and well drained and are found primarily on volcanic plateaus and hills. Slopes range from 2 to 30 percent. Elevation ranges from 4,200 to 5,000 feet above msl. The surface layer is sandy loam and the subsurface layer is loam. The subsoil is gravelly loam and gravelly clay loam in the upper portion, and extremely stony clay loam in the lower portion with depth to bedrock being more than 60 inches. Main tree species found within the Loveness soils include ponderosa pine, incense cedar, and white fir. Common under story plants include squaw carpet, snowbrush ceanothus, greenleaf manzanita, squirreltail, and mule ears.

Hunsinger soils are deep, well drained, and commonly found on volcanic plateaus, hills, and mountains. Slopes range from 2 to 50 percent. Elevation ranges from 3,800 to 4,500 feet above msl. The surface layer is gravelly sandy loam. The subsoil is very cobbly sandy clay loam underlain by basalt. Depth to bedrock ranges from 40 to 60 inches. Main tree species of the Hunsinger soils are Jeffrey pine, ponderosa pine, incense cedar, and California black oak. Common understory plants are squaw carpet, bluegrass, needlegrass, greenleaf manzanita, Idaho fescue, and antelope bitterbrush.

Lava flows are areas of jagged and broken lava, primarily basalt. These areas support sparse to no vegetation.

Soil Type	Sustainable Uses	Timber Harvested
Loveness-Hunsinger-Lava Flow	Timber products	Ponderosa pine, Jeffery pine, incense cedar, California black oak, and white fir

Jimmerson-Gasper-Scarface

This soil association is dominant in the forested areas that have moderate rainfall. This soil group is very deep, gently sloping to steep, well-drained soils on lava plateaus and hills. The soils formed in material derived from extrusive igneous rock and tephra. Elevation ranges from 3,000 to 5,100 feet above msl. The average annual precipitation is 25 to 50 inches, and the average annual temperature is 45-50ºF. The average frost-free period is 80 to 100 days. Slopes range from 2 to 50 percent. Areas of this unit are used mainly for timber production. Common vegetation types of the Jimmerson-Gasper-Scarface soil group are mixed conifers and shrubs.

Jimmerson soils are well drained, found primarily on volcanic plateaus. Slope ranges from 2 to 15 percent. Elevation ranges from 3,300 to 4,500 feet above msl. The surface layer is loam. The subsoil is clay loam in the upper portion and cobbly clay loam in the lower portion with depth to bedrock up to 70 inches. Primary tree species found on Jimmerson soils are Douglas fir, ponderosa pine, white fir, sugar pine, and incense cedar. Common understory plants are greenleaf manzanita, Idaho fescue, skunk bush sumac, snowbrush ceanothus, squaw carpet, antelope bitterbrush, gooseberry, and deer brush.

Gasper soils are well drained. These soils are found primarily on volcanic plateaus and hills with slopes ranging from 15 to 30 percent. Elevation ranges from 3,200 to 5,100 feet above msl. The surface layer and subsurface layer are gravelly sandy loam. The subsoil is very cobbly to extremely stony sandy loam in the upper portion to very cobbly sandy clay loam in the lower portion with depth to bedrock more than 60 inches below ground surface. Main tree species of the Gasper soils are ponderosa pine, sugar pine, incense cedar, and white fir; common understory plants are squaw carpet, bottlebrush squirreltail, greenleaf manzanita, snowbrush ceanothus, and needlegrass.

Scarface soils are well drained with a surface layer and subsurface layer of sandy loam. They are underlain by gravelly sandy clay loam and gravelly clay loam with depth to bedrock of more than 60 inches. Elevation ranges from 3,400 to 4,400 feet above msl. Main tree species of the Scarface soils include the California black oak, incense cedar, sugar pine, and white fir. The common understory plants are greenleaf manzanita, antelope bitterbrush, serviceberry, and squaw carpet.

Soil Type	Sustainable Uses	Timber Harvested
Jimmerson-Gasper-Scarface	Timber products	Ponderosa pine, sugar pine, Jeffery pine, incense cedar, California black oak, Douglas-fir, and white fir

Mountain Soils

Gosch-Witcher-Trojan

The Gosch-Witcher-Trojan soil association is found primarily in areas of lowest rainfall. These soils are derived from tephra and extrusive igneous rocks. These soils are generally deep, gently sloping to steep, and well drained. Elevation ranges from 4,600 to 6,500 feet above msl. The average annual precipitation is 18 to 25 inches, and the average annual temperature is 39–45ºF. The average frost-free season is 50 to 80 days with slopes ranging from 2 to 50 percent. Common vegetation includes juniper, Jeffrey pine, white fir, and shrubs.

Gosch soils are generally found on mountains with slopes ranging from 2 to 50 percent. Elevation ranges from 4,600 to 6,500 feet above msl. The surface layer is gravelly sandy loam. The subsurface layer is extremely stony sandy loam. The subsoil is extremely stony sandy clay loam to extremely stony clay loam in the upper portion, and extremely gravelly clay loam in the lower portion of the profile underlain by andesite. Depth to bedrock ranges from 40 to 60 inches. Primary tree species include white fir, ponderosa pine, and incense cedar; common understory plants include greenleaf manzanitas, squaw carpet, curl leaf mountain mahogany, mules ear, bitter cherry, Sierra chinkapin, snowbrush ceanothus, and mountain big sagebrush.

Witcher soils are also generally found on mountains with slopes ranging from 2 to 50 percent. Elevation ranges from 4,600 to 6,500 feet above msl. The surface layer is sandy loam. The subsoil is sandy clay loam in the upper part and very gravelly clay loam in the lower portion underlain by andesite. Depth to bedrock typically ranges from 40 to 60 inches. Main tree species found in the Witcher soils are white fir, Jeffrey pine, ponderosa pine, and incense cedar; common understory plants are greenleaf manzanita, squaw carpet, bitter cherry, Sierra chinkapin, snowbrush ceanothus, and serviceberry.

Trojan soils are present on slightly steeper mountains and hills with slopes of 15 to 30 percent. Elevation ranges from 5,800 to 6,500 feet above msl. The surface layer is loam. The subsurface layer is cobbly loam. The subsoil is gravelly clay loam to extremely gravelly clay loam underlain by volcanic tuff. Depth to bedrock ranges from 40 to 60 inches. Main woodland species of the Trojan soils are Jeffrey pine and western juniper; common understory plants include mountain big sagebrush, bluebunch wheatgrass, arrow leaf balsamroot, Idaho fescue, bottlebrush squirreltail, and mountain mahogany.

Soil Type	Sustainable Uses	Timber Harvested
Gosch-Witcher-Trojan	Timber products and some grazing	Ponderosa pine, Jeffery pine, incense cedar, and white fir

Divers-Lapine-Kinzel

This soil association is found primarily in the Black Mountain area in the northwestern portion of the watershed. The Divers-Lapine-Kinzel soils are derived from recent volcanics and contain pumice deposits. The soils are moderately deep-to-deep and well drained. Slope ranges from 1 to 60 percent. Elevations range from 6,500 to 7,900 feet above msl. Annual precipitation ranges from 35 to 45 inches and the frost-free season ranges from 40 to 70 days. These soils support red fir forest or mixed conifer forests of lodgepole pine, western white pine, red fir, and mountain hemlock. Understory vegetation may include penstemon, prostrate manzanita, mint, snowberry, and chinquapin.

Divers soils are moderately deep and very well drained with rapid permeability in the pumice underburden. Slope ranges from 10 to 30 percent. Elevations range from 6,600 to 7,500 feet above msl. The soil surface consists of gravelly sandy loam with a subsurface of very gravelly sand, gravelly sand and cobbly sandy loam. Soil thickness is up to 60 inches. Common vegetation in Diver soils are mixed conifer forests of red fir, lodgepole pine, western white pine, and understory vegetation of mountain hemlock, prostate manzanita, and mint.

Lapine soils are moderately deep, excessively drained with rapid permeability. These soils are found primarily atop cinders. Slope ranges from 2 to 30 percent. Elevation ranges from 6,600 to 7,500 feet above msl. These soils generally have a surface of very gravelly sand and a subsurface of extremely gravelly coarse sand, very gravelly sandy loam, and extremely gravelly loamy coarse sand. Soil thickness is up to 60 inches. Common vegetation in Lapine soils are mixed conifer forests of red fir, lodgepole pine, western white pine and understory vegetation of mountain hemlock, prostate manzanita, and mint.

Kinzel soils are moderately deep and found atop weakly cemented volcanic ash and cinders. They are well drained and permeability is moderately rapid. Slope ranges from 2 to 25 percent. Elevation ranges from 6,600 to 7,500 feet above msl. The soil surface consists of gravelly loamy sand with a subsurface of very cobbly sandy loam. Common vegetation in Kinzel soils is western white pine, lodgepole pine, rabbitbrush, lupine, and mint.

Soil Type	Sustainable Uses	Timber Harvested
Divers-Lapine-Kinzel	Timber products	Lodgepole pine, western white pine, and red fir

Rivalier-Tionesta-Blankout
This soil association exists primarily in areas of moderate rainfall. The Rivalier-Tionesta-Blankout soils formed in material derived from tephra. These soils are moderately deep to very deep, gently sloping to very steep, and well drained with slopes ranging from 2 to 75 percent. Elevation ranges from 4,300 to 6,300 feet above msl. The average annual precipitation is 25 to 35 inches, and the average annual temperature is 39–45ºF. The average frost-free season is 50 to 80 days. Common vegetation types include oak, fir, sugar pine, and shrubs.

Rivalier soils are moderately deep, found in mountainous terrain with slopes ranging from 15 to 75 percent. Elevation ranges from 4,800 to 6,300 feet above msl. These soils are generally very gravelly to extremely gravelly sandy loam underlain by volcanic tuff. Depth to bedrock ranges from 20 to 40 inches. Primary tree species found on Rivalier soils include ponderosa pine, incense cedar, white fir, California black oak, and sugar pine; common understory plants include serviceberry, snowbrush ceanothus, rubber rabbitbrush, and rose.

Tionesta soils are very deep and generally found on gently sloped hills ranging from 2 to 30 percent. Elevation ranges from 5,000 to 5,800 feet above msl. These soils are pumiceous, very gravelly loam to coarse sand. They are underlain by gravelly coarse sandy loam, extremely gravelly coarse sandy loam, and extremely gravelly loamy coarse sand. Depth to bedrock is more than 60 inches. Tree species found on the Tionesta soils include white fir, ponderosa pine, incense cedar, and sugar pine; common understory plants are snowbrush ceanothus, greenleaf manzanita, antelope bitterbrush, squaw carpet, and squirreltail.

Blankout soils are also very deep and generally found on gently sloped hills ranging from 2 to 30 percent. Elevation ranges from 4,300 to 5,400 feet above msl. The surface layer is commonly coarse sandy loam. The subsoil is gravelly coarse sandy loam underlain by extremely gravelly coarse sandy loam. Depth to bedrock is more than 60 inches. Main tree species include white fir, sugar pine, ponderosa pine, and incense cedar. Common understory plants are greenleaf manzanita, squaw carpet, Sierra chinkapin, snowbrush ceanothus, and antelope bitterbrush.

Soil Type	Sustainable Uses	Timber Harvested
Rivalier-Tionesta-Blankout	Timber products	Ponderosa pine, sugar pine, incense cedar, California black oak, western juniper, and white fir

Anatone-Bearskin-Merlin
Predominately found in the higher elevations of the Warner Mountains and on Likely Mountain in the south-central portion of the watershed. This unit is composed of shallow soils found on mountain uplands and remnants of basalt plateaus. Slope ranges from 1 to 90 percent. Elevation ranges from 5,500 to 7,500 feet above msl. Annual precipitation ranges from 20 to 30 inches and frost-free season is 60 to 90 days. The principal use for these soils is rangeland and wildlife habitat.

Anatone soils are well drained with moderately rapid permeability. Slope ranges from 40 to 70 percent. Elevation ranges from 5,500 to 7,000 feet above msl. The soil surface consists of cobbly loam with a subsurface of very cobbly loam. Soil thickness is up to 20 inches. Common vegetations on Anatone soils are western juniper, low sagebrush, rabbitbrush, mountain mahogany, Idaho fescue, and cheatgrass.

Bearskin soils are well drained with slow permeability. Slope ranges from 40 to 60 percent. Elevation ranges from 5,500 to 7,000 feet above msl. The soil surface consists of cobbly loam with a subsurface of cobbly silty clay loam. Soil thickness is up to 20 inches. Vegetation found on Bearskin soils is western juniper, ponderosa pine, low sagebrush, big sagebrush, rabbitbrush, mulesear, paintbrush, wheatgrass, cheatgrass, and Idaho fescue.

Merlin soils are well drained with slow permeability. Slope ranges from 35 to 60 percent. Elevation ranges from 5,500 to 7,000 feet above msl. The soil surface consists of very cobbly clay loam with a subsurface of gravelly clay. Soil thickness is to 20 inches. Vegetation found on Merlin soils is western juniper, low sagebrush, big sagebrush, western yarrow, and Idaho fescue.

Soil Type	Sustainable Uses	Timber Harvested
Anatone-Bearskin-Merlin	Timber products and some grazing	Ponderosa pine and western juniper

Cheadle-Superior-Behanin

This soil association is found predominately in the higher elevations of the Warner Mountains. These soils are shallow to moderately deep forming on upper sideslopes, crests, and ridges of the higher elevations of the Warner Mountains. Slope ranges from 5 to 100 percent. Elevation ranges from 7,000 to 9,900 feet above msl. Annual precipitation ranges from 25 to 35 inches with a frost-free season of less than 30 days up to 70. These soils are either rangeland soils or support semi-dense stands of whitebark pine, with some lodgepole pine, western white pine, and quaking aspen.

Cheadle soils are well drained with moderate permeability and are derived from andesite, tuff, or obsidian. Slope ranges from 35 to 60 percent. Elevation ranges from 7,600 to 9,700 feet above msl. The soil surface consists of very cobbly loam with a subsurface of very cobbly clay loam. Soil thickness is up to 20 inches. Common vegetations on Cheadle soils are whitebark pine, big sagebrush, low sagebrush, mulesear, and Idaho fescue.

Superior soils are well drained with moderate permeability and are derived from andesite, tuff, or obsidian. Slope ranges from 15 to 40 percent. Elevation ranges from 7,000 to 8,000 feet above msl. The soil surface consists of gravelly fine sandy loam with a subsurface of very gravelly sandy loam. Soil thickness is up to 30 inches. Common vegetation on Superior soils is white fir, big sagebrush, low sagebrush, mulesear, and Idaho fescue.

Behanin soils are well drained with moderate permeability and are derived from andesite and tuff. Slope ranges from 15 to 40 percent. Elevation ranges from 7,000 to 8,000 feet above msl. The soil surface consists of very gravelly loam and a subsurface of extremely gravelly loam. Soil thickness is up to 60 inches. Common vegetation on Behanin soils is lodgepole pine, white pine, Washoe pine, quaking aspen, western white pine, prostrate manzanita, and ceanothus.

Soil Type	Sustainable Uses	Timber Harvested
Cheadle-Superior-Behanin	Timber products and some grazing	White bark, lodgepole, and western white pine

Canyoncreek-Hermit
At the highest elevations this soil association is dominantly in the Cal Pines area and has the coolest soil temperatures. These soils formed in tephra and are generally deep, gently sloping to steep, and well drained. Elevation ranges from 6,000 to 7,100 feet above msl. The average annual precipitation is about 20 to 25 inches, and the average annual temperature is about 38–43ºF. The average frost-free season ranges from 40 to 50 days. Slopes range from 2 to 50 percent. Common vegetation includes white fir, ponderosa pine, and shrubs.

Typically, the surface layer of the Canyoncreek soils is sandy loam. The subsoil is very stony loam to extremely gravelly loam underlain by tuff. Depth to bedrock ranges from 40 to 60 inches. Elevation ranges from 6,000 to 7,100 feet above msl. Primary tree species of the Canyoncreek soils include white fir and ponderosa pine. Common understory plants include serviceberry, snowbrush ceanothus, sticky currant, sierra chinkapin, and bitter cherry.

Surface layers of the Hermit soils are generally sandy loam. The subsoil is sandy loam in the upper portion and very gravelly sandy loam in the lower portion underlain by tuff. Depth to bedrock ranges from 40 to 60 inches. Primary tree species include white fir, ponderosa pine, and incense cedar. Common under story plants include Sierra chinkapin, bitter cherry, serviceberry, snowbrush ceanothus, and sticky currant.

Soil Type	Sustainable Uses	Timber Harvested
Canyoncreek-Hermit	Timber products	Jeffery pine, ponderosa pine, and white fir

CLIMATE

Historical Record

No real-time climate data are available before approximately 1900. In order to evaluate historic climate trends, scientists commonly use glacial cores, lakebed deposits, tree line inventory, and tree ring data. California has experienced a number of significant trends in both temperature and precipitation very different from what is considered "normal." Around 1850, just as large numbers of Europeans entered western ecosystems, the region experienced a marked shift in climate from the abnormally cool and moderately dry conditions of the previous two centuries (the "Little Ice Age"), to the relatively warm and wet conditions that have characterized the past 145 years (Matthes, 1939). This climactic shift is important to land managers for two interrelated reasons. First, the landscape changes that have occurred since 1850 are not entirely anthropogenic but rather attributable in part to the shift in climate. Second, the landscape of the immediate period should not be considered an exact model for what the watershed would be today had Europeans never colonized the region. Thus, attempts to restore "natural conditions" as part of an overall management plan should focus not on the pre-European landscape but rather on the landscape that would have evolved during the past century and a half in the absence of Europeans (Stine, 1996).

The period of the mid-1600s to mid-1800s is characterized as abnormally cool and dry. Scientists believe the dry period proceeded several centuries of cool, wet conditions. For the past 145 plus years, warm and relatively wet conditions are common. This is documented in glaciers, tree rings and lake deposits. Much of the data for the watershed were extrapolated from data collected from the Sierra Nevada.

General Evidence

Records show (Clark and Gillespie, 1995; Curry, 1969) after thousands of years of little or no glaciation (adding ice), the high elevation areas of the Sierra Nevada experienced an accumulation for several hundred years prior to 1850. This accumulation corresponds to a period of cooling over much of the globe that began in the fourteenth or fifteenth century and continued through the middle of the nineteenth century (Grove, 1988). Matthes (1939) speculates the small glaciers reached peak extent around 1850 and retreated up to 87 feet between 1933 and 1941. Theoretically, this minor glaciation of the mid-sixteenth through mid-nineteenth centuries is attributable to some combination of increased precipitation (leading to greater accumulation) and decreased temperature (leading to less melting and sublimation). The lake level records presented earlier in this chapter consistently support relatively dry climate during this period, conclusion drawn as a working hypothesis is relatively low temperatures caused the advance of the ice. Various types of dendroclimatological evidence support this hypothesis. The dendroclimatic record (tree rings) verifies that climate was both relatively cool and dry during the centuries preceding the California gold rush (Stine, 1996).

Graumlich's tree ring record from the southern Sierra provides the most detailed view of variations in the latest Holocene climate. That record confirms that the period from 1650 to 1850 was generally dry, although it points up an important exception not evident in the lake or glacial records: the interval 1713–32 was anomalously wet. Graumlich's work also provides corroboration that the period from 1650 to 1850 was, by both Holocene and modern standards abnormally cool (Stine, 1996).

The tree ring studies allow the temperature factor to be isolated from the precipitation factor; an advantage that the lake record or the glacial record cannot provide. Graumlich concluded that:

- Growing-season temperatures reached their lowest level of the past millennium around 1600 and remained low, by modern (1928–88) standards, until around 1850

- Although the period 1713–32 was, by modern standards, characterized by relatively wet conditions, it was preceded by a century dominated by low precipitation and followed by 130 years (particularly the period 1761–64) of anomalous drought

- The period 1937–86 was the third-wettest half-century interval of the past 1,000 and more years

Graumlich stresses that others reflect her inferred droughts and temperature variations in other tree-ring studies undertaken in and adjacent to the Sierra Nevada.

Recent Record

Recent climate within the Upper Pit River Watershed is generally characterized as hot dry summers and cold winters, although it varies considerably with elevation. Six active National Weather Service (NWS) cooperative weather stations are located within the Upper Pit River Watershed at the Adin,

Table 1-6 WEATHER STATION IDENTIFICATION					
Station ID	**Name**	**Latitude (dd.mm)**	**Longitude (ddd.mm)**	**Elevation (msl)**	**Years of Record**
Active					
040029-2	Adin Ranger Station	41.12	120.57	4,190	1948–2002
041476-2	Canby Ranger Station	41.27	120.52	4,310	1948–2002
040161-2	Alturas Ranger Station	41.30	120.33	4,460	1931–2002
044374-2	Jess Valley	41.16	120.18	5,300	1948–2002
040731-2	*Bieber	41.07	121.08	4,130	1948–2002
041614-3	Cedarville	41.32	120.10	4,670	1948–2002
042306-2	*Day	41.13	121.23	3,650	1948–2002
Inactive					
040867-2	Blacks Mountain	40.46	121.12	7,210	1948–1976
040870-2	Blacks Mountain Ranch	40.44	121.15	5,600	1948–1960
041237-2	Butte Lake	40.34	121.18	6,060	1961–1976
041475-2	Canby 11sw	41.22	121.03	4,500	1959–1973
041614-3	Cedarville	41.32	120.10	4,650	1931–1957
042184-1	Crowder Flat	41.53	120.44	5,180	1958–1976
042296-2	Davis Creek	41.44	120.22	4,750	1959–1970
042311-2	Dead Horse Res 2 Se	41.42	120.33	5,060	1958–1976
042595-3	Eagle Lake Stone Ranch	40.30	120.39	5,130	1959–1961
043824	Hat Creek PH-1	40.56	121.33	3,020	1948–2000
044816-3	Lassen Creek Upper	41.45	120.15	6,790	1958–1976
044988-2	Little Valley	40.53	121.11	4,170	1960–1975
045086-1	Long Bell Stn	41.28	121.25	4,380	1958–1976
045093-2	Lookout 3 Wsw	41.12	121.12	4,180	1963–1977
045505-1	Medicine Lake	41.46	121.50	4,400	1952–1959
046173-2	New Pine Creek 2 E	41.59	120.16	5,290	1960–1961
046751-3	Patterson Meadow	41.11	120.12	7,000	1958–1976
046803-2	Pepperdines Camp	41.27	120.14	6,310	1958–1976
047106-2	Potters Sawmill	41.14	121.13	4,210	1961–1963
048074-3	Secret Valley	40.30	120.16	4,440	1962–1977
048075-3	Secret Valley M S	40.40	120.16	4,660	1959–1962
048521-1	Steele Swamp	41.52	120.57	4,550	1948–1950
048724-2	Sweagert Flat	41.14	120.47	6,000	1958–1976
049691-1	Willow Creek Ranch	41.50	120.45	5,200	1964–1966
*Hourly precipitation data available Source: Western Regional Climate Center					

Canby, Alturas, Jess Valley, Bieber, and Day ranger's stations. Because of its proximity to the watershed and good period of record, the Cedarville station located east of the watershed boundary was also evaluated for data. In addition, 24 historic weather stations collected data throughout the watershed beginning in approximately 1931. The longest recorded dataset is at the Alturas ranger station, which has collected data since 1931. A summary of both active and inactive weather stations including location, elevation, and years of record can be found in Table 1-6. Station locations are shown in Figure 1-15.

Certain general trends can be attributed to the climate within the watershed:

- Temperatures generally decline with increasing elevation in the range, though drainage of cold air into valley bottoms can provide exceptions to this rule

- Precipitation generally increases with increasing elevation in the range, though wind can keep high-elevation areas swept of snow

- Winds generally strengthen with increasing elevation in the range

- Snowfall composes a greater percentage of total precipitation at higher elevation in the range

Temperature/Evaporation and Growing Seasons

Average annual temperatures within the watershed range from a low of approximately 30ºF to a high of 63ºF. Temperatures are typically warm in the summer months with the average maximum monthly temperatures occurring in July at approximately 87ºF in Alturas and 85ºF in Adin. Temperatures of at least 90ºF are common throughout the watershed. Maximum temperatures have been recorded in July at 110ºF and 107ºF in Adin and Alturas, respectively.

Temperatures in winter months average from 33ºF in Adin to 31ºF in Alturas. Extreme low temperatures are common in the Warner Mountains and in the eastern portions of the watershed. The lowest recorded temperature in Alturas was -34ºF in December of 1972. Average monthly temperatures for Alturas are included in Figure 1-16.

July is generally the last month of freezing temperatures in the Warner Mountains, although can be as early as mid-May in areas surrounding Alturas. In the valley locations, the first fall freeze generally occurs in September. At higher elevations, it is not uncommon to experience freezing temperatures throughout the year.

Hourly temperatures were plotted for January and July, the coldest and hottest months in Alturas. During January, Alturas experienced daily temperature fluctuations of approximately 15 degrees; in July temperatures fluctuate nearly 40 degrees. The hourly temperature plots are included in Figure 1-17.

Data collected by the California Irrigation Management Information Systems (CIMIS) McArthur (No. 43) and Alturas stations (No. 90) show reference evapotranspiration (ETo) rates to be consistent throughout the watershed. ETo is the amount of water lost from a well-watered actively growing closely clipped grass that is completely shading the soil surface. Although typically used to schedule irrigation events, ETo data closely reflects the evaporation rates of surface water.

Both ETo and Pan Evaporation Rates are used to predict evapotranspiration. The pan coefficient or correction factor applied to convert pan evaporation rates to lake evaporation rates vary by location and season, but usually range between 0.6 and 1.0. Without site-specific data, the correction factor of 0.8 (i.e. pan evaporation rates are approximately 20 percent higher than lake evaporation) is generally used. The difference is due primarily to edge effects. Using the September average pan value supplied by the DWR (6.07 inches) and the average September ETo value (4.9 inches), the calculated pan coefficient is 0.81.

CIMIS data show that the minimum monthly ETo rate of 0.75 of an inch occur in December, while a maximum of approximately 8 inches occurs in the months of July and August. Plots summarizing ETo rates for the McArthur and Alturas CIMIS stations are included in Figures 1-18 and 1-19, respectively.

The growing season, based on the freezing dates, is approximately 80 to 120 days in most valley locations and shortens considerably in the mountainous regions to approximately 40 to 80 days.

Precipitation

Most areas of the Upper Pit River Watershed receive approximately 13 to 16 inches of precipitation per year. Most of the precipitation falls during the winter months with 35 percent of the annual total received between December and February. Monthly averages are highest in January with 2.26 inches falling in Adin and 1.55 inches falling in Alturas. Rainfall during the summer months is limited. Although thundershowers occur approximately 5 to 10 days per year, they account for only a small percentage of the annual precipitation. The Upper Pit River Watershed receives approximately 2.6 million acre-feet of average precipitation per year.

Annual precipitation data for the City of Alturas was plotted to identify periods of drought or heavy rains. Results show very few abnormalities in the yearly hydrologic cycle, although the late 1930s to 1970s and early 1980s received less than average precipitation. Precipitation recurrence data show that the City of Alturas receives more than 20 inches of annual precipitation in 3 out of 100 years. Based on the recurrence data Alturas receives between 7 and 13 inches of precipitation every 2 to 4 years.

An isohyetal map of the watershed is included as Figure 1-20. A plot summarizing the precipitation recurrence intervals for the City of Alturas is included in Figure 1-21.

Snowfall

The amount of snowfall received by the watershed varies significantly with elevation. Snowfall data collected at the Adin Ranger Station (elevation 4,190 ft msl), the lowest weather station in the watershed, shows January as having the highest average snowfall at approximately 11.5 inches with average annual snowfall of approximately 46.5 inches. The highest total snowfall recorded at the Adin Ranger Station was 108.10 inches in 1968–69.

Snowfall data collected at the Jess Valley Weather Station (elevation 5,300 ft msl) show January as having the highest average snowfall at approximately 13.75 inches with average annual snowfall of approximately 72.75 inches. The highest total snowfall recorded at Jess Valley was 126.60 inches in 1998–99. Snowpack data was found for Cedar Pass (elevation 7,100 ft msl) located just inside the eastern watershed boundary. The average snowpack for Cedar Pass from April 1931 to April 2003 is 46.7 inches with a maximum depth of 81.7 inches recorded in 1952.

In the lower elevations, snow does not on the ground for long periods. In January, the average snow depth in Adin is less than two inches where as in Jess Valley an average of four to six inches is present throughout the month.

Significantly higher amounts of snowfall can be found in the highest elevations of the watershed, such as Eagle Peak (elevation 9,892 ft msl) and Warren Peak (elevation 9,710 ft msl), but data is not available for those locations.

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Section 2

Section 2
GENERAL WATERSHED HISTORY

TABLES

FIGURES

Section 2
GENERAL WATERSHED HISTORY

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The Upper Pit River Watershed has been influenced and changed by input from both man and nature. The most recent period of influence and change has been in response to the arrival of Europeans beginning in the middle of the nineteenth century. In the last 150 years, Europeans have molded the watershed environment to fit their needs. The most significant impacts are related to the exclusion of fire, introduction of non-native grasses and brush species, mining, and development. Prior to the arrival of Europeans, native peoples also managed the landscape to meet their specific needs.

NATIVE PEOPLES

The watershed was inhabited by the Achomawi (Pit River) and Atsugewi peoples at the time of historical contact. It is believed the watershed area supported approximately 2,100 individuals; however, this is reported to be little more than a guess (Kniffen, 1928). By 1900, this number is believed to be significantly less. The Achomawi claimed all of the Pit River above what is now Montgomery Creek as their territory (Dixon, 1908). Their territory was bordered on the west by the Northern Yana and Shasta; north by the Modoc; south by the Yana; and east by the Paiute.

The Achomawi preferred to live independently in their own small family groups, and outsiders were discouraged, although intermarriage between family groups and the adjoining Agewani did occur. The family groups were autonomous from other groups. Each had its own organizational structure and customs. They inhabited permanent villages only in the winter, which were generally located near streams (Olmstead and Stewart, 1978). During the summer season, they moved throughout the territory (Dixon, 1908). Movements of the family or tribal units followed the changes in available resources of the seasons. The Achomawi family groups owned certain resources such as deadfall trap pits and fishing locations. These were passed on from father to son. Generally, the dead were buried or cremated depending on the practices of the individual family group (Olmstead and Stewart, 1978). However, the Achomawi band cremated their dead (Heizer, R., 1978). Kniffen supported that no one burial method was used throughout the large Achomawi territory.

Horse use is not widely documented; however, references report that the Achomawi traded for horses (Omstead and Stewart, 1978). In general, it is assumed that materials were carried by family members or cached until the return in spring or fall. Travel was via footpath and trail. No farming activities were documented. It is documented that the Achomawi used fire to manage the resources available to them (Blackburn and Anderson, 1993).

The Achomawi territory included hundreds of acres of rich riparian environments, which provided them with a wide array of fish, shellfish, and migratory fowl. Upland areas were covered in pine, fir, juniper, and sage. Swamp areas provided the utle plant, which was used as both food and building materials. Meadows offered a ready supply of herbs, grasses, and foraging areas for game animals. The volcanic past of the area provided obsidian, a superior material for stone tool use and an object of great trading value (Olmstead and Stewart, 1978).

Although the Achomawi were hunters and gatherers, they were also adept resource managers and modified the environment to suit their needs. The individual resources and management techniques, which provided food varied by the area of the Pit River that was inhabited. It is generally agreed that the Achomawi depended heavily on the salmon below the great falls of the Pit River, which is outside the watershed boundary, and on California sucker in the Upper Pit River and its tributaries as a primary food source (Olmstead and Stewart, 1978). Sucker and salmon were fished using nets, baskets, wires, spears, and stone traps. First-fish rituals, common in cultures heavily dependent on salmon for food, are documented among the Achomawi people (Powers, 1874). Further dependence on the river is evident in the documented use of the canoe. Canoes were made from hollowed-out pine logs.

Acorns, pine nuts, and young shoots constituted a large portion of the available food for Achomawi peoples of the watershed. Large and small mammals were also an important source of food. Hunting strategies include bow and arrow, clubs, fire, atlatl, straps, and snares. Dead fall pits, used to hunt larger game such as deer, were placed along deer trails leading to watering holes. The many pits dug in the area of the river gave the Pit River its name. The practice was discouraged by European settlers as many cattle and settlers themselves fell into the pits. Large amounts of herbaceous plants were used as food (Blackburn and Anderson, 1993). In the spring, which was the most difficult time for native residents, grass seeds, bulbs, and shoots were the primary sources of food. Grasses, bulbs, and sprouts were most productive in the presence of reoccurring fire. The Achomawi are documented to have used fire for a variety of reasons, including improvement of basket materials, management of game, collection of edible insects, and to "manage" the ecosystems they inhabited (Blackburn and Anderson, 1993).

The Achomawi are also documented to have managed juniper forests and individual trees for the production of bow wood (Blackburn and Anderson, 1993).

Beckwith commented on the "superior bows of cedar" (probably the western juniper, *J. occidentalis*) he saw used by the Indians on the Pit River in northeastern California in 1854. Usually considered Achomawi territory, although the Indians insisted they were "Pah Utahs." Their pierced nasal septa, ornamented with bars of bone or shell suggest they were Achomawi (Steward and Wheeler-Voegelin 1974: 100 [repaginated]). In the Sacramento River drainage of northern California, western juniper was sometimes used for bows. Saxton Pope described bows as follows:

> It was a short, flat piece of mountain juniper (*J. occidentalis*) backed with sinew. The length was forty-two inches (107 cm). . . . It was broadest at the center of each limb, approximately two inches, and half an inch thick. . . . The wood was obtained by splitting a limb from a tree and utilizing the outer layers, including the sap wood. . . . Held in shape by cords and binding to another piece of wood, he let his bow season in a dark, dry place. Here it remained from a few months to years, according to his

needs. After being seasoned, he backed it with sinew. (Blackburn and Anderson, 1993)

Additional information on the use of fire and other management tools by Native Americans is discussed later in this section.

EARLY CONTACT

Trappers and early explorers of Spanish, Russian, and American descent were the first Europeans to enter the watershed. Peter Skend Ogden is reported to have been the first European. He is credited with naming the Pit River in approximately 1826. The first contact between native peoples and Europeans was documented happening in the 1820s as Hudson Bay Company trappers traveled down the Pit River from the north. It has been estimated that malaria, introduced by trappers, reduced the population of the Native people in the watershed by more than 75 percent between 1830 and 1833. A summary of key dates of early contact is included in Table 2-1.

Table 2-1
KEY DATES OF EARLY CONTACT

Date	Event
1820s	First contact between Native Americans and Europeans as Hudson Bay Company trappers traveled down the Pit River
1826	Peter Skend Ogden is first European to enter area; names Pit River
1830–1833	Malaria reduces population of native people by more than 75 percent
1843	Joseph Chiles party travels through area
1846	Scott-Applegate party passes through area
1848	Peter Lassen party moves through area
1854	Pacific Railroad explorations enter area
1857	Several wagon trails are established
1864	First permanent white settlement by James Townsend in Surprise Valley
1867	Town of Surprise Valley established
1874	Modoc County officially named
1880	Population of Modoc County reaches 4,400
1900–1910	First bank, school, and library built in Alturas
1904	Electricity arrives in area
1908	First railroad established
1910	Population of Modoc County reaches 6,200
1929	Pickering Lumber Company mill built in western Alturas

Source: University of Virginia, Geospatial and Statistical Data Center

During the 1840s, several overland parties traveled through the region. These included, among others, the Joseph Chiles party in 1843, the Scott-Applegate party in 1846, and the Peter Lassen party in 1848. The common routes of the trappers' early visits to the area are shown on Figure 2-1. During the 1850s, several groups traversed the area, including two Pacific Railroad explorations in 1854. By 1857, several wagon trails through the Pit River area had been established. Those trails are shown in Figure 2-1.

By 1864, the first permanent European settlement was established by James Townsend in Surprise Valley near what is now the area south of Cedarville. The town of Surprise Valley, later named

Cedarville, was established in 1867. In 1870, Presley, Carlos, and Jim Dorris settled the town of Dorris Bridge, later to become the City of Alturas. At about the same time, settlers established homes in the area of modern Adin.

Beginning in the 1850s, there was continually increasing hostility between the European settlers and Native American Indians. Over the years, many people of both groups were killed in skirmishes, raids, and battles. As settlers became more prominent in the area, they demanded that the Native Americans be removed from their homes and placed on the Klamath Reservation. This led to increasing hostility and the eventual breakout of the Modoc War on April 11, 1873. The Native Americans were defeated and sent to a reservation in Oklahoma.

Between 1850 and 1880, the boundaries of the northeastern California counties changed significantly, which hinders development of any historic consensus data. Figure 2-2 shows the differing location of the counties. Modoc County was officially made a county in 1874, and by 1880 there were about 4,400 people in Modoc County. The population tended to concentrate in Surprise Valley and along the Pit River. Surprise Valley was at this time the most populous area of the county. In addition to Alturas, several towns had been established, including Canby, Eagleville, Likely, Adin, Lake City, and Cedarville. Several mills were operating in the county. The predominant economic activity was agriculture, with the lumbering business also being considerable.

The period of 1880 to 1910 saw steady expansion of the population (by 1910 the population was about 6,200). The population concentrated in existing town areas. The exception was the High Grade mining district, which saw substantial expansion across the Warner Mountains at the north end of the county, but only for a brief period. During that decade (1900–1910), the first bank, school, and library were built in Alturas. The railroad arrived in 1908, four years after electricity.

Most logging and agricultural activities were localized in 1910. Many small sawmills were located on tributary creeks. Some exports occurred, but production was local-service oriented. World War I had a substantial effect on the local economy and population. Many people left the county and most of the small mills shut down. Following the end of the war, renewed economic activity occurred. Population increased to about 5,400 in 1920 and to 8,000 in 1930. New mills were being built, including the Pickering Lumber Company in western Alturas around 1925. At the time, the Pickering Mill was considered to be the largest of its kind in the world. However, the Great Depression had a substantial dampening effect on the local economy and the mill was never finished. As elsewhere, many businesses closed.

By 1940, economic recovery was taking place in Modoc County. There were nine active mills that produced over 107 million board feet of lumber in 1940. One-tenth of the county population (and one-third of all adult males) was employed in the lumber mills. Agriculture was the other major economic activity in the county. Agriculture was dominated by livestock productions including sheep, beef cattle, dairy cows, and horses. See more information under "Grazing" later in the section.

By 1940, only 42 percent of the population lived in rural areas. The increase of export economy caused more non-agricultural based residents to come to the county. Even the farming operations were changing from subsistence crops to income producing livestock and export crops. The remaining 58 percent of the population was, according to Robert Pease, classified in several ways:

> The rural market-service centers showed some decline in retail business districts, in part owing to the economic depression of the 1930s. In Cedarville and Adin, specialty stores were relinquishing their trade to establishments of the general merchandise type. Former hotels had either fallen into disuse or had been converted to residences. On the other hand, residential areas in Adin and Canby had expanded because of the presence of lumber mills nearby. In Adin, new residents bolstered the declining retail function somewhat, but Canby and Willow Ranch, both connected by surfaced road to nearby larger towns, benefited but little. . . .
>
> The company-owned lumber camps were all in upland areas, and with the exception of Big Lakes, were all located on the western edge of the Devils Garden. The largest, Tionesta, in 1940, was the second-largest town in the county, with more than 700 residents. . . . The other company lumber towns were Whitehorse, Long-Bell Camp Number 1, and Big Lakes, all in reality semi-permanent logging camps. Alturas had almost doubled in size between 1912 and 1940. Growth resulted because of the increasing functions of a county seat and the fact that the town was by far the best retail center in the county. Rate of growth had not been constant, however, for a decline occurred during World War I and again during the depression years of the 1930s, when many of the town residents went to the mill town to gain employment.
>
> Pavement of the major highways through the county had benefited Alturas in two ways. More retail trade was coming from outlying areas at the expense of the rural market centers, and the beginnings of regional highway traffic through the county permitted Alturas to cater to motorists passing through the volcanic lands. The town had continued to grow on the north side of the North Fork of the Pit River. Main Street was now a part of the U.S. Highway 395, and new stores and service stations were located on this regional thoroughfare north of the old business district. Residential subdivisions had spread westward toward the unfinished Pickering Mill, laid out with the hope that mill workers would build on the subdivided lots when the mill was completed. By 1940, only a scattering of houses had been built in the western subdivision, in contrast with the heavier density of residential areas near the old business district.
>
> In 1940, the town was described as containing 654 dwellings with no home worth more than $10,000.00, but with only 32 worth less than $1,000.00. There were more than 100 retail establishments and shops, adequate high schools and elementary schools, library, five churches, fraternal halls, theater, three hotels, county hospital, and various government offices. The town had a modern sewer system, waterworks, paved streets, and sidewalks. Gradual expansion of the population and the economy, plus the revival of the transit role in the economy by railroads and regional motorists, had made Alturas the most important town center in Modoc County. (Pease, 1965)

Although the lumber industry reached its peak in the 1940s, the county continued to grow through the 1950s. This growth was fueled in large part by the homesteading of World War II veterans in the Tulelake area. Since that time, the population has declined somewhat. The lumber industry has declined substantially, as has agriculture, but to a lesser extent.

HISTORY OF RESOURCE USE

Since human arrival in the area, the available resources of the area have been used to sustain the population. This section summarizes primary resources and management tools historically employed and attempts to present how these uses molded the ecosystems we see today.

Fire

Years of aggressive fire protection and timber management have dramatically changed the character of all of California's forest communities, including those of the Upper Pit River Watershed. Evidence suggests that pre-European forests were open, park-like pine and fir forests subject to frequent low-intensity fires. These forests consisted of large, mature individuals with only a grass understory. Undergrowth was minimal and consisted of small aggregations of individual regeneration. Frequent fires rejuvenated the meadow and riparian areas (Kozlowski and Ahlgren, 1974). The fires were low intensity, creeping fires that consumed only dead, down materials. Fast-moving crown fires, common today, rarely occurred. Only infrequently did fire consume mature individuals. See Section 11, "Fire and Fuel Management" for a more detailed discussion of the impact of fire on ecosystems.

Prior to suppression efforts in the twentieth century, lightning and native peoples ignited forests. Pre-settlement fire return intervals were generally less than 20 years throughout a broad zone extending from the foothills though the mixed conifer forests (McKelvey et al., 1996). There is evidence for almost every tribe in the western United States utilizing fire to modify their respective environments. It is now widely accepted that early Native Americans used fire extensively as a tool, both for hunting and managing the resources needed for survival (Blackburn and Anderson, 1993). This included burning grasslands to improve basket materials; foothills to assist in hunting small game; encouraging new edible shoots; and in coniferous forests to assist in hunting and keep the forests open and passable. In addition, use of seeding and oak management to augment food supplies is documented (Blackburn and Anderson, 1993). Within California, at least 35 tribes used fire to increase the yield of desired seeds, 33 used fire to drive game, and 22 groups used it to stimulate the growth of wild tobacco. Other reasons included making vegetable food available, facilitating the collection of seeds, improving visibility, and protection from snakes (Blackburn and Anderson, 1993). While the use of fire is noted for almost every Native American group in California, little is known about the timing or methods.

For example, the Wintu burned the valley and hill slopes to improve basket materials and habitat for deer and other animals. Fire was also used as a tool to move mammalian game and insects to be collected for food. Wintu collected grasshoppers "by burning off large grass patches" in chaparral, woodland grass, and coniferous forest areas similar to those inhabited by the Achomawi (DuBois, 1935). Unfortunately, neither the specific vegetational cover nor the time of year in which the burning took place is mentioned.

> The second method was used on the more open hills of the north side of the river, where the white oak grew. When the oak leaves began to fall, fires were set on the hills. Then they came down . . . in the late fall. . . . It was at this time they had the big drive, encircling the deer with fire (DuBois 1935).

Sources disagree as to whether the Achomawi preferred spring or fall burning, but they were reported to have burned in the spring to encourage sprouting species and prevent growth of dense underbrush (Kniffen, 1928). Karuk, Wintu, and Shasta peoples burned grass, brush, and riparian areas to improve basket-making raw materials. Hazel sticks were required for ribs for baskets with prime shoots being one to two years after fire (Blackburn and Anderson, 1993). Many tribes, especially in the fall, used fire to drive game. Deer were driven into snares or circled by fire and killed.

Local resource managers believe that Native Americans in the Warner Mountain likely used fall burning because spring conditions were often too variable. Blackburn and Anderson document general features of Native American patterns of burning. Fall, and secondarily spring, burning involved not simply an intensification of the natural pattern of fires but a pronounced departure from the seasonal distribution of natural fires. The pattern previously shown for the woodland, grassland, and coniferous forest involved the intensification of the natural pattern. Whether fall or spring burning, this idea implies that early Native American people played a fundamental role in the evolution of California's chaparral. Ethnographic data strongly indicate that such a pattern of environmental manipulation and control did exist. By creating and maintaining openings within the chaparral, Native Americans increased the overall resource potential of an area and created the enclosures, or "yarding areas," where these resources could be readily exploited.

In many cases, Native American groups that exploited woodland-grass and chaparral also hunted animals and collected plants within portions of the coniferous forest belt, particularly the ponderosa pine regions of the Sierra Nevada and the redwood-Douglas fir areas of the northern Coast Range. The evidence indicates that Native Americans had significant impact in the maintenance and evolution of vegetation types. Although ethnographic data is lacking, field studies in fire ecology show that frequent burns were common throughout the coniferous belt and foothills of the Sierra Nevada.

The ethnographic and field references to the time of burning indicates that Native American burning occurred in the coniferous forests during the late summer or early fall. Discussing the southern Maidu, in the foothills and mountains east of Marysville and Sacramento, Beals (1933) noted the overall effect of burning:

> The land was apparently burned over with considerable regularity, primarily for the purpose of driving game. As a result, there were few young trees and all informants were agreed that in the area of permanent settlement, even so far up in the mountains as Placerville, the timber stand was much lighter than at present. . . . The Indians insist that before the practice of burning was stopped by the whites, it was often a mile or more between trees on the ridges, although the canyons and damp spots held thickets of timber.

The Achomawi of the Pit River are suggested to have employed another common method of burning:

> The valley center of this area is of limited extent and is set off by steep walls. Winter brings heavy snows to the high flat above the river; the valley has rain rather than snow. . . . The heavy precipitation results in a dense and varied vegetation cover. With the pine and fire of the hills are the manzanita, dogwood, yew, ash,

> maple, and oak of the valley. What would have been a dense undergrowth was prevented by annual spring burnings following the retreating snow. (Kniffen 1928:313)

The area described by Kniffen (1928) is apparently in the lower regions of the Upper Pit River at an elevation of approximately 2,000–3,000 feet. It is a transition zone between brushlands and coniferous forests. There is a pattern of spring burnings, which tends to favor sprouting species over non-sprouting species accompanied by a reduction in brushy areas. However, other than having noted, "what would have been a dense undergrowth was prevented," no other description is given as to the species controlled with the spring burnings.

Historic pre-European forests in the vicinity of the Upper Pit River Watershed were not documented. Historical records from similar ecosystems allude to larger open stands of pine and fir with a short reoccurrence and common fire return interval. Most scientists agree that the vast ponderosa pine forests of the West evolved with frequent low-intensity ground fires. In some places, land that had as many as 30 or 40 large ponderosa pines scattered across an acre in the early 1900s, in grassy park-like stands, now have 1,000 to 2,000 smaller-diameter trees per acre (Trachtman, 2003). These fuel-dense forests are susceptible to destructive crown fires, which burn in the canopy and destroy most trees and seeds.

The decision to exclude fire from public lands came about as a result of a debate over whether to permit light fire, such as burnings by Native Americans, or use complete suppression. Logging and grazing interests held that light fires were beneficial because they reduced fuel loading and created more open forests. The U.S. Forest Service (USFS) excluded fire on national forests after the "Big Blow-Up" in 1910, a firestorm that "incinerated 3 million acres in Idaho and Montana" (Trachtman, 2003). The California Forestry Commission was created to hear disagreement on both sides of the argument. Finally, a study completed by Show and Kotok in 1923 reported that repeated burning maintained an open and park-like condition, but it killed young trees and discouraged regeneration of forests. The argument continued that if forests were to provide a sustainable timber supply, regeneration was required. In 1924, the Clarke-McNary Act was passed by Congress, which clearly established fire exclusion as national policy. Decades ago, Aldo Leopold (1950) warned that working to keep fire out of the forest would throw nature out of balance and have untoward consequences. "A measure of success in this is all well enough," he wrote in the late 1940s, "but too much safety seems to yield only danger in the long run."

Several large wildfires have occurred in the Upper Pit River Watershed in the last 90 years for which records were maintained. California Department of Forestry and Fire Protection (CDF) fire history records from 1910 indicate a total of 316 wildfires within the Upper Pit River Watershed. Of these fires, 178 have been in excess of 100 acres in size. In August 2001, the most recent wildfire, the Blue Fire burned 34,425 acres in the Modoc National Forest located in the northeast portion of the watershed. The largest fire of record is the Glass Mountain Fire of 1910 that burned a total of 107,912 acres within the watershed.

Historical fire acreage is included in Table 2-2 and major areas burned by decade are shown in Figure 2-3.

Table 2-2 HISTORICAL FIRE ACREAGE			
Date	**Fire Type**		**% Watershed Burned**
	VMP Acres	**Wildfire Acres**	
1910–1919		**119,153**	5
1920–1929		**19,823**	1
1930–1939		**17,304**	1
1940–1949		**18,950**	1
1950–1959		**55,915**	3
1960–1969		**7,609**	0
1970–1979		**107,905**	5
1980–1989	**1,523**	**18,619**	1
1990–1999*	**19,430**	**29,845**	21
2000–2001	(Pending)		
Total	**20,953**	**429,523**	**19%**

- Last complete year of records
- VMP – vegetation management program (CDF) or prescribed fire

Fire has significantly affected the landscape of rangelands in the watershed and all of California. The early Native Americans, sheepherders, and cattlemen used fire as a tool to manage natural landscapes. Many set fires behind them as they left the grazing lands in the fall. Ecologists disagree whether the fires were beneficial or damaging. They did open large areas of mountain and foothill communities for additional or transitional grazing (Menke et al., 1996). Since the fire suppression of the 1920s, most if not all of this original transitional range has been lost to over-dense brush or timber. Additional range was created only in response to wildfire (Menke et al., 1996).

Quantitative studies of the hydrologic responses of watersheds, where dense vegetative cover has been replaced with range and forage grasses, consistently show increases up to 50 percent or more (equivalent to 3 to 5 acre-inches per acre) in annual runoff over long periods of measurement (Burgy, n.d.). These runoff studies cover the variety of conditions found in Northern California. About half of the yield increase occurs in the latter portion of the season, giving usable flow in dry periods. The balance of the increase is produced as increased outflow during the post-storm periods (Burgy, n.d.).

Forests today have undergone significant changes in species composition and structure. They now contain multi-level stands with a ladder fuel structure. Fires that occur are carried into the tree crowns by the ladder fuels. Once in the tree crowns, the fires move quickly with greater intensity. Fires that do occur have become larger and more devastating.

Vegetation

The vegetation of the Upper Pit River Watershed has changed significantly since the arrival of the first European settlers including changes in species composition, diversity, and density. The vegetation we see today is very different from the "natural" communities that existed before the arrival of the settlers. The two primary forces that modified the natural vegetation in the watershed were the introduction of non-native species and the exclusion of naturally occurring and Native American-set fire in the ecosystem. Climate, grazing, timber management, and mining have also modified pre-European vegetation.

Beginning with seeds introduced during the Spaniard's establishment of the missions in Northern California and ending with the ornamental plants of the twentieth century, the natural ecosystem of vegetative communities were bombarded by competition from non-native plants. Non-native species adapted well to the climate of California since it resembles their native Mediterranean climates. Besides adapting well to the climate, these non-natives lacked the natural pests and diseases to control their growth and development. In addition, many have minimal compatibility to native wildlife.

Most of the weeds present in our ecosystem today were imported within the last 150 years. Common weeds should be differentiated from noxious weeds discussed later in this document. Noxious weeds are those that pose a serious commercial or ecological threat and whose control is regulated and watched with concern. These will be discussed in detail in the Section 7, "Botanical Resources." Common non-native weeds that can be found in the watershed are included as Table 2-3.

Reference characteristics for major vegetative communities found in the watershed are discussed below. Actual site-specific data was available through interviews, historical journals, and letters. Much of the description below has been interpreted from areas similar to the Pit River where historic community relationships have been documented.

Grasslands

Before 1769, only native deer, elk, and antelope grazed over grassland dominated by perennial species and best developed in the northern half of California. The character of the grassland was dramatically altered when European livestock entered Southern California in 1769 with the arrival of Spanish soldiers and the missionary Fathers. Cereals and fruits were soon imported and grown around the missions established along the coast. Other plants were also introduced some purposely and some accidentally. The accidents were the casual weeds transported in animal hair, packing materials, ship ballasts, or in soil surrounding fruit cuttings. Most of these weeds were annuals, and many were grasses: red brome *(Bromus madritensis* ssp. *rubens)*, downy chess *(Bromus tectorum),* False foxtail fescue *(Festuca myuros),* European foxtail *(Festuca bromoides),* foxtail fescue *(Festuca megalura),* hare barley *(Hordeum leporinum),* glaucous barley *(Hordeum glaucum),* nitgrass *(Gastridium ventricosum),* purple falsebrome *(Brachypodium distachyon),* and silver hairgrass *(Aira caryophyllea).* The early Spaniards may have directly imported seeds of wild oats *(Avena fatua),* slender wild oats *(Avena barbata),* annual ryegrass *(Lolium multiflorum)*, and perhaps even soft chess *(Bromus mollis)* and ripgut *(Bromus diandrus)* for all of these were proven excellent animal forage.

The important annual legume, Bur clover *(Medicago polymorpha)* and the filarees *(Erodium spp. E. botrys, E. obtusiplicatum, E. cicutarium,* and *E. moschatum),* were probably imported as proven and valuable sheep forage. Without a doubt, impurities, which were weedy species of far lower forage value, were carried in the imported seed. The forage and weedy annuals soon became well established in the mission areas and eventually spread inland as animal grazing areas advanced. Great herds of animals grazed around the missions and still greater numbers on the large ranchos.

Table 2-3 COMMON NON-NATIVE WEEDS	
Annual herb	
Summer pheasant's eye	*Adonis aestivalis*
Jointed goat grass, jointed goatgrass	*Aegilops cylindrica*
Barbed goatgrass, goatgrass	*Aegilops triuncialis*
Small alyssum, pale alyssum, sweet alyssum	*Alyssum alyssoides*
Desert alyssum, desert madwort	*Alyssum desertorum*
European alyssum, small-flowered alyssum	*Alyssum minus* ssp. *micranthum*
Tumbleweed, pigweed amaranth, tumbleweed	*Amaranthus albus*
Rough pigweed, green amaranth, red-root pigweed, red-rooted amaranth, redroot amaranth, rough pigweed	*Amaranthus retroflexus*
Low ragweed, annual ragweed, common ragweed	*Ambrosia artemisiifolia*
Giant ragweed	*Ambrosia trifida*
Mayweed, dog-fennel, mayweed, stinking chamomile	*Anthemis cotula*
Dense silky-bent, dense silkybent	*Apera interrupta*
Mouse ear, arabidopsis, mouse ear cress	*Arabidopsis thaliana*
Thyme-leaf sandwort, thyme-leaved sandwort	*Arenaria serpyllifolia* ssp. *serpyllifolia*
German-madwort, madwort	*Asperugo procumbens*
Two-scale saltbush	*Atriplex heterosperma*
Redscale, tumbling oracle, tumbling saltweed	*Atriplex rosea*
Common wild oats, wild oat	*Avena fatua*
Five-horn bassia, fivehook bassia	*Bassia hyssopifolia*
Common mustard, field mustard, rape mustard	*Brassica rapa*
Rattlesnake chess, rattlesnake brome	*Bromus briziformis*
Bromegrass, ripgut, ripgut brome, ripgut grass	*Bromus diandrus*
Soft brome, soft chess	*Bromus hordeaceus*
Downy-sheathed cheat, hairy chess, Japanese brome, Japanese chess	*Bromus japonicus*
Foxtail chess, foxtail brome, Madrid brome, Spanish brome, foxtail chess	*Bromus madritensis*
Foxtail chess	*Bromus madritensis* ssp. *madritensis*
Foxtail brome, foxtail chess, foxtail grass, foxtail, red brome	*Bromus madritensis* ssp. *rubens*
Chess, chess brome, rye brome	*Bromus secalinus*
Cheatgrass, downy brome, downy chess, downy brome, downy brome grass, cheatgrass	*Bromus tectorum*
False flax, little-podded falseflax, littleseed falseflax	*Camelina microcarpa*
Shepherd's-purse, shepherd's purse	*Capsella bursa-pastoris*
Mat sandbur	*Cenchrus longispinus*
Batchelor button, garden cornflower	*Centaurea cyanus*
Barnaby's thistle, yellow star thistle, yellow star-thistle, yellow-starthistle	*Centaurea solstitialis*
Large mouse ears, mouse-ear chickweed, mouse-eared chickweed, sticky chickweed	*Cerastium glomeratum*
Spotted spurge	*Chamaesyce maculata*
Common pineapple-weed, pineapple weed	*Chamomilla suaveolens*
Lambs-quarters, lamb's quarters, white goosefoot	*Chenopodium album*
Jerusalem oak, Jerusalem oak goosefoot, goosefoot	*Chenopodium botrys*
Blite goosefoot, strawberry blite	*Chenopodium capitatum*
Goosefoot, low goosefoot	*Chenopodium chenopodioides*
Leafy goosefoot, strawberry blite	*Chenopodium foliosum*
Oak-leaved goosefoot	*Chenopodium glaucum*

Table 2-3 (cont.) COMMON NON-NATIVE WEEDS	
Nettle-leaf goosefoot, nettle-leaved goosefoot, nettleleaf goosefoot, sowbane	*Chenopodium murale*
Tasmanian goosefoot, clammy goosefoot	*Chenopodium pumilio*
Crossflower	*Chorispora tenella*
Hare's ear mustard	*Conringia orientalis*
Wart-cress, lesser swine cress, lesser swinecress	*Coronopus didymus*
Hearded creeper, common crupina	*Crupina vulgaris*
Foxtail prickle grass, foxtail pricklegrass	*Crypsis alopecuroides*
Swamp Picklegrass, swamp grass, swamp pricklegrass	*Crypsis schoenoides*
African prickle grass, African pricklegrass	*Crypsis vaginiflora*
Jimson weed, jimsonweed	*Datura stramonium*
Flix weed, herb sophia	*Descurainia sophia*
Watergrass, barnyardgrass, barnyard grass, barnyardgrass	*Echinochloa crus-galli*
Rough barnyard grass, rough barnyardgrass	*Echinochloa muricata*
Asian waterwort	*Elatine ambigua*
Stinkgrass	*Eragrostis cilianensis*
Little lovegrass	*Eragrostis minor*
Coastal heron's Bill, redstem filaree, red-stemmed filaree, redstem filaree, redstem stork's bill	*Erodium cicutarium*
Treaclemustard, spreading wallflower	*Erysimum repandum*
Syrian mustard	*Euclidium syriacum*
Lamarck's bedstraw	*Galium divaricatum*
Small geranium, small-flowered geranium	*Geranium pusillum*
Halogeton, saltlover	*Halogeton glomeratus*
European heliotrope	*Heliotropium europaeum*
Jagged chickweed	*Holosteum umbellatum* ssp. *umbellatum*
Barley, Mediterranean barley	*Hordeum marinum* ssp. *gussoneanum*
Farmer's foxtail, foxtail barley, mouse barley	*Hordeum murinum*
Blue foxtail, foxtail, smooth barley	*Hordeum murinum* ssp. *glaucum*
Farmer's Foxtail, Foxtail, mouse barley, Hare barley, foxtail barley, leporinum barley	*Hordeum murinum* ssp. *leporinum*
Wall barley	*Hordeum murinum* ssp. *murinum*
Mexican-fireweed, summer-cypress, summercypress, common red sage	*Kochia scoparia*
Narrow-leaved wild-lettuce, willow lettuce, willowleaf lettuce	*Lactuca saligna*
Prickly wild lettuce, prickly lettuce	*Lactuca serriola*
Giraffe's head, henbit, dead-nettle, giraffe head, henbit deadnettle	*Lamium amplexicaule*
Purpleanther field pepperweed, variable-leaved pepper-grass, variable-leaved pepperwort	*Lepidium heterophyllum*
Klamath pepper-grass, shield cress, shield peppergrass, clasping pepperweed	*Lepidium perfoliatum*
Virginia pepperweed, wild pepper-grass	*Lepidium virginicum* var. *virginicum*
Common flax	*Linum usitatissimum*
Gromwell	*Lithospermum arvense*
Darnel, Darnel ryegrass	*Lolium temulentum*
Broad-leaved loosestrife, spatulaleaf loosestrife	*Lythrum portula*
Three-bracted loosestrife, threebract loosestrife	*Lythrum tribracteatum*
Cheeseweed, cheeseweed mallow	*Malva parviflora*
Indian chickweed, green carpetweed	*Mollugo verticillata*

Table 2-3 (cont.) COMMON NON-NATIVE WEEDS	
Changing forget-me-not, forget-me-not	*Myosotis discolor*
Small-flowered forget-me-not	*Myosotis micrantha*
Tobacco, many-flowered tobacco, manyflower tobacco	*Nicotiana acuminata* var. *multiflora*
Smooth witchgrass, fall panicgrass	*Panicum dichotomiflorum*
Bluegrass, annual blue grass, annual bluegrass	*Poa annua*
Four-leaved polycarp, four-leaved all-seed, four-leaved allseed, fourleaf manyseed	*Polycarpon tetraphyllum*
Black bindweed	*Polygonum convolvulus*
Lady's thumb, spotted ladysthumb	*Polygonum persicaria*
Bushy knotweed, yellow knotweed	*Polygonum ramosissimum*
Rabbit's foot, rabbitfoot grass, rabbitsfoot grass, annual beard grass, rabbitfootgrass, rabbitsfoot grass	*Polypogon monspeliensis*
Purslane, common purslane, little hogweed	*Portulaca oleracea*
Tubercled crowfoot	*Ranunculus testiculatus*
Russian thistle, Russian-thistle, Russian thistle, prickly Russian thistle, tumbleweed	*Salsola tragus*
Cereal rye, cereal rye, rye	*Secale cereale*
Tumble mustard, tumbling mustard, tall tumblemustard, tumble-mustard	*Sisymbrium altissimum*
Rocket, small tumbleweed mustard	*Sisymbrium loeselii*
Hedge mustard, hedgemustard	*Sisymbrium officinale*
Cutleaf nightshade, three-flowered nightshade	*Solanum triflorum*
Sow thistle, prickly sow thistle, prickly sow-thistle	*Sonchus asper* ssp. *asper*
Spurry, Starwort, corn spurrey, stickwort	*Spergula arvensis* ssp. *arvensis*
Chickweed, common chickweed	*Stellaria media*
Medusa-head, medusahead	*Taeniatherum caput-medusae*
Fan-weed, field pennycress	*Thlaspi arvense*
Puncture-vine, puncturevine	*Tribulus terrestris*
Shamrock clover, shamrock, suckling clover	*Trifolium dubium*
Wheat, common wheat	*Triticum aestivum*
Annual stinging nettle, dwarf nettle	*Urtica urens*
Cowherb, Spanish cockle, cow soapwort	*Vaccaria hispanica*
Speedwell, corn speedwell	*Veronica arvensis*
European foxtail fescue, Six-Weeks Fescue, brome fescue	*Vulpia bromoides*
Foxtail fescue, rat-tail fescue, rattail fescue	*Vulpia myuros*
Fox-tail fescue, foxtail fescue, rat-tail fescue, Zorro fescue, foxtail fescue, hairy rattail fescue	*Vulpia myuros* var. *hirsuta*
Annual herb, Vine	
Bur chevril, bur-chervil, burr chervil	*Anthriscus caucalis*
Hairy vetch	*Vicia villosa*
Wooly vetch, hairy vetch, winter vetch	*Vicia villosa* ssp. *villosa*
Annual herb, Vine (parasitic)	
Alfalfa dodder	*Cuscuta approximata*
Annual, Biennial herb	
White sweetclover	*Melilotus alba*
Yellow sweetclover	*Melilotus officinalis*
Cultivated radish, jointed charlock, wild radish	*Raphanus sativus*
Annual, Perennial herb	
Hiennial sagewort	*Artemisia biennis*
Featherleaf pepperweed, wayside pepper-grass	*Lepidium pinnatifidum*
Dwarf mallow, common mallow	*Malva neglecta*
Black medick	*Medicago lupulina*

Table 2-3 (cont.) **COMMON NON-NATIVE WEEDS**	
Dooryard knotweed, common knotweed, oval-leaf knotweed	*Polygonum arenastrum*
Purple sand spurry, ruby sandspurry, sand spurry, red sandspurry	*Spergularia rubra*
Northern wildrice, wild rice	*Zizania palustris* var. *interior*
Perennial herb	
Russian knapweed	*Acroptilon repens*
Desert crested wheatgrass, desert wheatgrass	*Agropyron desertorum*
Colonial bent, colonial bent, colonial bentgrass	*Agrostis capillaris*
Creeping bentgras, giant bentgrass, redtop	*Agrostis gigantea*
Creeping bent, redtop, creeping bent, creeping bentgrass	*Agrostis stolonifera*
Meadow foxtail	*Alopecurus pratensis*
Common burdock, lesser burdock, small burdock	*Arctium minus*
Tall oatgrass	*Arrhenatherum elatius*
Smooth brome	*Bromus inermis* ssp. *inermis*
Lens-podded hoary cress	*Cardaria chalepensis*
Hoary cress, heart-podded hoary-cress, hoary cress	*Cardaria draba*
Longstalk whitetop, white-top	*Cardaria pubescens*
Plumeless thistle, plumeless thistle, spiny plumeless thistle	*Carduus acanthoides*
Musk thistle, musk thistle, nodding plumeless thistle	*Carduus nutans*
Diffuse knapweed, white knapweed	*Centaurea diffusa*
Spotted knapweed	*Centaurea maculosa*
Spreading thistle	*Centaurea squarrosa*
Common mouse-eared chickweed, mouseear chickweed, big chickweed, common chickweed	*Cerastium fontanum* ssp. *vulgare*
Skeleton weed, hogbite, skeleton weed	*Chondrilla juncea*
Chicory	*Cichorium intybus*
Canada thistle	*Cirsium arvense*
Beaumont thistle, yellow-spined thistle, yellowspine thistle	*Cirsium ochrocentrum*
Wavy-leaved thistle, wavyleaf thistle	*Cirsium undulatum*
Bull thistle, bullthistle	*Cirsium vulgare*
Poison hemlock	*Conium maculatum*
Purple houndstongue, gypsyflower, hound's tongue	*Cynoglossum officinale*
Orchard grass, orchardgrass, orchard-grass, orchardgrass	*Dactylis glomerata*
Queen Anne's lace, wild carrot, carrot	*Daucus carota*
Fuller's teasel, Fullers' teasel, wild teasel	*Dipsacus fullonum*
Tall wheatgrass	*Elytrigia elongata*
Pubescent wheatgrass, intermediate wheatgrass	*Elytrigia intermedia* ssp. *intermedia*
Rush wheatgrass	*Elytrigia pontica* ssp. *pontica*
Quack grass, quackgrass	*Elytrigia repens*
Leafy spurge	*Euphorbia esula*
Alta fescue, reed fescue, tall fescue	*Festuca arundinacea*
Meadow fescue	*Festuca pratensis*
Hard fescue, rough-leaved fescue	*Festuca trachyphylla*
Great plains resinweed, curlycup gumweed	*Grindelia squarrosa* var. *serrulata*
Baby's breath	*Gypsophila paniculata* var. *paniculata*
Prairie sunflower	*Helianthus petiolaris* ssp. *petiolaris*
Mediterranean hoary-mustard, mustard, summer mustard, Wild mustard, short-podded mustard, shortpod mustard	*Hirschfeldia incana*
Velvet grass, velvetgrass, common velvetgrass	*Holcus lanatus*
Hops, common hop	*Humulus lupulus*

Table 2-3 (cont.) COMMON NON-NATIVE WEEDS	
Klamath weed, Klamathweed, common St. Johnswort	*Hypericum perforatum*
Lawn marsh-pennywort, lawn marshpennywort	*Hydrocotyle sibthorpioides*
Biennial wild-lettuce, tall blue lettuce	*Lactuca biennis*
Hawkbit, lesser hawkbit	*Leontodon taraxacoides*
Lesser hawkbit	*Leontodon taraxacoides* ssp. *taraxacoides*
Broad-leaved pepper-grass, broadleaved pepperweed	*Lepidium latifolium*
Oxe-eye daisy, oxeye daisy	*Leucanthemum vulgare*
Dalmatian toad-flax, toadflax	*Linaria genistifolia* ssp. *dalmatica*
English rye-grass, perennial ryegrass, perennial ryegrass	*Lolium perenne*
Bird's-foot-trefoil, broadleaf birdsfoot trefoil, bird's foot trefoil, bird's-foot trefoil, birdfoot deervetch	*Lotus corniculatus*
Common horehound, white horehound, horehound	*Marrubium vulgare*
Spearmint	*Mentha spicata* var. *spicata*
Yelloweye forgetmenot, forget-me-not, true forget-me-not	*Myosotis scorpioides*
Catnip	*Nepeta cataria*
American white waterlily, water-lily	*Nymphaea odorata*
Scottish thistle	*Onopordum acanthium* ssp. *acanthium*
Garden parsnip, wild parsnip	*Pastinaca sativa*
Common timothy, cultivated timothy, timothy	*Phleum pratense*
Husk tomato	*Physalis pubescens*
English plantain, narrow-leaved plantain, ribgrass, ribwort, narrowleaf plantain	*Plantago lanceolata*
Common plantain	*Plantago major*
Bulbous bluegrass, bulbous blue grass, bulbous bluegrass	*Poa bulbosa*
Canada bluegrass, Canada blue grass, Canada bluegrass	*Poa compressa*
Fowl bluegrass, fowl blue grass, fowl bluegrass	*Poa palustris*
Kentucky bluegrass, Kentucky blue grass, Kentucky bluegrass	*Poa pratensis*
Kentucky Bluegrass, Kentucky blue grass	*Poa pratensis* ssp. *pratensis*
Japanese knotweed	*Polygonum cuspidatum*
Beard grass, ditch beard grass, ditch rabbitsfoot grass	*Polypogon interruptus*
European alkali grass, weeping alkaligrass	*Puccinellia distans*
Crowfoot, creeping buttercup, creeping buttercup	*Ranunculus repens*
Austrian field cress, Austrian yellowcress	*Rorippa austriaca*
Common sheep sorrel, sheep sorrel	*Rumex acetosella*
Curly-leaved dock, rhubarb, curly dock	*Rumex crispus*
Mediterranean sage	*Salvia aethiopis*
Burnet, garden burnet, small burnet	*Sanguisorba minor* ssp. *muricata*
Soapwort, bouncing bet, bouncingbet	*Saponaria officinalis*
Late goldenrod	*Solidago altissima* var. *altissima*
Field sowthistle, perennial sow thistle	*Sonchus arvensis*
Common tansy, tansy	*Tanacetum vulgare*
Dandelion, common dandelion, red-seeded dandelion	*Taraxacum officinale*
Goat's beard, yellow salsify	*Tragopogon dubius*
Purple salsify, salsify	*Tragopogon porrifolius*
Jack-go-to-bed-at-noon, meadow salsify	*Tragopogon pratensis*
Strawberry clover	*Trifolium fragiferum*
Red clover	*Trifolium pratense*
White clover	*Trifolium repens*
North Africa grass, ventenata-grass	*Ventenata dubia*
Moth mullein	*Verbascum blattaria*
Woolly mullein, common mullein	*Verbascum thapsus*

Table 2-3 (cont.) **COMMON NON-NATIVE WEEDS**	
Water speedwell	*Veronica anagallis-aquatica*
Perennial herb, Vine	
Orchard morning-glory, bindweed, field bindweed	*Convolvulus arvensis*
Bird vetch	*Vicia cracca*
Perennial, Biennial herb	
Dyer's woad	*Isatis tinctoria*
Shrub	
Matrimony vine	*Lycium barbarum*
Shrub (stem succulent)	
Venus penstemon	*Penstemon venustus*
Cranberry	*Vaccinium macrocarpon*
Tree, Shrub	
Fourstamen tamarisk, smallflower tamarisk, tamarisk	*Tamarix parviflora*
Vine	
Angled pea, angled pea-vine	*Lathyrus angulatus*
Vine, Shrub	
Bittersweet, climbing nightshade	*Solanum dulcamara*

Many areas were overgrazed, which placed additional stress on native vegetation. The aggressive, well-adapted European annuals fared well and became dominant in many areas.

Cereal farming in the mid-1800s quickly removed additional native grassland. Later, more diversified and extensive agriculture removed still more native grassland. Improvement of the natural dry pastures in the last 50 years has introduced several high-yielding annual clovers *(Trifolium* spp*, T. hirtum, T. subterraneum*, and *T. incarnatum)* along with a perennial, Harding grass (*Phalaris tuberosa* var. *stenoptera*). Both types of plants originate in the Mediterranean region. The current management practices of the valley and foothill ranges favor development of the best resident annual forage grasses or recommend seeding superior forage species. It is unlikely that even remnant areas of the California grassland exist in the watershed. Some species such as prairie wedgegrass, pinegrass, Junegrass, small-flowered melic, and California oatgrass are still found in the more isolated regions and protected watersheds.

Sage/Foothill Communities

The size, density, and relative dominance of the individual species changed significantly. Stands are composed of smaller, denser trees. Brush species predominate in the understory and made passage difficult, if not impossible, throughout much of the area, affecting movement of both humans and animals. Dense monoculture stands of juniper replaced many areas once comprised of sage complexes.

As with the grassland community, the understory grasses of the sage and chaparral areas have been replaced by annual invaders. They have, in addition to suppressing fire, reduced the frequency and number of pine and oak regeneration.

Coniferous Forest

Coniferous forests in both the watershed and California have undergone significant changes in the last 100 years. While there are many factors that contributed to the change, the primary factor affecting the alteration in this community is likely the exclusion of fire. Climate, as well as resource management activities, also changed forest composition.

Historically, these forests consisted of large mature individuals with a grass and forbes understory. Undergrowth was minimal and consisted of small aggregations of individual regeneration. These forests were dominated by shade-intolerant species such as ponderosa pine, Jeffrey pine, and lodgepole pine. White fir, incense cedar, and Douglas fir were incidental codominants. Today's forests are dominated by shade-tolerant codominant trees and a dense understory of shade-tolerant species, with significant fuel loading and fire danger potential.

No detailed accounts of the early forests specific to the Upper Pit River Watershed were found. C. F. Cooper, John Muir, and others describe similar ponderosa pine forests and other coniferous forests in California in their literature. Excerpts from this literature follow.

Cooper described ponderosa pine forests of the Southwest:

> they used to be open, park-like forests arranged in a mosaic of discrete groups, each containing 10 to 30 trees of a common age. Small numbers of saplings were dispersed among the mature pines, and luxuriant grasses carpeted the forest floor. Fires, when they occurred, were easily controlled and seldom killed a whole stand. . . .
>
> Today, dense thickets of young trees have sprung up everywhere in the forests. The grass has been reduced, and dry branches and needles have accumulated to such an extent that any fire is likely to blow up into an inferno that will destroy everything in its path. . . .
>
> Lightening is frequent in the ponderosa pine region, and the Indians set many fires there. Tree rings show that the forests used to burn regularly at intervals of 3 to 10 years. The mosaic pattern of the forest has developed under the influence of recurrent lightening fires. Each even-aged group springs up in an opening left by the death of a predecessor. (Cooper, 1952)

Muir described a similar mosaic of open even-aged stands in the Sierra Nevada:

> The inviting openness of the Sierra woods is one of their most distinguishing characteristics. The trees of all the species stand more or less apart in groves, or in small irregular groups, enabling one to find a way nearly everywhere, along sunny colonnades and through openings that have a smooth, park-like surface. . . . (Muir, 1894)

Harold Biswell characterizes presettlement forests in the following way:

> California's primitive forests were kept open and park-like by frequent surface fires set by lightening and by the Indians. The forests were in a stable equilibrium, immune to extensive crown fires. (Biswell, 1968)

The Bitterroot National Forest provides the best pictorial description of 80 years of change in a ponderosa pine forest (see Fig. 7-5 in Section 7, "Botanical Resources"). Although located in

Montana, the forest type and species composition are extremely similar to the forests in the Upper Pit River Watershed.

Besides fire, livestock management and use played a key role in development of the ecological communities of today, especially in the area of the Warner Mountains. Although actual numbers of livestock in the Upper Pit River Watershed are poorly documented, extensive grazing by cattle and sheep is mentioned.

Grazing

Livestock production has been and continues to be a significant contributor to the economic stability of the Pit River region. Over 345,000 acres of the Upper Pit River Watershed is currently managed for the production of livestock as pasture and hay crops, summer range, or winter range. This includes both public and private lands. Historic sheep and cattle populations for Modoc and Lassen Counties are given in Tables 2-4 and 2-5, and in Figure 2-4.

Before 1700, the Spanish first introduced livestock into California. It is not known when the first livestock entered the Pit River drainage, but it is estimated to have been prior to 1840. However, not until the Modoc National Forest was established in 1903, livestock numbers in the area of the Pit River recorded. Until the Taylor Grazing Act of 1934, little attention was given to the carrying capacity of the watershed rangelands, public or private. Livestock numbers fluctuated significantly over time and the effect of grazing on the vegetative communities of the Upper Pit River Watershed responded to the appropriate pressures.

Prior to 1934, most livestock grazing in California was unregulated. Before the establishment of the Modoc National Forest and the Lassen National Forest, the entire Modoc Plateau was subject to intense transient grazing by cattle and sheep. The high sheep populations jeopardized the range allotments and the local livestock economy (Menke et al., 1996). Droughts from 1917 to 1935 and additional livestock grazing during the war years further exacerbated an already critical problem. The invasion of non-native species, especially cheatgrass, prevented the depleted native perennial grasslands from returning despite lower sheep populations.

From 1863 to 1864, severe droughts devastated California's livestock industry. Large numbers of animals died. Many were pushed into the higher elevations and less developed areas of the Modoc Plateau for forage. The most significant damage to native California perennials occurred from 1860 to 1870. Early in the history of the Upper Pit River Watershed, sheep co-dominated the available range. Historical accounts agree that the sheep grazing affected rangeland conditions much more so than cattle grazing. The greater impact appears to be due to a higher number of concentrated animals over a longer season. This was exacerbated by the sheepherders' burning practices that were more frequent and intense than those of Native Americans (Waggoner 1886). Because of the lack of early regulations and nomadic nature of early range users, the vegetation was overused and given little opportunity to recover. The individual sheepherder's herd management was reasonable. As each herd would move on, they would not return to the same grazing site for a suitable rest period. It appears that the combined effect of the unregulated number of herds created the overuse.

The sheep industry in California and in the Pit River drainage developed in two distinct periods. The first period is from 1848 to 1860. During this first phase, California herds were developed

Table 2-4
HISTORICAL SHEEP POPULATIONS:
UNITED STATES CENSUS OF AGRICULTURE,
1919–2001

Year	Lassen County	Modoc County
1919	60,220	109,630
1924	101,132	90,555
1925	75,528	80,565
1940	44,764	37,293
1945	27,024	11,981
1954	32,748	23,265
1959	27,831	26,110
1964	67,000	24,022
1965	16,000	21,200
1966	16,000	21,600
1967	24,200	24,200
1968	8,300	26,400
1969	7,700	25,400
1970	6,000	24,900
1971	4,800	18,200
1972	4,000	11,600
1973	3,500	8,600
1974	3,600	10,700
1975	2,600	11,100
1976	2,000	10,900
1977	1,800	10,000
1978	1,800	10,000
1979	1,700	18,000
1980	1,900	15,000
1981	2,500	17,000
1982	2,700	17,000
1983	2,700	13,400
1984	2,600	17,100
1985	2,500	12,500
1986	2,600	12,700
1987	2,500	14,700
1988	1,600	11,000
1989	3,100	8,000
1990	3,100	8,000
1991	2,700	9,000
1992	2,700	8,000
2000	4,000	4,000
2001	4,250	4,200

Table 2-5
HISTORICAL CATTLE POPULATIONS:
UNITED STATES CENSUS OF AGRICULTURE, 1925–2001

Year	Lassen County	Modoc County
1925	32,713	63,593
1940	38,191	59,137
1945	41,159	49,652
1950	37,850	67,100
1954	55,100	84,243
1959	57,355	84,119
1964	67,800	105,200
1965	73,300	118,400
1966	63,400	110,700
1967	57,600	105,200
1968	61,500	113,600
1969	56,800	105,500
1970	57,900	109,300
1971	57,000	104,200
1972	65,500	80,800
1973	54,400	93,000
1974	59,000	93,000
1975	57,500	93,000
1976	44,300	86,100
1977	46,500	89,500
1978	44,000	82,500
1979	50,000	80,600
1980	64,000	82,000
1981	72,000	89,000
1982	73,000	88,000
1983	73,000	90,000
1984	95,000	85,000
1985	97,000	78,000
1986	97,000	78,000
1987	97,000	70,000
1988	81,000	51,800
1989	100,000	57,000
1990	90,000	61,000
1991	80,000	65,000
1992	71,000	68,000
2000	22,400	29,500
2001	23,520	30,000

to feed the mining efforts of the Gold Rush and the growing municipalities in the Bay Area and Sacramento regions. The second phase occurred after 1860 and involved the growth and development of an internal California band. Beginning in 1860, drought and pressure from farming and other interests, including cattle, forced the sheep higher into the eastern mountains. At the time, most cattle, especially those associated with dairy efforts, pastured on lower-elevation, higher-quality ranges that were often fenced. Sheep dominated the other rangelands (Sudworth, 1900; Leiberg, 1902). Throughout the year, nomadic herders tended the sheep. During this time, there was no limit on how long the animals used the resources. Many attributed the reduction of native perennials and replacement by more aggressive annuals in upper elevation grassy meadows and hillside systems to this unregulated sheep grazing (Muir, 1894; Douglass and Bilbao, 1975; Rowley 1985; Beesly, 1996). John Muir coined the term "hoofed locusts," for sheep, due to their observed effects on Sierran uplands. Regardless of whether the contemporary observers were accurate or not in their assessment of the damage caused by sheep, their views shaped the future of range and forest policy.

As early as 1872, the areas around the Pit River were identified as prime grazing land for sheep. Sheep rancher Henry Compton is reported to have run over 6,000 head in Modoc County prior to the outbreak of the Modoc Indian wars. When notified of an impending attack by Indians, he removed his family back to Chico and later returned for his sheep. Limited data is available about the number of sheep that grazed the area; however Elder is reported to have had 50,000 head in Lake County that grazed "into California," and O'Keefe and others are reported to have had bands of 30,000 or more in the vicinity of the Lava Beds. In 1877, the Union Land and Cattle Company ranged over 45,000 sheep and 45,000 head of cattle in Washoe County and "into California." The largest increases in sheep in Modoc County were reported to have occurred following World War. I (Wentworth, 1948).

Between 1890 and 1920, cattle and sheep grazing reached a peak in Northern California. In the 15 years from 1880 to 1896, 20,000 to 80,000 head of sheep left California through the Gordon Trail, which extended from Red Bluff to north of Mt. Lassen, and north from Madeline Plains through the Upper Pit River Watershed, exiting California approximately 60 miles south of the Oregon border (Wentworth, 1948). As many as 6,000–18,000 head per drive used a "trail" 50 to 60 miles wide as required for forage. Between 1870 and 1900, sheep were exported by the thousands to the Midwest, Wyoming, and Idaho from California (Wentworth, 1948). Muir described the aftermath of sheep passage through Lassen:

> Incredible numbers of sheep are driven to the mountain pastures every summer, and their course is ever marked by desolation. Every wild botanic garden is trodden down, the shrubs are stripped of leaves as if devoured by locusts, and the woods are burned. Running fires are set everywhere, with a view to clearing the ground of prostrate trunks, to facilitate the movements of the flocks, and improve the pastures. The entire forest belt is thus swept and devastated from one extremity of the range to the other. . . . Indians burn off the underbrush in certain localities to facilitate deer hunting. Mountaineers carelessly allow their campfires to run, so do lumbermen, but the fires of the sheepmen or *Muttoneers*, form more than ninety percent of all destructive fires that range the Sierra Forests. (Muir, 1894)

The range report for the Sierra Nevada Ecosystem Project (SNEP) states that there is evidence that USFS personnel were aware of depleted and degenerating rangeland conditions. The following was excerpted from the SNEP Report: "The proper thing to do is to reduce the number of stock to meet forage conditions. This we have been planning to do for several years, but because. . . the precarious condition of all the stockmen concerned we feel that it is a most inopportune time to make reductions" (from the 1933 Annual Grazing Report, Modoc National Forest). A quote from the 1924 Annual Grazing Report for the Modoc National Forest states: "The meadows are too closely fed, there is not much reseeding on the range, and browse, especially in the southwestern portion of the allotment is becoming too closely fed, and some of it killed."

World War I demands for food and fiber caused use to increase from 1914 to the mid-1920s. Also during this time, grazing allotments were large with many being "community allotments" that had several permittees. This made monitoring of land use extremely difficult and resulted in increased use. During this time, the primary limitation to use was the lack of watering sources for stock; thus, areas close to water sources were depleted while remote areas were used less.

During World Wars I and II, livestock use increased dramatically on public lands (Menke et al., 1996). These increases caused overuse for the periods from 1914 to 1920 and from 1939 to 1946. In the period from 1914 to 1920, sheep use was elevated as a result of the demand for wool and mutton to supply the armed forces. In the later period, cattle demand increased. Early livestock use numbers are not available to match the geographic area of the Upper Pit River Watershed because all historical data is compiled by county.

The Warner Mountains are some of the most productive rangeland in the Modoc National Forest (Menke, et al., 1996). Because of the abundant water sources, the rangeland was used heavily by a greater number of the smaller livestock operations.

The passage of the Taylor Grazing Act in 1934, which required assessment and evaluation of range conditions, resulted in significant adjustments in grazing levels. Reports form the Modoc National Forest stated that "cattle were reduced by 39 percent and sheep 28 percent since 1934. . . . Seasonal adjustments account for 40 percent of the reductions with actual cuts in stock numbers accounting for the other 60 percent."

Gradually during this period, cattle began to replace sheep in many areas. The overuse of rangeland by cattle increased soil compaction and the effect of livestock on the riparian zones (Lux, 1995). Following 1930, the USFS adopted policies intended to balance range use and conditions. The policies included instituting term grazing privileges; limiting animals allowed under certain conditions; and closing some areas to grazing to allow recovery following the 1900s. During that time, the USFS also initiated predator control programs and poisonous plant reduction programs. The 1934 passage of the Taylor Act challenged the USFS control of watershed rangelands by creating a rival Grazing Service in the Department of the Interior. The competition between the two agencies forced the USFS to modify its practices to include longer lease periods and increase permit numbers. This resulted in increased use of rangelands following 1930 from the previous 20 years.

Stocking rates were increased somewhat during the period of 1939–1946 in response to the needs of World War II but in most cases were half of the 1920 stocking rates (Menke et al., 1996). During this period of time, economic reasons caused many allotments to be split into smaller units and numerous sheep allotments converted to cattle.

Many range improvements were implemented during the 1934–1944 period. One of the improvements included the addition of water sources for livestock to better disperse use. The addition of artificial water sources actually made additional upland areas suitable for grazing. In an effort to correct the overgrazing of the previous decade, the USFS conducted significant plantings and seedings. Unfortunately, little attention was given to the use of native seed so seed mixtures used for reseeding were largely exotic. The seed mix most commonly used included wheat grass, common timothy, and smooth brome. Eradication of willows and aspens to maximize forage production was also common (Menke et al., 1996).

During 1950–1970, permanent reductions in the number of livestock occurred on most allotments in the Modoc and Lassen National Forests. Records are not available for BLM lands. Seasons of use were also reduced during that time and uneconomical allotments were abandoned. Many of these were sheep allotments, because sheep were previously grazed on lands unsuitable for cattle grazing. Since 1970, public agencies have increased the use of monitoring on rangelands. This coupled with declines in prices for beef and lamb resulted in the reduction of grazing numbers. Also, USFS increased its focus on the rehabilitation of the riparian communities in allotment areas.

Three experimental stewardship organizations were authorized under the 1978 Public Rangeland Improvement Act. The Modoc/Washoe Experimental Stewardship Program, which includes portions of the Warner Mountains and land to the east, is one. The programs work on a consensus basis to find solutions to land management issues on BLM and USFS–managed lands in northeastern California and extreme northwest Nevada. This program has focused specifically on rangeland management issues. Members represent a wide range of interest groups, including grazing permit holders, environmental groups, recreation interests, state wildlife agencies, and local governments. The programs continue today and have accomplished significant improvements to range, forage, and watershed conditions through collaborative efforts.

Wildlife

Wildlife populations are particularly dependant on vegetation and habitat changes. Changes in vegetation described above have significantly effected wildlife populations in the Upper Pit River Watershed. The changing vegetation and ecosystem dynamics in the Upper Pit River Watershed resulted in changes in the wildlife populations (see Section 8, "Wildlife," for additional information).

The significance of the lower edges of the chaparral belt where woodland-oak forest and grasslands meet have been identified as areas of exceptional abundance for game animals during the early historical period of California.

> Prior to settlement, deer seem to have occurred principally along "edges" where forest and grassland met or on recent burns in the forest. Neither dense timber nor extensive prairie supported many deer. The woody shrubs and tree reproduction which constitute staple items of deer diet are characteristic of sub-climax ecological conditions (in other words, of early stages in a forest successional cycle), such as occur even today on prairie borders where woody plants encroach on the grass only to be pushed back periodically by drought or fire . . . the borders of the Sacramento Valley were maintained in young brush by recurrent fires, some of them probably set by Indians for the specific purpose of producing more game. (Leopold, 1950)

Studies in California wildlife management have shown the significance of various relationships between animal populations and environments subject to fire succession (Biswell and Gilman, 1961; Biswell et al., 1952; Komarek, 1963; Leopold, 1950). Depending upon local environmental factors and the conditions under which fire takes place, it has been shown that deer in recently burned-over cover show marked increases in numbers, size, and improvement of health:

> An area of prescribe-burned chamise and chaparral was compared with a similar unburned area as a control. Counts of deer in the burned area showed a summer population density of about 98 per square mile after the initial burning treatment. This rose to 131 in the second year, and dropped to 84 in the fifth and sixth years. In the dense, untreated brush the summer density was only 30 deer per square mile. Ovulation rate in adult deer was 175 percent in treated brush and only 82 percent in untreated brush. Deer weights were higher in prescribed-burned brush than in the untreated area. (Bidwell, 1967; Bidwell, 1961)

Small-game populations are similarly affected. Research in the chaparral regions (Biswell et al., 1952) has shown that valley quail are found in numbers two-and-a-half times greater in burned areas than in unburned areas, jackrabbits two to four-and-a-half times as great, with the number of doves simply noted as having increased.

Regulations that prohibit the hunting of mountain lions or trapping of coyotes will similarly effect on local deer and wildlife populations.

At the time of European settlement, large herds of tule elk (*Cervus elaphus*) and pronghorn (*Antilocapra Americana*) were documented in the interior valleys; mule deer (*Odocoileus hemionus*) dominated the foothills; and mountain sheep (*Ovis canadensis*) occupied the crest and western slopes. All four ungulates were hunted heavily by early European settlers, which greatly reduced populations. The settlers converted their prime habitats to use for domestic livestock. During the nineteenth and early twentieth centuries, fur trapping for beaver (*Castor canadensis*); mink (*Mustela vison*); otter (*Lutra canadensis*); red fox (*Vulpes vulpes*); marten (*Martes americana*); and fisher (*Martes pennanti*), and trapping and shooting wolverines (*Gulo gulo*) as vermin greatly reduced all of these species.

Both bighorn sheep and grizzly bear inhabited the watershed. The last California grizzly bear (*Ursus arctos*) identified with reasonable certainty was killed by cattleman Jesse B. Agnew near Horse Corral Meadow, Sequoia National Forest, in August 1922; identification by lower canine tooth was made by C. Hart Merriam (Storer and Tevis, 1955). Grizzly bears were well distributed in California at the time of Spanish settlement and recorded everywhere but for the Great Basin, deserts, and eastern Modoc Plateau. They were concentrated in the open country of the valleys and coastal plains, especially in the riparian zones. They appear to have been distributed throughout the range, selecting open country including montane meadows and the alpine zone during the snow-free months. Although largely herbivorous, grizzlies preyed upon cattle and other stock so settlers set out systematically to eradicate them. The closest surviving grizzly populations are in northeastern Washington and the northern Rocky Mountains.

Grazing affected species composition. In addition, the introduction of domestic livestock resulted in a reduction of native populations of certain wildlife such as the California bighorn sheep. Bighorn sheep, once common in the Warner Mountains and surrounding areas of the plateaus region, are all but extinct in the area. Originally hunted for food by early settlers, the sheep were essentially eliminated by contact with domestic sheep, which transmitted Pasteurella bacteria. The wild strains, much like Native American peoples, had no natural resistance to the bacteria and died by the hundreds. Although bighorn sheep have been reestablished twice in the Upper Pit River Watershed, epidemics of Pasteurella continue to hamper reintroduction efforts.

Ranching also resulted in the introduction of the feral horse. Now protected and managed by the BLM, many consider the horse a symbol of our American heritage. But to others, it is an uninvited guest robbing both domestic livestock and native populations of deer, elk, and antelope of forage and cover.

Native to eastern United States, Bullfrogs are now widely distributed in ponds and slow-moving streams in the watershed. Bullfrogs have almost completely replaced red-legged frogs and foothill yellow-legged frogs in many locations, and are a factor in the precipitous declines of the native Ranid frog species (Moyle, 1973; Hayes and Jennings, 1986). Bullfrogs also prey on young western pond turtles, where they may be a significant factor in the decline of this species, as well as on ducklings and other aquatic and riparian vertebrates.

Fisheries

Since the late 1800s, native fish populations in the West have been augmented with fish propagated in fish hatcheries. In order to accommodate the fishing needs of a growing human population and to lessen the impact of over harvesting, fish hatcheries plant millions of trout annually to provide for the demand of anglers and to maintain a balanced fish population (Leitritz, 1970).

Mules and wagons were the initial mode of transport for early settlers. Although the railroad allowed fish to be moved over large distances, transportation from train to the water was accomplished using mules and wagons. In 1907, the state of California bought and modified a car to function as a fish transport (Leitritz, 1970). As roads and cars became more abundant, wagons and the railroad became obsolete (Leitritz, 1970). Mules, however, remained a valuable means of transportation to reach remote areas, such as high mountain lakes that are inaccessible by road (Leitritz, 1970). In 1946, the airplane replaced mules after it was discovered that fingerlings could be dropped into lakes without apparent harm (Leitritz, 1970). Recent evidence however, has shown that fish dropped from planes are temporarily stunned or disorientated and without nearby cover, exposing them to predators (Chappell, 2003, pers. comm.).

Fish, other than trout, have been sporadically planted from hatcheries or transplanted legally and illegally from other streams, lakes, and reservoirs.

The number of fish planted in the Upper Pit River Watershed from 1930 to 2002 is given by species in Table 2-6. The data depicted in the two right-most columns of Table 2-6 were obtained from unpublished data in a California Department of Fish and Game (CDFG) stream surveys book that contained planting data for Modoc County from 1908 to 1913. Trout plantings by size class (i.e., catchable, subcatchable, fingerling, brood stock) in the Upper Pit River Watershed from 1930 to 2002 are shown in Figure 9-2. Table B-1 in Appendix B of Section 9, "Fisheries and Aquatic

Resources," provides a detailed summary of rainbow trout planting records by water body from 1930 to 2002.

Table 2-6
FISH PLANTED BY SPECIES AND SIZE IN THE UPPER PIT RIVER WATERSHED FOR 1908–2002 AND MODOC COUNTY FOR 1908–1913

Fish Species	Catchable	Sub-Catchable	Fingerling	Brood Stock	Cans (1908–1913)	# Fish (1908–1913)
Rainbow	2,211,346	474,087	5,893,818	10,413	21	196,500
Brook	606,503	502	3,597,471		3	71,500
Brown	147,549	26,013	2,407,423	198	2	40,000
Eagle Lake	775,626	44,588	1,038,775	199		
Lahontan Cutthroat	10,225		411,894			
Eagle Lake x Rainbow	16,840		3,888			
Silver Salmon	3,978	5,416				
Steelhead			100,000			
Arctic Grayling			13,100			
Bluegill	unknown					
Catfish	24,000					
Channel Catfish	15,365					
Redear Sunfish			107			
Sacramento Perch	346					
Largemouth Bass			1,070			
Spotted Bass	unknown					
Striped Bass						200

Within the watershed, the main arteries (i.e., North Fork of the Pit River, South Fork of the Pit River, and mainstem Pit River) have received minimal planting events throughout the twentieth century. The earliest records show that the South Fork of the Pit River received four cans with an unspecified number of rainbow trout in 1908, 6,000 brook trout in 1911, and the first planting of 12,500 brown trout in 1913. The North Fork of the Pit River received 200 yearling striped bass near Alturas in 1910 and 15,000 brown trout in 1937. The earliest planting records for the mainstem Pit River dated to 1951 when 24,000 catfish were planted near Bieber in Big Valley. In 1961, 5,005 channel catfish were planted near Canby in Warm Springs Valley, and 10,360 channel catfish were planted near Pittville in Fall River Valley and Bieber in 1968.

LAND MANAGEMENT

United States Forest Service (USFS)

The creation of the USFS established control over much of the land in the watershed. Congressional action in 1905 transferred the forest reserves to the Department of Agriculture under the direction of Gifford Pinchot. In 1907, these reserves were officially designated as national forests. Prior to 1940, most early activities were custodial in nature. Principal duties of these early resource managers were to establish accurate boundaries; prevent theft of timber and trespass; suppress fires; manage special use activities like mining and grazing; build ranger facilities; prepare and supervise limited timber sales; and build campgrounds. Until 1945 under Pinchot and other forest chiefs, balancing the stewardship of all resources was emphasized. The limited demand for timber from 1907 to 1920 plus the reduced demand for timber during the great depression (1929–1939), made the balance of use relatively easy to maintain (Ayers, 1958; Sedjo, 1991).

By 1945, the USFS had acknowledged that demands for fiber meant production of timber from national forests would have a predominant role. Wartime demand increased the requirement of the development of California timberlands and persisted through the 1970s. To meet these demands, both public and private forestry in the postwar period moved toward more "intensive timber management" practices. Timber supplied by the national forests in the West rose to almost one-third of the national supply (White, 1991). The largest increases occurred in the Pacific Northwest. However, the forests of Northern California and the Sierras were affected by the local market demands in California. Between 1940 and 1960, the timber harvest in California grew from 2 billion to 6 billion board feet. Growing concern about the lack of a multiple use approach and threat of nonsustainable harvesting resulted in the passage of the Multiple Use Sustained Yield Act of 1960. Emphasis was placed on preservation of wilderness areas and wildlife habitat.

State of California

Between 1905 and 1919, the State of California established a second state board of forestry. The first had failed to address many of the early issues facing California timber and rangelands. The second board of forestry again attempted to address issues of fire control, reforestation of cutover lands, and protection of state-held lands. In 1911, a state conservation commission was established. The primary goal of the commission was to address issues associated with water conservation and hydroelectric power development. During the period from 1911 to 1935, the development of power was an issue critical to the successful development of California suburban centers, and much of the emphasis targeted at the large river systems. In 1927, Governor Young created the Department of Natural Resources, which placed the jurisdiction of forest and rangelands under a single state agency. In 1929, the Division of Water Resources (forerunner of the Department of Water Resources) was established within the California Department of Public Works. Until 1945, four goals dominated resource issues in the state:

- Provide sufficient funding to suppress fire
- Gain control of logged-over parcels
- Reforest cutover lands
- Survey and develop water for irrigation and domestic use

WATER RESOURCES

Initial settlers to the Upper Pit River Watershed developed numerous small reservoirs to retain the highly variable precipitation for domestic stock and farming uses. The initial reservoirs were constructed in the late 1800s. Located on the current Hagge Ranch, the oldest recorded dam/reservoir was constructed in 1880. The four largest reservoirs in the watershed, which account for over 80 percent of the stored water, are Big Sage, Tulelake, West Valley, and Dorris. They were constructed in 1921, 1904, 1936, and 1930, respectively. Roberts Reservoir was constructed in 1905. Numerous diversions were established on the many perennial streams leaving the Warner Mountains and other mountains of the area. The adjudications for many of these diversions were not competed until the mid-1950s. Major diversions include:

- South Fork of the Pit River — 1954 (West Valley)
- North Fork of the Pit River — 1939 (Dorris)
- Rattlesnake — 1934 (Big Sage)
- Ash Creek — 1947
- Pit River — 1959 (Roberts)

While small irrigation concerns continued to exert influence on water policy and protection of watersheds in the early century, the impoundment of water for large-scale irrigation, hydroelectric power generation, and urban use emerged as a primary concern. During the Great Depression, the federal Bureau of Reclamation took control of the state proposed Central Valley Project. The project construction began in 1930. However, the majority of the dams and aquaducts, constituting most of project, were not completed until the mid-1950s, including the main storage structure for the project, Shasta Dam, which was completed in 1945.

A detailed discussion and summary of diversions in the watershed is included in Section 5, "Hydrology."

DEMOGRAPHICS

Early population numbers for the Upper Pit River Watershed are all but impossible to assemble, due to the many changes of county boundaries of Northern California. County boundaries were not delineated formally until after 1870. Early boundary changes are shown in Figure 2-2 and a summary of settlements and their respective dates of establishment are summarized by original name in Table 2-7.

Table 2-7
FOUNDING DATES OF MAJOR SETTLEMENTS

Town/Settlement	Date Founded	Comments
Surprise Valley	1867	First permanent white settlement established in Modoc County by James Townsend.
Dorris Bridge	1870	Founded by Dorris family. Later renamed Alturas.
Warm Springs Valley	1869	Founded by Hess family. Later renamed Canby in 1874.
Likely	1878	Small farming community north of Modoc-Lassen County lines.
Adin		Small town in the Big Valley vicinity.
Lookout		Site of the famous Lookout Lynching.
Fall City	1871	Founded by Capt. William Henry Winter. Later renamed Fall River Mills in 1888–89. Although not the first settlement to be established in the Fall River Valley, the town grew in the 1870s and 1880s to become the principal industrial and agricultural center of eastern Shasta County. By 1886, Fall City consisted of two hotels, a blacksmith and wagon shop, two livery stables, three stores, two saloons, a harness shop, a boot and shoe shop, a millinery, Winter's flour mill, Florins Bros.' wooden-ware and sash and door factory, and was home to 300 people.
Deep Creek	1864	Later renamed Cedarville.
Source: Modoc County Historical Society		

The demographics of the watershed have changed over time with the movement of people and consolidation of industrial centers in the valley area close to transportation corridors of railroads, highways, and waterways. Population estimates for county areas are given in Table 2-8 and presented graphically in Figure 2-5.

Table 2-8
DECENNIAL CENSUS DATA

Decade	Population (by County)			
	Lassen	Modoc	Shasta	Siskiyou
1850	---	---	378	---
1860	---	---	4,351	7,620
1870	1,327	---	4,173	6,848
1880	3,340	4,399	9,492	8,610
1890	4,239	4,986	12,133	12,163
1900	4,511	5,076	17,318	16,962
1910	4,802	6,191	18,920	18,801
1920	8,507	5,425	13,361	18,545
1930	12,589	8,038	13,927	25,480
1940	14,479	8,713	28,800	28,598
1950	18,474	9,678	36,413	30,733
1960	13,597	8,308	59,468	32,885
1970	16,796	7,469	77,640	33,225
1980	21,661	8,610	115,613	39,732
1990	27,598	9,678	147,036	43,531
2000	33,828	9,449	163,256	44,301

INTERVIEWS: LOCAL VIEWS OF RESOURCE USE HISTORY

The history and issues presented below have been compiled from interviews held with people who have lived in the watershed from 50 to 80 years. Interviews were conducted with: Jackie McGarva, South Fork region; Casey Kearny, South Fork region; Bill Flournoy, South Fork region; John Flournoy, South Fork region, Jerry Hoxsey, North Fork region; Albert Albaugh, McArthur region; Bill Joiner, Lookout region; Dean Leventon, Lookout region; and Bob Shaw, Lookout region. Comments expressed and documented from these resident interviews are personal observations and may not be supported by scientific research. Over the years, irrigated land use has replaced dry land management in conjunction with increased residential use properties and woody vegetation. According to these long time residents, land use changes (i.e., cropland to grazing or vise versa) and the increased woody vegetation are believed to be the largest contributors to current water shortages in the Upper Pit River Watershed.

Land Use

Large family holdings have diminished in size over the years as corporate farms buy property or property is divided into rural residential ranchettes. Agricultural land use has also shifted from dry land crops and pasture to irrigated crops and pasture. Increased irrigation demands have contributed to the diminished water supply in the Upper Pit River Watershed.

Farmers and ranchers began to settle in the South Fork region of the Upper Pit River Watershed in the 1870s. In 1873, the Flournoy family settled in the Likely area and currently retains ownership of the 20,000-acre ranch (B. Flournoy, 2003, pers. comm.). Ranches in the South Fork Valley have historically functioned as cow-calf operations with some hay production for winter-feed. Family-operated cow-calf ranches have diminished in size and numbers over the years as absentee landowners continue to buy more property (McGarva, 2003, pers. comm.). At this time there are only two large family-operated ranches left in the South Fork Valley, with the rest of the land having been broken into smaller holdings or bought by absentee landowners (McGarva, 2003, pers. comm.). The landowner with the largest amount of property in the South Fork Valley is currently Alturas Ranches, which primarily produces irrigated crops including alfalfa, wild rice and grass hay (McGarva, 2003, pers. comm.). Generally, the land use in the area has changed from grazing pasture to irrigated crops with absentee land ownership.

Farmers and ranchers settled the McArthur region of the Upper Pit River Watershed area in the 1870s. The Albaugh property, originally purchased or homesteaded sometime in the late 1800s, has been irrigated by the Pit River since 1871 (Albaugh, 2003, pers. comm.). Property owners in the area primarily ran cow-calf operations but gradually switched to irrigated crops and nursery products starting in the late 1960s. As residential land use increases in conjunction with irrigated crop production, grazing land available for cattle has diminished. The rapid increase of irrigated crops and residential use properties in the McArthur region of the Upper Pit River Watershed area has also created an increased demand for water.

Farmers and ranchers began to settle in the Lookout region of the Upper Pit River Watershed in the late 1800s. Farmers and ranchers in this area focused on raising and training horses from the late 1800s through to the early 1900s (Shaw, 2003, pers. comm.). Gradually the cattle industry became the primary agricultural focus until technology allowed water usage in areas previously not suited to flood irrigation. Sprinkler systems have enabled landowners to grow more irrigated crops, decreasing the amount of land available for grazing pasture (Leventon, 2003, pers. comm.). The increase in irrigated croplands has created a higher demand for water in turn creating a diminished water supply in the Lookout region of the watershed.

Fire

Decades of fire suppression have allowed vegetation to become an extreme fire hazard and a large draw on the water supply in the Upper Pit River Watershed. The settlers of the area used to burn brush and deadfall piles and grain stubble. The settlers did not use fire to clear the land, but fires set by lightning were allowed to burn. Government agencies spent many years suppressing fires instead of managing them that fuels have built to dangerous levels (Leventon, 2003, pers. comm.). When fires were allowed to burn naturally, they rarely reached the crown level of wooded areas and served to clear brush and rejuvenate grasslands. The USFS and BLM perform controlled burns intermittently in an attempt to reduce fire fuels, but the attempts are not very successful (Shaw, 2003, pers. comm.). The increased vegetative fire fuels also capture and use the water that would normally enter the watershed system.

Vegetation

An increase in both irrigated cropland and woody vegetation has escalated water demand while reducing water availability in the Upper Pit River Watershed. The valley lands were predominantly devoted to grazing pasture with some cereal grain and hay production. Over the years, additional land has been devoted to irrigated crop production, decreasing available grazing land and increasing water consumption (McGarva, 2003, pers. comm.; J. Flournoy, 2003, pers. comm.). Rangeland vegetation has increased dramatically in the last 90 years, visible in the photographs obtained from the McGarva family (Figures 2-6 and 2-7). Fire suppression, restricted grazing, and limited timber harvest have contributed to the increased woody vegetation on the rangeland (McGarva, 2003, pers. comm.; J. Flournoy, 2003, pers. comm.). The most detrimental woody vegetative species on the rangelands are the rapidly encroaching juniper trees, because a 30-year-old juniper tree consumes 50 gallons of water in one day when the water is available (J. Flournoy, 2003, pers. comm.).

Grazing

Properly managed grazing benefits rangelands by consuming and knocking down grasses and young brush species thereby reducing fire fuels. Livestock and other cloven-hoofed animals are primary contributors to the reseeding of grasses, which allows properly managed grazing to be a factor in grassland health (J. Flournoy, 2003, pers. comm.). Poorly managed grazing contributes to undesirable weed growth, as livestock will overgraze desirable plants eliminating the competition for the ignored undesirable species (McGarva, 2003, pers. comm.). Livestock transport from one geographic region to another is also a major source of the weeds spreading into the Upper Pit River Watershed area (McGarva, 2003, pers. comm.).

Wildlife

Wildlife populations have changed to reflect current land use and wildlife regulations. In the early 1900s, there were no deer or antelope in the Upper Pit River Watershed area, but by the 1940s there were big herds of deer and antelope in the area (McGarva, 2003, pers. comm.; Shaw, 2003 pers. comm.). Some residents believe the deer herds are much smaller due to predation by an uncontrolled mountain lion population (McGarva, 2003, pers. comm.). The deer seem to congregate in the valley areas away from the mountain lions. The antelope seem to congregate in the valley areas as well, feeding on alfalfa fields as shown in Figure 2-8. Since the alfalfa fields have replaced the dryer sagebrush kidding grounds, antelope herds seem to be developing disabling hoof rot due to the wetter conditions (McGarva, 2003, pers. comm.). Elk, permanently migrating into the area from the north, are increasing in the Warner Mountains and creating problems for livestock owners with permits to graze in the Warner Mountains. The elk are grazing the area down to or beyond the level at which ranchers are supposed to pull livestock off of the permitted land before the livestock are ever put on to the rangeland (B. Flournoy, 2003, pers. comm.).

Pheasant populations have severely decreased over the years as alfalfa crops replace grain crops (B. Flournoy, 2003, pers. comm.). The skunks, raccoons, and coyotes are contributing to the decline of bird populations in the Upper Pit River Watershed area (B. Flournoy, 2003, pers. comm.). The coyotes are also preying on livestock and the ranchers have lost the ability to control the coyote population with the use of poisons and traps (J. Flournoy, 2003, pers. comm.).

Fisheries

Naturally occurring fish populations have changed over time due to the introduction of non-native species and the decreased water availability. The South Fork Valley was originally a swamp until the current irrigation and drainage system was created. In the water system of the South Fork Valley, there used to be a large population of catfish and bullfrogs until a population of crayfish were introduced to the system (McGarva, 2003, pers. comm.). Mr. Flournoy stated, "Trout used to be found in East Creek, however drought conditions have almost destroyed the fish in that creek (B. Flournoy, 2003, pers. comm.)."

In the McArthur area, the Pit River used to be fished for mudcats, perch, and bass (Albaugh, 2003, pers. comm.). It is believed that 30 or 40 years ago a population of channel cats were introduced into the Pit River and since then the mudcat and perch populations have diminished (Shaw, 2003, pers. comm.). The fish most often caught out of the Pit River in the McArthur area are channel cats. Some trout are found in Horse Creek, since the Pit River tends to be too muddy for the trout (Albaugh, 2003, pers. comm.).

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Section 3

Section 3
LAND USE AND DEMOGRAPHICS

TABLES

FIGURES

Section 3
LAND USE AND DEMOGRAPHICS

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This section will discuss the predominant land uses and the laws regulating those uses in the watershed.

LAND OWNERSHIP

Land use in the Upper Pit River Watershed is heavily influenced by ownership. While private individuals who use these areas for agriculture (ranching and farming) and residential uses hold most of the low- and mid-elevation lands, the upper elevations are held by commercial timber companies and the U.S. Forest Service (USFS) or the Bureau of Land Management (BLM).

Historical

County boundaries fluctuated during the last half of the nineteenth century. Variations in county boundaries in the Upper Pit River Watershed are shown in Figure 3-1. Siskiyou County was established in 1852, Lassen County in 1864, Modoc County in 1874, and Shasta County in 1850, with Yreka, Susanville, Alturas, and Redding serving as their respective county seats. Both Lassen and Tehama Counties were formerly part of Shasta County.

The first Euro-American settlers came to Surprise Valley in 1846, and by 1871 most areas in the watershed were settled. Most of the original land grants were made in the last half of the nineteenth century through the Homestead Act of 1862 to help populate the western territories.

Cattle ranchers and Basque sheepherders, like the original Native Americans, modified the landscape of the watershed to meet their needs. Ranchers raised hay in the fertile valleys and grazed cattle on the high mountain meadows and the vast Devil's Garden in the summer. Homesteaders used lumber cut from timber tracts by numerous small family-run sawmills. Around the turn of the century, sheep became the largest constituent of livestock in the area. Overgrazing prompted settlers to petition the U.S. government to create the Warner Mountain and Modoc Forest Reserves in 1904, which later became the Modoc National Forest in 1908. See Section 2, "General Watershed History," for a more detailed history of land ownership and use.

Current

Current ownership within the watershed is shown in Figure 3-2. Land ownership in the Upper Pit River Watershed is approximately 60 percent public and 40 percent private. The number of acres in each ownership classification is shown in Table 3-1.

Table 3-1
LAND OWNERSHIP ACREAGE BY LAND AREA
IN THE UPPER PIT RIVER WATERSHED STUDY AREA

Ownership	Total Acres	Percent
Bureau of Land Management	338,819.18	16
U.S. Fish and Wildlife Service	7,581.54	0
USFS	983,982.84	45
Subtotal Federal Acres	1,330,383.56	61
Department of Fish and Game	17,111.24	1
Department of Parks and Recreation	4,309.40	0
State Lands Commission	6,019.76	0
Subtotal State Acres	27,440.40	1
Tribal Ownership	10,492.77	0
Subtotal Tribal Acres	10,492.77	0
Unclassified Private Ownership	580,269.27	27
Industrial Timber Companies	236,91749	11
Subtotal Other Acres	817,186.76	38
Total	**2,185,503.49**	**100%**

Public Lands

The USFS, the Bureau of Land Management, U.S. Fish and Wildlife Service, and the California Department of Fish and Game hold approximately 56 percent of the watershed. The federal Bureau of Indian Affairs and State Lands Commission also own small portions of the watershed. One national wildlife refuge (Modoc) is located in the northern watershed, and another state-owned wildlife area (Ash Creek) is located in the middle portion of the watershed. An additional reserve owned by the state, Ahjumawi Lava Springs State Park, is located in the southwest portion of the watershed.

Land management activities on public lands have traditionally focused on timber management, livestock grazing, mining, and management of lands for production of water. In recent years, the various land management plans for these public agencies have de-emphasized timber and livestock production and focused more closely on watershed management and preservation of wildlife habitats. This "ecosystem approach" to management has significantly reduced the amounts of timber harvested from these public lands, increased scrutiny on livestock grazing, and put more emphasis on research and development of conservation techniques.

Resource management on public lands is generally designed to:

- Improve rangeland conditions, with permitted grazing and forage capacity in balance

- Provide timberlands with a diversity of age and size classes

- Provide a full range of recreation opportunities, ranging from primitive to modern recreation settings

- Improve water quality and riparian areas

- Increase populations of threatened and endangered species, snag dependent species, and early successional wildlife, and improved fisheries production

While at the same time

- Protect significant cultural resources
- Provide mineral and energy resources development
- Continue to offer firewood commensurate with public demand
- Maintain soil productivity
- Ensure scenic attractiveness from major public use areas
- Continue wetland development
- Maintain viable populations of all native and non-native desirable vertebrate species

Private Lands

The primary land users on private property, excluding urban areas, are those associated with timber production, recreation, and agriculture (ranching, hay/alfalfa, and wild rice). The passage of the California Land Conservation Act of 1965, commonly known as the Williamson Act, enables local governments to enter into 10-year contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. In exchange, landowners receive lower property tax assessments, based upon farming and open space uses rather than current market value. The local government receives the lost property tax revenues from the state via the Open Space Subvention Act of 1971.

Lassen, Shasta, and Siskiyou Counties recognize Williamson Act lands, with Modoc County recently implementing the program in 2002. The majority of the land held by the Act within the Upper Pit River Watershed is considered grazing land, and while the per acre production potential of these lands is not as high as irrigated areas; they support a valuable economic resource. The sale of cattle and calves rank third among dollar values for all California agricultural commodities (CFB, 2002).

Land use has changed little in the watershed during the last 68 years. In 1938, agricultural and irrigated lands totaled 19,493 acres. In 2000, the USFS conducted a survey of vegetation types in the watershed and found agricultural and irrigated lands totaled 17,431 acres.

Large timberland owners and several hundred private ranches own approximately 40 percent of the watershed. The nontimber uses of these lands vary from commercial and residential to agriculture and grazing. Although individuals hold these properties, the counties, by means of the boards of supervisors and county general plans, oversee development and use.

For a complete and definitive overview of private land uses, detailed objectives, and specific land use designations in the Upper Pit River Watershed, refer to the representative county general plan.

SUBDIVISIONS

County Boundaries

The Upper Pit River Watershed is spread across four counties, including Modoc, Lassen, Siskiyou, and Shasta. Current county boundaries are shown in Figure 3-3.

Legislative Boundaries

The Upper Pit River Watershed is divided into two congressional districts paralleling the north-south borders of Siskiyou and Shasta Counties from Modoc and Lassen Counties. District 04 includes Modoc and Lassen Counties, and District 02 includes Shasta and Siskiyou Counties (CVF, 2002). Watershed congressional district boundaries are shown on Figure 3-4.

The watershed includes two assembly districts. Modoc, Siskiyou, and Shasta Counties fall within District 2 and Lassen County is in District 3. Assembly district boundaries are shown on Figure 3-5.

RCD Boundaries

There are six resource conservation districts (RCDs) located in the Upper Pit River Watershed. They are the Lava Beds/Butte Valley, Pit, Central Modoc, Honey Lake, Goose Lake, and Fall River RCDs. RCD locations and boundaries are shown in Figure 3-6.

Irrigation District Boundaries

There are two active and two inactive agricultural water purveyors located in the watershed. These suppliers include

- Big Valley Irrigation District (inactive)
- Fall River Valley Irrigation District (inactive)
- Hot Springs Valley Irrigation District
- South Fork Irrigation District

Active district boundaries are shown in Figure 7. These districts are discussed in more detail in Section 5, "Hydrology."

Other Districts

The Lassen Modoc Flood District was established to manage the proposed Allen Camp Dam. This district has continued even though the dam has not been constructed. Currently the District manages the storage, control, and distribution of water in parts of the watershed.

LAND USE

Land use in the watershed is mixed. This section will discuss the various land uses in the watershed, providing a brief overview of public and commercial forestlands, and private lands.

Grazing

Private ranches make up a large percentage of the privately owned land used for agriculture. According to the California Department of Conservation, grazing land made up approximately 66 percent of the total privately held acreage within the watershed. In 2001, livestock profits were two of the top five grossing crops in the Upper Pit River Watershed. According to the California Farm Bureau, profits totaling over $18.1 million were reported.

History

The Spanish first introduced livestock into California prior to 1700. It is not known when the first livestock entered the Pit River drainage, but it is estimated to have been prior to 1840 (Blackburn and Anderson, 1993). However, not until the Modoc National Forest was established in 1903, were livestock numbers in the area of the Pit River recorded. Until the Taylor Grazing Act of 1934, little attention was paid to the carrying capacity of the watershed rangelands, public or private. Livestock numbers fluctuated significantly over time and the effect of grazing on the vegetative communities of the Upper Pit River Watershed responded to the appropriate pressures.

Prior to 1934, most livestock grazing in California was unregulated. Before the establishment of the Modoc National Forest and of the Lassen National Forest in 1916, the entire Modoc Plateau was subject to intense transient grazing by cattle and sheep. The use increased to the point of jeopardizing local range allotments in the local livestock economy (Menke, 1996). The droughts from 1917 to 1935 and additional livestock during the war years exacerbated an already critical problem. During World Wars I and II, livestock use increased dramatically on public lands (Menke, 1996). These increases caused overuse for the periods from 1914 to 1920 and from 1939 to 1946. From 1914 to 1920, sheep use was higher due to the demand for wool and mutton to supply the armed forces. In the later period, cattle demand increased. It is not possible to separate the livestock use number from early data to match the geographic area of the Upper Pit River Watershed because this historical data is compiled by county.

Stocking rates were increased somewhat during the period of 1939–1946 in response to the needs of World War II, but in most cases were half of stocking rates (Menke, 1996). During the latter period of time many allotments were split into smaller units and numerous sheep allotments were converted to cattle allotments due to economic reasons.

Many range improvements were implemented during the 1939–1944 period. These included the addition of water sources for livestock to better disperse use. The addition of artificial water sources actually made additional upland areas suitable for grazing. In an effort to correct the overgrazing of the previous decade, the USFS conducted significant plantings and seedings. Unfortunately, little attention was given to the use of native seed, and the items and seed mixtures used for reseeding were largely exotic. The seed mix most commonly used included wheatgrass, common timothy, smooth brome, and so forth. Eradication of willows and aspens to maximize forage production was also common (Menke, et al., 1996).

During 1950–1970, permanent reductions in the number of livestock occurred on most allotments in the Modoc and Lassen National Forests. Records are not available for BLM lands. Seasons of use were also reduced during that time and uneconomical allotments were abandoned. Many of these were sheep allotments, because sheep had previously used lands unsuitable for cattle grazing. Since 1970 public agencies increased the use of monitoring on rangelands, and declines in prices for beef and lambs resulted in a reduction in grazing numbers. The USFS began to concentrate on the rehabilitation of the riparian communities in allotment areas.

Vegetation Trends

Sagebrush Steppe rangelands have undergone significant change since European settlement. Heavy livestock grazing plus climate change resulted in the loss of native perennial grasses and increase in sagebrush and alien annual grasses, especially cheatgrass. This has increased fire frequency (Menke, et al., 1996). Although Tisdale, Menke, and others have shown that the systems appear to be stable from any number of perspectives, they continue to be invaded by new weed species which increases fire frequency. The increased frequency of fire tends to provide additional sagebrush removal, exacerbating the problems. This replacement of brush species with grasses is evident from Table 3-2, which shows that the percentage of big sagebrush cover has declined.

Table 3-2
BIG SAGEBRUSH, NATIVE PERENNIAL GRASS, AND FORB COMPOSITION (%) IN SAGEBRUSH-STEPPE COMMUNITIES OVER FIVE DECADES FROM PARKER TRANSECT

Forest	Before 1956	1956–1965	1966–1975	1976–1985	1986–1995
Modoc	(9)	(3)	(0)	(1)	(11)
Big sagebrush	15.4	22.0	---	15.0	14.8
Perennial grasses	7.3	3.0	---	6.0	10.5
Forbs	21.7	24.3	---	27.0	18.2
Lassen	(0)	(12)	(2)	(0)	(8)
Big sagebrush	---	12.8	17.0	---	11.2
Perennial grasses	---	6.5	6.5	---	8.4
Forbs	---	19.8	20.0	---	22.1

Note: Cheatgrass (*Bromus tectorum*), medusahead (*Taeniatherum caput-medusae*), filaree (*Erodium* spp.), dandelion (*Taraxacum officinale*), wheatgrass (*Agropyron* spp.), plantain (*Plantago* spp.), and bull thistle (*Cirsium* spp.)

Work to restore the sagebrush steppe ecosystems has resulted in an increase of native perennial grass composition of approximately one-third on the Modoc and Lassen National Forests (Tables 3-3 and 3-4).

The Modoc National Forest has one of the highest percentages of composition cheatgrass. Medusahead was known as a new invader of many sagebrush and grasslands in the 1980s and 1990s. The effects of cheatgrass also reduce surface soil erosion and cover percentages. Cheatgrass litter is much less effective in protecting soils from surface erosion than the native perennial grasses or sage canopy, which protects against raindrop erosion (Menke, 1996).

Table 3-3 NON-NATIVE SPECIES COMPOSITION (%) IN SAGEBRUSH-STEPPE COMMUNITIES OVER FIVE DECADES FROM PARKER TRANSECT					
Forest	**Before 1956**	**1956–1965**	**1966–1975**	**1976–1985**	**1986–1995**
Modoc	(9)	(3)	(0)	(1)	(11)
Cheatgrass	0.8	3.7	---	0	2.5
Medusahead	0	0	---	0	0.6
Filaree	0.1	0	---	0	0
Dandelion	0.1	0	---	0	0
Lassen	(0)	(12)	(2)	(0)	(8)
Cheatgrass	---	0	2.0	---	0.1
Filaree	---	0.4	0	---	0
Note: Cheatgrass (*Bromus tectorum*), medusahead (*Taeniatherum caput-medusae*), filaree (*Erodium* spp.), dandelion (*Taraxacum officinale*), wheatgrass (*Agropyron* app.), plantain (*Plantago* spp.), and bull thistle (*Cirsium* spp.)					

Table 3-4 NON-NATIVE SPECIES COMPOSITION (%) IN WET AND MESIC MEADOWS OVER FIVE DECADES FROM PARKER TRANSECT					
Forest	**Before 1956**	**1956–1965**	**1966–1975**	**1976–1985**	**1986–1995**
Modoc	(2)	(9)	(9)	(0)	(10)
Bluegrass	0	0.6	3.4	---	10.5
Redtop	0	0.4	0.8	---	0.6
Dandelion	0	0	0.1	---	0.5
Cheatgrass	0	2.7	0.1	---	1.0
Medusahead	0	0	0.3	---	0.3
Wheatgrass	0	0	0.1	---	1.2
Orchardgrass	0	0	0	---	0.1
Alopecurus sp.	0	0	0	---	0.1
Lassen	(0)	(13)	(13)	(1)	(15)
Bluegrass	---	2.4	4.1	0	6.7
Redtop	---	0.2	0.1	0	0.7
Dandelion	---	0.5	0.1	0	1.3
Timothy	---	0	0	0	0.3
Silver hairgrass	---	0.1	0	0	0
Clover	---	0	0	0	0.3
Tumble mustard	---	0	0	0	0.2
Note: From SNEP Chapter 22, Volume 3					

Grazing impacts vary significantly with both the season and timing of grazing and species of livestock (cattle versus sheep and horses). Livestock grazing of mountain meadow areas remains controversial. Livestock grazing effects can be positive, neutral, or negative depending on the level and timing of use. Ecosystem improvement can occur when appropriate grazing strategies are followed.

Moderate livestock grazing usually increases the diversity of native plant species in both wet and mesic meadows but can depress diversity in dry meadows (Ratliff, 1985). Particularly where grasslike plants (*Carex* spp. especially) dominate wet parts of meadows, livestock grazing can reduce dominance and litter accumulations and can allow more species to inhabit a site. These species are usually native. Heavy grazing usually reduces foliage density and increases bare ground in the community thereby making sites available to invasion of exotic species if they are present on a grazing unit. Many of the so-called "increasers" in mountain meadow rangelands are native forbs that substantially increased in abundance with frequent grazing (Ratliff, 1985).

Trampling impacts can also indirectly affect plant species diversity. Trampling reduces soil porosity, especially when soils are wet and of high clay content. Repeatedly trampled wet or mesic meadows tend to become drier and of lower productivity due to reduced water infiltration and water holding capacity, and increased runoff. It is imperative that meadows be managed carefully since they often provide the bulk of an allotment's forage productivity.

In certain situations, livestock use restored and improved certain ecotypes. Many scientists and range managers concede that livestock use in vernal pool ecosystems assists in controlling the invasion of non-native grasses. Trampling actually increases site diversity through soil disturbance, thereby increasing micro-site differences.

In the 1990s, impairment of riparian ecosystem function became a primary issue in range management. Natural meandering keeps water on meadows longer thereby creating or maintaining water tables and more mesic or wet meadow conditions. A common meadow riparian problem is one where meanders have been lost; streams have become straighter with steeper gradients, and have downcut due to faster-moving water. One primary livestock-related cause of loss of meanders is overgrazing and loss of woody plants or reduced vigor of graminoids that provide armoring of bends in meanders. Results are that much of the undercut bank structure and other features contributing to aquatic habitat quality are lost. Likewise, meadow productivity is depressed due to lowered water tables. Many streams degraded due to a combination of grazing disturbance and flood events, especially before land management agencies were established and before humans knew the importance of riparian ecosystem dynamics.

Loss of riparian vegetation and trampling of stream banks caused by overgrazing allows stream banks to widen and become shallower. This increases the impacts of solar radiation on water and results in high temperatures.

The non-native species Kentucky bluegrass is the primary invader of mountain meadows on national forests in Northern California (Menke, 1996). Generally, bluegrass appears to be increasing on mountain meadows, especially in the Modoc and Lassen National Forests. Redtop grasses are the second-most common non-native component of meadows. Increases in composition of redtop are occurring but to a lesser degree than bluegrass. Common dandelion is the third-most common non-native species occurring on mountain meadows. Cheatgrass was the most common invader on drier parts of meadows in the Pit River system. Meadow and riparian ecosystems have greater potential for response to management and recovery than any other range ecosystem type. By their very nature, they are well-watered systems; plant growth is rapid; and species composition is diverse.

Public Land Allotments

Public land plays a vital role in the watershed livestock industry. Most cattle ranchers use public lands for a three- to six-month period when it is necessary to have irrigated lands in hay production for winter-feeding. Current allotments for USFS land total 66 and BLM allotments total 98. A map of the current allotments is shown on Figure 3-8. Ranchers pay grazing fees to the USFS and BLM. In turn, the county is paid approximately 25 percent of the grazing fee in the form of a possessor's tax. A majority of the fees collected for grazing are reinvested by the various agencies in the form of range betterment and advisory services.

Grazing legislation and allotment issues are a major concern in the Upper Pit River Watershed. The Modoc-Washoe Experimental Stewardship Program (ESP) focuses on resolving range management conflicts through consensus and direct involvement of stakeholders. The program has shown how people with different interests can agree on solutions to management problems. This program resulted from the mid-1970s controversy over the grazing of public lands. The BLM was charged with failing to consider the environmental impacts of their grazing program and forced to propose reductions in grazing allotments. BLM failed to inform the ranchers of the proposed reductions. These actions resulted in many lawsuits filed by ranchers and an intense mistrust of the BLM.

Responding to the turmoil, Congress passed the 1978 Public Rangelands Improvement Act (PRIA). Section 12(a) directs the secretaries of the Interior and Agriculture to develop and implement an experimental program that explores innovative grazing management policies and practices, and provide incentives to permittees whose management style improves range conditions. The program also includes collaboration on large watershed health issues such as forest and fuel management.

Since 1980, the Modoc-Washoe ESP has enjoyed notable success; including the development of at least 35 allotment-management plans. It is also responsible for wilderness recommendations; actual-use billing; grazing fee credits for rancher-constructed range improvements; a structured herd management policy for wild horses; and reintroduction of California bighorn sheep and other native habitat.

Modoc County is one of the few counties in the United States to assert its right to help manage the public lands within its jurisdiction. In fact, federal statute mandates that counties and management agencies will coordinate actions concerning public lands. The Federal Land Policy and Management Act, the National Environmental Policy Act, and the Endangered Species Act are just a few of the policies shaping the management practices in the Upper Pit River Watershed. Current livestock summary numbers for Modoc and Lassen Counties are summarized in Table 3-5.

Cropland

Wide varieties of crops are grown throughout the watershed. These range from field crops to vegetables and specialty crops. According to the California Farm Bureau in 2001, the top five crops in Modoc and Lassen Counties by value were alfalfa, cattle, timber, pasture, and potatoes. Complete lists of the crops grown in the watershed are shown in Figure 3-9. Many of the values presented for sales are approximations due to the manner in which they are reported. The Upper Pit River Watershed includes areas from parts of four counties; however, the information is extrapolated to include mostly data from Modoc and Lassen Counties, because the majority of the Siskiyou County area within the watershed is not farmed and the eastern portion of Shasta County is difficult to separate from other data, with exception of the wild rice grown in the Fall River Valley.

Table 3-5 RECENT LIVESTOCK VALUE SUMMARY–MODOC AND LASSEN COUNTIES					
Livestock	Year	Number of Head	Total cwt	*Price per cwt $	Total $
Modoc County					
Beef	2001 2000	30,000 29,500	180,000 177,000	68.00 65.00	12,240,000 11,505,000
Sheep	2001 2000	4,200 4,000	4,830 4,600	68.00 60.00	328,440 276,000
Wool	2001 2000		370 350	0.14/lb 0.29/lb	5,180 10,150
Lassen County					
Beef	2001 2000	23,520 22,400	165,275 157,425	65.00 66.00	10,386,350 10,061,900
Sheep	2001 2000	4,250 4,000	5,110 4,800	68.00 74.00	349,500 355,200

Source: Lassen County Annual Crop Report, 2001 & Modoc County Annual Crop Report, 2001
*Price averaged from sale of cows, heifers, calves steers, and bulls. Cwt=cost per thousand pounds
**Combined sheep/lamb price

Alfalfa is estimated to be the largest-grossing crop in Modoc County with approximately 31,000 acres in production and a market value of $15.3 million. A summary of the types of crops grown, acreage, and total value for 2001 are listed in Table 3-6.

Farmland Mapping and Monitoring

In 1980, the California Department of Conservation, Division of Land Resource Protection, began work to supplement the Soil Conservation Service (SCS) conservation programs through a Farmland Mapping and Monitoring Program (CDC, 2001). This program, designed to inventory important farm and grazing lands in the form of important Farmland Series maps, became California Law in 1982. Its purpose is to monitor conversion of the state's agricultural land to and from agricultural use, and report concerns to the Legislature, local government, and the public. A map of the types of farmland within the watershed is shown on Figure 3-10.

The guidelines identified five categories of farmlands: prime farmland, farmland of statewide importance, unique farmland, farmland of local importance, and grazing land. All five designations of land use are found throughout the Upper Pit River Watershed. According to the California Department of Conservation, the state's total agricultural land use acreage has grown by approximately nine percent. Change by area of land use is shown in Table 3-7. The Department of Conservation defines these five categories as described in the sections below.

Prime Farmland

Prime Farmland is land, which has the best combination of physical and chemical characteristics for the production of crops. It has the soil quality, growing season, and moisture supply needed to produce sustained high yields of crops when treated and managed, including water management, according to current farming methods. "Prime Farmland" must have been used for the production of irrigated crops within the last three years. It does not include publicly owned lands for which there is an adopted policy preventing agricultural use.

Table 3-6 ACREAGE AND VALUE OF CROPS GROWN IN THE WATERSHED							
Crop	**Year**	**Harvested Acres**	**Per Acre**	**Total**	**Unit**	**Avg/Unit (dollars)**	**Total (dollars)**
Lassen County							
Alfalfa	2001 2000	30,000 32,000	3.5 4.8	103,500 153,600	ton	110.00 95.00	11,550,000 14,592,000
Forage Hay/Silage	2001 2000	37,500 38,500	2.1 3.0	76,700 105,500	ton	80.00 67.50	6,136,000 7,957,500
Garlic	2001 2000	238 275	140 100	33,320 27,500	cwt. cwt.	13.00 15.00	433,160 412,500
Pasture (irrigated)	2001 2000	22,000 23,000	3.3 5.0	72,600 115,000	aum aum	19.00 19.00	1,379,400 2,185,000
Pasture (dryland)	2001 2000	22,00 22,00	0.05 0.1	1,100 2,200	aum aum	12.00 13.00	13,200 28,600
Strawberry	2001 2000	407 530	475 475	193,325 251,750	Plants in units of 1,000	51.00 49.00	9,859,575 12,335,750
Wheat	2001 2000	1,500 2,000	2.10 2.30	3,150 4,600	ton	95.00 100.00	299,250 460,000
Modoc County*							
Alfalfa	2001 2000	31,100 31,000	4.5 4.5	139,950 139,500	ton	110.00 95.00	15,395,500 13,252,500
Grain Hay	2001 2000	8,311 6,000	2.00 1.75	16,622 10,500	ton	75.00 75.00	1,246,650 787,500
Meadow Hay	2001 2000	20,000 20,000	1.50 2.00	30,000 40,000	ton	70.00 70.00	2,100,000 2,800,000
Pasture (irrigated)	2001 2000	50,000 50,000		250,000 300,000	aum	14.00 14.00	3,500,000 4,200,000
Pasture (dryland)	2001 2000	320,000 320,010		336,000 480,000	aum	7.00 7.00	2,352,000 3,360,000
Shasta County							
Wild Rice	2001 2000	4,000 3,500**	1,367 1,388	5,468,000 4,858,000	lb	0.38 0.45	2,077,900 2,186,100
Note: A variety of crops are grown in Siskiyou County, but not within the watershed boundary, hence its omission from this table. Source: California Farm Bureau Crop Reports 2001/Shasta County *Wild Rice was not included in the Modoc County Crop Report **Likely not all in watershed area							

Farmland of Statewide Importance

Land other than "Prime Farmland" that has a good combination of physical and chemical characteristics for the production of crops. It must have been used for the production of irrigated crops within the last three years. It does not include publicly owned lands for which there is an adopted policy preventing agricultural use.

Unique Farmland

Land that does not meet the criteria for "Prime Farmland" or "Farmland of Statewide Importance" and that is currently used for the production of specific high economic value crops. It has the special combination of soil quality, location, growing season, and moisture supply needed to produce sustained high quality or yields of a specific crop when treated and managed according to

Table 3-7 CHANGE BY LAND USE MODOC COUNTY ONLY					
Land Use Category	Total Acreage Inventoried				
	1992	1994	1996	1998	2000
Prime Farmland	38,331	39,597	73,191	73,193	73,058
Farmland of Statewide Importance	37,822	38,639	47,664	48,079	49,103
Unique Farmland	2,234	2,588	8,110	8,369	9,040
Farmland of Local Importance	110,525	103,780	100,330	99,885	97,476
Important Farmland Subtotal	**188,912**	**184,604**	**229,295**	**229,525**	**228,677**
Grazing Land	566,837	568,849	602,389	601,263	602,123
Agricultural Land Subtotal	**755,749**	**753,453**	**831,683**	**830,788**	**830,800**
Urban and Built-Up Land	3,276	3,301	3,460	3,317	3,171
Other Land	12,333	13,307	17,133	17,300	17,470
Water Area	52,796	52,813	55,390	56,262	56,225
Total Area Inventoried	**824,154**	**822,873**	**907,666**	**907,666**	**907,666**
Note: Information not available for the entire watershed					

current farming methods. Examples of such crops may include oranges, olives, avocados, rice, grapes, and cut flowers. It does not include publicly owned lands for which there is an adopted policy preventing agricultural use.

Farmland of Local Importance
Land currently producing crops, or the capability of production. "Farmland of Local Importance" is land other than "Prime Farmland," "Farmland of Statewide Importance," and "Unique Farmland." This land may be important to the local economy due to its productivity. It does not include publicly owned lands for which there is an adopted policy preventing agricultural use.

Grazing Land
Land defined in Section 65570(b)(2) of the Government Code as "and on which the existing vegetation, whether grown naturally or through management, is suitable for grazing or browsing of livestock." The minimum mapping unit for "Grazing Land" is 40 acres.

Water

The quantity, quality, and availability of water resources are vital to the natural and human activities within the watershed. Water is essential to the viability and, most notably, agriculture. Wise and prudent planning and management of surface and groundwater resources is fundamental to providing a substantial economic base for its residents. Water is discussed in detail in Section 5, "Hydrology."

Agriculture is by far the largest water-using industry in the Upper Pit River Watershed. Although changes in the irrigation practices will result in better water resource management, the predominant future use of water in the area will continue to be for agriculture.

There are a number of irrigation districts, which deliver water to agricultural lands in addition to water supplies developed by individual farmers and ranchers. The average water use for Modoc County is 3 acre-feet/acre/year. Water use by crop ranges from 2.1 acre-feet/acre/year to 4.8 acre-feet/acre/per. The estimates for applied water per crop in the watershed are shown in Table 3-8a. (Modoc County, General Plan 1988). Similar data from 2000 provided by the Department of Water Resources (DWR) is included as Table 3-8b.

Table 3-8a
APPLIED WATER DEMAND BY CROP TYPE

Crop	1980 to 2010 (in acre-feet)
Grain	1.9
Alfalfa	3.2
Alfalfa (partially irrigated)	2.0
Pasture	3.2
Pasture (partially irrigated)	2.2
Meadow pasture	3.3

Table 3-8b
APPLIED WATER DEMAND BY CROP TYPE – DWR 2000 DATA

Crop	DAVI30		DAVI32	
	ETAW	AW	ETAW	AW
Grain	1.3	1.8	1.1	1.4
Alfalfa	2.5	3.4	2.2	3.0
Alfalfa (Partially Irrigated)	1.2	1.5	1.1	1.4
Pasture	2.6	4.0	2.2	3.2
Pasture (Partially Irrigated)	1.3	1.6	---	---
Meadow Pasture	2.4	3.1	2.1	2.8

COMMERCIAL TIMBERLANDS

Comprising just over 30 percent of the land base in the watershed, privately owned timberlands provide significant commercial activity. The major private landowners (Roseburg Resources Co., Sierra Pacific Industries, and John Hancock Insurance) and major private timberland managers (W.M. Beaty and Associates, Inc.) have individual land management planning documents for their lands that outline goals and objectives for the various properties. These specify timber harvest levels; vegetation and stocking plans; wildlife management plans; and limited public uses. While these plans vary by owner or manager, all must conform to the requirements for commercial timberlands outlined by the State Board of Forestry, administered through the California Department of Forestry and Fire Protection.

Land dedicated to commercial forest management provides not only building materials; energy for industrial processes; firewood, county revenue for roads and schools; and employment opportunities; but also wildlife habitat, recreational opportunities, aesthetic enjoyment, and watershed protection. Maintaining timber operations and preservation of valuable timberlands are important to the economic base and the natural resource values of the Upper Pit River Watershed.

The commercial forestland in the Upper Pit River Watershed is generally slower growing compared to the western side of the Sierras. Timber production in the watershed has declined dramatically in the last 20 years, but not to the extent elsewhere in California. See Section 7, "Botanical Resources," for a graph of timber harvesting trends. In 1983, Modoc County reported $8.4 million in timber sales compared to 2001, which only totaled $6.9 million.

In 1976, the California State Legislature enacted the Forest Taxation Reform Act. The Act restructured the taxation of timber and timberlands by replacing the annual ad valorem property tax on timber and timberland with yield tax on harvested timber. This reduced the immediate demand on standing timber and reduced the high grading that had accompanied the need to always cut the larger trees on private holdings to reduce tax liability. The annual wood product values for counties in the watershed area for 2000 and 2001 are listed in Table 3-9.

Table 3-9
WOOD PRODUCTS BY COUNTY

Wood Product	Year	Volume		Value
Modoc County				
Timber	2001 2000	27.166 41.628	Million Bd. Ft. Million Bd. Ft.	$6,904,355 $12,031,131
Shasta County				
Timber	2000 1999	144.513 155.660	Million Bd. Ft. Million Bd. Ft.	$40,399,186 $49,412,637
Lassen County				
Saw Timber	2001 2000	54.683 60.566	Million Bd. Ft. Million Bd. Ft.	$14,792,790 $20,653,676
Siskiyou County				
Timber	2001 2000	193.400 134.829	Million Bd. Ft. Million Bd. Ft.	$63,797,993 $36,224,679

Source: Modoc, Shasta, Lassen, and Siskiyou Counties 2001 Crop Reports.
*No data were available for 2002 harvest as of December 2003.

RECREATION

Limited data is available on the recreation opportunities available in the Upper Pit River Watershed. The majority of the data found for the watershed is from public lands (USFS and BLM), specifically the Modoc National Forest. Recreational activity may be either local in origin or involve tourism, which is in turn a subset of all activity related to the travel industry. Unfortunately, there is very limited data from private opportunities.

It is also important to note the relatively low density of human settlement in the Upper Pit River Watershed is accompanied by large areas of open space that are privately owned. Much of this land is fenced and posted against trespass, while other land remains generally accessible for informal public recreational activities of a dispersed, low-intensity nature. These activities include camping; hunting; fishing; running; walking; mountain biking; cross-country skiing; snowmobiling; and nature study. Similar activities occur on large private land holdings at higher elevations, especially those that are interspersed with public lands. Recreational users often cross between public and private lands on a single trail, for example, without even knowing whether they are on federal, state, local, or private land at a given time. Recreational use estimates described in this section record only those activities that occur no lands or resources within the management jurisdiction for the reporting public agency. Additional recreational activities occur on private lands, and the potential for conflicts over trespass are highest at the public-private land interface. Moreover, reduction in informal public access to privately owned open spaces are also likely as human settlement increases parcelization and population density on large blocks of private land.

Recreational activity is a function of many factors. For most types of recreation, ecological conditions are not necessarily the dominant factor. The availability of developed facilities and a wide range of behavioral considerations, including cultural factors, are equally important. The institutional arrangements for the provision of recreational opportunities (e.g., whether they are public or private and whether or not there is a fee for the activity) also influence recreational activity. Finally, aesthetic considerations are important for many types of outdoor recreation.

In general, the current recreational activities appear to be directed more toward "developed" and "front-country" activities than many of the traditional wilderness-type uses that were so important in the past three decades. Increased affluence, together with decreased access to other open space, could change those patterns within a single generation.

The Modoc National Forest is best known for its remote location and uncrowded recreation opportunities. Most visitors enjoy hunting, fishing, and camping, while others delight in touring, hiking, horseback riding, swimming, and picnicking.

Recreational use is commonly measured in Recreational Visitor Days (RVD). One RVD equals one 12-hour visit to a site or twelve hours of a recreational activity. Statewide, the USFS classifies its nonwilderness recreational activities using the following activity classes: (1) camping; (2) picnicking, swimming; (3) travel; (4) hiking, horseback riding, water travel; (5) winter sports; (6) resorts; (7) hunting; (8) fishing; and (9) other activities.

The most popular recreational activities in the nine forests of the Sierra Nevada as presented in the SNPE were activity classes of "automobile travel" (32 percent) and "camping, picnicking, and swimming" (29 percent) (Duane, 1996). Together with resorts (11 percent), these three general classes of recreational activity accounted for nearly three-quarters (72 percent) of all RVDs on USFS units in the Sierra Nevada (Duane, 1996). Distribution of mean annual RVDs by USFS class in the Sierra for the period 1987–1993 showed:

- Camping/Picnicking/Swimming 29 percent
- Travel 32 percent
- Hiking/Horseback Riding/Water Travel 6 percent
- Winter Sports 9 percent
- Resorts 11 percent
- Hunting 2 percent
- Fishing 6 percent
- Nature Study/Interpretive Activities 2 percent
- Other Activities 3 percent

The current Land and Resource Management Plan (LRMP) published 1991 for the Modoc National Forest reports total recreation use on the Forest was 377,440 RVDs and wildlife and fish user days (WFUDs). In the watershed, developed recreation sites are managed by the USFS or the private sector, and amount to less than 20 percent of the total recreation use (USFS, 1991). The average for other forests in the region is 42 percent. Use on the Modoc is lower because of less private development, and the popularity of dispersed activities such as hunting and fishing.

The Modoc National Forest has 20 developed campgrounds, two picnic sites, two boat ramps, and a swimming beach (USDA, MNF, 2002). Camping is a major activity and estimated by the USFS to represent more than 80 percent of developed uses (USFS, 1991). Recreation supply is affected by the number of people developed sites can accommodate. The Modoc National Forest provides a capacity of 165,000 RVDs. Practical capacity is 40 percent of theoretical capacity (all sites occupied for 100 percent of the time, all season long). Use levels between 50 percent and 100 percent of practical capacity are considered ideal (83,000–165,000 RVDs). Use at less than 50 percent is inefficient, while use of 100 percent will not maintain a quality recreation experience, prevent resource damage, and allow for peak use periods. Although use on the Modoc National Forest as a whole is within this optimum range, sites at Lily Lake, Cave Lake, and Plum Valley receive well over 100 percent use (USFS, LRMP, 1991).

More than 80 percent of the recreation use on the Modoc National Forest occurs in dispersed areas (areas that are not developed for intensive recreation use). Big game hunting and driving for pleasure are the major dispersed recreation activities. From 1977 to 1981, an average of 17,000 deer hunters per year visited the Modoc National Forest.

The current trail inventory for the Modoc National Forest includes 118 miles of trails, 79 miles of which are in the South Warner Wilderness. The Modoc National Forest has two National Recreation Trails. The Highgrade Trail traverses an historical gold mining area in the North Warner Mountains. Use is light, but plans to interpret its historical values may increase use. The Blue Lake Trail circles Blue Lake in the South Warners. It receives moderate use, which is generated by the nearby-developed sites.

The Modoc National Forest has more land available to Off Highway Vehicles (OHV) than any forest in the region. 94 percent of the land in the Modoc National Forest is open to OHV use. Gathering firewood and hunting are the primary activities associated with OHV use. People are creating additional trails to access firewood areas. Although past use has not been significant, some resource damage has occurred. Even if large areas of the Modoc National Forest are closed to OHV use in the future, outstanding OHV opportunities will be available (Duane, 1996).

DEMOGRAPHICS

Historic watershed demographics were discussed in Section 2, "General Watershed History." The highest population densities are found in the central portion of the watershed and are concentrated in the cities of Alturas and Fall River Mills.

Population trends in the watershed have fluctuated very little in the last 120 years. The first census taken in the area was in 1880. The area has experienced a steady overall climb in population over the years. The largest drop in the area's population came during the economically and politically troubled times from the 1960s to the mid-1980s. 2002 census information is shown in Figure 3-13.

The 2000 census revealed the population has begun to drop most dramatically in the 25- to 45-year age group. Some of the reasons for this decline can be contributed to the lack of an economic base in the area. Census numbers show that service positions top the list of occupations. Historically, service positions pay minimum wage and have very high turn over rates. The overall lack of jobs available in the area also contributes to the decline in the 25- to 45-age group. Unemployment for the nation averages approximately 5 to 6 percent, yet in the four counties that make up the watershed, unemployment has averaged approximately 11 percent for the last fifteen years.

Another major issue in the watershed is the large percentage of the population living below national poverty standards. According to US Census data, approximately 20 percent of the residents in the watershed have lived in poverty for the last 10 years. In December 2000, FEMA gave the California's Emergency Food and Shelter Plan $21 million. Various amounts were given to each county in the state. Lassen County received $18,546, Modoc County $8,099, Siskiyou County $42,508, and Shasta County $124,351. These funds are used to support programs that provide food for the hungry, shelter to the homeless, and to prevention of homelessness (FEMA, 2001).

Residential use in the watershed is divided into three or four categories, depending on the county. The majority of current residential development is in the Alturas area, with the largest population center of the watershed having 2,892 residents. According to the 2000 Census data, Modoc County had a population density of 2.4 people per square mile. This low concentration of people has made the restriction on parcel size, found in most County General Plans around the state, including Shasta County, non-applicable to the watershed. The population is isolated in small rural community centers in Canby, Bieber, McArthur, Likely, and Adin. Population density form the 2000 Census is displayed graphically on Figure 3-11. County populations and historic trends are shown on Table 3-10. Significant populations declines have occurred recently in Big Valley with the closure of the lumber mill and planing mill.

LAND USE REGULATIONS

Many laws and regulations govern the manner in which both public and private lands are managed on the federal, state, and county level (SCOS, 2001). This section will discuss some of the laws most relevant to the watershed and its citizens. This is not an all-inclusive list and the reader is cautioned to not use the following as legal or regulatory advice.

Federal

- **The Forest Reserve Act of 1891.** The Forest Reserve Act gave the president the authority to deem any or all public lands with forest or undergrowth a public reserve.

- **The Taylor Grazing Act of 1934.** The Taylor Grazing Act provides a way to regulate the occupancy and use of public land; preserve the land from destruction or unnecessary injury, and provide for orderly use, improvement, and development.

- **The Wild Horse Annie Act of 1959.** This law prohibits the use of motorized vehicles to hunt wild horses and burros on all public lands.

- **The Multiple Use-Sustained Yield Act of 1960.** Congress stated that the national forests are established and shall be administered for a variety of uses, such as outdoor recreation, range, timber, watershed, and wildlife and fish purposes. The management of all the various renewable surface resources of the national forests will best meet the needs of the American people.

Table 3-10 HISTORICAL POPULATION DATA				
Decade	Population (by County)			
	Lassen	Modoc	Shasta	Siskiyou
1850	---	---	378	---
1860	---	---	4,351	7,620
1870	1,327	---	4,173	6,848
1880	3,340	4,399	9,492	8,610
1890	4,239	4,986	12,133	12,163
1900	4,511	5,076	17,318	16,962
1910	4,802	6,191	18,920	18,801
1920	8,507	5,425	13,361	18,545
1930	12,589	8,038	13,927	25,480
1940	14,479	8,713	28,800	28,598
1950	18,474	9,678	36,413	30,733
1960	13,597	8,308	59,468	32,885
1970	16,796	7,469	77,640	33,225
1980	21,661	8,610	115,613	39,732
1990	27,598	9,678	147,036	43,531
2000	33,828	9,449	163,256	44,301
Source: University of Virginia Geospatial and Statistical Data Center				

- **The National Environmental Policy Act (NEPA) of 1969.** The purposes of this Act are to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere, and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.

- **The Wild Free-Roaming Horses and Burros Act of 1971.** Issues not included in the Wild Horse Annie Act were subsequently included in this law. The law provided for the necessary management, protection, and control of wild horses and burros (BLM, 2001).

- **Clean Water Act (Federal Water Pollution Control Act Amendments) of 1972.** The primary purpose of the 1972 Clean Water Act was to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." To achieve that goal, the law prohibits the discharge of pollutants into "navigable waters," defined in the act as "waters of the United States," without a permit. The law has historically been understood to protect traditionally navigable waters, tributaries of navigable waters, wetlands adjacent to these waters, and other wetlands, streams and ponds that, if destroyed or degraded, could affect interstate commerce.

- **The Endangered Species Act of 1973.** The Endangered Species Act recognizes that various species of fish, wildlife, and plants in the United States have been rendered extinct because of economic growth and development, and that other species of fish, wildlife, and plants have been so depleted in numbers that they are in danger of, or threatened with, extinction. The United States has pledged to conserve to the extent practicable the various species of fish or wildlife and plants facing extinction.

- **The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974.** This Act directed the Secretary of Agriculture to prepare a Renewable Resources Assessment every 10 years. These assessments include "an analysis of present and anticipated uses, demand for, and supply of the renewable resources, with consideration of the international resource situation, and an emphasis of pertinent supply, demand and price relationships trends."

- **The Federal Land Policy and Management Act of 1976.** This law deemed that public lands be managed in a manner that will protect the quality and value. In certain cases, the preservation and protection of certain public lands in their natural condition will provide food and habitat for fish and wildlife and domestic animals, and will provide for outdoor recreation and human occupancy and use.

- **The Public Rangelands Improvement Act of 1978.** The law gave public land administrators the authority to charge a fee for livestock grazing permits and leases on the public lands, based on a formula reflecting annual changes in the costs of production, and enabled formation of ESIP.

- **The Government Performance and Results Act of 1993 (GPRA).** The GPRA directs all government agencies to develop a strategic plan that covers 3 to 5 years. Four major themes of the USFS RPA are: (1) enhance recreation, wildlife, and fisheries resources; (2) ensure environmentally acceptable commodity production; (3) improve scientific knowledge about natural resources; and (4) respond to global resource issues.

State

- **Porter-Cologne Water Quality Act of 1969.** This law, passed by the legislature, deemed the state and regional water quality control boards the primary governing bodies responsible for the coordination and control of water quality. Coordination of their respective activities shall be to achieve a unified and effective water quality control program in California.

- **California Environmental Quality Act (CEQA) of 1970.** CEQA is closely modeled on the National Environmental Policy Act (NEPA). Unlike NEPA, CEQA imposes an obligation to implement mitigation measures, or project alternatives to mitigate significant adverse environmental effects, if these measures or alternatives are feasible. Thus, CEQA establishes both a procedural obligation to analyze and make public adverse physical environmental effects, and a substantive obligation to mitigate significant impacts.

- **California Endangered Species Act (CESA) of 1984.** CESA generally parallels the main provisions of the federal Endangered Species Act, which is administered by the California Department of Fish and Game (CDFG). Under CESA, the term "endangered species" is defined as a species of plant, fish, or wildlife which is "in serious danger of becoming extinct throughout all, or a significant portion of its range," and is limited to species or subspecies native to California.

- **California Land Conservation Act (Williamson Act) of 1965.** The law enables local governments to enter into contracts with private landowners to restrict specific parcels of land to agricultural or related open space use. In return, landowners receive property tax assessments, which are much lower than normal because they are based upon farming and open space uses as opposed to full market value. Local governments receive an annual subvention of forgone property tax revenues from the state via the Open Space Subvention Act of 1971.

- **Z'berg-Nejedly Forest Practices Act of 1973.** The Z'berg-Nejedly Forest Practices Act (Forest Practices Act), was enacted in 1973 to create a comprehensive regulatory act to protect timberlands with the intent to restore, enhance, and maintain forest productivity, and to sustain high-quality timber products while taking into account "recreation, watershed, wildlife, range and forage, fisheries, regional economic vitality, employment, and aesthetic enjoyment." This is an all-encompassing law enacted to involve timber, loggers, and environmentalists alike in forest management decisions.

Typical Permit Requirements

The numerous statutory requirements that apply to lands in the watershed generate volumes of regulations to manage how actions occur on both state and federal properties. Although not inclusive an example of the types of permits and administrative actions required to conduct activities, such as restoration projects, in the watershed are summarized below.

A permit is an authorization or other control document issued by a federal, state, or local agency to implement the requirements of a law or regulation. The type of permits that would be required for a project depend on the

- Source of project funding (private, state, or federal)
- Type of project and resources affected
- Ownership of land on which the project occurs
- Physical location of the project

Most permits require a fee. The permitting process for *any* project can be complicated and difficult to understand. This section is not intended as a comprehensive guide for project permitting. Because it is the responsibility of the permit applicant to ensure they have applied for all the right permits, the goal of this section is to present enough information to assist project managers in asking the correct questions and searching out appropriate sources of assistance. Some permits apply to specific project types. Others, like CEQA compliance, apply to all projects. There is significant distinction in permit requirements between projects on public and private lands. Most permits are resource use specific. For example, the preparation of a timber harvest plan and submittal of the plan to CDF is required to remove timber. Any project, which disrupts a stream channel or waterway, requires a 1600 (stream bed alteration) permit from the Department of Fish and Game. Cinder pits require compliance with SMARA. Water re-use projects that may impact water quality will require review by the Regional Water Quality Control Board or the Department of Water Resources. Most all projects will require NEPA or CEQA review as no permit may be issued without the primary agency completing this process.

Brief descriptions of regulatory agencies that may be involved in the project are found in Table 3-11.

A possible project matrix and likely permit requirements for private lands is included as Table 3-12. This table is provided *only* to present areas where permits may be required.

In general, project permitting will take a minimum of 120–180 days. It is important in all project planning and permit operations to

- Prepare a well-defined project description that minimizes disturbance
- Prepare clear and concise plans
- Contact agencies early
- Maintain a positive attitude

FEMA ISSUES

The Upper Pit River Watershed is located in FEMA's Region IX, which covers the states of California, Arizona, Nevada, Hawaii, and the United States Territory of Guam.

FEMA conducts flood-mapping services in addition to emergency services. Flood mapping for the watershed is included on Figure 3-12.

Due to the area's low amounts of precipitation and the agricultural economic base, drought issues are by far the highest priority for the citizens of the watershed and representatives of the local and federal government. During June 2001, FEMA representatives along with members of the Farm Service Agency began their State Preliminary Damage Assessment of farms in the area.

LAND USE PLANNING

Public Land

Each federal and state agency has its own policies concerning land use and management. Legislation dictating public land use by agency is summarized in the following section.

U.S. Forest Service (USFS)
The USFS, which oversees the Modoc, Lassen, and Shasta-Trinity National Forests, is required by the Rangeland Renewable Resource Planning Act of 1974 (RPA), as amended by the National Forest Management Act of 1976 (NFMA), to prepare individual forest plans. The RPA requires the USFS to conduct an assessment of the nation's renewable resources and to develop a program of use. The assessment determines the capability of all national forest lands to provide goods and services, as well as a forecast of demands for them.

NFMA requires the USFS to develop an integrated land management plan for each national forest. Each region distributes its share of national production targets for each of its forests. The share each forest receives is based on detailed information gathered at the forest level.

Assessment of the plan's environmental impacts is required by the National Environmental Policy Act (NEPA) and is contained in an accompanying environmental impact statement (EIS). The EIS

Table 3-11 PERMIT-ISSUING AGENCIES		
Agency	**Function**	**Area**
Local:		
City/County Planning Department	Many city or county planning departments have local ordinances pertaining to grading creeks and wetlands, and depending on the nature of the project, several other permits/exceptions/approvals may be required as well. Planning departments are commonly the lead agency for CEQA documentation. County planning department are commonly the lead agency for mine applications	Modoc, Lassen, Shasta Counties
City/County Environmental Health Department	Local Environmental Health Departments provide monitoring and enforcement relating to food and hazardous materials handling. This agency may be involved if work on the stream, or discharge into the stream pose a pubic health hazard, such as with water re-use. Health departments commonly are lead agency for well permits, water re-use and reclamation, and underground storage tank contamination limited to soil.	Modoc, Lassen, Shasta Counties
Local Irrigation, Water, or Flood Control District	Irrigation, Water, or Flood Control Districts are empowered to protect water resources within their jurisdiction which may require a permit for certain projects	Modoc, Lassen, Shasta Counties
State:		
California Department of Fish and Game	The California Department of Fish and Game requires a Stream Alteration Agreement (1600 permit) for projects that will divert or obstruct the natural flow of water, change the bed, channel or bank of any stream, or use any material from a streambed. The 1600 permit is a contract between the applicant and the CDFG stating what can be done in the riparian zone and stream course. The permit is required for removal of vegetation and such activities, as placement of culverts requires independent CEQA review for all 1600 permits and will serve as lead agency if the review is not considered previously. CDFG can also be expected to provide input to projects through the CEQA and NEPA review process.	Region 1 (Northern California & North Coast Region) 601 Locust Street Redding, CA 96001 (530) 225-2300
California Regional Water Quality Control Boards	There are nine Regional Water Quality Control Boards. Regional Boards engage in a number of water quality functions. One of the most important is preparing and periodically updating Basin Plans, which set water quality standards. Regional Boards regulate all pollutant discharges that may affect either surface water or groundwater. Private, state, and federal projects require RWQCB permits. The permits obtained from the RWQCB would include: Waste Discharge Requirements The discharge of waste or waste water to land that may impact water quality. The RWQCB is allowed through regulation to issue waivers for certain discharges if a set of specific conditions applies. The RWQCB recently adopted waivers for discharge from 1) irrigated lands and 2) timber harvest. National Pollution Discharge Elimination System (NPDES) Permit – This permit is required when proposing to, or discharging of waste into any surface water. For discharges to surface waters, these requirements become a federal National Pollution Discharge Elimination System (NPDES) issued by the RWQCB. Federal Clean Water Act (CWA) Section 401 Water Quality Certification – This certificate is required for every federal permit or license or for any activity which may result in a discharge into any waters in the United States. Activities include flood control channelization, channel clearing, and placement of fill. Federal CWA Section 401 requires that every applicant for a US Army Corps of Engineers CWA Section 401 permit or Rivers and Harbors Act Section 10 permit must request a state certification from the RWQCB that the proposed activity will not violate state and federal water quality standards. The RWQCB reviews the request for certification and may waive certification, or may recommend either certification or denial of certification to the State Board Executive Director.	Redding Branch Office (5R) Redding, CA (530) 224-4845

Table 3-11 (cont.) **PERMIT ISSUING AGENCIES**		
State (cont.):		
State Water Resources Control Board Division of Water Rights	Anyone wanting to divert water from a stream or river not adjacent to his or her property must first apply for a water rights permit from the State Board. The State Board issues permits for water rights specifying amounts, conditions, and construction timetables for diversion and storage. Any persons or agencies intending to take water from a creek for storage or direct use on non-riparian land must first obtain a Water Rights Permit. The goal of the Board is to assure that California's water resources are put to a maximum beneficial use and that the best interests of the public are served. CDFG also must concur on the permit.	Division of Water Rights 1001 "I" Street, 14th Floor Sacramento, CA 95814 (916) 341-5300
Federal:		
U.S. Army Corps of Engineers	Federal and state projects planning work in a river, stream, or wetland may require a Corps permit. The regulatory authority of the Corps for riparian projects is based on Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Section 404 of the Clean Water Act requires Corps authorization for work involving intentional or unintentional placement of fill or discharge of dredged materials into any "waters of the United States." This applies even if there is a chance the winter rains may cause erosion leading to sediment discharges into the "waters." Section 10 of the Rivers and Harbors Act requires Corps authorization for work or structures in or affecting "navigable waters." Corps jurisdiction extends up to the ordinary high water line for non-tidal waters. Corps review can be shortened through the use of General Permit categories. These are areas where the AOC has determined with SWRCB concurrence that a special permit is not required and published BMPs or General Permit conditions are acceptable	Sacramento District – (916) 557-5250 New Redding Office
U.S. Fish and Wildlife Service	The US Fish and Wildlife Service (USFWS) is the principal federal agency for conserving, protecting, and enhancing fish, wildlife, plants, and their habitats. USFWS and National Marine Fisheries Service share responsibility for administration of the Endangered Species Act. USFWS enforces the federal Endangered Species Act, ensures compliance with the National Environmental Policy Act, and reviews and comments on all water resource projects. The Fish and Wildlife Coordination act requires that all federal agencies consult with the USFWS, the National Marine Fisheries Service, and state wildlife agencies for activities that affect, control, or modify waters of any stream or bodies of water. Under the Act, the USFWS and NMFS have responsibility for project review. In addition, the USFWS functions in an advisory capacity to the Corps of Engineers under the provisions of the Fish and Wildlife Coordination Act and other legislation. Incidental Take Permits – If a project may result in "incidental take" of a listed species, an incidental take permit is required. An incidental take permit allows a non-federal landowner to proceed with an activity that is legal in all other respects, but that results in "incidental taking" of a listed species. Habitat Conservation Plan – A Habitat Conservation Plan must accompany an application for an incidental take permit. The purpose of an HCP is to ensure that the effects of the permitted action on listed species are adequately minimized and mitigated. The incidental take permit authorizes the take, not the activity that results in the take. The activity itself must comply with other applicable laws and regulations.	2800 Cottage Way, Room W-2606 Sacramento, CA 95825-1846 (916) 414-6464

Table 3-11 (cont.) PERMIT ISSUING AGENCIES		
Federal (cont.):		
National Marine Fisheries Service	The National Marine Fisheries Service (NMFS) is the federal agency responsible for the conservation and management of the nation's living marine resources. Projects or activities that may affect marine fish and related habitat within NMFS jurisdiction are reviewed for any potentially harmful effects. The purpose of reviews conducted by NMFS is to ensure those sensitive populations of marine and anadromous fish (such as salmon and steelhead), as well as the aquatic and riparian habitat that support these fish, can survive and recover in the presence of human activities. The types of projects and activities of interest to NMFS include stream bank stabilization, streambed alteration, habitat restoration, flood control, urban and industrial development, and water resource utilization. When projects or activities require a federal permit, such as a Clean Water Act section 404 permit from the Army Corps of Engineers, then NMFS conducts a consultation with the federal agency under section 7 of the ESA. When there is no federal involvement, then for projects that incidentally "take" a listed species a permit under section 10 of the ESA is required. Because the Upper Pit River Watershed is behind numerous dams, NMFS consultation is not required.	N/a
Tribal Review		
Tribal Review	For projects on federal and state lands, tribal review is required. For projects on private lands with federal money, review would apply. Private land projects with private money do not require tribal review.	

Table 3-12
PROJECT PERMIT EXAMPLES–COUNTY OR OTHER LEAD AGENCY

Is Your Project:	City/County Planning Dept Grading, Mining, etc	City/County Health Dept	Water/Irrigation Flood Control District	California Dept of Fish & Game		State Water Resources Control Board/Division of Water Rights	Regional Water Quality Control Board			US Army Corps of Engineers	County or Other Agency (CEQA)	National Environmental Policy Act (Federal Lead Agency)	Tribal Review	US Fish and Wildlife Service
				1600	Other		WDR	NPDES	401 Cert					
On federal land with federal funding?												×	×	
On private land with private funding?	×				×						×			
On private land with federal funding?									×	×	×	×	×	×
On private land with state funding?											×			
Result in stormwater discharge into the creek?					×				×					
Divert or obstruct the natural flow; or change the natural bed or bank of the creek?				×		×					×			
Involve repair, rehabilitation, or replacement of any structure or fill adjacent to creek?				×					×	×	×			
Involve fish and wildlife enhancement, attraction, or harvesting devices and activities?				×	×						×			×
Use materials from a streambed (including but not limited to boulders, rocks, gravel, sand, and wood debris?	×		×	×	×		×		×	×	×			
Require the disposal or deposition of debris, waste, or any material containing crumbled, flaked, or ground pavement with a possibility that such material could pass into the stream?				×	×		×		×	×	×			×
Involve grading or fill near the creek?				×				×						
Involve a bridge or culvert?				×				×						
Involve water re-use?		×	×				×							
Involve a septic or leach field?		×					×							
Require a water well?		×												
Involve work within historic or archaeological area?											×	×	×	
Remove water from creek for storage or direct use on non-riparian land?						×								
Require that hazardous materials be generated and/or/stored on site?		×					×	×						
Involve a land disturbance of five acres or more?	×					×			×	×				
Involve a project with species listed as endangered or threatened?					×									×

Source: Portions for CARCD Guide to Watershed Project Permitting describes, in detail, the existing forest environment and management, supply-and-demand factors, and the environmental effects of implementing the proposed forest plan. Reasonable alternatives are also presented. The plan summarizes demand and supply potential, amplifies the preferred alternative, and applies its management direction to each management area. When approved, the forest plan will supersede most previous forest resources management plans. Plans deemed consistent with and still appropriate for the current forest plan include

- Wild Horse Management Plan
- Modoc Sucker Recovery Action Plan
- Transportation Plan
- Deer Herd Plans—Warner Mountain, Adin
- Three Sisters Bald Eagle Winter Roost Management Plan
- Mt. Dome Bald Eagle Winter Roost Management Plan
- Pronghorn Management Plan
- South Warner Wilderness Fire Management Plan

District rangers and their staff administer these plans along with the changes and improvements made to other programs in the forest plan.

As discussed previously in this section, in January 2001 the Sierra Nevada Framework amended the land and resources management plans of eleven national forests in the Sierra Nevada region. Additional goals and standards included:

- Management direction and goals

- Desired future conditions expected over the next 50 to 100 years

- Standards and guidelines to be used in designing and implementing future management actions

- A strategy for inventory, monitoring, and research to support adaptive management

Only the existing plan standards and guidelines in conflict with the Record of Decision (ROD) were modified or abandoned. Specifically the ROD replaced all previous California spotted owl management direction. The ROD amended the regional guides for those portions within the Modoc Plateau where existing regional guides were in conflict.

Individual plans mentioned in the Sierra Nevada Framework are the Upper Pit River Watershed Restoration Project, Hackamore Ecosystem Restoration and Enhancement Project, Warner Mountain Rangeland Management Planning, Experimental Stewardship Project, and the Big Valley Sustained Yield Unit. These specific plans will continue as originally designed due to the progressive collaborative nature, innovative techniques, and proven success rates.

Current USFS chief Dale Bosworth identified four main threats to western forests in the United States:

- Overgrown forests that need thinning or controlled burning to prevent catastrophic fires
- Invasive species that threaten native plants

- Habitat fragmentation from development near forest lands
- Unmanaged recreation

One of the issues causing a stir in California environmental circles is a USFS plan to double logging to avert devastating wildfires. In his speech, Bosworth, the Chief of the Forest Service referred to "the bogus debate over logging," and said there is a misperception that the USFS is eagerly chopping down trees to make money. He said the amount of timber cut in the United States has dropped from 12 billion board feet a year two decades ago to 2 billion board feet a year now. It takes about 10,000 board feet to build an average house.

Sierra Nevada Framework

In January 2004, the USFS issued the Sierra Nevada Forest Plan Amendment (SNFPA), Record of Decision. This amendment supersedes the land and resource management plans of Modoc and Lassen National Forests within the Upper Pit River Watershed, and nine other national forests in the Sierra Nevada region. The decision is in accordance with the 1982 National Forest Management Act (NFMA) planning regulations (36 CFR 219). These regulations were recently changed (65 FR 67513), however, and transitional language in the new regulations permits this decision to be made under the 1982 regulations.

The plan is designed to focus on providing an integrated, collaborative framework of concepts, principles, and goals for the Sierra Nevada region that can be used to help guide future land-use decisions. The effort integrates recent science into natural resource management through a variety of approaches and at a mixture of geographic scales. It also works toward more effective means of coordination, cooperation, and collaboration among the various parties.

The 2001 and amended 2004 Sierra Nevada Forest Plan focuses on five problem areas:

- Old forest ecosystems and associated species
- Aquatic, riparian, and meadow ecosystems and associated species
- Fire and fuels
- Noxious weeds
- Lower Westside hardwoods ecosystems

The principal focus of each area, strategy, risks, uncertainties, and likely trade-offs required to achieve desired future conditions are all addressed in the plan.

The newest Record of Decision (ROD), adopted in January 2004, includes an integrated strategy for vegetation management that is aggressive enough to reduce the risk of wildfire to communities in the urban-wildland interface; while modifying fire behavior over the broader landscape. The amended ROD incorporates thinning projects that may significantly reduce the threat of catastrophic fires to wildlife and watersheds.

Bureau of Land Management

The Bureau of Land Management (BLM), which is a department within the U.S. Department of Agriculture (USDA), is directed under Title II, section 202 [43 U.S.C. 1712], of the Federal Land Policy and Management Act of 1976 to develop, maintain, and periodically update land use plans for all tracts or areas for the use by the public. When land use plans are prepared or revised, they must observe the principles of multiple use and sustained yield set forth by the Multiple Use-Sustained Yield Act of 1960. The BLM is currently updating their Resource Management Plan.

Resource Management Plans represent the BLM's preferred management plans, environmentally preferred alternatives in terms of minimizing environmental impact, and guidelines for the uses of the public lands in the planning area. The alternatives attempt to meet the BLM's statutory mission under the Federal Land Policy and Management Act to provide for multiple uses of the public lands; identify actions to protect resources; and avoid or minimize environmental harm.

California Department of Fish And Game

The Department of Fish and Game is directed under the California Public Resources Code, Section 515, to produce and submit a general plan for each land acquisition, which has been classified or reclassified by the State Park and Recreation Commission. Effective January 2002, Bill AB1414 amended the current laws to require the Department of Fish and Game to submit land management plans to better address resource, habitat, and species for state-held lands.

The management plans will address the goals and strategies for managing the land; and identify and describe both ongoing and any necessary restoration, rehabilitation, and improvement projects for the land. These goals and strategies also include enforcement of the Federal Endangered Species Act and the California Endangered Species Act.

United States Fish and Wildlife Service

The Government Performance and Results Act of 1993 directs the U.S. Fish and Wildlife (USFWS) to publish a strategic plan, which covers a 3- to 5-year period. The main objectives of the USFWS are sustainability of fish and wildlife populations, habitat conservation, and providing recreation and enjoyment.

The National Wildlife Refuge System Improvement Act of 1997 instructs the Fish and Wildlife Service to protect and conserve the biological integrity, diversity, and environmental health of refuge lands, and to ensure the longevity of fish and wildlife species. Within the Upper Pit River Watershed, the USFWS oversees the Modoc National Wildlife Refuge.

California Department of Parks And Recreation

Achomawi State Park is administered by the California Department of Parks and Recreation. The California state legislature has delegated the responsibility of preparing the California Outdoor Recreation Plan to the California State Park and Recreation Commission. The Public Resources Code (Section 540) states the commission will produce a comprehensive recreational policy for the state of California.

The recreation plan is designed to meet specific program responsibilities of the federal Land and Water Conservation Act of 1965. This ensures that state parks receive financial assistance from the fund for outdoor recreation planning, acquisition of land and waters or interests in land and waters, and facilities development.

Private Land Designations

The four counties represented in the Upper Pit River Watershed each have their own unique land use designations and general plans. Government Code, Article 6, Chapter 3, Section 65,103, mandates that every county shall adopt, amend, and revise a general plan when deemed necessary.

The general plan is designed to identify both direct and indirect natural resource values. That is, in addition to identifying the direct economic commodity value of agricultural and timber production, it will identify non-economic values such as clean air and water.

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Section 4

Section 4
GEOMORPHOLOGY

TABLES

FIGURES

Section 4
GEOMORPHOLOGY

INTRODUCTION

Geomorphology is the study of landforms and the processes that create landforms, and fluvial geomorphology is the study of channel-forming processes. Understanding fluvial processes and the current condition of stream channels within the Upper Pit River Watershed is an important component of this watershed assessment.

Channel-forming processes include erosion, transport, and deposition. Erosion includes removal of sediment from hill slopes above the channel network as well as from channel banks and beds. Erosion within the channel may be lateral causing channels to get wider, or vertical causing channels to get deeper or to form gullies. Transport refers to the entrainment and movement of the material that is delivered to the channel, whether the material originates from within the channel or upslope. Channels transport water, sediment, and other materials such as wood and debris. Deposition of sediment, wood, and debris occurs when streams lose the physical capacity to transport the material. Deposition may occur within or above the channel.

The condition of the channel network in a watershed affects a wide variety of resources including the amount of water, sediment, and debris that the channel is capable of carrying; timing and duration of high-flow or flood events; health and vigor of riparian vegetation communities; water quality conditions including water temperature and turbidity; and habitat and passage conditions for fish and other aquatic organisms. Issues that precipitated the Upper Pit River Watershed Assessment are related primarily to water quality, specifically temperature, dissolved oxygen, and nutrient loading. Sediment and turbidity are also issues of potential concern. Channel condition and channel-forming processes directly impact these issues.

Glossary

A glossary of commonly used terms in fluvial geomorphology follows.

Accretion flow
In rivers and streams, the increase in discharge by gradual addition of flow from outside. Accretion may be from either surface flows or from groundwater or spring inflows.

Adjustment
Channel or watershed response to changes in input variables (such as water runoff or sediment input), disturbance, or pressure. Channel adjustments can include incision, widening, aggradations, or degradation, and change in channel form, to name a few. See also disturbance.

Aggradation
Channel-forming process in which the streambed elevation is raised, or aggraded, by the net deposition of sediment.

Alluvium
Sediment deposited by flowing water. Also, alluvial material.

Anastomosed Channel
Multiple-thread, distributary channels that typically occupy very low gradient valleys and delta regions. Slopes are less than 0.5 percent, and typically less than 0.01 percent (Rosgen, 1996). These channels are very stable over time. The banks and floodplains generally contain a high percentage of fine sediment, such as sand, silt, and clay, and organic material, such as peat. Anastomosed channels that are not associated with deltas are often in broad valleys and are associated with extensive wetlands and riparian vegetation. Often, these systems remain stable because the rate of vertical accretion is balanced by a similar rate of subsidence, due to tectonic activity such as the normal faulting that is common throughout the Modoc Plateau. Compare to braided channel and distributary channel.

Bankfull
The stream discharge, or flow, at which water begins to spill out of the banks in a properly functioning channel system and onto a floodplain or flood prone area. There are numerous measurements of channel geometry, or shape, related to the bankfull discharge. Use of comparative measures, for example of channel width to valley width in determination of confinement (see confinement), refer to channel width at bankfull flow.

Bedload
The portion of the solid sediment load that is supported by the unmoving streambed and by intermittent contact with other moving solids supported by the streambed. Modes of movement of these particles include sliding, rolling, and "hopping".

Braided Channel
Braided channels typically appear as multiple thread channels at low-flow conditions, but often appear as one broad channel that may fill a valley bottom during floods. Although the banks at the edges of the active channel or valley walls may be stable, the individual channel braids lack cohesive banks. The streambeds of braided channels are very unstable, typically as a result of very high bedload supply, and shift planform almost constantly. Compare to anastomosed channel and distributary channel.

Colluvium
Accumulation of soil and rock on hill slopes, in hollows, and at the base of cliffs. The accumulation is the result of hill slope processes, not deposition from running water.

Confinement
Confinement is an index of the degree to which a channel is free to move laterally (i.e., sideways). For the purposes of this assessment, a confined channel was defined as having a valley width less than two times the channel width; moderately confined channels have a valley width between two and four times the channel width; unconfined channels have a valley width greater than four times the channel width. Channel width refers to bankfull.

Debris Flow
Downslope movement of a mass of unconsolidated material that has been sufficiently liquefied (e.g., by precipitation) or vibrated (e.g., by earthquake) that "substantial internal deformation (i.e., change of shape) accompanies the movement" (Wohl, 2000). Compare to landslide.

Degradation
Channel-forming process in which the streambed elevation is lowered, or degraded, by the net removal of sediment (see incision).

Distributary Channel
Relatively smaller channels that branch off of a mainstem channel as it flows into an unconfined area, such as a meadow, delta, or alluvial fan. These channels may or may not be very stable in place and over time. Compare to anastomosed channel and braided channel.

Disturbance
Channel disturbances are events or changes in input variables resulting from events that are substantial enough to have physical manifestations in the channel network. Disturbances are likely to result in immediate morphological channel adjustments. These events may be either natural or human caused or a combination of the two. The resulting adjustments may be short-lived and localized or they may persist for years or decades and propagate upstream or downstream from the point of initiation.

Fluvial
Formed, produced by, or associated with the action of flowing water.

Incision
Erosion of the streambed and net export of the eroded material that result in a lowering of the elevation of the streambed. Incision results in separation of the channel and floodplain, such that normal inundation of the floodplain happens less frequently than it should. Incision can ultimately lead to a complete disconnection between channel and floodplain.

Landslide
Downslope movement of a mass of unconsolidated material along a discrete failure plane without internal deformation or change of shape (Wohl, 2000). Slides may occur as slumps in which the failure plane is curved, or as blocks along a straight failure plane. Compare to debris flow.

Perturbation
Perturbations are changes in channel input variables that do not immediately produce any physical manifestation in the channel network, but which may either individually or in combination with other perturbations apply enough pressure to the channel system to result in morphological adjustments.

Response Reach
Channel reaches that are likely to exhibit pronounced and persistent morphologic adjustments to changes in sediment supply or other disturbance or perturbation.

Source Reach
Channel or hill slope areas with slopes greater than 20 percent. These areas are likely to store colluvium and be subject to mass-wasting events, such as debris flows and landslides. Channels in such high slope areas are generally debris-flow-dominated channels.

Suspended Load
The fine fraction of sediment in transport that is mixed "intimately" with the flowing water (Leopold, 1994). Suspended load tends to make water muddy. As water becomes less turbulent, sediment in suspension will begin to settle out. As long as there is at least intermittent turbulence, however, these particles remain in suspension.

Thermal Stratification
In lakes, ponds, or reservoirs, heating by the sun may result in the formation of a layer of warm, low-density water at the surface of the water body, a cool, dense layer at the bottom of the water body, and a transition zone between them called a thermocline. Because of the distinct density difference between the two layers, they are very resistant to mixing and will usually persist until there is not enough solar heating to maintain the warmer temperature in the upper layer.

Thermocline
In lakes, ponds, or reservoirs that experience thermal stratification, the thermocline is the thin, middle layer that separates the warm water of the epilimnion and the cold water of the hypolimnion.

Transport Reach
Channel reaches that have a high enough slope (i.e., 3–20 percent) to act as a conduit for rapid sediment transport and delivery to downstream reaches.

Geomorphic Province

Geographic regions are commonly divided into geomorphic provinces based on dominant topographic structures and recent geologic history (Norris and Webb, 1990). Because the physical characteristics of a geomorphic province may have a significant bearing on channel characteristics, a brief description of the geomorphic province that encompasses the Upper Pit River Watershed follows.

The Upper Pit River Watershed, from the headwaters to the historical confluence with Fall River, is within the Modoc Plateau Geomorphic Province. The Modoc Plateau is bordered on the west by the Cascade Range, to the south by the Sierra Nevada, and to the east by the Basin and Range geomorphic provinces. The headwater tributary streams of the North Fork and South Fork of the Pit River drain the Warner Mountains, which form the boundary between the Modoc Plateau and the Basin and Range geomorphic provinces.

The Modoc Plateau is a volcanic highland that covers about 41,000 square kilometers (16,000 square miles) in northeastern California and south-central Oregon. It is a geologic transition zone comprising overlapping features of the Basin and Range to the east, Cascades to the west, and high lava plains to the north (Montgomery, 1988). The dominant feature of the Modoc Plateau is the thick accumulation of late Cenozoic volcanic deposits. These volcanic rocks, along with interbedded sedimentary deposits, are several thousand meters thick (MacDonald, 1966; Fuis et al., 1987; Montgomery, 1988). Upper volcanic strata of the Modoc Plateau are largely tholeiitic (high silica content) basalt associated with the flood basalt of eastern Oregon and with more recent Basin and Range volcanism (MacDonald, 1966; Fuis et al., 1987; Montgomery, 1988). These flows of highly fluid basalt typically erupted from fissures and flowed down into valleys forming broad flat surfaces. Lower strata are dominantly andesitic and are associated with an earlier period of Cascade volcanism, when the Cascade Range axis was east of its current position (MacDonald, 1966; Fuis et al., 1987; Montgomery, 1988). Basin and Range–style normal faulting cuts across much of the volcanic strata of the Modoc Plateau, but the topographic expression is relatively subdued and the faults are highly fragmented compared to faults in the Basin and Range Province (Montgomery, 1988).

General hydrologic characteristics of the Modoc Plateau Geomorphic Province include low rainfall (average annual precipitation of 12.5 inches at Alturas), high evaporation (average annual pan evaporation of 50.5 inches at Alturas), and large areas of poorly defined drainages.

Hydrogeology

The Upper Pit River is a runoff-dominated river with substantial snowmelt from the Warner Mountains. Flows are augmented by spring discharge in some reaches. As the Upper Pit River crosses the Modoc Plateau, it loses water through its stream channel to the underlying groundwater. Often, a channel that loses water is identified as a losing reach or channel. Although the portion of the Upper Pit River that loses water is poorly defined, MacDonald (1966) concluded that stream segments above about 4,000 feet above mean sea level (amsl) lose water, while stream segments below 4,000 feet amsl gain water (i.e., water from the groundwater reservoir enters the channel). For reference, Bieber is at an elevation of 4,127 feet amsl. Norris and Webb (1990) concluded that the Upper Pit River and its tributaries lose water to groundwater from Goose Lake to Fall River.

Large, high-volume springs are formed at the edge of the Modoc Plateau where the porous, highly fractured, volcanic rock layer rests on top of a layer of less permeable lake deposits (Norris and Webb, 1990). Springs associated with the Fall River system collectively produce a nearly constant discharge of approximately 1,100 to 1,200 cubic feet per second (USDA, 2002). This system is among the largest freshwater spring systems in the United States (Meinzer, 1927). Throughout much of the year, the addition of Fall River water increases the discharge of the Pit River by an order of magnitude.

METHODS

Data Sources

Digital elevation model (DEM) data obtained from the U.S. Geological Survey (USGS) were used to delineate stream channels throughout the watershed. A set of stereo aerial photographs taken in 2001 covering most of the watershed was obtained from U.S. Bureau of Land Management (BLM) office in Alturas. Additional aerial photographs from 1967 were obtained from the U.S. Forest Service (USFS) office in Alturas. The USFS also provided proper functioning condition (PFC) assessment data for individual stream segments under their administration. The Central Modoc Resource Conservation District provided data on additional stream segments.

Assessment Methodology

The stream channel network was evaluated using assessment procedures developed by the Washington State Forest Practices Board (DNR, 1997). Although the DNR methodology was developed for timbered watersheds, it is broadly applicable to steep and timbered areas or agricultural areas. The DNR stream channel assessment methodology outlines several assessment levels depending on the desired goals of the analysis. The channel assessment procedures used for the Upper Pit River Watershed followed the Level 1, or lowest assessment level. A Level 1 assessment is defined as a "reconnaissance assessment, relying predominantly on maps and remotely sensed information with some field checking."

The Level 1 assessment procedures were modified to account for the large size of the study area and large number of tributary watersheds. Although it is generally considered more accurate to calculate channel slope manually from topographic maps (DNR, 1997), DEM data were used to delineate channel slope ranges for this assessment. Other modifications to the DNR methodology were associated with data management. Whereas the DNR Level 1 assessment is paper-based, information obtained for this assessment was input directly into a digital spreadsheet.

Data Analysis

The Level 1 assessment calls for the division of the channel network into slope ranges of greater than 20 percent, between 3 and 20 percent, and less than 3 percent. These slope ranges divide the channel network into areas that are likely to respond similarly to changes in input variables.

Channels and unchanneled areas with slopes greater than 20 percent are classified as source reaches. These very steep slope areas are likely to be dominated by mass-wasting processes (e.g., debris flows, landslides, etc.) and contribute sediment and debris to stream channels downstream or downslope. Channels with slopes between 3 and 20 percent are classified as transport reaches. Both mass-wasting and fluvial processes may significantly influence these moderate-to-steep reaches, but the channel slopes are steep enough to transport the sediment and debris. Channels with slopes less than three percent are classified as response reaches because they are "likely to exhibit pronounced and persistent morphologic adjustments to changes in sediment supply" (DNR, 1997).

In addition to the three slope ranges listed above, the channel network was further divided into finer slope-based ranges for future use. A summary of the slope ranges and response potentials are summarized in Table 4-1.

Table 4-1
CHANNEL SLOPE RANGES, RESPONSE POTENTIALS
TYPICAL BED MORPHOLOGIES

Slope Range (percent)	Response Potential	Typical Channel Bed Morphology
>20	Source	Colluvial
8–20	Transport	Cascade
4–8	Transport	Step-pool
3–4	Transport	Plane-bed, forced pool-riffle
2–3	Response	Plane-bed, forced pool-riffle
1–2	Response	Pool-riffle, plane-bed
<1	Response	Pool-riffle, regime

Channel response potential is also affected by channel confinement, which is the degree to which the channel and floodplain are contained by valley walls or hill slopes that restrict flood dissipation. The more confined the channel, the more the channel bed and banks are subjected to higher flood energies. A low-gradient channel that is highly confined, for example, may respond more like a transport reach than a response reach.

Channel reaches were divided into three confinement categories including unconfined (i.e., valley width greater than four times the channel width), moderately confined (i.e., valley width between two and four times the channel width), and confined (i.e., valley width less than two times the channel width). Classifications of confinement were completed using topographic data included on the plot maps and on the stereo aerial photographs. Topographic data were adequate to ascertain that channel reaches in the broad flat valleys were unconfined. Most other confinement classifications were made based on the aerial photographs.

Additional stream segment breaks were made at major tributary confluences when slope and confinement would not otherwise have dictated a segment break. This approach was used to account for the potential significance of tributary input to a mainstem that may not be reflected by slope or confinement.

All of the stream channel segments delineated using slope and confinement were numbered, starting at the downstream end of the watershed and continuing up the mainstem channel as far as possible (i.e., until it forked into the north and south forks). After that, the tributaries were numbered in similar fashion starting from the downstream end of the watershed. Finally, the river mile designations, which had been assigned previously by the geographic information system (GIS), were merged with the segment numbering system.

The channel network maps with river miles, slope, and confinement delineations were examined. Each segment was assigned a number, slope range, discrete upstream and downstream endpoints, and confinement classification. These data were entered into a database. Subsequently, the stereo aerial photographs were examined to find signs of adjacent, local, or upstream disturbance or channel adjustment. Signs of disturbance and adjustment were assigned to the individual segments in which they could be ascertained and these data were entered into the database. Assessment of conditions was limited to areas for which aerial photographs existed.

To facilitate data management and interpretation, the study area was divided into watershed subunits: (1) lower mainstem Pit River and its tributaries (from the Fall River confluence to upstream of Stone Coal Creek); (2) upper mainstem Pit River and its tributaries (from upstream of Stone Coal Creek to the confluence of the North Fork and South Fork of the Pit River); (3) North Fork of the Pit River and its tributaries; and (4) South Fork of the Pit River and its tributaries. These subunits were based on geography (North Fork and South Fork subunits) and on previous work conducted by Moyle and Daniels (1982).

Data Comparison

Available data from cooperating agencies and other entities were compared to the information compiled in the database, to corroborate and fine-tune the assessment of channel conditions. Because this is a Level 1 assessment, detailed site-specific data were not collected. Where field data and other observations were available, however, they were incorporated into the database.

RESULTS

Channel Delineation

River miles were digitally assigned to the mainstem Pit River, beginning with zero at the confluence of Fall River and increasing upstream. River miles were also assigned to each tributaries starting with zero at their confluences and increasing to their upstream ends.

Excluding tributaries not included in the digital database, the channel assessment included 601 miles of delineated channel. Generally, the tributaries that were not included were small and likely to be minor players in the overall channel condition of the watershed.

The lower mainstem Pit River subunit accounted for 263 miles of delineated channel. The upper mainstem Pit River subunit contained 113 miles of channel. The North Fork of the Pit River subunit contained 99 miles of channel. The South Fork of the Pit River subunit contained 126 miles of channel.

Channel Slope and Confinement

Source, transport, and response slope classifications for the Upper Pit River Watershed channel network are shown in Figures 4-1a though 4-1d. These results are summarized by river mile and watershed subunits on Figure 4-2. A more detailed breakdown is shown on Figure 4-3. Slope confinement categories are summarized on Figure 4-4.

Of the 601 miles of channel in the study area, 455 miles (76 percent) were response channels and 142 miles (24 percent) were transport channels. Only four miles of channel (<1 percent) were classified as source channels; these were almost entirely located within the tributaries of the North and South Fork of the Pit River subunits. The North and South Fork of the Pit River subunits, as expected, have a higher proportion of moderate-to-high gradient channel that was classified as transport channel. Although the lower mainstem Pit River subunit contains more than twice the channel distance of the upper mainstem subunit, the proportions of response and transport channel types are similar, both containing 84 percent response channel and 16 percent transport channel. The large majority of response-type channels, 313 miles or almost 70 percent of the 455 miles of response channel, was unconfined.

One of the premises of the DNR methodology is that unconfined response-type channels are most susceptible to disturbance or perturbation. This is due to a generally greater potential for bank erosion and channel widening or migration. For the same reasons, these channels are more likely to create perturbations to the system as a result of their adjustments. For example, banks in unconfined reaches are more likely to erode and release a large amount of sediment. This sediment may create a disturbance or perturbation in downstream reaches.

Disturbances and Perturbations

The 1967 and 2001 aerial photographs were reviewed to identify potential disturbances and perturbations. The primary disturbance or perturbation-causing features that could be identified included instream dams; channelized (straightened and leveed) channel reaches; diverted channels that were disconnected from their downstream reaches; channel reaches that were impinged by roads and railroads; logged areas; and an open-pit mine and spoil pile. No large-scale natural disturbances, such as large landslides, were noted in the inspected photographs. In areas where the 1967 and 2001 photographs overlapped, the same disturbances were visible. This similarity demonstrates that the major channel adjustments predate 1967.

Figures 4-5a through 4-5d show the distribution of the various types of channel disturbances or adjustments found in the channel network. This information is summarized on Figure 4-6.

A comparison of Figures 4-5a through 4-5d to Figures 4-1a though 4-1d illustrates that visible channel disturbances and adjustments were almost entirely within response-type channel reaches, and the majority of the disturbances were in the unconfined response-type channel reaches. This distribution is consistent with the premise that unconfined response-type reaches are the most susceptible to disturbance or perturbation.

Restoration Activities

Activities on National Forest lands have been focused on the restoration of channels that had significant levels of disturbance from historic uses. Many of the restoration projects have focused on habitat of the Modoc sucker (Federally endangered) and the Goose Lake redband trout (Forest Service sensitive). This restoration work has occurred in headwater streams where lateral and vertical erosion was causing headcutting, health and vigor of the riparian vegetation community was poor, and water quality was declining. Restoration activities ranged from the construction of enclosures to protect critical reaches of streams to structural improvements (log weirs and juniper revetment) that were used in conjunction with changes in livestock management. More recent restoration has focused on vegetative treatments to reduce the risk of catastrophic wildfire and juniper management. The development of wetlands on National Forest lands has allowed control of the timing and duration of flows in limited areas of the Forest. The Warner Mountain Rangeland Project, which specifically focused on restoring watershed conditions on the Warner Mountains, was selected as a National Watershed Demonstration Project. It included changes in grazing strategies as well as upland treatments for watershed restoration, and a long-term, trend monitoring program. Forest effectiveness monitoring has showed that vegetative recovery in many of the formerly degraded channels has reduced water temperatures during critical times of the year and has changed discharge from many ephemeral streams to perennial flow.

The BLM, Central Modoc Resource Conservation District, and Fall River Resource Conservation District are also conducting restoration activities in the watershed.

DISCUSSION

The following description of channel types applies to ideal conditions, in other words, watersheds that have not experienced significant levels of disturbance or perturbation. The purpose of these descriptions is to set the stage for comparison of at-potential channel conditions versus the various conditions found in the Upper Pit River Watershed.

General Conditions

All natural channels are formed within the constraints set by the dominant geology and physiography of their watershed. A complex balance of water and sediment supply, erosive and resistance forces, and energy dissipation tendencies creates the channel morphologies within this framework (Leopold and Wolman, 1957; Church, 1994; Leopold, 1994).

Source reaches (i.e., channels that are greater than 20 percent slope) are dominated by colluvial processes. Sediment and other debris tend to accumulate in these channels, not as a result of running water (fluvial processes), but as a result of debris flows, landslides, soil creep, and other mechanisms related more to weathering and gravity.

Transport reaches (i.e., channels between 3 and 20 percent slope) exhibit a high variability of channel forms (Table 4-1). Generally, cascades dominate channels between 8 and 20 percent. The cascades may be vertical at some locations (e.g., at knickpoints where falling water has undercut a resistant rock outcrop), but may also fall along the hill slope gradient. These channels may be deeply entrenched within walls that range from bedrock to various types of unconsolidated colluvial material or they may be within shallow crenulations in a steep hill slope. Whatever the bank configuration, the steepness of the channel does not allow anything but very coarse substrate to remain, so channel beds are usually dominated by bedrock or boulders. In the four to eight percent slope range, channels are likely to have step-pool morphologies in which relatively short (typically vertical) cascades alternate with plunge pools. The spacing of the pools is inversely related to channel steepness: the steeper the gradient the shorter the distance between pools. Specifically, pool spacing is related to the ratio of step steepness (height/length of the step) to the average channel slope, which is commonly between one and two in free-forming step-pool channels (Abrahams et al, 1995). Pool lengths are typically on the order of only three to four channel widths (Church, 1994). Figures 4-7 and 4-8 illustrate typical configurations of high and moderate gradient transport-type channel. In the three to four percent slope range, the likely channel types are plane-bed and forced pool-riffle.

Plane-bed channels may vary in roughness (i.e., coarseness of dominant substrate and amount of coarse material protruding from the bed), but they lack alternate pool-riffle or step-pool morphology. Instead, the beds are more uniform and relatively flat in both cross-section and longitudinal profile. Forced pool-riffle morphology is commonly found in bedrock-controlled channels. Bedrock outcropping along one side of a channel commonly results in scour of mobile material that creates and anchors a pool adjacent to the outcrop. Material scoured out of the pool tends to deposit immediately downstream of the pool creating a shallow riffle. The length and spacing of pools and riffles are controlled by the location of the resistant outcroppings rather than sediment transport and energy dissipation processes of free-forming pool-riffle channels (Church, 1994). As a result, pools and riffles in this channel type may have very irregular lengths and spacing.

As with transport reaches, response reaches (i.e., channels with slopes less than three percent), which are the dominant channel morphology in the watershed, exhibit a variety of likely bed forms. The standard DNR channel assessment has a single slope range from two to four percent. As discussed previously, we split this range in half to avoid difficulties with overlap between transport and response channel types. The likely channel types associated with the two to three percent slope range, however, are the same as that of the three to four percent range: plane-bed and forced pool-riffle (see description above). In the one to two percent slope range, the likely bed morphologies include plane-bed (see description above) and pool-riffle. Pool-riffle beds are free-forming channels whose beds are constructed primarily of alluvium. The dominant features of these beds are the regularly spaced pools and riffles. The spacing of riffles and pools is found to be in close balance to channel dimensions; riffles and pools are typically spaced every five to seven bankfull channel widths (Leopold, 1994). Pool-riffle beds are also common at slopes less than one percent. Figures 4-9 and 4-10 illustrate common response type channel forms typical of low slope ranges. The other typical channel type associated with this slope range is regime bed.

Regime bed channels have sand beds and lack regular pool-riffle morphology. Regime beds typically do have bedforms such as ripples, dunes, and bars. Because of their low slopes and relatively lower sediment transport capacities, regime channels are among the most susceptible channel forms to perturbation and adjustment (Montgomery and Buffington, 1993). Figure 4-11 illustrates a relatively uncommon channel type; in other words, an anastomosed channel, which may have existed in very low gradient portions of the broad, flat valleys.

Regardless of slope range or channel form, channels in undisturbed conditions exhibit common proportional relationships between discharge and the key parameters of channel dimension, specifically width, depth, and velocity. These relationships, collectively known as hydraulic geometry, represent the central tendencies of channels to form based on the dominant hydrologic conditions and sediment supply and to accommodate the relatively uncommon high-flow events (Church, 1994; Leopold, 1994).

One of the key features of undisturbed channels is their ability to accommodate high-flow conditions without large-scale damage to their morphologies. Undisturbed channels almost universally possess floodplains or analogous flood-prone areas immediately above the top of their banks (Figures 4-12 and 4-13). By accessing these floodplains, excessive erosive forces of high-flow events are dissipated with a minimum of incremental force exerted against the channel banks and bed. The morphologies of these flood-prone surfaces vary with channel steepness, bed type, and channel size, but they all function the same way and are critical for a channel's ability to maintain itself.

Channel Adjustments

The following is a common type of adjustment feedback loop. Although this loop is not intended to describe exact events at any specific location in the Upper Pit River Watershed, there are signs that this type of adjustment feedback loop has been common in the study area.

In past decades it was common practice on grazing lands to remove riparian corridors from meadow channels in an effort to reduce potential loss of water due to transpiration by woody riparian species. Removal or alteration of the riparian vegetation can weaken the natural erosion-resistance of the stream banks by altering root depth and density. This can result in increased lateral (sideways) erosion of the banks and channel widening. Channel widening increases the capacity of the channel, so as this process progresses, more and more of the relatively frequent flood events become completely contained within the new resized channel. In undisturbed channels, runoff events with a recurrence interval of 1.5 to 2 years will flow over the channel banks and begin to inundate the floodplain. In doing so, excessive erosive forces of these high-flow events are minimized within the channel and absorbed by the floodplain, which in undisturbed systems is relatively unsusceptible to erosion. As the channel capacity increases with widening, more and more erosive forces are directed at the bed and banks. Lateral erosion is likely to continue. In addition, vertical erosion (i.e., incision) is likely to start, making the channel deeper, and further exacerbating the problem of high-flow containment. With fewer high-flow events reaching the elevation of the floodplain, it is inundated much less frequently. This commonly results in a reduction in plant vigor and productivity. In addition to reducing plant productivity on the meadow, as the base water-surface elevation drops below the meadow surface, any tributaries that join the stream in the meadow will begin to adjust their base flow elevations. This adjustment typically takes place rapidly and dramatically in the form of headward erosion (i.e., headcutting or gullying) of the tributary stream. Ultimately, as these adjustments continue, there may be a complete or nearly complete disconnect between the channel and the meadow surface, which leads to a shift in vegetation type from wet meadow to dry meadow species and significant loss of grazing productivity. In addition to the onsite degradation of the channel and other resource conditions, the formerly stable reach becomes a net source of sediment to the channel network downstream. The channel degradation is also likely to propagate upstream in the main channel as well in the form of headward erosion. The adjustments within the reach become perturbations and ultimately disturbances that work in both directions away from the initial perturbation.

This adjustment feedback loop may take several decades or more before reestablishing some quasi-equilibrium within the reach. In the mean time, a significant volume of soil may be eroded from the meadow, hydrologic conditions will be altered within the reach as well as downstream and potentially upstream, quality of habitat conditions for wildlife and domestic species will generally be reduced, and the economic value of the land may be reduced. Figures 4-14 and 4-15 illustrate some common channel adjustments in both transport and response type channels. These illustrations show channels that have become net sources of sediment by way of channel incision and/or widening.

Upper Pit River Conditions

Major sediment sources in the Upper Pit River Watershed prior to human-caused disturbances are likely to have been the tributaries to the North Fork and South Fork of the Pit River. Sediment load reaching the forks of the Pit River would have been primarily gravel and smaller-size bedload and suspended sediment. The low-gradient forks and mainstem of the Pit River would not have transported much bedload for a very long distance. Suspended sediment, however, would have been carried much greater distances into the valley reaches.

The large valleys would have experienced frequent flooding, but because of their size and ability to attenuate flood flows and dissipate energy, smaller flood events may have been virtually undetectable in the extensive floodplains created by these valleys. Except at its downstream end, Warm Springs Valley is at least one mile wide and averages about three miles wide. Big Valley has a minimum width of about four miles and a maximum width approaching 20 miles. The following statement from an article in the February 5, 1870 edition of the Shasta Courier (Shiolet 1988) provides an excellent summary of these at-potential conditions: "The Pit River runs with slow current through its center, and a portion of the valley is subject to overflow during the rainy season. But when the water recedes in the spring, the land which it covered in the winter is quickly clothed with a rank of vegetation". Based on still-visible channel remnants types, these valleys likely contained swamps or wetlands near the channels. The remnants of multiple, large tortuously meandering channels in Big Valley and Warm Springs Valley indicate significant portions of the mainstem Pit River in these valleys may have been anastomosed channels. The historic channel conditions demonstrated by these large, well-defined, tortuously meandering remnants, whether or not they were anastomosed, suggest the existence of perennial flow in the valley channels prior to irrigation development. Such conditions are extremely unlikely to have occurred in a system that naturally dried up for a substantial portion of the year, particularly during the region's short summer growing season.

Under these conditions, temperature and suspended sediment load (Moyle and Daniels, 1982) would have been lower than under present conditions. A large proportion of the present-day suspended sediment load in the study area is derived from stream banks within response reaches. Prior to disturbance, the stream banks would have been both more resistant to erosion and subjected to lower erosive pressure.

Disturbances and Perturbations

Disturbances and perturbations can occur as man-caused or natural processes in a watershed. Severe storms for example, may result in disturbances such as debris flows, landslides, and large-scale tree blow-downs that are substantial enough to cause geomorphic channel adjustments. An example of a natural perturbation would be a lightening-caused wildfire resulting in a change in storm runoff rates or an increase in sediment influx to a channel that begins to push the channel network out of its old balance and toward a new one.

Generally speaking, human-caused disturbances or perturbations are much more effective at causing systemic geomorphic channel adjustments than most natural disturbances. This is true even when the mechanisms (for example, fire) are identical. Part of the difference is that many human-caused disturbances or perturbations are ongoing and widespread, causing cumulative impacts that are more complex than naturally occurring perturbations.

Events that create watershed perturbations or disturbances include, but are not limited to, fire; severe storms; tectonic activity; flooding; grazing; logging; agriculture; roads; dam construction; water diversion; stream channelization; mining; and urbanization.

Fire

Fire deserves some specific discussion in its role as a disturbance/perturbation. Natural wildfires are among the agents that can cause disturbance within a watershed. Fire may also, however, be an intentional, human-caused disturbance or perturbation. In addition, fire has a greater potential to cause disturbance or perturbation since the advent of fire suppression as a forest management practice early in the twentieth century. Fire suppression has resulted in widespread overaccumulation of fuels throughout the forests in the west. Now, when wildfires ignite, they burn with much greater intensity and are more detrimental to the ecology than they would have been before fire suppression. High-intensity burns are more likely to result in disturbance or perturbation than presuppression wildfires that burned in more open forest stands with lighter fuel loads (see Section 11).

Roads
Roads can also create significant watershed perturbations by channel impingement and increased sediment supply, leading to bank instability and sedimentation (i.e., sediment deposition and reduction of dominant substrate sizes within the channel). Failure of road crossings, particularly culverts, can cause disturbances including, bed and bank erosion and change in channel course. Ungated roads may also promote erosion by allowing vehicles into areas that should be closed seasonally because of sensitive conditions.

Dams and Diversions
Jurisdictional dams began to be constructed within the Upper Pit River Watershed as early as the 1880s. There are presently 63 jurisdictional dams and an unknown number of smaller dams and reservoirs in the study area. Instream dams are very common along the mainstem and forks of the Pit River and may result in a variety of different effects. Although instream dams are normally associated with negative impacts from the standpoint of channel form and function, they may also have a nonnegative impact under the current conditions. The water surface elevations in these dammed sections are kept artificially high to allow for improved use of the water. This creates a de facto connection between the channel and the meadow (floodplain) surface that has otherwise been disconnected by channel incision. This connection, however, does not provide the benefits of a true channel/floodplain connection, including dissipation of erosive flood flow energies (protection of the banks and bed), groundwater recharge into the meadow during floods, or soil enrichment from sediment deposition during floods, to name a few. This connection maybe protecting the stream banks from excessive channel widening by maintaining the riparian vegetation in better condition than expected in an incised channel and providing some groundwater recharge through the banks. Channel conditions in the valleys might have gotten considerably worse over the past 100-plus years than they did if all reservoir storage had been off-channel.

In-channel dams, as well as diversions and off-channel reservoirs also create passage barriers for fish preventing them from moving either upstream or downstream. Permanent barriers can prevent fish from moving in and out of seasonally critical habitat, such as spawning tributaries. Seasonal barriers, on the other hand, can result in entrapment problems for fish isolated within impounded waters.

These conditions may limit the natural abilities of fish to escape localized suboptimal habitat conditions, for example during the warm season, and access spawning tributaries (in the case of disconnected channels). Fish passage barriers may also have isolated populations and eliminated gene flow of Modoc suckers, which appear to be restricted to a few tributaries. In channelized areas, habitat diversity has been reduced, which is likely to have reduced the diversity and resiliency of the trophic web in the system.

Cases where fish passage barriers may be beneficial typically occur in disturbed watersheds where invasive, non-native fish or other aquatic species may pose a threat to native species. Specialized native species are often at a disadvantage compared to more aggressive invasive species and are at risk of displacement and replacement if non-native species migrate into key habitat areas. Instances in which natural or artificial barriers have benefited native species include Shasta crayfish in the Fall River drainage (Ellis, 1999), and golden trout in the upper Kern River basin, southern Sierra Nevada (Thelander, 1994).

The many in-channel dams in the mainstem Pit River during the irrigation season create a string of impoundments that may have more in common with pond habitat than stream or river habitat: they are deeper and slower-moving than natural stream habitat. The artificial depth, longer water residence time, and repeated diversion and return of irrigation water to the channel can result in heating of the upper layer of water leading to thermal stratification within the impoundments. Thermal stratification can maintain cooler temperatures in the lower layer than could be maintained without stratification. This condition may benefit fish that are intolerant of warm water conditions. On the other hand, high photosynthetic productivity in these reaches lower dissolved oxygen levels that may negatively impact cold-water fish species.

The construction of off-channel reservoirs or the diversion of stream flow to a reservoir on a neighboring subdrainage can also create a disconnection in the channel network. Such disconnections not only create fish passage barriers, but also disrupt or eliminate normal channel processes, such as sediment transport, that can be critical to channel and fish spawning habitat maintenance. It is likely that the disconnection of drainages in the Upper Pit River Watershed, including Parker Creek, Pine Creek, Fitzhugh Creek, and Big and Little Juniper creeks has resulted in reduction of bedload sediment to the forks of the Pit River, fining (reduction of average particle size) of the existing bed material, and reduction of spawning potential for fish, such as trout, in these areas.

Another adjustment, namely the increased mining of sediment from meadow channel banks and beds may have exacerbated substrate fining in the mainstem Pit River. Although it is likely that meadow channel beds in the mainstem Pit River were dominated by fine sediments prior to disturbance, post-disturbance channel incision and widening combined with nearly continuous impoundments have likely resulted in substantial fine sediment retention in the reaches.

Suspended sediment transport is practically universal in river systems and fish have adapted to a certain degree of turbidity and silt deposition. Suspended sediment levels may be critical, during spawning periods. While adult fish may be able to move away from excessive suspended sediment levels (assuming there are not barriers), their eggs cannot; silt deposition can cover the eggs and inhibit oxygen exchange to the developing fish embryos (Hynes, 1979).

Surface Water Flows

Surface water allocations for the major tributaries, including the North and South Forks of the Pit River (1939 and 1934, respectively), Pine Creek (1933), and Rattlesnake Creek (1934) were established during the 1930s drought. Water rights in Big Valley were established shortly after the area was settled in the early 1870s.

Pre-irrigation development flow conditions in the Upper Pit River Watershed cannot be determined directly from available data. Hydrologic data are not available prior to 1904 when the Tule Lake reservoir with a capacity of 39,500 acre-feet, the second-largest reservoir in the system, was constructed. Rutter (1908) pointed out that the South Fork of the Pit River had been "almost drained" by 1898. Despite the absence of pre-irrigation development flow measurements in the upper watershed, pre-irrigation flows can be estimated using available flow data in conjunction with available diversion data. The California Department of Water Resources (DWR) estimated annual unimpaired flow at Canby between 1919 and 1954 at 360 cfs (260,000 acre-feet per year). Unimpaired annual flow estimates based on more recent USGS flow data are 398 cfs at Canby (288,000 acre-feet per year) and 705 cfs at Bieber (510,000 acre-feet per year).

Typically, there is a strong snowmelt component to the hydrograph in the upper watershed from the Warner Mountains. Peak discharges are normally in the late winter and spring. Figures 5-20 through 5-23 show pre- and post-irrigation development hydrographs averaged from available data for Canby and Bieber. These graphs give a reasonable representation of the timing of the runoff hydrograph. As they were compiled from available hydrology data, however, they may not fully represent pre-irrigation development flow conditions.

Figure 5-19 shows the recurrence intervals for peak annual flows in the Upper Pit River at Canby. The peak flow associated with the two-year recurrence interval is just over 2,000 cfs, which is slightly higher than the discharge generally considered to be the bankfull stage. In an undisturbed channel system, water begins to overflow the banks at the bankfull flow and inundate the floodplain. This means that prior to adjustments, such as widening and incision, any discharge higher than 2,000 cfs would have caused flooding on the meadow floodplains.

At-Risk Channel Segments

Generally speaking, the most at-risk channel types in the study area are the lowest-gradient, unconfined channels. This channel type may be found throughout most of the watershed, with the exception of the steepest headwater tributary reaches. Low-gradient, unconfined channels are most prevalent, however, in the broad valleys of the study area (Figures 4-1a through 4-1d). Most of these areas already exhibit evidence of disturbance or perturbation and channel adjustment (Figures 4-5a through 4-5d and Figure 4-6), and are at continued risk.

Channels downstream of disturbed, perturbed, or adjusting channels are at risk, due to adjusting reaches upstream. Within the watershed, most susceptible channels are already adjusting. There are portions of the mainstem downstream of adjusting valley reaches that appeared to be at potential, despite the adjustments occurring upstream. These reaches were in confined canyons between Turner Creek and Stone Coal Creek and between Big Valley and the Fall River Valley area. Although the slope of the channels in these reaches classify them as response reaches, it is probable that the confinement and resistant geology of the canyon reaches makes them act more like transport reaches; these reaches are relatively unsusceptible to perturbation. They may temporarily accumulate sediment from the adjusting reaches upstream, but then transport it through during high flow events without any noticeable geomorphic adjustments.

Unusual Watershed Conditions

Some unusual geomorphic conditions were noted in upland areas of the watershed during the aerial photography inspection. Specifically, in the middle reaches of Little Juniper and Fitzhugh Creeks (South Fork of the Pit River subunit), an area was located in which water collected on an upper plateau and flowed over a fault scarp through a distinct channel onto a lower plateau, on which the flow again dispersed and fanned out. Although conditions were dry when the aerial photographs were taken, these fanning patterns were clearly visible on the ground. Prior to human intervention, portions of this unchanneled flow ultimately ended up draining both northward into Fitzhugh Creek and southward into Little Juniper Creek. Presently, the flow across this unchanneled feature is funneled by a levee into Little Juniper Creek. It is not uncommon to have channels that flow intermittently (i.e., flowing water existing in disconnected parts of the channel, but not throughout the channeled reach), but it is less common to see drainages change back and forth between unchanneled and channeled sections.

Data Limitations

Stereo aerial photography coverages (digital files) from 2001 (the most recent) and 1967 (the oldest known available) were selected for review in order to maximize the differences in channel conditions that might be detectable. Because of differences in geographical focus of these two coverages, however, there was less overlap in key portions of the channel network than anticipated. Furthermore, because much of the watershed was not covered by both sets of aerial photographs, the photographic evaluation did not cover the entire watershed.

The channel slope delineation "found" a large number of very short distances of the lowest slope range (i.e., less than 1 percent slope). Such short stream distances (e.g., less than 0.05 miles) of low slope are unlikely to be truly accurate given the DEM resolution issues. However, this potential anomaly had no significant impact on the conclusions of this assessment as these short segments were usually combined with larger segments that were still classified as response-type channel segments.

Reliance on the DEM data also resulted in not all tributaries being included in the network. The tributaries that were not included were likely to be small, relatively minor players from the standpoint of overall watershed condition, but future efforts should attempt to identify any such tributaries to verify their condition and potential significance to other reaches.

Assignments of channel disturbance and adjustment attributes to the GIS were made by segment, not by specific river mile location. As a result, use of the GIS to determine what segments contain different disturbances or adjustments will yield accurate results, but these data are not precise from the standpoint of exact locality within the channel segment.

CONCLUSIONS

This geomorphic channel assessment was created as a tool to help stakeholders and resource managers understand the channel-forming processes that are operating in the watershed, the importance of channel function, and the potential repercussions of perturbations, disturbance, and improperly functioning channels. The results should help identify at-risk areas and direct future investigations of site-specific channel conditions. This assessment was reconnaissance-level, based primarily on remote data. Despite some data limitations and data availability issues, as discussed above, the available data provided a solid, representative assessment. The delineated response type channels are reliable for this level of assessment. The channel disturbances and perturbations identified are accurate, as are the identified segments in which they are located.

Using the channel assessment, one can with reasonable accuracy identify areas that have been affected by disturbance or perturbation, areas that maybe at risk (i.e., stream reaches downstream of adjusting reaches), and areas in which channels are functioning at potential. More detailed site-specific field data collection will be necessary, however, as part of any higher-level assessment or implementation of resource management measures. Reaches that appear to be functioning at potential may still have disturbances and/or perturbations, upstream or upslope, and site-specific restoration or improvement efforts may well be justified in these areas. Watersheds and stream channels do not fit well into one-size-fits-all or cookbook remediation schemes; site specific data must always be collected and analyzed.

Based on percentages of channel response types, the North Fork of the Pit River subunit is the least susceptible subunit in the study area to disturbance, although it must still be considered susceptible. There is a relatively small amount of source reach and nearly 50 percent of the reach is transport channel, which is relatively resistant to disturbance and perturbation. Still, more than 50 percent of the subunit is response-type channels, which are susceptible.

The rest of the study area subunits contain at least 70 percent response-type channels, with the mainstem Pit River subunits containing 84 percent response channels. On average, response-type channels accounted for 76 percent of the delineated channels in the watershed. These subunits are very susceptible to disturbance or perturbation.

In addition, the lower the confinement of the lower slope channel areas, the more susceptible they are to disturbance and adjustment and the more likely they are to become perturbations to the system if they are destabilized. A large majority of the response reaches are also unconfined.

Evidence could not be gained from the aerial photographs showing upward or improving trends in channel condition, although such evidence is more difficult to see than downward trends. Also, the majority of the channel restoration projects completed to date have been along tributaries not included in the aerial coverage. In general, channel conditions in the tributaries were better than in the mainstem.

This assessment indicates that some channel reaches in the Upper Pit River Watershed are in an impaired condition. There has been an increased awareness of the importance and benefits of a healthy functioning watershed, both from an ecological and an economical standpoint. There has also been an increase in the cooperative planning and funding of resource improvement projects. Overall, based on the results, it is certainly possible to improve management practices to reduce disturbance and perturbation potential in the Upper Pit River Watershed.

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Section 5

Section 5
HYDROLOGY

TABLES

FIGURES

Section 5
HYDROLOGY

Basic information about the surface water and groundwater hydrology of the Upper Pit River Watershed is presented in this section. The surface water portion includes a discussion of the general watershed characteristics, reference conditions, surface water runoff, dams, diversions, and water rights. The groundwater portion includes a discussion of key groundwater basins, groundwater extraction and water use, and groundwater regulations

SURFACE WATER HYDROLOGY

A portion of the hydrologic data presented in this section is based on the water year calendar. A water year begins on October 1 and ends 12 months later on September 30. Each water year is designated by the calendar year in which the 12-month period ends. For example, the third highest instantaneous peak flow recorded along the main stem of the Pit River occurred at Canby on December 11, 1937. Based on the water year calendar, this event occurred in 1938.

Watershed Characteristics

The Upper Pit River Watershed is located in northeastern California at the eastern edge of the Great Basin Province. The general vicinity of the watershed is shown in Figure 1-1. The North and South Forks of the Pit River drain the northern portion of the watershed. The North Fork of the Pit River originates at Goose Lake, an enclosed basin, except during rare events when it spills over into the Pit River. The North Fork headwaters include a number of tributaries in the Warner Mountains. The South Fork of the Pit River originates in the southern Warner Mountains at Moon Lake in Lassen County. The North and South Forks of the Pit River converge in the town of Alturas and then flow in a southwesterly direction into Shasta Lake in Shasta County, and hence into the Sacramento River. The southern limit of the Upper Pit River Watershed is marked by the confluence of the Pit River and Fall River in eastern Shasta County.

As defined by the Pit River Watershed Alliance, the Upper Pit River Watershed encompasses approximately 3,415 square miles. It is important to note at this point that the Upper Pit River Watershed, as defined by the Pit River Watershed Alliance, and the Upper Pit River Hydrologic Unit, as defined by the U.S. Geological Survey (USGS), are different. As mentioned, the Upper Pit River Watershed encompasses approximately 3,415 square miles and USGS Hydrologic Unit 18020002 encompasses approximately 2,440 square miles (2003a). The boundary of the Upper Pit River Watershed as defined by the California River Assessment (CARA, 2003) is similar to the boundary of USGS Hydrologic Unit 18020002. The watershed boundary as defined by Pit River Watershed Alliance is shown in Figure 1-2, and major tributaries are listed on Table 5-1.

Elevation within the watershed varies from 9,833 feet above mean sea level (msl) at the Eagle Peak summit, located in the southeast portion of the Warner Mountains, to the Fall River Valley floor, elevation 3,200 feet msl.

The low gradient of valley floors throughout the watershed is attributed to the deposition of large amounts of volcanics. Abundant volcanic flows were often channeled into the relatively narrow valleys, which confined the flows. This confinement along with the inherent viscosity of the magma combined to form nearly flat valley floors throughout the watershed. The overall flat topography of the Upper Pit River Valley also plays a significant role in the ecological and physical characteristics of the river.

Table 5-1
MAJOR TRIBUTARIES
UPPER PIT RIVER WATERSHED

Region	Major Tributaries	Length (Miles)
North Fork	Parker Creek	21
	Thoms Creek	12
	Joseph Creek	8
South Fork	Pine Creek	27
	Fitzhugh Creek	15
	Big Juniper Creek	15
	Dry Creek	21
	Warm Creek	4
	Cedar Creek	11
	Mill River	27
Canby	Rattlesnake Creek	42
	Noble Creek	5
	Hot Creek	3
	Horse Creek	2
	Canyon Creek	18
	Cloverswale Creek	19
	Toms Creek	13
Lookout	Westlake Creek	4
	Turner Creek	4
	Stone Coal Creek	6
	Ash Creek	38
Fall River	Bull Run Slough	12
	Horse Creek	14
	Beaver Creek	22
	Fall River	15

Many of the numerous flat or gently sloping plateaus throughout the watershed were formed by more recent lava flows. Faulting subsequently broke up the plateaus, creating many uplifted sections that form the dominant ridges of the watershed. The uplifted sections are seen as mountain blocks, typically steep on one side and gently to steeply sloping on the other. General elevation bands and general slope classes are included as Figures 1-6 and 1-7, respectively.

Reference Conditions

Hydrologic data for the Upper Pit River Watershed prior to the turn of the century is limited. Assuming annual flows in the Upper Pit River correlated with annual flows in the Sacramento River, hydrologic conditions along the Upper Pit River prior to the turn of the century can be estimated from Sacramento River data.

In the Sacramento River watershed, multi-year droughts were recorded between 1912–13, 1918–20, 1929–34, 1947–50, 1959–61, 1976–77, and 1987–92 (DWR, 2000). The 1929–34 drought represents the most severe drought recorded. This historical record has been supplemented using tree ring data to estimate runoff in the Sacramento River between A.D. 869 and 1977 (Meko, et. al., 2001). This study was funded by the California Department of Water Resources (DWR) and was conducted at the Laboratory for Tree Ring Research at the University of Arizona. Based on tree ring data, the 1929–34 droughts were less severe than epic droughts experienced around 1150 and 1350. These epic droughts lasted more than 100 years.

The lowest recorded Pit River flows at Canby were in response to the 1929–34 (average annual flow of 19.7 cubic feet per second [cfs] in 1934) and 1987–92 (average annual flow of 25.8 cfs in 1992) droughts. More recently, precipitation and river flows recorded during the 2001 water year also reflect drought conditions. During 2001, annual precipitation in Alturas was the lowest on record (WRRC, 2003), and the annual flow in the Pit River at Canby was the third lowest on record (USGS, 2003a).

Sources of Data

Historically, USGS and DWR have maintained more than 25 surface water gauging stations within the Upper Pit River Watershed. These stations are located in USGS Hydrologic Unit 18020002 (Upper Pit River), which extends from the upper reaches of the watershed to Bieber; and in the upper portion of USGS Hydrologic Unit 18020003 (Lower Pit River) that extends from Bieber to Shasta Lake. Bieber is located at the head of Muck Valley (USGS, 2003a).

Six surface water gauging stations located within the Upper Pit River watershed are currently maintained. These stations are located on the South Fork of the Pit River near Likely (Station Number 113345500), main stem of the Pit River near Canby (Station Number 11348500) and four stations in Muck Valley. Real time data are available for the Likely and Canby stations.

Data from these stations were used for the analyses presented in this section. These data are available on the Internet (USGS, 2003a). Additional sources of information are listed in the "References" subsection.

Trends

The Mann-Kendall statistical procedure was used to evaluate trends for average annual flows and flows recorded during January and July at the Likely and Canby Stations. January and July data were selected because high and low monthly precipitation occurs during these months. Data from Likely (1928 to 2000) and Canby (1904 to 2000) were selected for this analysis because these stations are active and long-term data was available.

Likely

Average annual flow data for the Likely station show a statistically increasing trend at the 95 percent confidence level. January flow data show a statistically decreasing trend at the 90 percent confidence level, and July flow data show a statistically increasing trend at the 99 percent confidence interval.

Decreasing January flows and increasing July flows are uncommon in California unless the flows are affected by upstream storage. West Valley Reservoir is located upstream from the Likely station and was constructed in 1904 to increase summer flows for irrigation. The decreasing January and increasing July flows are shown on Figure 5-1.

Canby
Average annual flow data for the Canby station show no statistically increasing or decreasing trends annually or during January or July, at the 80 percent confidence level or above. In other words, based on the historic record, average annual flows, and January and July flows at the Canby station have been relatively constant.

Surface Water Runoff

As previously mentioned, the USGS and DWR operate a number of stream gages throughout the watershed. Station locations are shown in Figure 5-2, and available data are summarized on Tables 5-2 and 5-3 (USGS, 2003a).

The most complete hydrologic records are available for the Likely and Canby stations. The Likely station is located on the South Fork of the Pit River downstream from West Valley Reservoir, east of Likley. The drainage area contributing to this station is approximately 247 square miles. The Canby station is located on the main stem of the Pit River, west of Canby. The drainage area contributing to this station is approximately 1,431 square miles or approximately 60 percent of the Upper Pit River Hydrologic Unit (approximately 42 percent of the Upper Pit River Watershed). Continuous daily records are available for the Likely and Canby stations from approximately 1928 until present.

Likely
Average annual flows for the Likely station, between 1929 and 2000, are summarized on Figure 5-3. As shown, the minimum average annual flow of 24 cfs occurred in 1931, and the maximum average annual flow of 180 cfs occurred in 1984. The average annual flow during the period of record is 83 cfs.

Average monthly flows for the Likely station, between 1929 and 2000, are summarized on Figure 5-4. As shown, average monthly flows vary between 28 cfs in November and 232 cfs in May. The minimum average monthly flow of 3.3 cfs was recorded in December 1979, and the maximum average monthly flow of 570 cfs was recorded in June 1998.

Canby
Average annual flows for the Canby station, between 1932 and 2001, are summarized on Figure 5-5. As shown, the minimum average annual flow of 20 cfs occurred in 1934, and the maximum average annual flow of 648 cfs occurred in 1971. The average annual flow during the period of record is 257 cfs. Average annual flows for the Canby station are plotted against precipitation, as measured at Alturas, on Figure 5-6. The results show that runoff at Canby station is strongly correlated with precipitation at Alturas ($R^2 = 0.72$).

Table 5-2
DAILY FLOWS
UPPER PIT RIVER WATERSHED

Site ID	Site Description	Lat. (dd.mm.ss)	Long. (ddd.mm.ss)	Area (sqm)	Elev (msl)	Daily Flows (CFS)				
						Begin	Count	Min	Max	Avg
11342945	Thomas Creek near Cedarville	41.33.50	120.16.05	1.06	---	---	---	---	---	---
11342960	NF Pit River near Alturas	41.34.35	120.26.05	2.36	---	---	---	---	---	---
11343000	Parker Creek near Alturas	41.31.10	120.28.20	80.9	---	10/30–09/31	365	0	9	1.3
11343500	NF Pit River near Alturas	41.30.00	120.29.18	203	4391	10/29–09/67	4748	0	1770	48.3
11344000	NF Pit River @ Alturas	41.28.56	120.32.16	212	---	04/29–09/85	6027	0	2810	62.1
11344500	SF Pit River @ Jess Valley	41.14.00	120.20.24	100	---	04/29–09/31	913	2	138	30.1
11345500	SF Pit River near Likely	41.13.61	120.26.10	247	4508	10/28–09/01	26663	0.8	1220	82.5
11345800	SF Pit River Trib near Likely	41.13.51	120.27.35	1.59	---	---	---	---	---	---
11346000	Crooks Canyon near Likely	41.16.27	120.34.28	33.8	---	03/290–9/31	944	0	74	1.3
11346500	Fitzhugh Creek near Alturas	41.22.40	120.30.10	36.7	---	10/29–09/31	730	0	85	5.0
11347500	Pine Creek near Alturas	41.25.54	120.26.22	23.5	---	10/18–09/31	4748	2.7	195	16.9
11348000	Pit River @ Alturas	41.28.20	120.33.33	857	---	12/28–09/31	1034	0.1	851	53.8
11348080	Big Sage Reservoir near Alturas	41.35.00	120.41.55	2.54	---	---	---	---	---	---
11348200	Pit River near Alturas	41.29.00	120.37.46	1080	---	10/65–09/71	2191	4.1	4940	244.5
11348500	Pit River near Canby	41.24.22	120.55.36	1431	4266	04/04–09/01	26482	0	8580	253.3
11348560	Turner Creek near Canby	41.30.45	121.02.25	0.97	---	---	---	---	---	---
11349000	Pit River near Lookout	41.19.27	121.07.36	1585	---	04/29–09/80	6482	0	8910	289
11349030	Pit River Trib near Lookout	41.18.38	121.08.02	0.47	---	---	---	---	---	---
11349500	Ash Creek @ Ash Valley	41.07.50	120.45.30	136	---	10/28–09/31	1095	7	289	21.1
11349850	Johnson Creek Trib near Adin	41.18.28	120.58.43	0.66	---	---	---	---	---	---
11350500	Ash Creek @ Adin	41.11.54	120.56.32	258	---	4/04–09/82	11263	2.1	2560	78.3
11350850	Willow Creek above Indian Springs	40.59.43	120.48.20	9.51	---	---	---	---	---	---
11351000	Willow Creek near Adin	41.06.30	120.55.40	63	---	04/30–09/31	548	2.9	13	5.8
11351500	Widow Valley Creek near Lookout	41.11.00	121.12.30	27.7	---	04/30–09/31	548	0.1	10	4
11351700	Muck Valley PP	40.58.21	121.15.10	---	3340	10/91–09/01	3653	0	660	210
11351946	Pit R bypass below Muck Valley PP	41.00.55	121.09.13	2475	4120	01/94–09/01	2557	0	72	39.4
11351948	Pit R Ogee Weir below MV PP	41.00.55	121.09.13	2475	4120	10/94–09/01	2557	0	16700	446
11351950	Pit R below Div Muck Valley PP	41.00.55	121.09.13	2475	4120	10/92–09/01	2922	0	16800	429
11352000	Pit River near Bieber	41.00.55	121.09.13	2475	4080	04/04–09/75	13149	0	17700	489
11352500	Horse Creek @ Little Valley	40.53.54	121.10.24	237	---	04/29–09/67	3835	2.1	3770	21.8
11352620	Pit R Tributary #2 near Bieber	40.57.20	121.15.40	0.31	---	---	---	---	---	---

Table 5-3
PEAK FLOWS
UPPER PIT RIVER WATERSHED

Site ID	Site Description	Lat. (dd.mm.ss)	Long. (ddd.mm.ss)	Area (sqm)	Elev (msl)	PEAK FLOWS (CFS)				
						Begin	Count	Min	Max	Avg
11342945	Thomas Creek near Cedarville	41.33.50	120.16.05	1.06	---	63–73	11	34	119	64.4
11342960	NF Pit River near Alturas	41.34.35	120.26.05	2.36	---	62–72	11	13	109	66.4
11343000	Parker Creek near Alturas	41.31.10	120.28.20	80.9	---	---	---	---	---	---
11343500	NF Pit River near Alturas	41.30.00	120.29.18	203	4391	30–67	11	258	2530	1416
11344000	NF Pit River @ Alturas	41.28.56	120.32.16	212	---	72–85	13	191	3570	1245
11344500	SF Pit River @ Jess Valley	41.14.00	120.20.24	100	---	---	---	---	---	---
11345500	SF Pit River near Likely	41.13.61	120.26.10	247	4508	32–01	70	130	1620	472
11345800	SF Pit River Trib near Likely	41.13.51	120.27.35	1.59	---	64–73	9	2.1	256	89.4
11346000	Crooks Canyon near Likely	41.16.27	120.34.28	33.8	---	---	---	---	---	---
11346500	Fitzhugh Creek near Alturas	41.22.40	120.30.10	36.7	---	---	---	---	---	---
11347500	Pine Creek near Alturas	41.25.54	120.26.22	23.5	---	19–31	13	34	275	107
11348000	Pit River @ Alturas	41.28.20	120.33.33	857	---	---	---	---	---	---
11348080	Big Sage Reservoir near Alturas	41.35.00	120.41.55	2.54	---	62–73	11	15	175	106
11348200	Pit River near Alturas	41.29.00	120.37.46	1080	---	66–71	6	383	7040	3347
11348500	Pit River near Canby	41.24.22	120.55.36	1431	4266	04–01	71	90	13000	2743
11348560	Turner Creek near Canby	41.30.45	121.02.25	0.97	---	62–73	11	2.6	42	22.7
11349000	Pit River near Lookout	41.19.27	121.07.36	1585	---	---	---	---	---	---
11349030	Pit River Trib near Lookout	41.18.38	121.08.02	0.47	---	62–73	10	1.6	62	33
11349500	Ash Creek @ Ash Valley	41.07.50	120.45.30	136	---	---	---	---	---	---
11349850	Johnson Creek Trib near Adin	41.18.28	120.58.43	0.66	---	63–72	11	12	86	40.6
11350500	Ash Creek @ Adin	41.11.54	120.56.32	258	---	04–82	27	110	2950	1472
11350850	Willow Creek above Indian Springs	40.59.43	120.48.20	9.51	---	---	---	---	---	---
11351000	Willow Creek near Adin	41.06.30	120.55.40	63	---	63–73	11	4.7	48	20
11351500	Widow Valley Creek near Lookout	41.11.00	121.12.30	27.7	---	---	---	---	---	---
11351700	Muck Valley PP	40.58.21	121.15.10	---	3340	---	---	---	---	---
11351946	Pit R bypass below Muck Valley PP	41.00.55	121.09.13	2475	4120	---	---	---	---	---
11351948	Pit R Ogee Weir below MV PP	41.00.55	121.09.13	2475	4120	---	---	---	---	---
11351950	Pit R below Div Muck Valley PP	41.00.55	121.09.13	2475	4120	---	---	---	---	---
11352000	Pit River near Bieber	41.00.55	121.09.13	2475	4080	04–78	38	464	33800	6837
11352500	Horse Creek @ Little Valley	40.53.54	121.10.24	237	---	29–67	11	20	5290	686
11352620	Pit R Tributary #2 near Bieber	40.57.20	121.15.40	0.31	---	62–73	9	7.1	68	20.6

Figure 5-6 illustrates a very important concept; a 50 percent decrease in precipitation will not result in a 50 percent decrease in runoff. For example, during the 2001 water year, precipitation in Alturas was 56 percent of normal. Using the relationship shown in Figure 5-6, the estimated annual runoff at Canby would be 13 percent of normal, or 35 cfs. The recorded annual runoff during 2001 at Canby was 52 cfs, or 20 percent of normal.

Average monthly flows for the Canby station, between 1932 and 2000, are summarized in Figure 5-7. As shown, average monthly flows vary between 46 cfs in August and 556 cfs in March. In contrast, the minimum average monthly flow of 0.2 cfs was recorded in August 1934, and the maximum average monthly flow of 2,774 cfs was recorded in April 1952. Average monthly flows calculated for several different time periods are shown on Figure 5-8. The lowest summer flows occurred during the drought conditions encountered during the 1930s.

Historically, flows in the Upper Pit River decrease significantly during the summer. Because low summer flows are an ongoing concern, historic daily flows for the Canby station during August and September are summarized on Figures 5-9 and 5-10. Except during the drought conditions encountered during the 1930s and early 1990s, daily flows have been relatively consistent over the period of record. The probability of having daily flows equal to or less than a given value during August and September are shown in Figures 5-11 and 5-12. The results show that daily flows are equal to or less than 10 cfs, 20 percent in August, and 10 percent of the time in September.

In general, data from the Lookout station are similar to data from the Canby station. In contrast, annual flow, average monthly flow, August daily flow and September daily flow data for the Bieber station are presented in Figures 5-13 through 5-18. Although the average annual flows at the Bieber station are greater than the average annual flows at Canby and Lookout, the flows in August and September are significantly less. In August and September, the daily flows at Bieber are less than 1 cfs approximately 30 percent of the time.

Flood History

Annual peak flows recorded at the Canby station are listed in descending order in Table 5-4. The largest recorded flow at the Canby station occurred on March 8, 1904. The estimated peak flow on this date was 13,000 cubic feet per second. The estimated gage height was 15 feet. The most recent flood flow occurred on January 2, 1997. The recorded flow on this date was 7,280 cfs. The corresponding gage height was 11.82 feet. Annual peak flows do not show an increasing or decreasing trend during the period of record.

The recurrence interval for annual peak flows greater than or equal to a given value are shown on Figure 5-19. Figure 5-19 was generated using annual instantaneous peak flows between 1932 and 2000, and the equation:

$$\text{Recurrence Interval} = (\text{years of record} + 1) \,/\, \text{rank}_{\text{(1 for highest peak flow)}}$$

Using Figure 5-19, it is possible to estimate how often the peak instantaneous flow at Canby will be equal to or greater than a given value. For example, the annual instantaneous peak flow at Canby can be expected to exceed 2,000 cfs once every two years.

Table 5-4 ANNUAL PEAK FLOW UPPER PIT RIVER WATERSHED			
Year	Date	Peak Flow (cfs)	Gage Height (feet)
1904	Mar 8	13000	15
1986	Feb 19	9180	12.87
1937	Dec 11	8210	12.65
1997	Jan 02	7280	11.82
1970	Jan 24	6690	10.93
1962	Oct 14	6460	10.72
1980	Apr 14	5880	10.53
1952	Apr 05	5870	9.82
1971	Mar 27	5710	10.04
1995	May 02	5620	10.39
1982	Feb 17	4930	9.59
1972	Feb 29	4550	9.03
1967	Jan 30	4350	8.65
1940	Feb 28	4280	8.72
1955	Dec 23	4260	8.39
1964	Dec 24	4020	8.32
1996	Feb 21	3920	8.67
1998	May 13	3900	8.7
1969	Jan 22	3640	7.91
1993	Mar 18	3320	7.88
1943	Jan 22	3290	7.61
1942	Jan 28	3280	7.6
1989	Feb 25	3160	7.86
1999	Mar 03	3100	7.82
1983	Dec 17	3050	7.61

Pre-Irrigation Flows

Low summer flows are an ongoing concern along the Upper Pit River. For this reason, an attempt was made to estimate pre-irrigation average annual and average monthly flows. The primary objective of this analysis is to qualitatively evaluate the potential impact of agricultural diversions on water supply.

Average Annual Flows

In conjunction with the Upper Pit River hydrologic study conducted by DWR (1960), pre-irrigation flows at the proposed location of the Allen Camp Dam were estimated. The Allen Camp reservoir was to be located at the head of Big Valley, where the Pit River entered Big Valley a few miles above Lookout and would have flooded the canyon nearly back to Canby Bridge. DWR estimated that the pre-irrigation or un-impacted average annual flow at this location between 1919 and 1954 was 360 cfs, or approximately 260,000 acre-feet per year. In contrast, DWR estimated that the average annual post-irrigation flow at this location was 220 cfs, or approximately 158,000 acre-feet. The difference between the recorded flows and the estimated pre-irrigation flows represents the estimated irrigation diversions. Using more recent recorded flows (USGS, 2003a) and estimated irrigation diversions (USGS, 2003b), updated pre-irrigation and post irrigation annual flows for Canby and Bieber include:

- Estimated average annual pre-irrigation flow at Canby is 398 cfs (288,000 acre-feet per year). Estimated average annual post-irrigation flow at Canby is approximately 257 cfs (185,000 acre-feet/year).

- Estimated average annual pre-irrigation flow at Bieber is 705 cfs (510,000 acre-feet per year). Estimated average annual post-irrigation flow is approximately 470 cfs (340,000 acre-feet/year).

Average Monthly Flows

Monthly hydrographs were developed for flow data collected around the turn of the century to estimate pre-irrigation monthly flows from the pre-irrigation annual flows. Early hydrographs were used for this analysis because, in general, a single peak occurring in February, March, and April characterizes them. A hydrograph for Canby from 1905 is shown on Figure 5-20. In contrast, later hydrographs show two or more peaks. A sample bimodal hydrograph for Canby in 1953 is shown on Figure 5-21.

Monthly percentages developed from several early hydrographs were applied to the estimated pre-irrigation annual flows to estimate pre-irrigation monthly flows. Estimated pre-irrigation monthly flows for Canby and Bieber are presented in Figures 5-22 and 5-23. In general, the results show that the pre-irrigation summer flows were not significantly higher than the post-irrigation flows. Summer flows consistently decline to less than 10 cfs. In contrast, it has been estimated that stable spring fed flows in the lower portion of the Pit River, below Fall River, average between 2,000 and 2,500 cfs from July through August (USDA, 2002).

Dams And Diversions

As previously shown on Figure 5-1, dams and irrigation diversions have altered the seasonal distribution of flow in the Upper Pit River Watershed. Major dams and diversions are summarized in this section.

Dams

Sixty-three jurisdictional dams are located within the Upper Pit River Watershed. Jurisdictional dams are defined as "Artificial barriers, together with appurtenant works, which are 25 feet or more in height or have an impounding capacity of 50 acre-feet or more." Any artificial barrier under 6 feet, regardless of storage capacity, or that has a storage capacity less than 15 acre-feet, regardless of height, are not considered jurisdictional (CARA, 2003). Jurisdictional dams located in the Upper Pit River Watershed are summarized in Table 5-5 and are shown in Figure 5-24. Numerous smaller dams occur in the watershed. The impact of these dams has not been documented.

Table 5-5 JURISDICTIONAL DAMS UPPER PIT RIVER WATERSHED									
Dam Name	County	Stream Dammed	National Dam ID	Latitude	Longitude	Capacity (Acre-Feet)	Basin Area (Sq Miles)	Area of Reservoir (Acres)	Year Built
Big Sage	Modoc	Rattlesnake Cr	CA00233	41.578	-120.625	77000	107	5270	1921
Tule Lake	Lassen	Cedar Creek	CA00956	41.083	-120.367	39500	82	2650	1904
West Valley	Modoc	West Valley Cr	CA00300	41.222	-120.41	23000	134.8	1050	1936
Dorris	Modoc	Stockdill Slough	CA10144	41.488	-120.488	11100	6	1060	1930
Big Dobe North	Modoc	Tr Rattlesnake Cr	CA00467	41.633	-120.562	6530	17	1600	1912
Roberts	Modoc	Trib Pit River	CA00485	41.23	-121.137	5500	23.2	640	1905
Cloverswale	Modoc	Tr Witcher Crk	CA01088	41.533	-120.833	4620	4.7	462	1973
S-x	Modoc	Tr Pit River	CA00461	41.512	-120.747	4225	12	330	1917
Silva Flat	Lassen	Juniper Creek	CA00512	40.968	-120.922	3900	15.5	815	1926
Big Dobe South	Modoc	Tr Rattlesnake Cr	CA00468	41.622	-120.56	3860	28	800	1912
Spooner	Lassen	Trib Ash Creek	CA00957	41.015	-120.63	3123	6.6	635	1906
Ingals Swamp	Modoc	Ingals Swamp	CA00474	41.708	-120.668	2850	9	262	1918
Payne	Modoc	Tr Sfk Pit Rv	CA00475	41.398	-120.467	2850	4.5	526	1928
Duncan	Modoc	Trib Pit River	CA00480	41.518	-120.94	2575	11	353	1919
Bayley Reservoir	Modoc	Crooks Canyon	CA00920	41.262	-120.627	2390	33.5	328	1954
Reservoir C	Modoc	Trib Clover Swale	CA82492	41.66	-120.772	2028	14.3	0	1911
Iverson	Lassen	Tr Juniper Cr	CA00946	41.078	-121.053	1800	1.7	102	1968
Huffman Antelope	Modoc	Clover Swale	CA00462	41.575	-120.785	1550	36	332	1922
Taylor Cr No 1	Modoc	Taylor Creek	CA00463	41.225	-121.19	1500	42.2	77	1952
Little Juniper	Modoc	L Juniper Crk	CA00471	41.342	-120.48	1370	9	160	1926
Mason-capik	Modoc	Tr Nfk Pit Rv	CA00466	41.672	-120.402	1367	5.4	196	1965
Crowder Mountain	Lassen	Tr Telephone Flat	CA10321	41.788	-120.582	1298	5.3	0	1977
Danhauser	Modoc	Tr Sfk Pit Rv	CA00487	41.408	-120.49	1258	1.5	208	1890
Donovan	Modoc	Rye Grass Swale	CA00494	41.408	-120.693	1234	35.2	207	1953
Toreson	Modoc	Toms Creek	CA00483	41.392	-120.82	1140	17.8	92	1898
Graven	Modoc	Tr Canyon Creek	CA00472	41.287	-120.672	1100	6	214	1917
Jack's Swamp Dam #2	Modoc	Trib Pit River	CA01425	41.546	-120.813	1013	7.45	457	1926
Mcbrien	Modoc	Pit River	CA00459	41.457	-120.697	1000	1087	700	1880
Holbrook	Lassen	Ash Creek	CA00945	41.077	-120.63	719	14	122	1952
Beeler	Modoc	Turner Creek	CA10311	41.505	-121.217	640	3.3	0	1974

Table 5-5 (cont.)
JURISDICTIONAL DAMS
UPPER PIT RIVER WATERSHED

Blue Lake	Modoc	Outlet Creek	CA10233	41.15	-120.283	600	0	0	1960
Deadhorse	Modoc	Tr Logan Slough	CA10312	41.725	-120.563	600	7.6	0	1931
Halls Meadows	Modoc	Couch Creek	CA01208	41.643	-120.328	581	1.2	137	1941
Lauer	Modoc	Trib Pit River	CA10163	41.658	-120.465	576	7	500	1893
Rye Grass Swale	Modoc	Tr Canyon Cr	CA00481	41.365	-120.648	530	14	120	1923
Pickering Lumber	Modoc	Trib Pit River	CA00460	41.482	-120.578	500	0.1	72	1932
Lookout	Modoc	Pit River	CA00489	41.208	-121.138	430	2427	41	1930
Elkins And Lane	Lassen	Trib Ash Creek	CA00947	41.082	-120.758	412	7	74	1953
Cummings Res # 1	Modoc	Wfk Rock Creek	CA00479	41.517	-120.643	400	6	80	1912
Albaugh No 1	Lassen	Trib Pit River	CA00948	41.138	-121.002	335	2	60	1953
Cummings Res No 2	Modoc	Trib Pit River	CA82497	41.544	-120.644	300	2.5	0	1910
Mud Lake	Modoc	Tr Nfk Pit River	CA00469	41.55	-120.495	300	2.7	100	1926
White	Modoc	Trib Pit River	CA00482	41.375	-120.78	290	1.36	55	1918
Myers	Lassen	Trib Ash Creek	CA00953	41.127	-120.97	279	1.6	34	1957
Albaugh No 2	Lassen	Tr Willow Creek	CA00949	41.16	-120.97	270	0.45	35	1966
Upper Pasture	Modoc	Yankee Jim Sl	CA00488	41.427	-120.463	250	5	50	UNKNOWN
Emigrant Springs	Modoc		CA82502	41.588	-120.542	200	7.3	0	1974
Hines Brothers	Modoc	Tr Pit River	CA00917	41.27	-121.148	200	0.95	40	1955
Leonard No 2	Lassen	Trib Ash Creek	CA00960	41.117	-121.038	187	2.81	25	1968
Plum Canyon	Modoc	Plum Creek	CA00473	41.442	-120.372	184	0.26	30	1913
Jacks Butte	Modoc	Fairchild Swmp	CA10314	41.592	-120.838	166	0.7	0	1976
Burger	Modoc	Trib Upper Lake	CA00919	41.565	-121.322	161	0.28	14	1968
Nine Springs	Lassen	Tr Bull Run Slough	CA00951	41.123	-121.203	125	2.75	25	1954
Leonard Johnson	Modoc	Dry Creek	CA00492	41.64	-120.408	120	5	23	1948
Kramer	Modoc	Widow Valley Cr	CA00484	41.185	-121.208	118	27.7	20	1937
Gerig	Lassen	Pit River	CA00941	41.153	-121.148	110	1893	10	1939
James Porter	Modoc	Tr Parker Cr	CA00925	41.508	-120.42	106	0.06	19	1928
Lindauer Concrete	Modoc	Pit River	CA00914	41.435	-120.723	101	1087	20	1920
Shedd	Modoc	Tr Nfk Pit Rv	CA00923	41.628	-120.403	100	0.23	13	1962
Carpenter Wilson	Modoc	Cooley Gulch	CA00491	41.422	-120.872	93	3	17	1948
Chace Valley	Lassen	Tr Butte Creek	CA00950	41.15	-120.888	92	1.5	30	1955
Junkers Reservoir	Modoc	Trib Pit River	CA00470	41.56	-120.487	71	4.1	36	1923
Clarke	Modoc	Tr Nfk Pit Rv	CA00493	41.69	-120.382	70	0.05	12	1939
Total	---	---	---	---	---	220,827	---	21,328	---

Total storage capacity for the reservoirs associated with the jurisdictional dams is approximately 220,000 acre-feet, and the total surface area of the reservoirs, when full, is approximately 21,000 acres. For comparison, the Clear Lake dam and reservoir located east of Tulelake in the Lost River watershed has a capacity of 527,000 acre-feet and a surface area of 26,000 acres, at capacity (USBR, 2002).

As shown in Table 5-6, nearly 70 percent of total storage capacity in the Upper Pit River Watershed is associated with four reservoirs. These reservoirs include Big Sage (77,000 acre-feet), Moon Lake (39,500 acre-feet), West Valley (23,000 acre-feet) and Dorris (11,100 acre-feet). The Tule Lake dam (Moon Lake) was constructed on Cedar Creek in 1904 and Big Sage dam was constructed in 1921. The West Valley and Dorris dams were constructed in the 1930s. It has been reported that these reservoirs increase summer flows during June, July, August and September (DWR, 1960).

Table 5-6
MAJOR DIVERSIONS
UPPER PIT RIVER WATERSHED

Area	Major Tributary	Allocation (cfs)	Percent of Total	Major Reservoir	Estimated Acre-Feet	Primary Agreement	Controlling Party
Likely	South Fork of the Pit River	225	26	West Valley	60,000	Judgment 1954	South Fork Irrigation District
Alturas	North Fork of the Pit River	185	22	Dorris	50,000	Adjudication 1939	State Watermaster
Hot Springs Valley	Rattlesnake Creek	100	12	Big Sage	26,000	Agreement 1934	Hot Springs Valley Irrigation District
Adin	Ash Creek	130	15	None	34,000	Judgment 1947	State Watermaster
Big Valley	Pit River	215	25	Roberts	57,000	Adjudication 1959	State Watermaster
Total	---	855	100	---	227,000	---	---

Estimated Acre-Feet = (Allocation in cfs) * (80 irrigated acres per cfs) * (2.5 feet of water per acre) / 0.75; where 80 irrigated acres per cfs = average for watershed, 2.5 feet of water per acre = annual consumptive water use, and 0.75 = fraction of irrigation diversions lost to seepage.

Diversions

It has been estimated (USGS, 2003b) that approximately 230,000 feet of surface water were diverted annually to irrigate crops within the Upper Pit River Watershed between 1985 and 1995. Of this volume, approximately 170,000 acre-feet were lost to evapotranspiration. Many of the dams installed to divert this water are located on the main stem of the Pit River. For example, the Hot Springs Valley Irrigation District uses several concrete flashboard structures of varying width and approximately 10–12 feet in height. The flashboards are placed April first or later, when irrigation becomes necessary, and removed September 30. The dams and diversions are operated in accordance with established water rights.

Major water rights in the Upper Pit River Watershed are summarized in Table 5-7. In general, these rights are associated with the South Fork of the Pit River, North Fork of the Pit River, Rattlesnake Creek, Big Valley, and Ash Creek. Water rights are discussed in more detail in Section 6, "Water Quality."

Table 5-7
MAJOR WATER RIGHTS OF RECORD IN THE UPPER PIT RIVER

Location and Description	Flow, in Second-Feet	Storage, in Acre/Feet
South Fork Pit River		
W.E. Armstrong vs. Frank McArthur, et al, Judgement and Decree No. 3273, Superior Court of Modoc County, October 30, 1954	227.19	---
Pine Creek Agreement of 1954	60.00	---
South Fork Irrigation District license on water rights Application No. 7860 (for storage in West Valley Reservoir)	---	17,000
North Fork Pit River		
North Fork Pit River Statutory Adjudication resulting in Decree No. 4074, Superior Court of Modoc County, December 14, 1939	110.55	---
Franklin Creek Adjudication by Court Reference Procedure, Crowder, et al, vs. Indart, et al, resulting in Decree No. 3118, Superior Court of Modoc County, Septermber 8, 1933	11.65	---
Pit River in Hot Springs Valley		
Agreement of November 7, 1934	102.00	---
Hot Springs Valley Irrigation District permit on water right Application No. 3353 (for storage in Big Sage Reservoir)	---	50,000
Pit River in Big Valley		
Pit River Statutory Adjudication, Decree No. 6395 of the Superior Court of Modoc County, February 17, 1959	714.05	167,766
Ash Creek Adjudication by Court Reference Procedure, Charles A. Gerig vs. C.W. Clarke Co., et al, resulting in Decree No. 3670, Superior Court of Modoc County, October 27, 1947	152.80	---
Note: The amounts for Big Valley include applications for the Allen Camp Reservoir.		

Water Rights

Water rights in the Upper Pit River Watershed are either appropriated or riparian. An appropriated right is an exclusive right to take a specific amount of water from a particular source for a specific use on a specific site for a specific amount of time. Riparian rights, on the other hand, belong to the land bordering a water source. The following discussion is provided as a general introduction to the concept of water rights and should not be considered legal opinion.

Appropriated Rights

An appropriative right is an entitlement to water based on a specific use. This type of right may be sold or transferred with the property or separately. In general, the party that first diverts the water has priority rights over subsequent appropriators or users. Actual levels of priority are generally specified in the appropriation. In situations where priorities conflict, or in situations where rights were established prior to the appropriation system, the rights may be adjudicated. Adjudications are judgments decreed by the court and carry the full force of law. The court or an assigned watermaster generally administers adjudicated rights. Most of the water rights in the Upper Pit River Watershed have been adjudicated. These are discussed later in this section.

A senior may not change an established use of the water to the detriment of a junior. This restriction includes junior's reliance on a senior's return flow. A senior may not enforce a water right against a junior if such a right would not be put to beneficial use.

The elements of appropriation include:

- Intent to use the water
- Diversion or control of the water
- Reasonable and beneficial use of the water
- Priority of appropriation

Appropriative right is an acquisition of a water right subject to the issuance of a permit by the State Water Resources Control Board. The priority is based on the date a permit is issued. A priority-based permit system was implemented under the Water Commission Act of 1913. Presently the system is codified in CWC § 1200, et seq.

Riparian Rights

A riparian right is the right to use water based on the ownership of property that abuts a natural watercourse. Water claimed by virtue of a riparian right must be used on the riparian parcel. Such a right is generally attached to the riparian parcel of land except where a riparian right has been preserved on non-contiguous parcels after the land has been subdivided, *Hudson v. Dailey*, (1909) 156 Cal. 617. Riparian rights were adopted in California as a part of the English Common Law when California entered statehood in 1850. At that time, however, gold miners were already operating under their own system of prior appropriation to claim water rights. Conflicts between appropriations and riparian rights have continued since.

In general, riparian users are entitled to enough water to make beneficial use of the water on the land as long as no other riparians are harmed by such use. Riparian rights in California are now limited to "reasonable and beneficial use." In contrast to appropriative rights, there is no priority of riparian right; senior and junior riparians do not exist. Water conflicts between riparian users are resolved on the basis of reasonable use. The court has held that in times of water shortage, all riparians must adjust water use to allow for an equal sharing of the available water supply.

California Doctrine

The California Doctrine is a system of water rights that recognizes both appropriative and riparian rights. Early California law recognized both appropriation and riparian rights by applying priority to disputes between appropriators and by applying riparian principles to disputes between riparians. In 1872, California officially recognized the rights of appropriators by allowing the filing of water claims with county recorders. Within 14 years, the California Supreme Court had to determine who had superior water rights when a downstream riparian rancher and an upstream appropriator each claimed a superior right to use water. The Court held that a riparian's rights are superior to the rights of an appropriator except in cases where the water had been appropriated before the riparian acquired the patent to his land, and after the passage of the 1866 Mining Act which recognized appropriation. Generally, a reasonable use by a riparian will trump an appropriative right so long as the patent to the riparian parcel was acquired from the United States prior to the date of appropriation.

In 1926 the Court held that a riparian could assert priority over an appropriator to make beneficial use of the water even if the riparian use was unreasonable. In response, in 1928 the California Constitution was amended to require all water use in California to be "beneficial and reasonable." Generally today, a riparian user cannot defeat an appropriative right unless the riparian user proves the appropriation is causing undue interference with the riparian's reasonable use of the water.

Pit River Water Allocations

Surface water allocations associated with the South Fork of Pit River, North Fork of Pit River, Rattlesnake Creek, Big Valley, and Ash Creek are discussed in detail in this section. Major water rights of the Pit River are included on Table 5-7.

South Fork of the Pit River

Water rights along the South Fork of the Pit River were established under Judgment and Decree 3273, dated October 30, 1934. This Judgment and Decree addressed water rights on the South Fork from the western slope of the Warner Range of mountains in the southerly portion of Modoc County and the northerly portion of Lassen County, flowing in a generally westerly direction from Jess Valley past Likely and northerly to its confluence with Pine Creek, near Alturas.

The allotments are divided into two priority classes. First priority classes are for continuous usage without regard to season. The second priority class on the South Fork of the Pit River and its tributaries are allotted on a rotational schedule from April 1 to October 15. Fitzhugh Creek and its tributaries second priority class rights are for continuous usage from April 1 to October 15, inclusive.

The South Fork Irrigation District (SFID) includes 12,900 acres below West Valley Reservoir. First and second priority rights of SFID total 159.80 cfs. The first and second priority rights above West Valley Reservoir totaling 52.39 cfs are regulated by the District's Watermaster, but are not included in SFID. A total of 15.00 cfs is allotted from Fitzhugh Creek, which is also not a part of the SFID. The rotational schedule described in the Decree for the South Fork of the Pit River is only implemented when water volumes are low, and only within the district boundaries. Within SFID, water transportation is through gravity flow ditches from flashboard dam diversions. There are no pumps operating within SFID.

The South Fork of the Pit River and Little Juniper Creek, a tributary to Fitzhugh Creek, are fully appropriated (SWRCB, 2002).

North Fork of the Pit River

Water use in the area began in the mid to late 1800s. The North Fork of the Pit River was adjudicated under Judgment and Decree 4074 in December 1939. The Judgment and Decree addressed the waters of the North Fork of the Pit River and all its tributaries, including Linville Creek, Joseph Creek, Thoms Creek, Stony Canyon Creek, Mile Creek, Gleason Creek, Parker Creek and Shields Creek. Franklin Creek was not included as it was previously adjudicated under Judgment and Decree 3118, in September 1933. The North Fork of the Pit River and its tributaries provide irrigation to approximately 11,500 acres through 171 diversion points described in the adjudication.

Studies were completed prior to the adjudications to determine the typical amount of water available in the river and its tributaries from snow pack and springs. Based on the results of the studies it was shown that there was not enough water to supply all of the needs, so flow allotments and a priority system was established. The allotments on each tributary are divided up into to five priority classes. The first priority class of the North Fork and its tributaries and the second priority class for Gleason Creek are for domestic and stock water purposes and for continuous usage without regard to season. The remaining priority classes are for continuous usage from April 1 to September 30, inclusive. The remaining priority classes on Gleason Creek are for continuous usage from April 15 to September 30, inclusive. Typically, water is available for first priority class throughout the season. The rest of the priority classes do not receive water for the entire irrigation season.

The State Watermaster regulates the North Fork of the Pit River and its tributaries. According to the latest Watermaster records, the following amounts are the total diverted (all priorities) from each tributary:

- Linville Creek 8.30 cfs
- Joseph Creek 11.98 cfs
- Thoms Creek (net consumptive use) 6.44 cfs
- Stony Canyon Creek — from Mile Creek 4.40 cfs
- Gleason Creek 4.55 cfs
- Parker Creek 17.87 cfs
- Shields Creek 7.70 cfs
- North Fork of the Pit River 52.08 cfs

Additional adjudications (individual springs) are described in the Judgment and Decree, but are not included under Watermaster service. Franklin Creek, also regulated by the State Watermaster, has a total diverted flow of 11.655 cfs to irrigate 909.3 acres. The adjudication breaks the rights into four priority classes. The first and second priority allotments are for continuous use without regard to season. All third and fourth priorities are limited to usage during irrigation season, April 1 to September 30 inclusive. A second priority right of 1.46 cfs from September 15 to March 31 is not included in the total diverted flow and is not regulated by the Watermaster. There are 27 points of diversion described in the decree.

Diversions are typically flashboard structures that divert water to a weir box then outlet to a ditch for flood irrigation. A few pumps are used, but they are located in holding ponds located off stream. Some water users are currently investigating pumping of groundwater to supplement adjudicated water.

The North Fork of the Pit River, Franklin Creek, and Thoms Creek are fully appropriated (SWRCB, 2002).

Pine Creek

Pine Creek is adjudicated per agreement dated November 22, 1933. The initial adjudication allowed for 60.00 cfs to be diverted from Pine Creek. An additional 0.20 cfs was adjudicated under supplemental agreement dated December 1934. The current total water right of 60.20 cfs is diverted from Pine Creek under first and second priority classes. All of the allotments under the first and second priority classes are limited to diversion during the irrigation season, April 1 to September 30 inclusive. There are 15 points of diversion irrigating 5,715 acres, including 2,700 acres of Dorris Reservoir. Pine Creek is regulated by the State Watermaster. Diversions on Pine Creek are flashboard structures diverted to ditches for flood irrigation.

Rattlesnake Creek

The waters of the Pit River and Rattlesnake Creek in Hot Springs Valley were adjudicated under agreement made December 1934 (Hot Springs Valley Agreement, 1934). Water use in the area began in the 1880s. The Hot Springs Valley Irrigation District was formed in the early 1920s when Big Sage Reservoir was built. Big Sage Reservoir was built to capture water during the winter and spring and hold it for release during the irrigation season when it was needed. Typically, the reservoir holds a two-year reserve of water for its users. Water in the reservoir is allocated based on the number of irrigated acres in the district, which is used to determine a percentage of the total amount of water in the reservoir. During normal water years, water is not released from Big Sage Reservoir until May. Prior to May, the flow in the river is sufficient to meet all the allotments.

The Hot Springs Valley Irrigation District water users currently irrigate approximately 7,000 acres. There are eight private dams and three district dams in operation. The dams are concrete flashboard structures of varying width approximately 10 to 12 feet in height. Flashboards are placed April first or later, when irrigation becomes necessary, and removed September 30. A total of 21 pumps are used, with approximately one-half pumping to ditches for flood irrigation and the other half for sprinkler wheel lines. Historically, since the construction of Big Sage Reservoir, water needs of the users within the district have been met throughout the irrigation season.

The riparian allotments described in the agreement are divided into two priority classes. First priority class rights (14.0 cfs) are for continuous usage without regard to season. Second priority class rights (88.0 cfs) are for diversion during the irrigation season, April 1 to September 30, inclusive of each year.

Big Valley and Ash Creek

Water use in Big Valley began with the settlement of the area about 1871. Nearly all of the water rights were acquired shortly after that date and before the Water Commission Act of 1914, which required that appropriative rights be initiated by filing an application with the State. Consequently, the only Big Valley water rights of importance on file with the State Water Rights Board are those for reservoir storage that were initiated after 1914. Subsequently, most of the water rights between Canby and the Lower end of Big Valley have been determined by adjudication proceedings. Major adjudications include:

- Canby Bride to Muck Valley gage stations, excluding Ash Creek — California Superior Court Decree 6395 dated February 1959

- Ash Creek — California Superior Court Judgment and Decree 3670 dated October 1947

Based on Decree 6395, water allocation on the Pit River and its tributaries is divided into four priority classes. The only first priority allocation on the Pit River is 15 cfs to maintain channel storage and provide stock water. In general on the Pit River, irrigation allocations are assigned second priority. Priorities three and four are also for irrigation. A total of approximately 15,000 acres are irrigated in Big Valley by the Pit River diversions. A total of 215.34 cfs in priorities 2, 3 and 4 are regulated by the State Watermaster. Flows in the Pit River through Big Valley are typically not enough to supply the adjudicated irrigation allotments throughout the irrigation season.

Water is diverted from the Pit River through pumps and flashboard structures. Pumps are mainly used upstream of Lookout, with flashboard diversions located in the valley.

The rights from tributaries described in Decree 6395 are not controlled by the State watermaster. First priority class rights are allocated on the tributaries, not maintained instream as in the main stem of the Pit. A total of 3,871 acres are irrigated with a total (all priorities) of 55.48 cfs, from various tributaries and springs. There are additional rights described in the decree that are not regulated by the State Watermaster.

Decree 3670 includes Ash Creek and its tributaries, Rush Creek, Butte Creek, and Willow Creek. Studies were completed prior to the adjudication to determine the typical amount of water available in Ash Creek and its tributaries from snow pack and springs. Based on the results of the studies it was shown that there was not enough water to supply all of the needs, so flow allotments and a priority system was established. Typically allotments, other than first priority, are not available for the entire irrigation season. Diversions are typically flashboard structures.

The State Watermaster regulates Ash Creek and its tributaries. Water for irrigation is diverted from April 1 to October 15 inclusive. Water required for domestic and stock water uses is entitled to be diverted from October 15 to March 31 inclusive. The following is a detail of the allotments and irrigated acreages for each creek.

- The Rush Creek allotments described in the decree total 5.25 cfs. However, the right of 0.08 cfs was abandoned in 1997. There are 11 diversion points that irrigate approximately 300 acres. Rush Creek rights are not broken down into priority classes.

- Butte Creek allotments are broken down into two priority classes and divert a total of 3.40 cfs to irrigate 291.6 acres.

- Water rights on Willow Creek total 12.60 cfs and are prioritized into four classes. Acreage supplied is approximately 1,430 acres. Nine points of diversion are noted in the Watermaster records.

- Ash Creek rights total 108.50 cfs. Nine allotments totaling 5.95 cfs have been abandoned and have had no Watermaster billings as of 1989. The total amount diverted currently is

102.55 cfs. Water rights on Ash Creek are prioritized into five classes. Acreage irrigated by Ash Creek allotments is approximately 8,500 acres.

The Pit River in Bug Valley and Ash Creek are fully appropriated (SWRCB, 2002).

Other Water Rights

State of California
The State of California is authorized (Section 10500 of the Water Code) to file an application for any water not appropriated which, in its judgment, may be required in the development and the completion of the whole or any part of a general or coordinated plan looking toward the utilization and conservation of the State's water resources. The State is also authorized to assign its applications to an agency, which undertakes the construction of a project that is substantially in conformance with that set forth in the state application (DWR, 1960).

State applications were made in connection with the development of the Sacramento River at Shasta Dam and were subsequently assigned to the United States. The following condition is contained in the assignment of Applications Nos. 5625, 5626, 9364, and 9365:

> Subject to depletion of the stream flow above Shasta (formerly Kennett) Dam by the exercise of lawful rights to the use of water for the purpose of development of the counties in which such water originates, whether such rights have been heretofore or may be hereafter initiated or acquired, such depletion not to exceed in the aggregate four million five hundred thousand (4,500,000) acre-feet of water in any consecutive ten-year period, and not to exceed a maximum depletion in any one year in excess of seven hundred thousand (700,000) acre-feet.

Pacific Gas and Electric
The water rights held by the Pacific Gas and Electric Company for operation of its power plants downstream from Big Valley constitute a major component of water rights in the Pit River. Water rights on file with the State Water Rights Board in support of the existing and proposed developments of the company are shown on Table 5-8.

Table 5-8
PIT RIVER WATER RIGHTS HELD BY
PACIFIC GAS AND ELECTRIC COMPANY

Application Number	Date Filed	Place of Use	Amount, in Second-Feet	Status
1891	July 2, 1920	Pit No. 3	3,000	License
1892	July 2, 1920	Pit No. 4	3,000	Permit
14743	April 7, 1952	Pit No. 6	4,500 (40,000 acre-feet)	Permit
14928	July 28, 1952	Pit No. 4	500	Permit
15407	July 9, 1953	Pit No. 7	4,850	Permit
20532	December 19, 1961	Pit No. 7	155,000 acre-feet	Permit

Water is diverted from Fall River for power generation at Pit No. 1 Power Plant. Use of water at the Pit No. 5 Power Plant is under a claim of riparian rights. The Pit No. 5 Power Plant, located near Iron Canyon Creek, is unique in that it operates under claim of riparian rights. Pit No. 5 has an installed nameplate rating capacity of 128,000 kilowatts. The company lists the peak output from this plant at 152,000 kilowatts, with a corresponding peak flow of 3,500 second-feet.

Allen Camp Reservoir
Two water rights applications were filed for the Allen Camp Project in Big Valley. They cover a total of 156,000 acre-feet, substantially the storage rights required for the entire project.

Unassigned State Application No. 5643 includes 80,000 acre-feet of water for Allen Camp Reservoir. It was filed on July 30, 1927, pursuant to Section 10500 of the Water Code. That section now exempts state applications from the requirements of diligence. As long as the exemption is continued and the State retains custody of this application, its priority is assured. The usual requirements of diligence will apply, however, upon assignment of the application for construction purposes or upon a failure by the legislature to extend the exemption in the future.

Big Valley Irrigation District
The Pit Soil Conservation District as trustee for the Big Valley Irrigation District filed application No. 14602 on December 13, 1951. It seeded to appropriate 76,000 acre-feet from the Pit River to be collected each season between October 1 and April 30, and to be used for irrigation purposes on a net area of 35,166 acres within a gross area of 39,772 acres within the boundaries of the Big Valley Irrigation District. It proposed a project similar to the Allen Camp Project proposed in State Application No. 5643. The Pacific Gas and Electric Company protested application No. 14602.

Riparian Rights
Use of the waters of the Pit River under riparian rights for irrigation in Fall River Valley constitutes the major consumptive use of water between Big Valley and Lake Shasta. This use is affected by several diversions from the river near McArthur for irrigation on a narrow strip of land bordering the river. These rights to the use of Pit River water are not on record with the State Water Rights Board, but could be asserted against the projects under consideration in this bulletin.

Water Districts and Agencies
The Big Valley Irrigation District was organized for the purpose of constructing and operating water projects for the benefit of farmers in Big Valley. The district was formed on October 12, 1925, after two previous efforts to organize had failed.

The gross area of the new district was 12,430 acres, of which 11,000 were irrigable. The plan, as then proposed, was to store water in a reservoir in Jess Valley east of Likely, in cooperation with other interests. Negotiations failed, and the district remained inactive until 1933.

In 1933, a new plan was proposed by the district involving the storage of 15,000 acre-feet of water at a reservoir site on the Pit River about 12 miles above Lookout. An application for a loan of $206,400 was filed with the Federal Public Works Administration for funds with which to finance the proposed project, but the funds did not materialize and the plan was dropped.

In 1951, the National Association of Soil Conservation Districts established a pilot district program for the purpose of developing a comprehensive plan for proper conservation of all lands within one soil conservation district in each state. Subsequently, the Pit Soil Conservation District, which includes that portion of Big Valley that lies within Lassen County, was selected as the pilot district for California.

The Adin-Lookout Soil Conservation District operates in that portion of Big Valley that lies within Modoc County. The interests of Big Valley Irrigation District and the two soil conservation districts are closely allied.

The Big Valley Mutual Company was formed in 1942 for the purpose of acquiring Lower Roberts Reservoir. The company has obtained water from this reservoir as a supplemental supply for use on lands of its shareholders along the Pit River in Big Valley.

The Lassen-Modoc County Flood Control and Water Conservation District was created by an act of the 1959 Legislature (Chapter 2127, Statutes of 1959). The district comprises all of Lassen County and that portion of Modoc County situated within the drainage area of the Pit River.

GROUNDWATER HYDROLOGY

In the mountain valleys and basins of the Upper Pit River Watershed, groundwater has been developed to supplement surface water supplies. Most of the rivers and streams of the area have adjudicated water rights that go back to the early 1900s, and diversion of surface water has historically supported agriculture. These adjudications were summarized previously.

Drought conditions and increasing competition for surface water has led to significant groundwater development for irrigation in many of the alluvial basins located within the watershed. These groundwater supplies are generally quite reliable in areas that have sufficient aquifer storage or where surface water replenished supply throughout the year. In areas that depend on sustained runoff, water levels can be significantly depleted in drought years and many old, shallow wells can be dewatered. During 2001, an extreme drought year on the Modoc Plateau, many well owners experienced groundwater supply problems. Groundwater resources within the Upper Pit River are summarized in this section.

Background

Groundwater can be defined as the portion of water occurring beneath the earth's surface, which completely fills (saturates) the void space of racks or sediment. Given that all rock has some degree of void space, it is fairly safe to say that groundwater can be found underlying nearly any location in the State. Several key properties help determine whether the subsurface environment will provide a significant, usable groundwater resource. Most of California's groundwater occurs in material deposited by streams, called alluvium. Alluvium consists of coarse deposits, such as sand and gravel, and finer-grained deposits such as clay and silt. The coarse and fine materials are usually coalesced in thin lenses and beds in an alluvial environment. In an alluvial environment, the coarse materials such as sand and gravel deposits usually provide the best source of water and are termed aquifers; whereas, the finer-grained clay and silt deposits are relatively poor sources of water and are referred to as aquitards. Groundwater development also may occur in fractured rock, such as the volcanic material underlying much of the Modoc Plateau.

Sources of Data

Key sources of information presented in this section include:

- Groundwater Basins of California, Bulletin 118–80 (DWR, 1980)
- Northeastern Counties Groundwater Update, 1982 (DWR, 1982)
- Draft California Groundwater Update 2003 (DWR, 2003a)

Additionally, the California Department of Water Resources collects semi-annual groundwater level data from 11 wells in the Alturas groundwater basins, 18 wells in the Big Valley groundwater basin, and from two wells in the Round Valley groundwater basins. Data for these wells are available on the Internet (DWR, 2003b).

Groundwater Basins

A groundwater basin is defined as alluvial aquifer or a stacked series of alluvial aquifers with reasonably well-defined boundaries in a lateral direction and a definable bottom. Lateral boundaries are features that significantly impede groundwater flow such as rock or sediments with very low permeability or a geologic structure such as a fault. Bottom boundaries would include rock or sediments of very low permeability if no aquifers occur below those sediments within the basin.

Groundwater basins identified within the Upper Pit River Watershed are shown in Figure 5-25, and the major alluvial basins are summarized in Table 5-9. As summarized, the Alturas and Big Valley Groundwater Basins are the largest alluvial groundwater basins located within the Upper Pit River Watershed.

Alturas Basin, South Fork of the Pit River Subbasin

The South Fork of the Pit River Groundwater Subbasin is bounded on the east by Plio-Pleistocene basalt and Pleistocene Pyroclastic rocks of the Warner Mountains, to the north by Pleistocene basalt of Devils Garden, to the south by Plio-Pleistocene basalt, and to the west by Warm Springs tuff (Gay, 1968). The South Fork of the Pit River enters the basin near the community of Likely and flows north through the South Fork of the Pit River Valley to its confluence with the North Fork of the Pit River at the town of Alturas. Annual precipitation ranges from 13 to 19 inches.

Table 5-9
GROUNDWATER BASINS

Groundwater Basin	Acres
Alturas Basin – South Fork Subbasin	114,000
Alturas Basin – Warm Springs Valley Subbasin	68,000
Big Valley	92,000
Round Valley	7,270
Jess Valley	6,710
Rock Prairie Valley	5,740
Egg Lake Valley	4,100
Hot Springs Valley	2,400

Water-Bearing Formations

The principal water-bearing formations are Holocene sedimentary deposits (which include alluvial fan deposits, intermediate alluvium, and basin deposits), Pleistocene lava flows and near-shore deposits, and Plio-Pleistocene Alturas Formation and basalts. The following summary of water-bearing formations is from the Department of Water Resources (DWR, 1963).

Holocene Sedimentary Deposits. The Holocene sedimentary deposits include alluvial fan deposits, intermediate alluvium, and basin deposits, each up to a thickness of 75 feet. Alluvial fan deposits consist of unconsolidated to poorly consolidated, crudely stratified silt, sand and gravel with lenses of clay. These deposits generally have high permeability and are capable of yielding large amounts of water to wells. This unit may include confined as well as unconfined water.

Intermediate alluvium consists of unconsolidated poorly sorted silt and sand with some lenses of gravel. These deposits have moderate permeability and yield moderate amounts of water to shallow wells. Basin deposits consist of unconsolidated, interstratified clay, silt and fine sand. These deposits have moderate to low permeability and yield small amounts of water to wells.

Pleistocene Near-Shore Deposits. The Pleistocene near-shore deposits consist of slightly consolidated to cemented poorly to well stratified pebble and cobble gravel with lenses of sand and silt to a thickness of 200 feet. The most extensive near-shore deposits occur in the northeast corner of the basin where the North Fork of the Pit River enters the valley. Other minor areas of these deposits occur but are not considered significant as water-bearing areas. These deposits have moderate permeability and may yield fair to moderate amounts of unconfined and confined water to wells.

Pleistocene and Plio-Pleistocene Volcanic Rocks The Pleistocene volcanic rocks consist of lava flows of layered, jointed basalt ranging in thickness from 50 to 250 feet. These basalt flows serve as recharge zones where exposed in the uplands surrounding the basin. Within the basin, where saturated, scoriaceous zones and joints in the basaltic flows can yield moderate amounts of water to wells. These flows occur interbedded with the upper member of the Alturas Formation in the valley areas.

Plio-Pleistocene Alturas Formation The Plio-Pleistocene Alturas Formation consists of moderately consolidated, flat-lying beds of tuff, ashy sandstone and diatomite, and are widespread both at the surface and at depth. The upper and lower sedimentary members of the formation are each about 400 feet thick, and are separated by a basalt member and the Warm Springs tuff. The sediments of the Alturas Formation are the principal water-yielding materials in the South Fork of the Pit River subbasin. These sediments have a moderate to high permeability and, where saturated, can yield large amounts of groundwater to wells. The formation contains both confined and unconfined groundwater.

Restrictive Structures and Groundwater Trends

Exposures of Warm Springs tuff in Sections 10 and 15, Township 42 North, Range 11 East, act as a partial barrier to the westward movement of groundwater from South Fork of the Pit River Valley to Warm Springs Valley (DWR, 1963).

Water levels generally declined up to 10 feet in the northern part of the basin during the period from the early 1980s through the early 1990s and have recovered to former levels through 1999.

Alturas Basin, Warm Springs Valley Subbasin

The Warm Springs Valley Groundwater Subbasin is bounded on the east by a low mesa of the Plio-Pleistocene Alturas Formation (separating Warm Springs Valley from South Fork of the Pit River Valley); to the north by the Pleistocene basalt of Devils Garden; to the south by Plio-Pleistocene Warm Springs tuff and basalt; and to the west by Pleistocene basalt (Gay, 1968).

The groundwater regime between Warm Springs Valley and South Fork of the Pit River Valley is continuous through a north-to-northwest trending highland, west and south of Alturas, that forms two distinct valleys with separate surface drainage. From the confluence of the North and South Forks of the Pit River, just to the east at Alturas, the Pit River flows westerly through Warm Springs Valley. The average annual precipitation in the basin ranges from 13 to 19 inches increasing toward the west.

Water-Bearing Formations

The principal water-bearing formations are Holocene sedimentary deposits, Pleistocene lava flows, and Plio-Pleistocene Alturas Formation and basalts. The following summary or water-bearing formations is from DWR (1963).

Holocene Sedimentary Deposits The Holocene sedimentary deposits include alluvial fan deposits, intermediate alluvium, and basin deposits, each up to a thickness of 75 feet. Alluvial fan deposits consist of unconsolidated to poorly consolidated, crudely stratified silt, sand and gravel with lenses of clay. These deposits generally have high permeability and are capable of yielding large amounts of water to wells. This unit may include confined as well as unconfined water. Intermediate alluvium consists of unconsolidated poorly sorted silt and sand with some lenses of gravel. These deposits have moderate permeability and yield moderate amounts of water to shallow wells.

Basin deposits consist of unconsolidated, interstratified clay, silt, and fine sand. These deposits have moderate to low permeability and yield small amounts of water to wells.

Pleistocene and Plio-Pleistocene Volcanic Rocks The Pleistocene volcanic rocks consist of lava flows of layered, jointed basalt ranging in thickness from 50 to 250 feet. These basalt flows serve as recharge zones where exposed in the uplands surrounding the basin. Within the basin, where saturated, scoriaceous zones and joints in the basaltic flows can yield moderate amounts of water to wells. These flows occur interbedded with the upper member of the Alturas Formation in the valley areas.

Plio-Pleistocene Alturas Formation The Plio-Pleistocene Alturas Formation consists of moderately consolidated, flat-lying beds of tuff, ashy sandstone and diatomite, and are widespread both at the surface and at depth. The upper and lower sedimentary members of the formation are each about 400 feet thick, and are separated by a basalt member and the Warm Springs tuff. The sediments of the formation are the principal water-yielding materials in the Warm Springs Valley Subbasin. These sediments have a moderate to high permeability and where saturated can yield large amounts of groundwater to wells. The formation contains both confined and unconfined groundwater.

Restrictive Structures and Groundwater Trends

Exposures of Warm Springs tuff in Sections 10 and 15, Township 42 North, Range 11 East, act as a partial barrier to the westward movement of groundwater from South Fork of the Pit River Valley to Warm Springs Valley (DWR, 1963).

Upland recharge areas consist of permeable lava flows of Plio-Pleistocene and Pleistocene age. Precipitation falling on these areas infiltrates the lava flows and moves toward the valley floor (DWR, 1963). Water levels declined approximately 20 feet in the western part of the subbasin during the period between 1985 and the early 1990s and have recovered by approximately 15 feet by 1999.

Big Valley Groundwater Basin

Big Valley is a broad flat plain extending about 13 miles north-to-south and 15 miles east-to-west consisting of a series of depressed fault blocks surrounded by tilted fault block ridges. The basin is bounded to the north and south by Pleistocene and Pliocene basalt and Tertiary pyroclastic rocks of the Turner Creek Formation, to the west by Tertiary rocks of the Big Valley Mountain volcanic series, and to the east by the Turner Creek Formation.

Water-Bearing Formations

The primary water-bearing formations in Big Valley are Holocene sedimentary deposits, Pliocene and Pleistocene lava flows, and the Plio-Pleistocene Bieber Formation. The following summary of water-bearing formations is from DWR (1963).

Holocene Sedimentary Deposits The Holocene sedimentary deposits include basin deposits, intermediate alluvium, and alluvial fans — each having a thickness of up to 150 feet. Basin deposits, located predominately in low-lying areas in the central part of the valley, consist of unconsolidated interbedded clay, silt, and organic muck, all having low permeability. These deposits are not considered to be a significant water-bearing formation. Intermediate alluvium, found along the perimeter of the valley, consists of unconsolidated silt and sand with some clay and gravel. These deposits are generally moderately permeable with gravel zones being highly permeable. Alluvial fans consist of unconsolidated poorly stratified silt, sand, and gravel with some clay lenses. Because the fans occur in only a few small areas, they are not considered a significant source of water. Locally they may yield moderate amounts of water to wells.

Pliocene to Pleistocene Volcanic Rocks Pliocene volcanic rocks consist of jointed and fractured basalt flows occurring to the north and south of Big Valley. Deposits range in thickness to 1,000 feet. The lavas are moderately to highly permeable and serve as recharge areas in the uplands and contain unconfined and confined zones in the valley. Pleistocene volcanic rocks consist of jointed and fractured basalt flows having moderate to high permeability. Deposits range from 50 to 150 feet thick. These flows serve as recharge areas and yield moderate to large amounts of confined and unconfined groundwater to wells in the southern part of the valley.

Plio-Pleistocene Bieber Formation The Bieber Formation consists of lake deposited diatomite, clay, silt, sand, and gravel. These interbedded sediments are unconsolidated to semi-consolidated and are moderately permeable. The formation ranges in thickness from 1,000 to 2,000 feet and underlies all of Big Valley. The principal water-bearing zones consist of white pumiceous sand and black volcanic sand and yield large amounts of water to wells where there's sufficient thickness and continuity.

Groundwater Trends
Water levels of the confined aquifer system declined 12 to 15 feet during the period between the mid-1980s and the 1990s. Water levels through 1999 had recovered 10 to 12 feet.

Northern California Volcanic-Rock Aquifers
Northern California volcanic-rock aquifers are located in the Modoc Plateau and the Cascade Mountains in volcanic terrains that extend into Oregon. In general, these aquifers are not distinct, readily identifiable aquifers because they contain water in fractures, volcanic pipes, tuff beds, rubble zones, and interbedded sand layers, primarily in basalts of Miocene age or younger. Areas in which permeable zones are sufficiently large and interconnected to provide a good source of water to wells are usually found only through exploratory drilling because surficial fracturing might not reflect fracturing in the subsurface.

Well depths commonly are 75 to 200 feet, but some wells are reported to be as deep as 2,700 feet. Yields from wells completed in basalt commonly range from 100 to 1,000 gallons per minute and can be as large as 4,000 gallons per minute. Because of the unpredictable distribution of the permeable zones, however, exploration is speculative, and, in many cases, several dry holes are drilled for every productive well. Drilling near fault zones is usually a good strategy because the stress and shear forces generated in these zones can cause exceptional fracturing of the rock, and thus, the probability of large ground-water yields is high (USGS, 1995). Numerous springs also occur where the contact between recent and older volcanic deposits are exposed.

Volcanic-rock aquifers located within the watershed that are of particular interest include the Medicine Lake Highlands and the recent volcanic deposits feeding springs from the Fall River Valley. The Highlands are important because this area has been identified as a Geothermal Resource Area and two geothermal facilities are proposed for the area. One of these proposed facilities is to be located within the watershed. The Fall River Springs are important because it is one of the largest spring groups in the United States (Rose, et. al., 1996).

The hydrologic units in this area consist of recent Medicine Lake Volcanic Rocks, Pliocene to recent lava flows of the Modoc Plateau, and deep geothermal reservoir. In general, the groundwater flow direction in the volcanic aquifers is from north to south, and field data suggest that the deep geothermal reservoir is isolated from the overlying volcanic aquifers (USDOI, 1999).

Although there appears to be significant debate about the source of the groundwater discharging from Fall River Springs (Weis, 1997), the most likely source is precipitation infiltrating into the volcanic rock aquifer located between the springs and the Medicine Lake Highlands to the north. This area includes the Fall River Graben and surrounding areas. Assuming that the Fall River Springs yield 869,000 acre-feet per year (USGS, 1998), the recharge area receives approximately 24 inches of precipitation annually, and 35 percent of the precipitation infiltrates into the underlying aquifer system, it is estimated that the recharge area would cover approximately 2000 square miles (approximately 45 miles by 45 miles). The groundwater recharge rate of 35 percent is high to reflect that fact that the area generates little direct surface water runoff.

Groundwater Extraction and Water Use

Between 1985 and 1995, the USGS (2003b) estimated surface water consumptive use in the Upper Pit River Watershed to be approximately 170,000 acre-feet per year. In contrast, the estimated groundwater consumptive use was estimated to be 50,000 acre-feet per year. In both cases, irrigation was the primary water user. For comparison, average annual runoff at Bieber is approximately 340,000 acre-feet per year.

If the number of irrigation wells can be used as an indicator, groundwater usage in the Upper Pit River Watershed has increased approximately 10 fold in the last 40 years. For example, the number of irrigation and municipal wells within the Alturas basin increased 3.6 times between 1960 and 1979, and 2.3 times between 1979 and 1997. Within the Big Valley basin, the number of municipal and irrigation wells increased by 5.9 times between 1960 and 1979, and 1.8 times between 1979 and 1997.

Statewide, well drilling peaked in 1977, in response to the 1975–76 drought; and in 1993, in response to the 1987–92 drought (DWR, 2000). USGS estimated that approximately 50,000 acre-feet of water were used consumptively for irrigation in the watershed in 1990, and approximately 80,000 acre-feet of water were used consumptively for irrigation in 1995 (USGS, 2003b).

A summary of the number of irrigation wells and annual extraction rates is presented in Table 5-10.

Table 5-10
IRRIGATION WELLS AND ANNUAL EXTRACTION RATES

	1960	1979		1997		Construction	
Basin	Number Wells	Number Wells	Annual Extraction (aft/yr)	Number Wells	Annual Extraction (aft/yr)	Average Depth (feet)	Average Yield (gpm)
Alturas	14	50	4,400	113	16,000	488	870
Big Valley	16	94	19,000	171	29,000	482	875
Total	30	144	23,400	284	45,000	---	---

Source: DWR, 1982 and 2003a

Water Levels

The California Department of Water Resources collects semi-annual groundwater level data from 11 wells in the Alturas groundwater basins, 18 wells in the Big Valley groundwater basin, and from two wells in the Round Valley groundwater basins. Water level data for representative wells located in the Alturas and Big Valley groundwater basins are shown on Figures 5-26 and 5-27. In general, the results show declining water levels during the irrigation season when the underlying groundwater is used for agricultural use, and increasing levels in the spring. These annual fluctuations are superimposed on longer-term fluctuations that reflect annual precipitation, declining during the 1987 to 1992 drought and more recent drought conditions.

Groundwater Balance

Although a detailed water budget has not been conducted for the Upper Pit River Watershed, it is possible estimate the annual volume of groundwater recharge and surface runoff using rainfall data for the watershed and surface water runoff and groundwater recharge parameters estimated for nearby watersheds. Using this information, a general water balance is presented in Table 5-11.

Table 5-11
PRELIMINARY WATER BALANCE

Parameter	Factor	Volume (acre-feet/year)	Source
Precipitation	---	2,400,000	2,475 square mile watershed at Bieber (USGS, 2003a) * 18.4 inches average precipitation (CARA, 2003)
Pre-Irrigation Runoff at Bieber.	---	510,000	Estimated in Text
Runoff Factor	0.21	---	510,000/2,400,000
Direct Infiltration of Precipitation Factor	0.085	205,000	2,400,000 * 0.085 (LBBVRCD, 2002)
Channel Seepage Factor	0.26	---	USGS, 1981 and 2003b
Seepage from Channel to Groundwater	---	180,000	510,000/(1–0.26) – 510,000
Estimated Groundwater Recharge	---	385,000	205,000 + 180,000
Using Maxey and Eakin (1950) approach for estimating groundwater recharge, annual estimate is 2,400,000 acre-feet of precipitation * 0.15 (factor for precipitation range between 15 and 20 inches per year) = 360,000 acre-feet per year			

Estimated USGS (2003b) annual consumptive use is 170,000 acre-feet for surface water, and 50,000 acre-feet for groundwater. Based on the preliminary water balance, this represents 33 percent of the total available surface water, and 13 percent of the available groundwater.

Regulations

When the Water Commission Act of 1913 (Stats. 1913, Ch. 586) became effective in 1914, appropriative surface water rights became subject to statutory permitting process. This appropriation procedure can be found in Water Code Section 1200 et seq. Groundwater classified as underflow of a surface stream, or as a "subterranean stream flowing through a known and definite channel" was made subject to the state permit system. However, groundwater in California is presumed to be "percolating water," that is, water in underground basins and groundwater that has escaped from streams. This percolating water is not subject to a permitting process. As a result, California does not have a statewide management program or statutory permitting system for groundwater. Some local agencies have adopted groundwater ordinances under their police powers, or have adopted groundwater management programs under a variety of statutory management schemes. Most of the body of law governing groundwater use in California today has evolved through a series of court decisions beginning in the early twentieth century (DWR, 2003a). Key cases are listed in Table 5-12.

Table 5-12 SIGNIFICANT COURT CASES RELATED TO THE RIGHT TO USE GROUNDWATER IN CALIFORNIA	
Case	**Issue Addressed**
Katz v. Walkinshaw, 141 Cal. 116 (1903)	Prior to the Katz decision, landowners enjoyed absolute ownership of groundwater underneath their property. The 1903 decision established the Correlative Rights Doctrine analogous to a riparian right. In other words, each overlying landowner is entitled to make reasonable beneficial use of groundwater.
Peabody v. City of Vallejo, 2 Cal. 2d 351 (1935)	Limited riparian rights under the reasonable and beneficial use requirement of the 1928 constitutional amendment; requirement of reasonable and beneficial use.
Pasadena v. Alhambra, 33 Cal. 2d 908 (1949)	This decision established the doctrine of "mutual prescription." Mutual prescription provided groundwater rights to both overlying users and appropriators in depleted groundwater basins by prorating their rights based on the highest continuous amount of pumping during the five years following commencement of the overdraft.
Niles Sand and Gravel Co. v. Alameda County Water District, 37 Cal. App. 3d 924 (1974)	Established right to store water underground as a servitude.
Techachapi-Cummings County Water District v. Armstrong, 49 Cal. App. 3d 992 (1975)	Modified the Mutual Prescription Doctrine articulated in Pasadena v. Alhambra. Overlying owners' water rights must be quantified on the basis of current, reasonable and beneficial need, not past use.
Los Angeles v. San Fernando, 14 Cal. 3d 199 (1975)	The court found that Los Angeles had prior rights to all of the yield pursuant to its "pueblo rights." This pueblo was held to be superior to the rights of all overlying landowners.
Wright v. Goleta Water District, 174 Cal. App. 3d 74 (1985)	The unexercised water rights of overlying owners are protected from appropriators; notice and opportunity must be given to overlying owners to resist any interference with their rights.
Hi-Desert County Water District v. Blue Skies County Club, 23 Cal. App. 4th 1723 (1994)	Retention of overlying right; no acquisition of prescriptive right by overlying owner.
Baldwin v. Tehama County, 31 Cal. App. 4th 166 (1994)	City and County regulations of groundwater through police power. County limitations on export upheld.
City of Barstow v. Mojave Water Agency, 23 Cal. 4th 1224 (2000)	Held that in considering a stipulated physical solution involving equitable apportionment, court must consider correlative rights of parties that did not join the stipulation.

Agencies And Districts

Modoc County adopted a groundwater management ordinance in 2000. Water agencies and districts located with the watershed include:

- City of Alturas
- California Pine Community Service District
- Hot Springs Valley Irrigation District
- Lassen County WD No. 1
- Lassen-Modoc County Flood Control and Water Conservation District
- Adin Community Service District

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Section 6

Section 6
WATER QUALITY

TABLES

FIGURES

Section 6
WATER QUALITY

The main stem Pit River has been identified as an "impaired water body" under the Section 303(d) of the Federal Clean Water Act (CWA). Water quality parameters named in the 303(d) listing include temperature, dissolved oxygen and nutrient loading. Although not listed, sediment and turbidity are also suspected of being at unacceptable levels (PWA, 2003). The original listing was made based primarily on professional judgment, although observations of high temperature and low dissolved oxygen have been recorded. Causes of these conditions have not been conclusively demonstrated, although various natural and management related phenomena are suspected.

The 303(d) listing means that the Regional Water Quality Control Board (RWQCB) has determined on a preliminary basis that the concentration or level of the listed parameters exceed the numeric or narrative standards that apply to existing or potential beneficial uses assigned to the Upper Pit River Watershed. These beneficial uses and standards are presented in the Water Quality Control Plan (Basin Plan) for the Sacramento and San Joaquin River Basin (RWQCB, 1998). As a result of the 303(d) listing, the RWQCB is required to develop Total Maximum Daily Loading (TMDL) criteria and an implementation plan to attain these new criteria for the Upper Pit River Watershed by 2011.

Information on the beneficial uses, corresponding numeric and narrative standards included in the Basin Plan, and a summary of available water quality data for the Upper Pit River Watershed are summarized in this section. Key river segments and sample locations discussed in this section are shown on Figure 6-1.

WATER QUALITY STANDARDS

Section 303 of the CWA, 33 U.S.C. §1313, provides for promulgation of water quality standards by states. The standards consist of designating uses of water and developing water quality criteria based on the designated uses (40 CFR §131.3(i)). The criteria are "elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use" 40 CFR §131.3(b). Water quality standards for the Upper Pit River Watershed are presented in the Water Quality Control Plan for the Sacramento and San Joaquin River Basin (RWQCB, 1998).

The CWA requires states to protect beneficial uses of waters of United States within their jurisdictional boundaries. U.S. Environmental Protection Agency (USEPA) regulations to implement the CWA further require states to adopt water quality criteria (referred to as "objectives" in California) that protect the designated "beneficial uses" of water bodies. The designated beneficial uses, the water quality criteria to protect those uses, and an antidegradation policy constitute water quality standards.

A water quality standard defines the water quality goals for a water body, or portion thereof (in part), by designating the beneficial use or uses to be made of the water. States adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the CWA. "Serve the purposes of the Act" as defined in Sections 101 (a) (2) and 303 (c) of the CWA means that water quality standards should, at a minimum:

- Provide, wherever attainable, water quality for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water. This goal is commonly restated as the water should be "fishable and swimmable"

- Consider the use and value of State waters for public water supplies, propagation of fish and wildlife, recreation, agriculture, and industrial purposes, and navigation (USEPA 1994)

According to Section 13050 of the California Water Code, Basin Plans consist of a designation or establishment for the waters within a specified area of beneficial uses to be protected, water quality objectives to protect those uses, and a program of implementation needed for achieving the objectives. State law also requires that Basin Plans conform to the policies set forth in the Water Code beginning with Section 13000 and any state policy for water quality control. Since beneficial uses, together with their corresponding water quality objectives, can be defined per federal regulations as water quality standards, the Basin Plans are considered regulatory references for meeting state and federal requirements for water quality control (40 CFR 131.20).

A Basin Plan must identify all of the following (Water Code Section 13240-13244):

a) Beneficial uses to be protected
b) Water quality objectives
c) Program of implementation needed for achieving water quality objectives
d) Surveillance and monitoring to evaluate the effectiveness of the program

Basin Plans are adopted and amended by the RWQCB using a structured process involving peer review, public participation, state environmental review, and state and federal agency review and approval.

The Basin Plan for the Sacramento and San Joaquin River Basin, which includes the Upper Pit River Watershed, was first adopted in 1975. In 1989, a second edition was published. The second edition incorporated all the amendments which had been adopted and approved since 1975, updated the Basin Plan to include new state policies and programs, restructured and edited the Basin Plan for clarity, and incorporated the results of triennial reviews conducted in 1984 and 1987. In 1994 a third edition was published incorporating all amendments adopted since 1989, including new state policies and programs, restructuring and editing the Basin Plan to make it consistent with other regional and state plans, and substantively amending the sections dealing with beneficial uses, objectives, and implementation programs. The current edition or fourth edition incorporates two new amendments adopted since 1994. One amendment deals with compliance schedules in permits and the other addresses agricultural surface drainage discharges.

Since publication of the fourth edition, federal rules regarding USEPA approval of water quality standards have changed. When a state adopts a water quality standard that goes into effect under state law on or after May 30, 2000, it becomes the applicable water quality standard only after USEPA approval, unless the USEPA promulgates a more stringent water quality standard for that state, in which case the USEPA promulgated water quality standard is the applicable water quality standard for purposes of the CWA (65 FR 36046 codified at 40 CFR 131.21). This new regulation applies to all surface waters of the state.

The CWA establishes a goal that, where attainable, all waters will be "fishable-swimmable" (CWA Section 101(a)(2)). In implementing this goal, USEPA requires that states designate all waters as "fishable-swimmable." In addition to the mandatory beneficial use protections, the CWA also requires the identification of other beneficial uses to be protected. Uses may be designated as either existing, or potential future uses. An existing use is any use that has existed in the stream at any time since November 28, 1975 (40 CFR 131.3). Existing uses must be fully protected and cannot be removed (40 CFR 131.12[a][1]). A potential use is a use that may or may not have existed in the water body since November 28, 1975. A potential beneficial use may only be removed or modified through a formal Use Attainability Analysis (UAA). To develop water quality standards, states first identify all attainable uses of a water body. Examples of such uses include aesthetic enjoyment, fishing, swimming, and protection of aquatic life and wildlife. States then adopt water quality standards for individual designated uses.

Water Quality objectives are set in the Basin Plans and are the combination of beneficial uses and criteria to protect the identified use. The Porter-Cologne Water Quality Control Act defines water quality objectives as "… the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area" (Water Code Section 13050[h]). In establishing water quality objectives, the RWQCB considers, among other things, the following factors:

- Past, present, and probable future beneficial uses
- Environmental characteristics of the hydrographic unit under consideration, including the quality of water available
- Water quality conditions that could reasonably be achieved through the coordinated control of all factors, which affect water quality in the area
- Economic considerations
- The need for developing housing within the region
- The need to develop and use recycled water

As noted earlier, California water quality standards include the designation and protection of beneficial uses and the water quality objectives adopted to protect these uses.

Beneficial Uses

Beneficial use designations are the foundation of water quality management strategies in California. State law defines beneficial uses of California's waters that may be protected against quality degradation to include (and not be limited to) "...domestic; municipal; agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves" (Water Code Section 13050[f]). Protection and enhancement of existing and potential beneficial uses are primary goals of water quality planning.

Significant points concerning the concept of beneficial uses are:

- All water quality problems can be stated in terms of whether there is water of sufficient quantity or quality to protect or enhance beneficial uses

- Beneficial uses do not include all of the reasonable uses of water. For example, disposal of wastewaters is not included as a beneficial use. This is not to say that disposal of wastewaters is a prohibited use of waters of the State, it is merely a use, which cannot be satisfied to the detriment of beneficial uses. Similarly, the use of water for the dilution of salts is not a beneficial use although it may, in some cases, be a reasonable and desirable use of water

- The protection and enhancement of beneficial uses require that certain quality and quantity objectives be met for surface and ground waters

- Fish, plants, and other wildlife, as well as humans, use water beneficially

Designated beneficial uses of the Upper Pit River, including the North and South Forks, and the main stem from Alturas to Hat Creek, are listed on Table II-1 of the Basin Plan. The beneficial uses include (RWQCB, 1998):

Municipal and Domestic Supply (MUN) Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply. This use is designated as existing on the North and South Forks of the Pit River, and along the main stem between Alturas and Hat Creek.

Agricultural Supply (AGR) Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation (including leaching of salts), stock watering, or support of vegetation for range grazing. This use is designated as existing on the North and South Forks of the Pit River, and along the main stem between Alturas and Hat Creek.

Hydropower Generation (POW) Uses of water for hydropower generation. This use is designated as existing along the main stem between Alturas and Hat Creek.

Water Contact Recreation (REC-l) Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs. This use is designated as potential or existing on the North and South Forks of the Pit River, and along the main stem between Alturas and Hat Creek.

Non-contact Water Recreation (REC-2) Uses of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any likelihood of ingestion of water. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities. This use is designated as existing on the North and South Forks of the Pit River, and along the main stem between Alturas and Hat Creek.

Warm Freshwater Habitat (WARM) Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. This use is designated as existing on the North and South Forks of the Pit River, and along the main stem between Alturas and Hat Creek.

Cold Freshwater Habitat (COLD) Uses of water, that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. This use is designated as existing on the North and South Forks of the Pit River, and along the main stem between Alturas and Hat Creek.

Wildlife Habitat (WILD) Uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources. This use is designated as existing on the North and South Forks of the Pit River, and along the main stem between Alturas and Hat Creek.

Spawning, Reproduction, and/or Early Development (SPWN) Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish. This beneficial use is limited to specific species for both cold and warm-water spawning. This use is designated as existing for warm and cold-water species on the North and South Forks of the Pit River, and for warm water species along the main stem between Alturas and Hat Creek.

Numeric and Narrative Water Quality Standards

As previously mentioned, the main stem Pit River has been identified as an "impaired water body" under the Section 303(d) of the CWA. Water quality parameters named in the listing include temperature, dissolved oxygen, and nutrient loading. Additionally, sediment and turbidity are suspected of being at unacceptable levels. The numeric and narrative water quality standards identified in the Basin Plan for these water quality parameters are summarized below.

Temperature

Temperature objectives for COLD interstate waters, WARM interstate waters, and Enclosed Bays and Estuaries are as specified in the Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays of California including any revisions. There are also temperature objectives for the Delta in the State Water Resources Control Board's (SWRCB) May 1991 Water Quality Control Plan for Salinity. Narrative temperature objectives include:

- The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the RWQCB that such alteration in temperature does not adversely affect beneficial uses

- At no time or place shall the temperature of COLD or WARM intrastate waters are increased more than 5 °F above natural receiving water temperature. In determining compliance with the water quality objectives for temperature, appropriate averaging periods may be applied provided that beneficial uses will be fully protected

Dissolved Oxygen

For surface water bodies outside the legal boundaries of the Delta, the monthly median of the mean daily dissolved oxygen concentration shall not fall below 85 percent of saturation in the main water mass, and the 95-percentile concentration shall not fall below 75 percent of saturation. The dissolved oxygen concentrations shall not be reduced below the following minimum levels at any time:

- Waters designated WARM 5.0 mg/l
- Waters designated COLD 7.0 mg/l
- Waters designated SPWN 7.0 mg/l

Nutrients (Biostimulatory Substances)

Water shall not contain biostimulatory substances that promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses.

Other Parameters

The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits:

- Where natural turbidity is between 0 and 5 Nephelometric Turbidity Units (NTUs), increases shall not exceed 1 NTU

- Where natural turbidity is between 5 and 50 NTUs, increases shall not exceed 20 percent

- Where natural turbidity is between 50 and 100 NTUs, increases shall not exceed 10 NTUs

- Where natural turbidity is greater than 100 NTUs, increases shall not exceed 10 percent

In determining compliance with the above limits, appropriate averaging periods may be applied provided that beneficial uses will be fully protected.

Exceptions to the above limits will be considered when a dredging operation can cause an increase in turbidity. In those cases, an allowable zone of dilution within which turbidity in excess of the limits may be tolerated will be defined for the operation and prescribed in a discharge permit.

Specific numeric limits are also identified in the Policy for Implementation of Toxic Standards for Inland Surface Waters, Enclosed Bays and Estuaries of California (SWRCB, 2000).

SOURCES OF DATA

Key water quality investigations conducted in the Upper Pit River Watershed are briefly reviewed in this section. In conjunction with this watershed assessment, analytical data from these investigations were compiled and input into a database. The results are presented in more detail in the General Water Quality Section.

Upper Pit River Investigation (DWR, 1960)

The Upper Pit River Investigation was conducted by the Department of Water Resources (DWR) to develop a plan for water development that would achieve optimum conservation of the limited water supply available to Big Valley. Emphasis was placed on the engineering feasibility and economic justification for developing the Allen Camp Dam project. In conjunction with this investigation, surface water along the main stem Pit River and several tributaries were sampled periodically between 1951 and 1957. The primary objective of the sampling effort was to evaluate the quality of the water for irrigation purposes. For this reason, the routine samples were analyzed for conductivity and turbidity. Several samples were also collected to classify the water for agricultural purposes (i.e., turbid, slightly hard, calcium-sodium bicarbonate-type water).

Pit River Water Quality Investigation (RWPCB, 1962)

In September 1962, the Regional Water Pollution Control Board (RWPCB) conducted a short-term survey of the Pit River basin for the purpose of defining existing water quality conditions and for reviewing the many factors which contribute to these conditions. This study was the first water quality investigation in the Upper Pit River Watershed to focus on the impacts of temperature and dissolved oxygen.

The investigation involved reviewing historical data and collecting physical and chemical samples from 39 surface water locations between the headwaters of the Pit River and Lake Shasta. The samples were collected in September 1962. Physical parameters included temperature and turbidity; and chemical parameters included pH, dissolved oxygen, general minerals and trace metals. Conclusions from this study follow:

- Existing Pit River basin waters are everywhere suitable for all agricultural purposes. There is no evidence that this excellent agricultural quality will materially change in the future.

- Existing Pit River basin waters are aesthetically unattractive in many areas due to turbidity and dark color. Basic causes of these physical factors are:

    - Volcanic soils and ancient lake bottom silts that contribute a relatively permanent turbidity to area waters.

    - Topography that creates torpid reaches where aeration (oxygen supply) is minimum; and temperature fluctuates widely in correspondence with atmospheric temperatures, and with intensity of sunlight.

- Intensive application of waters from agricultural practices. Irrigation via flooding is a major contributor to temperature fluctuations.

- Existing basin waters are limited in their fish carrying capacities by physical rather than chemical qualities, warm waters, often low in oxygen content, support primarily carp, suckers, and bullheads. Intermediate temperature waters, usually of better oxygen content, support bass, sunfish, and catfish. Cold water, of high oxygen content, provides an environment where trout thrive.

- Because the factors responsible for water temperatures and oxygen content are largely natural, or inextricably associated with agriculture, fishery enhancement will continue to be limited by existing temperature and oxygen conditions.

- Existing domestic and industrial discharges (other than agricultural) are currently so regulated and of such minor nature as to exert no significant effect on basin water quality. Future growth predictions for this basin indicate that waste disposal problems, in regard to water quality, will remain inconsequential. Continued regulation of new and expanding discharges, as currently practiced under central valley regional water pollution control board procedures, will adequately protect local areas.

- Mineral and physical degradation of Pit River basin waters will hold at current levels in future years, with some areas showing local improvement or deterioration. Trends in water quality will depend directly upon the ratio of new water developed in the area to expanding use of water by agricultural interests.

- Minor but worthwhile betterment in water quality will derive from irrigation, farming, and forestry methods.

- Development of water supplies for the specific objective of water quality improvement offers promise for considerable quality improvement. Such objective is now recognized in federal projects as a non-reimbursable benefit.

Pit River Water Quality Study (DWR, 1982)

The Pit River Water Quality Study was conducted to expand the knowledge of the Pit River and its quality variations so that this important water supply could be managed and protected. The study area extended from the headwaters of the Pit River to Lake Britton. At the time, water quality in the Pit River at Canby had been monitored for nearly 30 years, and water quality in the South Fork of the Pit River at Likely had been monitored for 21 years.

A review of historical data showed that water quality problems were apparent at various locations through the river system. Problems related to excessive productivity were predominant in Lake Britton and reaches of the Pit River at Fall River Valley and Big Valley. As part of this investigation, field samples were collected between spring 1977 and summer 1980. Daily and seasonal water samples were collected from twelve locations. In general, the samples were analyzed for physical, chemical, and biological parameters.

Temperature
The highest peak temperatures and greatest daily variations were observed in the North Fork of the Pit River near Alturas and in the Pit River at Pittville. At Alturas, the maximum water temperature of 88 ºF was observed in July 1977, and daily variations exceeded 34ºF. The maximum observed water temperature at Pittville was 82ºF, and daily variations exceeded 18ºF. Daily variations of less than 6ºF were observed in October. Between Alturas and Pittville, high temperatures ranged between 75 and 79ºF, with daily variations ranging between 8 and 13ºF. Downstream from Pittville to Lake Britton, maximum summer water temperatures were just over 68ºF, and daily variations ranged between 7ºand 9ºF.

Dissolved Oxygen
As part of this study, dissolved oxygen levels along the North Fork and South Fork of the Pit River generally ranged between 5.5 and 9.0 mg/l. At Canby, levels generally ranged between 5 and 15 mg/l. The lowest observed level at Canby was 3.6 mg/l. Downstream at Lookout and Bieber, the levels ranged between 5.5 and 10.2 mg/l.

Nutrients
Nitrate nitrogen levels ranged from 0.0 to 0.31 mg/l, with a median concentration of 0.07 mg/l. The total ammonia plus organic nitrogen concentrations ranged from 0.16 to 3.6 mg/l, with a median concentration of 1.1 mg/l in the Pit River from Alturas to Bieber. The median concentration was 0.06 mg/l between Pittville and Lake Britton.

Total phosphorus concentrations ranged from 0.04 to 0.5 mg/l, with a median value of 0.18 mg/l upstream from Bieber and 0.07 mg/l downstream to Lake Britton. Dissolved orthophosphate levels varied between 0.0 and 0.28 mg/l. The median concentration was 0.10 mg/l between Alturas and Bieber, and the median concentration was 0.003 mg/l between Pittville and Lake Britton.

Other Parameters
DWR (1982) reported that turbidity in the Upper Pit River increases downstream to Pittville. From Pittville to Lake Briton, sampling stations showed less turbidity due to groundwater inflow and clear tributaries. Turbidity was highest from January through April when flows are highest. This is due mostly to eroded humic (lignitic) soils. Other sections of the Pit were turbid during warmer months due to algal growth (the result of high temperatures, low flows and nutrients).

Conductivity of the Pit River rarely exceeded 400 microSiemen per centimeter (uS/cm). In the lower reaches, the levels were usually less than 250 uS/cm.

The pH of the Pit River waters usually ranges between 7.0 and 9.0, with the highest values usually occurring in the summer (DWR, 1982).

Macro-invertebrate collector organisms generally dominated the trophic structure, but scraper organisms were usually well represented. This indicates that particulate organic matter was the most important food source, though primary productivity may have been equally important in some areas.

Summary Report, Pit River Water Quality Study (RWQCB, 2003)

During 2001 and 2002, RWQCB staff conducted a water quality investigation along the upper reaches of the Pit River. The objectives of this investigation were to:

- Assess existing water quality in the Pit River and provide a basis for comparison with past and future studies.
- Evaluate to what extent existing water quality may be limiting aquatic resources and other beneficial uses.
- Evaluate the appropriateness of the 303(d) listing.
- Provide input to the ongoing watershed assessment for the Pit River and protection/restoration efforts underway by the Resource Conservation Districts and the Pit River Watershed Alliance.

This investigation involved collecting periodic samples from eight locations between the headwater of the Pit River and Pittville. Depending on the analyses, the samples were collected weekly or monthly. Water temperature was recoded on a continuous basis. Routine samples were analyses for nutrients, total and fecal coliform, turbidity, suspended solids, dissolved oxygen, electrical conducting and pH. Selected samples were analyzed for general minerals, metals and macro-invertebrates.

Temperature
River temperature patterns were relatively consistent through the study reach, i.e., there was no significant increase or decrease in water temperature as one goes from the upstream stations to the downstream stations. The coldest water was observed on the South Fork of the Pit River near Likely. This station also showed the least daily variations in temperature during the summer.

Dissolved Oxygen
Dissolved oxygen readings ranged from a low of 3.0 mg/l to 14 mg/l, with the lowest readings generally occurring in the early morning hours. This occurrence is consistent with the process whereby algae and green plants produce oxygen via photosynthesis during the day. Diurnal sampling in July showed 24-hour variations between 4.0 mg/l dissolved oxygen in the early morning and 12 mg/l dissolved oxygen in the late afternoon.

Nutrients
There were no obvious upstream or downstream trends in nutrient concentrations. There were no observed seasonal trends in nutrients except that nitrate concentrations were somewhat higher in the winter than in the summer.

Other Parameters
According to the 2003 RWQCB study, there were no upstream or downstream trends in turbidity or sediment. Elevated turbidity in the South Fork of the Pit River near Likely was attributed to highly turbid West Valley Reservoir releases

Conductivity generally ranged from 50 to 200 uS/cm at the headwater stations and between 200 and 400 uS/cm on the main stem. A moderate increase in conductivity was observed during the summer months. The pH values at the samples locations ranges between 6 and 10, with the highest values usually occurring in the summer.

Macro-invertebrate communities on the North Fork and South Fork of the Pit River near Alturas were less robust compared to the communities at the other river stations. This trend is apparent in each of the selected metrics, including Taxa Richness, percent EPT, Shannon Diversity, percent Tolerant Taxa and percent Intolerant Tax.

Of a total of 168 individual fecal coliform samples, 13 exceeded 400 MPN (most probable number). The Basin Plan (RWQCB, 1998) standard for fecal coliform to protect the beneficial use of contact recreation (REC-1) is not more than 10 percent of the total number of samples taken during any 30-day period shall exceed 400 MPN per 100 milliliters of water. Of the total 96 e-coli samples, eight exceeded 235 MPN. There were no observed upstream or downstream trends in bacteria concentrations. Overall, bacteria concentrations in the Pit River are not particularly high relative to other surface waters with comparable land and water use practices.

Additional Water Quality Studies

Additional water quality studies have or are being conducted in the Upper Pit River Watershed. In general, data from these activities has not been published or made available to the general public. Ongoing or recently completed studies include:

- Pit River Watershed Alliance conducted sampling during August and September 2002 on tributaries within the Upper Pit River Watershed. Samples were analyzed for temperature, general minerals, metals, turbidity, and particulate matter. Sample locations are identified on Figure 6-1.

- U. S. Bureau of Land Management is currently sampling several major tributaries within the Upper Pit River Watershed. The sampling activities include using continuous recording equipment for stream flow and other physical parameters. The results from this study have not been published.

- Central Modoc Resource Conservation District is currently sampling several tributaries for stakeholders in the watershed. These data have not been published.

- Routine water quality sampling is conducted at the Malacha Hydro facility located in Muck Valley. The sample results are submitted to the RWQCB on an annual basis.

- U.S. Forest Service has on ongoing water quality sampling program in the Warner Mountains.

It has been reported that the University of California Extension has completed a water quality study to evaluate diurnal temperature and dissolved oxygen levels in the Upper Pit River.

GENERAL WATER QUALITY

Key water quality parameters within the Upper Pit River Watershed include temperature, dissolved oxygen, nutrient loading, and turbidity. Analytical data for these parameters were compiled from the above-mentioned reports and transferred to a digital database for analysis. The annual number of temperature readings collected along the main stem of the Pit River between Alturas and Bieber are summarized on Figure 6-2. As shown, the majority of the readings were collected in conjunction with the 1962 RWPCB, 1982 DWR, and 2003 RWQCB studies.

For this analysis, data were divided into two groups. The groups included data collected between 1950 and 1982, and data collected between 1982 and 2001 to 2002. In general, it was assumed that data collected between 1950 and 1982 represent conditions in 1975, and data collected by the RWQCB in 2001 and 2002 represent current conditions. The year, 1975, is important because the CWA states that any designated beneficial present on, or established since, November 28, 1975, is an existing use and cannot be changed. For example, if a cold water fisheries did not exist on November 28, 1975, and it has not been established since, cold water fisheries in not an existing beneficial use. It is a potential beneficial use. Potential beneficial uses can be modified or abandoned.

The analysis also compares pre-1983 data to current data to determine if the water quality of the river has changed dramatically over the last 25 years. If the river is undergoing rapid change, it may be necessary to identify and implement interim restoration efforts in a relatively short time period. If, on the other hand, very little change has occurred, restoration can proceed in an orderly, well-planned manner.

Temperature

Water temperature is a fundamental parameter of water quality and an integral component of aquatic habitat. Chronic and significant water temperature exceedances above natural variability of a stream are likely to impact aquatic biota (Haynes, 1970 and Beschta et al., 1987). Furthermore, elevated temperatures can trigger conditions that affect other water quality parameters such as dissolved oxygen. Natural watershed parameters that impact stream temperature include (WFP, 1997):

- **Geography** (latitude, longitude, elevation)
- **Climate** (air temperature, relative humidity, wind velocity and cloudiness)
- **Stream Channel Characteristics** (stream depth, width, velocity, substrate composition and water clarity)
- **Riparian or Topographic Blocking** (percent shade, canopy, vegetation height, crown radius and topographic angle.)
- **Water Source** (mountain streams, low elevation runoff or groundwater)

Physical conditions along the main stem Upper Pit River that impact water temperatures include low flows, shallow slow moving water, and largely unvegetated stream banks. With an elevation drop of less than 10 feet per mile between Alturas and Canby, there is insufficient slope to keep the main stem flowing rapidly. As a result, the Upper Pit River meanders through several open valleys, often in shallow braided stream segments, and is subject to warming by high summer temperatures. Seasonal discharge from storage reservoirs and discharge from numerous hot springs located between Alturas and Canby may contribute to elevated temperatures along the main stem.

Water temperature is important because fish and most aquatic organisms are cold-blooded. Consequently, their metabolism increases with increasing water temperature. Each aquatic species has an optimum water temperature. If the water temperature shifts from optimum, organisms become stressed. The optimum water temperature for coldwater species such as juvenile and adult trout is between 45 and 65ºF (Heiskary et al., 1988; USEPA, 1987; Edwards et al., 1983 and Stuber et al., 1982), and the optimum water temperature for warm water species such as adult bass is between 65 and 85ºF (USEPA, 1987; Newbury et al., 1993; Raleigh, 1982; Raleigh et al., 1984a; Raleigh et al., 1984b and Pauley et al., 1989)

Current Basin Plan Standards

At no time or place shall the temperature of COLD or WARM intrastate waters increase more than 5ºF above natural receiving water temperatures. In determining compliance with the water quality objectives for temperature, appropriate averaging periods may be applied provided that beneficial uses will be fully protected.

Analytical Evaluation

Minimum, maximum and average monthly water temperatures in the South Fork of the Pit River and in the Pit River at Canby and Bieber are shown in Figures 6-3 (a-c), 6-4 (a-c), and 6-5 (a-c).

- **South Fork of the Pit River.** Monthly minimum water temperatures recorded in April and May prior to 1983 are higher than the monthly minimum water temperatures recorded between 2001 and 2002. Monthly maximum and average water temperatures recorded prior to 1983 and between 2001 and 2002 are nearly equal.

- **Canby.** In general, monthly minimum water temperatures recorded between 2001 and 2002 are several degrees higher than the monthly minimum water temperatures recorded prior to 1983. Again, however, the monthly maximum and average water temperatures are similar.

- **Bieber.** Monthly minimum and average water temperatures recorded in July prior to 1983 are nearly 10ºF higher than the monthly minimum and average water temperatures recorded between 2001 and 2002.

Overall, it appears that the monthly water temperatures recorded prior to 1983 and between 2001 and 2002 are similar. Based on this observation, average monthly temperatures calculated using the entire database are shown on Figure 6-6. The results show that average monthly water temperatures at each station generally fall within a range of 5ºF, with the following exceptions:

- The average April water temperature at the Pittville station is approximately 10ºF higher than the average water temperatures recorded at the other stations

- The average October water temperatures at the North Fork and South Fork of the Pit River stations are approximately 15ºF lower than the average water temperatures recorded at the other stations.

- The average November water temperatures at the Canby and South Fork of the Pit River stations are approximately 5ºF lower than the average water temperatures recorded at the other stations.

Based on Figure 6-6, it appears that water temperatures in the Upper Pit River do not change significantly between Alturas and Pittville. The RWQCB (2003) also concluded that there is "no significant increase or decrease in water temperature as one goes from the upstream stations to the downstream stations."

An exceedance probability chart developed using the historical data collected between June and September is included on Figure 6-7. Using this chart, one can determine, for example, that the water temperatures recorded between June and September exceeded 70ºF nearly 30 percent of time.

Daily or Diurnal Variations

The difference between the daily minimum water temperature and daily maximum water temperature averages 8ºF, ranging between 12ºF in the summer to less than 5ºF in the winter. In contrast, the difference between the daily minimum air temperature and the daily maximum air temperature averages approximately 38ºF.

Water versus Air Temperature

Monthly water and air temperatures for the Pit River at Canby are shown on Figure 6-8. The results suggest that average monthly water temperatures are approximately 5ºF higher than average monthly air temperatures. Furthermore, the monthly minimum water temperatures are approximately equal to the monthly average air temperatures between December and April; and are slightly less than the monthly average air temperatures between May and November. The monthly maximum water temperatures are approximately equal to the average maximum air temperatures; except in July, August, and September.

Effects of Temperature on Other Processes

The temperature of a water body directly and indirectly controls many other water quality parameters. For example, the solubility of dissolved oxygen increases with decreasing temperature, and the solubility of most salts increase with increasing temperature. Additionally, sunlight increases metabolic activity and algal growth that, in turn, affects pH.

Discussion

Conclusions based on an evaluation of the temperature data collected prior to 1983 and between 2001 and 2002 include:

- Water temperature data collected along the Upper Pit River prior to 1983 are consistent with the water temperature data collected between 2001 and 2002

- Water temperatures in the Upper Pit River do not change significantly between Alturas and Pittville (i.e., on any give day, the water temperature in the Pit River at Alturas is similar to the water temperature in the Pit River at Canby and Pittville)

- Water and air temperatures are highly correlated. Average monthly water temperatures are approximately 5ºF higher than the average monthly air temperatures. This difference may reflect the fact that most of the water temperature readings were collected during the day

- Monthly minimum water temperatures are approximately equal to the average monthly air temperatures between December and April; and are slightly less than the average monthly air temperatures between May and November

- Monthly maximum water temperatures are approximately equal to the average maximum air temperatures; except in July, August and September

- Water temperature readings collected between June and September exceeded 70ºF nearly 30 percent of time

Dissolved Oxygen

Dissolved oxygen is gaseous oxygen dissolved in water. It is generated by diffusion from the surrounding air, as a byproduct of photosynthesis and from turbulence. A simplified formula for the production of dissolved oxygen by photosynthesis is given by the equation (VanDemark et al., 1987):

Carbon dioxide	+	Water	Light	Oxygen	+	Carbohydrate Molecule
CO_2		H_2O	$\rightarrow$	O_2		(CH_2O)

In general, green plants and certain microorganisms produce oxygen by photosynthesis. Animals and other microorganisms consume oxygen and produce carbon dioxide.

Dissolved oxygen levels are usually reported in milligrams of oxygen per liter of water (mg/l). The unit mg/l is roughly equivalent to parts per million (ppm). Dissolved oxygen can also be expressed as percent saturation, or the actual mass of oxygen dissolved in water relative to the total amount possible based on temperature, pressure and salinity.

Key factors that effect dissolved oxygen concentrations in water include:

- Rate at which dissolved oxygen is produced by photosynthesis

- Rate at which dissolved oxygen is consumed by respiration

- Solubility of oxygen in water (solubility depends on temperature, pressure, and salinity)

- Diffusion rate between the atmosphere and water (atmosphere contains 21 percent oxygen and water, at standard conditions, contains approximately 0.0005 percent dissolved oxygen)

- Turbulence caused by rocky bottoms or steep gradients (turbulence increases the transfer of atmospheric oxygen to water)

Photosynthesis, because it requires light, occurs during daylight hours. Respiration and decomposition, on the other hand, occur 24 hours per day. This difference alone can account for the large daily variations in dissolved oxygen concentrations. For example, during the night when the production of oxygen by photosynthesis does not counterbalance the loss of oxygen through respiration and decomposition, dissolved oxygen concentrations decline steadily. Dissolved oxygen concentrations are usually at their lowest point just before dawn, when photosynthesis resumes. Processes that impact dissolved oxygen concentrations are summarized in Table 6-1. Seasonal and diurnal variations in dissolved oxygen concentrations are well illustrated in a figure produced by DWR (1982) using data from the Pit River at Canby. This figure is reproduced as Figure 6-9.

Table 6-1
DISSOLVED OXYGEN PROCESS

Mechanism	Seasonal		Diurnal	
	Winter	Summer	Day	Night
Rate dissolved oxygen is produced through photosynthesis	Lower	Higher	Higher	Lower
Rate dissolved oxygen is consumed through respiration	Lower	Higher	Higher	Lower
Solubility of oxygen in water	Higher	Lower	Lower	Higher
Dominant Mechanism controlling dissolved oxygen concentration	Solubility		Photosynthesis	

Fish and other aquatic organisms require dissolved oxygen to survive. As water moves past gills or other breathing apparatus, microscopic bubbles of dissolved oxygen are transferred from the water into to their blood by diffusion. Like other diffusion processes, however, the transfer is more efficient above certain concentrations. In other words, although dissolved oxygen may be present, concentrations may be insufficient to fully support aquatic life.

Dissolved oxygen concentrations sufficient to fully support aquatic life depend on the organism and other parameters such as physical condition, water temperature and presence of other chemicals or pollutants. Consequently, it is difficult to designate minimum dissolved oxygen concentrations for individual fish and other aquatic species. For example, at 41ºF, trout require about 50–60 milligrams (mg) of oxygen per hour. At 77ºF, they may require up to 5 or 6 times this amount. Typically, it is assumed that dissolved oxygen concentrations greater 6 and 8 mg/l are sufficient for the normal warm and coldwater fish activity, respectively (USEPA, 1987).

Current Basin Plan Standards

For surface water bodies outside the legal boundaries of the Delta, the monthly median of the mean daily dissolved oxygen concentration shall not fall below 85 percent of saturation in the main water mass, and the 95-percentile concentration shall not fall below 75 percent of saturation. The dissolved oxygen concentrations shall not be reduced below the following minimum levels at any time:

Waters designated WARM 5.0 mg/l
Waters designated COLD 7.0 mg/l
Waters designated SPWN 7.0 mg/l

Analytical Evaluation
Dissolved oxygen has been measured in the Upper Pit River since the 1950s. A summary of the dissolved oxygen data collected at the major Pit River stations is provided in Table 6-2, and the frequency of occurrence of dissolved oxygen in the South Fork of the Pit River and in the Pit River at Canby and Bieber are shown in Figures 6-10, 6-11, and 6-12.

- **South Fork of the Pit River.** The average dissolved oxygen concentration in the South Fork of the Pit River did not change significantly between pre-1983 and 2001 to 2002 (7.0 and 7.1 mg/l, respectively). However, prior to 1983, all of the dissolved oxygen readings were between 5 and 10 mg/l. In contrast, between 2001 and 2002, 24 percent of the readings were less than 5 mg/l, and 24 percent of the readings were greater than 10 mg/l.

- **Canby.** The average dissolved oxygen concentration in the Pit River at Canby declined slightly between pre-1983 and 2001 to 2002 (9.3 and 8.6 mg/l, respectively). Furthermore, prior to 1983, 0.5 percent of the dissolved oxygen readings were less than 5 mg/l, and 36.5 percent were greater than 10 mg/l. Between 2001 and 2002, 5.9 percent of the readings were less than 5 and 23.5 percent of the readings were greater than 10 mg/l.

- **Bieber.** The average dissolved oxygen concentration in the Pit River at Bieber declined slightly between pre-1983 and 2001 to 2002 (8.5 and 7.8 mg/l, respectively). Furthermore, prior to 1983, 3.2 percent of the dissolved oxygen readings were less than 5 mg/l, and 22.2 percent were greater than 10 mg/l. Between 2001 and 2002, 6 percent of the readings were less than 5 mg/l and 10 percent of the readings were less than 23.5 percent.

2001 to 2002 dissolved oxygen data for the Pit River at Canby are plotted along with the minimum and maximum pre-1983 levels on Figure 6-13. In general, data collected during 2001 are within the pre-1983 minimum and maximum levels. In contrast, data collected during 2001 and 2002 are consistently less than the pre-1983 data and the 2001 data. On average, during any given week, the 2002 dissolved oxygen readings are 1.3 mg/l less than the 2001 data.

A probability chart developed using the entire Canby data set is included on Figure 6-14. Using this chart, for example, one can determine that 10 percent of the dissolved oxygen readings at the Canby station were less than 7 mg/l.

Table 6-2 DISSOLVED OXYGEN PRE-1983 AND 2001 TO 2002							
Station	**Sampling Period**	**Count**	**Minimum (mg/l)**	**Maximum (mg/l)**	**Max-Min (mg/l)**	**Average (mg/l)**	**Median (mg/l)**
South Fork-A	Pre-1983	74	5.4	9.6	4.2	7.0	6.8
	2001–2002	52	2.7	12.7	10	7.1	6.5
Canby	Pre-1983	401	3.6	13.4	9.8	9.3	9.3
	2001–2002	52	3.5	12.7	9.2	8.6	9.0
Bieber	Pre-1983	63	3.7	12.3	8.6	8.5	8.2
	2001–2002	50	2.4	14	11.6	7.8	7.4

A = at Alturas.

Annual and Diurnal Variations
On a seasonal basis, dissolved oxygen levels decrease with increasing temperature because dissolved oxygen is less soluble in warm water. In contrast, on a daily basis, dissolved oxygen levels increase during the day in response to the production of oxygen by photosynthesis. Examples of this seasonal trend are shown in Figures 6-9 and 6-13. An example of a diurnal variation is shown on Figure 6-15. As shown, the highest recorded dissolved oxygen reading on Figure 6-15 occurred at approximately 2:00 PM, and lowest recorded reading occurred between midnight and 2:00 AM. The total variation was approximately 2 mg/l. Overall, DWR (1982) concluded that daily variations of between 5 and 7 mg/l were common in the summer. Although the 2003 RWQCB study may have included one or more diurnal sampling episodes, the data were not included in the draft or final report.

The impact of seasonal and diurnal trends is evident in Table 6-3. The average winter dissolved oxygen level at all of the stations is 9.4 mg/l. In contrast, the average summer dissolved oxygen level is 7.2 mg/l. The difference reflects the higher solubility of dissolved oxygen in water during the winter. Furthermore, the average difference between the maximum and minimum levels is 5.7 mg/l in the winter and 10.2 mg/l in the summer. In part, this difference reflects the diurnal production of oxygen during the summer.

Discussion
Conclusions based on an evaluation of the dissolved oxygen data collected prior to 1983 and between 2001 and 2002 include:

- The average dissolved oxygen concentration in the Pit River at Canby declined slightly between pre-1983 and 2001 to 2002 (9.3 to 8.6 mg/l, respectively). Prior to 1983, 0.5 percent of the dissolved oxygen readings were less than 5 mg/l, and 36.5 percent were greater than 10 mg/l. In contrast, between 2001 and 2002, 5.9 percent of the readings were less than 5 and 23.5 percent of the readings were greater than 10 mg/l.

- Historically, 10 percent of the dissolved oxygen readings at the Canby station were less than 7 mg/l.

Table 6-3 DISSOLVED OXYGEN 1950 TO 2002							
Sampling Period	**Station**	**Count**	**Minimum (mg/l)**	**Maximum (mg/l)**	**Max-Min (mg/l)**	**Average (mg/l)**	**Median (mg/l)**
Winter	North Fork-A	3	5.5	10.9	5.4	8.8	10.0
	South Fork-A	3	3.5	11.0	7.5	7.4	6.9
	Alt-Canby	3	5.0	9.7	4.7	7.6	8.0
	Canby	72	8.8	13.4	4.6	11.4	11.4
	Lookout	11	8.0	14.0	6.0	11.1	11.3
	Pittville	6	6.0	12.0	6.0	10.3	6.5
Summer	North Fork-A	74	3.5	13.0	9.5	7.3	7.0
	South Fork-A	74	2.7	12.3	9.6	6.5	6.2
	Alt-Canby	72	0.7	11.6	10.9	7.1	7.0
	Canby	153	3.5	12.0	8.5	7.8	7.8
	Lookout	56	2.4	13.5	11.1	7.3	7.4
	Pittville	77	1.9	13.4	11.5	7.7	7.6
A = at Alturas.							

- In general, data collected during 2001 fall within the pre-1983 minimum and maximum dissolved oxygen levels. In contrast, data collected during 2001 to 2002 are consistently less than the pre-1983 data and the 2001 data.

- On average, during any given week, the 2002 dissolved oxygen readings at Canby were 1.3 mg/l less than the 2001 data.

- Diurnal variations in dissolved oxygen concentration of between 5 and 7 mg/l are common during the summer.

Nutrients

The occurrence of algae blooms has been identified as a potential problem along the main stem Pit River. Algae are defined as phototropic, eukaryotic microorganisms. Algae that float or are suspended in water are called phytoplankton. Phototropic means that cell energy is derived from light, and eukaryotic means a cell with a true nucleus. Examples of cells with true nucleus include protozoa, fungi, animal, and plant cells (VanDemark et al., 1987).

The predominate elements in all cells, including phytoplankton, are carbon, oxygen, hydrogen, nitrogen, phosphorus and sulfur. Together, these six elements account for more than 95 percent of the dry weight of a microbial cell. Carbon, oxygen and hydrogen are the primary constituents of most organic molecules and cell structures. Nitrogen is found primarily in amino acids, and phosphorus is found primarily in nucleic acids, phospholipids, teichoic acids, and nucleotides. In addition to these six elements, potassium, magnesium, calcium, and iron are required for many enzyme reactions (VanDemark et al., 1987).

Phosphorus usually limits cell growth in freshwater aquatic environments, and nitrogen usually limits cell growth in marine environments (Watersheds, 2003). In other words, if algae growth is limited or controlled by low levels of phosphorus or nitrogen, adding phosphorus or nitrogen to the water body will increase algae growth. In the absence of a controlling or limiting growth factor, algae blooms will eventually cloud the water and block the sunlight required for cell energy. As this process continues, the algae and other aquatic plants will die and decay. Dissolved oxygen is used as organic matter decays, resulting in depressed dissolved oxygen levels. This process is called eutrophication. The depressed dissolved oxygen levels may adversely impact cold and warm water fish species.

Nutrients are listed as impairment to the Upper Pit River because of eutrophication. The Upper Pit River is dominated by agricultural land use, and soluble forms of phosphorus and nitrogen are commonly applied as fertilizer to agricultural lands.

Water shall not contain biostimulatory substances that promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses.

Phosphorus

Phosphorus is an essential element for algae and aquatic plants. Total phosphorus includes both organic and inorganic phosphate. Inorganic phosphate are rapidly taken up by algae (phytoplankton) and other aquatic plants. Phosphate occurs as orthophosphate, metaphosphate or condensed phosphate, and organically bound phosphorus. Orthophosphates are used for fertilizers and are soluble in water. Metaphosphates are used in detergents and commonly found in wastewater discharge. Organically bound phosphorus is an essential component in proteins. Key sources of phosphorus include soil erosion, fertilizers, animal and human wastes.

The availability of phosphorus is usually the first limiting element in freshwater algae growth. For this reason, small increases in phosphorus concentrations can lead to excessive algae growth. Typical phosphorus levels in freshwater lakes range between 0.01 and 0.03 mg/l. To prevent eutrophication, the average annual total phosphate concentration should not exceed 0.10 mg/l in streams and 0.05 mg/l in streams flowing to lakes and reservoirs (MacKenthum, 1973 and MacDonald et al., 1991).

Analytical Results

Based on the DWR (1982) study, total phosphorus concentrations ranged from 0.04 to 0.41 mg/l, with an average concentration of 0.17 mg/l. Dissolved orthophosphate levels ranged from 0.02 to 0.28 mg/l., with an average concentration of 0.09 mg/l. In general, the total phosphorus and dissolved orthophosphate levels were higher between Alturas and Bieber than between Pittville and Lake Britton.

As part of the RWQCB 2003 study, samples were analyzed for total phosphorus. The results are summarized in Table 6-4. In addition, the dissolved orthophosphate levels were estimated from the total phosphorus levels using a factor of 0.53 (DWR, 1982). Overall, the results suggest that the total phosphorus and orthophosphate levels have increased since 1982. The average dissolved orthophosphate level estimated from the RWQCB (2003) data exceeds the criteria of 0.10 mg/l to prevent eutrophication.

Table 6-4 PHOSPHORUS RWQCB 2003				
Station	**Minimum Total P (mg/l)**	**Maximum Total P (mg/l)**	**Average Total P (mg/l)**	**Estimated Ortho P (mg/l)**
North Fork-J	<0.02	0.84	0.26	---
South Fork-L	0.09	1.63	0.33	---
North Fork-A	0.15	0.9	0.31	---
South Fork-A	<0.02	0.92	0.50	---
Alt-Canby	0.07	1.42	0.41	---
Canby	0.05	0.71	0.29	---
Lookout	<0.02	2.23	0.32	---
Pittville	0.06	1.61	0.32	---
Overall (main stem only)	<0.02	2.23	0.36	0.20
J = near Joseph Creek, L = near Likely, A = at Alturas.				

Discussion

Conclusions based on an evaluation of the nutrient data collected prior to 1983 and between 2001 and 2002 include:

- To prevent eutrophication in phosphorus-limited systems, the average annual total phosphate concentration should not exceed 0.10 mg/l in streams.

- Prior to 1983, the average dissolved orthophosphate concentration was 0.10 mg/l in the Upper Pit River between Alturas and Bieber. Between 2001 and 2002, the average dissolved orthophosphate concentration was estimated to be 0.20 mg/l.

- Prior to 1983, the average total phosphorus concentration was 0.17 mg/l in the Upper Pit River between Alturas and Bieber. Between 2001 and 2002, the average total phosphorus concentration was 0.36 mg/l.

- Overall, total phosphorus and dissolved orthophosphate levels have increased in the Upper Pit River since 1982. The average annual total phosphate level may exceed 0.10 mg/l.

Nitrogen

Nitrogen, like phosphorus, is an essential element for algae and other aquatic plants. Unlike phosphorus, however, nitrogen comprises 79 percent of the atmosphere. Common forms of nitrogen are atmospheric nitrogen (N), ammonia (NH_3), nitrite (NO_2), nitrate (NO_3), and organic nitrogen. Natural sources of nitrogen in aquatic environments result from the conversion of atmospheric nitrogen into nitrates and ammonia by bacteria and blue-green algae, and the conversion of ammonia into nitrite, and nitrite into nitrate. This conversion process is part of the nitrogen cycle. Organic nitrogen is found primarily in amino acids. Human sources of nitrogen include effluent from wastewater treatment plants and runoff from feedlots, pasture, and agricultural lands that have been fertilized.

Nitrites are relatively short-lived because they are quickly converted to nitrates by bacteria. Nitrites produce a serious illness (brown blood disease) in fish, even though they don't exist for very long in the environment. Nitrites also react directly with hemoglobin in human blood to produce methemoglobin, which destroys the ability of blood cells to transport oxygen. This condition is especially serious in babies under three months of age as it causes a condition known as methemoglobinemia or "blue baby" disease (Straub, 1989).

In nitrogen-limited systems, concentrations of less than 0.3 mg/l nitrate-nitrogen will prevent eutrophication (Brooks et al., 1991 and Cline 1973). The U.S. Public Health Service has established 10 mg/l of nitrate-nitrogen as the maximum contamination level allowed in public drinking water. Selected nitrogen criteria are summarized on Table 6-5 (AWWA, 1990).

Analytical Results

Previous studies have attempted to quantify several forms of nitrogen. Dissolved nitrate was analyzed from the early-70s through approximately 1978. After 1978, nitrogen as ammonia and nitrate was analyzed. In 2003, the RWQCB analyzed samples for dissolved nitrate and dissolved ammonia.

According to the 1982 DWR study, nitrogen is usually present as nitrate, ammonia and organic nitrogen. Dissolved nitrate concentrations ranged from <0.02 mg/l to 0.25 mg/l, with an average concentration of 0.07 mg/l. Total organic nitrogen concentrations ranged from 0.6 mg/l to 1 mg/l, with an average concentration of 0.73 mg/l. Dissolved ammonia concentrations ranged from <0.02 mg/l to 0.12 mg/l, with an average concentration of 0.05 mg/l. Total ammonia concentrations ranged from 0.03 mg/l to 0.18 mg/l, with an average concentration of 0.11 mg/l.

As part of the RWQCB 2003 study, samples were analyzed for dissolved nitrate and dissolved ammonia. Overall, the dissolved nitrate levels ranged between <0.05 mg/l and 0.25 mg/l, with an average concentration of 0.075 mg/l. The dissolved ammonia concentrations ranged between <0.02 mg/l and 1.52 mg/l, with an average concentration of 0.08 mg/l. These levels are similar to the levels observed prior to 1983. Dissolved nitrate levels are summarized in Table 6-6.

The pre-1983 and more recent data suggest that the system might be nitrogen, not phosphorus limited (i.e., although dissolved orthophosphate level exceed the level identified to prevent eutrophication, the average dissolved nitrate level is significantly less than the level identified to prevent eutrophication). In other words, the high availability of phosphorus may not result in continued algae production because the system is nitrogen limited. Nitrate was not detected in 58 percent of the samples collected in conjunction with the 2003 RWQCB study.

Table 6-5 NITRATE-NITROGEN CRITERIA	
Designated Use	**Limit (mg/l)**
Nitrate	
Human Consumption	10.0
Aquatic Life	
Warm water fish	90.0
Industry	
Brewing	30.0
Nitrite	
Human Consumption	1.0
Aquatic Life	
Warm water fish	5.0
Nitrate plus Nitrite	
Human Consumption	10.0
Agriculture (Livestock etc.)	100.0
Aquatic life	
Estuaries (recommended)	
maximum diversity	0.1
moderate diversity	1.0

Table 6-6 DISSOLVED NITRATE RWQCB 2003			
Station	**Minimum Nitrate (mg/l)**	**Maximum Nitrate (mg/l)**	**Average Nitrate (mg/l)**
North Fork-J	<0.05	0.31	0.06
South Fork-L	<0.05	1.98	0.14
North Fork-A	<0.05	0.42	0.06
South Fork-A	<0.05	0.43	0.06
Alt-Canby	<0.05	0.57	0.08
Canby	<0.05	0.35	0.06
Lookout	<0.05	0.22	0.04
Pittville	<0.05	1.05	0.14
Overall (main stem only)	<0.05	1.05	0.07
J = near Joseph Creek, L = near Likely, A = at Alturas.			

Discussion

Conclusions based on an evaluation of the dissolved oxygen data collected prior to 1983 and between 2001 and 2002 include:

- In nitrogen-limited systems, concentrations of less than 0.3 mg/l nitrate-nitrogen will prevent eutrophication.

- Prior to 1983, nitrate concentrations ranged from <0.02 mg/l to 0.25 mg/l, with an average concentration of 0.07 mg/l.

- Nitrate was not detected (<0.02 mg/l) in 58 percent of the samples collected in conjunction with the 2003 RWQCB study.

- Overall, the nitrate levels recoded between 2001 and 2002 are similar to the levels recorded prior to 1983.

- Based on a comparison of the nitrate and phosphate levels, the Pit River system may be nitrogen limited.

Other Parameters

Turbidity
Turbidity is a measure of the degree suspended particles, including organic mater such as algae and inorganic particles, such as silt and clay, scatter light passing through a water column. Light scattering increases with increasing sediment load. Turbidity is commonly measured in Nephelometic Turbidity Units (NTU). Simply stated, turbidity is the measure of relative clarity of a liquid. The drinking water standard is 0.5 NTU. The most frequent causes of turbidity in lakes and rivers are plankton and soil erosion.

The predominant contributing factor to seasonal turbidity in the Upper Pit River appears to be peak flows in the winter, when volcanic soils are eroded and are carried downstream as suspended load or total suspended solids (TSS). Elevated temperatures and high nutrient content also contribute to algae growth which impacts turbidity. A summary of the turbidity levels reported along the Upper Pit River is presented in Table 6-7.

DWR (1982) reported that turbidity in the Upper Pit River increases downstream from Alturas to Pittville. From Pittville to Lake Briton, turbidity decreases due to groundwater inflow and clear tributaries. Turbidity was highest from January through April when flows are highest. This is due mostly to eroded humic (lignitic) soils. Other sections of the Pit were turbid during warmer months due to algal growth (the result of high temperatures, low flows and nutrients present.

According to 2003 RWQCB study, there were no upstream or downstream trends in turbidity or sediment. Elevated turbidity in the South Fork of the Pit River near Likely was attributed to releases from West Valley Reservoir.

Conductivity.
Electrical conductivity is a measure of the total dissolved salts or dissolved ions in water. Electrical conductivity is reported in microSiemens per centimeter (uS/cm), or the electrical current (I) that passes through the water between two electrodes located exactly 1.0 cm apart. A constant voltage (V) is applied across the electrodes. The current that flows through the water is proportional to the concentration of dissolved ions in the water—the more ions, the more conductive the water resulting in a higher electrical current which is measured electronically. Distilled or deionized water has very few dissolved ions and so there is almost no current flow across the gap.

Table 6-7 TURBIDITY						
Month	Pittville	Lookout	Canby	Alt-Canby	North Fork-A	South Fork-A
January	18.60	15.50	17.20	19.70	26.30	15.90
February	---	---	---	---	---	---
March	26.77	23.70	24.37	22.80	16.80	29.40
April	10.19	19.58	16.24	14.38	12.73	14.04
May	12.25	27.09	10.83	12.62	12.14	18.52
June	7.58	14.78	5.23	16.50	3.25	28.28
July	5.77	7.91	4.21	38.41	3.69	10.03
August	16.56	22.14	13.79	50.40	3.95	21.69
September	10.16	27.68	2.44	32.23	4.51	7.80
October	---	---	---	---	---	---
November	12.30	19.40	20.40	14.30	7.70	8.90
December	17.60	105.00	127.00	384.00	221.00	36.50
Flowing water will generally look clear if the levels are less than 10 NTU and muddy if the levels are greater than 500 NTU. The drinking water standard is 0.5 NTU.						

The conductivity of North and South Fork of the Pit River water is less than 200 uS/cm. When runoff from winter storms or spring runoff is high, the conductivity values often drop below 100 uS/cm. As these waters flow through the recent alluvial and quaternary lake deposits, the conductivity values increase to more than 350 uS/cm at Alturas. Values in the Pit River at Canby range between 150 and 325 uS/cm, with the highest values occurring between October and December, and the lowest values occurring in March and April (DWR, 1982).

Conductivity values generally range from 50 to 200 uS/cm at the headwaters to between 200 and 400 uS/cm along the main stem Upper Pit River. Moderate increases are noted during the summer months (RWQCB, 2003). Based on a comparison of the DWR and RWQCB data, it appears that conductivity values remained relatively constant between pre-1983 and 2001 to 2002.

pH

pH or potential of hydrogen is defined as the logarithm of the reciprocal of hydrogen ion concentration in gram atoms per liter. Where values less than 7 are identified as being acidic and values greater than 7 are identified as being basic, pH ranges between 0 and 14. If a substance has a pH value of 7, it is considered neutral, neither acidic nor basic. Because the pH scale is logarithmic, a difference of one pH unit represents a tenfold, or ten times change. For example, the acidity of a sample with a pH of 5 is ten times greater than that of a sample with a pH of 6. Although this relationship is often overlooked, it becomes important if it becomes necessary to change pH of through dilution.

Prior to 1983, pH of the Pit River waters ranged between 6.8 and 9.8, with an average value of 7.9 (DWR, 1982). Between 2001 and 2002, pH ranged between 5.9 and 10.1, with an average value of 8.4 (RWQCB, 2003). In general, the highest values occur in the summer. The Basin Plan water quality objective states, "the pH shall not be depressed below 6.5 nor raised above 8.5."

Biological

Macro-invertebrate collector organisms generally dominated the trophic structure, but scraper organisms were usually well represented. This indicates that particulate organic matter was the most important food source, though primary productivity may have been equally important in some areas (DWR, 1982).

Macro-invertebrate communities on the North Fork and South Fork of the Pit River near Alturas were less robust compared to the communities at the other river stations. This trend is apparent in each of the selected metrics, including Taxa Richness, percent EPT, Shannon Diversity, percent Tolerant Taxa, and percent Intolerant Tax (RWQCB, 2003).

Of a total of 168 individual fecal coliform samples, 13 exceeded 400 MPN (most probable number). Of the total 96 e-coli samples, eight exceeded 235 MPN. There were no observed upstream or downstream trends in bacteria concentrations. Overall, bacteria concentrations in the Pit River are not particularly high relative to other surface waters with comparable land and water use practices (RWQCB, 2003).

CONCLUSIONS

Overall, key conclusions include:

Temperature

- Water temperature data collected along the Upper Pit River prior to 1983 are consistent with water temperature data collected between 2001 and 2002.

- Water temperatures in the Upper Pit River do not change significantly between Alturas and Pittville (i.e., on any give day, the water temperature in the Pit River at Alturas is similar to the water temperature in the Pit River at Canby and Pittville).

- Average monthly water temperatures are approximately 5ºF higher than the average monthly air temperatures.

- Water temperature readings collected between June and September exceeded 70ºF nearly 30 percent of time.

Dissolved Oxygen

- Overall, the average dissolved oxygen concentrations at key sampling stations along the Upper Pit River did not change significantly between pre-1983 and 2001 to 2002. However, the occurrence of readings that are less than 5 mg/l and greater than 10 mg/l has increased. For example, at Canby, the average dissolved oxygen levels decreased from 9.3 to 8.6 mg/l. Prior to 1983, however, 0.5 percent of the dissolved oxygen readings were less than 5 mg/l, and 36.5 percent were greater than 10 mg/l. Between 2001 and 2002, 5.9 percent of the readings were less than 5 and 23.5 percent of the readings were greater than 10 mg/l.

- Historically, 10 percent of the dissolved oxygen readings at the Canby station were less than 7 mg/l.

Nutrients

- Prior to 1983, the average dissolved orthophosphate concentration was 0.10 mg/l between Alturas and Bieber. Between 2001 and 2002, the average dissolved orthophosphate concentration was estimated to be 0.20 mg/l. To prevent eutrophication in phosphorus-limited systems, the average annual total phosphate concentration should not exceed 0.10 mg/l in streams.

- Overall, the nitrate levels recoded between 2001 and 2002 are similar to the levels recorded prior to 1983. Nitrate was not detected (<0.02 mg/l) in 58 percent of the samples collected in conjunction with the 2003 RWQCB study. In nitrogen-limited systems, concentrations of less than 0.3 mg/l nitrate-nitrogen will prevent eutrophication.

Other Parameters

- Pre-1983 conductivity, pH and turbidity readings are similar to the readings collected between 2001 and 2002.

RECOMMENDATIONS

Seasonally, water temperatures along the main stem between Alturas and Pittville exceed 70ºF. As these elevated temperatures have been present for more than 30 years and are not protective of cold-water fisheries, watershed activities to enhance cold-water conditions should focus on identifying and improving conditions along marginal tributaries.

Nutrient levels, specifically phosphate, appear to be increasing along the main stem Upper Pit River. In turn, these increasing levels impact temperature, pH, and dissolved oxygen levels along the river. Sources and management practices contributing to the nutrient loading should be identified.

Finally, the overall impact of common land use practices on key water quality parameters should be quantified. For example, how will incremental changes in current land use impact nutrient loading and sediment. Once these impacts are quantified, it will be possible to evaluate the cost and benefit of proposed improvement activities.

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Section 7

Section 7
BOTANICAL RESOURCES

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Section 7
BOTANICAL RESOURCES

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INTRODUCTION

The 2.2 million acres of the Upper Pit River Watershed lie on the Modoc plateau of northeastern California. The vegetation that characterizes this Upper Pit River Watershed includes conifer forests, sagebrush and juniper, chaparral, agricultural and grass-covered areas, wet meadows, strips of riparian vegetation, and aspen stands. The composition of these ecological communities has changed drastically over the last 150 years. The reasons for these changes are both natural and anthropogenic – they pertain to climate, fire, invasive exotic plants, agriculture, timber harvest and livestock grazing.

In this section the themes introduced above are discussed in greater detail. Sources of local and regional information are evaluated. An overview of the ecological processes shaping vegetation patterns is provided. The current and historical quantities and conditions of broad vegetation types found in the Upper Pit River Watershed are analyzed and assessed. The role of fire and fire suppression in conifer forests and other vegetation is noted. The issue of juniper encroachment into other vegetation types (e.g., sagebrush, pine, aspen) and possible ecological effects is examined. Invasive non-native plants are listed and discussed. The potential for rare, threatened and endangered plants existing within the Upper Pit River Watershed is also addressed. Finally, conclusions are reached regarding needs for gathering additional information and initiating further study towards the goal of maintaining balance between human and botanical resources in the Upper Pit River Watershed.

SOURCES OF DATA

A variety of literature provides general information on botanical resources of interest in the Upper Pit River Watershed. The published results of local and regional research are discussed where applicable to resource issues such as juniper encroachment and the ecology of Warner range forests. A complete bibliography of references is included at the end of this section. Several sources of remote-sensed imagery are analyzed to help describe the current distribution of vegetative communities in the Upper Pit River Watershed. Additionally, historic vegetation maps are used to compare past and current conditions. Ancillary geographic information systems (GIS) layers (e.g., annual precipitation, historic fire perimeters) and spatial analysis of the vegetation layers discussed above are employed to further elucidate local patterns. The California Wildlife Habitat Relationship (CWHR) and Calveg classification systems are used to categorize vegetation. Additionally, the CWHR 8.0 habitat suitability model is used to demonstrate connections between vegetation and wildlife habitat. Information on locally occurring invasive plants has been provided by the Modoc

County Department of Agriculture. The California Natural Diversity Database is used to identify known occurrences of rare, threatened and endangered plants. Information is also provided by various experts and persons with local knowledge. Although not all of these individuals are explicitly cited in the section, they are Robert Laacke (retired) of the U.S. Forest Service; Tim Burke and Lori White-Bagnaschi of the Bureau of Land Management; Ann Manji and Pete Figura of the California Department of Fish and Game; Joe Moreo of the Modoc County Department of Agriculture; and Wendy Johnson and Jennifer Williams of VESTRA Resources Inc.

ECOLOGICAL PROCESSES AND PATTERNS

Vegetation patterns are shaped by the ecological forces at work in a region. Climate, topography, soil, the frequency of natural disturbance such as fire, and human management are all driving factors that affect how vegetation is distributed on the landscape. Unfortunately, patterns in nature are rarely an unchanging picture. Individual trees grow and die. Fires and other natural calamities periodically destroy entire forests. In this sense, the mosaic of vegetation types (e.g., conifer forest, sagebrush, aspen, etc.) constantly changes with time. To give an extreme example, a mere twelve thousand years ago glacial ice covered what is now mature conifer forest in the Warner Mountains. On a time scale closer to one we live in, we can use ecology to describe the range of variability in vegetation patterns, and the trend of change in a place.

The Modoc Plateau in California spans approximately 5.6 million acres of volcanic tablelands east of the southern Cascade and northern Sierra mountain ranges in Modoc, Lassen and Siskiyou counties. A series of lava flows beginning 25 millions years ago built up the plateau. Most of the plateau is porous or fractured so that water often percolates down instead of running off into streams. The flattest portions of the region trap accumulations of sediment. Ephemeral wetlands called vernal pools are found in poorly drained depressions.

Cold continental air moving off the Great Basin area of Nevada and eastern Oregon sets the stage for cold winter temperatures, and a growing season that is shorter than in other parts of northern California. Weather coming off the Pacific is forced upward by the Cascade and Sierra mountains to the west of the Modoc province. As the clouds rise they cool, condense, and shed most of their moisture as storms in the mountains. This creates a rain shadow effect on the Modoc side. Average annual precipitation generally drops from 30 inches at higher elevations to a mere 10 inches in the flats (see Figure 7-1).

Plants create food from sunlight by a chemical process called photosynthesis. Net primary production, a term ecologists use to describe growth, is the total amount of energy that all the plants in an area capture minus the energy lost through processes of life and death. Temperature, soil nutrients, and the availability of water influence and limit productivity indirectly. On the Modoc Plateau, limited rainfall, summer drought, and a short growing season result in a lower level of productivity than in wetter, more temperate regions to the west. Compared to the coastal region, trees on the plateau are shorter in stature and take much longer to grow to large diameters. The distribution of forest on the Modoc Plateau is restricted to the higher elevations where annual precipitation is sufficient to permit higher levels of productivity. In the dry basins of the plateau, grasses and sagebrush cover much of the area. Juniper is found in the middle elevations. Above forests of pine and white fir, productivity drops again due to thinner soils and strong winds found at higher elevations in the Warner Mountains. The harsher conditions here support a subalpine belt of whitebark pine.

The differing physiologies of plants explains how the seeds of pine trees are best adapted to germinate in bare mineral soil and grow in sunny open conditions. On the other hand, the flattened needles of fir trees are better adapted to capturing diffuse light in the shaded understory of a denser forest. However, firs are more easily killed by drought than pines.

Historically, fire played a key role in the patterns of vegetation found in the Modoc region and throughout western North America. Frequent low intensity ground fires consumed downed wood and killed the smaller trees. The result was that much of the forest had an open park-like condition with grasses under widely spaced large diameter ponderosa pine and Jeffrey pines. Of course, the effects of fire were not uniform. The catastrophic stand-replacing fires that are more common today occurred in the past as well. In moister areas on sheltered north facing slopes, classic late seral forests developed. In these places, the ecological process of forest succession proceeded further between disturbance events. White fir seed blown across the winter snows seeded in the spring below established pines. The shade-tolerant fir trees eventually grew into multiple layers of a closed canopy forest. Over time and at increased densities, individual trees died creating gap as well as snags (e.g., standing dead trees) and downed logs. Both the open park-like and the classic old growth forests described above existed on the Modoc landscape. However, limited productivity and frequent fires also kept large portions of the plateau in grassland and sagebrush. Grass fires consumed colonizing tree seedlings thus checking the expansion of juniper and other trees into lower elevation areas.

Humans are also part of the ecosystem. Their activities affect the distribution of vegetation. Native Americans are believed to have used fire widely as a tool, both for hunting and to manage other resources needed for survival (Blackburn and Anderson, 1993). This included the burning of grasslands to improve basket materials; grassland and sage communities to assist in hunting small game and encourage new edible shoots; and in the coniferous forests to assist in hunting and keeping the forests open and passable. In addition, management of juniper for augmenting food supplies and producing bow materials is documented. It is unclear to what extent human caused burning augmented or conflicted with the natural low intensity fire regime in the Modoc region.

Over the last 150 years, settlers, mostly European descent, have significantly altered ecological conditions on the plateau and in the Upper Pit River Watershed. Spanish soldiers and missionaries from Mexico first brought cattle and other livestock to southern California in the second half of the eighteenth century. Grazing and the introduction of exotic cereal grains and grasses such as barley, rye and clover markedly altered the composition of California native grasslands. Overgrazing stressed perennial species such as native bunchgrasses. Well-adapted, opportunistic European annual species fared better in the disturbed environment. They have become the dominant species of today's grasslands. The United States' acquisition of California from Mexico in 1848 and the discovery of gold in 1849 led to large numbers of new settlers moving westward. Sheep grazing began on the Modoc Plateau in the 1870s. According to a report on the history of the Modoc National Forest:

> When the first pioneers settled in Modoc County, the entire country was covered with a stand of waving grasses. Not only was this true of the valley meadows, but also of the vast sagebrush flats and mountain areas…. The transient sheepmen, whose stock had pretty well eaten themselves out of house and home in the forests of the main Sierra Nevada further south, about 1880, discovered the still luxuriant ranges of the Modoc country and the nomad

> bands of sheep invaded the last great frontier ranges of California…. By the turn of the century, a little more than three decades after their first general grazing use, the Modoc ranges were in a sorry condition and in places had become mere dust beds from the trampling of myriads of sheep hoofs. (Brown, 1945)

With the late 1920s-era construction of narrow gauge railroads into the woods, timber harvesting became a big industry in Modoc County. Between 1934 and 1943, the acres of cut over areas in Modoc County increased five-fold from 52,000 to 260,000 acres. During this period many of the slow-growing large pine trees were removed at an unsustainable rate. However, the suppression of wildfires over the last 50 to 100 years has altered forest structure to at least a great a degree as timber harvest. The absence of frequent low intensity fires over most of the landscape has allowed the stocking of shade tolerant and fire intolerant species to increase. Today, conifer forests are denser and contain more white fir than was the case one hundred years ago. These conditions make it harder for pine regeneration to occur naturally. Additionally, the range of western juniper has spread ten fold over the last 130 years largely in response to the absence of fire as a limiting factor.

Besides invasive exotic weeds and fire suppression, agriculture has changed the character of Modoc grasslands. Native bunchgrasses have been replaced by alfalfa and other annual crops. Due to the condition of low rainfall, extensive irrigation has been required to support these crops. Not all of the effects of human management on the environment are negative. Cattle, timber, and agricultural crops are valuable products and help to support local economies. Thinning can be used as a tool to reduce tree densities in the absence of frequent low intensity fires. Irrigation for agricultural purposes can create artificial wetlands that serve as resting habitat for migrating birds.

VEGETATION CONDITIONS

Four remote-sensed data sets (Table 7-1) are used to describe the current mosaic of vegetation communities covering the Upper Pit River Watershed. All of these sources have significant limitations, but taken together they provide qualified information about the large-scale distribution of vegetation in the Upper Pit River Watershed. The accuracy of the imagery may not be reliable for characterizing areas less than 500 to 5,000 acres in size.

The Larry Fox et al. (1997) Wildlife Habitat Map and Database for the Oregon-California Klamath Bioregion is derived from 1994 multi-spectral LANDSAT TM imagery. Vegetation types are classified using modified categories of the CWHR system. The CWHR system stratifies vegetation into tree-dominated, shrub-dominated, herbaceous-dominated and non-vegetative types. The key criterion for tree-dominated types is at least 10 percent area cover in trees. Size and density classes within vegetation types are explained in Table 7-2. The Fox data uses broader vegetation type classes than CWHR, but keeps the same CWHR size and density classes for tree-dominated types. The Fox data set is a grid cell GIS layer where the cell size is 30 meters by 30 meters (i.e., 0.25-acre). This resolution lends itself to picking out smaller scale elements such as clumps of large trees or grasses within a forest, but it may be less effective for characterizing stand level features such as canopy cover.

Table 7-1 REMOTE-SENSED IMAGERY USED TO DESCRIBE THE CURRENT DISTRIBUTION OF VEGETATIVE COMMUNITIES IN THE UPPER PIT RIVER WATERSHED	
Data Set	**Description**
Fox, Wildlife Habitat Map and Database for ORCA (Oregon-California) Klamath Bioregion Derived from LANDSAT imagery	1994 habitat mapping from LANDSAT TM cross-walked to modified CWHR classification created by Larry Fox et. al. (1997) of Humboldt State University. 0.25-acre (30 meter pixel) grid cell data. No grouping up into polygons.
LCMMP, Vegetation Data Fire and Resource Assessment Program	1996 vegetation mapping from LANDSAT TM using Calveg system but cross-walked to the CWHR classification system. 2.5-acre (100 meter pixel) minimum mapping unit. Algorithms used to group pixels into larger polygons with similar vegetation characteristics.
Gap, Land Cover/Vegetation Layer California Gap Analysis Project	Vegetation mapping crosswalked to WHR. Source data is 1990 LANDSAT TM and other supporting sources such as aerial photography and soil maps. 100 or 250-acre minimum mapping unit depending on vegetation type.
BLM Juniper Bureau of Land Management, Alturas Field Office	Juniper mapping derived from 1995 black and white digital orthoquad (DOQQ) aerial photography using Lifeform and Covercalc software. 6.5 million acres of mapping for larger portions of Lassen and Modoc counties. Five partially overlapping data scenes are clipped to Upper Pit River Watershed boundary.

Table 7-2 THE CWHR CLASSIFICATION SYSTEM FOR TREE-DOMINATED HABITATS			
Classification Attribute	**Classification Scheme**		
Size	1	Average tree diameter:	< 1 inch
	2	Average tree diameter:	1–6 inches
	3	Average tree diameter:	6–11 inches
	4	Average tree diameter:	11–24 inches
	5	Average tree diameter:	> 24 inches
Density	S	Canopy closure:	10–25 %
	P	Canopy closure:	25–40 %
	M	Canopy closure:	40–60 %
	D	Canopy closure:	60–100 %

The LCMMP vegetation data is also derived from LANDSAT TM imagery. The Fire and Resource and Assessment Program, a cooperative project of the California Department of Forestry and Fire Protection and the U.S. Forest Service (USFS), maintains the spatial database that is available on the Internet. The LCMMP imagery for the Upper Pit River Watershed is from 1996. It also has a resolution of 30 meters by 30 meters. However, algorithms have been used to combine clusters of cells sharing similar vegetation characteristics into larger polygons. The minimum mapping unit is 100 meters by 100 meters (i.e., 2.5 acres). One advantage of the pixel combination process is that information on percent vegetation cover (e.g., dense or open forest) is more meaningful at larger scales. LCMMP uses the Calveg vegetation classification system (USFS, 1981). However, the data is cross-walked into the CWHR classification system. Accuracy statistics for the LCMMP data are available online.

The Gap vegetation layer was created by the University of California at Santa Barbara's California Gap Analysis Project. Portions of the data set for the Modoc Plateau are primarily derived from 1990 LANDSAT TM 30-meter imagery, but aerial photography and soil maps were used to refine the satellite data. The GAP data use the CHWR classifications for vegetation type and density class. However, the mapping scale is much larger than for the Fox and LCCMP data. The minimum mapping unit for Gap is either 100 or 250 acres depending on the vegetation type.

For the purposes of this Upper Pit River Watershed Assessment, CWHR, and Calveg classes from the Fox, LCMMP and Gap data are grouped in order to simplify presentation and discussion of the data for such a large area (Table 7-3).

Table 7-3
MAJOR VEGETATION GROUPS USED IN THIS UPPER PIT RIVER WATERSHED ASSESSMENT AND THE CROSSWALKING OF CWHR AND CALVEG VEGETATION CLASSIFICATION SYSTEMS

Major Vegetation Group	CWHR Types Included in Group	Calveg Types Included in Group
Conifer Forest	Eastside Pine, Sierran Mixed Conifer, Ponderosa Pine, White Fir, Red Fir, Lodgepole Pine, Subalpine Conifer	Eastside Pine, Mixed Conifer-Pine, Mixed Conifer-Fir, Ponderosa Pine, Ponderosa Pine-White Fir, Lodgepole Pine, White Fir, Red Fir, Whitebark Pine
Sagebrush Scrub	Sagebrush, Low Sage, Bitterbrush	Basin Sagebrush, Low Sagebrush, Bitterbrush, Rabbitbrush
Juniper	Juniper	Western Juniper
Chaparral	Montane Chaparral, Mixed Chaparral	Montane Mixed Chaparral, Ceanothus Mixed Chaparral, Curlleaf Mountain Mahogany, Upper Montane Mixed Shrub, High Desert/Montane Chaparral Transition
Grassland/ Agriculture/ Pasture	Annual Grassland, Perennial Grassland, Cropland, Pasture	Annual Grass/Forbs, Agricultural
Oak	Montane Hardwood, Montane Hardwood-Conifer, Blue Oak-Foothill Pine	California Black Oak, Oregon White Oak
Aspen	Aspen	Quaking Aspen
Riparian	Montane Riparian	Willow
Wetland	Wet Meadow, Fresh Emergent Wetland	Wet Meadows (Grass/Sedge/Rush)

The last imagery set used for mapping vegetation in the Upper Pit River Watershed is the Bureau of Land Management's Juniper data. These maps were created from low elevation black and white aerial photography. The photographs were converted to digitized and ortho-corrected data files that are downloadable from the Internet at http://www.gis.ca.gov. Lifeform and Covercalc software developed by the USFS Pacific Southwest Research Station were used to map juniper, approximately 6.5 million acres in Modoc and Lassen counties, based on the brightness and contrast of pixels from the digital photographs. The photo-interpretative software and more detailed information about how it works can be downloaded from the Internet by going to http://ncncr-isb.dfg.ca.gov/itp and clicking on Habitats under Terrestrial Resources. The BLM juniper GIS layer includes information on the location and density of juniper. The four density classes are zero to five percent cover, five to 20 percent cover, 20 to 35 percent cover and greater than 35 percent cover. The data is broken into separate quadrangle scenes that partially overlap each other. Five scenes cover the Upper Pit River Watershed. Due to differences in photographic exposure between the scenes, there are seam lines and density value differences between scenes in the areas of overlap. For the purposes of this Upper Pit River Watershed analysis, the juniper information from the five scenes is weight averaged by area after being clipped to the Upper Pit River Watershed boundary in order to estimate the overall amount and density breakdown of juniper in the watershed.

The estimated relative amounts of the different vegetative communities present in the Upper Pit River Watershed are featured in Table 7-4. Vegetation maps using the Fox, LCMMP and Gap data are featured in Figures 7-2, 7-3, and 7-4. Coniferous forest makes up about one third of the Upper Pit River Watershed. It is generally restricted to mountainous portions of the Upper Pit River Watershed and places with more than 22 inches of average annual precipitation. Agricultural lands and other grasslands cover about one tenth of the Upper Pit River Watershed. These areas are concentrated in the lower, flatter portions of the Upper Pit River Watershed where average annual precipitation is generally below 18 inches. As much as one half of the Upper Pit River Watershed is covered by sagebrush and juniper in areas of middle elevation and precipitation. The variation in the amount of juniper indicated by the different imagery sources may be related to density and interspersion of this vegetation type within others. According to the BLM data, about 20 percent of the Upper Pit River Watershed is covered by higher density juniper (e.g., greater than 20 percent cover) with at least another 20 percent where lower density juniper is encroaching. Other less prevalent vegetation types include chaparral concentrated in the western portion of the Upper Pit River Watershed, and aspen concentrated in the southern Warner range. The amount of wetland may vary depending on flooding in the valleys because of irrigation and natural factors.

CONIFER FOREST

Historically, large portions of the conifer forest in the Upper Pit River Watershed consisted of widely spaced large and old pine trees over grasses. Regularly occurring fire consumed fuels and kept the understory open. These forests were mostly dominated by shade intolerant species such as ponderosa pine (*Pinus ponderosa*) and Jeffrey pine (*Pinus jeffreyi*). White fir (*Abies concolor*) and incense cedar (*Calocedrus decurrens*) were less common. However, densely stocked old growth stands of mixed species existed on higher productivity sites found on middle slopes and middle elevations on northerly aspects. Research on fire scars and historical conditions from the Blue Mountains of eastern Oregon suggests that less than 20 percent of dry east-side pine forested landscapes were covered by dense, multi-layered old growth forest prior to twentieth century fire suppression. These refugia would have been located in places where topographical conditions prevented frequent fires (USFS, 2001). However, there is little hard data about the condition of early forests specific to the Upper Pit River Watershed. Similar ponderosa pine forests and other coniferous forests in California and the western United States are described in the literature by Cooper and Muir.

Table 7-4 VEGETATIVE COMMUNITIES OF THE UPPER PIT RIVER WATERSHED					
Vegetation Type	**Overall Estimate**	**Fox**	**Calveg**	**Gap**	**BLM**
Conifer Forest	**30 – 35 %**	35.1 % (767,379)	35.3% (770,573)	30.8% (672,779)	n/a
Sagebrush Scrub	**20 – 30 %**	N/a	31.2% (681,257)	20.5% (447,886)	n/a
Juniper	**5 – 20 %,** dominant **40 %,** dominant or encroaching	7.1% (154,535)	13.5% (295,385)	30.6% (668,439)	6.2%: **>35% cover** (134,617) 20.8%: **>20% cover** (454,335) 42.8%: **>5% cover** (481,489)
Chaparral	**2 – 6 %**	n/a	5.6 % (122,292)	2.1% (44,888)	n/a
Agriculture/Grassland	**9 – 12 %**	9.2% (201,646)	9.0% (196,435)	12.3% (269,853)	n/a
Oak	**0.2 – 0.3%,** dominant **1.6%,** component	1.6% (34,927)	0.3% (5,903)	0.2% (3,668)	n/a
Aspen	**0.1 – 0.2 %**	n/a	0.2 % (3,931)	0.1% (1,414)	n/a
Riparian	**0.2 – 0.3 %**	n/a	0.3% (6.337)	0.2% (3,481)	n/a
Wetland	**0.5 – 1.8 %**	0.5% (10,927)	1.8% (38,371)	1.0% (22,108)	n/a
Water	**0.7 – 1.6 %**	0.7 % (15,495)	1.6% (35,279)	0.9% (19,093)	n/a
Barren/Urban	**1.1 – 1.2 %**	n/a	1.2% (25,192)	1.1% (23,169)	n/a

Ponderosa pine forests of the Southwest were described by Cooper, who notes that:

> …they used to be open, park-like forests arranged in a mosaic of discrete groups, each containing 10 to 30 trees of a common age. Small numbers of saplings were dispersed among the mature pines, and luxuriant grasses carpeted the forest floor. Fires, when they occurred, were easily controlled and seldom killed a whole stand…
>
> Lightening is frequent in the ponderosa pine region, and the Indians set many fires there. Tree rings show that the forests used to burn regularly at intervals of three to 10 years. The mosaic pattern of the forest has developed under the influence of recurrent lightening fires. Each even-aged group springs up in an opening left by the death of a predecessor.

A similar mosaic of open even-aged stands was described in the Sierra Nevada by Muir and was cited earlier in Section 2, "General Watershed History":

> The inviting openness of the Sierra woods is one of their most distinguishing characteristics. The trees of all the species stand more or less apart in groves, or in small irregular groups, enabling one to find a way nearly everywhere, along sunny colonnades and through openings that have a smooth, park-like surface. . .

The reduced frequency of wildfire over the last 50 to 100 years has increased density and changed species composition for forests in the Upper Pit River Watershed. A photographic record from the Bitterroot National Forest provides an excellent pictorial description of 80 years of change in a ponderosa pine forest. Although located in Montana, the forest type and species composition are extremely similar to coniferous forests in the Upper Pit River Watershed. The photo series history, taken from the same location by the Bitterroot Ecosystem Management Research Project, USFS, shows species and density changes resulting from fire exclusion. This six-photo series (Figure 7-5) depicts the change that likely occurred over the last century on forests in the Upper Pit River Watershed. It demonstrates the shift from open stands of large pine to overstocked mixed species forest of small and medium sized trees.

Conifer encroachment into sagebrush-dominated areas may also be occurring because of changes in fire frequency and other reasons. The issue of juniper encroachment is discussed in further detail later in this section. Research from the Warner Mountains suggests that over recent decades, white fir (*Abies concolor*) has been expanding into the sagebrush as well (Vale, 1975; Vale, 1977).

Both the LCMMP and Gap imagery show that approximately two thirds of the coniferous forest in the Upper Pit River Watershed currently has canopy cover (or density) of greater than 40 percent. The estimate for the area greater than 60 percent canopy cover is about one third of the forest. However, closed canopy forest is not evenly distributed throughout the Upper Pit River Watershed. The densest areas of forest are concentrated in the southern Warner range and the mountains encircling Big Valley (Figure 7-6 below). Further analysis of the LCMMP and Gap imagery suggest that 60 to 75 percent of the forest is dominated by ponderosa pine or Jeffrey pine. The same data also suggests that 20 to 40 percent of the forest has a sizeable component of white or red fir in the overstory. Although tree densities and the fir component are significantly higher here than they were a century ago, the problem of overly dense fir forests may be more severe in the Cascade and Sierra mountains to the west of the Upper Pit River Watershed.

Forest composition varies with elevation. Ponderosa pine dominates the lower elevations (4,000–6,500 feet) whereas Jeffrey pine can tolerate colder temperatures and higher elevations. Washoe pine (*Pinus wahoensis*) and whitebark pine (*Pinus albicaulis*) are found in the Warner Mountains. It is hypothesized that the rarely occurring Washoe pine is the legacy of an ancient hybridization between Jeffrey pine and the Rocky Mountain variety of ponderosa pine (Lanner, 1999). Red fir (*Abies magnifica*) and lodgepole pine (*Pinus contorta*) are often found in single species stands at elevations over 6,000 feet. However, red fir is not present in the Warner Mountains. Lodgepole pine is associated with wet, poorly drained soils at higher elevations in the Warners. Lodgepole pine is also present on the wet flats in other places at about 4,500 feet in elevation. There is some concern that in recent decades this species may be colonizing areas once dominated by wet meadows and aspen (*Populus tremuloides*) groves. Once again, fire exclusion may be a factor. The ground story shrubs of the conifer forest include snowbrush (*Ceanothus cordulatus*) and greenleaf manzanita (*Arctostapylos patula*) at higher elevations and sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*) and mountain mahogany (*Cercocarpus montanus*) at lower elevations. Prominent herbaceous plants include mule ears (*Wyethia amplexicaulis*), arrowleaf balsamroot (*Balsalmorhiza sagittata*), Idaho fescue

(*Festuca idahoensis*), pinegrass (*Calamagrostis rubenscens*), bluebunch wheatgrass (*Agropyron spicatum*), and bottlebrush squirreltail (*Sitanion hystrix*) (Mayer and Laudenslayer, 1988).

Even after the heavy timber harvests of the 1930s and 1940s, large and old trees remained on much of the forest in the Upper Pit River Watershed. An analysis of a GIS layer of a 1945 inventory map of Modoc County timberlands shows that 56 percent of the 850,000 acres mapped in the Upper Pit River Watershed were classified as "old growth" (USFS: Remote Sensing Lab, Region 5). Unfortunately, the definition of the term, old growth, for the purpose of the inventory is unclear. Analysis of the Fox and LCMMP imagery suggests that only between five and 13 percent of the forested land in the Upper Pit River Watershed presently contains areas where the quadratic mean diameter at breast height (i.e., measured at 4.5 feet above the ground) of the trees in greater than 24 inches. The difference in resolution scale (e.g., ¼ versus >2.5 acres) between the Fox and LCMMP data suggests that small clumps of large trees (e.g., greater than about 24 inches in diameter) remain scattered throughout the landscape, but concentrations of large trees in groups greater than two or three acres in extent are less frequently encountered.

The amount of timber harvesting each year varies due to fluctuations in log prices and other economic factors. Since the 1970s, state and federal laws have placed constraints on logging in order to ensure sustainability of the resource and protect endangered species such as the northern spotted owl (*Strix occidentalis*). Timber resource statistics compiled by the USFS Pacific Northwest Research Station (Waddel and Bassett, 1997) show that a period of heavy logging in Modoc County ended in the late 1940s (Figure 7-7). After this period of bounty, harvest levels remained below those of other interior northern California counties until the mid-1970s. The year 1977 was a highpoint in local harvest levels. The data also suggests that the recent precipitous drops in north state timber harvest volumes may be less pronounced in Modoc County. This may be because most of the forest in Modoc County and the Upper Pit River Watershed are outside of the range of the northern spotted owl and timber harvests were previously not as high as other counties.

The CWHR 8.0 habitat suitability model is a useful tool for inferring relationships between vegetation conditions and habitat quality for multiple species of wildlife. The predictive model combines the collective knowledge of numerous species experts. Although the state of knowledge for many individual species has advanced since the CWHR models were first developed in the 1980s, the overarching patterns shown in Figure 7-8 are likely valid. The figure shows the numbers of species associated with different stages of Eastside Pine forest in Modoc county. More species of wildlife find suitable feeding habitat in open than closed forests regardless of tree size. Except in exceptionally dense forests, more species find suitable reproductive and cover habitat in forests with larger trees. Of course, the patterns shown below simplify an important nuance that different groups of species are tied to different habitats regardless of overall biodiversity. For example, northern goshawk (*Accipiter gentilis*) and pileated woodpecker (*Dryocopus pieatus*) are two birds that require patches of dense forest with large trees for nesting. In contrast, the calliope hummingbird (*Stellula calliope*) requires open forest for feeding, breeding, and cover. And then are species such as sage grouse (*Centrocercus urophasianus*) and pronghorn antelope (*Antilocapra americana*) that only find suitable habitat in non-forested areas such as sagebrush and grassland.

Whitebark pine characterizes the subalpine zone of the Warner Mountains. It is often found as a broad-crowned tree inhabiting high ridges, and meadows with lodgepole pine. The caching of its large winged seeds by Clark's nutcrackers (*Nucifraga columbiana*) is an important dispersal and regeneration mechanism for the pine (Lanner, 1999). In other parts of the tree's range (e.g., Rocky

Mountains), there is concern that its abundance is rapidly decreasing due to factors such as white pine blister rust (*Cronartium ribicola*) and mountain pine beetle (*Dendroctomus ponderosae*) infestations. Local research suggests that the range of whitebark pine in the Warners is actually expanding in the zone below 8,100 feet as the conifer species colonizes sagebrush areas (Figura, 1997). According to the LCCMP data, there are approximately 4,400 acres of whitebark pine forest in the Upper Pit River Watershed.

SAGEBRUSH AND JUNIPER COMMUNITIES

Sagebrush is the defining vegetation type that makes the Upper Pit River Watershed different from other areas to the west. Sagebrush scrub covers between 20 and 30 percent of the Upper Pit River Watershed. Big sagebrush (*Artemesia tridentata*) and low sagebrush (*Artemesia arbuscula*), western juniper (*Juniperus occidentalis occidentalis*), antelope bitterbrush (*Purshia dentata*), rabbitbrush (*Chrysothamnus spp.*), and grasses occur in varying mixtures. Sagebrush is also a groundstory component of open conifer forests in the Upper Pit River Watershed. Sagebrush provides important winter range habitat to mule deer (*Odocoileus hemionus*), and the most important source of forage for pronghorn antelope (*Antilocapra americana*) (California Department of Fish and Game, 2002). Cheatgrass (*Bromus terctorum*), medusahead (*Taeniatherum caput-medusae*) and other exotic annual plants have displaced many of the native bunchgrasses present on the sagebrush steppe.

Western juniper is the dominant species for approximately 20 percent of the Upper Pit River Watershed. It is rapidly expanding into another 20 percent of the area. On the Modoc Plateau, western juniper is considered a separate subspecies from those junipers growing at high elevations in the Sierra Nevada. Pinyon pine (*Pinus edulis*) does not occur in the juniper woodland within the Upper Pit River Watershed, as is the case in other Great Basin juniper communities.

Since the 1880s a drastic increase in the range and density of various juniper species has occurred throughout the western United States. The spread has resulted in the encroachment of juniper into other vegetation communities, notably sagebrush scrub, aspen and pine forest. Over the last 130 years, western juniper has spread ten fold in northeastern California (Bureau of Land Management, 2003). Young and Evans measured similar rates of expansion on a 2,500-acre study area in western Lassen County, although they found different rates of spread in big sagebrush and low sagebrush communities. These researchers noted that 84 percent of western junipers growing in big sagebrush areas established from 1890 to 1920. Miller and Rose report analogous findings for southeastern Oregon. Analysis of the BLM data for the Upper Pit River Watershed gives an estimate that 43 percent of the area currently has juniper cover above five percent, 21 percent of the area has juniper cover above 20 percent, and six percent of the area has juniper cover above 30 percent. The distribution of juniper is variable; it is most concentrated in the northeastern half of the Upper Pit River Watershed (Figure 7-9). The density distribution breakdown for the entire 6.5 million-acre BLM juniper data set yield somewhat lower values for the higher density classes; only 14 percent of the area has juniper cover above 20 percent (White-Bagnaschi, 2003). It is unclear if this difference is the result of actual differences on the ground, or is related to differences in how the data is analyzed. Aside from this question, the rate of spread of new juniper encroachment in northeastern California is estimated at about 50,000 acres per year (Burke, pers. comm., 2003).

Although a direct cause and effect connection has not been established, the reasons for the expansion of juniper pertain to climate, fire suppression, and overgrazing. The paleobotanical record (e.g., fossilized pollen and other plant macrofossils) shows that over the last 10,000 years the range of juniper has expanded and contracted several times in response to shifts in climate (Miller and Wigland, 1994). Following the end of the Little Ice Age in the mid-1880s, mild conditions and increased precipitation favored the copious production of juniper berries resulting in a pulse of regeneration and spread into the sagebrush. Juniper berries are a food source for wildlife and as such are dispersed and passed in the guts of animals (Laacke, 2003a, pers. comm.; Burke, 2003, pers. comm.). The concurrent histories of overgrazing and fire suppression have likely facilitated the spread of juniper. The eating down of grasses by livestock reduced fine fuels and the frequency of fire in the sagebrush-juniper interface. Juniper regeneration is particularly susceptible to fire until it reaches about 50 years of age (Young and Evans, 1981), and natural fire return intervals in sagebrush were historically on the order of 15 to 25 years (Miller and Rose, 1995). It is also suspected that the spread of juniper and other woody plants may be linked to climate change and the role of increased carbon dioxide levels in increasing growth rates (Knapp and Soule, 1998).

There appears to be a fair amount of controversy surrounding the issue of the possible ecological effects of juniper encroachment and proposed management options (Belsky, 1996). The disputed effects include alteration of the fire disturbance and hydrological regimes, displacement of sagebrush and other vegetation, and adverse impacts to wildlife habitat for some species including the sage grouse (*Centrocercus urophasianus*). Locally, two literature reviews have been undertaken by researchers to assess the effects of juniper encroachment and changes expected after its removal (Komar, 2003; Laacke, 2003b).

Depending on a combination of site-specific climatic and geological factors, juniper alters hydrology in semi-arid environments where it grows. Juniper root systems can out compete other plants for available soil moisture. Its lateral roots may extend out to a distance of 2.5 times tree height. Juniper also starts transpiring earlier in the spring than other plants (Gedney et al., 1999). Interception of precipitation by the branches and foliage of junipers may be a significant factor in reducing the delivery of water to the soil. Intercepted snow and rain is evaporated or sublimated back into the atmosphere. A California study found that interception by juniper canopies reduced precipitation reaching the ground by one half compared to adjacent open areas (Young and Evans, 1984). An Oregon study (Eddleman and Miller, 1992) measured losses from juniper interception of 45 to 63 percent. Transpiration is another process by which juniper and other plants use water. Transpiration is the process by which plants uptake water through their roots and either convert it and carbon dioxide into food through photosynthesis, or evaporate it through stomata under the leaves or needles. Eddleman and Miller measured a transpiration rate of 4,700 gallons over a nine-month period per typical juniper of 17.5 inches in diameter at ground level.

The most promising evidence that the removal of juniper may increase available soil moisture and downstream water yield comes from Texas. Complete and partial removal of ashe juniper from four watersheds resulted in increased water yields of between 100,000 and 120,000 gallons per acre per year. In another, watershed modeling was used to predict an increased water yield of 30,000 gallons per acre per year (Hoffman, 2002). Application of these results to the Upper Pit River Watershed situation should be qualified in that Texas experiences summer rains whereas most precipitation on the Modoc Plateau comes during the winter months. Additionally, the relationship between juniper removal and hydrology will likely vary depending on numerous regional and site-specific factors including climate, topography, soil, pre-treatment vegetation composition and density, and management. However, it stands to reason that due to the arid conditions in the Upper Pit River Watershed during the growing season, extra moisture would be available to sagebrush and grasses in the absence of juniper, and that water that infiltrates below the reach of plant roots would be available to recharge the aquifer.

Besides hydrology juniper encroachment alters plant community composition in sagebrush and other systems. In a study including some lands within the Upper Pit River Watershed as well as parts of southeastern Oregon, Miller et al. found a significant relationship between increased juniper density and decreased big sagebrush, perennial herb and aspen densities. For example, they report that when juniper canopies reached 50 percent of maximum woodland cover, the shrub layer declined to 80 percent of maximum potential in the big sagebrush communities they examined. Although it is unclear how this information translates into absolute cover values, the graphs included in the research indicate that most of the elasticity in non-juniper response occurs below 20 percent juniper cover. In other words, it appears that junipers effectively dominate and exclude other vegetation on sites where the tree canopy closure is above about 20 percent. As noted earlier the BLM data show 21 percent of the entire Upper Pit River Watershed to be in this condition. Figure 7-5 illustrates the relative distribution of these areas at the Calwater 2.2 Upper Pit River Watershed scale.

The removal of juniper is a potential management tool for checking the spread of juniper. To date only a small amount of removal has occurred on public lands in the Upper Pit River Watershed. On BLM and USFS lands in northeastern California there have only been about 1,000 acres treated in recent years (Burke, 2003, pers. comm.). A juniper removal project is a multi-step process. First, the large seed producing trees are removed. Subsequent herbicide treatment is necessary to control sprouting. After three to four years, burning or another herbicide application is needed to kill germination of dormant seeds. However, it may not be necessary to achieve complete eradication of juniper from an area. Bringing juniper densities to 10 percent cover or lower will significantly enhance grass and forage productivity (Laacke, 2003, pers. comm.).

OTHER VEGETATION COMMUNITIES

California native grasslands used to be dominated by perennial bunchgrasses. On the Modoc Plateau, the native grasslands of a few hundred years ago were influenced more by Great Basin species than California Central Valley species. Widespread native grasses in the Upper Pit River Watershed would have included needle grasses (*Stipa spp.*), Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropryron spicatum*), and basin wildrye (*Elysmus cionereus*). They would have dominated flat areas of the lower elevations, but also would have flourished among the sagebrush and open pine communities. Today, the distribution of these grasses has been greatly reduced by competition with introduced annual grasses. In particular, cheatgrass (*Bromus tectorum*) has invaded Great Basin grasslands. In the early spring, this weed quickly develops a deep root system thus out-competing native plants for available moisture (Barbour et al., 1993). Cheatgrass is used as an early season source of pasture forage for livestock. However, it increases the frequency and volatility of fire. Medusahead (*Taeniatherum caput-medusae*) is another exotic invader of grasslands and other communities in the Upper Pit River Watershed. Partly due to its high silica content, the plant has a low palatability and nutritional value to livestock and wildlife. Both cheatgrass and medusa head do well on disturbed sites. Consequently, overgrazing can facilitate the spread of these species. Lists of invasive exotic grasses and other pest plants of concern in the Upper Pit River Watershed are given in Tables 7-7.

Much of the potential grassland in the Upper Pit River Watershed has been converted to agricultural use. Alfalfa is the principle crop. According to the LCMMP and Gap data, about 85 percent of the grass dominated area in the Upper Pit River Watershed is cropland. Grasses are an important component in other vegetation types found in the watershed. However, overgrazing, juniper encroachment, fire exclusion, and density increases in the conifer belt are factors that reduce the distribution of grasses in these communities.

Chaparral is a shrub-dominated vegetation type characterized by manzanita (*Arctostaphylos spp.*), mountain whitethorn (*Ceanothus cordulatus*), deerbrush (*Ceanothus integerrimus*), scrub oak (*Quercus berberidifolia*), and other species. About two to six percent of the Upper Pit River Watershed area consists of the chaparral community. It is scattered throughout the Upper Pit River Watershed, but the largest concentrations are found in the western part of Upper Pit River Watershed. In particular, large areas of chaparral regenerated in places burnt by the 1977 Scarface Fire. However, much of the brush in this area has been recently removed and re-planted with conifer seedlings. Chaparral is a fire-adapted community. Many chaparral species have reproductive methods that are dependent on periodic fire. In the absence of fire, manzanita and other brush species become dense and decadent so that fewer new shoots are produced, and there is no growing space for younger plants or a diversity of vegetation. Without young new shoots, old growth, chaparral looses its nutritional value as browse for wildlife.

A mere four to six thousand acres of hardwood and hardwood-conifer forest lie in the far western portion of the Upper Pit River Watershed. Oaks are mixed in with the conifers in the mountains between Fall River Mills and Bieber. The Pit River drainage extends the range of black oak (*Quercus kellogii*) and blue oak (*Quercus douglasii*) farther east than in many other parts of northern California. Oaks also exist as a component in some areas of conifer-dominated forest.

Narrow strips of riparian vegetation including willow (*Salix spp.*) and cottonwood (*Populus fremontii*) line rivers and streams in the Upper Pit River Watershed. However, much of this vegetation type has been cleared from river edges through the valleys. Forest succession and the increase of conifer stocking in the absence of fire may be affecting the regeneration of riparian vegetation in the forested belt. About 1,400 to 4,000 of acres of aspen grow in meadows and other mesic sites in the southern Warner Mountains.

Vernal pools are seasonally flooded depressions in the landscape. An impervious claypan limits drainage during the winter and spring, but these wetlands dry out as water evaporates in the summer heat. Vernal pools are ecologically important because they often support populations of rare and endemic plants and aquatic organisms that are adapted to the unique habitat conditions provided by the ephemeral pools. Per NDDB the Upper Pit River Watershed contains at least one known complex of northern basalt flow vernal pools and numerous occurrences in other places of rare plants (e.g., *Gratiola heterosepala, Orcuttia tenuis, Pogogyne floribunda, Polygonum polygaloides* ssp. *esotericum*) associated with this type of vernal pool. Northern basalt flow vernal pools vary in size from a fraction of an acre to over 100 acres. They occur on singly or in clusters on flat plains, and are typically surrounded by sagebrush or juniper (Keeler-Wolf et al., 1998).

SPECIAL-STATUS PLANTS

Rare plants are either limited in geographic distribution or they occur in small isolated populations. The reasons for rarity can be natural or human. Some plants may be adversely affected by the destruction of habitat or the introduction of exotic invasive weeds. Other plants may be naturally rare because of unique biological or genetic features. Still others may be abundant, but extensive surveys have not been conducted. Endemism in rare plants adapted to limited soil types or to climatic conditions that were characteristic of past eras is also a factor (Nakamura and Nelson, 2001).

Special-status plants are species that are protected under the California and federal Endangered Species Acts, or other regulations. Special-status plants are also species considered sufficiently rare by the scientific community that they qualify for consideration and/or protection pursuant to the California Environmental Quality Act (CEQA).

Categories of special-status plants include:

- Plants listed or proposed for listing as threatened or endangered under the Federal Endangered Species Act (50 CFR 17.12 [listed plants] and various notices in the Federal Register [proposed species])

- Plants listed or proposed for listing by the State of California as threatened or endangered under the California Endangered Species Act (14 CCR 670.5), or listed as rare under the California Native Plant Protection Act (California Fish and Game, Code, Section 1900 et seq.)

- Plants that meet the definitions of rare or endangered under CEQA (State CEQA Guidelines, Section 15380)

- Plants considered by the California Native Plant Society (CNPS) to be "rare, threatened, or endangered in California" (Lists lB and 2 in CNPS 2003)

- Plants listed by CNPS as plants about which more information is needed to determine their status and plants of limited distribution (Lists 3 and 4 in CNPS 2001), which may be included as special-status species on the basis of local significance or recent biological information

Because of the size of the Upper Pit River Watershed, the following assessment for the potential of occurrences of special status plants is limited to a search of the California Natural Diversity Database (CNDDB) (April 2003 data) within Upper Pit River Watershed boundaries. The database only contains known occurrences. Therefore, additional special status plants may occur in the Upper Pit River Watershed. Additionally, plants with known occurrences in the vicinity of the Upper Pit River Watershed may also occur inside the Upper Pit River Watershed if suitable habitat exists. The CNPS maintains an online Inventory of Rare Plants (California Natural Diversity Database, 2003) that features information on the habitats and statewide distribution of special status plants. Additionally, a publication of the University of California (Nakamura and Nelson, 2001) provides pictures and identification tips for selected rare plants of northern California. The CNDDB search yielded a total of 57 special status plants known to occur within the Upper Pit River Watershed. This includes two California-listed endangered plants; one federally listed threatened plant; one federal candidate species and 14 CNPS List 1B plants. All of the plants are listed in Table 7-5 below.

Table 7-5 SPECIAL STATUS PLANTS KNOWN TO OCCUR IN THE UPPER PIT RIVER WATERSHED				
Scientific Name	**Common Name**	**Legal Status**	**Family**	**Number of Occurrences**
Alisma gramineum	Narrow-leaved water-plantain	2	Alismataceae	6
Arnica fulgens	Hillside arnica	2	Asteraceae	18
Astragalus anxius	Ash Valley milk-vetch	1B	Fabaceae	9
Astragalus lemmonii	Lemmon's milk-vetch	1B	Fabaceae	1
Astragalus pulsiferae var. *suksdorfii*	Suksdorf's milk-vetch	1B	Fabaceae	13
Atriplex gardneri var. *falcate*	Falcate saltbush	2	Chenopodiaceae	3
Calochortus longebarbatus var. *longebarbatus*	Long-haired star-tulip	1B	Liliaceae	122
Carex atherodes	Awned sedge	2	Cyperaceae	6
Carex comosa	Bristly sedge	2	Cyperaceae	2
Carex halliana	Hall's sedge	2	Cyperaceae	12
Carex limosa	Shore sedge	2	Cyperaceae	1
Carex petasata	Liddon's sedge	2	Cyperaceae	1
Carex praticola	Meadow sedge	2	Cyperaceae	1
Carex sheldonii	Sheldon's sedge	2	Cyperaceae	6
Claytonia megarhiza	Fell-fields claytonia	2	Portulacaceae	1
Collomia larsenii	Talus collomia	2	Polemoniaceae	1
Dimeresia howellii	Doublet	2	Asteraceae	30
Downingia laeta	Great Basin downingia	2	Campanulaceae	6
Drosera anglica	English sundew	2	Droseraceae	2
Eriogonum prociduum	Prostrate buckwheat	1B	Polygonaceae	27
Eriogonum pyrolifolium var. *pyrolifolium*	Pyrola-leaved buckwheat	2	Polygonaceae	3
Galium glabrescens ssp. *modocense*	Modoc bedstraw	1B	Rubiaceae	4
Geum aleppicum	Aleppo avens	2	Rosaceae	1
Gratiola heterosepala	Boggs Lake hedge-hyssop	CE, 1B	Scrophulariaceae	22
Ivesia baileyi var. *beneolens*	Owyhee ivesia	2	Rosaceae	1
Ivesia paniculata	Ash Creek ivesia	1B	Rosaceae	37
Lathyrus rigidus	Rigid pea	2	Fabaceae	2
Lomatium hendersonii	Henderson's lomatium	2	Apiaceae	32
Lupinus latifolius var. *barbatus*	Bearded lupine	1B	Fabaceae	2
Lupinus uncialis	Lilliput lupine	2	Fabaceae	18
Mertensia cusickii	Toiyabe bluebells	2	Boraginaceae	1
Mertensia longiflora	Long bluebells	2	Boraginaceae	1
Mertensia oblongifolia var. *amoena*	Beautiful bluebells	2	Boraginaceae	6
Mertensia oblongifolia var. *oblongifolia*	Sagebrush bluebells	2	Boraginaceae	1
Mimulus cusickii	Cusick's monkeyflower	2	Scrophulariaceae	2
Nemophila breviflora	Great Basin nemophila	2	Hydrophyllaceae	6
Orcuttia tenuis	Slender Orcutt grass	CE, FT, 1B	Poaceae	2
Osmorhiza depauperata	Blunt-fruited sweet-cicely	2	Apiaceae	2
Phacelia sericea var. *ciliosa*	Blue alpine phacelia	2	Hydrophyllaceae	10
Phlox muscoides	Moss phlox	2	Polemoniaceae	2
Pogogyne floribunda	Profuse-flowered pogogyne	1B	Lamiaceae	17
Polygonum polygaloides ssp. *esotericum*	Modoc County knotweed	1B	Polygonaceae	2
Potamogeton epihydrus ssp. *Nuttallii*	Nuttall's pondweed	2	Potamogetonaceae	1
Potamogeton filiformis	Slender-leaved pondweed	2	Potamogetonaceae	3
Potamogeton zosteriformis	Eel-grass pondweed	2	Potamogetonaceae	6

Table 7-5 (cont.) SPECIAL STATUS PLANTS KNOWN TO OCCUR IN THE UPPER PIT RIVER WATERSHED				
Scientific Name	**Common Name**	**Legal Status**	**Family**	**Number of Occurrences**
Potentilla basaltica	Black Rock potentilla	FC, 1B	Rosaceae	2
Ranunculus macounii	Macoun's buttercup	2	Ranunculaceae	2
Ribes hudsonianum var. *petiolare*	Western black currant	2	Grossulariaceae	1
Saxifraga cespitosa	Tufted saxifrage	2	Saxifragaceae	1
Scutellaria galericulata	Marsh skullcap	2	Lamiaceae	3
Senecio indecorus	Rayless mountain ragwort	2	Asteraceae	1
Silene oregano	Oregon campion	2	Caryophyllaceae	4
Stachys palustris ssp. *pilosa*	Marsh hedge nettle	2	Lamiaceae	8
Stenotus lanuginosus	Woolly stenotus	2	Asteraceae	15
Thelypodium howellii ssp. *howellii*	Howell's thelypodium	1B	Brassicaceae	4
Trimorpha acris var. *debilis*	Northern daisy	2	Asteraceae	1
Triteleia grandiflora var. *howellii*	Howell's triteleia	2	Liliaceae	1

Slender Orcutt grass (*Orcuttia tenuis*) is a California-listed endangered and a federally listed threatened plant. It grows in vernal pools and occasionally on reservoir edges or stream floodplains. It is associated with clay soils subject to seasonal flooding in valley grassland, coniferous forest and sagebrush scrub. This plant sprouts while pools are full, but grows and flowers after the soil has dried out. It is an annual grass covered by sticky aromatic secretions. It flowers from May through June or July and is best identified after flowering until the onset of winter rains (Nakamura and Nelson, 2001). There are two known occurrences from CNDDB in the Upper Pit River Watershed. Both are located about 1.5 miles apart in the Knobcone Butte map quadrangle. Both occurrences were first observed in 2000.

Boggs Lake Hedge-Hyssop (*Gratiola heterosepala*) is also a California-listed endangered plant. It similarly grows in vernal pools, reservoir edges, and mudflats where there are wet clay soils. The types of surrounding vegetation may be highly variable from place to place and the plant is found at elevations between 50 and 5,000 feet. The plant is a small annual herb with stems one to four inches in height. Flowering occurs between April and July depending on elevation and precipitation. This is also the best time to identify the plant in the field (Nakamura and Nelson 2001). There are 21 known occurrences from CNDDB of the plant in the Upper Pit River Watershed. The occurrences were first observed between 1985 and 1998.

INVASIVE PLANTS AND OTHER NOXIOUS WEEDS

Some experts consider invasive species to be a serious threat to global biodiversity second in importance only to direct habitat loss and fragmentation. Invasive plants are usually non-native species that spread easily and displace native species. The problem of these “weeds” or “pest plants” in California is widespread and serious due to the State’s varied topography, geology and climate. Invasive plants can adversely impact native vegetative communities by altering patterns of nutrient cycling, hydrological processes, and the intensity of fire (Bossard et al., 2000).

Plant pests are defined by law, regulation, and technical organizations, and regulated by many different sources, which include the California Department of Food and Agriculture (CDFA), United States Department of Agriculture, and the California Exotic Pest Plant Council. The CDFA uses an action-oriented pest-rating system. The rating assigned to a pest by the CDFA does not necessarily mean that one with a low rating is not a problem, but the rating system is meant to prioritize response by the CDFA and County Agricultural Commissioners. Plants on the CDFA's highest priority "A" list are defined as plants, "of known economic importance subject to state-county enforced action involving eradication, quarantine regulation, containment, rejection or other holding action."

A group of technical experts called the Exotic Pest Plant Council has developed a list of plant pests specific to California wildlands. The "CalEPPC" list is based on information submitted by land managers, botanists, and researchers throughout the state and on published sources. The list highlights non-native plants that pose serious problems in wildlands (i.e., natural areas that support native ecosystems, including national, state and local parks, ecological reserves, wildlife areas, national forests, BLM lands, etc.). Plants found mainly in disturbed areas, such as roadsides and agricultural fields, and plants that establish sparingly and have minimal impact on natural habitats are not included on the list. The CDFA and CalEPPC list categories are explained in more detail in Table 7-6 below.

Table 7-6
CDFA AND CALEPPC LIST CATEGORIESFOR INVASIVE PLANTS AND NOXIOUS WEEDS

CDFA List Categories	
A	An "A" rated organism is one of known economic importance subject to state-county enforced action involving eradication, quarantine regulation, containment, rejection or other holding action.
B	An organism of known economic importance subject to eradication, containment, control or other holding action at the discretion of the individual county agricultural commissioner, or an organism of known economic importance subject to state endorsed holding action and eradication only when found in a nursery.
C	An organism subject to no state enforced action outside of nurseries except to retard spread, generally at the discretion of a commission or an organism subject to no state enforced action except to provide for pest cleanliness standards in nurseries.
Q	An organism requiring temporary "A" action pending determination of a permanent rating. The organism is suspected to be of economic importance but its status is uncertain because of incomplete identification or inadequate information.
D	No action.
CalEPPC List Categories	
A	Most Invasive Wildland Pest Plants; documented as aggressive invaders that displace natives and disrupt natural habitats. Includes two sub-lists: List A-1: widespread pests that are invasive in more than three Jepson regions, and List A-2: regional pests invasive in three or fewer Jepson regions.
B	Wildland Pest Plants of Lesser Invasiveness; invasive pest plants that spread less rapidly and cause a lesser degree of habitat disruption; may be widespread or regional.
Red Alert	Pest plants with potential to spread explosively; infestations currently small or localized. If found, alert CalEPPC, County Agricultural Commissioner, or California Department of Food and Agriculture.

The Modoc County of Agriculture maintains a list of the CDFA-rated invasive plants known to occur in the county. This list and the CDFA and CalEPPC designations of these plants are provided in Table 7-7 below. Pictures and information on many of these plants are featured at the Pit River

Table 7-7 CDFA AND CALEPPC-LISTED INVASIVE PLANTS OF MODOC COUNTY		
Scientific Name	**Common Name**	**List**
Linaria genistifolia dalmatica	Dalmatian Toadflax *	CDFA A
Centaurea diffusa	Diffuse Knapweed *	CDFA list: A
Onopordum acanthium var. *Acanthium*	Scotch Thistle *	CDFA list: A
Centaurea maculosa.	Spotted Knapweed *	CDFA list: A CalEPPC: Red Alert
Centaurea squarrosa	Squarrose Knapweed *	CDFA list: A
Crupina vulgaris	Bearded Creeper	CDFA list: A CalEPPC: Red Alert
Euphorbia esula	Leafy Spurge *	CDFA list: A CalEPPC list: A2
Halogeton glomeratus	Halogeton *	CDFA list: A CalEPPC: Red Alert
Physalis longifolia	Long-Leafed Ground Cherry	CDFA list: A
Carduus nutans	Musk Thistle *	CDFA list: A
Sonchus arvensis	Perennial Sowthistle *	CDFA list: A
Carduus acanthoides	Plumeless Thistle	CDFA list: A
Cirsium undulatum	Wavyleaf Thistle	CDFA list: A
Cirsium ochrocentrum	Yellowspine Thistle	CDFA list: A
Acroptilon repens.	Russian Knapweed	CDFA list: B
Isatis tinctoria	Dyer's Woad	CDFA list: B
Lepidium latifolium	Perennial Pepperweed	CDFA list: B CalEPPC: A1
Rorippa austriaca	Austrian Fieldcrest	CDFA list: B
Cirsium arvense	Canada Thistle *	CDFA list: B CalEPPC: B
Cardaria pubescens	Globe-Podded Hoarycress	CDFA list: B
Cardaria draba	Heart-Podded Hoarycress	CDFA list: B CalEPPC: A2
Polyganum cuspidatum	Japanese Knotweed	CDFA list: B
Aegilops cylindrical	Jointed Goatgrass	CDFA list: B
Salvia aethiopis	Mediterranean Sage *	CDFA list: B
Chorispora tenella	Purple Mustard	CDFA list: B
Elytrigia repens	Quackgrass	CDFA list: B
Centaurea solstitialis	Yellow Star thistle *	CDFA list: C CalEPPC: A1
Cuscuta ssp.	Dodder	CDFA list: C
Convolvulus arvensis	Field Bindweed	CDFA list: C
Hypericum perforatum	Klamath Weed*	CDFA list: C CalEPPC: B
Taeniatherum caput-medusae	Medusa Head	CDFA list: C CalEPPC: A1
Tribulus terrestris	Puncture Vine *	CDFA list: C
Salsola tragus	Russian Thistle	CDFA list: C
Notes: Source is Modoc County Department of Agriculture, 2003. Asterisk denotes those weed species for which there is a focused control project underway in Modoc County per the Calweed database.		

Alliance's website. Weed Management Areas (WMA) are local organizations that bring together various private and government officials to cooperatively coordinate efforts for controlling the spread of common invasive plants. The Modoc WMA is participating in a multi-county effort to map occurrences of invasive plants. The current iteration of this GIS map includes spatial data for about 25 species in Modoc County (Moreo pers. comm., 2003).

Once invasive plants have spread into native vegetative communities such as annual grassland or conifer forest, it is very difficult to eradicate them. Weed control methods include physical control (e.g., burning, hand pulling), chemical control (e.g., selective or non-selective herbicides) and biological control (e.g., insects that eat the pest). A group of sixteen State and federal agencies called the California Interagency Noxious Weed Coordinating Committee created the Calweed database that provides information on weed control projects underway in California counties. According to the database there are presently 37 weed control projects in Modoc County including focused efforts against 14 of the species listed in Table 7-7 above.

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Section 8

Section 8
WILDLIFE

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Section 8
WILDLIFE

INTRODUCTION

The Upper Pit River Watershed hosts a diversity of wildlife species. Wildlife, as covered in this section, refers to species including birds, mammals, amphibians, and reptiles. In this section, the complex interaction of wildlife and their habitats are discussed. Examples are provided describing how wildlife populations are affected by physical changes in the environment. Also described is one of the standard wildlife and habitat classification systems used by biologists, known as the California Wildlife Habitat Relations System. The final portion of the section discusses the status, distribution, life history, and population trends of individual wildlife species. Species are grouped into native, exotic, and threatened and endangered wildlife.

REVIEW OF EXISTING INFORMATION/SOURCES OF DATA

Existing information on special-status birds and mammals in the watershed was reviewed for this section. Biologists Mary Flores (USFS), Richard Shinn (CDFG), Paul Schmidt (BLM), Frank Hall (CDFG), Ken Romberger (USFS), Chuck Rowe (USFS), Steve Breth (USFS), Ron Jackman, Terry Hunt, Jim Irvin (USFS), Bob Shaffer (CDFG), Ron Jurek (CDFG), Shannon Ludwig (MNWR), Janet Linthicum, Marty Yamagiwa (USFS), Ted Beedy, Scott McWilliams, Lee Ashford (CDFG), and Scott Gardner (CDFG) were contacted and provided information and insight on local special-status wildlife occurrences and sources of information.

Pertinent survey reports, primary and gray literature, and websites containing wildlife information were also reviewed. Rare species occurrence records from the California Department of Fish and Game's (CDFG) California Natural Diversity Data Base (CNDDB 2003) and California Wildlife Habitat Relationships (WHR) database were accessed to create distribution maps and evaluate distributional data.

Some potentially useful information was made available but was not summarized in this section. The Klamath Basin National Wildlife Refuge has conducted aerial waterfowl censuses for approximately 20 years in northeastern California. These surveys are conducted starting in fall and continue until spring. Although surveys are not always conducted each month of each year, the refuge has compiled an abundance of data. Unfortunately, the data is not summarized, and in spreadsheet format. Although available, this data was not summarized or analyzed for this section.

WILDLIFE HABITAT RELATIONSHIPS

California supports one of the most diverse lists of wildlife species in the nation. This diversity is the result of the diverse landscape and associated habitat types. Few states lie adjacent to the ocean, and even fewer show a range of habitats types from desert, at or below sea level, to alpine habitats over 7,500 feet in elevation. Although the number of habitat types in the watershed is only a subset of those found in the state, the diversity is impressive. These habitat types provide food, water, and cover for many species.

Habitat and species diversity has changed through time and continues to change today. Reduced amounts of rainfall and snow impact wildlife populations locally and regionally. For example, small mammal populations such as gophers and mice are typically "controlled" by unusually wet or dry years, or unusually cold winters. Of course, species preying on these rodents are also affected by the changes in the prey's population; often showing changes one or two years later. Several other species are affected by rainfall and snow. Many of the stock ponds and reservoirs, in the watershed, provide critical drinking water for a variety of species. Other species, such as ducks, gulls, and osprey depend on the food sources in the water.

Forestry and agriculture are the largest "scale" activities. Fire suppression in forested habitats is well documented on its affect on many wildlife species dependent on early succession habitats. Shrub vegetation that typically grows in disturbed or "exposed" areas becomes out competed as trees mature. Many mammal and bird species dependent on those shrubs for nesting and foraging must find other locations in order to survive, while those species dependent on trees for nesting and foraging benefit. Livestock grazing in grassland and sagebrush communities also affects habitat and wildlife species diversity. In fact, it is hypothesized that the combination of grazing and fires suppression contributes to the expansion of juniper woodlands. The theory concludes that grazing has reduced the amount of "fine fuels" that would typically "carry" the fire through the grassland and burn the smaller juniper trees. Fire suppression compounds this natural process by extinguishing grassland fires that might otherwise thin some of the junipers.

The conversion of native habitats to agriculture habitats has also affected wildlife populations. While some species populations have been reduced from these conversions, others have increased. Those species that have increased have often benefited because of the greater availability of agricultural habitat for foraging. Resident and migratory geese (Ross', snow, and white-fronted) feed in shorter forage habitats such as pasture, grain, and alfalfa in the spring. In addition, several wintering and resident raptor species including red-tailed hawk, rough-legged hawk, Ferruginous hawk, Swainson's hawk, and northern harrier take advantage of high rodent populations found in perennial crops. Many native mammalian herbivores, most notably deer and squirrels, also benefit from the forage value of the agriculture crops. Species negatively affected by agriculture typically include grassland and riparian dependent species. A few include western meadowlarks, savannah sparrows, blue grosbeak, and gray fox.

Other human activities affect wildlife populations on a smaller scale. The use of bird feeders has allowed many hungry wintering and migratory sparrows to survive, and humming bird feeders provide a nectar source for resident breeders such as the Anna's hummingbird, and migratory species such as the rufous hummingbird. Woodcutting reduces the number of large snags (>2 feet diameter breast height (dbh)) available for cavity nesting birds and mammals. Several woodpecker species including northern flicker, hairy woodpecker, and pileated woodpecker require relatively large snags for nesting substrate. When these cavities become unusable by these species, other species such as cavity nesting ducks, including mergansers, wood ducks, and bufflehead, may use them.

Through time, the federal and state governments have established lands to primarily provide habitat for wildlife species. Five refuges are present within the Upper Pit River Watershed. These include the Modoc National Wildlife Refuge, Ash Creek Wildlife Area, and a handful of State Game Refuges (Hayden Hill/Silva Flat, Blacks Mountain, and Warner Mountain). Table 8-1 summarizes the administrative agency and acreage, and Figure 8-1 depicts their location.

Table 8-1 WILDLIFE REFUGES AND GAME AREAS		
Name of Refuge	**Administering Agency**	**Acres**
Ash Creek Wildlife Area	State of California Resource Agency	14,754
Modoc National Wildlife Refuge	Department of Interior, US Fish & Wildlife Service	7,018
Hayden/Hill/Silva Flat Game Refuge	U.S. Forest Service	26,569
Blacks Mountain Game Refuge	U.S. Forest Service	17,078
Warner Mountain Game Refuge	U.S. Forest Service	31,278
South Warner Wilderness Area	U.S. Forest Service	4,431
Long Bell State Game Refuge	U.S. Forest Service	34,957
Devil's Garden Natural Area	U.S. Forest Service	58

CALIFORNIA WILDLIFE HABITAT RELATIONSHIPS (CWHR) AND HABITAT TYPES

As mentioned earlier, California has a diversity of habitat types and wildlife species. Biologists have been recording wildlife species occurrences in a variety of habitat types throughout the state for many years. From these observations, patterns were found relative to each habitat type. For instance, many of the same bird and mammal species were found in oak woodland habitats located in Los Angeles County and Shasta County. In order to help understand the life history requirements for these wildlife species and their habitat associations, the state of California developed a database or information system in 1983 known as California Wildlife Habitat Relationships (CWHR).

Depending on user needs, the CWHR information system provides a variety of uses. Biologists often reference the system to document expected occurrences of wildlife species based on specific habitat types. For example, typing in a specific habitat type, and requesting a list of mammals, birds, amphibians and reptiles expected to occur queries the CWHR database system, which then provides the information, requested concerning that specific habitat. Alternatively, the variety of habitat types that would support an individual species could be queried. Resource managers use the database to assist with management decisions. A list of species potentially impacted, both positively and negatively, by a land management practice, can be obtained by searching for habitat.

In addition to computer queries, several publications are part of the information system. Three of the publications, each a separate volume, describe the distribution and life history requirements for amphibians/reptiles, mammals, and birds (Zeiner et al., 1990). A search for the total number of each of these species groups expected to occur in or adjacent to the Upper Pit River Watershed resulted in:

- Reptiles
- Amphibians
- Mammals
- Birds

Another publication describes the habitat types (California Department of Fish and Game, 1988), often referred to as the WHR habitat types. There are 59 wildlife habitats: 27 tree, 12 shrub, 6 herbaceous, 4 aquatic, 8 agricultural, 1 developed, and 1 non-vegetated habitats described by the CWHR system.

As with any identification/classification system, the CWHR system has its challenges. These challenges rest primarily on the differences in professional opinion regarding exactly how "course" or "fine" to describe habitat types. Additionally, wildlife species often are renamed, split, or lumped, causing the database to be outdated with each taxonomic change. These challenges often result in individuals or groups promoting another indentification/classifcation system. A handful of others exist for plant communities or habitat types, including Holland.

A brief discussion of the plant communities and wildlife species associations for each of the major habitat types found in the Upper Pit River Watershed are provided below. Complete vegetation descriptions of these habitat types can be found in Section 7, "Botanical Resources."

Sagebrush Scrub

Sagebrush scrub habitats are dominated by *Artemesia* and rabbitbrush species, and are located throughout the Upper Pit River Watershed. Typical bird species in these habitats include sage sparrows, horned larks, savannah sparrow, vesper sparrow, western meadowlark, and sage grouse. Typical mammals include black-tailed jackrabbits, pronghorn antelope, Belding ground squirrels, and mule deer.

Juniper Woodland

Juniper woodland is found throughout the Upper Pit River Watershed between conifer forest habitats, agriculture, or sagebrush scrub. The understory and surrounding habitats are typically dominated by sagebrush, and thus many of the species in this habitat type are found in the sagebrush habitat type. The presence of juniper trees provides potential nesting and roosting sites for red-tailed and Swainson's hawks, ravens, western-screech owls, lark sparrows, American magpie (formerly black-billed magpie), bushtit, oak titmouse, and bats.

Ponderosa Pine Forest

Ponderosa pine forests are found above the juniper woodlands and below the mixed conifer forests. Most of this habitat type is privately owned and intensively managed for timber production. A relatively open structure has been maintained in most areas, and some larger trees or groups of larger trees are present. Northern flickers, white-breasted nuthatches, brown creepers, and western gray squirrels are common species present in this habitat type. Relatively small, isolated stands of older-aged forest exist in a few places. Northern goshawks, Stellar's jays, pileated and hairy woodpeckers, fishers, and martens potentially exist in these stands.

Sierran Mixed Conifer, Jeffrey Pine, and Lodgepole Pine Forest

Sierran mixed conifer, Jeffrey pine, and lodgepole pine forests are found above the eastside yellow pine forests. Portions of this habitat type are located at higher elevations in the Upper Pit River Watershed. As with yellow pine forests, a relatively open structure has been maintained with some larger trees or groups of larger trees present, and small isolated patches of older forest in a few places. These forests intergrade with yellow pine forests on both sides of the Sierra-Cascade crest. Stands of lodgepole pine typically are located near large wet meadows. Red crossbills, Williamson's sapsuckers, hairy woodpecker, western tanagers, mountain chickadees, dusky-footed woodrats, and

Douglas squirrels are common species associated with this habitat type. California spotted owls, winter wrens, olive-sided flycatchers, blue grouse, and western red-backed voles may exist in older-aged stands.

Mixed Chaparral

Mixed chaparral habitat is dominated by white oak, gray pine, mahogany, manzanita, and *Ceanothus* species. This habitat type is more common in the southern portion of the Upper Pit River Watershed and lies between the yellow pine forest and sagebrush scrub habitats. Common wildlife species in this habitat type include ringtail, Heerman's kangaroo rat, porcupine, acorn woodpecker, lazuli bunting, rattlesnake, and mule deer.

Annual Grassland

Sagebrush scrub and mixed woodland give way to annual grassland at the valley floors. Horned larks, western meadowlarks, savannah sparrows, Botta's pocket gophers, and broad-handed moles are common species in these grasslands. Several raptor species forage on small mammals in the grasslands, including American kestrel, northern harrier, rough-legged hawk, ferruginous hawk, Swainson's hawk, red-tailed hawk, golden eagle, and prairie falcon. Resident raptors, including white-tailed kites, northern harriers, and burrowing owls, also use the grassland habitat.

Several swallow species forage over grasslands and other low-lying habitat types. Barn swallows, cliff swallows, bank swallows, tree swallows, violet green swallows, and northern rough-winged swallows occur throughout the project area. During the nesting season, these species travel throughout low-lying areas capturing flying insects.

Agricultural Land

Agricultural lands are located primarily along the valley bottoms. Agricultural lands include permanent pasture, alfalfa, wheat, wild rice, peppermint, garlic, and strawberries. Although the diversity of wildlife is limited, those species that do occur in the area are abundant. Mammals including house mice, California meadow mice, black-tailed hare, and the Botta pocket gopher are common in the unplowed grassland areas. Bird species that also use the unplowed grassland areas include savannah sparrows, western meadowlarks, and mourning dove. Around the farms, other wildlife species, particularly birds, are common because these areas have occasional trees, unlike the grassland and agriculture crops. American kestrel, barn owls, great horned owls, and northern flickers nest in trees that were planted to shade homes or create wind rows. Common reptiles include the western fence lizard and Pacific gopher snake. Additionally, rats, deer mice, Brewer's blackbirds, and European starlings occur in and around barns and feedlots.

Rock Outcrops and Cliffs

Rock outcrops and cliff habitat occur in several areas of the Upper Pit River Watershed, especially in the northern portion. These areas provide a unique nesting structure for several birds and remote denning areas for mammals. Mountain lions, bear, skunk, bobcat, and deer use rock outcrops to den or rest. Ravens, barn owls, golden eagles, peregrine, and prairie falcons build nests on protected and isolated cliffs.

Lakes (Lacustrine)

A few natural lakes, and several man-made reservoirs, are scattered throughout the Upper Pit River Watershed. Bald eagles, ospreys, waterfowl, and other waterbirds are present in these water bodies. The lakes and reservoirs are especially important for migratory waterbirds. During long migration periods, species including phalaropes, gulls, coots, pelicans, swans, geese, ducks, grebes, and loons stop at these lakes to either rest and/or replenish energy needed for migration.

Perennial Drainage (Riverine)

Much perennial drainage occurs in the Upper Pit River Watershed, especially in the northern portion. Habitats along these watercourses are variable. In small perennial streams, such as creeks, foothill yellow-legged frogs and Pacific tree frogs are among the aquatic amphibians that could exist. American dippers and a small number of waterbird species may also be found in this habitat. In the largest perennial drainage, the Pit River, many more wildlife species occur. Western pond turtles and bullfrogs are abundant. River otter, beaver, and muskrat are common mammals using the aquatic habitat. The shoreline provides feeding opportunities for several bird species. Bald eagles, great-blue herons, great egrets, common mergansers, and many other waterfowl species forage in the deep water or shallow margins.

Seasonal Drainage (Riverine)

Seasonal drainages are commonly found throughout the Upper Pit River Watershed due to the impervious soils. These drainages carry water for variable amounts of time, but mostly during the winter during heavy rains or rapid snow melt. The number of wildlife species using them is limited because of their unpredictability. Foothill yellow-legged frogs and Pacific tree frogs could potentially use seasonal drainages that lasted into the late spring. Other species using this habitat type would vary depending on surrounding habitats. Seasonal drainages in grassland habitats establish with low-growing forbs, and provide food for grassland species including small mammals and birds.

Montane Riparian and Riparian Scrub

Montane riparian and riparian scrub habitats occur along the perennial and seasonal drainages. Willow, cottonwood, Oregon ash, maple, and alder trees dominate the upper canopy layer. Various shrub, grass, and herbaceous species can provide cover in the understory. The greatest wildlife diversity is found in high quality riparian areas. Many mammals including deer, bear, mountain lion, weasels, skunks, and fox commonly use riparian areas for food and shelter. In riparian vegetation, an incredible number of migratory and resident birds forage, rest, and nest. Many snakes, lizards, and frogs also use the riparian vegetation for food and cover.

Wet Meadow

Wet meadow habitat occurs along the margins of some lakes and reservoirs and small linear patches of this habitat type are located along some perennial and ephemeral streams. Many of the wet meadow habitats in the Upper Pit River Watershed are used for grazing. In these habitats, several duck and geese species, migratory shorebirds including black-bellied plover, killdeer, greater and lesser yellowlegs, dunlin, and sandpipers, horned larks, American pipit, and blackbird species use low growing vegetation. In denser vegetation, sandhill crane, northern harrier, willet, long-billed curlew, short-eared owl, common snipe, and ducks may nest. At the water fringes, pocket gophers, meadow voles, and other small rodents burrow and feed in the meadow. Garter snakes, western toads, and Pacific tree frogs also occur in this habitat type.

Fresh Water Emergent Wetlands

Fresh water emergent wetlands with dominant plants such as tule and cattail are found along perennial streams, lakes, water delivery ditches, and seasonally managed wetlands. In addition to numerous waterfowl and shorebirds, marsh habitat also provides cover and nesting opportunities for a diverse group of wildlife species. Soras and Virginia rails use the lower growing vegetation in the high marsh. In the lower marsh where cattail and tules grow, several bird species nest, including song sparrow, common yellowthroat, spotted towhee, yellow headed and red-winged blackbird, sandhill crane, American bittern, and American coot. Several migratory birds also use the emergent wetland vegetation including Lincoln's, white-crowned, and golden-crowned sparrow. Mammals can be found when water levels drop. When water levels are high, muskrat, beaver, and river otter swim within the vegetation in search of food and cover.

Vernal Pool and Vernal Swale

Vernal pools are depressions that pond water during the rainy season. They drain internally and lack a drainage outlet. They occur as isolated pools either in annual grasslands or in an intricate matrix with seasonal swales. Vernal swales are natural, gently sloping broad drainages that convey runoff during and for short periods after rainfalls and may be connected with vernal pools. Both vernal pools and vernal swales support a distinctive biota adapted to periodic or continuous inundation during the wet season and the absence of either ponded water or wet soil during the dry season.

Vernal pools in the aquatic phase often support diverse and dense assemblages of invertebrates, particularly crustaceans and insects. Common crustaceans in vernal pools include copepods, seed shrimp, fairy shrimp, and tadpole shrimp. Diving beetles and fly larvae are typical insects in vernal pools. Many invertebrates thrive in vernal pools because of the absence of fish, which are their primary predators in other aquatic habitats. The abundance of invertebrates provides food for a variety of bird species, including cinnamon teal, mallards, and other ducks as well as shore and wading birds such as avocets, killdeer, and yellowlegs. Vernal pools provide important breeding grounds for several amphibians, including the western toad and Pacific tree chorus frog.

WILDLIFE POPULATIONS (NATIVE)

Locally Important

Many native wildlife species are locally important because of their recreational value. Like few other places in California, hunting is an important cultural value to local residents of Modoc County. Game species also attract people from outside of the Upper Pit River Watershed. Tourists hunting game species spend an undocumented amount of money on equipment and supplies, travel and lodging, consultant fees for guides, and butchering. In addition, a few landowners are enrolled in state monitored hunt programs (e.g. Private Lands Habitat Enhancement and Management Area Program [PLM]), while many others charge fees for access to their property to hunt game species.

A few other non-game species are considered locally important. The mountain lion is one of the more politically charged species in the state. Aside from those, that want all lions protected, livestock owners and local residents with outside pets know mountain lion individuals and populations must be controlled.

Below, information is provided for a few of these species, including their historic and current distribution, habitat requirements, and population trends.

Mammals

Deer

Deer are a significant wildlife species in California and an integral component in the food chain. They serve as grazers of wildland plants and as prey for carnivores, including the mountain lion, coyote, and golden eagle. Additionally, deer are California's most popular game mammal, attracting between 165,000 to 200,000 hunters annually, based on 1998 data. Deer habitat, especially browse and forage species, are mainly comprised of early successional vegetation (grass, brush, and young trees). Deer are also an indicator species for a variety of other birds and mammals (song birds, blue grouse, mountain quail, mice, voles, coyotes) since they utilize similar habitats. As populations of deer fluctuate based on available habitat other wildlife populations associated with those populations' rise and fall.

There has been significant documentation over the past 50 years that deer thrive in an environment that is comprised of large amounts of early successional vegetation. In general, there is a period between two to thirty years following forest disturbances (fire, logging) when brush, shrubs, and young trees are at their peak in terms of overall abundance and quality for forage. During this period, deer and their dependent species thrive. As disturbances decrease, naturally or through human intervention, early successional habitat decreases, resulting in an overall reduction in deer feed, habitat, and populations.

Disturbances in the early and mid part of the twentieth century created significant amounts of early successional habitat. This, in turn, allowed for the increased deer populations seen in the 1950s and 1960s. Overall, populations of deer in California peaked during this period. Since 1960, population levels are significantly lower statewide. The California Department of Fish and Game (CDFG) suggests these population decreases are a result of declining habitat quality. This is displayed in Figure 8-2. The increasing role of fire suppression and the reduction in logging has decreased the amount of early successional habitat available for deer populations. This reduction directly impacts deer through decreased food sources and increased competition for the limited available food reserves. The decreased food source ultimately affects the ability of the populations to thrive.

Deer are the most abundant big game animal found in the Upper Pit River Watershed. There are two subspecies of deer in the Upper Pit River Watershed. The Rocky Mountain Mule Deer (*Odocileus hemionus* ssp. *Hemionus)* is the most abundant and is found throughout the area.

Found in lesser numbers in the western part of the Upper Pit River Watershed is the Columbian black-tailed deer (*Odocileus hemionus* ssp. *Columbianus*). As with all forms of wildlife, food, water, and cover are the essential environmental factors necessary for the maintenance of a deer herd. Cover and water supplies may at times constitute a localized limiting factor. The primary limiting factor of the deer herds is the food supply.

Virtually the entire Upper Pit River Watershed is deer range. The deer herds are migratory, ranging to lower elevations in winter. However, deer can be found throughout the area during normal snow-free periods. The Devils Garden area provides a winter range for a deer herd, which summers in Oregon. Snows at higher elevations usually force deer to migrate to winter ranges at lower elevations. Since winter ranges receive less precipitation, there is less forage produced than at higher elevations, and deer are forced to concentrate on available forage. As a result, deer winter ranges are the key factor in the maintenance of the deer populations. Livestock as well as deer graze most winter ranges. Deer winter ranges are located on both public and private land.

The size of the deer population fluctuates with changes in range conditions, availability of forage, land development, competition with agricultural uses, and various environmental factors. There has been, however, a significant overall decline in the deer population over the past 20 years. For example, the Warner Mountains herd declined from 32,330 in April of 1965 to 7,086 in April 1983. This is a drop of 78 percent in the deer population over the 18-year period, an average rate of 4.33 percent per year.

Fire suppression has reduced the overall early successional habitat in the Upper Pit River Watershed. This reduction of early successional habitat is across vegetation and corresponding WHR habitats, resulting in older vegetation communities. This lack of disturbance eliminates rejuvenation of brush and grass species, which are an important component of deer habitat.

CDFG manages deer in California using established deer herds, which are based on approximate natural boundaries of reproductively isolated populations. The herds are described in 80 deer herd management plans.

The Upper Pit River Watershed is part of the Cascade-North Sierra Nevada Deer Assessment Unit (DAU), one of eleven statewide units that assess deer habitat status, population trends, and issues surrounding deer management. This DAU comprises about 7,000 square miles from the Oregon border south to the Lake Almanor area and the Feather River drainage. Within this DAU, the CDFG has estimated that deer populations have decreased from 100,000 in 1952 to 25,000 in 1996. The main habitat issues in the DAU are lack of habitat disturbances that create early successional communities, and localized overgrazing by livestock on summer range habitats. They report that decadent shrubfields dominate much of this range and may serve as climax vegetation communities in some areas.

The decline in numbers of animals is thought to be primarily due to loss of early successional habitat in deer summer range. This summer range provides deer with needed forage for development of fat reserves, which help them survive the winter. In studies sponsored by the CDFG, it was determined that deer are beginning to metabolize (or use) their fat reserves in late summer and early fall, a time when they should be continuing to build up their fat reserves. Because of this early use of fat reserves, deer lack adequate fat to flourish over winter. This lack of nourishment in the summer results in smaller, animal size; reduced fawning; and increased mortality rates of both adults and fawns.

The CDFG has developed significant information on deer habitat, migration patterns, and population estimates in the Upper Pit River Watershed. Critical winter range is abundant within the Upper Pit River Watershed and consists of habitat used during winter months. These areas provide important food resources and cover. Habitat loss and encroaching development are primary concerns. The CDFG estimates that 20 percent of deer utilizing this winter range are permanent residents. Many have taken advantage of adjacent residential areas where people provide food for them throughout the winter (Smith, 2003, pers. comm.). Historic prescribed burning efforts by local landowners provided substantial benefits to this habitat by maintaining young vegetation in conditions that provide optimal forage for deer and associated wildlife populations. Burning has not been conducted in the recent past.

As temperatures increase and spring vegetation emerges, deer move from winter range to summer range, following the new vegetation. Deer predominantly migrate from the winter range to the summer range along major ridgelines. Migration routes shown represent significant routes that have remained relatively unchanged over time.

Most of the mule deer in California, including the populations in the Upper Pit River Watershed, exhibit seasonal movement in response to weather. Geographic areas have been mapped in some areas as winter range, summer range, fawning areas, and holding areas. Most of the habitat management in past years was focused on winter range because these areas are smaller in size than summer range and because constant fire and timber harvest-related disturbances in the upper elevations (summer range) tended to create favorable habitat conditions for early successional species like mule deer. However, decreases in fire occurrence and timber harvest activities over the past several decades have led to conditions that many feel are limiting deer populations.

Harvest data

Deer hunting is managed in California by the CDFG with hunting zones, which are based on individual herd boundaries or groups of herds with similar management requirements. The Upper Pit River Watershed falls within portions of five of these zones. They are X1, X2, X3a, X3b, and X4. These zones are part of the group of X zones that delineate the herds of California mule deer, one of six recognized subspecies of mule deer in California. The CDFG collects harvest data for each zone using hunting tag returns and uses that data to estimate the total harvest. The CDFG sets management objectives and adjusts seasons and tag quotas for each zone based on population estimates and the ratio of bucks to does and ration of fawns to does derived from annual field survey data. The CDFG has determined that a minimum threshold ratio of 3 bucks to 100 does is necessary to ensure that no significant reproductive impact occurs to deer populations. All of the hunting tags issued in the zones within the Upper Pit River Watershed are allocated using a lottery drawing as opposed to other zones in California that are sold over the counter. Harvest estimates, fall buck and fawn ratios, buck ratio objectives, and current average population estimates for the zones in the Upper Pit River Watershed are summarized in Table 8-2 (California Department of Fish and Game, 2003a).

Population trend data

The PLM administered by the CDFG provides economic incentives to landowners by allowing them to market high-quality fee hunting opportunities through flexible seasons and increased bag limits. The landowner must obtain a license, pay fees, prepare a habitat improvement plan, and implement habitat improvement projects on their property. While the PLM program is available for several game species, deer make up the majority of the total program statewide. The PLM is, and always has been, somewhat controversial. Some critics feel that the program can have a negative impact on genetics by removing large-antlered deer when they are vulnerable during the rut (breeding season).

Table 8-2 ESTIMATES FOR HARVEST, FALL BUCK AND FAWN RATIO, NUMBER OF DEER AND BUCK RATIO OBJECTIVES WITHIN PROJECT						
2002 Harvest			Objective	Fall 2002		Pop. Est.
Area	Reported	Estimated Harvest	Buck Ratio	Buck Ratio	Fawn Ratio	3-Year Average
X-1	367	513	20	18	61	8,223
X-2	48	51	12	17	61	857
X-3a	104	142	15	16	25	2,517
X-3b	183	251	20	38	98	4,223
X-4	103	131	20	21	47	2,467

Proponents cite that the program results in wildlife benefits through required habitat improvements and limits the number of animals that can be harvested on the property, which is not limited without the program. Proponents also argue that the PLM program provides additional incentives for landowners to improve habitat conditions and increase wildlife populations due to the increased economic value of wildlife.

Antelope

On the pristine grasslands of California, antelope were the most abundant big game species. The historic range of antelope included the central valleys, the southern deserts, the Inyo-Mono area, and the plateau areas of northeastern California. Because of environmental changes such as agricultural, industrial, and urban development, antelope range in California has been severely restricted. Today, California's largest antelope populations are located in the northeastern and eastern portion of the state, including Siskiyou, Modoc, Lassen, Shasta, and Mono Counties. Successful reintroductions have occurred in Colusa, San Benito, San Luis Obispo, Kern, Los Angeles, Santa Clara, and Monterey County. Antelope ranges, migration routes, and kidding grounds have been mapped in the Modoc County General Plan (Figure 8-3).

Antelope require relatively flat, unobstructed open rangeland with a variety of forbs, grasses, and browse plants for forage. They also forage in agriculture areas that include grain and alfalfa. Unobstructed migration routes between summer and winter ranges and freedom of access to ancestral kidding areas are critical to the antelope. They are highly susceptible to stress factors and in general do not react favorably to contact with human activities. Adequate cover and relatively easy access to water are also important.

Within the Upper Pit River Watershed, antelope are observed in most areas. The CDFG conducts annual antelope surveys. Since 1940, antelope numbers in northeastern California fluctuated drastically for ten years, steadily rose to a peak estimate in 1992 of 8,000, and have since declined to approximately 5,000 individuals (Figure 8-4) (California Department of Fish and Game, 2003d). The severe population decline in 1992 was attributed to a harsh winter with heavy snow. There have been fluctuations as well as increases in antelope numbers due in part to the quality and quantity of available habitat, and severity of winter weather.

Elk

Although thought by many to be uncommon in the Upper Pit River Watershed, elk are present. Historic populations of elk in California consist of individuals from two sub-species. These sub-species include Roosevelt elk and tule elk. Both subspecies were dramatically reduced from market hunting and conversion of native grassland habitats to agricultural practices (California Department of Fish and Game, 2003b). Third elk sub-species, the Rocky Mountain elk, were never thought to be native to California. However, this sub-species is now present in three or four distinct geographic regions of the state (Figure 8-5).

Within the Upper Pit River Watershed, Rocky Mountain elk have been documented as occurring in the Warner Mountains (Modoc and Lassen County), Devils Garden (Modoc County), Whitehorse Reservoir, and Egg Lake area (Modoc and Siskiyou County). An additional herd also occurs just south of the watershed in the Burney and Pit River area (Shasta County). Elk sightings by local residents have also occurred on Big Valley Mountain, Lassen County, and Adin Pass near the Lassen and Modoc County line (Knoch, 2003, pers. comm.). These sightings suggest that the once isolated populations in the Warners and Shasta County may have individuals mixing between the herds.

Habitat requirements of elk change with the season. During the spring, elk graze on grasses, forbs, and seedlings. As vegetation matures and fruits, elk add berries, saplings, and mushrooms to their diet. When winter arrives, elk will consume dried grass, bark from aspen and maple, and browse on lichen, shrubs, and trees. Radio collared elk have been documented moving long distances to forage and complete their life history requirements in one year. One individual traveled from Montague to Egg Lake, east through Adin pass to the Devils Garden, and further east into the Madeline Plains before returning (Shaffer, 2003, pers. comm.).

Rocky mountain elk require forested habitats for shelter and feeding. Trees provide thermal protection during cold periods, and provide cover during rain and snow. The encroachment of juniper across the Upper Pit River Watershed has been hypothesized to positively affect elk since they generally like to stay concealed by tree canopy cover (Shaffer, 2003, pers. comm.).

Population estimates for Rocky Mountain elk are difficult because they are primarily found in forested areas, making aerial survey problematic. However, in 2000 to 2001, the Rocky Mountain Elk Foundation teamed with the CDFG and radio collared seven individuals in the Upper Pit River Watershed. The animals were collared to study their migratory movements and habitat use. From this effort, elk distribution, habitat use, and populations were studied for 2 years. Results from this study suggested that each of these four areas listed earlier have at least 100 individuals in the herd, and CDFG estimates the overall northeastern California herd to have between 500 to 700 animals (California Department of Fish and Game, 2003b).

The northeastern California elk population is increasing. Due to this, the former Shasta Rocky Mountain Elk Hunt Area was increased for the 2003 hunt season. Figure 8-5 depicts the former hunt area and the new hunt area for 2003. Population and harvest models conclude that removal of 10 bull and 10 cow elk during each hunting season would result in no decline in the total population size over a ten-year period (California Department of Fish and Game, 2003b). CDFG will use current data each year to establish appropriate harvest levels in the future.

Bighorn Sheep
Bighorn sheep have been occasionally reported to occur in the Warner Mountains within the Upper Pit River Watershed boundary. However, there are no known populations within the Upper Pit River Watershed, and the sightings are probably from occasional individuals that have wandered away from herds that are more distant. The nearest bighorn sheep herd to the Upper Pit River Watershed boundary is located in the Hayes Range in Nevada. Earlier attempts by the CDFG to relocate and establish big horn sheep to the east side of the Warner Mountains had failed due to the herd becoming extirpated from bacterial pneumonia. The population was estimated at slightly over fifty individuals before the herd died from the pneumonia.

Bear
The Sierra Nevada black bear is the only species of bear living in the Upper Pit River Watershed. Historically, black bears and California grizzly bears occupied relatively distinct areas when the European explorers and settlers arrived. The black bear historically resided in forest communities and the grizzly resided in chaparral communities. When the grizzly was eliminated in the 1930s, the black bear expanded its range into chaparral habitat types of California.

Black bears are members of the order Carnivora, though meat makes up a small portion of their diet. When emerging from their winter dens, bears forage on green grasses and forbs, as wells as insects and carrion. In the summer and fall months, they feed on berries and acorns to put on fat for hibernation. Some bears do take advantage of seasonal runs of anadromous fish during fall months; however, salmon do not constitute a major part of their diet (California Department of Fish and Game, 2003c). Occasionally bears kill deer or eat carrion left over by other predators, such as the mountain lion. Suitable habitat for black bear can be characterized as forested areas with a mixture of vegetation types, providing both cover and a variety and abundance of food. If the vegetation mixture in one area is not sufficient enough to provide food for the bear all year, they will move relatively long distances to take advantage of seasonal abundance.

The bear population exists in comparatively low numbers. Unlike other animals, bears are counted individually across a large area due to their secretive nature and occurrence in forested areas. The population estimates are inferred from ongoing field studies, hunter-killed bears, and observations of hunted and un-hunted populations. From this information, CDFG constructs habitat and population models, and uses these models when considering harvest limits (California Department of Fish and Game, 2003c).

Mountain Lion
Mountain lions or cougars are native to California and are known to exist in the Upper Pit River Watershed. Lions are found in many diverse habitats throughout California, from deserts to humid coast rain forests, and from sea level to 10,000-foot elevations. They spend most of their time on the ground, but are adept at climbing trees. Mountain lions prefer rocky canyons, escarpments, rim rocks, or dense brush, usually avoiding heavily timbered areas. They prefer to den in an overhanging ledge, a crevice in a cliff, an enlarged badger burrow, a cavity under the roots of a tree, or a dense thicket.

Mountain lions are very powerful and normally prey upon larger animals, such as deer, bighorn sheep, and elk. However, they also prey on smaller animals such as raccoon, coyote, squirrels, feral pigs, rabbits, and beavers. They are also known to feed on mice, and other rodents, and insects such as grasshoppers, if necessary.

An adult male's home range often spans over 100 square miles. Females have smaller ranges at between 20 to 60 square miles. In ideal habitat, such as the west side of the Sierra Nevada, as many as 10 adult lions may occupy the same 100 square mile area. Cougars do not usually have fixed dens, except for mothers with cubs. Typically, they spend the day in thick cover if in a forest, perhaps in a cave or under an overhang, or in a rock fissure in more mountainous areas. A mountain lion's natural life span is about 12 years. Natural enemies include other large predators such as bears and other lions.

No specific population data are available for the Upper Pit River Watershed. From 1907 to 1963, the mountain lion was classified as a Bountied Predator in California. During that 57-year period, more than 12,500 were taken or an average of 219 per year. When the bounty period was effective, no less than 350 cougars were killed in one year. In 1963, it was reclassified as a non-game mammal and held that classification until 1969 when the mountain lion was again listed as a game mammal. The cougar stayed a game mammal for only two years until 1972, when a package of laws prevented further hunting. During the two years it was hunted as a game mammal, only 59 animals were taken each year on over 4,300 tags that were purchased. In 1990, Proposition 117 was passed that banned trophy hunting and human "management" of lion populations. Figure 8-6 summarizes the number of mountain lion permits issued and lions depredated for the years through1972-1999 (Outdoor California, 2000).

Beaver

The beaver may be one of the most ecologically and culturally important species in California. Ecologically, the beaver life history strategy of building dams to impound water greatly influences stream hydrology. Sediment is retained in the dams, and the dams minimize flood flows by slowing water at regular intervals where the dams occur. In addition, the dams hold water during the summer at a time when water is scarce. This summer water provides drinking water for various wildlife species, raises the water table and benefits upland grasses for foraging livestock, maintains dams where the water is used for irrigation, and propagates emergent vegetation, trees, and backwater that is used by other aquatic and terrestrial wildlife. Culturally, the pursuit of beaver for their pelts and the economic benefit from them brought more settlers to California. The increased number of fur trappers pursuing beaver exposed even more natural resources in the state, and California was soon discovered for its' bountiful resources, beauty, diversity of habitats, and fertile soil for agriculture.

Although the beaver was native to California, it was not native to the entire state. Three subspecies historically occurred, the Shasta beaver (northern California), the golden beaver (Central Valley), and the Sonora beaver (lower Colorado). Beavers were most likely not native to the Sierra Nevada (Tappe, 1942). Within the Upper Pit River Watershed, Tappe documented beaver in Devil's Garden area and Upper Pit River Valley. Although his records don't indicate traveling into the lower Pit River areas such as Big Valley and Fall River Valley, he concluded that beaver were native, and common in the Pit River drainage.

Several habitat requirements must be present for beavers to survive. The first, and most important, is a perennial supply of water. Their dams always allow some water through, and therefore more water is needed to supply the "pond" where lodges are constructing and beavers raise their young. Enough water must also be present to sufficiently pond at depths that will minimize freezing during winter, and to cache green twigs in the autumn to eat during the winter (Ingles, 1965). This depth generally corresponds to approximately two feet (Tappe, 1942). The final important requirement is a stable food supply. Beaver consume many different plants, but prefer woody plants of the genus *Populus* (eg. cottonwoods), while willows and alders are less preferred. Beavers also consume emergent vegetation including tules, cattail, and many *Juncus* species. Although not consumed often, they have been recorded to eat, or at least topple, trees including fir, pine, juniper, oak, hazel, dogwood, and birch.

At a minimum, a beaver colony consists of a male, female, and one or two litters each year. Beaver colonies have also been reported to reach many individuals, as many as ten to thirteen, but the average colony size in the west lies somewhere around seven or eight. Females give birth in early spring, and litter sizes range between two and six. Man is probably the most important predator, either directly from trapping, or indirectly from habitat degradation. Coyote, bobcat, and mountain lions are also suspected to capture beavers when they travel overland to cut trees or disperse.

Beaver are found sporadically in the Upper Pit River Watershed. Although they once occurred in most all-perennial streams, few streams today are reported to support beavers. No recent watershed wide surveys have been conducted.

Other Furbearers and Mammalian Predators

The most prominent furbearers found throughout the Upper Pit River Watershed include muskrat, mink, badger, skunk, raccoon, and weasel. The primary mammalian predators are the coyote, gray fox, and the bobcat. They are essentially carnivorous and often prey on game species or domestic livestock. Coyotes have received the most of the furbearer attention in the Upper Pit River Watershed. They commonly prey on livestock species and cause considerable financial loss to the landowner. When observed on the valley bottoms or rangeland areas, coyotes are regularly depredated by farmers and ranchers. Other furbearers including the American marten, fisher, wolverine, and Sierra Nevada red fox are uncommon, and seldom observed.

In general, the terrestrial furbearing species require heavy cover for concealment. Some species populations have likely decreased due to the diminished amount of cover resulting from the degradation and removal of riparian habitats.

Raptors

Raptors are bird species belonging to the orders Falconiformes and Strigiformes (i.e., hawks, owls, falcons, eagles) and are locally important species for a variety of reasons. The Upper Pit River Watershed supports one of the most diverse and abundant groups of wintering raptors in the state. During winter, two "northern" species (rough-legged hawk and ferruginous hawk) winter in the valleys in large numbers where they frequent agricultural areas to prey on small rodents. Several other resident raptors including prairie falcon, golden eagle, red-tailed hawk, American kestrel, Cooper's hawk, sharp-shinned hawk, northern harrier, and bald eagle can also be regularly observed during winter in these areas. Short-eared owls can also occasionally be observed in marshy areas. Finally, two other species, the merlin and American peregrine falcon, are common during winter and migration months but occur in low numbers and are more difficult to find.

During the breeding season, many of the raptors use forested areas to nest. A large proportion of the state's bald eagle and osprey populations, nest among trees, along a reservoir or river in the

Upper Pit Watershed. Other species are more closely associated with forested areas and include the northern goshawk, great-horned owl, Cooper's hawk, sharp-shinned hawk, northern pygmy- owl, western screech owl, flammulated owl, and northern saw-whet owl. Golden eagle and Swainson's hawk are more associated with juniper scrub habitat and forage in agriculture areas during the breeding season.

Raptors often provide some of the most exciting wildlife viewing opportunities for people. Because they are predatory, their pursuit of prey can be dramatic and easily observed by humans. Many people using the rivers and lakes have observed osprey and bald eagles hunt for fish, and some even have been fortunate enough to observe bald eagles, golden eagles, and falcons in aerial pursuit of other smaller birds. Finding a falcon or eagle in a full "stoop," a tactic of diving from high in the air with wings fully tucked can be exhilarating because one can actually hear the air as it passes over the body of the bird creating a "jet" sound. One can also witness the attack (talons extended) and collision with their prey, or even a maneuvering pursuit analogous to two planes chasing one another.

Unfortunately, raptors have been illegally shot and captured for several reasons. They are often thought of as causing population declines in other game bird species (i.e., pheasant and duck), and thought to take small livestock. Although raptors on occasion will prey on these species, they more commonly prey on other prey species. Rarely do predators control prey populations. Rather, prey populations fluctuate with climatic changes and predator populations typically "cycle" with prey abundance. Raptor populations have also been reduced due to poisoning of rodents, which in turn poisons the raptor after consuming the poisoned prey.

Waterfowl

Wetlands and agriculture habitats in the Upper Pit River Watershed provide important habitat for primarily migratory waterfowl, and to a lesser extent-nesting waterfowl (Kadlec and Smith, 1989). Four species of artic nesting geese (cackling Canada, Snow, Ross, and white-fronted), one swan species (Tundra swan), and eighteen duck species feed and rest in the Upper Pit River Watershed during the fall, winter, and spring. The Upper Pit River Watershed lies within the Pacific Flyway, one of the most prominent migration "corridors" in the United States. Waterfowl abundance has changed over time, with some species becoming more abundant during the spring and fall, while others species are infrequently observed. Some changes in populations are the result of activities in the Upper Pit River Watershed. In other instances, populations are affected in the breeding areas north of the Upper Pit River Watershed or wintering habitat south of the Upper Pit River Watershed. Nevertheless, public and private land in the Upper Pit River Watershed provides excellent opportunities for waterfowl hunting and other non-consumptive uses.

Waterfowl abundance changes seasonally in the Upper Pit River Watershed. The most noticeable changes occur during the migration periods (August to October and February to April). During this time, waterfowl are moving great distances between their breeding and wintering areas. They arrive in the Upper Pit River Watershed in large concentrations, and will stay for shorter periods in the fall (one or two weeks) or for longer periods during the spring (up to two months). These short term or long term visits to the Upper Pit River Watershed during the migration period are referred to as staging. The most abundant species in the Upper Pit River Watershed include tundra swan, northern pintail, green-winged teal, Pacific white-fronted geese, and Ross and snow geese. As many as 5,000 to 10,000 individuals of each species have been observed in at least one of the four watershed valleys, Fall River, Big Valley, Warm Springs, or upper Pit River. The southern portion of the Upper Pit River Watershed typically receives more use during the staging period due to the slightly warmer climate in late winter and early spring.

Winter and summer waterfowl use is much different from that of the fall or spring. Species wintering in the Upper Pit River Watershed must be able to survive through freezing weather. Great basin Canada geese are probably the most common and abundant waterfowl species during the winter. They use open water habitat to roost during the evening, and spend the daytime feeding in agriculture or freshwater marshes. Other waterfowl species that can use un-frozen deep-water habitats include bufflehead, lesser scaup, and ring-necked duck. Mallard and gadwall, two dabbling duck species that are commonly found in deeper ponds, can also be abundant during winter.

Waterfowl are least noticeable during the summer. This is the result of a lower abundance and the need to stay concealed from predators. The number of nesting species is much smaller than those found during spring or fall. Common breeding species includes the Canada goose, mallard, cinnamon teal, gadwall, and common merganser. Other species may nest in the Upper Pit River Watershed in small numbers including cinnamon teal, northern pintail, northern shoveler, American wigeon, lesser scaup, bufflehead, and ruddy duck.

Several factors are responsible for the variable trends of waterfowl in the Upper Pit River Watershed. One of the most important factors causing these is the availability of agriculture habitats for foraging. A few examples are noteworthy. Nearly the entire population of cackling Canada geese once used the Upper Pit River Watershed for spring staging in the late 70s and early 80s. However, in the early 90s, numbers started decreasing in the Upper Pit River Watershed and increasing in the Willamette Valley, Oregon. An increased amount of grass and grain crops acreage was being grown in Oregon, a preferred food for cackling Canada geese. Today, very few cackling Canada geese stage in the Upper Pit River Watershed while most of the population occurs in the Klamath Basin and Willamette Valley. Although in this example, a large-scale change in agriculture practices resulted in decreased waterfowl in the Upper Pit River Watershed, another example has had the reverse effect. The increased production of wild rice in the Upper Pit River Watershed has attracted several dabbling duck species. The practice of late-winter and early spring flooding to control weeds and germinate rice provides excellent foraging conditions for dabbling duck species. Other species also benefit. Tundra swans, white-fronted geese, and a host of other waterbird species use the flooded rice fields to forage and rest.

Upland Game Birds

Sage Grouse

The sage grouse is listed as a species of special concern by the state of California and is designated by the USFS as a management indicator species. In California, sage grouse only occur in the Great Basin in eastern California in Modoc, Lassen, and northern Inyo Counties. The species occurs in low densities within the overall sagebrush community, but can be locally abundant in specific areas seasonally.

As their name suggests, sage grouse are dependent on sagebrush plant communities. Suitable habitat has been described as plant communities dominated by a canopy of either draft, low, or big sagebrush, and a diverse understory of bunchgrasses and forbs (Nevada Wildlife Federation, 2002).

Habitat requirements change with the season and life cycle of the species, and interested readers should review Connelly et al. for a detailed description of habitat requirements during the breeding, summer-late brood rearing, fall, and winter time periods.

Sage grouse mating occurs at a traditional site where males display communally. This location is referred to as a "lek." During each spring, several males compete for an area on the lek where they display (call, inflate brightly colored air sacs on their neck, and perform ritualized dances or strutting). Females approach the lek and select a male to mate with before leaving to lay eggs and rear young on their own. Males at the center of the lek are often the most dominant males, and tend to mate with more females than males on the periphery of the lek (Ehrlich et al., 1988).

Sage grouse populations throughout the west have declined precipitously (Connelly et al., 2000). The primary threat to populations is the degradation of high quality habitat. Mechanical spraying using 2-4D, prescribed burning, habitat conversion to agriculture crops, and over grazing have been cited as the major reasons for degraded habitat. Additionally, the elimination or disturbance of lek areas has also been reported to affect sage grouse populations.

Sage grouse populations are scattered throughout the relatively flat sagebrush associated areas of the Upper Pit River Watershed. Several historic leks are no longer active (Figure 8-7). All of the active leks in the Upper Pit River Watershed occur in Warm Springs or the Upper Pit River Valleys. Sage grouse have been extirpated from the Fall River Valley, and a small population exists in Big Valley, although the lek for this population has not been found active.

Mourning Dove

The mourning dove is one of the most important upland game species in the state. The Upper Pit River Watershed provides important nesting and foraging habitat for thousands of doves between March and September. Doves are found in most habitat types in the Upper Pit River Watershed, and the highest densities of nesting occur in mixed woodland habitat with oaks. Mourning doves migrate to southern climates during late August or the first part of September.

Mountain and California Quail

Mountain quail were at one time relatively numerous in concentrated areas of the Upper Pit River Watershed. There has been a marked decline in mountain quail numbers in recent years, although the exact reason for the decline is not fully understood. The species migrates to lower elevations in winter where available winter food and cover may be critical factors. Populations of California quail are also found throughout the Upper Pit River Watershed.

Blue Grouse

Blue grouse are found at the higher elevations of the Upper Pit River Watershed and associated with fir stands, aspen groves, and montane meadow systems. Blue grouse are relatively uncommon due to their secretive nature. They nest on the forest floor and forage on a variety of berries, insects, flowers, and seeds during the summer. During winter, their dietary requirements change, as they forage on fir needles and conifer buds (Ehrlich et al., 1988).

Migratory Passerines

Several species of small birds occurring in the order Passeriformes migrate to and from the Upper Pit River Watershed. These small bird species have received recent attention because of their migratory nature, population declines, and the diversity of species occupying several habitat types.

Common species in the watershed include black-headed grosbeak, hermit warbler, house wren, Brewer's sparrow, and western wood-pewee. Each of the above species nest in the watershed but migrate to southern latitudes during the winter.

WILDLIFE POPULATIONS (EXOTIC)

Many wildlife species currently found in the Upper Pit River Watershed were not found historically. These species are often referred to as exotic. Some were introduced from other counties (e.g. European starlings), while others were introduced from other regions of the United States (e.g. muskrat). Regardless of the method of introduction, exotic wildlife species often fill an "unused" niche, or simply out compete and displace other native wildlife species. Large amounts of taxpayer dollars have been spent trying to eradicate some of these species due to a variety of reasons. Some of the more prominent exotics are discussed below.

Wild Horses

Wild horses were introduced to North America during European settlement in the 1600s. Soon thereafter, Native Americans used horses on the plains and this use helped horses spread throughout the western United States. In the last 150 years, the U.S. cavalry, explorers, ranchers, miners, and farmers used horses. Some horses were turned loose to pasture and never captured again and became wild. The relatives of some of these horses are thought to be present in the Upper Pit River Watershed. The only known herd occurs on the Devils Garden Wild Horse Territory north of Alturas (Figure 8-8).

Most of the wild horse herds in the west occur on public lands. Because of people "mistreating" wild horses in the early 1900s, the U.S. Congress passed a bill in 1959 that prohibited the use of motorized vehicles to hunt and gather wild horses and burrows on public lands. Twelve years later, after wild horse populations continued to decline, Congress passed the Wild Free-Roaming Horses and Burros Act. The Act provided direction for the management, protection, and control of wild horses and burros. The Act was later amended in 1976 (Federal Land Policy and Management Act) to allow the Dept. of Agriculture to use helicopters and motorized vehicles to manage wild horses and burros, and in 1978 (Public Rangelands Improvement Act) to manage and monitor rangeland conditions, and facilitate the adoption and removal of wild horses and burros.

The BLM and USFS manage wild horses and burros on public lands. Most of the wild horse and burro populations occur on BLM land, but those that occur on USFS are often managed by that agency. For each wild horse and burro herd, a Herd Management Area (HMA) is defined and the agency develops a management plan to meet objectives including the maintenance of the herd, population range, genetic stock, removing excess animals, and environmental compliance.

Population estimates of wild horses and burro in the Upper Pit River Watershed are not well known until the passing of the Act. The HMA for the Devil's Garden Wild Horse Territory has set an appropriate management level at 325 horses, plus or minus twenty horses. Since then, estimating herd size has been difficulty because the area they occupy is heavily forested (Irvin, 2003, pers. comm.). The herd was thought to be around 800 individuals until the harsh winter of 1992 and 1993 culled the population to an estimated 150 animals. Within three years, the herd had rebounded to an estimated 800 individuals. The high production rate was attributed to change in herd age structure. Prior to the 1992 and 1993 die-offs, the average animal age in the herd was fifteen. After the die-off the average herd age was eight. This age structure change resulted in a production change from 20 percent to 40 percent (Irvin, 2003, pers. comm.).

The USFS monitors the HMA for over use by horses. If over used areas are found, then the yearly round-up/adoption program focuses on horses in these areas. Typically, 60 to 100 horses are removed each year and placed in the adoption program.

The wild horses are not thought to significantly affect other native wildlife species. Although they directly complete with cattle, deer, elk, antelope, and other herbivores, the range conditions in the Devil's Garden area are considered good.

Rock Dove (Pigeon)

The rock dove, more commonly known as a pigeon, is found throughout the Upper Pit River Watershed. Rock doves are found in irregularly used barns, buildings, cliffs, and bridges that provide high perches away from predators. They can be found in most habitat types, but especially thrive near humans and agriculture areas in the Upper Pit River Watershed where they exploit waste grain and agriculture crops.

The rock dove was introduced in North America from Europe by immigrants in 1606 and was discovered in Ohio by the 1930's. The species spread rapidly throughout the U.S. because of its general food requirements and from the domestication and intentional releases of white rock doves at weddings and funerals. The species is known to be a carrier of dangerous epidemics and infections, and can infect native doves with vectors and avian bacteria.

Competition with other native avian species is not well documented. However, because of their presence in natural habitat features such as cliffs, they would directly compete for nesting sites with other cliff nesting species including owls, hawks, and corvids. Other than direct competition and the transfer of infectious vectors to other native doves, doves probably do not exploit food resources that other native birds would consume, due to their preference for waste grain and other agriculture crops.

European Starling

The European starling is probably one of the most well documented exotic birds in North America. They are found throughout the United States and in parts of Mexico and Canada. In fact, their population explosion is one of the most impressive and puzzling examples of an exotic species. Sixty individuals were released in New York's Central Park in 1890, and within one century, the population in the United States was estimated at 200 million (Erlich et al., 1988)

The impacts of starling invasions extend beyond their effects on native birds. They are a serious pest to agriculture and urban areas. It has been documented that as many as one million individuals flock together during the winter to feed in agriculture areas. They often feed in "mixed-flocks," with a variety of blackbird species. Urban areas are not immune to their disturbance. Large roosting flocks occur in a tree or clump of trees, and their fecal material, constant noise, and general dominance of the roost site makes them an unwelcome bird. Thousands of dollars have been spent attempting to learn about their life history and impacts on humans, agriculture areas, and native bird population, and several thousand more have been spent trying to eradicate them. Native bird species would benefit from their eradication. They are known to out-compete other cavity nesting species such as bluebirds, flycatchers, and several woodpecker species.

Muskrat

The muskrat occurs in freshwater marsh habitat throughout the Central Valley, northeastern California, and the Colorado River Basin. Within the Upper Pit River Watershed, muskrats can be found in freshwater marsh habitat along reservoirs, rivers, creeks, and flooded wetlands. Although their appearance suggests that they are related to rats or beavers, muskrats are more closely related to mice (Ingles, 1965). Their name is derived, in part, by two musk glands located in the lower abdomen. They are adept swimmers and commonly seen in water at dawn or dusk.

Although muskrats are native to North America, they were introduced to the Upper Pit River Watershed around 1930 after escaping from the Mt. Shasta Fur Farm (Storer, 1937). They quickly colonized available habitat and are found in most deep-water habitats with emergent vegetation, such as tule and cattail. They build "lodges" from emergent vegetation that provide them protection from the weather and areas to nest. They also burrow in banks for the same reason, and because of this behavior, they are responsible for the deterioration of levees, and instability of soils near the land-water fringe. Associated increases in sedimentation from wave action and bank failure are undesirable for aquatic invertebrates and fish. Muskrats are not thought to directly compete with any freshwater marsh herbivores.

Muskrats are actively pursued for their effects on banks, and the marketability of their fur. Muskrats have been trapped for their fur throughout the Upper Pit River Watershed. Fur prices have declined recently, and local groups have conducted research on effective control measures to reduce their populations in order to decrease their impacts to banks (Marcum, 2003, pers. comm.). The result of these studies have proven that control with paraffin bait is ineffective, and control measures such as shooting must occur for several successive years to reduce the population (Marcum and Whisson, 2002).

Feral Cat

The feral cat is not often thought of as an exotic species. Nevertheless, feral cats are present in the Upper Pit River Watershed and mostly concentrated in and near (within two miles) of towns or human dwellings. Many were once domesticated cats, but have since become "feral", wild, due to abandonment, or becoming lost. Even though most domesticated cats don't survive long without human help, occasional individuals are able to live in the wild and reproduce without human provided food.

Feral cats hunt and survive similar to their relatives (bobcat, lion). They primarily feed on small rodents and birds. Therefore, they impact native and non-native wildlife species and directly compete with other predators including fox and coyote. Both domesticated and feral cats are known to significantly reduce local populations of mice and birds in urban and rural areas.

Because they are lost or abandoned, feral cat programs are ubiquitous. Animal shelters are forced to kill an estimated 15 million cats each year in the United States, and cost taxpayers fifty million dollars a year. Many local interest groups participate in capture, spay or neutering, and finding these cats a new home. Unfortunately, the majority die in the wild or are "put to sleep."

Ring-necked Pheasant

Ring-necked pheasants are medium size game birds known to exist in the Upper Pit River Watershed. The ring-necked pheasant is not native to this continent. It was first introduced from China to the Willamette Valley of Oregon in 1881, and then introduced sometime in the 1880s in California. By 1925, the pheasant population established itself in California in sufficient numbers for a hunting season. The pheasant population has maintained itself since, with an estimated 732,214 birds throughout the state, and a density of 0.66 to 12 acres per bird (California Department of Fish and Game, 2000). Pheasant populations are higher in areas where weedy vegetation is allowed to grow along water delivery systems.

Ring-necked pheasants are generally found on agricultural lands, where grain crops exist near herbaceous and woody cover. No known pheasant surveys have been conducted, but the species is known to occur in each of the four watershed "valleys" in relatively low numbers. Wild pheasant hunting does occur within the Upper Pit River Watershed at low levels. Current statewide hunting regulations permit the harvest of males only. On occasion, private groups will also purchase "pin-reared" ring-necked pheasants, release them on their land, and invite others to join them hunting the birds. Reportedly, few of these surviving pheasants establish populations at their release location.

Pheasants are not reported to cause reductions in other native species. Because of their association with agriculture crops, only other generalist wildlife species would directly compete for food resources. Many native animals probably benefit from the presence of pheasants, especially those that prey on their eggs and chicks (raccoon, skunk, fox, coyote, otters) or adults (coyotes, fox, Cooper's hawk).

Wild Turkeys

Several sub-species of turkey are native in North America. They were, and still are, a species associated with the eastern deciduous forest. They were nearly voted as our National bird, but lost to the bald eagle by one vote on the congressional ballot (Ehrlich et al., 1988). No wild turkeys were known to occur in California, and they were first introduced in the west by the CDFG in 1908 (Beedy, 2003, pers. comm.). The CDFG is no longer introducing turkeys in California due to the controversy of non-native species introductions and because current populations appear stable or increasing (Gardner, 2003, pers. comm.). Today, two sub-species are common in California, the Merriam's and Rio Grande. Rio Grandes are generally found in lower elevations than Merriam's, but the two sub-species interbreed where their ranges overlap. Higley notes that generally, the Rio Grande's tips of the rump feathers and tail feathers are buff, while those of a Merriam's are white.

Wild turkeys occur in a variety of habitat types. They appear to be more abundant in lower elevations in the foothills where habitat consists of open grasslands and meadows, and mixed forest types with oak species. As the elevation increases the forest becomes dominated by conifers, turkey abundance decreases. Turkeys are known to make elevational movements during the year and select warmer-dryer areas during winter (Higley, 1990).

Turkeys form flocks during winter (40 to 50 birds) and roost at night in trees. They breed during the spring and females select nests sites on the ground where they scrape a shallow dirt depression among tall grass and woody vegetation. Females lay ten to twelve eggs and incubate eggs for 27 days. Young can fly within six to ten days (Ehrilich et al., 1988). Turkeys eat a variety of food items including nuts/seed, insects, plants, terrestrial invertebrates, and small vertebrates.

California's first spring season wild turkey hunt occurred in 1971. Since then, hunting seasons and dates have changed. Currently, a fall hunt occurred between November 9 and November 24, 2002, and a spring hunt between March 29 and May 4, 2003. Hunters are allowed to shoot one bearded bird/day, and three per season. California's turkey population is estimated at 100,000 individuals, and 18,607 turkeys were reported as taken during last year's hunting season (National Wild Turkey Federation, 2003).

Wild turkeys are common in the Upper Pit River Watershed but not abundant. The species is known to occur throughout the Upper Pit River Watershed at several locations in mountain regions around each of the large valleys.

THREATENED & ENDANGERED

The terms threatened and endangered are often applied to a wildlife species whose populations are thought to be low. However, the terms threatened and endangered (T&E) have a special legal meaning, and their accurate usage should be noted. An endangered species is defined as a native species or subspecies of a bird, mammal, fish, amphibian, reptile, invertebrate, or plant that is in serious danger of becoming extinct throughout all, or a significant portion, of its range (because of loss of habitat, change in habitat, over exploitation, predation, competition, or disease). When a wildlife species becomes legally defined as "threatened" or "endangered," an entire formal process is set in motion. This section defines a broad variety of definitions applied to wildlife species whose populations are low, discusses the implications of "special-status" species designations, and briefly describes some of the T&E species in the Upper Pit River Watershed.

A wildlife species can be designated as T&E, or "listed," under the California or Federal Endangered Species Acts (ESA). For a species to receive such listing, any individual or group can petition the appropriate agency (US Fish and Wildlife Service for federal, and California State of Fish and Game Commission for state). The petition is reviewed and a decision is made whether the petition is warranted. If a petition to list a species as threatened or endangered is warranted and approved, then a formal set of procedures occur. These include identifying habitat critical to the species recovery (only applied to federal species and referred to as Critical Habitat), and developing and implementing a plan to conserve and ensure the survival of the species (referred to as a Recovery Plan). The ESA's also defines how T&E species can be treated from a consumptive or management view.

Species legally designated as T&E affect many land management decisions by resource agencies and private entities. Both the California and Federal ESA prohibit "take." Take is defined slightly differently under the California and Federal ESA, but essentially means that individuals are not allowed to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct. When applied to federally listed species, suitable and occupied habitat is part of "take," but no such provision is present in the California ESA. Individuals or entities not complying with the "take" provision can be assessed up to $50,000 or up to one-year imprisonment if convicted.

Even though strict laws apply to T&E species, the ESA's allow for some form of "take" if appropriate documentation is provided. For federally listed species, a process known as "Section 7 Consultation" can be followed if a project has federal involvement. Section 7 of the federal ESA requires that any activities and programs authorized, funded, or carried out, in whole or in part, by a federal agency must not jeopardize the continued existence of a listed species or adversely modify the species' critical habitat. If it is determined that a project may potentially affect a federally listed species, then the appropriate federal agency must consult with the U.S. Fish and Wildlife Service or National Marine Fisheries Service. This often results in the federal agency preparing a Biological Assessment (BA) that outlines the project, its impacts on the species, and project measures implemented to minimize these impacts. The USFWS or NMFS responds to the BA with a Biological Opinion (BO), and determines whether the project or action is likely to jeopardize the species or its habitat. The BO can "approve" the incidental taking of listed species, often resulting in specific terms and conditions required by the project proponent.

Section 10 of the Federal ESA allows the incidental take of listed species when no federal nexus is present. In this instance, a private project proponent would develop a Habitat Conservation Plan (HCP) that identifies the project, impacts, measures to minimize impacts on the species, and other relevant information. Going through the Section 10 process takes longer and is often more costly than going through Section 7.

The process of authorizing "take" for state listed species is conceptually similar. Projects where the state is the lead agency must consult with CDFG if the project would likely result in the extinction of any listed species. If impacts on listed, species are likely, the lead agency would prepare information similar to that in a BA, and CDFG would respond with appropriate measures to minimize impacts and reasonable and prudent measures consistent with conserving the species. In cases where there is no state involvement, project proponents can develop Management Permits and Habitat Management Plans under Section 2081 of Fish and Game code. These Management Permits are analogous to the ESA's incidental take permits. Another alternative is the preparation of a Natural Community Conservation Plan (NCCP). The NCCP process was established to provide a regional or area wide protection of wildlife diversity, while allowing compatible development.

Several other designations for wildlife species exist. The federal ESA also defines candidate species and proposed species, and the state ESA identifies candidate species. Unless these designated species become listed as threatened or endangered, they are not afforded the same protection as T&E species. The USFWS used to identify federal species of concern, defined as a species that may or may not be listed in the future (formerly C2 candidate species or species under consideration for listing for which there is insufficient information to support listing). However, this list is no longer maintained. The state designates species of special concern, and fully protected species; and maintains a database for their occurrences (known as the California Natural Diversity Database). For each of the above designations, these species are afforded protection under the California Environmental Quality Act (CEQA) or National Environmental Policy Act (NEPA). Any impacts on these species must be disclosed, and depending on the circumstances, mitigation measures may or may not be required for impacts.

Many species designated as T&E, special concern, fully protected, candidate, proposed, or species of special concern also have other designations by the USFS or BLM. Those species listed as sensitive by these agencies trigger special management emphasis to ensure their viability and preclude trends toward endangerment for projects on their lands. For USFS and BLM projects, documents referred to as Biological Evaluations (BE's) are often prepared to comply with the federal ESA that actions of federal agencies (i.e., BLM, USFS, etc.) do not jeopardize or adversely modify habitat of federally listed species. The USFS and BLM also have a list of species referred to as Management Indicator Species (MIS) and Sensitive Species. MIS is part of the Forest Plan and selected because their population changes are believed to indicate the effects of management activities.

Collectively, all the species designations listed above can be grouped and referred to as special-status wildlife species. As discussed above, each designation applies to species legally protected under state and federal ESA or other regulations, and species that are considered sufficiently rare by the scientific community to qualify for such listing. The specific references for each type of special-status animals are provided below:

- Animals listed or proposed for listing as threatened or endangered under the federal ESA
- Animals that are candidates for possible future listing as threatened or endangered under the federal ESA
- Animals designated as sensitive by the USFS
- Animals designated as Management Indicator Species by the USFS
- Animals listed or proposed for listing by the State of California as threatened or endangered under the California ESA
- California animal species of special concern to CDFG (Remsen 1978 [birds], Williams 1986 [mammals], Jennings and Hayes 1994 [reptiles and amphibians])
- Animals fully protected in California (California Fish and Game Code, Sections 3511 birds, 4700 mammals, and 5050 reptiles and amphibians)
- Animals designated as sensitive by the BLM

Table 1 identifies 43 bird and 15 mammal special-status species that may potentially occur in the Upper Pit River Watershed. Eight of the forty-three bird species; and two of the 15 mammals are state or federally listed as threatened or endangered. Most all of the species in the table occur in low numbers, and although some are not known to occur, suitable habitat is present, and a limited amount of survey effort has been conducted for their presence. For each species in the table, their distribution, habitat, reason for decline and occurrence in the Upper Pit River Watershed is described. More specific information for T&E species is provided below in the "Species Accounts," and the reader can find more detailed information for most all of the other special-status species on state, federal, or special interest group web sites (ex. http://www.dfg.ca.gov/hcpb/index.shtml) or the references listed above.

Species Accounts

Greater Sandhill Crane
The greater sandhill crane is listed as threatened under CESA and is designated a USFS sensitive and management indicator species. Historically, greater sandhill cranes nested in eastern Siskiyou County, northeastern Shasta County, and at Honey Lake in Lassen County (Zeiner et al., 1990). In the most recent study of crane reproduction in 2000, nesting populations were found in Lassen, Modoc, Plumas, Shasta, Sierra, and Siskiyou Counties (Ivey and Herziger, 2001).

The greater sandhill crane is a migratory species. Peak fall migration occurs between October 1 and November 30, and breeding individuals arrive and establish their territories in late February and early-March (Tacha et al., 1992). Most of the greater sandhill cranes nesting in the Upper Pit River Watershed spend the winter in southern Sacramento and northern San Joaquin Counties in the Delta region.

The greater sandhill crane nests in open areas of wet meadows. These areas are often interspersed with emergent marsh. Sandhill cranes usually build their nests over shallow water. This species forages in emergent marsh and meadow habitats during the nesting season. During winter, sandhill cranes forage in pastures, flooded grain fields, and seasonal wetlands (Zeiner et al., 1990). Breeding activity begins in April and ends in August (Zeiner et al., 1990).

Sandhill cranes nest throughout the Upper Pit River Watershed in emergent marsh and wet meadow habitats. More nests are found in Modoc County compared to Shasta and Lassen (Figure 8-9).

Bald Eagle
The bald eagle is listed as endangered under the CESA, and as a federally threatened species under ESA. Due to increases in numbers, it has been proposed for delisting. It is also designated as a fully protected species by the state of California. Historically, the bald eagle bred throughout California; however, its current breeding distribution is restricted primarily to the mountainous habitats in the northern quarter of the state, including the Sierra Nevada, Cascade Range, and northern Coast Ranges. The bald eagle nesting population in the state has increased over the last 30 years, in response to reduction of DDT-based compounds in the environment and substantial management effort.

Although the bald eagle is a migratory species, individual eagles in the Upper Pit River Watershed are residents and defend their territories during winter (Jackman, 2003, pers. comm.). Some individuals, presumably from Canada and Alaska, pass through the Upper Pit River Watershed during spring and fall migration.

Bald eagle nesting territories in California are found primarily in ponderosa pine and mixed conifer forests. Nest sites are always associated with a lake, reservoir, river, or other large water body that supports abundant fish, waterfowl, or other water bird prey. Nest trees are usually located in mature and old growth stands within 1 mile of water. Nests are constructed in trees that provide an unobstructed view of the water body; nest trees are one of the largest trees available in the stand (Buehler, 2000). Bald eagles forage from hunting perches at large bodies of water or rivers with abundant fish. Breeding activity begins as early as February and ends in July (Zeiner et al., 1990).

Several bald eagles are known to nest in the Upper Pit River Watershed (California Natural Diversity Data Base, 2003) (Figure 8-10). Modoc and Shasta Counties have the highest densities of nesting bald eagles in California. Between 1959 and 1977, only two bald eagle territories were documented in the Upper Pit River Watershed. Since then, 16 have been recorded (California Department of

Fish and Game, 2001). While the reasons for this populations increase are partially a result of increased search effort, the statewide bald eagle estimates have increased in the last twenty years, and the increase in eagle numbers in the Upper Pit River Watershed certainly reflects a "real" population increase.

Swainson's Hawk

The Swainson's hawk is listed as a threatened species under the California ESA, and is designated by the USFS as sensitive and a management indicator species. This species was historically abundant in open grassland communities throughout most of lowland California but its distribution is presently limited to extreme northeastern California and the Sacramento and San Joaquin Valleys.

The Swainson's hawk is a migratory species. During the fall, small and large groups form prior to migration where they feed on superabundant food resources, often the result of agriculture practices (i.e., disking of a perennial low-growing crop). Peak fall migration occurs in September and October, and spring migration in March. Most Swainson's hawks winter in South America, while a handful is known to winter in the California Delta (England et al., 1997). No Swainson's hawks winter in the Upper Pit River Watershed.

Throughout its range, the Swainson's hawk nests almost exclusively in trees. A survey of nesting birds in California during 1979 revealed that Swainson's hawks nested almost exclusively in large, sparsely vegetated flatlands characterized by valleys, plateaus, broad floodplains, and large expanses of desert (England et al., 1997). Single trees or riparian areas were used most often for nesting. Native valley oaks, cottonwoods, and black walnuts are the trees most commonly used as nest sites. Nesting habitat comprises riparian habitats along a stream course, small tree groves, and solitary trees adjacent to suitable foraging habitat (England et al., 1997).

The natural foraging habitat of Swainson's hawks is relatively open stands of grass-dominated vegetation and sparse shrublands. Swainson's hawks can also forage in many crops. The species is often found more abundant in areas of moderate cultivation than in either grassland or areas of extensive cultivation (Schmutz, 1987). Agricultural crops, including hay and grain, dryland pastures, and certain row crops, provide foraging habitat for the Swainson's hawk.

Within the Upper Pit River Watershed, the Swainson's hawk is an uncommon breeding species in the southern portion but common in the northern portion. The CNDDB reported 21 occurrences of nests in the Upper Pit River Watershed, with recorded dates occurring from 1977 through1994 (Figure 8-11). The number of currently active Swainson's hawk nesting locations in the Upper Pit River Watershed is unknown. Most of the CNDDB recorded nest sites were located in the Upper Pit River Valley (17), while fewer were present in Warm Springs Valley (2) and Big Valley/Round Valley (2). Isolated pairs have been suspected to nest in the Fall River Valley based on sightings of adults during the summer.

American Peregrine Falcon

The American peregrine falcon is listed as endangered under CESA, and has been delisted from the Federal Endangered Species Act. Historically, it was found throughout the Sierra Nevada and most of California, California Department of Fish and Game, 1980, U.S. Fish and Wildlife Service 1982). Now, it is an uncommon breeding resident and uncommon as a migrant (Zeiner et al., 1990).

The peregrine falcon is a migratory species. Individuals nesting at higher latitudes typically migrate to latitudes that are more southern. Peak fall migration occurs between mid-September and mid-November, and individuals arrive on breeding grounds and establish territories in early March (White et al., 2002). No peregrine falcons are known to winter in the Upper Pit River Watershed, but individuals have been observed during migration periods.

The American peregrine falcon nests on vertical cliffs with large potholes or ledges inaccessible to land predators. Because this species preys primarily on birds, nest sites are usually located near areas that support large populations of birds, such as coastal areas or wetlands with an abundance of waterfowl and shorebirds. However, the species is known to prey on a diverse group of animals, including invertebrates and fish (White et al., 2002). Peregrine falcons may travel long distances from their nesting grounds to forage near or within forested habitat (Grinnell and Miller, 1944, California Department of Fish and Game, 1980). Breeding activity begins as early as March and ends in August (Zeiner et al., 1990).

Peregrine falcons are not known to nest in the Upper Pit River Watershed (California Natural Diversity Data Base, 2003; Jurek, 2003, pers. comm.; Hunt, 2003, pers. comm.; Linthicum, 2003, pers. comm.). However, extensive surveys have not been conducted for this species, and suitable nesting habitat occurs in areas where vertical cliffs are present.

Great Gray Owl

The great gray owl is listed as endangered under the California ESA and is designated as a USFS sensitive species. The species is also designated as a Forest Service Sensitive Species. Great gray owls are residents in the Sierra Nevada in small sections of Tuolome, Marisposa, Madera, and Fresno Counties. Within the Upper Pit River Watershed, great gray owls are only known to occur in Modoc County.

The great gray owl is associated with montane meadows with large trees near the meadow edge for nesting. They forage primarily on rodents, including moles and gophers, and occasionally take weasels, hares, and birds (Bull and Duncan, 1993). Large meadows with dense prey availability appear to be selected. They are unique among North American owls for their ability to hear prey under snow, and plunging through surface crust to capture prey.

The effects of logging and grazing have been cited as potential reasons for great gray owl population declines. Since owls often nest in large diameter dead and live trees, removal of these trees from forestry practices likely affects the amount of suitable nest sites, roosting, cover, and protection. Other hypothesized affects are strychnine poisoning of pocket gophers, and reduction of rodent populations in meadows from excessive livestock grazing. Collisions with automobiles have also been documented to be a major cause of mortality for some years (Bull and Duncan, 1993).

One great gray owl has been reported to occur in the Upper Pit River Watershed (California Natural Diversity Data Base, 2003). This record identified that an individual was observed and heard in Patterson meadow in 1972. No other great gray owl occurrences are known in the Upper Pit River Watershed. A single male great gray owl was observed during the summer in Crowder flat approximately 7–10 miles north of the Upper Pit River Watershed boundary in the northern portion of the Upper Pit River Watershed (Figure 8-12) (Yamagiwa, 2003, pers. comm.). Most of the habitat types thought to be suitable for great gray owls on the Modoc NF have not been surveyed. This species appears to be expanding in Oregon (Romberger, 2003, pers. comm.).

Spotted Owl
The northern spotted owl is federally listed as threatened under the federal ESA, and is designated as a species of special concern by the state of California. The owl ranges from southwestern British Columbia through western Washington and Oregon to the northern Coast Ranges and Cascade Ranges of northern California (Johnsgard, 1990). In California, the range extends east to western Modoc County (north of Hwy 299), south to Marin County, and north to the Oregon border. The California spotted owl is designated as a species of special concern by the state of California. This subspecies was recently considered for listing under the federal ESA, but listing was declined. The range of the California spotted owl is Highway 299 south through the southern Cascade Mountains, the Sierra Nevada, the transverse range, and the coast range in Southern California. Regent genetics work suggests that the Pit River Watershed lies in a zone where there is a mixing of the genetics of the northern and California subspecies (Haig, et al. *in press*), but no analysis specific to the owls in this watershed has been conducted.

The spotted owl is medium-sized owl closely associated with conifer forests. The species is well known for its affiliation with mature and old growth forest habitats and incorporates large tracts of these forests into home range (Forsman et al. 1984, Carey et al. 1990, Solis and Gutierrez 1990). Throughout its range, however, the owl uses a wide array of nesting habitats. The species has the ability to utilize dynamic forest stands that continue to undergo significant change in tree density, proportion of tree size classes, and tree species composition (Everett et al. 1977). The owl exhibited in its ability to persist and successfully reproduce in forests managed for commercial wood production in all conifer forest types (Pious 1989, Everett et al. 1997, Irwin et al. 2004).

The spotted owl nesting habitat is characterized as forest, with well-developed, multi-tiered stratification, large trees, and a considerable degree of decadence, such as trees with broken tops and cavities for nesting, dead snags, decaying logs, and debris on the forest floor (Thomas et al., 1990).

Regional differences apparently exist regarding the need for old-growth forest structure for successful owl nesting. Previous studies conducted in the Oregon Coast Ranges and in Douglas-fir forests in northwestern California suggest that owls select home ranges and nest sites that emphasize old-growth within the landscape (Carey et al., 1990; Solis and Gutierrez, 1990; Ripple et al. 1991). East of the Cascades in Oregon however only 27 percent is old growth with the remainder in various stages of stand development (Buchanan et al. 1991). Home range size expands with decreasing proportion of late seral-stage forest. Likewise, in some areas the density of breeding populations decreases with increased forest fragmentation (Carey et al., 1992). These data indicate a strong selection of old-growth stands by owls for foraging and roosting, whereas early to middle stages were used less than or in proportion to their availability within home ranges (Carey et al. 1990; Solis and Gutierrez 1990).

In contrast, studies conducted within the redwood forest region of northwestern California (Diller, 1989) indicate that northern spotted owls use stands that were dominated by younger age classes. In general, studies by Diller and Hibbard indicate that nesting and roosting habitat in coastal redwood forests is more dependent on the structural attributes of old growth than foraging habitat. On a landscape level, habitat mosaics surrounding nesting spotted owls contain a greater amount of younger age-class forest (31 to 60 years) than older age classes (61 to >200 years).

Although large trees and high canopy closure are characteristic of nesting sites, nesting has been confirmed in stands 31 to 45 years and 46 to 60 years (Diller and Hibbard, 1993). Others have also noted that suitable owl nesting habitat in coastal redwoods can exist in relatively young second-growth stands 50 to 80 years old (Thomas et al., 1990).

Recent studies have found that nesting habitat, and its associated elements of roosting habitat, are only one component of forest landscapes which support spotted owl populations. Considerably more is know about foraging habitat than was available at the time of the listing of the northern spotted owl. A nine-year study of climate, habitat quality, and fitness in northern spotted owl populations in northwestern California (Franklin et al. 2000) suggests that a mosaic of older forest interspersed with other vegetation types and age classes of forest promoted high fitness (a measure combining survival with the production of offspring) in northern spotted owls.

In addition, Irwin et al. 2004, still in the middle of analyzing data regarding spotted owl habitat in managed forest landscapes (for both subspecies) are finding strong correlations between selection of foraging habitat and abiotic factors, such as distance to streams, elevation, and nest sites.

Loss of late seral forest habitat from timber harvest was considered the primary reason for the decline of the northern spotted owl (Thomas et al., 1990). In some areas, habitat fragmentation may also have contributed to declines because of spatial considerations and the lack of dispersal into isolated habitat fragments. Other related factors included the reduced distribution and abundance of owl prey species in managed and fragmented forests; the range expansion of the barred owl, a species that competes for resources with the spotted owl; and additional habitat loss from wildfires (Thomas et al., 1990).

The FWS is currently conducting a status review for the northern spotted owl and the preliminary findings are that the threats against the owl are qualitatively different from the threats at the time of listing. The rate of habitat loss due to tree harvest is greatly reduced but threats to the habitat from insects and stand-replacing fires are at least as, and perhaps more, significant than in 1990. Loss of northern spotted owls from disease, such as the West Nile virus, extirpation, predation by barred owls are of much greater concern than at the time of listing (presentation by R. Gutierrez at the June 22, 2004 meeting of the Northern Spotted Owl Status Review Team [http://www.sei.org/owl/meetings.htm]).

A small number of northern spotted owl nesting pairs are reported in the Upper Pit River Watershed (California Natural Diversity Data Base, 2003) (Figure 8-13).

Bank Swallow

The bank swallow is listed as threatened under the California ESA. Bank swallows historically nested throughout the northern half of the state where suitable habitat was present along river margins. Currently, most bank swallow populations occur along the Sacramento River, with smaller populations found along the Feather, American, and Pit Rivers.

Bank swallows are migratory and arrive in California typically around late-April or early May. Peak fall migration occurs in late-August and early September, where bank swallows migrate to and winter in South America (Garrison, 1999).

Bank swallows primarily select breeding locations along ocean coasts, rivers, streams, lakes, reservoirs, and wetlands (Garrison, 1999). Vertical banks, cliffs, and bluffs in alluvial, friable soils characterize nesting colony sites throughout their range (Garrison, 1999). Nesting colonies are also found in road cuts, and in sand, gravel, and other mining quarries. Most all colonies are associated with or located near a river or reservoir. The reduction in the California bank swallow population is thought to have occurred from degradation of habitat. Much of the historic habitat along rivers has been eliminated by flood and erosion control projects. The re-sloping of banks to 45 degrees and the addition of rip-rap make the sites unsuitable for nesting (Garrison, 1999).

Six bank swallow colonies are reported in the Upper Pit River Watershed (California Natural Diversity Data Base, 2003) (Figure 8-14). All of the colonies occur along the Pit River. Four colonies occur on the Pit River between 3 to 10 miles southwest of Alturas, one five miles north of Alturas, and one colony near McArthur. Currently the McArthur colony is active, but it is unknown whether any of the other colonies are still active.

Willow Flycatcher

The willow flycatcher is listed as endangered under the California ESA and is considered a USFS sensitive species. Historically, willow flycatchers occurred throughout California where habitat conditions were suitable. The present distribution of those in northern California is limited to relatively isolated populations in the Sierra Nevada and the Cascade Range and occasionally in the northern Coast Ranges (Harris, 1991; Green et al., 2003, Zeiner et al., 1990). Approximately 315 territories are thought to occur in California (Green et al., 2003).

The willow flycatcher is a migratory species. Peak fall migration occurs between mid-August and mid-September, and breeding individuals arrive in their breeding territory around late May and early June (Sedgwick, 2000). Willow flycatchers are thought to primarily winter in Central America. No willow flycatchers winter in the Upper Pit River Watershed.

The willow flycatcher primarily nests in dense willow thickets in montane meadows and along streams. Standing or running water or "boggy" meadow conditions during part of the nesting season is a common habitat characteristic. Thick shrubby vegetation, often from clumps of willows or alders, and meadow or grassland vegetation adjacent to the riparian vegetation is important. This species forages in riparian and meadow habitats during the nesting season. It arrives on the breeding grounds in May and June and migrates to southern Mexico and Central America in August (Green et al. 2003, Harris et al. 1987, Sedgwick 2000, Zeiner et al. 1990, Green et al. 2003).

Several factors have contributed to their low abundance. Habitat alteration and overgrazing are cited as the two most responsible factors (Remsen, 1978; Serena, 1982). Generally throughout the range of the willow flycatcher, historic wet meadow habitats have been drained for agriculture purposes and a percentage converted to crop production More recently, predators and brood parasitism have been discovered to negatively influence survival and reproduction (Green et al. 2003).

Many meadows not converted to crops have also become unsuitable. Meadow desiccation appears to be the single-most important factor in the willow flycatcher decline in the Sierra Nevada (Green et al. 2003). Many factors, alone or in combination, may have played a role in the alteration of the hydrology of mountain meadows, including historic overgrazing by livestock, poorly designed or constructed roads, recreation, fire suppression, water diversions, and drought. The degradation of wet meadows, may take several decades to occur. Drier meadows, result in reduction of standing willow cover and standing water, leading to encroachment by conifers. Lack of standing water and the presence of conifers creates habitat accessible to forest rodents that are predators of willow flycatcher nests (Cain et al. 2003). The increased predation rates on these nests may be the primary cause most influencing willow flycatcher population decline in the Sierra Nevada (Green et al. 2003).

A small number of willow flycatchers occur in the Upper Pit River Watershed. In two locations (Blue Lake Ranch and Dry Creek), one singing male was reported (California Natural Diversity Data Base, 2003), and the Modoc NWR reported a pair nesting on the refuge in 1986 (Ludwig, 2003, pers. comm.). In the early 1900s, willow flycatchers were recorded in Davis Creek, Dry Creek, Joseph Creek, Lassen Creek, and Cold Creek (Florez, 2003, pers. comm.). It is uncertain which subspecies these individuals are from because the boundary between E.t. brewsteri and E.t. adastus is uncertain in the Great Basin of California. Regardless of which subspecies occurs, or both, all active willow flycatcher territories in the Upper Pit River Watershed are located in the northern portion of the Upper Pit River Watershed (Figure 8-15), and known populations are small and at risk.

California Wolverine

The California wolverine is listed as threatened under the California Endangered Species Act and is designated as a Forest Service Sensitive Species. It is considered an extremely scarce resident in California, the known former habitat extending from Del Norte and Trinity counties east through Siskiyou and Shasta Counties, and south through the Sierra Nevada to Tulare County. In the Sierra Nevada, most sightings occur at mid-to-high elevations (Zeiner et al., 1990b), and the number of sightings has diminished over time. An extensive survey of previously occupied habitats, for example, failed to detect a single wolverine.

In the northern Sierra Nevada, wolverines inhabit mixed conifer, red fir, and lodgepole pine habitats and probably use subalpine conifer, alpine dwarf-shrub, wet meadows, and montane riparian habitats (Zeiner et al., 1990). In the southern Sierra Nevada, wolverines inhabit lodgepole pine, red fir, mixed conifer, subalpine conifer, alpine dwarf-shrub, barren, and probably wet meadows, montane chaparral, and Jeffrey pine habitats (Zeiner et al., 1990). California wolverine use high elevation cirque basins for den sites and forage in open to sparse tree habitats on the ground, in trees, burrows, among rocks, and sometimes in shallow water. Wolverines are generally considered to avoid areas disturbed by logging, road building, and general human use.

Wolverines are not known to occur in the Upper Pit River Watershed. The nearest wolverine occurrence is a single wolverine sighting in 1973, near the Pit 1 Forebay, west of Fall River Mills (PG&E, 1993). Conifer forests in the project area and the high areas at the top of mountainous regions in the Upper Pit River Watershed are considered potential habitat for wolverines. However, it appears most likely that the wolverine is highly uncommon in the Upper Pit River Watershed.

Sierra Nevada Red Fox

The Sierra Nevada red fox is listed as threatened under CESA and is designated as a Forest Service Sensitive Species. In California, this species occurs in low numbers throughout the Sierra Nevada at high elevations.

The Sierra Nevada red fox inhabits forested areas interspersed with riparian and meadow habitats, and brush fields. Preferred forest types include red fir, lodgepole pine, subalpine fir and mixed conifer types. They forage in these habitats and forest openings.

Sierra Nevada red foxes are not known to occur in the Upper Pit River Watershed (California Natural Diversity Data Base, 2003). Conifer forests in the project area are considered potential habitat for red foxes; however, the likelihood of occurrence is low given the lack of records from the site or surrounding areas. This species is known to regularly occur in Lassen National Park, and it has been recorded on the Hat Creek Ranger District near Highway 44 approximately 15 miles south of the southern Upper Pit River Watershed boundary (Breth, 2003, pers. comm.).

EXTIRPATED

Several wildlife species have been extirpated, which means the species no longer occurs in the Upper Pit River Watershed, but still occurs in other areas of their historic range. Some of these species such as the grizzly bear and wolf would probably not be welcomed back by locals living in the Upper Pit River Watershed. However, advocacy groups for these species have made progress by reintroducing them in other areas of the United States and Canada.

A handful of other wildlife species have been extirpated in the Upper Pit River Watershed and the disappearance of these species has largely gone unnoticed. For example, sharp-tailed grouse, a prominent game species in the mid-west, once occurred in the Upper Pit River Watershed before being eliminated by habitat conversion. Other bird species that no longer breed in the Upper Pit River Watershed include the yellow-billed cuckoo, common loon, and the Barrow's goldeneye. Although the disappearance of these species is a concern, a greater concern exists for a long-list of species, that occur in low numbers and located in Table 8-3. Local landowner, managers, and residents in the Upper Pit River Watershed share the responsibility to ensure that populations of these species are maintained or increased to demonstrate a reverence of good stewardship.

Table 8-3 SPECIAL-STATUS WILDLIFE SPECIES WITH POTENTIAL TO OCCUR IN THE UPPER PIT RIVER WATERSHED					
Common and Scientific Name	**Status [a] Federal/State**	**California Distribution**	**Habitats**	**Reason for Decline**	**Occurrence in Watershed**
Common loon *Gavia immer*	--/SSC	Primarily a winter visitor to California, but an occasional year-round resident; found along the entire coast and large inland bodies of water; formerly nested in northeastern California	Near shore coastal waters and bays; less common at large inland bodies of deep water with productive fisheries	Human disturbance at nest sites, especially by boats	Found in large lakes and reservoirs during spring and fall migration; species has been extirpated during breeding season
American white pelican *Pelecanus erythrorhynchos*	--/SSC	Historically, nested at large lakes throughout California; only breeding colonies in the state occur at lower Klamath National Wildlife Refuge, Siskiyou County, and at Clear Lake, Modoc County. Winters along the California coast from southern Sonoma County south to San Diego County; inland, occurs at the Salton Sea, inland from the San Francisco Bay through the Delta region, and in areas in Kings, Kern, Riverside, and Imperial Counties and the Sacramento Valley	Freshwater lakes with islands for breeding; inhabits river sloughs, freshwater marshes, salt ponds, and coastal bays during the rest of the year	Loss of wetland habitat from agricultural and urban development, vulnerable to human disturbance at breeding colonies	Found during migration and after young have fledged during the summer in rivers, lakes, reservoirs, ponds, and sloughs with fish populations; historical nesting unknown
Double-crested cormorant *Phalacrocorax auritus*	--/SSC	Winters along the entire California coast and inland over the Coast Ranges into the Central Valley from Tehama County to Fresno County. A permanent resident along the coast from Monterey County to San Diego County, along the Colorado River, Imperial, Riverside, Kern, and King Counties, and the islands off San Francisco; breeds in Siskiyou, Modoc, Lassen, Shasta, Plumas, and Mono Counties; also breeds in the San Francisco Bay Area and in Yolo and Sacramento Counties	Rocky coastlines, beaches, inland ponds, and lakes; needs open water for foraging, and nests in riparian forests or on protected islands, usually in snags	Loss of coastal and riparian breeding sites, human disturbance	Found sporadically in lakes, reservoirs, and ponds throughout the watershed; no known nesting locations present, but limited surveys have been conducted
White-faced ibis *Plegadis chihi*	--/SSC	Both resident and winter populations on the Salton Sea and in isolated areas in Imperial, San Diego, Ventura, and Fresno Counties; breeds at Honey Lake, Lassen County, at Mendota Wildlife Management Area, Fresno County, and near Woodland, Yolo County; winters in Merced County and along the Sacramento River in Colusa, Glenn, Butte, Sutter, and Yolo Counties	Prefers freshwater marshes with tules, cattails, and rushes, but may nest in trees and forage in flooded agricultural fields, especially flooded rice fields	Loss of wetlands to agriculture and urban development	Found more in recent years during migration in freshwater marshes and meadows; no known nesting colonies have been reported, but summer residents birds suggest they may be nesting locally
Aleutian Canada goose *Branta canadensis leucopareia*	T/--	The entire population winters in Butte Sink, then moves to Los Banos, Modesto, the Delta, and East Bay reservoirs; stages near Crescent City during spring before migrating to breeding grounds	Roosts in large marshes, flooded fields, stock ponds, and reservoirs; forages in pastures, meadows, and harvested grainfields; corn is especially preferred	Introduction of predators on breeding grounds, loss of traditional wintering habitat	Occurs occasionally during migration as individuals in mixed goose flocks

Table 8-3 (cont.) SPECIAL-STATUS WILDLIFE SPECIES WITH POTENTIAL TO OCCUR IN THE UPPER PIT RIVER WATERSHED					
Common and Scientific Name	**Status [a] Federal/State**	**California Distribution**	**Habitats**	**Reason for Decline**	**Occurrence in Watershed**
Osprey *Pandion haliaetus*	MIS/SSC	Nests along the north coast from Marin County to Del Norte County, east through the Klamath and Cascade Ranges, and the upper Sacramento Valley; important inland breeding populations at Shasta Lake, Eagle Lake, and Lake Almanor and small numbers elsewhere south through the Sierra Nevada; winters along the coast from San Mateo County to San Diego County	Nests in snags or cliffs or other high, protected sites near the ocean, large lakes, or rivers with abundant fish populations	Vulnerable to human disturbance at nest sites, pesticide contamination, breeding range and populations increasing in many areas	Small number of nesting pairs occur along the Pit River and near lakes, reservoirs, and stock ponds with fish populations in the watershed
White-tailed kite *Elanus leucurus*	--/FP	Lowland areas west of Sierra Nevada from head of Sacramento Valley south, including coastal valleys and foothills to western San Diego County at the Mexico border	Low foothills or valley areas with valley or live oaks, riparian areas, and marshes near open grasslands for foraging	Loss of grassland and wetland habitats to agriculture and urban development	Occasional sightings at Modoc NWR and Ash Creek WA during spring and fall; no known nesting pairs in the watershed
Bald eagle *Haliaeetus leucocephalus*	T/E,FP	Nests in Siskiyou, Modoc, Trinity, Shasta, Lassen, Plumas, Butte, Tehama, Lake, and Mendocino Counties and in the Lake Tahoe Basin; reintroduced into central coast; winter range includes the rest of California, except the southeastern deserts, very high altitudes in the Sierras, and east of the Sierra Nevada south of Mono County; range expanding	In western North America, nests and roosts in coniferous forests within one mile of a lake, a reservoir, a stream, or the ocean	Nest sites vulnerable to human disturbance, pesticide contamination	Known to nest at several locations; forages at several locations during winter and migration (see Figure 8-10)
Golden eagle *Aquila chrysaetos*	FSS/SSC, FP	Foothills and mountains throughout California; uncommon nonbreeding visitor to lowlands such as the Central Valley	Cliffs and escarpments or tall trees for nesting; annual grasslands, chaparral, and oak woodlands with plentiful medium and large-sized mammals for prey	Habitat loss to urbanization; vulnerable to disturbance at nest sites	Nests throughout the watershed although only a limited number of nests have been documented
Northern harrier *Circus cyaneus*	--/SSC	Throughout lowland California; has been recorded in fall at high elevations	Grasslands, meadows, marshes, and seasonal and agricultural wetlands providing tall cover	Loss of habitat to agricultural and urban development	Low numbers suspecting nesting in freshwater marshes, meadows, and some agriculture fields with thick vegetation in valley lowlands
Sharp-shinned hawk *Accipiter striatus*	--/SSC	Permanent resident on the Sierra Nevada, Cascade, Klamath, and north Coast Ranges at mid-elevations and along the coast in Marin, San Francisco, San Mateo, Santa Cruz, and Monterey Counties; winters over the rest of the state except very high elevations	Dense canopy ponderosa pine or mixed-conifer forest and riparian habitats	Human disturbance at nest sites, pesticide contamination, timber harvesting near nesting sites	Known to nest in low densities in forested and riparian areas in the watershed; wintering birds are often seen foraging in the valley bottoms

Table 8-3 (cont.) SPECIAL-STATUS WILDLIFE SPECIES WITH POTENTIAL TO OCCUR IN THE UPPER PIT RIVER WATERSHED					
Common and Scientific Name	**Status [a] Federal/State**	**California Distribution**	**Habitats**	**Reason for Decline**	**Occurrence in Watershed**
Cooper's hawk *Accipiter cooperii*	--/SSC	Throughout California except high altitudes in the Sierra Nevada; winters in the Central Valley, southeastern desert regions, and plains east of the Cascade Range; permanent residents occupy the rest of the state	Nests primarily in riparian forests dominated by deciduous species; also nests in densely canopied forests from digger pine-oak woodland up to ponderosa pine; forages in open woodlands	Human disturbance at nest sites, loss of riparian habitats, especially in the Central Valley; pesticide contamination	Known to nest in forested areas in the watershed during the summer; winter birds are often seen foraging in the valley bottoms
Northern goshawk (North American pop.) *Accipiter gentilis*	FSS/SSC	Permanent resident on the Klamath and Cascade Ranges, on the north Coast Ranges from Del Norte County to Mendocino County, and in the Sierra Nevada south to Kern County; winters in Modoc, Lassen, Mono, and northern Inyo Counties; rare in southern California	Nests and roosts in older stands of red fir, Jeffrey pine, and lodgepole pine forests; hunts in forests and in forest clearings and meadows	Loss of nesting habitat and disturbance of nest sites	Known to nest in forested areas in the watershed during the summer; nest site location often varies each year
Swainson's hawk *Buteo swainsoni*	FSS,MIS/T	Lower Sacramento and San Joaquin Valleys, the Klamath Basin, and Butte Valley; the state's highest nesting densities occur near Davis and Woodland, Yolo County	Nests in oaks or cottonwoods in or near riparian habitats; forages in grasslands, irrigated pastures, grain fields, and vegetable crops	Loss of riparian, agriculture, and grassland habitats; vulnerable to human disturbance at nest sites	Limited number of nests suspected in the watershed; no current breeding pairs are known
Ferruginous hawk *Buteo regalis*	SC/SSC	Does not nest in California; winter visitor along the coast from Sonoma County to San Diego County, eastward to the Sierra Nevada foothills and southeastern deserts, the Inyo-White Mountains, the plains east of the Cascade Range, and Siskiyou County	Open terrain in plains and foothills where ground squirrels and other prey are available	Conversion of grasslands for agriculture and urban development	Found during winter throughout the watershed foraging in flat, low lying terrain in the valley bottoms
Merlin *Falco columbarius*	--/SSC	Does not nest in California; rare but widespread winter visitor to the Central Valley and coastal areas	Forages along coastlines, open grasslands, savannas, and woodlands; often forages near lakes and other wetlands	Unclear; possibly chemical contamination, illegal take of young	Found primarily during spring and fall migration, and occasionally during winter and summer; Not known or suspected to nest in the watershed
American peregrine falcon *Falco peregrinus anatum*	--/E,FP	Permanent resident on the north and south Coast Ranges; may summer on the Cascade and Klamath Ranges south through the Sierra Nevada to Madera County; winters in the Central Valley south through the Transverse and Peninsular Ranges and the plains east of the Cascade Range	Nests and roosts on protected ledges of high cliffs, usually adjacent to lakes, rivers, or marshes that support large populations of other bird species	Pesticide contamination; population recovering	Suspected to nest at a limited number of sites; no known nesting sites present

Table 8-3 (cont.) SPECIAL-STATUS WILDLIFE SPECIES WITH POTENTIAL TO OCCUR IN THE UPPER PIT RIVER WATERSHED					
Common and Scientific Name	**Status [a] Federal/State**	**California Distribution**	**Habitats**	**Reason for Decline**	**Occurrence in Watershed**
Prairie falcon *Falco mexicanus*	MIS/SSC	Found as permanent resident on the south Coast, Transverse, Peninsular, and northern Cascade Ranges, the southeastern deserts, Inyo-White Mountains, Modoc, Lassen, and Plumas Counties, and the foothills surrounding the Central Valley; winters in the Central Valley, along the coast from Santa Barbara County to San Diego County, and in Marin, Sonoma, Humboldt, Del Norte, and Inyo Counties	Cliffs or escarpments for nesting; adjacent dry, open terrain or uplands, marshes, and seasonal marshes for foraging	Possibly pesticide contamination, robbing of aeries by falconers and illegal shooting, human disturbance at nest site	Suspected to nest throughout the watershed based on observations of adults during summer; no known nesting sites have been documented
Sage grouse *Centrocercus urophasianus*	MIS/SSC	Great Basin lands in eastern California in Modoc, Lassen, and northern Inyo Counties	Dependent on sage-brush (*Artemisia tridentata*) for food and cover; restricted to flat plains or rolling hills	Human disturbance at display (lek) sites, pesticide contamination, habitat conversion	Contact Frank Hall for nesting locations 254-6808 (left message)
Blue grouse *Dedrogapus obscurus*	MIS/---	North Coast Range, Cascade Range, and Sierra Nevada Mountains in Del Norte, Humboldt, Trinity, Siskiyou, Shasta, Modoc, and Lassen Counties	Dependent on mixed conifer forests	Unknown	Found mostly in forested areas in the northern portion of the watershed
Greater sandhill crane *Grus canadensis tabida*	FSS,MIS/T,FP	Breeds on the plains east of the Cascade Range and south to Sierra County; winters in the Central Valley, southern Imperial County, Lake Havasu National Wildlife Refuge, and the Colorado River Indian Reserve	Summers in open terrain near shallow lakes or freshwater marshes; winters in plains and valleys near bodies of fresh water	Loss of freshwater marsh nesting habitat, disturbance by cattle during nesting, illegal hunting	Known to nest at several locations; forages during migration throughout watershed in a variety of habitats
Long-billed curlew *Numenius americanus*	--/SSC	Nests in northeastern California in Modoc, Siskiyou, and Lassen Counties; winters along coast or in interior valleys west of Sierra Nevada	Nests at high-elevation grasslands adjacent to lakes or marshes during migration and in winter; frequents coastal beaches and mudflats or interior grasslands and agricultural fields	Loss of wetland and grassland habitats to urbanization and agriculture	Very low breeding individuals known in the watershed and state; Only known breeding records occur on Modoc NWR; small groups or individuals can be observed in freshwater marsh habitat or wet meadows during migration
Black tern *Chlidonias niger*	--/SSC	Spring and summer resident of the Central Valley, Salton Sea, and northeastern California where suitable emergent wetlands occur	Freshwater wetlands, lakes, ponds, moist grasslands, and agricultural fields; feeds mainly on fish and invertebrates while hovering over water	Loss of wetland nesting and foraging habitat	Several known colonies occur in the Devil's Garden in seasonal wetland habitats; migratory individuals can be found using lakes and reservoirs
Western burrowing owl *Athene cunicularia hypugea*	--/SSC	Lowlands throughout California, including the Central Valley, northeastern plateau, southeastern deserts, and coastal areas; rare along south coast	Rodent burrows in sparse grassland, desert, and agricultural habitats	Loss of habitat, human disturbance at nesting burrows	Only a small number of nests are known to occur in the watershed (Modoc NWR); rarely observed in fall in low lying areas

Table 8-3 (cont.) SPECIAL-STATUS WILDLIFE SPECIES WITH POTENTIAL TO OCCUR IN THE UPPER PIT RIVER WATERSHED					
Common and Scientific Name	**Status [a] Federal/State**	**California Distribution**	**Habitats**	**Reason for Decline**	**Occurrence in Watershed**
Northern spotted owl *Strix occidentalis caurina*	T/SSC	A permanent resident throughout its range; found in the north Coast, Klamath, and western Cascade Range from Del Norte County to Marin County	Dense old-growth forests dominated by conifers with topped trees or oaks available for nesting crevices	Loss of nesting habitat	Known to nest at a limited number of locations (see Figure *)
California spotted owl *Strix occidentalis occidentalis*	FSS/SSC	Sierra Nevada from Lassen County south to northern Kern County; occurs in localized areas of the Transverse and Peninsular Ranges of southern California	Mature forest with permanent water and suitable nesting trees and snags; in southern California, nearly always associated with oak and oak-conifer habitats	Loss of nesting habitat	Known to nest at a limited number of locations (see Figure 8-13)
Great gray owl *Strix nebulosa*	FSS/E	Permanent resident of the Sierra Nevada in small portions of Tuolumne, Mariposa, Madera, and Fresno Counties	Old-growth coniferous forests bordering meadows; red fir, Jeffrey pine, and lodgepole pine dominate	Loss of old-growth nesting habitat, degradation of foraging habitat in meadows	Known to occur in the watershed in two locations (Figure 8-13); limited amount of surveys conducted
Long-eared owl *Asio otus*	--/SSC	Permanent resident east of the Cascade Range from Placer County north to the Oregon border, east of the Sierra Nevada from Alpine County to Inyo County, along the coast from Sonoma County to San Luis Obispo County, and eastward over the north Coast Ranges to Colusa County; winters in the Central Valley, Mojave and Sonora Deserts, and the Inyo-White Mountains; summers along the eastern rim of the Central Valley and Sierra foothills from Tehama County to Kern County	Dense riparian stands of willows, cottonwoods, live oaks, or conifers; uses adjacent open lands for foraging; nests in abandoned crow, hawk, or magpie nests	Loss of riparian habitats	Suspected to nest in riparian areas of the watershed in low numbers (ask Sterling about this one)
Short-eared owl *Asio flammeus*	--/SSC	Permanent resident along the coast from Del Norte County to Monterey County although very rare in summer north of San Francisco Bay, in the Sierra Nevada north of Nevada County, in the plains east of the Cascades, and in Mono County; small, isolated populations also nest in the Central Valley; winters on the coast from San Luis Obispo County to San Diego County, in the Central Valley from Tehama County to Kern County, in the eastern Sierra Nevada from Sierra County to Alpine County, on the Channel Islands, and in Imperial County	Freshwater and salt marshes, lowland meadows, and irrigated alfalfa fields; needs dense tules or tall grass for nesting and daytime roosts	Loss of wetland and grassland habitats to agriculture and urban development	Known to nest in freshwater marsh habitat in low numbers at Modoc NWR and Ash Creek WA; occasionally observed during winter in these areas
Black swift *Cypseloides niger*	--/SSC	Breeds locally in the Sierra Nevada and Cascade Range, the San Gabriel, San Bernardino, and San Jacinto Mountains; and in coastal bluffs from San Mateo County south to near San Luis Obispo County	Nests in moist crevice or cave on sea cliffs above the surf, or on cliffs behind, or adjacent to, waterfalls in deep canyons		Not known to nest in the watershed; suspected to nest in cliffs near waterfalls

Table 8-3 (cont.) SPECIAL-STATUS WILDLIFE SPECIES WITH POTENTIAL TO OCCUR IN THE UPPER PIT RIVER WATERSHED					
Common and Scientific Name	**Status [a] Federal/State**	**California Distribution**	**Habitats**	**Reason for Decline**	**Occurrence in Watershed**
Vaux's swift *Chaetura vauxi*	--/SSC	Coastal belt from Del Norte County south to Santa Cruz County; also nests rarely in mid-elevation forests of the Sierra Nevada	Nests in hollow, burned-out tree trunks in large conifers; most other activities are conducted in the air	Reduction in the number of suitable nest sites from logging and fire suppression	Nesting status unknown; known to occur during migration where individuals are observed foraging near lakes and rivers
Pileated woodpecker *Drycopus pileatus*	MIS/---	Coastal mountains from Del Norte County to Sonoma Counties, through Cascades to Lassen County; south in Sierra Nevada to Kern County	Coniferous forests and mixed woodlands; nests in cavities in large trees or snags	Loss of habitat from timber harvesting and woodcutting	Known to nest in low numbers in the watershed where large late seral forest exists
Hairy woodpecker *Picoides villosus*	MIS/---	Mountain ranges throughout California	Coniferous forests and mixed woodlands; nests in cavities in large trees or snags	Loss of habitat from timber harvesting and woodcutting	Known to nest throughout the watershed in forested areas
Red-breasted sapsucker *Sphyrapicus rubber*	MIS/---	Coastal mountains from Del Norte County to Sonoma Counties, through Cascades to Lassen County; south in Sierra Nevada to Kern County	Coniferous forests and mixed woodlands; nests in cavities in large trees or snags	Loss of habitat from timber harvesting and woodcutting	Known to nest throughout the watershed in forested areas
Red-naped sapsucker *Sphyrapicus nuchalis*	MIS/---	Eastern slope of Cascade and Sierra Nevada Ranges in Modoc, Mono, and Inyo Counties	Mixed woodland and riparian areas; nests in cavities in large trees or snags	Loss of habitat from timber harvesting and woodcutting	Occurrence in the watershed unknown (email Sterling)
Loggerhead shrike *Lanius ludovicianus*	--/SSC	Resident and winter visitor in lowlands and foothills throughout California; rare on coastal slope north to Mendocino County, occurring only in winter	Prefers open habitats with scattered shrubs, trees, posts, fences, utility lines, or other perches	Loss of habitat and pesticide use; still widespread in California	Suspected to nest in low numbers in lowland areas (email Scott McWilliams about this)
Willow flycatcher *Empidonax traillii*	FSS/E	Summer range includes a narrow strip along the eastern Sierra Nevada from Shasta County to Kern County, another strip along the western Sierra Nevada from El Dorado County to Madera County; widespread in migration	Riparian areas and large, wet meadows with abundant willows for breeding; usually found in riparian habitats during migration	Loss of riparian breeding habitat, nest parasitism by brown-headed cowbirds	Known to nest at a limited number of locations; occurs at several locations during migration (see Figure 8-15)
Purple martin *Progne subis*	--/SSC	Nests in Sacramento; uncommon or absent elsewhere in the Central Valley; breeds locally in coastal areas from Del Norte County south to Santa Barbara County; rare in southern California	Abandoned woodpecker holes in valley oak and cottonwood forests for nesting; also nests in vertical drainage holes under elevated freeways and highway bridges; open areas required for feeding	Competition from European starlings for nest sites, loss of riparian habitat, loss of nesting habitat	Not known to occur in the watershed. Limited number of surveys conducted (check out Devil's Garden biologist or Sterling)

Table 8-3 (cont.) SPECIAL-STATUS WILDLIFE SPECIES WITH POTENTIAL TO OCCUR IN THE UPPER PIT RIVER WATERSHED					
Common and Scientific Name	**Status [a] Federal/State**	**California Distribution**	**Habitats**	**Reason for Decline**	**Occurrence in Watershed**
Bank swallow *Riparia riparia*	BLMS/T	The state's largest remaining breeding populations are along the Sacramento River from Tehama County to Sacramento County and along the Feather and lower American Rivers and Cache Creek, in the Owens Valley; nesting areas also include the plains east of the Cascade Range south through Lassen County, northern Siskiyou County, and small populations near the coast from San Francisco County to Monterey County	Nests in bluffs or banks, usually adjacent to water, where the soil consists of sand or sandy loam to allow digging	Loss of natural earthen banks to bank protection and flood control, erosion control related to stream regulation by dams	Known to nest at a limited number of locations (see Figure 8-14)
Yellow-breasted chat *Icteria virens*	--/SSC	Uncommon migrant in California; nests in a few locations with appropriate habitat, such as Sweetwater and Weber Creeks, El Dorado County; Pit River, Shasta County; Russian River, Sonoma County; Little Lake Valley, Mendocino County; and upper Putah Creek, Yolo County	Nests in dense riparian habitats dominated by willows, alders, Oregon ash, tall weeds, blackberry vines, and grapevines	Loss of riparian breeding habitat	Not known to occur in the watershed
Yellow warbler *Dendroica petechia*	MIS/---	Nests over all of California except the Mojave Desert region, and high altitudes in the Sierra Nevada; winters along the Colorado River and in parts of Imperial and Riverside Counties; two small permanent populations in San Diego and Santa Barbara Counties	Primarily nests in riparian habitats adjacent to creeks and rivers	Loss of riparian habitat	Known to nest in low numbers along creeks and rivers throughout the watershed
Tricolored blackbird *Agelaius tricolor*	--/SSC	Largely endemic to California; permanent residents in the Central Valley from Butte County to Kern County; at scattered coastal locations from Marin County south to San Diego County; breeds at scattered locations in Lake, Sonoma, and Solano Counties; rare nester in Siskiyou, Modoc, and Lassen Counties	Nests in dense colonies in emergent marsh vegetation, such as tules and cattails, or upland sites with blackberries, nettles, thistles, and grain fields;	Loss of wetland and upland breeding habitats from conver-sion to agriculture and urban development and water development projects, pesticide contaminant, human disturbance of nesting colonies	Known to nest in a limited number of locations along the Pit River and water delivery canals
Pallid bat *Antrozous pallidus*	--/SSC	Coastal mountains from Del Norte County to Sonoma Counties, through Cascades to Lassen County; south in Sierra Nevada to Kern County	Rocky outcrops, cliffs, crevices and pine tree snags for roosting; access to open habitats required for foraging	Unknown; presumed from habitat alteration and reduction in number of large trees and snags	Known to occur in coniferous forests in the watershed
Western red bat *Lasiurus blossevillii*	FSS/---	Distribution scattered and unclear in California	Riparian areas; roost in tree foliage	Unknown	Status unknown in the watershed
Spotted bat *Eudurma maculatum*	---/SSC	Distribution is unclear; several occurrences throughout state in a variety of habitats	Varied; found in desert habitats and mountain regions, especially in arid Pondersoa pine forests and marshlands; roosts in small cracks found in cliffs or rock crevices	Unknown	Status unknown in the watershed

Table 8-3 (cont.) SPECIAL-STATUS WILDLIFE SPECIES WITH POTENTIAL TO OCCUR IN THE UPPER PIT RIVER WATERSHED					
Common and Scientific Name	**Status [a] Federal/State**	**California Distribution**	**Habitats**	**Reason for Decline**	**Occurrence in Watershed**
Pale Townsend's (western big-eared bat) *Corynorhinus townsendii pallescens*	--/SSC	Klamath Mountains, Cascades, Sierra Nevada, Central Valley, Transverse and Peninsular Ranges, Great Basin, and the Mojave and Sonora Deserts	Mesic habitats; gleans insects from brush or trees and feeds along habitat edges	Unclear; possibly human disturbance	Status unknown in the watershed
Pygmy rabbit *Brachylagus idahoensis*	--/SSC	Found in the Great Basin in portions of Modoc, Lassen, and Mono Counties	Associated with tall, dense sagebrush, bitterbrush, and piñon-juniper habitats	Loss of habitat, habitat degradation from brush clearing and overgrazing	Not known to occur but suitable habitat is present
Western gray squirrel *Sciurus griseus*	MIS/---	Occurs throughout California in mountainous regions and riparian areas of the Coast, Cascade, and Sierra Nevada Ranges and riparian areas in the Central Valley	Most commonly found in oak or mixed woodlands, but also known to use coniferous forests without oaks; enlarges abandoned woodpecker holes for denning; caches acorns for winter use	Unclear; potential habitat loss, and reduced numbers from hunting	Found throughout the watershed in forested areas
Oregon snowshoe hare *Lepus americanus klamathensis*	--/SSC	Occurs near Mt. Shasta and the Trinity Mountains in Shasta and Trinity Counties; may also occur in the Warner Mountains in Modoc County	Most commonly found in thick montane riparian habitats or stands of young conifers interspersed with chaparral	Unclear; potential habitat loss from logging	Suspected to occur in the watershed
White-tailed jackrabbit *Lepus townsendii townsendii*	--/SSC	Crest and eastern slope of the Sierra Nevada from the Oregon border to Tulare and Inyo Counties	Occurs in sagebrush, juniper, high elevation open meadow and early successional stages of conifer habitat	Habitat conversion and modification	Not known to occur
Sierra Nevada red fox *Vulpes vulpes necator*	FSS/T	Cascade Range east to the Sierra Nevada then south to Tulare County	Red fir and lodgepole pine forests, generally from 5,000 to 8,400 feet, associated with mountain meadows	Reason for decline unclear; altered habitat from logging, grazing, and recreational activities	Not known to occur in the watershed; nearest recent record is ca. 15 miles southwest of southern watershed boundary
Ringtail *Basariscus astutas*	--/FP	Little information on distribution and abundance; apparently occurs throughout the state except for the southern Central Valley and Modoc Plateau	Occurs primarily in riparian but also known from most forest and shrub habitats from lower to mid-elevations	Loss and fragmentation of lowland riparian habitat	Known to occur in the southern portion of the watershed in mixed woodlands

Table 8-3 (cont.) **SPECIAL-STATUS WILDLIFE SPECIES WITH POTENTIAL TO OCCUR IN THE UPPER PIT RIVER WATERSHED**					
Common and Scientific Name	**Status [a] Federal/State**	**California Distribution**	**Habitats**	**Reason for Decline**	**Occurrence in Watershed**
American marten *Martes americana*	FSS/SSC	Coastal mountains from Del Norte County to Sonoma Counties, through Cascades to Lassen County; south in Sierra Nevada to Kern County	Mixed conifer habitats with high overstory cover; preference for riparian areas and other ecotonal habitats	Altered habitat from logging, historic trapping	Documented north of Adin and west of Long Bell on the Modoc NF; also known to occur Hat Creek RD in the Horse Creek and Beaver Creek drainages
Pacific fisher *Martes pennanti pacifica*	--/SSC	Coastal mountains from Del Norte County to Sonoma Counties, through Cascades to Lassen County; south in Sierra Nevada to Kern County	Mixed conifer habitats with high overstory cover; preference for riparian areas and other ecotonal habitats	Altered habitat from logging, historic trapping	Contact the local biologists and timber company biologists
California wolverine *Gulo gulo luteus*	FSS/T	Klamath and Cascade Ranges south through the Sierra Nevada to Tulare County	Sighted in a variety of habitats from 1,600 to 14,200 feet; most common in open terrain above timberline and subalpine forests	Reason for decline unclear; altered habitat from logging and recreation activities	Not known to occur in the watershed but has potential
Pronghorn *Antilocapra americana*	MIS/---	Eastern slope of Cascade and Sierra Nevada Ranges in Modoc, Lassen, Plumas, and Sierra Counties.	Forage mostly in sagebrush scrub and juniper woodlands; use forested areas during migration	Limited range; heavy snow affects winter survival	Found throughout the watershed in valley bottoms; also found in forested areas during migration
Mule deer *Odocoileus hemionus*	MIS/---	Cascade Range and Great Basin Eastern	Summer at higher elevations in coniferous forests and riparian areas; winter in lower elevations near valley edges	Loss of summer range habitat; mortality from vehicles and lions	Found throughout the watershed in most habitats

[a] **Status definitions:**
E=Listed as Endangered under the federal or state Endangered Species Act
T=Listed as Threatened under the federal or state Endangered Species Act
SSC=California species of special concern
FP=California fully protected species
FSS=United States Forest Service Sensitive Species
BLMSS=Bureau of Land Management Sensitive Species
MIS=United States Forest Service Management Indicator Species

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Section 9

Section 9
FISHERIES AND AQUATIC RESOURCES

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Section 9
FISHERIES AND AQUATIC RESOURCES

INTRODUCTION

Hydrologic Cycle

Water is one of the most important resource on the planet and is critical for all life. Water is used on a daily basis for human consumption and recreation, to irrigate crops and water livestock, and to support the flora and fauna in a healthy, functioning ecosystem. Water is continuously cycled between bodies of water, land, and air. Heat from the sun evaporates water from lakes and reservoirs, wet ground, and plants (i.e., evapotranspiration) into the air. Water vapor is carried by air currents until the air temperature decreases and the water vapor condenses to form liquid water that falls as precipitation. Most of the precipitation will quickly run into streams and rivers to feed lakes and oceans. A smaller portion percolates into the ground where it is either used by plants or feeds aquifers. This water cycling process is called the hydrologic cycle (Leopold, 1974).

Aquatic Biology

Water is critical for all life, not just organisms that live in the water. A healthy watershed secures the future for farmers, recreationists, and the local economy, as well as fish and wildlife. For the farming and ranching community, a healthy watershed reduces the risk of severe floods, which can result in a loss of crops and pasture land, and create economic hardship. Many types of land use, including development for human use (e.g., paving, housing development, etc.), ranching, farming, logging, aquaculture, and others, can result in alterations to the stream banks, upslope areas, and/or timing and magnitude of runoff events that can impact conditions in streams, rivers, and lakes. Disturbance in a watershed can quickly result in channel instability in the form of stream course alteration, channel widening and/or incision (i.e., gullying), bank washouts, and bed aggradation. Recreation activities, such as boating, hiking, and fishing can also impact a watershed, but when managed properly, recreation can be sustainable and aid the local economy. Native flora and fauna have evolved their lifecycles around the physical aspects of the watershed. Alterations to the watershed can limit the growth and reproduction of flora and fauna, which can impact watershed biodiversity, which in turn affects people and the local economy.

Aquatic biology plays a major role in the biodiversity and health of a watershed. From an ecological point of view, all living organisms are interconnected in a large, complex, and continuous web. Each alteration in this web can disrupt the natural balance of an ecosystem. A web consists of four main parts: primary producers (plants), primary consumers (herbivores), secondary consumers (predators), and decomposers (bacteria). Primary producers, such as plants and algae, use nutrients and energy from the sun to grow (Campbell, 1990). They provide food for the primary consumers, such as herbivorous macroinvertebrates (e.g., insects, crustaceans, molluscs, and aquatic worms) and provide habitat and shelter for the primary and secondary consumers. Secondary consumers, such as predatory macroinvertebrates, fish (e.g., trout), reptiles (e.g., lizards), amphibians (e.g., frogs), birds, and mammals feed on the herbivorous macroinvertebrates. A possible tertiary consumer level can be found, that feeds on the secondary consumers. Species at this level are larger predatory fish (e.g., trout, bass), reptiles (e.g., snakes), birds (e.g., osprey, cormorant), and mammals (e.g., otter, bear). Decomposers break down dead or discarded organic matter from all groups (i.e., producers, 1°, 2°, and 3° consumers, and decomposers) and return the stored nutrients to the system, where they will once again enter the complex web of interactions (Begon et al., 1986; Campbell, 1990).

Aquatic biology is also important in terms of biological assessment programs. Aquatic biology studies can provide insight into the current health and/or biodiversity of a stream, lake, or watershed. The abundance and species diversity of macroinvertebrates, insects in particular, play a major role in aquatic biological assessment programs. Specific groups of insects are susceptible to specific types of disturbances (e.g., levels of suspended matter, altered temperature regimes, chemical spills) and therefore can be used as indicators to determine what alterations have occurred to a stream, lake, or watershed. This information can be used by local interest groups to setup management plans to limit disturbances, restore the damaged watershed sections, and strive to increase the overall health of a stream, lake, or watershed to its natural state. Ecosystems are extremely complex and although the species diversity in a system may be low (e.g., high alpine snowmelt streams) it may well be in pristine condition. On the same token, high species diversity does not automatically imply an undisturbed system. A firm understanding of the ecosystem as a whole is needed to determine if and what disturbances have taken place.

SOURCES OF DATA

Information on the distribution, abundance, and biology of native and exotic aquatic species was primarily obtained from literature (Calhoun, 1966; Jennings and Hayes, 1994; Moyle et al., 1995; Moyle and Daniels, 1982; Behnke, 1992; Moyle, 2002) and from unpublished data, some of which was obtained at the California Department of Fish and Game (CDFG) Honey Lake field office near Susanville, and the U.S. Forest Service (USFS) and Bureau of Land Management (BLM) offices in Alturas. Rutter (1908) and Moyle and Daniels (1982) provided fish distribution data for a range of sites throughout the watershed. Robert Daniels, Ph.D. allowed copies to be made of unpublished 1974 field data from Moyle and Daniels (1982), which provided fish abundance data for a range of sites throughout the watershed. The Yreka and Klamath offices of the U.S. Fish and Wildlife Service (USFWS) provided official lists of threatened and endangered species for Siskiyou and Modoc counties. The USFWS office in Sacramento provided threatened and endangered species lists for USGS 7.5-minute topographic maps located within the Upper Pit River Watershed and within their jurisdiction (i.e., Lassen, Shasta, and small sections of Siskiyou and Modoc counties). CDFG information on special status species was obtained, by VESTRA Resources Inc. from the California Natural Diversity Database (CNDDB). Additional biological data were compiled from prior surveys and reports done by Spring Rivers (Ellis and Hesseldenz, 1993; Ellis, 1996; Ellis and Cook, 1998; Cook and Ellis, 2001).

The most recent survey for the Pit River, which was conducted in 2002 by Reid et al. (2003), provides data on fish composition in the mainstem, North Fork, and South Fork of the Pit River. Reid et al. (2003) also makes species-specific comparisons of fish species found during historic collections and 2002 surveys for the region. Because it represents the most recent study on the Pit River, this document has been included in its entirety as an appendix to this section.

CDFG provided fish stocking information in the form of allotment data sheets for 2001 and 2002. These sheets were used to obtain a list of stocked water bodies that were located within the Upper Pit River Watershed. Maps, obtained from VESTRA Resources Inc., atlases, and an online topographic mapping service, topozone.com, were used to determine which bodies of water were within the study area. This list was then used to obtain annual fish stocking data from planting records and planting receipts located at the Crystal Lake Hatchery and the Mount Shasta Hatchery. While searching through the planting data, other water bodies within the project area were found and added to the list of stocked water bodies.

The annual planting data has been summarized in tabular form to show the number of fish planted by-species, as well as average, standard deviation, and range of fish planted annually, and the year or range of years that plantings occurred. Data from the two hatcheries were obtained from 1937 to present and 1955 to the present. The Mount Shasta Hatchery lacked planting records for before 1937 and for the period 1944 to 1957. The Crystal Lake Hatchery lacked planting records for before 1955, although the hatchery opened in 1947. Files, located at the CDFG Region I office in Redding, provided planting data for some of the missing years. These files also provided planting information on other water bodies in the project area, other hatcheries involved with planting trout and other gamefish, and letters and reports on dam constructions, water rights, water quality, biological surveys, and fish eradication practices.

RESULTS

Fish Assemblages

Moyle and Daniels (1982) created four distinct fish assemblages for the Upper Pit River Watershed based on the 1973 to 1974 surveys (Figure 9-1). The fishes in each assemblage are specifically adapted for definable sets of environmental conditions (Moyle and Daniels, 1982; Moyle, 2002). Although boundaries are generally not sharply defined and other fishes can dominate small stream sections, these fish assemblages provide a useful tool to characterize sections of the watershed.

The rainbow trout assemblage is found in cold, high-gradient upper reaches of tributaries, particularly in the upper reaches of tributary streams to the North Fork and South Fork of the Pit River in the Warner Mountains, the Adin Mountain range, and the headwaters of Willow Creek, a tributary to Ash Creek. Rainbow trout (or redband trout) were most abundant, although brown trout were also common, while high-elevation streams and lakes mostly contained brook trout. Pit sculpin and Sacramento sucker were often associated with the trout assemblage (Moyle, 2002).

The Pit sculpin-dace-sucker assemblage occupies most of the lower reaches of the North Fork of the Pit River tributaries in the Warner Mountains, the entire South Fork of the Pit River and its lower tributary reaches, Butte Creek (a tributary to Ash Creek), and the lower reaches of streams in the Adin Mountain range. In the upper reaches of these streams, this assemblage usually contains four species with Pit sculpin most abundant in riffles, speckled dace most abundant in pools, and Sacramento suckers and rainbow or brown trout are also present in lower abundance (Moyle, 2002). Diversity increases downstream as California roach, Sacramento pikeminnow, and green sunfish appear in small numbers. All stream sections containing Modoc sucker are occupied by the Pit sculpin-dace-sucker assemblage (Moyle, 2002). In the similar Sacramento-San Joaquin river system, trout show a higher trout abundance in this assemblage. The lower abundance may be a result from loss of riparian vegetation from cattle grazing (Moyle, 2002). These streams have moderate gradients and equal pool and riffle habitat. These streams may become intermittent in dry years with summer water temperatures of 20 to 25 °C (Moyle and Daniels, 1982; Moyle, 2002).

The pikeminnow-hardhead-sucker assemblage occurs in the North Fork of the Pit River, Rattlesnake Creek from Big Sage Reservoir outflow to the Pit River confluence, in the Pit River between Thoms Creek near Canby and the Turner Creek Watershed, Ash Creek and its tributary Willow Creek, and the Pit River canyon near and including Horse Creek. Sacramento pikeminnow, hardhead, and Sacramento sucker are most abundant and occur in deep, rocky-bottomed pools of these tributaries, characteristic of this assemblage's habitat (Moyle and Daniels, 1982), while tributary riffles are occupied by rainbow trout, speckled dace, and Pit sculpin (Moyle, 2002).

The introduced warm water fish assemblage dominates the mainstem Pit River in Warm Springs Valley (i.e., from Alturas to Canby), Big Valley, and the Fall River Valley upstream of the confluence of Fall River. The mainstem Pit River in the Warm Springs, Big, and Fall River valleys was originally occupied by fishes in the pikeminnow-hardhead-sucker assemblage (Rutter, 1908), but now consists of largemouth bass, golden shiner, bluegill, green sunfish, brown bullhead, and Sacramento sucker (Moyle, 2002). These species are found in slow moving, warm, turbid water including many of the reservoirs (Moyle and Daniels, 1982).

The most recent survey led by S. Reid from the USFWS in Klamath Falls (Reid et al, 2003) reported that the fish composition in the Pit River is largely similar to historic surveys. Redband trout were not found in the North Fork of the Pit River during the surveys conducted in the summer, which may be the result of dewatering or stagnation. There was no indication that Modoc suckers were present in the mainstem of the Pit River downstream of Alturas. Modoc sucker genetic markers, however, were found in Sacramento suckers from the upper South Fork of the Pit River, which suggests that Modoc suckers were either once found or may still occupy a tributary in the upper South Fork of the Pit River. The upper South Fork of the Pit River is well outside the previously known range of Modoc suckers in the Pit River drainage. Research is ongoing and questions should be directed to S. Reid of USFWS in Klamath Falls. Warm water fish assemblages dominate the Upper Pit River. In the sites surveyed in the upper Pit River, exotic species were only a relatively minor component of the fish communities. Exotic fishes that were most commonly collected during both the historic and 2002 surveys were green sunfish and brown bullhead in the mainstem of the Pit River near Alturas and brown trout in the upper South Fork of the Pit River. Largemouth bass and channel catfish were not encountered during the 2002 survey. Trout were not detected in the mainstem of the Pit River below Alturas.

Native Fishes

Lampreys: Family Petromyzontidae

Pit-Klamath Brook Lamprey

Pit-Klamath brook lamprey, *Lampetra lethophaga*, is endemic and widely distributed in the Upper Pit River Watershed. Ammocoete larvea occur in low-gradient reaches with cool, clear water, floating vegetation, and a muddy substrate in which the ammocoete larvae live (Moyle and Daniels, 1982). They also occur in muddy stream edges and backwaters of high-gradient water reaches. Species associated with Pit-Klamath brook lamprey are speckled dace, rough sculpin, and marbled sculpin. Pit-Klamath brook lamprey lacks a parasitic adult life stage. Channelization of a section of Rush Creek, Modoc County, resulted in an increase of ammocoetes in the mud bottom of a pool formed at the end of the channel (Moyle, 2002). Rutter and Chamberlain (Rutter, 1908) collected lamprey, which they identified as a Goose Lake lamprey (*Lampetra tridentata*), in the South Fork Pit of the River near the South Fork Post Office and in Goose Lake in 1898 (Table A-1 in Appendix 9-A).

During Moyle and Daniels' 1973 to 1974 surveys (1982), Pit-Klamath brook lampreys were found in the Ash Creek and Parker Creek drainages (Table A-2 in Appendix 9-A).

Minnows: Family Cyprinidae

Pit River Tui Chub

Moyle (2002) recognizes several subspecies of tui chub, *Siphateles* (=*Gila) bicolor*. Although the Pit River tui chub has been recognized as a subspecies, but needs further clarification in order to give it official subspecies status (Moyle, 2002). The tui chub's distribution is scattered and its status is uncertain (Moyle, 2002). Chub inhabit slow, deep water in lakes, reservoirs (e.g., Dorris Reservoir and West Valley Reservoir), and the backwater reaches of rivers (e.g., Fall River and Ash Creek) (Moyle and Daniels, 1982). Chubs have a wide optimum temperature range (i.e. 15 to 30° C), can tolerate high alkalinity (i.e., pH 9 to 11), and are able to survive in lakes with dissolved oxygen levels as low as 25 percent. Eggs are deposited on aquatic vegetation or algae-covered rocks and gravel in water less than 1.5 meters deep (Moyle, 2002).

Rutter and Chamberlain (Rutter, 1908) collected tui chub in the Pit River at Canby and Pittville, Ash Creek at Adin, and the South Fork Post Office on the South Fork of the Pit River (Table A-1 in Appendix 9-A). During Moyle and Daniels 1973 to 1974 surveys, a single tui chub was collected in both Ash Creek and Rattlesnake Creek (Table A-2 in Appendix 9-A). Moyle and Daniels (1982) do make note of CDFG or USFS records of tui chub in several reservoirs (e.g., West Valley Reservoir, Big Sage Reservoir).

Sacramento Pikeminnow

The Sacramento pikeminnow, *Ptychocheilus grandis*, is widespread and mainly inhabits pools and runs in clear, warm (18 to 8° C/64.4 to 46.4° F), low-gradient river sections with muddy or rocky bottoms and overhanging vegetation (Moyle and Daniels, 1982; Moyle, 2002). Spawning occurs at night with the males congregating in favorable spawning areas. Females release eggs near the bottom, which are simultaneously fertilized by one or more males and then sink to the bottom. A female releases 15,000 to 40,000 eggs, which adhere to rocks and gravel (Moyle, 2002).

Rutter and Chamberlain (Rutter, 1908) collected Sacramento pikeminnow from the Pit River at Canby, Bieber, and Pittville, the North Fork at Alturas, and Ash Creek at Adin (Table A-1 in Appendix 9-A). Sacramento pikeminnow were relatively common in the mainstem Pit River, North Fork of the Pit River, and the Ash Creek drainage, but are absent from the South Fork of the Pit River in 1973 and 1974 (Moyle and Daniels, 1982, Table A-2 in Appendix 9-A).

Speckled Dace

Speckled dace, *Rhinichthys osculus*, occur in most streams and lakes of the Upper Pit River Watershed. They inhabit virtually any habit from slow to fast moving water, small creeks to large rivers, and deep pools, as long as the water is well-oxygenated, clear, and provides ample deep cover in the form of vegetation and rocks (Moyle and Daniels, 1982; Moyle, 2002). They appear to have benefited from human stream channel alterations, such as dewatering of Pit River sections for hydroelectric power purposes, and channelization practices (Moyle and Daniels, 1982). Females deposit eggs under rocks or in gravel beds to which they adhere (Moyle, 2002).

Rutter and Chamberlain collected speckled dace in the mainstem Pit River at Canby, North Fork of the Pit River at Alturas, at the mouth of Joseph Creek, the South Fork of the Pit River at the South

Fork Post Office, and Ash Creek at Adin (Table A-1 in Appendix 9-A). In 1973 to 1974, Moyle and Daniels found speckled dace in Horse Creek and in the mainstem Pit River near the Horse Creek confluence. Speckled dace were most abundant in the North Fork of the Pit River and its tributaries, but were also collected in Ash Creek, Turner Creek, and Canyon Creek subdrainages. A few individuals were collected from Rattlesnake Creek in Warm Springs Valley and from Parsnip and Harvey creeks in the South Fork of the Pit River drainage (Table A-2 in Appendix 9-A).

Suckers: Family Catostomidae

Sacramento Sucker

Sacramento suckers, *Catostomus occidentalis*, are present throughout the Upper Pit River Watershed and seem to withstand pressure from exotic species well, particularly in the warmwater sections of the Pit River, such as Big Valley (Moyle and Daniels, 1982). Adult Sacramento suckers are most abundant in cool, larger streams and rivers with moderate gradient and many pools, while juveniles are often associated with tributaries and slower reaches of the large river (Moyle, 2002). Sacramento suckers congregate to spawn, eggs adhere to gravel, and females can deposit 4,700 to 11,000 eggs (Moyle, 2002). Sacramento suckers can be long-lived; in Crystal Springs in the upper Fall River drainage a 560-mm sucker was determined to be 20 years old. Sucker populations often have a nonuniform age structure strong year classes indicating that reproductive success is variable. Reproductive success is highest during wet years, when high flows improve access to spawning habitat and provide additional rearing habitat for larvae and small juveniles (Moyle, 2002).

Rutter (1908) reports Sacramento suckers from the South Fork of the Pit River at the South Fork Post Office (Table A-1 in Appendix 9-A). During Moyle and Daniels' 1973 to 1974 surveys, Sacramento suckers were found throughout the mainstem Pit River and the North Fork of the Pit River and its tributaries, but were absent from the South Fork of the Pit River and its tributaries (Moyle and Daniels, 1982, Table A-2 in Appendix 9-A). Moyle and Daniels (1982), however, do make note of a CDFG or USFS record of Sacramento sucker in West Valley Reservoir.

Trout, Salmon, Char, and Whitefish: Family Salmonidae

Rainbow Trout

Rainbow trout, *Oncorhynchus mykiss*, are native to the Pit River, but their distribution has increased dramatically due to fish planting above natural barriers (Moyle, 2002). Rainbow trout utilize most habitats, but are most abundant in cool, clear, high-gradient stream sections with adequate shade and riffles, and predominately rocky bottoms (Moyle and Daniels, 1982). The highest abundance of rainbow trout occurs in habitats where they coexist with pit sculpin, brown trout, and speckled dace (Moyle and Daniels, 1982). Females dig redds (i.e., spawning "nests") and lay eggs in gravel, usually at the end of a pool or in a riffle, at water depths of 10 to 150 cm and water velocities ranging from 20 to 150 cm/sec (Moyle, 2002). Females lay 200 to 12,000 eggs that hatch in 3 to 4 weeks, and fry emerge from the gravel 2 to 3 weeks later (Moyle, 2002).

Several tributaries of the North Fork of the Pit River (i.e., Joseph, Parker, and East creeks) contain rainbow trout that are genetically similar to Goose Lake redband trout, which is an unnamed subspecies of rainbow trout (*Oncorhynchus mykiss* subspecies) endemic to Goose Lake (Moyle, 2002). Redband trout collected in South Fork Parker Creek were anatomically similar to specimens collected by Snyder in 1904 (Behnke, 1992).

The historical distribution of rainbow trout in the Upper Pit River Watershed is difficult to assess. Rutter (1908, page 110) states the following:

> North Fork of Pitt River, when seen in September 1898, was a small stream almost dry. There were a few pools where fishes lived, where even trout were found, but it was a very insignificant stream. A sawmill near its source fills the water with sawdust and doubtless does much damage to fishes, though it is doubtful whether there are ever many valuable fishes in the stream.
>
> South Fork of Pitt River is a larger stream, with pure water, but it is almost drained by irrigation ditches.
>
> The upper Pit River, above the mouth of Fall River, was nearly dry in August 1898. What water it contained was of a slightly milky color. The rocks on the bottom were covered with a spongy slime. Such fishes as trout or salmon would not live in it at that time of year.

This account shows that by the late 1800s human activities had already significantly altered the natural system making it difficult to determine the natural condition. During surveys of the Upper Pit River Watershed by Rutter and Chamberlain in late August and early September of 1898 (Rutter, 1908) and Moyle and Daniels in the summers of 1973 and 1974 (Moyle and Daniels, 1982) rainbow trout were not found in the mainstem Pit River (Tables A-1 and A-2 in Appendix 9-A). During both surveys, rainbow trout were found in the North Fork and South Fork of the Pit River, but their greatest abundance was in the tributary streams. The abundance of rainbow trout in the North Fork was about 5% that in the North Fork tributaries, while the abundance of rainbow trout in the South Fork was about 17% the abundance in the South Fork tributaries (see Table A-2 in Appendix 9-A) (Moyle and Daniels, 1982). In 1973 to 1974, the tributaries to the mainstem that contained rainbow trout were Horse Creek and the Ash and Turner creek drainages (Moyle and Daniels, 1982).

Chinook Salmon

Chinook salmon, *Oncorhynchus tshawytscha*, once ascended the Pit River as far upstream as Fall River, but not into the Upper Pit River Watershed. The Pit River had spectacular runs of chinook salmon before the construction of Shasta Dam in 1945 (Moyle and Daniels, 1982). Prior to the construction of Shasta Dam, spring-run chinook ascended the Pit River to spawn in both Hat Creek and Fall River. Although the Pit River Falls may have been a barrier in dry years, salmon were able to pass the falls in high-water years, especially after a fish ladder was blasted into the south side of the falls in 1881 (Throckmorton, 1882; Yoshiyama et al., 2001). The following account is from Rutter (1908, page 110): "Pitt River Falls, which are 65 feet high, are thought by many to rival in beauty any to be seen in the Yosemite Valley. The middle portion is a sheer fall, but ledges break each side, so that it is possible in high water for fish to pass. A fish ladder has been blasted out of the rock near the left bank, and salmon now go over the falls in considerable numbers." Salmon did not go into the Upper Pit River Watershed above the confluence with Fall River (Rutter, 1903, 1908). The following description is from Rutter (1903, page 121 to 122): "The salmon of the spring run ascend the [Sacramento] river to the headwaters, such as the Upper Sacramento, McCloud River, and Hat Creek, and some of the earlier ones even pass Pit River Falls and ascend Fall River to its source. They are not found in Pit River above the mouth of Fall River. By the time they reach this portion of the stream, the Upper Pit River is very low and the water impure, and the salmon all turn into Fall River. The salmon of this, the spring run, spawn mainly in August."

Sculpins: Family Cottidae

Pit Sculpin

Pit sculpin, *Cottus pitensis*, occur in almost all reaches of the Pit River system where temperatures remain below 25° C (77° F) and dissolved oxygen is near saturation (i.e., 100 percent). They are absent from the Big Valley section of the Pit River (Moyle and Daniels, 1982). Pit sculpin predominately inhabit riffle sections, where they selectively search for benthic invertebrates without cases or shells (Moyle, 2002). Males make and defend nesting sites under rocks or submerged logs and entice several females to deposit eggs (Moyle, 2002). Although fecundity is relatively low (61 to 320 eggs per female) their population is stable, possibly in part, due to their aggressive nature of keeping other fish away from riffle areas (Moyle, 2002).

Rutter and Chamberlain's 1898 surveys showed a similar widespread distribution that also excluded locations in Big Valley (Rutter, 1908, Table A-1 in Appendix 9-A). During Moyle and Daniels (1982) 1973 to 1974 surveys, they found Pit sculpin in most reaches of the Upper Pit River Watershed, but they were not collected in the mainstem Pit River in Big Valley (Table A-2 in Appendix 9-A).

Surfperches: Family Embiotocidae

Tule Perch

Although Rutter (1908) records tule perch, *Hysterocarpus traski*, in the mainstem Pit River at Pittville, this record should be verified (Table A-1 in Appendix 9-A). Tule perch were not found by Moyle and Daniels (1982) in the Upper Pit River Watershed or any location upstream of the Pit River falls (Table A-2 in Appendix 9-A). Tule perch are found in the Pit River downstream of the Pit River falls (Moyle, 2002; PG&E unpublished data).

Threatened and Endangered Species

The following section presents a brief summary of the threatened and endangered aquatic species found within or adjacent to the Upper Pit River Watershed area. Table 9-1 provides a summary of all threatened and endangered aquatic species found within or adjacent to the Upper Pit River Watershed area. Appendix 9-A presents detailed species accounts on the distribution, habitat, diet, reproduction, parental care, growth rate, cover/shelter requirements, species interactions, potential impacts and reasons for species decline, and measures to avoid, minimize, or mitigate impacts for the federally and state-listed endangered Modoc sucker and Shasta crayfish, and the California-listed threatened rough sculpin.

Table 9-1
SPECIAL-STATUS AQUATIC WILDLIFE WITH POTENTIAL TO OCCUR IN THE UPPER PIT RIVER WATERSHED

Common and Scientific Name	Status [a] Federal/State	California Distribution	Habitats	Reason for Decline	Occurrence in Study Area
Shasta crayfish (A) *Pacifastacus fortis*	E/E NDDB (7)	Rivers and creeks in northeastern Shasta County	Cold clear headwater spring pools and streams with abundant lava cobbles and boulders on clean unembedded gravel or sand with minimal sediment transport, elevation around 1000 m	Non-native crayfish, habitat fragmentation	Absent, limited to mid-Pit and Fall rivers and Hat Creek drainages downstream of study area
Modoc sucker *Catostomus microps*	E/E NDDB (7)	Present only in Modoc County	Large pools (avoidance of extreme riffles) in medium gradient 3rd, 4th, and 5th order streams with water temperatures ranging between 15–22°C, elevation range 1300 m to 1540 m	Isolated populations, high susceptibility to local extinction from grazing, habitat loss, and water diversions, brown trout predation	Known to occur in Ash Creek and Turner Creek watersheds
Bull Trout (A) *Salvelinus confluentus*	T/E	Once present, but now extinct, in the McCloud River in Shasta and Siskiyou Co., it is likely that they were also present in coldwater reaches or spring creeks in the upper Sacramento and Pit rivers	Rivers with cold, clear water, often spring fed, with deep pools for adults and areas with large rocks or woody debris for juveniles.	Depletion of salmon runs, introduction of brook and brown trout, Shasta and McCloud dams sharply reduced and separated suitable adult and juvenile habitats	Absent
Lahontan cutthroat trout (A) *Oncorhynchus clarki henshawi*	T/–	Native to the eastern side of the Sierra Nevada: Carson, Walker, and Truckee rivers; also present in Owens, Yuba, Stanislaus, Mokelumne, and upper San Joaquin watershed	Variety of cool waters: from large terminal desert lakes to small mountain lakes, and from large rivers to headwater creeks	Isolated populations, high susceptibility to local extinction from: grazing, habitat loss, water diversions, introduced trout	Likely absent, the last of very few hatchery planting events occurred in 1986
Rough sculpin *Cottus asperrimus*	SC/T NDDB (1)	Present only in northeastern Shasta County	Cool, deep, clear, rapidly flowing water, rooted aquatic vegetation, and fine-grained substrate of gravel, sand, or silt	Habitat loss, sediment influx from human activity, warm water influx from rice paddies, and Hydroelectric projects	Absent, found downstream of study area in the Fall and Pit rivers
Redband trout *Oncorhynchus mykiss* subspecies	SC/SSC	Native to North Eastern California: Shasta, Siskiyou, and Modoc counties	Cold, clear, permanent streams with an abundance of riffles, some pools, and ample riparian vegetation cover	Hybridization with hatchery rainbow trout	Limited to a few tributaries of the North Fork of the Pit River
Bigeye marbled sculpin (A) *Cottus klamathensis macrops*	–/SSC NDDB (1)	Present only in northeastern Shasta County	Cool, deep, clear, rapidly flowing water, rooted aquatic vegetation, and moderately grained substrate of lava cobble	Habitat loss, sediment influx from human activity, warm water influx from rice paddies, Hydroelectric projects, and brown trout	Absent, found downstream of study area in the Fall and Pit river drainages

Table 9-1 (cont.)
SPECIAL-STATUS AQUATIC WILDLIFE WITH POTENTIAL TO OCCUR IN THE UPPER PIT RIVER WATERSHED

Common and Scientific Name	Status [a] Federal/State	California Distribution	Habitats	Reason for Decline	Occurrence in Study Area
Pit (=California) roach *Lavinia symmetricus mitrulus*	SC/SSC NDDB (4)	California roach are found in most of the state. They are native to the Sacramento-San Joaquin River drainage, Navarro, Gualala, and Russian rivers, streams tributary to Tomales Bay, Pascadero Bay (San Mateo Co.), and the Monterey Bay drainage. Pit roach, a subspecies, is found in the upper Pit River drainage	Generally found in small, warm intermittent streams; they are tolerant of high temperatures and low oxygen levels	Habitat loss from grazing riparian areas, road and house constructions, and water diversions and non-native fish	Known to occur in Beaver Creek (Lassen Co) and Ash Creek watershed
Hardhead (A) *Mylopharodon conocephalus*	–/SSC NDDB (3)	Widely distributed in low- to mid-elevation streams in the Sacramento-San Joaquin drainage	Typically found in larger low- to mid-elevation streams with clear, deep pools, sand-gravel-boulder substrates and slow water velocities	Habitat loss due to dams and water diversions and non-native fish	Known to occur in the mainstem Pit River
Cascade frog *Rana cascadae*	SC/SSC/FSS	From Shasta-Trinity region eastward to Modoc Plateau and southward to the Lassen region and upper Feather River system.	Bogs and ponds in mountain meadows at elevations from 230 m to 2500 m	Introduction of non-native predatory fish, loss of breeding habitat, potential habitat loss from fire suppression and elimination of grazing	Uncertain, possibly extant in the southwestern watershed near Lassen Volcanic National Park
Spotted frog *Rana pretiosa*	C/SSC/FSS NDDB (1)	Northeastern California, Modoc and Lassen counties; in Warner Mountains, and a tentative sighting at Sucker Springs Creek, Shasta County	Along marshy edges of ponds or lakes, or in algae grown overflow streams or pools, elevation range from 1000 m to 1450 m	Possibly at its most southern range limit	Likely occurs at several locations throughout the watershed
Northwestern pond turtle *Clemmys marmorata marmorata*	SC/SSC/FSS NDDB (1)	Northern California from the Oregon and Nevada borders to San Francisco Bay	Associated with permanent or nearly permanent water in a wide variety of habitats, elevation range from sea level to 1430 m	Habitat destruction	Known to occur in most of the watershed
Northern basalt flow vernal pool	NDDB (2)	Northeastern California	Ephemeral pools surrounded by juniper and sage scrub at 1500 m elevation		Known from Oak Ridge between Beeler Reservoir and Aspen Grove
Pit River drainage Modoc Sucker stream	NDDB (6)	Northeastern California	Modoc sucker habitat, elevation range from 1340 m to 1540 m	Stream channelization, grazing pressure, loss of riparian zone	Known from Ash Creek and Turner Creek drainages

[a] Status definitions:
A= Adjacent to assessment area
E=Listed as Endangered under the federal or state Endangered Species Act
T=Listed as Threatened under the federal or state Endangered Species Act
SC=Federal Species of Concern C=Federally listed Candidate species
SSC=California species of special concern
FSS=United States Forest Service Sensitive Species
CNDDB=California Natural Diversity Data Base (# of occurrences)

Suckers: Family Catostomidae

Modoc Sucker

Federal: Endangered
California: Endangered

The Modoc sucker, *Catostomus microps*, is limited to two small watersheds in the upper Pit River system: the Ash Creek and Turner Creek watersheds. In the Ash Creek watershed, Modoc suckers are found in Johnson Creek, Rush Creek, Dutch Flat Creek, and Willow Creek (Rutter, 1908; Moyle and Daniels, 1982; Scoppettone et al., 1992; Moyle, 2002, Tables A-1 and A-2 in Appendix 9-A). In the Turner Creek watershed, Modoc suckers are found in Turner Creek, Hulbert Creek, Washington Creek, Coffee Mill Gulch, and Garden Gulch (Scoppettone et al., 1992; Moyle, 2002). Modoc suckers inhabit large pools and avoid extreme riffles in medium-gradient 3rd-, 4th-, and 5th-order streams with water temperatures ranging between 15 to 22°C. Modoc suckers feed on detritus, algae, and some aquatic insects and crustaceans. Fish species associated with Modoc sucker are rainbow trout, speckled dace, California roach, and Pit sculpin (Moyle and Daniels, 1982). Spawning occurs over gravel beds, where fertilized eggs become lodged between gravel (Moyle, 2002). The main reasons for the endangered species listing of the Modoc sucker are (1) isolation, which increases the chance of local extinction, (2) channelization, which has reduced pool habitat, (3) grazing, which affected stream channel flows by removal of riparian vegetation, (4) water diversions, which reduced water flow in Modoc sucker habitat, and (5) predation by exotic brown trout (Moyle, 2002).

Trout, Salmon, Char, and Whitefish: Family Salmonidae

Lahontan Cutthroat Trout

Federal: Threatened
California: —

Lahontan cutthroat trout, *Oncorhynchus clarki henshawi*, are not native to the Upper Pit River Watershed, but a few introductions have been made since the first planting event in 1931. The historic range of Lahontan cutthroat trout was the Lahontan basin, exclusive of the Humboldt River system. They occurred in Truckee, Carson, Walker, and Quinn rivers and Lake Tahoe, Pyramid, Walker, Donner, Independence, and Summit Lakes (Behnke, 1992; Moyle, 2002). Native Lahontan cutthroat trout still occur in Independence Lake and Summit Lakes (Behnke, 1992). Lahontan cutthroat trout are noted for their ability to thrive in high alkaline (3,000 to 13,000 mg/liter total dissolved solids, pH 8.5 to 9.5) lakes. Lahontan cutthroat trout utilize cold streams (rarely more than 23° C) with high dissolved oxygen levels, and an abundance of cover and food (Moyle, 2002). Spawning females produce 400 to 8,000 eggs that they deposit on gravel riffles (Moyle, 2002). Lahontan cutthroat trout were federally listed as endangered in 1970, but their status was changed to threatened in 1975.

Bull Trout

Federal: Threatened
California: Endangered

Bull trout, *Salvelinus confluentus*, became extinct in the McCloud River in the 1970s. For nearly 100 years, bull trout were lumped with Dolly Varden trout (*Salvelinus malma)*, which is a largely anadromous (i.e., going up rivers from the ocean to spawn) coastal species. Although there is no record of bull trout in the Upper Pit River Watershed, Moyle (2002) speculated that this species may once have been present in the Fall River drainage based on their life strategies. They inhabit extremely cold, clear water, often with spring origins (Moyle, 2002) very similar to the Fall River. Females lay 1,000 to 12,000 eggs on gravel beds, often near upwelling water from springs and in low-gradient stream sections (Moyle, 2002).

Sculpins: Family Cottidae

Rough Sculpin

Federal: Species of Concern
California: Threatened

The original distribution of rough sculpin, *Cottus asperrimus*, is thought to have been confined to Fall River, Hat Creek, and the midreaches of the Pit River drainage below Lake Britton Reservoir (Daniels and Courtois, 1982; Daniels and Moyle, 1999; Moyle, 2002). Rutter and Chamberlain found rough sculpin in two sites in the Fall River (Fall River Mills, Dana) during their 1898 surveys (Rutter, 1908, Table A-1 in Appendix 9-A). Rough sculpin are not abundant in the mainstem Pit River, which is dominated by Pit sculpin, *Cottus pitensis* (Moyle and Daniels, 1982). The habitat of rough sculpin is characterized by cool, deep, clear, rapidly flowing water, rooted aquatic vegetation, and fine-grained substrate of gravel, sand, or silt (Moyle and Daniels, 1982). Rough sculpin deposit their adhesive eggs in nests under lava cobble or small boulders. Rough sculpin females oviposit 800 to 3,000 eggs in a nest. Males defend the nest for two to three weeks. Sculpin feed primarily on aquatic insect larvae. Rough sculpin occur in the same habitat as the federally endangered Shasta crayfish (Moyle, 2002).

Invertebrates

Shasta Crayfish

Federal: Endangered
California: Endangered

Shasta crayfish, *Pacifastacus fortis*, is one of only three crayfish species native to California and only five species native west of the continental divide (all in the genus *Pacifastacus*). Within the small range of the Shasta crayfish, its distribution is very fragmented and limited to only a few areas (USFWS, 1998). Most populations of Shasta crayfish occur in the pristine headwater spring pools and streams where there are abundant lava cobbles and boulders on clean gravel or sand (Ellis, 1997, 1999). Shasta crayfish prefer stable unembedded substrate in systems with minimal sediment transport. This type of habitat is found primarily in the Fall River and Hat Creek subdrainages and Sucker Springs Creek in the midreaches of the Pit River drainage. Because of the spring-fed nature of these waters, the habitat in the spring areas is generally pristine and constant, with almost no seasonal or annual change in water temperature, flow, or clarity. Shasta crayfish have also been found in a few areas that have been altered or degraded and that have considerable variation in temperature and turbidity (Ellis, 1997, 1999).

Shasta crayfish have been found in most of the major headwater springs to the Fall and Tule river system, including Thousand Springs, Rainbow Spring, Spring Creek, Lava Creek, Ja She Creek, Crystal Springs, and the springs around the northern edge of the upper Tule River and Big Lake

(Ellis, 1996, 1999). Other populations of Shasta crayfish have been found in the mainstem Fall River and along the Tule River levee system along Horr Pond, southeastern and northeastern upper Tule River, and southeastern Big Lake (Ellis, 1996, 1999). Shasta crayfish have also been found in the mainstem Pit River between the confluences of Fall River and Hat Creek (Ellis, 1996, 1999).

Sacramento River and Sacramento Delta Species
The USFWS species list for several of the Upper Pit River Watershed quadrangles includes the following Sacramento River and Sacramento Delta species: Central valley steelhead (*Oncorhynchus mykiss*), chinook salmon (*Oncorhynchus tshawytscha*), coho (=silver) salmon *Oncorhynchus kisutch*), delta smelt (*Hypomesus transpacificus*), Sacramento splittail (*Pogonichthys macrolepidotus*), and longfin smelt (*Spirinchus thaleichthys*). These species are not within the project area; so further discussions of these species are not included.

Species that occur just outside the upper Pit River system, mainly the Fall River system, have been included in the discussions. These include: Shasta crayfish (*Pacifastacus fortis*), rough sculpin (*Cottus asperrimus*), bigeye marbled sculpin (*Cottus klamathensis macrops*), and bull trout (*Salvelinus confluentus*). The latter was included based on its endangered listing status, biology, and the speculation that it may have occurred in the Fall River system (Moyle, 2002).

Other Special Status Species

The following section presents a brief summary of other special status aquatic species found within or adjacent to the Upper Pit River Watershed area. Table 9-1 provides a summary of all special-status aquatic species found within or adjacent to the Upper Pit River Watershed area. The focus report presents detailed species accounts on the distribution, habitat, diet, reproduction, parental care, growth rate, cover/shelter requirements, species interactions, potential impacts and reasons for species decline, and measures to avoid, minimize, or mitigate impacts for the federal species of concern and California species of special concern redband trout.

Trout, Salmon, Char, and Whitefish: Family Salmonidae

Redband Trout
Federal: Species of Concern
California: Species of Special Concern

Redband trout, *Oncorhynchus mykiss* subspecies, are only found in three tributaries of the North Fork of the Pit River: Joseph Creek, Parker Creek, and East Creek (Moyle, 2002). These trout are genetically similar to the endemic Goose Lake redband trout, a currently unnamed subspecies of the rainbow trout, *Oncorhynchus mykiss* (Moyle, 2002). Redband trout collected in the South Fork Parker Creek were also anatomically similar to specimens collected by Snyder in 1904 (Behnke, 1992). Hybridization between redband trout and planted rainbow trout has not been verified (Behnke, 1992).

Minnows: Family Cyprinidae

Pit (=California) Roach

Federal: Species of Concern
California: Species of Special Concern

In the upper Pit River and tributaries, Pit roach, *Lavinia symmetricus mitrulus*, have been recognized as a subspecies of the California roach (Moyle, 2002). Moyle considers the Pit roach and all other subspecies of the California roach, except the Sacramento roach, to be California Species of Special Concern (Class 1-3). Moyle et al. (1995) considered Pit roach to be a Class 2 Species of Special Concern because it has apparently disappeared from much of its former range in the upper Pit River drainage (Moyle and Daniels, 1982) and is confined to a few scattered populations. Moyle et al. (1995) states that Pit roach populations require management to prevent them from becoming a threatened species. California roach are small minnows (adults usually <10 cm SL) that are generally found in small, warm intermittent streams. Roach are tolerant of high temperatures and low oxygen levels (Moyle et al., 1995) and appear to be habitat generalists. The abundance of Pit roach was positively correlated with the abundance of other native fishes. Roach are bottom feeders and have a small, subterminal mouth. Roach feed primarily on filamentous algae, but may also feed on crustaceans, insects, detritus, and diatoms and other unicellular algae. Reproduction occurs from March to June or July depending on water temperature. During spawning season, schools of roach move into shallow areas with moderate flow and gravel/rubble substrate. Females deposit adhesive eggs in the substrate interstices and attendant males fertilize the eggs. The female typically produces 250 to 900 eggs that hatch in two to three days. The fry remain in the substrate until they are free-swimming.

Rutter and Chamberlain's 1898 surveys provided records from the North Fork of the Pit River at Alturas and at the mouth of Joseph Creek (Rutter, 1908, Table A-1 in Appendix 9-A). During the 1973 to 1974 surveys, the distribution of Pit roach was limited to Beaver Creek in Fall River Valley and the Ash Creek drainage in Big Valley, both tributaries to the mainstem Pit River (Moyle and Daniels, 1982, Table A-2 in Appendix 9-A). Pit roach are not known to occur in the Fall River drainage, but are in the Pit River and in Bear Creek above the Fall River drainage (Moyle and Daniels, 1982).

Hardhead

Federal: —
California: Species of Special Concern

Hardhead, *Mylopharodon conocephalus*, are large minnows that can reach in excess of 60 cm SL (Moyle et al., 1995). They are typically found in larger, middle to low elevation streams in clear, deep, pools with sand-gravel-boulder substrates and low water velocities (Moyle et al., 1995). Hardhead are generally found in association with Sacramento pikeminnow and Sacramento suckers and are usually absent from streams where introduced species, especially bass and sunfish, predominate (Moyle et al., 1995). Hardhead undergo a shift in their diet with smaller fish (<20 cm SL) feeding primarily on mayflies, caddisfly larvae, and small snails and larger fish feeding more on aquatic plants, especially filamentous algae, as well as crayfish and other large invertebrates (Moyle et al., 1995). Hardhead become sexually mature following their second year and presumably spawn in the spring.

During the 1898 surveys by Rutter and Chamberlain (1908), hardhead were found in the mainstem

Pit River at Pittville, Bieber, and Canby, in the North Fork of the Pit River at Alturas, and in Ash Creek (Table A-1 in Appendix 9-A). Moyle and Daniels' 1973 to 1974 surveys revealed similar distribution, but included the Horse Creek and Turner Creek confluences with the mainstem Pit River, and the Parker Creek confluence with the North Fork of the Pit River (Table A-2 in Appendix 9-A).

Sculpins: Family Cottidae

Bigeye Marbled Sculpin

Federal: —
California: Species of Special Concern

The original distribution of bigeye-marbled sculpin, *Cottus klamathensis macrops,* is thought to have been confined to Fall River, Hat Creek, and the midreaches of the Pit River drainage (Daniels and Courtois, 1982; Daniels and Moyle, 1999). Rutter and Chamberlain found bigeye-marbled sculpin in two sites in the Fall River (Fall River Mills, Dana) during their 1898 surveys (Rutter, 1908, Table A-1 in Appendix 9-A). Bigeye marbled sculpin are not abundant in the mainstem Pit River, which is dominated by Pit sculpin, *Cottus pitensis* (Moyle and Daniels, 1982). The habitat of bigeye-marbled sculpin is characterized by cool, deep, clear, rapidly flowing water, rooted aquatic vegetation, and lava cobble substrate (Moyle and Daniels, 1982). Bigeye marbled sculpin deposit their adhesive eggs in nests under lava cobble or small boulders. A female oviposits 139 to 650 eggs in a nest. Sculpin feed primarily on aquatic insect larvae. Bigeye marbled sculpin occur in the same habitat as the state threatened rough sculpin and the federally endangered Shasta crayfish, therefore populations of bigeye marbled sculpin tend to get indirect protection (Moyle, 2002). Although bigeye marbled sculpin populations currently appear to be stable, their population in Fall River appears to have declined since 1898, possibly due to reduced water quality from agricultural practices, flow changes from hydroelectric projects, loss of lava substrate, and trout predation (Moyle, 2002).

Reptiles

Northwestern Pond Turtle

Federal: Species of Concern, USFS Sensitive Species
California: Species of Special Concern

The northwestern pond turtle, *Clemmys marmorata marmorata*, is an aquatic turtle primarily found in ponds, marshes, and streams west of the Cascade and Sierra Nevada mountains between extreme southwest British Columbia and northwest Baja (Stebbins, 1985). Both subspecies, southwestern and northwestern pond turtles, have been classified as state species of special concern because of an observed decline in their numbers associated with habitat destruction. Habitat for northwestern pond turtles is in relatively good condition and abundant in the Intermountain Area. Northwestern pond turtles are plentiful in the Fall River and Hat Creek drainages and are common in the midreaches of the Pit River (Ellis and Hesseldenz, 1993; Ellis and Cook, 1998).

Amphibians

Spotted Frog

Federal: Candidate Species, USFS Sensitive Species
California: Species of Special Concern

Spotted frogs, *Rana pretiosa*, are moderate-sized (60 to 110 mm SVL), brown frog with a highly variable pattern of dark spots (Jennings and Hayes, 1994). Spotted frogs have prominent dorsolateral folds and a ventral surface that can be brick red, reddish-orange, orange, or yellow and appears painted on (Stebbins, 1985; Jennings and Hayes, 1994). In California, this species is known from only seven records, one of which was collected by Rutter and Chamberlain in the Fall River at Fall River Mills, Shasta County on August 29, 1898 (USNM 38806, elevation ~3,280 feet). A single occurrence of a spotted frog is listed in the CNDDB for the Study Area. In 1910, the spotted frog was found in Modoc County on the South Fork of the Pit River in the Warner Mountains. A tentative identification of a spotted frog was made at Sucker Springs Creek downstream of the Study Area in November of 1999 (Ellis personal observation). The last verified sighting of this species in California was beneath a woodpile at the Modoc National Forest Fire Station in Cedarville (Modoc County) on September 24, 1989 (Jennings and Hayes, 1994).

Cascade Frog

Federal: Species of Concern, USFS Sensitive Species
California: Species of Special Concern

A moderate-sized (50 to 75 mm SVL) brown, red-brown, or slightly greenish brown frog that is usually spotted with a few to more than 50 inky black, distinct-edged dorsal spots (Jennings and Hayes, 1994). Cascade frogs, *Rana cascade*, have prominent dorsolateral folds and a distinct light jaw stripe (Jennings and Hayes, 1994). The ventral surface is yellow to cream and there is a diffuse light and dark reticulum (i.e., network) in the groin (Jennings and Hayes, 1994). Although no occurrences of cascade frogs are listed in the NDDB within the Study Area, a cascade frog was identified in 1995 near the site of Pacific Gas and Electric Company's Pit 1 Powerhouse, which is just downstream of the Study Area of interest. Three additional cascade frogs were identified from upper Rock Creek, which is a tributary to the Pit 3 Reach of the Pit River (EA, 1995). Figure 19 in Jennings and Hayes (1994) indicates that there was a museum collection of a cascade frog from the upper Fall River, but no date or other information is given. The Sacramento office of the US FWS has cascade frogs listed on three USGS 7.5-minute maps pertinent to the Study Area. The three USGS maps (i.e., Corders Reservoir, Jellico, and Harvey Mountain) are located in the southwestern part of the Study Area in Lassen and Shasta Counties.

Non-Native Fish

Minnows: Family Cyprinidae

Golden Shiner

Introduced in 1891 (Dill and Cordone, 1997), golden shiner, *Notemigonus chrysoleucas*, have been widely used as a forage and baitfish and as such have become widely established particularly in reservoirs. Rutter and Chamberlain did not report golden shiner in the Pit River drainage in 1898. During the 1973 to 1974 surveys, however, golden shiners were only found in Big Valley in the warm, slow, turbid reaches of the mainstem Pit River (Moyle and Daniels, 1982, Table A-2 in Appendix 9-A). Females lay 2,700 to 4,700 eggs on submerged vegetation where a male will fertilize them. Fry form schools and feed on rotifers and diatoms, while larger fish feed on crustaceans (i.e., cladocerans, copepods) and other large zooplankton (i.e., protozoans, rotifers) (Moyle, 2002). Little is known about the impact golden shiner have had on native fish, but in coldwater lakes, they may negatively affect trout populations by competing for zooplankton (Moyle, 2002).

Carp

First introduced in California in 1872 (Dill and Cordone, 1997), carp, *Cyprinus carpio*, were not found in the Upper Pit River Watershed in 1973 to 1974, but have been reported from Big Lake in the Fall River drainage and in Lake Britton and Shasta Lake downstream (Moyle and Daniels, 1982). Carp are generally most common in low-elevation reservoirs with warm, turbid water where they bottom feed on insect larvae, molluscs, algae, and vegetation (Moyle, 2002). Females will oviposit 50,000 to 200,000 eggs (~500 at a time) per season, which adhere to vegetation and bottom debris. Fry will remain under cover of vegetation until they reach 7 to 10 cm (Moyle, 2002). In California waters, carp have been held responsible for the decline of native fish populations and the destruction of waterfowl habitat (Moyle, 2002).

Bullhead Catfishes: Family Ictaluridae

Black Bullhead

Introduced as a gamefish in the 1930s (Dill and Cordone, 1997), black bullhead, *Ameiurus (=Ictalurus) melas*, are native to the eastern United States. Although they are generally associated with bluegill and green sunfish, they appear to be absent from locations (i.e. Big Valley) in the Upper Pit River Watershed where these sunfish species occur (Moyle, 2002). A single record exists for the presence of black bullhead collected in Big Lake in August 1978 (Moyle and Daniels, 1982). They preferably inhabit slow moving, warm, turbid waters (e.g., ponds, lakes, sloughs, and river backwaters) with muddy bottoms (Moyle, 2002). Black bullheads are omnivorous and feed on aquatic insects, crustaceans, molluscs, algae, dead fish, and an occasional live fish. Females construct nests as a shallow depression in the substrate where 1,000 to 7,000 eggs are oviposited. After hatching, a parent guards the young until they reach approximately 25 mm in length (Moyle, 2002). Their range appears to be expanding as a result of plantings and self-dispersal, but it is uncertain what impact black bullheads have on native fishes (Moyle, 2002).

Brown Bullhead

Brown bullhead, *Ameiurus (=Ictalurus) nebulosus*, are native to areas east of the Great Plains and were first introduced in California in 1874 as a game/food fish (Dill and Cordone, 1997). In 1890, the California Fish Commission reported that brown bullhead had been planted in every county in California (Moyle, 2002). In the Upper Pit River Watershed, brown bullhead were most abundant in the low-gradient, warm, turbid water reaches of the mainstem Pit River in Big Valley, Ash Creek, and several reservoirs (Moyle and Daniels, 1982, Table A-2 in Appendix 9-A). They were also present in Horse Creek and the mainstem Pit River in the Fall River and Warm Springs valleys. Brown bullheads are omnivorous and feed on aquatic insects, crustaceans, molluscs, algae, dead fish, and an occasional live fish. Females construct nests as a shallow depression in sand or gravel near aquatic vegetation and oviposit 2,000 to 14,000 eggs. Both parents guard the egg clutch and young until the young reach a length of approximately 50 mm (Moyle, 2002). Although the aquaculture industry produces small numbers to stock ponds for fee fishing, their range appears to be static (Moyle, 2002). It is uncertain what impact brown bullhead have on native fishes (Moyle, 2002).

Channel Catfish

Channel catfish, *Ictalurus punctatus*, are endemic to the Mississippi-Missouri River system, but have been widely introduced and moved in California in the late 1800s and early 1900s (Moyle, 2002) after the initial introduction in 1891 (Dill and Cordone, 1997). Rutter and Chamberlain collected channel catfish in the North Fork of the Pit River near Alturas (USNM 58213) and in the mainstem Pit River in Lassen County (USNM 58200). The only site that Moyle and Daniels (1982) found channel catfish was in the Pit River in Big Valley near Bieber (Table A-2 in Appendix 9-A). Adult channel catfish move into river channels at night to feed on crustaceans and fish, while juveniles spend most of their time in riffles (Moyle, 2002). Channel catfish have a caverniculous nesting behavior (i.e., nest in caverns), and will use old muskrat burrows, undercut banks, log jams, or human objects (e.g., barrels) to oviposit 2,000 to 70,000 eggs. The male usually aerates and guards the egg clutch and young until the young are approximately 7 days old (Moyle, 2002). It is uncertain what impact channel catfish have had on native fishes, amphibians, and crustaceans, but Moyle (2002) speculates that it has not been positive based on their feeding habits.

Trout, Salmon, Char, and Whitefish: Family Salmonidae

Brown Trout

Brown trout, *Salmo trutta*, were first introduced from Europe into California in 1893 (Dill and Cordone, 1997) and into the Pit River in the 1930s (Moyle and Daniels, 1982). Their widespread distribution is spotty, which may reflect hatchery-planting practices. They occur in the Ash Creek drainage, Jess Valley, tributaries of the North Fork of the Pit River, and the South Fork of the Pit River and its tributaries (Moyle and Daniels, 1982, Table A-2 in Appendix 9-A). They inhabit lakes and clear, cool (12 to 20° C), well-shaded water with deep pools or deep runs often with aquatic plants. Brown trout have shown to be extremely adaptable to changing conditions. After 400 years of selection pressure from anglers, they are able to maintain relatively high populations even in the presence of high angling pressure. In Rush Creek, Modoc County, brown trout have been identified as a major factor limiting the population of the endangered Modoc sucker (Moyle, 2002). Females select gravel bottoms to build redds where they will lay 200 to 21,000 eggs (Moyle, 2002).

Brook Trout

Brook trout, *Salvelinus fontinales*, are native to eastern North America. They were first introduced into California in 1871 (Dill and Cordone, 1997) and have since been regularly planted in high-elevation lakes (e.g. Medicine Lake in Siskiyou Co.) and creeks (e.g. Canyon Creek in Modoc Co.) within the Upper Pit River Watershed. Moyle and Daniels' 1973 to 1974 surveys (1982) only recorded brook trout from the upper reaches of East Creek, a tributary to the South Fork of the Pit River (Table A-2 in Appendix 9-A). Brook trout introductions into fishless lakes can cause the decline of amphibian populations that require fishless lakes for overwintering habitat and to secure brood survival (Moyle, 2002). Fecundity ranges between 200 and 600 eggs, which females will deposit on gravel often near a spring with upwelling cold water. Brook trout are one of the few salmonids that has been able to adapt and survive in lakes without inlets and outlets normally used for spawning, instead they use gravel banks at shallow lake edges (Moyle, 2002).

Arctic Grayling

Since the first introduction in 1906 (Dill and Cordone, 1997), arctic grayling, *Thymallus arcticus*, have had numerous other introductions into California waters. Occasionally, arctic grayling populations become established, but there appears to be no current population in California (Moyle, 2002).

Live Bearers: Family Poeciliidae

Western Mosquitofish

In 1922, western mosquitofish, *Gambusia affinis*, were introduced into California from central North America in efforts to control mosquitoes (Dill and Cordone, 1997; Moyle, 2002). Although only collected in the Fall River during the 1973 to 1974 surveys (Moyle and Daniels, 1982), the dispersal of mosquitofish into the warmer reaches of the Pit River system appears likely. Mosquitofish feed on the most abundant food present, ranging from mosquito larvae, to algae, to zooplankton (Moyle, 2002). Mosquitofish exhibit internal fertilization and females give birth to live young in shallow water with aquatic vegetation (Moyle, 2002). Their minimal presence in the Pit River system has not resulted in a problem, but they have been recorded to negatively impact native invertebrates and the eggs of amphibians (i.e., California newt (*Taricha torosa*) and Pacific treefrog (*Hyla regilla*)) in California (Moyle, 2002).

Striped Basses: Family Moronidae

Striped Bass

Introduced as a gamefish in 1879 (Dill and Cordone, 1997), striped bass, *Morone saxatilis*, are native to east and south coast rivers and estuaries of North America, the Atlantic Ocean, and the Gulf of Mexico. In July 1910, W. E. Rachford released 200 yearling striped bass into the North Fork of the Pit River near Alturas. Moyle and Daniels (1982) did not collect striped bass in their surveys, which likely means that they are currently absent. Additionally, striped bass require large cool rivers to spawn, a large water body with large populations of prey fish for adults, and large estuaries with an abundance of invertebrates for juveniles in order to maintain a viable population (Moyle, 2002). On the West Coast, only the San Francisco Bay provides all three conditions for striped bass, but fish from this population have migrated up the Sacramento River as far as the Red Bluff Diversion Dam (Moyle, 2002).

Sunfishes and Basses: Family Centrachidae

Sacramento Perch

Sacramento perch, *Archoplites interruptus*, which are the only centrarchid that occurs naturally west of the Rocky Mountains, are native to the Sacramento-San Joaquin river system (Moyle, 2002). Sacramento perch have become established in the Upper Pit River Watershed, which is outside their native range, after their introduction in West Valley Reservoir (Modoc County) in 1972 (Moyle and Daniels, 1982). They originally inhabited slow moving, fairly clear rivers and lakes with abundant aquatic vegetation and submerged objects necessary for immature fish, but they have been able to adapt to the turbid water and lack of aquatic plants in Moon Lake (Moyle, 2002). Adult Sacramento perch are piscivorous (i.e., feed solely or primarily on fish) and appear to prey selectively on cyprinids (Moyle, 2002). Male Sacramento perch defend small territories with vegetation, rocks, and debris to which a female adheres her eggs (Calhoun, 1966; Moyle, 2002).

Bluegill

Introduced for sport fishing in 1908 (Dill and Cordone, 1997), bluegill, *Lepomis macrochirus*, is common in warmwater reservoirs and other suitable warmwater habitats over much of California.

Bluegill are abundant in much of the mainstem Pit River, particularly in the warm (27 to 32° C in summer), low-gradient, and turbid sections in Big Valley, Fall River Valley, Warm Springs Valley where there is emergent aquatic vegetation (Moyle and Daniels, 1982, Table A-2 in Appendix 9-A). Bluegills are highly prolific and, in combination with its broad feeding habits, they may have seriously impacted native fish populations (Moyle, 2002). Males form a nesting colony, but construct and defend their own nests made in gravel, sand, dead leaves, sticks, or mud (Calhoun, 1966; Moyle, 2002). Females have 2,000 to 50,000 eggs, which they deposit over many nests; a nest generally holds 2,000 to 18,000 eggs, but may hold as many as 62,000 (Moyle, 2002).

Redear Sunfish

Redear sunfish, *Lepomis microlophus*, were introduced in the early 1950s (Dill and Cordone, 1997), well after the establishment of most other exotic fishes in California. Redear sunfish have not been associated with the demise of native fishes due in part to their relatively recent introduction, but also because of their predominately invertebrate diet (e.g., snails, immature insects, and crustaceans) (Moyle, 2002). In 1973 to 1974, redear sunfish in the Upper Pit River Watershed were limited to a farm pond draining into Rush Creek in Modoc County (Moyle and Daniels, 1982, Table A-2 in Appendix 9-A). Males construct a nest in a nesting colony in sand, gravel, or mud (Calhoun, 1966). Female fecundity ranges from 9,000 to 80,000 (Moyle, 2002).

Green Sunfish

Introduced by mistake in 1891 or 1908 (Dill and Cordone, 1997), green sunfish, *Lepomis cyanellus*, were abundant in turbid, warmwater reaches of the mainstem Pit River in Fall River Valley and Big Valley and in the North Fork of the Pit River (i.e., near CA agricultural inspection station, Parker Creek confluence) (Moyle and Daniels, 1982, Table A-2 in Appendix 9-A). Green sunfish are opportunistic feeders that prey on insects, crustaceans, and small fish. This habit has probably been an important factor in the decline of the California roach in central California (Moyle, 2002), and may therefore also have impacted Pit roach populations in the Pit River drainage. Males construct nests on gravel or sandy bottoms, at locations that provide maximum exposure to full sunlight (Calhoun, 1966; Moyle, 2002). Females may spawn with several males and carry 2,000 to 10,000 eggs depending on their size (Moyle, 2002).

Largemouth Bass

Introduced as a gamefish in 1891 or 1895 (Dill and Cordone, 1997), largemouth bass, *Micropterus salmoides*, are widespread in the Upper Pit River Watershed, and mainly occur in reservoirs, farm ponds, and the warm, turbid, sluggish reaches of the mainstem Pit River in Big Valley and Warm Springs Valley (Moyle and Daniels, 1982, Table A-2 in Appendix 9-A). They are found in mud-bottomed, low-gradient reaches with substantial aquatic vegetation and are absent from fast-flowing reaches of the Pit River (Calhoun, 1966; Moyle and Daniels, 1982). In the Big Valley reach of the Pit River, largemouth bass are accredited for the absence of native cyprinids (Moyle, 2002). As a highly prized warmwater gamefish, largemouth bass have been widely planted and are under regulatory restrictions by the CDFG to maintain strong populations for anglers (Moyle, 2002). Males create nests near submerged objects or vegetation as depressions in sand, gravel, or debris bottoms in which females will oviposit 2,000 to 94,000 or more eggs (Calhoun, 1966; Moyle, 2002). Males guard the eggs and fry for two to four weeks (Moyle, 2002).

Smallmouth Bass

Smallmouth bass, *Micropterus dolomieu*, are native to the upper Mississippi and the Great Lakes watershed, but were introduced as a gamefish in California in 1874 (Dill and Cordone, 1997; Moyle, 2002). Moyle and Daniels (1982) did not collect a single specimen during their 1973 to 1974 study. Smallmouth bass, however, have been recorded more recently from Lake Britton (Moyle, 2002). Summer water temperature, which needs to range between 20 to 27° C, is an important factor in the establishment of smallmouth bass populations (Calhoun, 1966; Moyle, 2002). In California, most smallmouth bass populations occur in waters that have an extended summer water temperature period of 21 to 22° C (Moyle, 2002). Other habitat preferences are clear water with a moderate gradient, an intricate system of cobbles, pools, and runs, and overhanging riparian vegetation (Calhoun, 1966; Moyle, 2002). Crayfish appear to be an important prey item, and smallmouth bass may play a roll in controlling exotic crayfish populations (Moyle, 2002). Smallmouth bass also prey on other crustaceans, insects, amphibians, and small mammals. Females oviposit 2,000 to 21,000 eggs in the nest, which has been built by the male on gravel or sand bottoms near aquatic vegetation (Calhoun, 1966). Males will defend the nest and young for one to four weeks (Moyle, 2002). The impact smallmouth bass have on native fish populations is uncertain, but they may have caused local extinction of native frogs and other amphibians (Moyle, 2002).

Spotted Bass

Spotted bass, *Micropterus punctulatus*, are native to the central and lower Mississippi basin, but were introduced as a gamefish into California in 1933 (Moyle, 2002) or 1936 (Dill and Cordone, 1997). Similar to smallmouth bass, they have been recorded only in the lower Pit River and Lake Britton Reservoir. Spotted bass inhabit low-gradient, clear, warm river sections where they hold up in pools, while avoiding riffles and runs (Calhoun, 1966; Moyle, 2002). Males construct nests in gravel or among cobbles and boulders and defend the eggs (i.e., 2,000 to 14,000 per female) and young for one to four weeks (Moyle, 2002). The impact on native fish is uncertain, but Moyle (2002) states that they have had a negative affect on native fish populations (e.g., rough sculpin) that thrive in the lower Pit River hydroelectric reservoirs (i.e., Pit 4, Pit 5, and Tunnel reservoirs).

Non-Native Amphibians

Bullfrog

The bullfrog, *Rana catesbeiana*, is a highly aquatic frog native to eastern North America. Since its first introduction into California in 1896, bullfrogs now occur throughout the state up to elevations of 9,000 ft. Bullfrogs are large-sized (up to 150 mm SVL), olive-green or green-brown frogs, which often have green on the upper jaw. The hind legs have a dark banding pattern and the belly is creamy white-gray. Both the back and belly can have an irregular pattern of dark mottling. Males fight for territories and advertise their presence to females with their calls. Breeding occurs from February to July, and a female can deposit 6,000 to 20,000 eggs. Tadpoles are largely herbivorous, but will scavenge on dead animals. Adults are carnivorous and feed on a wide range of animals: fish, reptiles (e.g. snakes and lizards), amphibians (e.g., tadpoles and adult frogs, salamanders), small birds, and small mammals.

The bullfrog has received considerable attention from the research and wildlife management community for its apparent negative impact on native amphibians (Moyle, 1973; Hayes and Jennings, 1986; Kupferberg, 1997). While bullfrogs have received considerable attention, native amphibian habitat alterations (e.g., flood control, mining, and cattle grazing), introduced predatory fishes, and harvesting of native amphibians should not be overlooked as similarly important factors in native amphibian declines (Jennings, 1988).

Bullfrogs are best eliminated or prevented from entering reaches by natural high-flow events as have been observed in the Eel River of northwestern California (Kupferberg, 1996). Bullfrog tadpoles generally overwinter as tadpoles for at least one year. During the larval life stage they are dramatically reduced or removed by natural winter high-flow events.

During the 1974 surveys (Moyle and Daniels, 1982, unpublished data), incidental observations of bullfrogs were recorded for Beaver and Horse creeks (tributaries to the mainstem Pit River in Fall River Valley), Widow Valley Creek, the mainstem Pit River in Big Valley and Warm Springs Valley, and in the North Fork of the Pit River (Table A-2 in Appendix 9-A).

Non-Native Invertebrates

Signal Crayfish

Signal crayfish, *Pacifastacus leniusculus*, were first introduced into the watershed in the 1970s likely as a result of bait fishing (Daniels, 1980; Holdich, 2002). Signal crayfish, which originally had three distinct subspecies, were native to the Klamath River drainage in northwestern California, as well as Oregon, and Washington. The introduction of signal crayfish throughout California, the western United States, and Europe has resulted in overlapping distributions and extensive interbreeding so that the subspecies classification is now questionable (Hobbs, 1972). Signal crayfish mate in the fall and the female generally lays between 20 to 200 eggs on the ventral side of her abdomen (i.e., tail). The female carries the eggs over winter until they hatch in 166 to 280 days, generally between March and June (Holdich, 2002). Signal crayfish exhibit a higher activity rate, more aggressive behavior, and spend more time feeding than the federally and state-listed endangered Shasta crayfish, *Pacifastacus fortis* (Ellis, 1999). These abilities likely contribute to the faster growth rate and larger body size of signal crayfish as compared to Shasta crayfish, as well as the ability of signal crayfish to replace Shasta crayfish throughout most of its range (Ellis, 1999).

Fantail (=virile) Crayfish

The fantail or virile crayfish, *Orconectes virilis*, which is native to the midwestern United States, was introduced in the midreaches of the Pit River drainage in the 1960s. Although regulations that prohibit the use of crayfish as bait in the midreaches of the Pit River drainage have been in place since 1981, the presence of fantail crayfish in the upper Tule River–Big Lake area was the result of recent introductions from the illegal use of crayfish as bait since 1993. Fantail crayfish have been found in the Pit River upstream of the Pit 1 Powerhouse, lower Fall River in the downstream-most impoundment known as Fall River Pond, and portions of the upper Tule River–Big Lake area. Fecundity ranges from 20 to 320 eggs and females carry the eggs and young under their tail for several weeks (Holdich, 2002).

Although Daniels (1980) found fantail crayfish throughout the Pit River downstream of the Pacific Gas and Electric Company's Pit 1 Powerhouse in 1978, signal crayfish had replaced fantail crayfish in this reach by 1990 (Ellis, 1999). Fantail crayfish were still present, however, in the Pit River in warmer waters upstream of the Pit 1 Powerhouse. Based on this observation, it would appear that signal crayfish can out compete and replace fantail crayfish in colder water, whereas the two species can coexist in warmer waters.

Hatchery Fish Planting

Since the late 1800s, native fish populations in the West have been augmented with fish propagated in fish hatcheries in order to accommodate the fishing needs of a growing human population and to lessen the impact of over-harvesting (Leitritz, 1970). Fishing pressure can greatly impact the natural balance of fish populations. Consequently, fish hatcheries plant millions of trout annually to provide for the demand of anglers and to maintain balanced fish populations (Leitritz, 1970).

Over the past century, the mechanics of fish planting have seen an evolution in operating procedures. Mules and wagons were the initial mode of transport. While the railroad allowed fish to be moved over large distances, transportation from train to the water was done with mules and wagons. In 1907, the State of California bought and modified a car to function as a fish transport (Leitritz, 1970). As roads and cars became more abundant, wagons and the railroad became obsolete (Leitritz, 1970). Mules, however, remained a valuable means of transportation to reach remote areas, such as high mountain lakes that are inaccessible by road (Leitritz, 1970). In 1946, the airplane replaced mules after it was discovered that fingerlings could be dropped into lakes without apparent harm (Leitritz, 1970). Recent evidence has shown that fish dropped from planes are temporarily stunned or disorientated and without nearby cover exposing them to predators (Pers. Comm. Paul Chappell, 2003).

Three fish hatcheries: Mount Shasta Hatchery, Crystal Lake Hatchery (including the Pit River Hatchery), and Burney Creek Hatchery have contributed the majority of the planted trout in the Upper Pit River Watershed. Minor trout planting activities for this area have come from the Darrah Springs Hatchery, Lake Almanor Hatchery, Domingo Springs Hatchery, and the Coleman National Fish Hatchery. Shorts accounts on the history of these hatcheries have been provided below. Since 1910, fish, other than trout, have been sporadically planted from hatcheries (e.g., Central Valley Hatchery and Moccasin Creek Hatchery) or transplanted legally and illegally from other streams, lakes, and reservoirs.

The number of fish planted in the Study Area from 1930 to 2002 is given by species in Table 9-2. The data depicted in the two right-most columns of Table 9-2 were obtained from unpublished data in a CDFG Stream Surveys Book that contained planting data for Modoc County from 1908 to 1913. The number of trout planted by each individual hatchery has been summarized by trout size in Table 9-3. The CDFG has four trout class sizes: catchables (2 to 6 fish per pound), subcatchables (more than 6 but fewer than 16 fish per pound), fingerlings (16 or more fish per pound), and brood stock (fewer than 2 fish per pound). Trout plantings by size class (i.e., catchable, subcatchable, fingerling, brood stock) in the Upper Pit River Watershed from 1930 to 2002 are shown in Figure 9-2. Table B-1 in Appendix 9-B provides a detailed summary of rainbow trout planting records by water body from 1930 to 2002.

The earliest records show that South Fork of the Pit River received four cans with an unspecified number of rainbow trout in 1908, 6,000 brook trout in 1911, and the first planting of 12,500 brown trout in 1913. The North Fork of the Pit River received 200 yearling striped bass near Alturas in 1910, and 15,000 brown trout in 1937. The earliest planting records for the mainstem Pit River dated to 1951 when 24,000 catfish were planted near Bieber in Big Valley. In 1961, 5,005 channel catfish were planted near Canby in Warm Springs Valley, and 10,360 channel catfish were planted near Pittville in Fall River Valley and Bieber in 1968.

Table 9-2 FISH PLANTED BY SPECIES AND SIZE IN THE UPPER PIT RIVER WATERSHED FOR 1930 TO 2002 AND MODOC COUNTY FOR 1908 TO 1913 SOURCE: CDFG						
Fish Species	Catchable	Sub-Catchable	Fingerling	Brood Stock	Cans (1) (1908 to 1913)	# Fish (1908 to 1913)
Rainbow	2,211,346	474,087	5,893,818	10,413	21	196,500
Brook	606,503	502	3,597,471		3	71,500
Brown	147,549	26,013	2,407,423	198	2	40,000
Eagle Lake	775,626	44,588	1,038,775	199		
Lahontan Cutthroat	10,225		411,894			
Eagle Lake x Rainbow	16,840		3,888			
Silver Salmon	3,978	5,416				
Steelhead			100,000			
Arctic Grayling			13,100			
Bluegill	'unknown'					
Catfish (spp?)	24,000					
Channel Catfish	15.365					
Redear Sunfish			107			
Sacramento Perch	346					
Largemouth Bass			1,070			
Spotted Bass	'unknown'					
Striped Bass						200
(1) Fish cans were variable sized metal containers, generally resembling milk cans that were packed via horseback.						

Table 9-3 NUMBER AND SIZE OF TROUT PLANTED BY HATCHERY IN THE UPPER PIT RIVER WATERSHED FOR 1930–2002				
Major Hatcheries	Catchable	Subcatchable	Fingerling	Brood Stock
Burney Creek Hatchery	0	386	4,953,904	0
Crystal Lake Hatchery[a]	3,191,196	374,454	208,950	199
Mount Shasta Hatchery	463,562	155,029	7,740,107	7,981
Minor Hatcheries/Sources				
Coleman National Fish Hatchery	3,500	0	10,000	0
Darrah Springs Hatchery	110,355	20,737	251,508	2,630
Domingo Springs Hatchery	0	0	50,000	0
Lake Almanor Hatchery	0	0	263,000	0
U.S. Forest Service	0	0	5,800	0
[a] Crystal Lake Hatchery includes all fish planted from the Pit River Hatchery				

Major Hatcheries

Burney Creek Hatchery (1927 to 1949)

Burney Creek Hatchery was located on the Burney Creek arm of Lake Britton 0.5 miles below Burney Falls. Pacific Gas and Electric Company constructed the hatchery instead of building a fish ladder over the Lake Britton Dam. The hatchery provided millions of fish to lakes and streams in Modoc, Lassen, and Shasta counties (Table 9-4), but the limited space for expansion caused the hatchery to close and move its operations to Crystal Lake Hatchery when it was constructed in 1949. From 1931 through 1949, the Burney Creek Hatchery planted a total of 4,923,904 fingerlings in the Upper Pit River Watershed: 2.08 million fingerlings in the 1930s and 2.85 million fingerlings in the 1940s (Table 9-4). In Modoc County, the most commonly stocked waters were: Ash Creek, Fitzhugh Creek, Joseph Creek, Mill Creek, Parker Creek, Pine Creek, Rush Creek, Shields Creek, and South Fork of the Pit River. For Lassen County, only Blue Lake, Cedar Creek, and Horse Creek were planted. Beaver Creek in Shasta County was planted only once in 1939.

Table 9-4
BURNEY CREEK HATCHERY FISH PLANTING IN THE UPPER PIT RIVER WATERSHED FROM 1931–1949

Trout	Catchable	Subcatchable	Fingerling	Brood Stock
Rainbow	0	386[1]	2,672,604	0
Brook	0	0	836,300	0
Brown	0	0	1,380,000	0
Steelhead	0	0	35,000	0

[1]CDFG files indicate this as a single planting event from Burney Creek Hatchery in 1950

Crystal Lake Hatchery (1947 to present)

Crystal Lake Hatchery was the first major project undertaken by the California Wildlife Conservation Board. The location provided critical land and water resources to sustain the hatchery needs. Initial water supplies were taken from Crystal Lake, but a native myxosporean protozoan salmonid parasite, *Ceratomyxa shasta*, caused the total loss of the hatchery's rainbow trout stock in 1948 and 1949 (Noble, 1950; Schafer, 1968). After the water supply was changed from Crystal Lake to Rock Creek, only occasional occurrences of *Ceratomyxa* occurred (Wales and Wolf, 1955; Schafer, 1968).

Although the hatchery began operations in 1947, it was not entirely completed until 1955. In 1976, Crystal Lake Hatchery expanded and modernized their facilities and became one of the largest hatcheries in California. The hatchery supplies mostly catchable rainbow trout, brook trout, brown trout, and Eagle Lake trout to many of the lakes and streams in Shasta, Modoc, and Lassen counties.

Regarding the Upper Pit River Watershed, the Crystal Lake Hatchery records showed that the first releases were made in 1955, but the CDFG Region I office in Redding had records dating to 1949. Although Crystal Lake Hatchery has primarily planted catchable size trout—3,189,645 million catchable trout from 1949 through 2002—they also planted 374,454 subcatchables, 204,022 fingerlings, and 1,166 brood stocks in the Upper Pit River Watershed during this period (Table 9-5). Summarizing the planting records by decade, Crystal Lake Hatchery planted 310,602 catchables in the 1950s (including 1949), 365,088 catchables in the 1960s, 726,009 in the 1970s, 880,719 in the 1980s, and 672,274 in the 1990s. Waters stocked in Lassen County include Ash Creek, Blue Lake, and Butte Creek. Waters stocked in Modoc County include Ballard Reservoir, Bayley Reservoir, Pine Creek, South Fork of the Pit River, Reservoir "C," and West Valley Reservoir. Waters stocked in Siskiyou County include Bullseye Lake and Medicine Lake.

Pit River Hatchery (1965 to 1996)

The Crystal Lake Hatchery managed the Pit River Hatchery so plantings by Pit River Hatchery were not necessary specified as such. Plantings were recorded as Pit River Hatchery, Crystal Lake and Pit River hatcheries, or Crystal Lake Hatchery. The following five records were the only ones found that named the Pit River Hatchery as the only source of the planted trout. The Pit River Hatchery planted 5,005 catchable brown trout in Ash Creek and the South Fork of the Pit River from 1967 through 1969. In 1968, 4,928 rainbow trout fingerlings were planted in West Valley Reservoir. The data from Pit River Hatchery were combined with the Crystal Lake Hatchery in Table 9-5.

Table 9-5
CRYSTAL LAKE HATCHERY FISH PLANTING IN THE UPPER PIT RIVER WATERSHED FROM 1949–2002

Trout	Catchable	Subcatchable	Fingerling	Brood Stock
Rainbow	1,745,527	303,351	143,310[2]	0
Brook	557,273	502	25,240	0
Brown	145,677[1]	26,013	0	0
Eagle Lake	725,463	44,588	20,000	199
Lahontan Cutthroat	3,825	0	20,400	0
Eagle Lake x Rainbow	16,840	0	0	0

[1]Includes 5,005 catchables from Pit River Hatchery
[2]includes 4,928 fingerlings from Pit River Hatchery

Mount Shasta Hatchery (1888 to present)

Even before the Mount Shasta Hatchery was built, the March 14, 1877 issue of the Yreka Journal made reference to J. H. Sisson constructing a trout rearing pond so visitors would stay longer and bring more business to his tavern (Leitritz, 1970). The Mount Shasta Hatchery is the oldest, still active fish hatchery in the west. Initially it was mostly involved in egg collection from the chinook salmon that came up the Sacramento River to spawn. After the completion of Shasta Dam, chinook salmon lost approximately 80 percent of their spawning grounds (Moyle, 2002) and the age-old and tremendously large chinook salmon runs virtually ceased to exist (Moyle and Daniels, 1982). The Mount Shasta Hatchery switched its production towards trout and they have produced large numbers of trout, mostly to be released as fingerlings.

The Mount Shasta Hatchery has mainly been concerned with the planting of fingerlings, and has planted a total of 7,740,107 from 1930 through 2002 (Table 9-6). In the 1930s, Mount Shasta Hatchery planted 1,091,345 fingerlings, but in the 1940s only 307,206 fingerlings were planted. Since the 1950s, the number of fingerlings planted in the Upper Pit River Watershed each decade has been fairly stable. In the 1950s, 997,676 fingerlings were planted. In the 1960s, the hatchery planted 1,193,337 fingerlings. In the 1970s, the number was slightly higher with 1,414,701 fingerlings planted, and 1,190,715 fingerlings were planted in the 1980s. In the 1990s, 1,379,643 fingerlings were planted. The Pine Creek Lakes (1-4) in the South Warner Wilderness are still sporadically planted with rainbow, Eagle Lake, or brook trout fingerlings (Tables B-1 and B-2).

Table 9-6 MOUNT SHASTA HATCHERY FISH PLANTING IN THE UPPER PIT RIVER WATERSHED FROM 1930–2002				
Trout	**Catchable**	**Subcatchable**	**Fingerling**	**Brood Stock**
Rainbow	399,330	155,029	2,755,096	7,783
Brook	49,230	0	2,620,131	0
Brown	870	0	885,723	198
Eagle Lake	10,154	0	1,018,775	0
Cutthroat Lahontan	0	0	391,494	0
Eagle Lake x Rainbow	0	0	3,888	0
Steelhead	0	0	65,000	0
Coho (=Silver) Salmon	3,978	0	0	0

Although the Mount Shasta Hatchery has record-keeping books dating back to the 1890s the necessary data cannot easily be found within the large volume of books with daily narrative write-ups. It is not entirely certain how much actual fish planting information these books hold. Therefore, data on fish planting before 1930 is limited. Record books for the years 1914 to 1929 were lacking.

Minor Hatcheries

Darrah Springs Hatchery (1949 to present)

Named after Simon H. Darrah, the Darrah Springs Hatchery is located near Manton in Shasta County. The Darrah Springs Hatchery has a constant supply of 30 cubic feet per second (cfs) of 57° F water. In 1970, this installation became an important state hatchery capable of producing 400,000 pounds of trout annually.

Over the years, 1957 through 1986, only a small number of trout originating from Darrah Springs Hatchery have been planted in the Upper Pit River Watershed. The majority of planted fish (i.e., 110,355 fish) were in the catchable size range.

Domingo Springs Hatchery (1916 to 1937)

The hatchery was initially located at Domingo Springs, Lassen County, but moved in 1917 to Rice Creek, one of the major tributaries of the North Fork Feather River. A permanent building was in use after 1919 to supply Lake Almanor, Mount Lassen National Park, and the surrounding country with fry. Development of the eggs and fish was slow due to the extremely cold water in Rice Creek. The hatchery was closed after a damaging flood in 1937.

Central Valleys Hatchery (1937 to 1993)

Located near Elk Grove, Sacramento County, this 40-acre hatchery was the only hatchery specifically constructed and devoted to rearing warmwater gamefish (e.g., bass, catfish, and sunfish) until 1970. In 1949, attempts were made to rear rainbow trout during the slow winter months, but water temperatures often increased quickly in February, when planting locations were not yet accessible. This practice was stopped in 1954. Propagation of redear sunfish began after they were obtained from southern California in 1956. In 1958, channel catfish were trapped from the Sacramento River and Sutter Bypass for an experimental hatchery program. The hatchery was closed in 1993. Central Valley Hatchery was involved in channel catfish releases in the Pit River at Canby in 1961 and Pittville and Bieber in 1968.

Coleman National Fish Hatchery (1942 to present)

The Coleman National Fish Hatchery is located near Red Bluff on Battle Creek and is operated by the United States Fish and Wildlife Service. Completed in 1942, the hatchery was intended to compensate for the loss of salmon that would occur with the construction of Shasta Dam, which was completed in 1949. Shasta Dam destroyed suitable salmon spawning habitat above the dam and submerged the Baird Hatchery. Coleman National Hatchery, which replaced Battle Creek Hatchery and Mill Creek Hatchery, mostly focuses on rearing salmon and steelhead for the Sacramento River.

Lake Almanor Hatchery (1931 to 1953)

The Lake Almanor Hatchery was built after Clear Creek Hatchery was forced to close, because the Red River Lumber Company did not grant a lease for the additional land that was needed to expand the facility. The new hatchery was built near Chester, Plumas County, along Benner Creek. Due to winter freezing and summer warming of the creek, the hatchery was finally moved to Clear Creek near Westwood, Lassen County in 1933. Newer and more efficient hatcheries replaced the Lake Almanor Hatchery in 1953.

Moccasin Creek Hatchery (1949 to present)

Moccasin Creek Hatchery was established to fill the large void between Lake Tahoe and the Yosemite Valley. The City of San Francisco allowed the use of land and water near Moccasin, Tuolumne County in 1949. The most common trout species (i.e., rainbow, brook, cutthroat, brown, and lake trout) have been reared and distributed mainly in Tuolumne County as well as several of the surrounding counties. Moccasin Creek Hatchery was involved in arctic grayling releases in Little Medicine Lake during 1971 and 1972.

Silverado Fisheries Base (1960 to present)

Located in Yountville, the present day Silverado Fisheries Base started as a game-bird farm in the late 1940s when Rector Reservoir was created. The reservoir served as a water source for the California Veterans Home and the CDFG game-bird farm. In the 1960s, the location became a holding area for trout before further distribution to creeks and lakes. In the 1970s, the Silverado Fisheries Base became a fish quarantine facility, the only one in California to date. Chinook and sockeye salmon eggs are obtained from within California, while lake trout eggs come from Wyoming. All three species are in quarantine to prevent the spread of disease. Chinook and sockeye salmon are planted as fingerlings throughout the Sierras, while lake trout fingerlings are predominately planted in high elevation lakes in the northern Sierras. Approximately 400,000 catchable rainbow trout are shipped from other hatcheries to the Silverado Fisheries Base before being released in streams and lakes of nearby counties.

Silverado Fisheries Base was involved in arctic grayling plantings in Reservoir “C” in 1975, and in Little Medicine Lake in 1975 and 1981.

Planting Practices by Fish Species

A discussion follows for some of the most frequently planted water bodies on a per species basis. A complete overview of the planting data for all the water bodies can be found in Appendix 9-B. The earliest planting records found are from 1908 through 1913, but because they did not specify the size of the fish their numbers have not been included in the number fish released as discussed in each section. No planting data was found for the period from 1914 through 1929.

Rainbow Trout

Rainbow trout of all sizes (i.e., catchable, subcatchable, fingerling, and brood stock) have been the most common species stocked throughout the Upper Pit River Watershed. Since 1930, this area has received 2,211,346 catchable, 474,087 subcatchable, 5,893,818 fingerling, and 10,413 brood stock. The earliest record found on the stocking of rainbow trout dates to 1908, when 2 cans of fish were emptied in the South Fork of the Pit River and Pine Creek in Modoc County. These creeks and others in the area (e.g., Ash Creek and Fitzhugh Creek) were stocked into 1913. No planting records were found for 1914 through 1929. In general, the number of rainbow trout planted in a particular water body in the Study Area since 1930 has been fairly uniform. Several of the predominantly stocked and more important water bodies, however, have been selected in order to discuss their particular stocking occurrences.

Ash Creek. From 1911 through 1913, 37,000 rainbow trout (no specification on size given) were planted in Ash Creek. Records showed that Burney Creek Hatchery planted the only fingerlings (234,176 fish) in 1931, 1934, and annually from 1942 through 1949, which is 4.0 percent of the rainbow trout fingerlings planted in the Study Area. Although more sporadic in the 1960s, Crystal Lake Hatchery generally planted catchable trout annually from 1950 through 2002. A total of 117,713 catchable trout were planted in Ash Creek, which is 5.3 percent of the catchable trout planted in the Study Area.

Blue Lake. Several hatcheries (i.e., Domingo Springs, Lake Almanor, Burney Creek, and Crystal Lake) sporadically planted fingerlings in Blue Lake from 1931 through 1950. Darrah Springs Hatchery and the Coleman National Fish Hatchery made two more releases of rainbow trout fingerlings in 1965 and 1968, respectively. In total, 323,027 fingerlings have been planted, accounting for 5.5 percent of the rainbow trout fingerlings planted in the Study Area. The 28,445 subcatchable trout planted in the 1950s, account for 6.0 percent of the subcatchables planted in the Study Area. From 1950 through 2002, a total of 455,951 catchable rainbow trout were planted on a generally annual basis, which accounts for 20.6 percent of the catchable rainbow trout released in the Study Area. Blue lake received the highest number of brood stock: the 9,413 fish account for 90.4 percent of the rainbow brood stock planted in the Study Area.

Duncan Reservoir. Duncan Reservoir has received 4.3 percent (95,718 fish) of the catchable rainbow trout, 4.2 percent (250,201 fish) of the fingerling rainbow trout, and 11.7 percent (55,285 fish) of the subcatchable rainbow trout planted in the Study Area since 1941. Catchable trout were planted from 1955 through 2000, except for the 1980s. Subcatchable trout were planted in the 1950s and 1960s, and fingerlings were planted mostly in the 1940s and 1970s.

Medicine Lake. Medicine Lake has received 2,088,243 rainbow trout fingerlings or 35.4 percent of the total number of rainbow trout fingerlings planted in the Study Area since 1930. Fingerlings were planted sporadically from 1930 to 1970, but annual plantings became common from 1970 to 1998. Nearly one-third, 31.4 percent (694,254 fish), of the catchable rainbow trout were planted in Medicine Lake. Mount Shasta Hatchery was responsible for most of the plantings from 1930 to 1975, when Crystal Lake Hatchery took over planting catchables. The lake received 128,875 subcatchables or 27.2 percent of the subcatchable rainbow trout planted in the Study Area.

South Fork of the Pit River. Burney Creek Hatchery planted the only fingerlings, 352,703 fish, over the period from 1931 through 1949. A total of 96,506 catchable trout was planted chiefly by Crystal Lake Hatchery on an annual basis from 1951 through 2002, except for sporadic plantings in the 1960s and no plantings from 1984 to 1992. The number of rainbow trout released in the South Fork of the Pit River is only a small portion of all the rainbow trout released in the Study Area: planted fingerlings made up 6.0 percent (352,703 fish), catchables 4.4 percent (96,506 fish), and subcatchables 4.7 percent (22,159 fish) for the South Fork of the Pit River.

West Valley Reservoir. The first record of rainbow trout planted in West Valley Reservoir dates back to 1943. Planting was sporadic in the 1940s and absent in the 1950s. After 1963, planting is fairly frequent through 2000. A total of 151,542 catchable, 61,303 subcatchable, and 385,968 fingerling rainbow trout have been released in West Valley Reservoir from 1943 to 2000. West Valley Reservoir has received only 6.5 percent (385,968 fish) of the fingerling and 6.9 percent (151,542 fish) of the catchable rainbow trout, while it has received 12.9 percent (61,303 fish) of the rainbow trout subcatchables. The number of catchables has generally decreased over the years from approximately 10,000 in the mid 1970s to 1,000 to 3,000 in the late 1990s. Before 1967, West Valley Reservoir was stocked with brown trout (1961 to 1966) and Lahontan cutthroat trout (1959 and 1960). Eagle Lake trout have been planted simultaneously and intermittently with rainbow trout since 1969.

Steelhead

During the 1930s, a total of 100,000 steelhead fingerlings were released in Cottonwood Creek and Mill Creek in Modoc County, and Medicine Lake in Siskiyou County.

Eagle Lake Trout

The ability of Eagle Lake trout to withstand harsh conditions, such as high water temperatures, low dissolved oxygen levels, and high alkalinity, may explain why they have been introduced and continually planted in many reservoirs in the Upper Pit River Watershed. The first planting of Eagle Lake trout in the Study Area was in 1956. Pine Creek in Modoc County was the first creek to be planted with Eagle Lake trout, which were reared at the Crystal Lake Hatchery. The follow-up plant was not until 1969, when Blue Lake and West Valley Reservoir were stocked. A total of 775,626 catchables, 44,588 subcatchables, 1,038,775 fingerlings, and 199 brood stock Eagle Lake trout have been planted in the Study Area. The major water bodies where Eagle Lake trout have been planted are discussed below.

Bayley Reservoir. Bayley Reservoir was first planted in 1978 with 15,984 fingerlings from Mount Shasta Hatchery and 5,999 catchables from Darrah Springs Hatchery. Bayley Reservoir has since received nearly annual plantings of fingerlings and catchables. The total number of catchables, 95,462 fish, accounts for 12 percent of the Eagle Lake trout planted in the Study Area, while the 272,685 fingerlings account for 26 percent of the plants.

Blue Lake. Blue Lake was first planted in 1969 with 447 catchable Eagle Lake trout. Annual plantings of catchables occurred from 1986 through 2002. Since 1969, Blue Lake has received a total of 110,310 catchables, accounting for 14 percent of the catchable Eagle Lake trout planted in the Study Area.

Duncan Reservoir. From 1978 through 2000, Duncan Reservoir has received regular plantings of catchable Eagle Lake trout, predominately from the Crystal Lake Hatchery. From 1979 through 1995, the Mount Shasta Hatchery planted fingerlings in Duncan Reservoir. For the Study Area, Duncan Reservoir received 12 percent (95,724) of the catchable and 8.1 percent (84,046) of the fingerling Eagle Lake trout.

Nelson Corral. The Mount Shasta Hatchery has planted 176,240 Eagle Lake trout fingerlings in Nelson Corral since 1985. This accounts for 17 percent of the Eagle Lake trout fingerlings planted in the Study Area.

Reservoir "C." Darrah Springs Hatchery planted the first catchable Eagle Lake trout in Reservoir "C" in 1972. Annual plantings of catchables, mainly from the Crystal Lake Hatchery started in 1979 and continued through 2002. A total of 59,154 catchables have been released, accounting for 7.6 percent of the catchable Eagle Lake trout released in the Study Area. From 1974 through 1984, the Mount Shasta Hatchery had planted 64,995 fingerlings, accounting for 6.3 percent of the Eagle Lake trout fingerlings released in the Study Area.

West Valley Reservoir. A single release of 30,588 catchable Eagle Lake trout in West Valley Reservoir was done in 1969. The next plantings were conducted on a nearly annual basis from 1978 through 2002. In 1980, no catchable Eagle Lake trout were planted, but instead 15,000 fingerlings were released that year. West Valley Reservoir received the highest percent, 21 percent (165,075 fish), of catchable Eagle Lake trout, but only a minimal percent, 1.4 percent (15,000 fish), of the fingerlings planted in the Study Area. Releases of Eagle Lake trout in West Valley Reservoir have often been intermingled with rainbow trout releases.

Eagle Lake x Rainbow Trout Hybrid

From 1986 to 1988, the Crystal Lake Hatchery made four plantings of Eagle Lake x rainbow trout hybrids. A total of 16,840 catchables were released in Blue Lake, Bullseye Lake, Indian Spring Reservoir, and Medicine Lake. A single planting of fingerling hybrid trout from the Mount Shasta Hatchery occurred in Duncan Reservoir in 1975.

Brown Trout

The earliest record found of brown trout planted in the Upper Pit River Watershed dates back to 1910, which is 17 years after the first introduction of brown trout to California in 1893 (see Appendix 9-C). The first recorded planting consisted of two cans of fish, which were emptied in Pine Creek, a tributary of the North Fork of the Pit River. Consequent releases were made in following years and in nearby streams (e.g., Canyon Creek and Fitzhugh Creek). No planting data was found for the period of 1914 to 1929. Brown trout have been planted annually since 1930, except for two periods: no brown trout were planted from 1945 through 1959 and 1970 through 1976. The vast majority of brown trout planted from 1930 to 1944 were fingerlings (i.e., 2,317,750 fish) in large part from the Burney Creek Hatchery and the Mount Shasta Hatchery. After 1960, catchable brown trout (i.e., 146,679 fish) have been the primary fish planted in the Study Area. The Crystal Lake Hatchery produced most of the brown trout. The only planting record found for brood stock brown trout (i.e., 198 fish) was for Blue Lake in 2000.

The majority of brown trout planted in the Study Area have been planted in Ash Creek and the South Fork of the Pit River. The Mount Shasta Hatchery made most releases of brown trout fingerlings from 1930 to 1941 in Medicine Lake.

Ash Creek. Ash Creek received annual plantings of brown trout fingerlings during the 1930s, but received no brown trout during the 1940s and 1950s. Annual releases of catchable brown trout occurred in the 1960s, but were stopped during the 1970s. Sporadic releases of catchables occurred during the 1980s and 1990s. 1999 is the last year brown trout have been planted in Ash Creek. Ash Creek has received 25.1 percent (37,008 fish) of the catchable brown trout and 15.2 percent (365,000 fish) of the fingerlings released in the Study Area for the planting records.

Medicine Lake. Brown trout were only planted in Medicine Lake from 1930 through 1941, but the 1,092,750 fingerlings planted during this period make up 45.4 percent of all fingerling brown trout planted in the Study Area.

South Fork of the Pit River. The South Fork of the Pit River has received frequent plantings of fingerlings during the 1930s and catchables during the 1960s. Infrequent plantings occurred in the 1970s, while annual plantings of catchables took place from 1984 through 2001. The South Fork of the Pit River has received 37.4 percent (55,215 fish) of the catchable brown trout and only 11.0 percent (265,000 fish) of the fingerlings planted in the Study Area.

Brook Trout

Similar to brown trout, the earliest record of brook trout, *Salvelinus fontinales*, planted in the Study Area dates back to 1910, when 3 fish cans were emptied into Pine Creek, a tributary to the North Fork of the Pit River. Consequent releases were made in nearby streams (e.g. Mill Creek, South Fork of the Pit River, and Ash Creek) in following years (Appendix 9-B). No planting data was found for 1914 to 1929. Since 1931, brook trout have been planted annually within the Study Area, except for the years 1945 through 1947, 1955, and 1957. Fingerlings have been planted continuously throughout the years, while the first catchable brook trout were planted in 1963. Subcatchable brook trout were only planted in one year, 1967. There are no records of any brood stock brook trout planting events.

Brook trout have mostly been planted in high-elevation lakes (e.g., Medicine Lake and Pine Creek Lake #1 and #2) and selectively in the upper reaches of many creeks (e.g., Parker Creek, Pine Creek, East Creek, and Mill Creek). Pine Creek Lakes (1-4) and the upper reaches of Parker and Pine Creek (tributaries to the North Fork of the Pit River) and Mill and East Creeks (tributaries to the South Fork of the Pit River) are in the South Warner Wilderness. The majority of brook trout planted in the Study Area have been in Medicine Lake in Siskiyou County. More details about brook trout plantings in this lake and other water bodies are given below.

Ballard Reservoir. Between 1972 and 1990, Ballard Reservoir has mainly been stocked with fingerlings from the Mount Shasta Hatchery. A total of 66,688 brook trout were planted during these years on a near annual basis. Crystal Lake Hatchery planted 2,535 and 1,880 catchables in 1963 and 1984, respectively.

Blue Lake. The Burney Creek Hatchery and Lake Almanor Hatchery planted brook trout fingerlings from 1933 through 1938. Crystal Lake Hatchery made three plantings of catchables from 1964 through 1984, but have planted catchable brook trout on an annually basis since 1994 (except 1995). This lake received a total of 280,000 fingerlings and 31,710 catchables, making up 7.8 percent and 5.2 percent, respectively, of the brook trout planted in the Study Area.

Bullseye Lake. Bullseye Lake received a single planting of brook trout fingerlings in 1938. The next planting was not until 1954, when brook trout fingerlings were planted on a nearly annual basis from the Mount Shasta Hatchery through 1981. In 1982, the Mount Shasta Hatchery stopped planting fingerlings, but the Crystal Lake Hatchery started planting catchables annually through 2002. A total of 41,404 (1.2 percent) fingerlings and 13,315 (2.2 percent) catchables have been planted in Bullseye Lake.

Little Medicine Lake. The Mount Shasta Hatchery has planted fingerlings in Little Medicine Lake on a nearly annual basis from 1938 through 1976. The Crystal Lake Hatchery has planted catchable brook trout from 1984 through 2002. A total of 94,416 (2.6 percent) fingerlings and 8,882 (1.5 percent) catchables have been planted since 1938.

Medicine Lake. The Mount Shasta Hatchery has mainly been involved with the planting of fingerlings from 1935 through 1999. In 1965, the Crystal Lake Hatchery started to plant catchable brook trout in Medicine Lake as well. More or less annual plantings have amounted to a total of 2,217,803 fingerlings planted between 1935 and 1999, and a total of 519,159 catchable brook trout from 1965 through 2002. Medicine Lake has received the majority of brook trout planted in the Study Area: 61.6 percent of the fingerlings and 85.6 percent of the catchables.

Lahontan Cutthroat Trout
Lahontan cutthroat trout, *Oncorhynchus clarki henshawi*, reared at the Crystal Lake and Mount Shasta hatcheries, have only been introduced in two reservoirs. In 1931, 86,000 fingerling Lahontan cutthroat trout were planted in Medicine Lake. In 1960, 11,200 fingerling Lahontan cutthroat trout were planted in Randall Colis Pond.

West Valley Reservoir. From 1956 to 1960, West Valley Reservoir was stocked with 3,825 catchable and 306,294 fingerling Lahontan cutthroat trout from the Mount Shasta and Crystal Lake hatcheries.

Reservoir "C." Crystal Lake Hatchery planted 8,400 fingerlings in 1982 and Darrah Springs Hatchery made the most recent plant of 6,400 catchable Lahontan cutthroat trout in 1986.

Bull Trout
No bull trout have been planted in the Upper Pit River Watershed. Reintroductions of hatchery reared bull trout in the upper McCloud River have not been successful (Moyle, 2002).

Coho (=Silver) Salmon
In 1958, the Mount Shasta Hatchery planted 3,978 catchable coho salmon in Medicine Lake. In 1973, Darrah Springs Hatchery planted 3,008 subcatchable coho salmon in Moon Lake and 2,408 subcatchables in West Valley Reservoir.

Arctic Grayling
From 1971 through 1981, the Mount Shasta Hatchery, Moccasin Creek Hatchery, and Silverado

Field Operations Base planted 11,100 fingerling arctic grayling during four years in Medicine Lake. In 1975, the Silverado Field Operations Base planted 2,000 fingerling arctic grayling in Reservoir "C."

Bluegill
There was one CDFG record of bluegills planted into Lauer Reservoir in Modoc County in 1942, but there was no information as to the origin and number of fish released.

Channel Catfish
The Central Valley Hatchery released a total of 15,365 channel catfish into the Pit River near Canby in 1961, and Bieber and Pittville in 1968. The CDFG records also showed another release of an unspecified species of catfish in the Pit River near Bieber in 1951, these fish were obtained from Pearson Ranch Reservoir.

Largemouth Bass
The first record of largemouth bass planting dates to 1948, when Dorris Reservoir received 1,000 fingerling largemouth bass that were obtained from Dwinnell Reservoir in Siskiyou County.

Redear Sunfish
The only documented planting records for redear sunfish in the Study Area were in Big Jack Lake in Lassen County. In 1980, the Central Valley Hatchery planted 30 redear sunfish in Big Jack Lake. In 1987, 27 redear sunfish were planted in Big Jack Lake from Paynes Creek Pond (Tehama County). In 1996, 50 redear sunfish were planted in Big Jack Lake from Ewing Reservoir (Trinity County).

Sacramento Perch
In 1993, Dorris Brothers Reservoir and Moon Lake each received 173 Sacramento perch, which were obtained from Crowley Lake (Mono County).

Spotted Bass
Although records are vague, an unknown number of spotted bass appear to have been planted in Lauer Reservoir in 1942.

Striped Bass
The earliest record on the planting of a non-trout species dates to 1910, when 200 fingerling striped bass were planted in the North Fork of the Pit River near Alturas.

Aquaculture

The CDFG provided a list with contact information for registered freshwater aquaculture operations as of July 2002. The list, however, was not all-inclusive, because some owners had asked not to be listed. The listed aquaculture operations pertinent to the project area were contacted to obtain information on their operational history, procedures, and purpose. Contacts are included in Appendix 9-D.

Canyon Creek Catfish
This company has been in operation since the 1980s and provides a variety of fish to markets and restaurants for consumption and occasionally sells live fish from the ranch. The ranch is located on

a meadow at the confluence of Canyon Creek and a geothermal spring in Warm Springs Valley between Canby and Alturas in Modoc County. Human-made ponds and raceways are used to rear a variety of fish species: channel catfish, largemouth bass, mosquito fish, white sturgeon, carp, and, redear sunfish. The outflow from the ponds and raceways runs into Canyon Creek, and ultimately into the Pit River. According to the CDFG, Canyon Creek Catfish is registered to rear channel catfish, largemouth bass, mosquitofish, koi, rainbow trout, redear sunfish, and white sturgeon for sale.

Catfish Pond Ranch
This small company, which is located in Warm Springs Valley south of Highway 299 between Canby and Alturas in Modoc County, has been in operation since 1997/1998 and provides catch-and-release fishing to the public for crappie, bullhead, sunfish, bass, catfish, and trout. The fish are kept in several human-made ponds filled with water that is pumped from a well. An ephemeral creek on the property provides water to a single large pond, which holds any variety of fish species. Only in wet years does the pond overflow into Cal Pines Lake. According to the CDFG, Catfish Pond Ranch is registered to rear channel catfish, crappie, largemouth bass, and rainbow trout for sale and fishing by customers.

Kelly Hot Spring Fish Farm
In 2000, Kelly Hot Spring Fish Farm, located near Canby in Warm Springs Valley in Modoc County, started rearing bass and hybrid (sterile) carp for the Asian market in the Bay Area. They do not allow fishing on their property. Water from Kelly Hot Springs is used to rear fish in natural and artificial ponds. All water outflows, which are screened to prevent fish from escaping, flow into the Pit River. According to the CDFG, Kelly Hot Spring Fish Farm is registered to rear channel catfish, common carp, goldfish, largemouth bass, rainbow trout, tilapia, and white sturgeon.

The Fishery
A small part of this company is located on Flournoy Ranch near Likely on the South Fork of the river in Modoc County. Arrowhead Fisheries preceded the Fishery, which has been in operation for approximately seven years at this location, which was in operation at the same location for 3 to 4 years prior. Both companies used 70° F spring water in fish tanks for rearing white sturgeon for meat and caviar. Collected in ditches and ponds, the outflow water is used by the rancher for irrigation. Hybrid carp have been reared in these collection ponds, but collection and movement of the fish before irrigation was not practical and the practice was discontinued. According to the CDFG, The Fishery is registered to rear channel catfish, common carp, largemouth bass, mosquitofish, and white sturgeon.

The outflow from several of these aquaculture operations flows into the Pit River system. If improperly screened, these outflows could be a source for the introduction of exotic fish into the Pit River system. Whether a particular fish species survives outside the confines of the ponds and tanks depends on the species and the conditions found downstream from the outflow. Much lower or higher temperatures, increased water velocity, absence of suitable habitat for cover and breeding are all factors that will affect the establishment of these escapee fish.

Fish leaking from fish farms is the most likely method by which Mozambique tilapia, sailfin molly, porthole livebearer, and blue catfish have become established in California (Moyle, 2002). One significant example in close proximity to the Upper Pit River Watershed was the extinction of High Rock Springs tui chub. In the 1970s, a large number of tilapia were reared in an aquaculture facility on Honey Lake, escaped, and established a population in Honey Lake and its tributaries. As a direct result, High Rock Springs tui chub became extinct in 1989 (Moyle, 2002; Paul Chappell pers. comm., 2003).

In addition to CDFG's planting program, individuals may intentionally plant species in a water body, both legally and illegally. Individuals may request permission from CDFG to stock a water body. In 1988, L. R. Gibson of Adin requested and was granted permission to plant 300 pounds of 10- to 12-inch rainbow trout in Willow Creek, a tributary to Ash Creek (CDFG Honey Lake field office files). Many illegal plantings also occur by anglers planting bass and other centrachid species and catfishes. Live wells on bass boats have made moving fish between water bodies relatively easy.

ENVIRONMENTAL FACTORS

The health and vigor of fisheries and other aquatic resources is impacted by water quality parameters, such as dissolved oxygen, temperature, pH, turbidity/total solids, and nutrients. Physical characteristics of the channel and riparian corridor can also directly impact fisheries and other aquatic resources. In addition, the physical condition of the channel and riparian corridor can affect aquatic resources indirectly in a number of ways, for example by altering water quality parameters, creating passage barriers, or entrapping fish. Channelization, low water levels, loss of riparian habitat, and degradation of spawning habitat are examples of physical changes to the channel and riparian corridor that can create adverse conditions for fish. Historic and current fish eradication and hatchery-planting practices can also have an impact on fisheries and other aquatic resources.

Water Quality

The Pit River is listed as "impaired" under section 303(d) of the Clean Water Act due to organic enrichment, low dissolved oxygen, and high temperature. These conditions, as well as high-suspended solids and turbidity are water quality parameters that can affect fish and other aquatic resources. Impacts of some water quality parameters on aquatic resources are reviewed below.

Temperature

Water temperature affects the health of aquatic systems in many ways. Feeding, reproduction, metabolism, abundance, and diversity of aquatic biota may all be altered by water that is too warm or too cold. The rates of biological and chemical processes depend on temperature, and because most aquatic organisms (e.g., fish and invertebrates) are poikilotherms (i.e., cold blooded), they are highly affected by temperature changes. Their metabolic rates increase with higher temperatures and decrease with lower temperatures.

Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. The optimal temperature ranges for some examples of primary producers are as follows: diatoms 15 to 25°C (59 to 77°F), green algae 25 to 35°C (77 to 95°F), and blue green algae 35 to 40°C (95 to 104°F) (Hach, 2003). Benthic macroinvertebrates are also sensitive to temperature and will move in the stream to find their optimal temperature. Optimal temperatures for fish vary by species: some survive best in colder water, whereas others prefer warmer water. Each fish species has evolved to live under specific optimal temperatures. Although fish can move into areas within their preferred temperature range, if present, other factors, such as dissolved oxygen, food, shelter, etc. can also influence their location. The optimal temperature range for one organism is not necessarily optimal for other taxa or for the aquatic community as a whole. Prolonged exposure to temperatures outside the optimal range can result in stress and/or death of fish and other organisms.

For fish, limiting temperatures are assessed in two ways: the maximum temperature for short-time exposure and the maximum average temperature for weekly exposure (EPA, 2003). Both maximum temperatures depend on and change with fish species and life cycle stage. Spawning, egg development, and juvenile life stages are the most sensitive. Table 9-7 provides optimum and maximum temperatures for several species in or near the Upper Pit River Watershed.

Table 9-7
MAXIMUM WEEKLY AVERAGE AND SHORT-TERM MAXIMUM TEMPERATURES FOR GROWTH AND SPAWNING OF SELECTED FISH[a]

Species	Maximum Weekly Average Temperature for Juvenile Growth	Maximum Temperature for Juvenile Survival	Maximum Weekly Average Temperature for Spawning[b]	Maximum Temperature for Embryo Spawning[c]
Bluegill	32 °C (90 °F)	35 °C (95 °F)	25 °C (77 °F)	34 °C (93 °F)
Brook trout	19 °C (66 °F)	24 °C (75 °F)	9 °C (48 °F)	13 °C (55 °F)
Common carp	—	—	21 °C (70 °F)	33 °C (91 °F)
Channel catfish	32 °C (90 °F)	35 °C (95 °F)	27 °C (81 °F)	29 °C (84 °F)
Largemouth bass	32 °C (90 °F)	34 °C (93 °F)	21 °C (70 °F)	27 °C (81 °F)
Rainbow trout	19 °C (66 °F)	24 °C (75 °F)	9 °C (48 °F)	13 °C (55 °F)
Smallmouth bass	29 °C (84 °F)	—	17 °C (63 °F)	23 °C (73 °F)

[a] from http://www.epa.gov/volunteer/stream/vms53.html, Brungs and Jones 1977
[b] Optimum or mean of the range of spawning temperatures reported for the species
[c] Upper temperature for successful incubation and hatching reported for the species
[d] Upper temperature for spawning

Water temperature is an important factor in determining the composition of a stream or lake community, because it affects the oxygen content of the water (i.e., oxygen levels become lower as temperature increases); the rate of photosynthesis by aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites, and diseases. Stream temperatures also affect the solubility of compounds and rate of downstream nutrient flow (EPA, 2003). Warm water makes compounds, such as cyanide, phenol, xylene, and zinc more toxic to aquatic organisms (Hach, 2003). Stressed fish are more susceptible to parasites and predation.

Water temperature is influenced by many factors including geographic location (i.e., longitude, latitude, elevation), climate and weather (both seasonally and diurnally), shade (e.g., canyon walls, riparian vegetation), impoundments (i.e., a body of water confined by a barrier, such as a dam), influent water (e.g., reservoirs, tributaries, groundwater, urban stormwater, irrigation runoff), and the volume, depth, and clarity of the water body.

Dissolved Oxygen

Dissolved oxygen (DO) is important for fish, aquatic invertebrates, bacteria, and aquatic plants and each species have minimum DO requirements for survival. Stream and lake systems produce and consume oxygen. They gain oxygen from the atmosphere via diffusion, from aquatic plants via photosynthesis, and from water movement via churning (e.g., riffles, waterfalls). Running water dissolves more oxygen than still water, such as that in a reservoir behind a dam. Respiration by aquatic plants, animals, and bacteria, decomposition, and various chemical reactions consumes oxygen. Plant respiration is greatest at night when photosynthesis cannot take place.

Generally, DO levels fluctuate diurnally (i.e., daily) as well as seasonally, and they are influenced by temperature and altitude. Cold water holds more oxygen than warm water (Figure 9-3), and water holds less oxygen at higher altitudes (EPA, 2003). As water temperature increases, less oxygen remains dissolved in the water, so warmer water holds less DO per volume. Warm water discharges (e.g., from irrigation runoff and top-releasing reservoirs) raise the water temperature and lower the DO level. Aquatic species have adapted to certain temperatures and the DO levels associated with these temperatures. Aquatic animals are most vulnerable to lowered DO levels in the early morning on hot summer days when stream flows are low, water temperatures are high, and aquatic plants have not been producing oxygen since sunset (EPA, 2003; Hynes, 1970).

Lakes and some deeper rivers generally exhibit vertical stratification of DO, while most streams exhibit horizontal changes in DO level. Dissolved oxygen levels in and below-riffle areas, waterfalls, or dam spillways are typically higher than those in pools and slower-moving stretches. Fish and other aquatic species will inhabit areas that are within the limits of their DO requirements. A species' DO requirements depend upon its life history, its physical state, water temperature, and pollutants present. Consequently, it is impossible to accurately predict minimum DO levels for specific fish and aquatic animals. For example, at 5°C (41°F), trout use about 50 to 60 mg of oxygen per hour; at 25°C (77°F), they may need five or six times that amount (Hach, 2003). Fish are cold-blooded animals, so they use more oxygen at higher temperatures when their metabolic rate is higher. In general, good fishing water averages about 9.0 ppm DO, and while low concentrations of four to five ppm can still support a good diversity fish population, concentrations below about 3.0 ppm kill even the hardiest of non-game fish (Table 9-8) (Hach, 2003).

Table 9-8
EFFECTS OF DISSOLVED OXYGEN LEVEL ON SOME NON-NATIVE FISH [a]

Fish Species	Lowest DO level at which fish survive for:	
	24 hours (summer)	48 hours (winter)
Black Bass	5.5 mg/L	4.7 mg/L
Common Sunfish	4.2 mg/L	1.4 mg/L
Black Bullhead	3.3 mg/L	1.1 mg/L

[a] from: Water Quality Criteria, California Water Quality Resources Board, Publication No. 3-A, 1963 in http://www.hach.com/h2ou/h2wtrqual.htm#References.

To measure the effect of a dam on DO, it would be important to sample for DO behind the dam, immediately below the spillway, and upstream of the dam. Since DO levels are critical to fish, a good place to sample is in the pools that fish tend to favor or in the spawning areas they use (egg O_2 requirements). An hourly time profile of DO levels at a sampling site is a valuable set of data because it shows the change in DO levels from the low point just before sunrise to the high point sometime in the midday (EPA, 2003).

pH

Pure water has a pH of 7, which means that the concentration of positive hydrogen ions is in equilibrium with the concentration of negative hydroxide ions. Most streams and lakes in North America have pH values that are slightly acidic (pH < 7) or basic (pH > 7), but are within the range of 5.0 to 9.0, which is tolerable for most fish species (Hach, 2003). Biodiversity is greatest in waters with a pH range of 6.5 to 8.0. More acidic or basic water bodies show a decrease in biodiversity, because the pH levels stress the physiological processes of certain species. Table 9-9 provides a summary of the effects of pH on fish and aquatic life.

Table 9-9
EFFECTS OF pH ON FISH AND AQUATIC LIFE [a]

Minimum pH	Maximum pH	Effects observed under research
4.0	10.1	Fish eggs could be hatched, but deformed young were often produced
4.1	9.5	Limits for the most resistant fish species
4.3	—	Carp died in five days
4.5	9.0	Trout eggs and larvae develop normally
4.6	9.5	Limits for perch
5.0	—	Limits for stickleback fish
5.0	9.0	Tolerable range for most fish
—	8.7	Upper limit for good fishing waters
5.4	11.4	Fish avoided waters beyond these limits
6.0	7.2	Optimum (best) range for fish eggs
1.0	—	Mosquito larvae were destroyed at this pH value
3.3	4.7	Mosquito larva lived within this range
7.5	8.4	Best range for the growth of algae

[a] from: Water Quality Criteria, California Water Quality Resources Board, Publication No. 3-A, 1963 in http://www.hach.com/h2ou/h2wtrqual.htm#References.

The introduction of various chemicals in streams and lakes can substantially impact the pH of the water and bring it to levels that are detrimental to fish. For example, fish that generally withstand pH values as low as 4.8 will die at pH 5.5 if the water contains 0.9 mg/L of iron or small amounts of aluminum, lead, or mercury (Hach, 2003). The opposite may also occur, i.e., decreasing pH levels may increase the toxicity of some otherwise innocuous elements or compounds: under low pH conditions chemical reactions can free toxic elements, and make them accessible for absorption in plants and animals; rainbow trout are particularly sensitive to this (EPA, 2003). Invertebrates are also affected by the input of certain elements and compounds, such as iron, and as a result these waters usually have undergone a reduction in biodiversity (Hynes, 1970). Air pollution may lower the pH of rain or snow (i.e., "acid rain"). This phenomenon has compromised many bodies of water throughout and downwind of industrialized areas. Changes in a water body's acidity can be caused by acid rain, surrounding rock, and certain wastewater discharges.

Alkalinity, which is the capacity of water to neutralize acids, is directly coupled to pH. Alkaline compounds in the water such as bicarbonates, carbonates, and hydroxides chemically bind to free H^+ ions, thereby lowering the H^+ concentration and increasing the pH. These alkaline compounds act as a buffer, and prevent sudden changes in the pH of a water body. However, when extremely high concentrations of alkaline compounds bind all the free H^+ ions, the water body can become too basic for organisms to live in.

Rocks and soils, salts, certain plant activities, and certain industrial wastewater discharges can all influence the alkalinity in streams. Alkalinity is important in determining a stream's ability to neutralize acidic pollution from rainfall or wastewater and it is one of the best measures of the sensitivity of the stream to acid inputs (EPA, 2003).

Turbidity and Total Solids

Turbidity measures the clarity of water based on how much light is blocked by suspended particles (e.g., clay, silt, and sand), algae, plankton, microbes, and other substances. Total solids are a measure of the amount of suspended solids in water. Turbidity interferes with sunlight penetration and aquatic plants need light for photosynthesis. Higher turbidity levels increase water temperature and decrease light penetration, thereby reducing photosynthesis—and the production of oxygen for fish and aquatic life. Because warmer water holds less DO than cold water and decreased light penetration results in decreased photosynthesis and increased plant respiration, increased turbidity results in reduced DO levels. If light levels get too low, photosynthesis may stop altogether and plants and algae will die. It is important to realize that conditions that reduce photosynthesis in plants result in lower oxygen concentrations and higher carbon dioxide concentrations.

Excessive amounts of suspended materials can clog the gills of fish and shellfish, reduce resistance to disease, lower growth rates, negatively affect egg and larval development (by smothering), and result in direct mortality of fish and other aquatic resources. Turbidity can also affect behavior and species interactions. Decreased visibility in turbid waters may make it more difficult to find food, but easier to hide from predators.

Suspended particles can also function as carriers of toxics, because pesticides used on irrigated crops readily cling to suspended particles (EPA, 2003). Where solids are high, pesticide concentrations may increase well beyond those of the original application as the irrigation water travels down irrigation ditches (EPA, 2003).

Some level of turbidity is naturally occurring due to geomorphic processes. Turbidity can result from a wide range of activities or sources, including: soil erosion from agricultural fields, logging operations and naturally disturbed areas, eroding stream banks, large numbers of bottom feeders (e.g., catfish and carp) that stir up bottom sediments, waste discharge, urban runoff, and excessive algal growth. Turbidity and total solids can be useful indicators of the effects of runoff from agricultural practices, logging activities, construction, and discharges. Rainfall can sharply increase stream turbidity and total solids as a result of sediment runoff from disturbed areas (e.g., agricultural fields, logged areas, or natural land slides). Impervious surfaces transport rainwater and sediment quickly into streams, which increases the magnitude of flood flows and, thereby, bank erosion and channel scouring. Regular monitoring of total solids can help detect trends that might indicate increasing erosion in watersheds. Total solids are closely related to stream flow and velocity, and should be monitored over time at the same location to determine changes to the system (EPA, 2003).

Nutrients

Phosphorus and nitrogen are essential nutrients for plants and animals. When agricultural fertilizers (from crops or from livestock) enter rivers and lakes, however, the added nutrients (primarily phosphorus, nitrogen, and carbon) can dramatically increase the abundance and growth of algae and aquatic plants and significantly affect the DO levels. Phosphorus is usually the nutrient that limits plant growth. A small increase of phosphorus availability can start a chain of events, which begins with an algae bloom. Although plants produce oxygen when sunlight is available, water can only hold a certain DO concentration depending on temperature. When sunlight is limited (e.g. clouds or night) so is photosynthesis, and plant respiration depletes the dissolved oxygen. Reduced DO levels can ultimately result in the death of algae, plants, fish, invertebrates, and other aquatic animals (Campbell, 1990; EPA, 2003). Although dead plants provide food for bacteria, bacteria also require oxygen. The process by which elevated nutrient levels can promote the growth of algae, which depletes the water of oxygen and eliminates other organisms, is known as eutrophication.

Sources of phosphorus include soil and rocks, runoff from fertilized lawns and cropland, runoff from animal manure storage areas, disturbed land areas, drained wetlands, water treatment, wastewater treatment plants, and failing septic systems (Hynes, 1970; EPA, 2003).

Another important nutrient is nitrogen, which occurs in three main forms, each with its own toxicity. Ammonia (NH_3) is the most toxic to aquatic biota, yet most aquatic animals readily excrete it, because under normal conditions, it is easily dissolved in water without harmful effects. Bacterial breakdown of NH_3 results in the less toxic nitrite (NO_2^-), and finally nitrate (NO_3^-) (Campbell, 1990). Nitrates are essential plant nutrients, but although least toxic of the nitrogen compounds, excess amounts can cause significant water quality problems. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/l), but in the effluent of wastewater treatment plants it can range up to 30 mg/l (EPA, 2003).

Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, and industrial discharges that contain corrosion inhibitors (Hynes, 1970; EPA, 2003).

In most natural systems, the input and output of nutrients is in balance; a regular amount of nutrients enter water bodies via runoff from land, a certain amount cycles continuously through the food web, and a regular amount is lost through sedimentation and outflow (Campbell, 1990). Excessive input of nutrients, primarily phosphorus and nitrogen, from agricultural fertilizers, livestock, or sewage, increases the abundance and growth of aquatic plants and algae. The increase in plants and algae chokes waterways, results in increased oxygen production during the day, but oxygen depletion at night, and reduced light penetration. As plants and algae die, decomposers respond, increasing in numbers, depleting the dissolved oxygen, and killing most organisms in the water body (Campbell, 1990; EPA, 2003). Eutrophication can have severe and long-lasting impacts on a stream or lake. Pollution of Lake Erie caused eutrophication of the lake by the 1960s; stricter regulations on waste dumping allowed certain biota to rebound, but many fish and invertebrate species have still not recovered (Campbell, 1990).

Other Potential Impacts on Fish

The following section describes how fisheries and other aquatic resources can be impacted by changes in water quality, water quantity, channel condition, riparian corridor condition, or fish eradication and planting practices.

Altered Temperature Regime

Altered water temperatures, which are defined, as above the normal temperature range under undisturbed conditions or out of phase with normal seasonal fluctuations, may be the result of a number of factors, either separately or in combination. These factors include, but are not limited to the following: (1) reduced riparian canopy cover, which increases direct exposure to sunlight and heating, (2) reduced cool water inflow as a result of diversions or interceptions, and (3) warm water return flows from natural or human sources. Although less likely in the Upper Pit River Watershed, summer water temperatures downstream of large dams may be lower than normal due to stratification and differential heating of the reservoir. Elevated temperatures can also prevent the movement of fish. Temperatures in the upper reaches of North Fork Parker Creek are cool enough to support trout, but warm water in the lower section, which lacks riparian cover, inhibits trout movement between the lower and upper reaches.

Low Water Levels

Low water can be a problem in both reservoirs and creeks. Reservoirs can be drawn down to levels that are not suitable for the fish population. There are often conflicts between the water needs and desires of farmers, recreationists, and environmentalists. The farming community is dependant upon water for their crops and livestock, while the fishing community wants enough water to maintain the gamefish population.

Reduced water flows, as a result of reservoirs and diversions, can create a variety of barriers for fish movement and survival. Low water flows can create impassable falls hindering fish migration upstream to their spawning grounds. Fish already in spawning tributaries can be stranded in pools when riffles become dried up or too shallow to provide passage back downstream to their natural feeding grounds.

Low water levels in lakes and reservoirs can also create semi-dry streambed or riffle connections between the tributaries. Evaporation occurs, but is usually a minor problem unless a reservoir is drawn down to the minimum levels and still needs to support a fishery. Currently the CDFG insists that new reservoirs be outfitted with a conservation pool that will allow fish to survive during the summer months. This concept is not new, however, Robert's Ranches (Modoc County) has placed it in their legal contracts that the reservoirs they own will always have a conservation pool (Paul Chappell pers. comm.).

Entrapment

Fish screens on pumps and diversion canals are important in preventing the unintentional entrainment or passage of fish into irrigation diversions. If screens are not present, or they are inadequate, fish may pass into artificial structures or water bodies (e.g., ditches, canals, and/or reservoirs) in which they may ultimately become trapped or stranded. Fish mortality occurs when these water bodies dry up or when other environmental conditions (see below) within them become inhospitable to fish.

Physical Barriers
A variety of physical barriers, both natural and human-made, can be identified in the Upper Pit River Watershed. Dams, built to create reservoirs for irrigation, can dramatically alter the stream system both upstream and downstream. Upstream, reservoirs change the natural riverine conditions to lake conditions; this results in the replacement of native stream-adapted fish by lake-adapted fish and other aquatic species.

A wide variety of non-native fish has been introduced in the Upper Pit River Watershed, many of which are lake-adapted, and they have rapidly expanded their distribution and population size in newly constructed reservoirs. Reservoirs that function solely as a power source, however, may actually benefit native species because they are usually maintained at a full level and provide constant conditions similar to a giant riverine pool (Moyle, 2002). Conditions in Lake Britton are comparable to a giant riverine pool, and native fishes dominate over the introduced species (Moyle, 2002).

Downstream of a dam, water quality (e.g., temperature, dissolved oxygen, chemical composition) is usually altered and water clarity is often greater than it originally was. Water released from reservoirs can severely alter the natural stream temperature downstream of a dam. Water released from large and particularly deep reservoirs is often cold, especially when the release gate is below the thermocline (i.e., a transitional zone between upper warmer water and deeper colder water), while water released from small or shallow reservoirs is usually warmer (Hynes, 1979; Allen, 1996). As both situations alter the natural stream temperature, the fauna and flora composition will be altered.

Dams can inhibit the movement of fish, particularly in the upstream direction (Hynes, 1979; Allen, 1996). Because of the real potential for fish to be washed over dams during high flows, dams are less effective at inhibiting movement in the downstream direction. Currently, two fish passage barriers are in place on Pit River tributary streams (i.e., Turner Creek and Johnson Creek) to limit contact and hybridization potential between Sacramento sucker and the endangered Modoc sucker. Fish ladders can be used, with varying degrees of success, to allow fish passage over dams. In addition to fish passage issues, dams can also interrupt the natural movement of woody debris and bedload sediment, including spawning gravel.

Culverts can allow or prevent the passage of fish and other aquatic species. Placing the downstream side of the culvert above the surface of the water creates an impassable waterfall, and can prevent fish movement. When both sides of the culvert are in the water fish migration is rarely a problem. Placing boulders or baffles in extremely long culverts may aid fish migration, while the absence of boulders or baffles can prevent the upstream movement of unwanted fish and invertebrate species.

Natural barriers, such as waterfalls, have originally kept certain water reaches fishless and caused geographic isolation for species. The composition of the fish community (14 species) native to the Pit River drainage in northeastern California is due in large part to both the presence and removal of barriers to species movement. Northeastern California is a region that was subject to intense volcanism, mountain building, and tectonic activity (specifically normal faulting) over the course of relatively recent geologic history, i.e., from Oligocene through Pleistocene epochs (MacDonald, 1966; Montgomery, 1988; Norris and Webb, 1990). During the Pliocene and Pleistocene epochs highly fluid basalt flows erupted from fissures and flowed down into valleys forming broad flat surfaces that typify the upper strata of the Modoc Plateau. Lower strata are dominantly andesitic and are associated with an earlier period of Cascade volcanism, when the Cascade Range axis was east of its current position (MacDonald, 1966; Fuis et al., 1987; Montgomery, 1988). These lava flows would have repeatedly changed the face of the landscape joining and separating drainages in the area, creating and destroying barriers and isolating species. The current distribution and fossil record of several different species with restricted ranges, including freshwater mussels and snails, indicates that there have been connections in the relatively recent geologic past between what are the present-day Snake River, Pit River, and Klamath River drainages (Taylor, 1960, 1985; Taylor and Bright, 1987). The 14 fish species native to the present-day Upper Pit River Watershed are of either Sacramento or Klamath origin, including three endemic sculpins (i.e., Pit, rough, and bigeye marbled sculpin) and the endemic Modoc sucker (Moyle, 2002). The faunal commonalities between the Klamath and Pit drainages clearly support an interconnection. The fact that none of the endemic Sacramento species are present in the Klamath assemblages indicates that the Pit-Klamath connection had been severed prior to the integration of the Pit and Sacramento drainages (Robins and Miller, 1957).

The Klamath-derived fish fauna in the midreaches of the Pit River, including Pit-Klamath brook lamprey, rough sculpin, bigeye marbled sculpin, tui chub, and redband trout, appear to have been nearly overwhelmed by a more aggressive Sacramento River fauna that entered the region as the Pit River cut back into the lava plateau to capture the interior drainage by headward erosion (Hubbs and Miller, 1948; Robins and Miller, 1957). The Sacramento-San Joaquin fishes: Sacramento pikeminnow, hardhead, California roach, and Pit sculpin are all Pleistocene invaders that were able to pass the falls and rapids of the lower Pit River canyon. Hubbs and Miller (1948) stated that the Pit River species with ancestors in common with the modern Klamath fishes appeared to be relicts confined to the headwaters, particularly above the falls in the Pit and Fall Rivers. The Pit sculpin is presumably derived from the riffle sculpin of the Sacramento-San Joaquin drainage through isolation in the upper Pit River drainage (Moyle, 2002). The Sacramento sucker replaced the Modoc sucker except in streams isolated by natural barriers.

Winter ice can cause a high winterkill of trout and other fish in lakes and reservoirs, especially in high-elevation lakes, such as Little Medicine Lake and Bullseye Lake in Siskiyou County. Shallow lakes can freeze solid; while larger deeper lakes may experience reduced dissolved oxygen levels, which may cause fish to suffocate. These high-elevation lakes need to be planted annually if a fishery is to be maintained.

Channelization

From the 1940s through the 1970s, channelization of streams was common practice in California and other parts of North America. Stream channelization for drainage and water diversion eliminates silt deposition areas and creates long uniform stream segments (Hynes, 1979). A natural meandering stream is highly heterogeneous; it has a wide variety of habitats (e.g., riffles, pools, breeding sites, shelter) all creating their own variety of microhabitats that contribute to the diversity in aquatic biota (Hynes, 1979). A channelized stream section has lost most of the natural heterogeneity; it has been transformed into a uniform habitat that supports only a few taxa (low biodiversity), but these taxa are often present in large population numbers. In the 1970s, Moyle (1976) studied and compared natural and channelized sections of Rush Creek, a tributary to Ash Creek. He found that, compared to unchannelized sections, channelized sections contained smaller and fewer trout, as well as a lower overall biomass. Similar results were also found for the Modoc sucker; however, Pit sculpin were more numerous in the channelized sections (Moyle, 1976). The invertebrate composition and biomass were also much higher in the unchannelized sections versus the channelized sections (Moyle, 1976). The homogeneous conditions in some of the faster flowing canals allow blackfly (*Simuliidae*) populations to flourish and become a serious nuisance pest for humans (Hynes, 1979).

Loss of Riparian Zone

Access to water is important to wildlife, livestock, and humans. Activities in the natural system as well as from livestock and humans can severely impact the riparian zone (Hynes, 1979). Loss of the riparian zone can have severe impacts on the stream channel. Plant roots maintain the stability of the banks and prevent most natural erosion from occurring. Due to erosion, large amounts of soil can be transported downstream, which generally does not benefit either the natural system or the landowner. Besides stability, a riparian zone provides shade and cover. Shading a stream channel greatly reduces the amount of warming (i.e., increase in water temperature) by reducing exposure to direct sunlight. Overhanging plants and submerged roots also provide fish and other aquatic life with cover against predators (Hynes, 1979). Trampling of the riparian zone from livestock or human activities (e.g., angling, trails, roads, and campgrounds) can quickly destroy riparian vegetation. A fence, several yards from the stream bank, allows a strip of riparian vegetation to grow and stabilize the bank. Small sections can be left unfenced to allow cattle access to the water.

Degradation of Spawning Habitat

Movement of suspended sediment is common in river systems and fish have adapted to a certain degree of turbidity and silt deposition. Suspended sediment levels are particularly important during spawning periods. Silt deposition can cover fish eggs and reduce water flow over the eggs and inhibit oxygen exchange to the developing fish embryos (Hynes, 1979).

Livestock over use can negatively impact spawning grounds by either trampling redds (i.e., fish "nests") and thereby crushing and dislodging the eggs, or they can compact gravel beds rendering them not usable for redd construction. Fitzhugh Creek has received considerable attention because of the impacts livestock have on spawning grounds.

Fish Eradication Practices

Species introductions are probably the most damaging human influence on an ecosystem. Once established, introduced species often disperse and usually cannot be eradicated, while habitat can potentially be restored and the source of chemical pollutants can often be located and eliminated (Allan, 1996). Many lakes and reservoirs have been planted legally and illegally with native and exotic fish. Many high alpine lakes were originally fishless, but appear to have been planted by shepherds in the 1800s to provide a food supply (Paul Chappell pers. comm.). Introduction of fish (e.g., brook trout) in these fishless lakes has severely impacted amphibian populations that are often dependent on fishless lakes to rear their young (Moyle, 2002). Native fish populations have also been known to decline after the introduction of exotic fish. Illegally planted largemouth bass in Reservoir "C" were partially responsible for the decline of the trout fishery. Finally, most reservoirs have been planted with gamefish, but occasionally a non-gamefish (e.g., baitfish) population becomes established. In 1973, Reservoir "C" was treated with rotenone to eradicate the tui chub population and reestablish a trout fishery by planting trout after the eradication. A non-gamefish population can significantly hinder the growth and propagation of a gamefish population.

Chemical treatment of reservoirs, lakes, and streams with rotenone has been the most frequently used method to eradicate unwanted fish. Reasons for treatment have been pressure from anglers to create a better fishery, to experiment with a new gamefish species (e.g., Lahontan cutthroat trout in West Valley Reservoir in 1955), and to secure the future of an endangered species. Modoc sucker populations have been declining in part by brown trout predation and hybridization with Sacramento suckers. In 1983, chemical treatment of a section of Turner Creek was intended to eradicate all fish in order to replant the section with Modoc suckers and rainbow trout. Trout, suckers, and native cyprinids are up to 4 times more susceptible to rotenone than species such as bullhead, goldfish, and carp (Calhoun, 1966). Complete extermination of the latter three species has been extremely difficult to achieve (Calhoun, 1966). Chemical treatments were most prevalent in the 1940s, 50s, and 70s but occurred throughout the period and into the 1980s.

An alternative specific to reservoirs is the possibility to completely drain the water over the summer. This method would also be effective in reducing non-native bullfrog populations since their tadpoles generally overwinter one year.

Hatchery Planting Practices
For many years, fish hatcheries have been the assumed solution to the decline in fish populations resulting from water projects and heavy angling pressure (Moyle, 2002). According to Moyle (2002), their presence continues to have severe negative impacts on salmon and steelhead populations, but has generally been positive for the trout and bass fishery. The problems and benefits of hatcheries are briefly discussed below.

Genetics
Wild populations have long been under natural selection pressures specific to the area and habitats they live in. Their genetic distinctiveness is important for local adaptation, but interbreeding with hatchery fish is likely to affect the genetic fitness of future generations. (Moyle, 2002) Fish reared in hatcheries are under different selective pressures than wild populations, which severely impact the ability of hatchery fish to survive in the wild after only five to seven generations (Moyle, 2002).

Spawning Interference
Hatchery fish can compete with wild fish during spawning. Although male hatchery fish are generally less aggressive and less successful at obtaining mates, their sheer abundance can affect the natural breeding system (Moyle, 2002). Their activities can reduce the vigor of future wild fish generations, and cause a decline in production.

Spread of Disease or Parasites
Hatchery fish are reared under high densities making the outbreak of diseases and parasites more likely. These diseases and parasites can spread into wild populations when fish are planted, as has happened with whirling disease in the western United States (Moyle, 2002).

Juvenile Predation
Juvenile hatchery salmon and steelhead are generally larger than their native counterparts and will directly prey on them (Moyle, 2002). Juvenile hatchery fish, however, are generally more vulnerable to predation than their wild counterparts.

Life History Effects
Hatchery practices (e.g., phenotypic selection for early spawners, timing of juvenile fish planting) frequently change the life history strategies of wild populations after they interacted (Moyle, 2002).

Harvest Effects

Hatchery fish are largely raised for harvest, but in mixed-stock fisheries wild fish are invariably harvested leading to the further decline in wild population (Moyle, 2002). Harvest restrictions (e.g., limiting the harvest rate) allow a larger proportion of hatchery fish to reach the wild fish spawning grounds, placing further stress on the wild population (Moyle, 2002).

Other Management Effects

Studies have been performed to understand survival and migratory habits of salmonids. Hatchery-reared fry and smolts were used because they were available in large numbers, but the results from these studies cannot and should not be applied to wild fish, based on previously discussed points (Moyle, 2002).

Changes in Public Attitudes

Hatcheries are seen as permanent solutions to save salmon and steelhead populations (Black, 1995). Alternatives to maintain viable salmonid populations exist, but habitat restoration and dam removal are expensive projects and not yet globally accepted, although public opinion is slowly changing (Moyle, 2002).

Benefits of Hatcheries

Hatcheries can plant trout phenotypically selected to provide good angling opportunities for roadside creeks, reservoirs, and lakes, yet have little impact on wild populations (Moyle, 2002). Hatcheries can be used to rear and plant anadromous fish in streams undergoing restoration projects and they can provide public education programs to create public awareness and interest in local and global conservation issues (Moyle, 2002).

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Appendix 9-A

Historic Fish Surveys of the Upper Pit River Watershed

Table A-1
UNITED STATES FISH COMMISSION 1898 SURVEY SITES FROM THE UPPER PIT RIVER WATERSHED (RUTTER 1908)

Scientific Name **Common Name**	**Scientific Name** **Common Name** **(from Rutter 1908)**	Burney Creek (Burney)	Hat Creek (Cassel)	Fall River (Fall River Mills)	Fall River (Dana)	Bear Creek (on Bartle to Dana road)	Pit River (Pittville)	Pit River (Bieber)	Ash Creek (Adin)	Rush Creek (on Adin to Canby road)	Pit River (Canby)	North Fork Pit River (near Alturas)	North Fork Pit River (mouth of Joseph Creek)	North Fork Pit River (near source)	Joseph Creek (at mouth)	Goose Lake (several places)	Goose Lake (Davis Creek)	Goose Lake (Davis Creek P.O.)	South Fork Pitt River (South Fork P.O.)	South Fork Pitt River (Jesse Valley)
Lampetra lethophaga Pit-Klamath brook lamprey	*Lampetra cibaria* Western brook lamprey																			
Lampetra tridentata ssp. Goose Lake lamprey	*Entosphenus tridentatus* Lamprey															X			X	
Ptychocheilus grandis Sacramento Pikeminnow	*Ptychocheilus grandis* Sacramento pike			X			X	X	X		X	X			X					
Mylopharodon conocephalus Hardhead	*Mylopharodon conocephalus* Bluefish; Hardhead						X	X	X		X	X								
Siphateles bicolor Tui chub	*Rutilus bicolor* Klamath Lake roach		X		X		X		X		X					X			X	
Lavinia symmetricus mitrulus Pit roach	*Rutilus symmetricus* California roach											X	X							
Rhinichthys osculus Speckled dace	*Agosia robusta*	X		X	X				X		X	X			X	X		X	X	
Catostomus microps Modoc Sucker	*Catostomus microps* new species									X										
Catostomus occidentalis Sacramento Sucker	*Catostomus occidentalis* Western sucker								X		X	X	X			X			X	
Oncorhynchus mykiss Rainbow trout	*Salmo irideus* Rainbow trout	X	X	X	X	X				X		X		X		X		X	X	
Hysterocarpus traskii Tule Perch	*Hysterocarpus traskii* Fresh-water viviparous perch						X													
Cottus pitensis Pit sculpin	*Cottus gulosus* Sculpin; Bull-head	X	X	X[1]	X[1]					X	X				X					X
Cottus asperrimus Rough sculpin	*Cottos asperrima* new species			X	X															
Cottus klamathensis macrops Bigeye marbled sculpin	*Cottos macrops* new species			X	X															
	Survey Date	8/29/1898	8/30/1898	8/29/1898	8/28/1898				9/1/1898	9/1/1898		9/4/1898							9/5/1898	

Table A-2

MOYLE AND DANIELS' (1982) ABUNDANCE DATA FOR FISH BY SPECIES AND BULLFROGS AT UPPER PIT RIVER WATERSHED SITES SAMPLED FROM JULY 3 THOUGH SEPTEMBER 9, 1974. NATIVE SPECIES ARE IN BOLD TEXT, NON-NATIVE SPECIES ARE IN REGULAR TEXT

Valley/ Drainage	**Stream**	**Order**	**Elevation**	**Surface Water Temp**	**Human Modifications[a]**	**Stream Type[b]**	**Overall Fish Abundance[c]**	**% Native Species**	**Pit-Klamath brook lamprey**	**Sacramento Pikeminnow**	**Hardhead**	**Tui chub**	**Speckled dace**	**Pit roach**	Golden shiner	**Sacramento Sucker**	Brown bullhead	Channel catfish	**Rainbow trout**	Brown trout	Brook trout	**Pit sculpin**	Bluegill	Green sunfish	Largemouth bass	Bullfrog
Fall River Valley	Pit River	1	3220	20	4	4	2	25														25	15	25	2	
Fall River Valley	Pit River	1	3280	22	3	5	3	1			1							1					200	300	100	
Fall River Valley	Pit River	1	3320	19	1	5	2	12					15				1						13	35	28	
Fall River Valley	Pit River	1	3480		1	5	3	5		30			50			1	1					25	1	3	1	
Fall River Valley	Beaver Creek	2	5000	28	5	4	0	0																		2
Fall River Valley	Beaver Creek	2	3220	24		4	1	100								2										3
Fall River Valley	Beaver Creek	2	3280	19	1	2	3	0																10	2	
Fall River Valley	Beaver Creek	2	3480	19	1	2	1	25						4										15		
Fall River Valley	Horse Creek	2	4120	22	2	4	4	80					2			5	10		1			50			5	5
Fall River Valley	Horse Creek	2	3800	19	1	4	2	99		6	5					2			1			75	1			
Fall River Valley	Horse Creek	2	3640	20	1	4	2	100		1	1											30				1
Big Valley	Pit River	1	4100	21	1	4	2	40							5	15	15						1	1	2	
Big Valley	Pit River	1	4100	21	1	4	4	10							25	10	100						50	200	100	1
Big Valley	Pit River	1	4100	21	1	4	3	50		5					25	25	50							10	1	
Big Valley	Pit River	1	4120	24	3	4	1	40		10													1	2	10	
Big Valley	Pit River	1	4120	26	2	4	1	0															2	1	19	
Big Valley	Pit River	1	4120	26	4	5	1	5				1				5							10	10	20	
Big Valley	Widow Valley Ck	3	4200	21	2	4	2	40		8						20								10		1
Warm Springs V.	Pit River	1	4240	19	1	5	1	20								1							5	1	7	4
Warm Springs V.	Pit River	1	4240	19	1	5	3	97			25					100	3						3	3		2
Warm Springs V.	Pit River	1	4300	21	4	4	2	14								5						1	20	20	3	
Warm Springs V.	Pit River	1	4300	23	4	6	2	15			5												10	10	5	
Warm Springs V.	Pit River	1	4320	22	1	5	1	25		1													10	10	2	
Warm Springs V.	Rattlesnake Creek	2	4820	17	2	4	2	100		3		1	3			50										
N. Fork Pit River	N. Fork Pit River	2	4400	22	2	5	3	14	3							15						15		200		
N. Fork Pit River	N. Fork Pit River	2	4400	22	1	5	4	72		2						500						15		200		
N. Fork Pit River	N. Fork Pit River	2	4440	16	1	5	3	99	1	300						200								1		
N. Fork Pit River	N. Fork Pit River	2	4480	19	1	5	4	100					100			500			1							1
N. Fork Pit River	N. Fork Pit River	2	4560	21	1	4	3	100		10			2			50						20				
N. Fork Pit River	N. Fork Pit River	2	4600	19	1	4	2	100		20						30			1			30				
N. Fork Pit River	N. Fork Pit River	2	4640	14	1	4	2	100		25			3			30						16				

Table A-2 (cont.)
MOYLE AND DANIELS' (1982) ABUNDANCE DATA FOR FISH BY SPECIES AND BULLFROGS AT UPPER PIT RIVER WATERSHED SITES SAMPLED FROM JULY 3 THOUGH SEPTEMBER 9, 1974. NATIVE SPECIES ARE IN BOLD TEXT, NON-NATIVE SPECIES ARE IN REGULAR TEXT

Valley/ Drainage	Stream	Order	Elevation	Surface Water Temp	Human Modifications[a]	Stream Type[b]	Overall Fish Abundance[c]	% Native Species	**Pit-Klamath brook lamprey**	**Sacramento Pikeminnow**	**Hardhead**	**Tui chub**	**Speckled dace**	**Pit roach**	Golden shiner	**Sacramento Sucker**	Brown bullhead	Channel catfish	**Rainbow trout**	Brown trout	Brook trout	**Pit sculpin**	Bluegill	Green sunfish	Largemouth bass	Bullfrog
N. Fork Pit River	Joseph Creek	3	5600	15	1	4	1	100											10							
N. Fork Pit River	Joseph Creek	3	5120	19	2	4	1	100					10						8							
N. Fork Pit River	Joseph Creek	4	5800	8	1	4	0	0																		
N. Fork Pit River	Parker Creek	3	4480	17	3	4	5	100	25				100			50			50			2				
N. Fork Pit River	Parker Creek	3	4920		3	4	3	100	5				250						13			1				
N. Fork Pit River	Parker Creek	3	4960		1	4	3	100											35			10				
N. Fork Pit River	Parker Creek	3	4400	26	1	5	2	45		2						15								100		
N. Fork Pit River	Parker Creek	4	6000	12.5	1	4	1	100											8							
N. Fork Pit River	Thoms Creek	3	5840	9	1	4	3	100											25							
N. Fork Pit River	Thoms Creek	3	5720	10	1	4	3	100											32							
N. Fork Pit River	Thoms Creek	3	4560	24	1	2	3	100					100			150										
N. Fork Pit River	Couch Creek	4	5240	19	1	4	2	100					15						41			3				
N. Fork Pit River	Shields Creek	4	4920	23	2	4	4	100	4				200						1							
N. Fork Pit River	Shields Creek	4	5000	21	2	4	3	100	3				100						35							
N. Fork Pit River	Shields Creek	5	6640	12	1	4	1	100											9							
N. Fork Pit River	Shields Creek	5	6500	10	1	4	1	100											4							
S. Fork Pit River	S. Fork Pit River	2	4520	18	1	5	1	100	1							8+fry						20				
S. Fork Pit River	S. Fork Pit River	2	5000	15	1	4	2	95								12			1	3		1				
S. Fork Pit River	S. Fork Pit River	2	4880	15	1	5	1	80								10			8	5		5				
S. Fork Pit River	S. Fork Pit River	2	4600	22	1	4	1	100														20				
S. Fork Pit River	East Creek	3	7240	20	1	4	1	70											13		6					
S. Fork Pit River	East Creek	3	6760	19	1	4	2	100											30		1	10				
S. Fork Pit River	Harvey Creek	3	5240	21	1	4	1	100					20													
S. Fork Pit River	Mill Creek	3	5260	11	1	4	1	25												22		5				
S. Fork Pit River	West Valley Ck	3	4600	17	1	4																1				
S. Fork Pit River	Fitzhugh Creek	4	6280	20	1	4	1	100											25							
S. Fork Pit River	Parsnip Creek	4	5880	16	1	4	2	15											1	20		2				
S. Fork Pit River	Parsnip Creek	4	58850	16	1	4	1	20	1				5							12						
S. Fork Pit River	Parsnip Creek	5	6200	10	1	4	1	20											6	22						

[a] Human modification scale with a 0–5 rating of the extent to which human activities have visually modified the stream channel (0=most pristine and 5=most modified, e.g., channelized)
[b] Stream type-streams with lower ratings 1–3 are intermittent in flow (1=small, 2=medium, and 3=large) and streams with higher ratings 4–6 had permanent flow (4=small, 5=medium, and 6=large)
[c] Overall fish abundance in a 50 m reach rated on a 0–5 scale with 0=no fish, 1=one or two individuals, 2=3–10 individuals, 3=common, 4=abundant, and 5=large numbers

Appendix 9-B

Summary of Fish Planting Records by Water Body from 1930–2002

Table B-1

RAINBOW TROUT PLANTING RECORDS BY SUBSPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		RB Catchables	RB Subcatchables	RB Fingerlings	RB Brood stock	Steelhead Fingerlings	ELT Catchables	ELT Subcatchables	ELT Fingerlings	ELT x RT Catchables
Ash Creek	a	117,713	9,881	234,176			3,705			
	b	2,738 ± 2,190	3,561 ± 831	23,418 ± 9,110			1,235 ± 1,532			
	c	525–13,235	2,973–4,148	10,500–35,640			255–3,000			
	d	1950–63, 1970–02	1951, 1955, 1957	1931, 1934, 1942–49			1985, 1990, 1993			
	e	43	3	10			3			
	f	1961–62, 1985–86								
	g	Annually	Infrequently	Annually			Infrequently			
Ballard Reservoir	a	118,896	24,199	81,119			66,653		20,177	
	b	4,404 ± 2,043	4,824 ± 1,467	7,385 ± 5,035			3,703 ± 1,269		10,089 ± 87	
	c	200–9,015	2,520–6,617	3,000–15,000			1,404–5,860		10,027–10,150	
	d	1949–52, 1958–83, 1996, 1997	1943, 1950, 1964, 1967, 1969	1932, 1942, 1945–46, 1948, 1969–71, 1974, 1983, 1986			1979, 1984–2002		1991, 1992	
	e	33	5	11			18		2	
	f	1950, 1964, 1967, 1969					1988, 1993			
	g	Infrequently	Infrequently	Infrequently			Annually		Annually	
Bayley Reservoir	a	81,507	55,383	58,018			95,462	12,000	272,685	
	b	4,528 ± 2,496	5,538 ± 3,123	8,288 ± 3,096			4,546 ± 2,038		13,634 ± 2,880	
	c	838–8,409	702–12,039	4,000–12,930			1,170–8,000		5,061–15,984	
	d	1954–78, 1990, 1993, 1997	1953–57, 1964–69	1950–52, 1969–72, 1976			1978–2002	1980	1978–2002	
	e	18	10	7			21	1	20	
	f	1957, 1964–65, 1967, 1969, 1972–76	1966				1980, 1987, 1988, 1990		1981, 1987, 1992, 1998, 1999	
	g	Infrequently	Annually	Annually			Annually	Infrequently	Annually	
Bear Valley Reservoir	a	24,587		2,500						
	b	3,512 ± 7,976		833 ± 289						
	c	465–21,600		500–1,000						
	d	1956, 1967–73		1958, 1961						
	e	7		3						
	f	1972		1959						
	g	Infrequently		Infrequently						
Beaver Creek	a	857	1293							
	b	286 ± 201	647 ± 52							
	c	101–500	610–683							
	d	1954, 1956	1953–1955							
	e	3	2							
	f		1954							
	g	Annually	Infrequently							

Table B-1 (cont.)
RAINBOW TROUT PLANTING RECORDS BY SUBSPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		RB Catchables	RB Subcatchables	RB Fingerlings	RB Brood stock	Steelhead Fingerlings	ELT Catchables	ELT Subcatchables	ELT Fingerlings	ELT x RT Catchables
Big Jack Reservoir	a			2,160						
	b									
	c									
	d			1970						
	e			1						
	f									
	g			Infrequently						
Blue Lake	a	455,951	28,445	323,027	9,413		110,310			5,120
	b	9,119 ± 5,625	7,111 ± 4,060	26,919 ± 14,507	1,357 ± 559		6,128 ± 2,736			
	c	1,200–21,909	1,880–10,460	5,000–50,000	630–2,000		447–11,555			
	d	1950–2002	1950, 1954, 1955, 1957	1931–33, 1940–50, 1965, 1968	1962–63, 1970–75		1969, 1986–2002			1988
	e	50	4	13	7		18			1
	f	1951, 1955, 1970, 1984, 1986–87, 1989		1947–1949	1971					
	g	Annually	Infrequently	Infrequently	Annually		Annually			Infrequently
Bullseye Lake	a	38,422					2,870			1,760
	b	1,130 ± 666					957 ± 417			
	c	200–3,500					520–1,350			
	d	1956–57, 1967–2002					1983, 1985, 1993			1988
	e	34					3			1
	f	1968, 1984, 1988, 1993								
	g	Annually					Infrequently			Infrequently
Butte Creek	a	15,448		3,000						
	b	1,545 ± 3,047								
	c	297–10,175								
	d	1972–78, 1993		1966						
	e	9		1						
	f	1977, 1979–83, 1985								
	g	Infrequently		Infrequently						
Camp Carlsburg	a	16,970								
	b	1,886 ± 647								
	c	853–3,073								
	d	1970–78								
	e	9								
	f									
	g	Annually								

Table B-1 (cont.)

RAINBOW TROUT PLANTING RECORDS BY SUBSPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		RB Catchables	RB Subcatchables	RB Fingerlings	RB Brood stock	Steelhead Fingerlings	ELT Catchables	ELT Subcatchables	ELT Fingerlings	ELT x RT Catchables
Canyon Creek	a	8,864	810	67,390						
	b	521 ± 152	405 ± 209	9,627 ± 1,510						
	c	250–893	257–893	7,560–12,000						
	d	1951–64, 1972–78	1951, 1955	1940–46						
	e	17	2	7						
	f	1954–55, 1962–63								
	g	Annually	Infrequently	Annually						
Cedar Creek	a	205	633	39,650						
	b		317 ± 98	9,913 ± 5,260						
	c		247–386	2,650–15,000						
	d	1951	1950, 1952	1942–45						
	e	1	2	4						
	f			1945						
	g	Infrequently	Infrequently	Annually						
Cottonwood Creek	a			31,000		20,000				
	b			10,333 ± 4,509		10,000 ± 0				
	c			6,000–15,000						
	d			1932, 1935, 1939		1936, 1937				
	e			3		2				
	f									
	g			Infrequently		Annually				
Coyote Reservoir	a			168,526						
	b			84,263 ±12,888						
	c			75,150–93,376						
	d			1947, 1972						
	e			2						
	f									
	g			Infrequently						
Delta Reservoir	a	725		178,160			6,375		74,020	
	b	363 ± 53		89,080 ± 112,741			1,594 ± 474		12,337 ± 8,776	
	c	325–400		9,360–168,800			1,000–2,000		7,000–30,000	
	d	1997, 2002		1953, 1954			1995–2001		1993–2002	
	e	2		2			4		6	
	f						1996, 1997, 1999		1996–1999	
	g	Infrequently		Infrequently			Infrequently		Annually	
Dorris Brothers Reservoir	a	10,011		10,000						
	b	5,006 ± 6								
	c	5,001–5,010								
	d	1972, 1973		1972						
	e	2		1						
	f									
	g	Annually		Infrequently						

Table B-1 (cont.)
RAINBOW TROUT PLANTING RECORDS BY SUBSPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		RB Catchables	RB Subcatchables	RB Fingerlings	RB Brood stock	Steelhead Fingerlings	ELT Catchables	ELT Subcatchables	ELT Fingerlings	ELT x RT Catchables
Dorris Reservoir	a	35,680	34,989	82,000			33,461			
	b	3,244 ± 1,783	6,998 ± 4,399	27,333 ± 18,037			3,346 ± 1,545			
	c	648–5,010	2,001–14,100	10,000–46,000			1,008–5,000			
	d	1950–51, 1966, 1972, 1979–83, 1996, 1997	1951, 1953, 1967–69	1946, 1947, 1972			1978, 1984–87, 1995–2002			
	e	11	5	3			10			
	f						1996, 2000, 2001			
	g	Infrequently	Infrequently	Infrequently			Infrequently			
Duncan Reservoir	a	95,718	55,280	250,201			95,724		84,046	3,888
	b	4,162 ± 2,670	5,529 ± 3,314	13,168 ± 10,598			5,318 ± 2,461		6,003 ± 4,824	
	c	800–10,077	234–11,052	4,000–40,000			1,450–8,200		3,250–20,002	
	d	1955, 1958–78, 1990–2000	1955–1969	1960–1978			1978–2000		1979–1995	1975
	e	22	9	9			18		13	1
	f	1964–65, 1968–69, 1976–1977, 1993–95, 1998–99	1960–63, 1966, 1967	1961–68, 1976, 1977			1980, 1988, 1990–92, 1995 1996		1981, 1988, 1991, 1992	(Fingerlings)
	g	Infrequently	Infrequently	Infrequently			Annually		Annually	Infrequently
East Creek	a	7,042	4,516	183,242						
	b	1,408 ± 570	1,505 ± 945	22,905 ± 11,828						
	c	510–2,075	517–2,399	7,000–40,000						
	d	1951–1957	1949, 1950, 1955	1941–1949						
	e	5	3	8						
	f	1955–1956		1948						
	g	Infrequently	Infrequently	Annually						
Fitzhugh Creek	a	1,379	570	117,205						
	b	690 ± 298		10,655 ± 3,887						
	c	479–900		2,975–18,000						
	d	1951, 1980	1951	1931–32, 1938–47, 1980						
	e	2	1	11						
	f			1939, 19432						
	g	Infrequently	Infrequently	Infrequently						
Graven Reservoir	a			35,441			3,000		16,620	
	b			7,088 ± 171					8,310 ± 4,540	
	c			6,912–7,329					5,100–11,520	
	d			1980–1985			1979		1981, 1987	
	e			5			1		2	
	f			1981						
	g			Annually			Infrequently		Infrequently	

Table B-1 (cont.)

RAINBOW TROUT PLANTING RECORDS BY SUBSPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		RB Catchables	RB Subcatchables	RB Fingerlings	RB Brood stock	Steelhead Fingerlings	ELT Catchables	ELT Subcatchables	ELT Fingerlings	ELT x RT Catchables
Holbrook Reservoir	a	2,310							33,388	
	b								4,770 ± 4,512	
	c								3,000–15,000	
	d	1996							1993–2000	
	e	1							7	
	f								1998	
	g	Infrequently							Annually	
Horse Creek	a	720		75,000						
	b			15,000 ± 4,123						
	c			10,000–20,000						
	d	1950		1931, 1939, 1944, 1946–47						
	e	1		5						
	f									
	g	Infrequently		Infrequently						
Indian Spring Reservoir	a	9,330		8,080			6,612			1,000
	b	1,37 ± 99		2,020 ± 101			945 ± 99			
	c	945–1,290		1,920–2,160			800–1,012			
	d	1970–1983		1969–1972			1979–1992			1986
	e	9		4			8			1
	f	1977–1981					1981–1986			
	g	Annually		Annually			Annually			Infrequently
Jelly Springs Reservoir	a			3,046						
	b			435 ± 178						
	c			198–698						
	d			1951–1965						
	e			7						
	f			1952, 1954, 1955, 1959–63						
	g			Infrequently						
Joseph Creek	a	2,493	2,827	183,300						
	b	499 ± 206	565 ± 309	10,782 ± 3,627						
	c	265–727	235–998	5,000–20,000						
	d	1951–1957	1950–1957	1932–1949						
	e	5	5	16						
	f	1953, 1955	1952, 1954, 1956	1937						
	g	Annually	Frequently	Annually						

Table B-1 (cont.)

RAINBOW TROUT PLANTING RECORDS BY SUBSPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		RB Catchables	RB Subcatchables	RB Fingerlings	RB Brood stock	Steelhead Fingerlings	ELT Catchables	ELT Subcatchables	ELT Fingerlings	ELT x RT Catchables
Lauer Reservoir	a		2,900	24,980						
	b			12,490 ± 3,521						
	c			10,000–14,980						
	d		1954	1955, 1972						
	e		1	2						
	f									
	g		Infrequently	Infrequently						
Little Medicine Lake	a	9,414		1,100			2,740			
	b	672 ± 539					685 ± 232			
	c	100–2,350					500–1,000			
	d	1973–1992		1956			1983, 1985, 1989, 1993			
	e	14		1			4			
	f	1974–76, 1984, 1986, 1989								
	g	Annually		Infrequently			Infrequently			
Medicine Lake	a	694,254	128,875	2,088,243	1,000	65,000	78,075		236,804	8,960
	b	15,428 ± 10,152	9,913 ± 10,744	59,664 ± 45,169	500 ± 0	32,500 ± 3,536	19,519 ± 4,625		47,361 ± 24,765	
	c	50–42,697	4,368–41,625	7,000–188,800		30,000–35,000	14,900–24,800		25,000–85,140	
	d	1941, 1942, 1955–89, 1994–2002	1942–53, 1963, 2000	1930, 1934, 1941, 1942, 1946, 1952, 1955, 1957–79	1958–1959	1930, 1935	1983, 1987, 1989, 1993		1978, 1997–2000	1987
	e	45	13	35	2	2	4		5	1
	f	1956, 1988		1964, 1966–68						
	g	Annually	Frequently	Infrequently	Annually	Infrequently	Infrequently		Annually	Infrequently
Mill Creek (Jess Valley)	a	8,500	10,830	172,290		15,000				
	b	1,700 ± 1,066	2,708 ± 1,624	13,253 ± 7,632						
	c	285–3,000	1,500–5,100	1,800–30,000						
	d	1950–54, 1963	1950, ‘53, 1955, 1961	1931–33, 1940–49		1937				
	e	5	4	13		1				
	f	1953								
	g	Annually	Infrequently	Annually		Infrequently				
Moon Lake	a	5,001		8,000				2,000		
	b									
	c									
	d	1972		1935				1981		
	e	1		1				1		
	f									
	g	Infrequently		Infrequently				Infrequently		

Table B-1 (cont.)
RAINBOW TROUT PLANTING RECORDS BY SUBSPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		RB Catchables	RB Subcatchables	RB Fingerlings	RB Brood stock	Steelhead Fingerlings	ELT Catchables	ELT Subcatchables	ELT Fingerlings	ELT x RT Catchables
Nelson Corral	a			5,000					176,240	
	b								12,589 ± 8,008	
	c								5,001–35,003	
	d			1984					1985–2002	
	e			1					14	
	f								1990, 1992, 1998, 1999	
	g			Infrequently					Annually	
Nigger Springs Reservoir	a			2,203						
	b			551 ± 98						
	c			500–698						
	d			'57, '58, '64						
	e			3						
	f									
	g			Annually						
Parker Creek	a	8,259	3,020	152,663						
	b	751 ± 430	1,007 ± 408	12,722 ± 5,321						
	c	500–1,500	602–1,418	5,000–24,300						
	d	1951–1964, 1970	1950, 1953, 1955	1931–1949						
	e	11	3	19						
	f	1953, 1955, 1962, 1963		1933–37, 1939, 1940						
	g	Annually	Infrequently	Infrequently						
Pine Creek	a	2,503	7,153	177,460					42,240	
	b	626 ± 252	1,431 ± 804	14,788 ± 12,678						
	c	500–1,003	902–2,853	2,160–40,000						
	d	1951, 1954–57	1951–1955	1931–34, 1940–48					1974	
	e	4	5	11					1	
	f	1955							1956 (brood)	
	g	Infrequently	Annually	Annually					Infrequently (both)	
Pine Creek Lake #1	a			1,387						
	b			964 ± 217						
	c			540–847						
	d			1951, 1992						
	e			2						
	f									
	g			Infrequently						

Table B-1 (cont.)
RAINBOW TROUT PLANTING RECORDS BY SUBSPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		RB Catchables	RB Subcatchables	RB Fingerlings	RB Brood stock	Steelhead Fingerlings	ELT Catchables	ELT Subcatchables	ELT Fingerlings	ELT x RT Catchables
Pine Creek Lake #2	a			4,050					1,560	
	b			810 ± 69					520 ± 35	
	c			498–2,044					500–560	
	d			1989, 1993–1996					1999–2001	
	e			5					3	
	f									
	g			Annually					Annually	
Pine Creek Lake #4	a			283						
	b									
	c									
	d			1958						
	e			1						
	f									
	g			Infrequently						
Pine Creek Reservoir	a	78,585	3,330	8,320			29,645		1,000	
	b	1,786 ± 885	1,110 ± 500	2,080 ± 217			1,976 ± 1,212			
	c	488–3,563	598–1598	1,920–2,400			950–5,635			
	d	1950–2002	1949, 1952, 1955	1969–1973			1985–2002		1985	
	e	41	3	4			15		1	
	f	1959–61, 1985, 1988–90, 1992, 1993, 1995, 1999		1970			1994, 1995, 1997			
	g	Infrequently	Infrequently	Annually			Annually		Infrequently	
Pit River, South Fork	a	96,506	22,159	352,703						
	b	2,681 ± 2,389	3,693 ± 3,211	29,392 ± 12,965						
	c	290–8,721	340–8,750	8,000–46,980						
	d	1951–64, 1970–83, 1992–2002	1950–58, 2001	1931–1949						
	e	36	6	12						
	f	1962, 2001	1952–53, 1956–57	1933–34, 1937–41						
	g	Infrequently	Infrequently	Frequently						
Reservoir "C"	a	44,198	11,630	24,079			59,154		64,995	
	b	2,762 ± 1,085	3,877 ± 215	4,816 ± 412			2,689 ± 1,721		7,222 ± 2,741	
	c	999–4,804	3,628–4,002	4,080–5,016			720–7,100		4,088–10,400	
	d	1965, 1966, 1970–80, 1993, 1996–2002	1967–1969	1965, 1966, 1969, 1974, 1975			1972, 1979–2002		1974–1984	
	e	16	3	5			22		9	
	f	1973, 1979, 1998, 1999					1984, 1988, 1993		1977, 1981	
	g	Infrequently	Annually	Infrequently			Annually		Annually	

Table B-1 (cont.)

RAINBOW TROUT PLANTING RECORDS BY SUBSPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		RB Catchables	RB Subcatchables	RB Fingerlings	RB Brood stock	Steelhead Fingerlings	ELT Catchables	ELT Subcatchables	ELT Fingerlings	ELT x RT Catchables
Rush Creek	a	12,907	1,652	68,740						
	b	516 ± 273	551 ± 121	6,874 ± 3,314						
	c	148–1,488	470–690	1,000–11,400						
	d	1950–1979	1951, 1952, 1955	1931–32, 1941–49						
	e	24	3	11						
	f	1952, 1954–55, 1965–66								
	g	Annually	Infrequently	Annually						
Shields Creek	a	3,937	1,120	93,450						
	b	492 ± 158	560 ± 91	8,495 ± 2,925						
	c	190–770	496–624	3,000–12,000						
	d	1951–1959	1950, 1955	1931–32, 1941–49						
	e	8	2	11						
	f	1955								
	g	Annually	Infrequently	Annually						
Smith Flat	a	13,152					11,020			
	b	1,315 ± 369					1,574 ± 464			
	c	850–1,900					960–2,080			
	d	1958–86, 1991–97					1985–2002			
	e	27					7			
	f	1961, 1976–77, 1981–85, 1996					1987–95, 1997, 2001			
	g	Frequently					Infrequently			
Smith Flat Reservoir	a	33,607		995			5,745			
	b	1,245 ± 334					1,436 ± 297			
	c	500–1,900					1,020–1,725			
	d	1958–1975		1965			1983–1985, 1996			
	e	27		1			4			
	f	1961, 1964, 1965								
	g	Annually		Infrequently			Infrequently			
Thoms Creek	a	4,153	364	19,190						
	b	346 ± 178		9,595 ± 983						
	c	112–604		8,900–10,290						
	d	1954–1964	1953	1945–1946						
	e	10	1	1						
	f	1955								
	g	Annually	Infrequently	Infrequently						

Table B-1 (cont.)

RAINBOW TROUT PLANTING RECORDS BY SUBSPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		RB Catchables	RB Subcatchables	RB Fingerlings	RB Brood stock	Steelhead Fingerlings	ELT Catchables	ELT Subcatchables	ELT Fingerlings	ELT x RT Catchables
Toms Creek	a			36,000						
	b			12,000 ± 7,211						
	c			6,000–20,000						
	d			1932, 1937–1938						
	e			3						
	f									
	g			Infrequently						
West Valley Reservoir	a	151,542	61,303	385,968			165,075	30,588	15,000	
	b	6,314 ± 5,354	12,261 ± 5,470	42,885 ± 62,135			7,861 ± 4,348			
	c	200–25,007	6,110–20,008	4,928–201,600			2,550–19,660			
	d	1963, 1968–2000	1964, 1967–1969	1967–68, 1983–84			1976–2002	1969	1980	
	e	20	4	4			21	1	1	
	f	1974,1979, 1981–86, 1988, 1989, 1994, 1998					1977, 1980 1987, 1990–92			
	g	Infrequently	Infrequently	Infrequently			Annually	Infrequently	Infrequently	
White Reservoir	a			5,040						
	b									
	c									
	d			1960						
	e			1						
	f									
	g			Infrequently						
Wild Horse Reservoir	a			2,000						
	b									
	c									
	d			1972						
	e			1						
	f									
	g			Infrequently						
Willow Creek	a		1,000	20,760						
	b			10,380 ± 368						
	c			10,120–10,640						
	d		1955	1946, 1947, 1955						
	e		1	3						
	f									
	g		Infrequently	Infrequently						

Table B-2
NON-NATIVE SALMONID PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		BN Catchables	BN Subcatchables	BN Fingerlings	BN Brood stock	BK Catchables	BK Subcatchables	BK Fingerlings	CTL Catchables	CTL Fingerlings	Coho Sub-/Catchables
Ash Creek	a	37,008	10,004	365,000				25,000			
	b	1,850 ± 1, 071		28,077 ± 11,280							
	c	682–5,000		5,000–45,000							
	d	1962–69, 1981–1999	1961	1931–41, 1960, 1964				1939			
	e	18	1	13				1			
	f	1964, 1985, 1992									
	g	Infrequently	Infrequently	Annually				Infrequently			
Ballard Reservoir	a			70,000		4,415		66,688			
	b			23,333 ± 2,887		2,208 ± 463		4,168 ± 353			
	c			20,000–25,000		1,880–2,535		3,840–5,112			
	d			1933, 1936, 1940		1963, 1984		1972–90			
	e			3		2		16			
	f							1974, 1977, 1986			
	g			Infrequently		Infrequently		Annually			
Bayley Reservoir	a	4,004				8,452		12,960			
	b					4,226 ± 3,159					
	c					1,992–6,460					
	d	1963				1965, 1984		1969			
	e	1				2		1			
	f										
	g	Infrequently				Infrequently		Infrequently			
Bear Valley Reservoir	a	1,020									
	b	510 ± 14									
	c	500–520									
	d	1963, 1966									
	e	2									
	f										
	g	Infrequently									

Table B-2 (cont.)

NON-NATIVE SALMONID PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		BN Catchables	BN Subcatchables	BN Fingerlings	BN Brood stock	BK Catchables	BK Subcatchables	BK Fingerlings	CTL Catchables	CTL Fingerlings	Coho Sub-/Catchables
Beaver Creek	a							10,000			
	b										
	c										
	d							'39			
	e							1			
	f										
	g							Infrequently			
Blue Lake	a	14,740			198	31,710		280,000			
	b	3,685 ± 2,335				2,883 ± 3,055		40,000 ± 10,000			
	c	600–6,000				1,440–12,018		30,000–50,000			
	d	1984, 1986, 1987, 2001			2000	1965–2002		1933–38			
	e	4			1	11		6			
	f					1967–83, 1985–93					
	g	Infrequently			Infrequently	Annually		Annually			
Bullseye Lake	a			6,500		13,315		40,404			
	b					783 ± 878		1,837 ± 2,062			
	c					325–4,000		480–10,000			
	d			1931		1982–2002		1938, 1954, 1958–81			
	e			1		17		23			
	f					1983, 1989, 1992, 1993		1960,1977, 1978			
	g			Infrequently		Annually		Annually			
Butte Creek	a	285				480					
	b					240 ± 14					
	c					230–250					
	d	1984				1973, 1984					
	e	1				2					
	f										
	g	Infrequently				Infrequently					

Table B-2 (cont.)

NON-NATIVE SALMONID PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		BN Catchables	BN Subcatchables	BN Fingerlings	BN Brood stock	BK Catchables	BK Subcatchables	BK Fingerlings	CTL Catchables	CTL Fingerlings	Coho Sub-/Catchables
Canyon Creek	a	503				2,562					
	b					512 ± 37					
	c					451–541					
	d	1965				1966–1970					
	e	1				5					
	f										
	g	Infrequently				Annually					
Cedar Creek	a			15,000							
	b										
	c										
	d			1940							
	e			1							
	f										
	g			Infrequently							
Cottonwood Creek	a							5,000			
	b										
	c										
	d							1933			
	e							1			
	f										
	g							Infrequently			
Coyote Reservoir	a					3,900		142,464			
	b										
	c										
	d					1972		1972			
	e					1		1			
	f										
	g					Infrequently		Infrequently			

Table B-2 (cont.)

NON-NATIVE SALMONID PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		BN Catchables	BN Subcatchables	BN Fingerlings	BN Brood stock	BK Catchables	BK Subcatchables	BK Fingerlings	CTL Catchables	CTL Fingerlings	Coho Sub-/Catchables
Delta Reservoir	a	1,500									
	b										
	c										
	d	2002									
	e	1									
	f										
	g	Infrequently									
Dorris Reservoir	a						502				
	b										
	c										
	d						1967				
	e						1				
	f										
	g						Infrequently				
Duncan Reservoir	a					900					
	b										
	c										
	d					1963					
	e					1					
	f										
	g					Infrequently					
East Creek	a			5,000				135,300			
	b							33,825 ± 17,894			
	c							20,300–30,000			
	d			1960				1940–1943			
	e			1				3			
	f										
	g			Infrequently				Annually			

Table B-2 (cont.)
NON-NATIVE SALMONID PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		BN Catchables	BN Subcatchables	BN Fingerlings	BN Brood stock	BK Catchables	BK Subcatchables	BK Fingerlings	CTL Catchables	CTL Fingerlings	Coho Sub-/Catchables
Fitzhugh Creek	a	900		27,973				107,000			
	b			13,987 ± 15,575				15,286 ± 5,529			
	c			2,973–25,000				10,000–25,000			
	d	1980		1980				1931–37			
	e	1		1				7			
	f										
	g	Infrequently		Infrequently				Annually			
Horse Creek	a			190,000							
	b			15,833 ± 5,967							
	c			5,000–25,000							
	d			1931–43							
	e			12							
	f			1937							
	g			Annually							
Indian Spring Reservoir	a					1,000					
	b										
	c										
	d					1984					
	e					1					
	f										
	g					Infrequently					
Jelly Springs Reservoir	a	464									
	b	232 ± 40									
	c	204–260									
	d	1963, 1966									
	e	2									
	f										
	g	Infrequently									

Table B-2 (cont.)

NON-NATIVE SALMONID PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		BN Catchables	BN Subcatchables	BN Fingerlings	BN Brood stock	BK Catchables	BK Subcatchables	BK Fingerlings	CTL Catchables	CTL Fingerlings	Coho Sub-/Catchables
Little Medicine Lake	a			6,500		8,882		94,416			
	b					592 ± 228		3,256 ± 4,000			
	c					320–1,012		480–20,000			
	d			1931		1984–2002		1938–1976			
	e			1		15		29			
	f					1985, 1989, 1992, 1993		1942, 1944–48, 1955–57, 1974			
	g			Infrequently		Annually		Annually			
Medicine Lake	a	870		849,750		515,159		2,217,803		86,000	3,978
	b			77,250 ± 54,222		15,732 ± 9,512		58,363 ± 37,796			
	c			15,000–200,000		1,480–34,400		3,000–193,664			
	d	1938		1930–41		1965–2002		1935, 1938, 1943, 1950, 1954, 1962–1965, 1969, 1970–99		1931	1958
	e	1		11		29		38		1	1
	f			1938				1973,1975			(catchables)
	g	Infrequently		Annually		Infrequently		Annually		Infrequently	Infrequently
Moon Lake	a										3,008
	b										
	c										
	d										1973
	e										1
	f										(sub-catchables)
	g										Infrequently
Mill Creek	a			20,000				80,000			
	b			10,000 ± 7,071				13,333 ± 6,055			
	c			5,000–15,000				5,000–20,000			
	d			1932, 1944				1931–1940			
	e			2				6			
	f							1932, 1936–38			
	g			Infrequently				Annually			

Table B-2 (cont.)

NON-NATIVE SALMONID PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		BN Catchables	BN Subcatchables	BN Fingerlings	BN Brood stock	BK Catchables	BK Subcatchables	BK Fingerlings	CTL Catchables	CTL Fingerlings	Coho Sub-/Catchables
Nigger Springs Reservoir	a	260									
	b										
	c										
	d	1963									
	e	1									
	f										
	g	Infrequently									
Parker Creek	a			55,000				99,000			
	b			27,500 ± 3,536				12,375 ± 5,317			
	c			25,000–30,000				2,000–20,000			
	d			1939, 1940				1961			
	e			2				1			
	f										
	g			Annually				Infrequently			
Parsnip Creek	a							20,000			
	b							10,000 ± 0			
	c										
	d							1931, 1932			
	e							2			
	f										
	g							Annually			
Pine Creek	a			145,000				36,000			
	b			18,125 ± 7,350				12,000 ± 3,464			
	c			10,000–30,000				10,000–16,000			
	d			1933–40				1942–44			
	e			8				3			
	f										
	g			Annually				Annually			

Table B-2 (cont.)
NON-NATIVE SALMONID PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		BN Catchables	BN Subcatchables	BN Fingerlings	BN Brood stock	BK Catchables	BK Subcatchables	BK Fingerlings	CTL Catchables	CTL Fingerlings	Coho Sub-/Catchables
Pine Creek Lake #1	a							27,492			
	b							916 ± 297			
	c							500–1,600			
	d							1961, 1966–2002			
	e							28			
	f							1969, 1971, 1973, 1997, 2001			
	g							Infrequently*			
Pine Creek Lake #2	a							25,336			
	b							1,013 ± 243			
	c							522–1,600			
	d							1958, 1961, 1963, 1966–87, 1994, 2001–02			
	e							25			
	f							1969, 1971, 1973			
	g							Infrequently			
Pine Creek Lake #3	a							3,240			
	b							1,620 ± 537			
	c							1,240–2,000			
	d							1958, 1961			
	e							2			
	f										
	g							Infrequently			
Pine Creek Lakes #1-3	a							5,015			
	b										
	c										
	d							1958			
	e							1			
	f										
	g							Infrequently			

Table B-2 (cont.)

NON-NATIVE SALMONID PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		BN Catchables	BN Subcatchables	BN Fingerlings	BN Brood stock	BK Catchables	BK Subcatchables	BK Fingerlings	CTL Catchables	CTL Fingerlings	Coho Sub-/Catchables
Pine Creek Reservoir	a					7,711		1,216			
	b					1,102 ± 808					
	c					300–2,683					
	d					1963–70, 1984		1963			
	e					7		1			
	f					1964, 1967					
	g					Infrequently		Infrequently			
Pit River North Fork	a			15,000							
	b										
	c										
	d			1937							
	e			1							
	f										
	g			Infrequently							
Pit River, South Fork	a	55,215		250,000				125,000			
	b	1,904 ± 1,647		27,778 ± 18,219				20,833 ± 20,351			
	c	605–9,711		5,000–60,000				5,000–60,000			
	d	1962–2001		1932–1942				'31–35, '38			
	e	28		9				6			
	f	64,70–76,80–83		1935, 1936							
	g	Annually		Frequent				Frequent			
Randall Colis Pond	a									11,200	
	b										
	c										
	d									1960	
	e									1	
	f										
	g									Infrequently	

Table B-2 (cont.)
NON-NATIVE SALMONID PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		BN Catchables	BN Subcatchables	BN Fingerlings	BN Brood stock	BK Catchables	BK Subcatchables	BK Fingerlings	CTL Catchables	CTL Fingerlings	Coho Sub-/Catchables
Reservoir "C"	a	6,293				2,550		10,137	6,400	8,400	
	b	1,259 ± 869						5,069 ± 4,287			
	c	725–2,800						2,037–8,100			
	d	1989–93				1984		1969, 1984	1986	1982	
	e	5				1		2	1	1	
	f										
	g	Annually				Infrequently		Infrequently	Infrequently	Infrequently	
Rush Creek	a	1,094		60,000		1,164		8,000			
	b	547 ± 68		12,000 ± 2,739		291 ± 202					
	c	499–595		10,000–15,000		68–559					
	d	1963, 1965		1933–38		1966–70		1932			
	e	2		5		4		1			
	f			1934		1967					
	g	Infrequently		Annually		Annually		Infrequently			
Shields Creek	a			35,000				18,000			
	b			17,500 ± 10,607				9,000 ± 1,414			
	c			10,000–25,000				8,000–10,000			
	d			1939–1940				1932–1933			
	e			2				2			
	f										
	g			Annually				Annually			
Thoms Creek	a	621		40,000		303					
	b	311 ± 272									
	c	118–503									
	d	1963, 1965		1940		1966					
	e	2		1		1					
	f										
	g	Infrequently		Infrequently		Infrequently					

Table B-2 (cont.)

NON-NATIVE SALMONID PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		BN Catchables	BN Subcatchables	BN Fingerlings	BN Brood stock	BK Catchables	BK Subcatchables	BK Fingerlings	CTL Catchables	CTL Fingerlings	Coho Sub-/Catchables
Toms Creek	a			60,000							
	b			15,000 ± 10,000							
	c			10,000–30,000							
	d			1933, 1936, 1937, 1939							
	e			4							
	f										
	g			Infrequently							
West Valley Reservoir	a	22,772	16,009	191,700					3,825	306,294	2,408
	b	7,591 ± 2,301	8,005 ± 5	31,950 ± 18,161						51,049 ± 25,836	
	c	5,036–9,500	8,001–8,008	20,000–66,700						12,000–85,090	
	d	1961–1963	1965, 1966	1939–44, 1966					1960	1959, 1960	1973
	e	3	2	7					1	2	1
	f										(sub-catchables)
	g	Annually	Annually	Annually					Infrequently	Infrequently	Infrequently
Witcher Creek	a							1,000			
	b										
	c										
	d							1956			
	e							1			
	f										
	g							Infrequently			

Table B-3

OTHER NON-NATIVE FISH PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		Arctic Grayling	Bluegill	Channel Catfish	Largemouth Bass	Redear Sunfish	Sacramento Perch	Spotted Bass
Big Jack Lake	a				70	107		
	b				35 ± 21	36 ± 13		
	c				20–50	27–50		
	d				1978, 1996	1980, 1987, 1996		
	e				2	3		
	f							
	g				Infrequently	Infrequently		
Dorris Brothers Reservoir	a						173	
	b							
	c						1993	
	d							
	e						1	
	f							
	g						Infrequently	
Dorris Reservoir	a				1,000			
	b							
	c							
	d				1948			
	e				1			
	f							
	g				Infrequently			
Lauer Reservoir	a		Unknown number					Unknown number
	b							
	c							
	d		1942					1942
	e		1					1
	f							
	g		Infrequently					Infrequently
Little Medicine Lake	a	11,000						
	b	2,220 ± 1464						
	c	1,000–4,000						
	d	1971, 1972, 1975, 1981						
	e	4						
	f							
	g	Infrequently						

Table B-3 (cont.)

OTHER NON-NATIVE FISH PLANTING RECORDS BY SPECIES AND SIZE CLASS OVER THE PERIOD 1930 TO 2002 IN THE UPPER PIT RIVER WATERSHED WITH: A) TOTAL NUMBER PLANTED, B) ANNUAL AVERAGE ± S.D., C) RANGE, D) YEARS PLANTED, E) NUMBER OF YEARS FISH WERE PLANTED, F) YEARS NO FISH WERE PLANTED, G) GENERAL FREQUENCY OF FISH PLANTINGS

Water		Arctic Grayling	Bluegill	Channel Catfish	Largemouth Bass	Redear Sunfish	Sacramento Perch	Spotted Bass
Moon Lake	a						173	
	b							
	c							
	d						1993	
	e							
	f						1	
	g						Infrequently	
Pit River	a			39,365				
	b			13,122 ± 9,794				
	c			5,005–24,000				
	d			1951, 1961, 1968				
	e			3				
	f							
	g			Infrequently				
Reservoir "C"	a	2,000						
	b							
	c							
	d	1975						
	e	1						
	f							
	g	Infrequently						

Appendix 9-C

Board of Fish Commissioners Letter Dated April 25, 1893 Regarding the Introduction of Non-Native Fish to California

Recd. Apr. 25-1893
No. 10693.

COPY

BOARD OF FISH COMMISSIONERS.

San Francisco, California
Apr. 18, 1893

Hon. Marshall McDonald,
U.S, Fish Commissioner,
Washington.

My dear Sir:–

Your esteemed favor of the 11th received and contents noted. We wrote you on the 14 inst. in regard to transportation for 100,000 muskallonge [muskellunge], which the New York Commission have kindly agreed to furnish us. Mr. Green informs us that it will take thirty-three cans to successfully bring these fish to California. In order to do this, it would [be] necessary for [our] commission to charter a car and employ at least two men and even then, I fear, with the crude arrangements available, they would be unable to get to the fish here alive; besides, it would entail more expense than our appropriation will permit us to undertake. Our only hope now is that you will come to our aid, and send these fish out in one of your cars, together with Loch Leven trout and any other fish which you could spare that would be new to this coast. We realize that you are extremely busy with the World's Fair, and know that we are asking a great deal when we request you to let us have the use of this car; but we feel that it will be a great gain for our State to secure these fish, and the opportunity may not occur again for us to do so. If you so desire, we will make a collection of California fish to be returned to Chicago for the world's Fair exhibit with your car, provided they have space there and can care for them upon their arrival.

Please give this matter your careful consideration, and, if possible, grant our request.

Very truly yours,
(Signed) Wm. C. Murdoch,
Secretary.

Appendix 9-D

Contacts

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(530) 233-2356

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Galt, CA 95632
(916) 687-7475

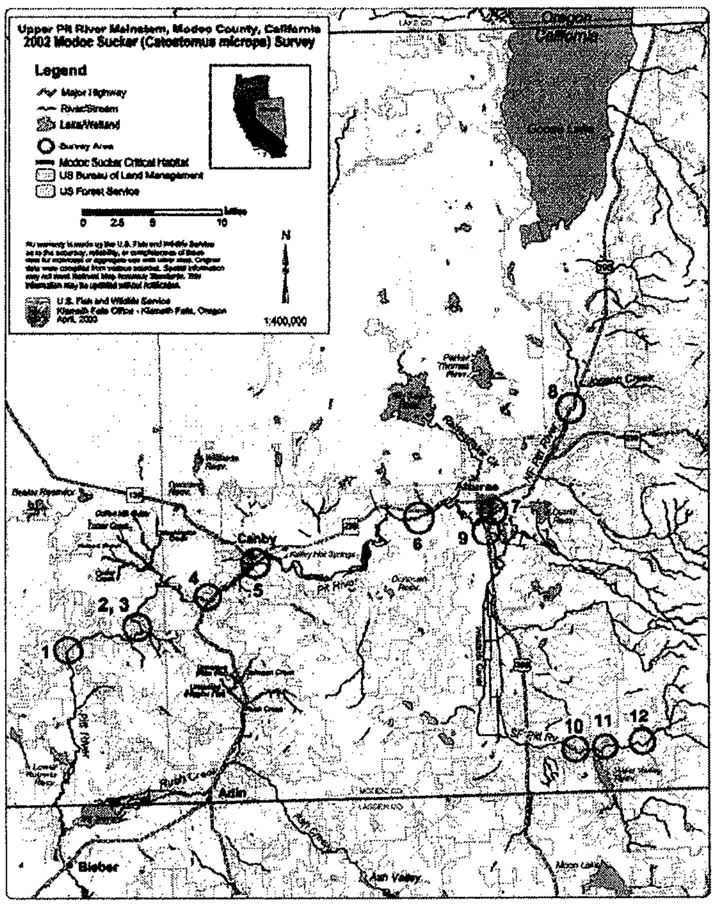
Appendix 9-E

Mainstem Upper Pit River Fish Surveys

Stewart Reid, July 2003

MAINSTEM UPPER PIT RIVER FISH SURVEYS

Including the North and South Fork Pit Rivers
September 2002



Stewart B. Reid (principal author) - USFWS, Klamath Falls
William Cowan and Stephanie Byers – USFWS, Reno

July 2003

MAINSTEM UPPER PIT RIVER FISH SURVEYS

Including the North and South Fork Pit Rivers
September 2002

Stewart B. Reid (principal author) - USFWS, Klamath Falls
William Cowan and Stephanie Byers – USFWS, Reno

July 2003

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Abstract

The 2002 Pit River fish surveys were intended to: 1) explore the possibility that unrecognized populations of the federally endangered Modoc sucker might be present in the mainstem rivers, and 2) provide a current fish survey that could be compared with historic collections in order to assess changes in the species composition of the mainstem Upper Pit River fish fauna over the last century (1898-2002). The results of the 2002 surveys will be incorporated into a current status review by the USFWS to determine whether the Modoc sucker has recovered to a point where downlisting or delisting under the Endangered Species Act is appropriate.

The surveys also provide a baseline and record of fish species composition at the various Upper Pit River sites monitored by the Pit River Watershed Alliance for water quality, habitat, and macroinvertebrate composition, and provide faunal information for assessing potential effects to aquatic resources as a result of water and fisheries management in the Pit drainage.

The results provided valuable information regarding the distribution of Modoc suckers in the upper Pit River Drainage. No indication of a resident population of Modoc suckers was found in the mainstem Pit River downstream of Alturas. However, the occurence of Modoc sucker genetic markers in the Sacramento sucker population in the upper South Fork of the Pit River (above Likely) suggests that either a previously resident population of Modoc suckers has been genetically swamped and replaced by Sacramento suckers, or that an unrecognized source population of Modoc suckers occupies a tributary to the South Fork, well outside the previously known range of Modoc suckers in the Pit Drainage. The South Fork and possible tributary populations are the subject of an ongoing assessment by USFWS. The 2002 survey also demonstrated that the native fish fauna of the upper Pit River has remained relatively stable throughout the last century, and that exotic fishes form a relatively minor component of the fish community. Two exotic species, largemouth bass and channel catfish, caught during historical surveys from the 1960-70's, were notably absent in the 2002 survey.

Introduction

The present project was undertaken primarily in order to explore the possibility that unrecognized populations of the federally endangered Modoc sucker, *Catostomus microps*, might be present in the mainstem river, as had been indicated by scattered individual suckers of uncertain identity caught during historic surveys of the Upper Pit River (Martin 1967, Cooper et al. 1978, Cooper 1983). This survey was also designed to provide survey information for various other local needs in the Upper Pit River, including: 1) a current fish survey that could be compared with historic collections in order to assess changes in the species composition of the mainstem Upper Pit River fish fauna over the last century, 2) faunal information for potential effects to aquatic resources as a result of water and fisheries management in the Pit drainage, and 3) a baseline and record of fish species composition at the various Upper Pit River sites monitored by the Pit River Watershed Alliance for water quality, habitat, and macroinvertebrate composition. These collections have also provided specimens and site-specific background on bioaccumulation of mercury for analysis of potential effects from the proposed ISOT hydrothermal project at Canby, as well as material for ongoing systematic and genetic studies of various Pit River fishes (lampreys, tui chubs, and suckers), including Modoc suckers. However, these results are part of other projects and will not be specifically discussed in this report (contact S. Reid, USFWS Klamath Falls for further information).

The Pit River is the largest northern tributary of the Sacramento River and drains a large portion of northeastern California (Fig. 1; Pease 1965, Moyle and Daniels 1982). The headwaters of the Pit River lie in the Warner Mountains, forming the North Fork Pit, which is the now disjunct outlet of the Goose Lake Basin, and the South Fork Pit, which flow together just west of Alturas to form the mainstem Pit River. The Pit River then flows through broad, flat Warm Springs Valley to just below the town of Canby, where it enters the Adin Mountains. The river then increases its gradient and passes through the mountains until it emerges into Big Valley near Rose Canyon, about 15 miles north of Bieber. In Big Valley it takes on flow from Ash Creek and meanders across the valley to the Big Valley Mountains. There it enters the steep Pit River Canyon and flows to its confluence with the clear, spring-fed Fall River. After receiving the considerable flow of the Fall River, the Pit River continues through the canyon of the lower Pit to its historic confluence with the Sacramento River, now flooded beneath Shasta Reservoir. For the purposes of this survey, the Upper Pit River drainage includes the North Fork, South Fork and the mainstem Pit River thru Warm Springs Valley and the Adin Mountains to where it enters Big Valley.

The Modoc sucker is a relatively small sucker endemic to the Pit River drainage, including the Goose Lake sub-basin. Its currently recognized range is limited to two subdrainages of the Pit River (Turner and Ash Creek drainages) and certain tributaries to Goose Lake. The Modoc sucker was listed as endangered under the Endangered Species Act (ESA) in 1985 (USFWS 1985). At that time, the primary threats to the species were considered to be adverse habitat conditions, limited population size and distribution, and hybridization with the Sacramento sucker, which is also native to the Pit River.

The Modoc and Sacramento suckers are very similar in outward appearance when not spawning. The similarity in non-spawning coloration and external morphology have made it difficult to field identify specimens visually without the excessive handling necessary for counts of fin rays and scales. Prior to 2001, the Modoc sucker was generally characterized as having 79-89 lateral line scales and 10-11 dorsal rays, compared to 56-75 lateral line scales and 11-15 dorsal rays for the Sacramento sucker (Martin 1967, 1972; Moyle 1976a, Ford 1977, Cooper et al.1978). Two authors used intermediate lateral line counts and slightly higher dorsal ray numbers (12 rays) to characterize presumptive "hybrids" between the two species (Cooper et al.1978, Mills 1980, Cooper 1983). Recent analysis of a more extensive data set of several hundred Modoc and Sacramento suckers, and including additional characters, suggests that there is no morphological support for hybridization and that there is natural overlap in the meristic counts for the two species (Kettratad 2001). Kettratad found the actual meristic ranges for Modoc sucker to be 73-91 lateral line scales and 9-12 dorsal rays, somewhat overlapping Sacramento sucker. Recent ongoing genetic studies have also increased our understanding of hybridization between the two species (Wagman and Markle 2000, Dowling et al. unpub. data, Topinka et al. in prep.; contact S. Reid, USFWS Klamath Falls for further information), and species-specific genetic markers have been developed allowing an assessment of genetic interaction between the two species, as well as identification of individuals containing predominant genes of either species (Topinka et al. in prep.).

The disjunct distribution of Modoc suckers in well-separated tributaries, the absence of physical barriers to their downstream movement into the river, and the historical difficulties in identification have led to speculation that a unrecognized resident population of Modoc suckers could exist in the mainstem Pit River. Martin (1967) identified a few specimens from the upper Pit with 76-79 lateral line scales, counts that are within the range for both sucker species, as Sacramento suckers. Cooper et al. also identified some specimens from the Pit River as "hybrids", based on character states shared by both Modoc and Sacramento suckers or thought to be intermediate (Cooper et al.1978, Mills 1980, Cooper 1983). The primary goal of the present survey was to examine representative reaches of the upper Pit River for the presence of extant Modoc suckers and to examine the genetics of all suckers in the Pit River for evidence of historic gene flow between Sacamento and Modoc suckers.

Historic Collections From the Mainstem Pit River

The mainstem of the Pit River has received little attention in fish surveys of the Upper Pit drainage. This is in part due to sampling constraints in the deeper river and to a focus on stream populations of specific fishes of interest to the various sampling projects.

In early September 1898, Cloudsley Rutter and his associates passed through the upper Pit drainage, collecting fish as part of a study of the natural history of young salmonids and the general distribution of fishes in the Sacramento-San Joaquin basin under the auspices of the U.S. Bureau of Fisheries (Rutter 1908).

In August 1904, J.O. Snyder, then professor of ichthyology at Stanford University, traveled through the upper Pit as part of a fish collecting expedition to the Oregon interior lakes, which he reported in his "Relationships of the Fish Fauna of the Lakes of Southeastern Oregon" (Snyder 1908). He collected in the North Fork Pit River, the mainstem Pit River, and in Rush Creek (tributary to Ash Creek).

In the mid-20th century few collections were made from the upper Pit drainage, and they were primarily by individual ichthyologists passing through the area, rather than drainage-wide surveys. Our information for those collections is derived from museum collections and field notes by the collectors. Examination of museum records for institutions likely to contain material from northern California (see Methods) resulted in only four sets of collections from the mainstem upper Pit River, including the North and South Forks. Murphy and Riddell (July 1940), Hubbs et al.(July 1942) and Miller et al. (July 1963) all made various collections from the South Fork Pit as they passed through. Hubbs (August 1934) also made a collection from the North Fork Pit on the way from Surprise Valley to Goose Lake, and Murphy (July 1940) made a collection from a slough tributary to the North Fork, just east of Alturas. Miller (August 1961) made a single collection from the mainstem Pit River below Canby at the Highway 395 bridge. Their field notes and museum collections are at the University of Michigan. Both Hubbs and Miller made various additional collections from tributaries of the Pit as well, but these are not comparable with the present mainstem survey. All of these collections were made with small seines, typically 12-15 ft long with ¼" mesh; Miller used a 30 ft seine for some of his collection at the Canby bridge.

In 1973-74 Moyle et al. made extensive collections throughout the Pit River drainage (primarily July to early September 1974 in the mainstem Pit River, 23-24 July in the South Fork, and 4-5 September in the North Fork), the distributional results of which were summarized and reported in Moyle and Daniels (1982). In 1978 (August), Cooper et al. surveyed the mainstem Pit River and its tributaries from Turner Creek down to Juniper Creek (Big Valley), as part of an assessment on impacts of the proposed Allen Camp Dam Project (Cooper et al. 1978, Cooper 1983). Moyle et al. primarily sampled with a backpack electroshocker or small seines, and they assessed the sampling of the mainstem Pit River as often inadequate due to deeper water depths and/or swift currents, as well as limited time (Moyle and Daniels 1982). Cooper et al. used an electroshocker floated on a johnboat, which was guided by waders in relatively shallow water of less than 1 m (Cooper et al. 1978). There have been no recorded fish surveys of the upper Pit River that we are aware of since 1978.

Methods

Fish collections for this survey were made at twelve sites from September 10-18, 2002 (see map: Fig. 1; Table 1; and Appendix A for site details). All sampling was done with various pulse D.C. electroshockers and dipnets, including: a gas-powered electroshocker (Smith-Root model GPP 5.0) mounted on either an inflatable 6-man boat (for deeper water) or on a small pontoon raft (where wading was feasible), or backpack units (Smith-Root model Type 7 and/or Dirigo model 850B) in smaller, shallower river reaches. Each unit was accompanied by a netting crew of typically 2-3 people using ¼" mesh long-handled dip nets. Each site was sampled sufficiently to ensure that all representative habitat was included and that the crew was not encountering additional species. Reaches were not isolated by nets and no attempt was made to specifically quantify abundance.

Fish collected were identified to species, measured and counted by a shore crew, including S. Reid, then generally released (see below). Length measurements were of Standard Length (SL) or Total Length (TL; lampreys only) in millimeters. Dorsal fin ray counts were made on all suckers, and non-lethal fin clips for genetic analysis were taken from all or a representative sample of the suckers collected at each site, including any sucker with 11 or fewer rays. Voucher specimens were collected of suckers, smaller minnows of uncertain identity (identified in the lab), and lampreys. Environmental variables recorded for each site included: water depth, temperature, conductivity, visibility, and flow conditions.

The genetic analysis that these specimens were included in is part of a larger ongoing study by Univ. California Davis and USFWS, and the present results should be considered preliminary; discussion of methodology will be defered to the report of that sudy (Topinka et al. in prep.; contact S. Reid, USFWS Klamath Falls, for further information).

Principal crew members included: Stewart Reid (USFWS, Klamath Falls); William Cowan, Stephanie Byers, Jesse Rivera, Alvin Duncan and Charles McCoy (USFWS, Reno).

Examination of museum records for institutions likely to contain historical specimens from northern California included: Univ. Washington, Oregon State Univ., Humboldt State Univ., U.C. Davis, Calif. Acad. Sci., L.A. Mus. Nat. Hist., Univ. Nevada, U.S. Natl. Mus., Am. Mus. Nat. Hist., and Univ. Michigan.

Site 1 : Rose Canyon
- Pit River, near confluence with Rose Canyon, at bridge on Shaw Ranch.

Site 2 : Stone Coal Pool
- Pit River, lg. pool at Stone Coal Creek confluence, just downstream of Road 85.

Site 3 : Stone Coal Rapids
- Pit River, rapids just upstream of Stone Coal Creek, at County Road 85 bridge.

Site 4 : Hwy. 139 Bridge
- Pit River, Hwy. 139 bridge public access, about 4 miles downstream of Canby.

Site 5 : Canby
- Pit River at County Road 54 bridge, ½ mile south of Canby.

Site 6 : Clark's Ranch
- mainstem Pit River about 5 miles west of Alturas.

Site 7 : Alturas
- North Fork Pit River in Alturas, behind River Center.

Site 8 : North Fork Pit River
- North Fork Pit River, at Thoms Creek, 1.4 miles downstream of Joseph Creek.

Site 9 : Talbot Ranch
- South Fork Pit River, about 1 mile south of Alturas.

Site 10 : South Fork Bridge
- South Fork Pit River, at bridge 1 mile downstream of West Valley Creek.

Site 11 : South Fork Diversion
- South Fork Pit River, above irrigation diversion upstream of West Valley Creek.

Site 12 : Jess Valley
- South Fork Pit River, outlet of Jess Valley, downstream of Jess Valley Bridge.

Site X : Kelley Warm Springs
- mainstem Pit River at outlet of Kelley Hot Springs channel (no collection made).

Table 1. Survey sites from the 2002 Upper Pit River surveys (see Map, Fig. 1). Site information, habitat conditions and sampling methods are detailed in Appendix A: Survey Sites.

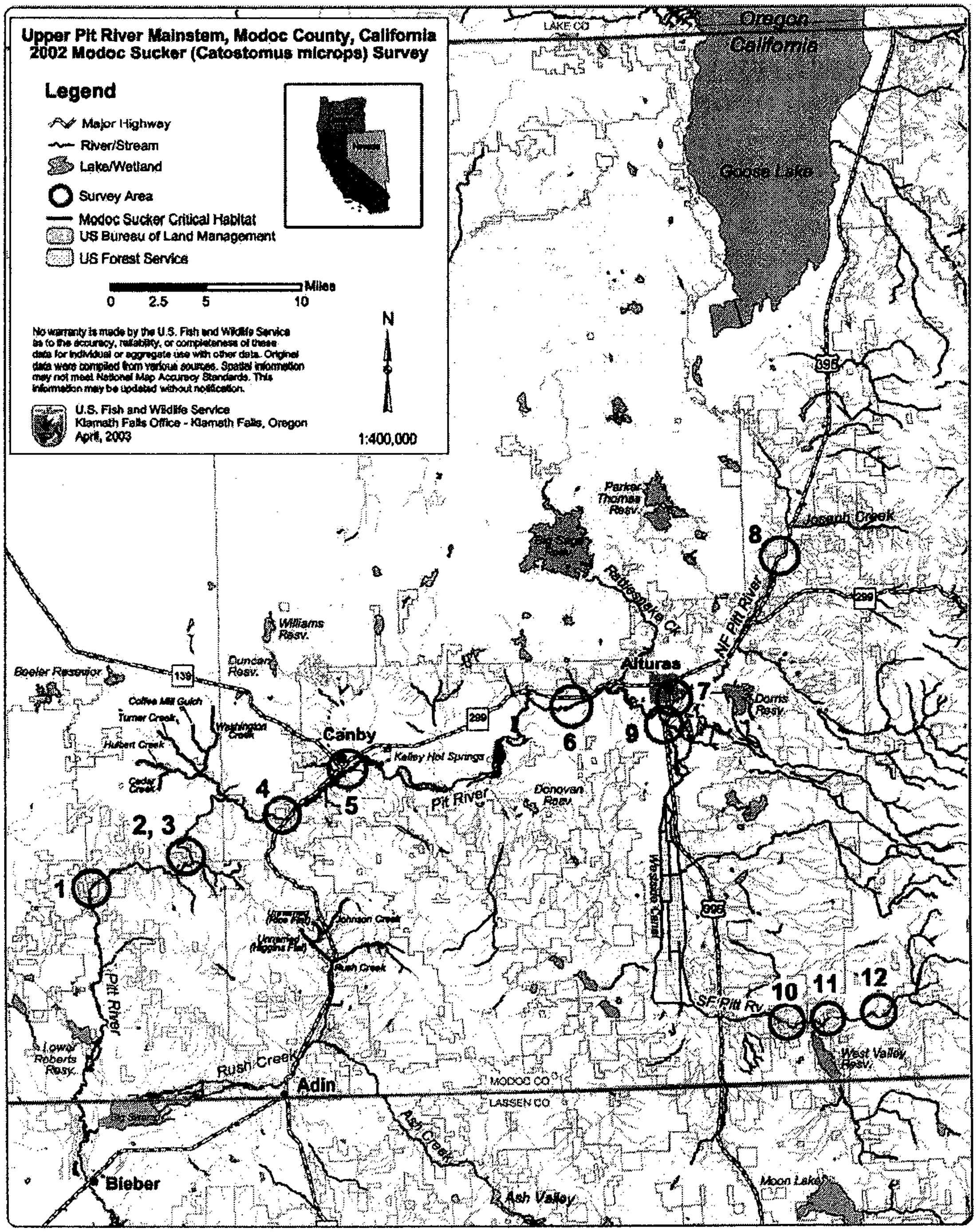

Figure 1. Map of upper Pit River watershed and fish survey sites. Survey sites are numbered. See Table 1 for site names and locations, and Appendix A for more detailed site information, habitat conditions and sampling methods.

Results

Fish collections were made at twelve sites from September 10-18, 2002 (see map: Fig. 1; site details: App. A). A total of over 1750 fish, representing fourteen species, were examined (Table 2-3). Length frequencies are shown in Appendix B. A summary of distribution, abundance and sampling considerations, where appropriate, for each species is provided below under Species Accounts. Historical comparisons with earlier collections (Tables 4-7) are also discussed below within the species accounts.

An attempt was made to sample in the Pit River at the outflow of Kelly Hot Springs channel (10-11 Sept.); however, when waded prior to sampling (water depth about 1m), there was no flow, the channel was choked with submerged aquatic plants, aquatic bugs (eg. dytiscid beetles) were abundant in the open water, suggesting an absence of fish, and multiple sweeps with a handnet caught no fish (see Appendix B: Site X, p. 38).

NATIVE SPECIES:	
Petromyzonidae	
Pit brook lamprey	*Lampetra lethophaga*
Salmonidae	
Redband/rainbow trout	*Onchorhynchus mykiss*
Cyprinidae	
Sacramento pikeminnow	*Ptychocheilus grandis*
Hardhead	*Mylopharodon conocephalus*
Tui chub	*Siphateles thalasinnus*
Speckled dace	*Rhinichthys osculus*
Pit Roach [1]	*Lavinia symmetricus*
Catostomidae	
Sacramento sucker	*Catostomus occidentalis*
Cottidae	
Pit sculpin	*Cottus pitensis*
INTRODUCED SPECIES:	
Salmonidae	
Brown trout (introduced)	*Salmo trutta*
Cyprinidae	
Golden shiner (introduced)	*Notemigonus chrysoleucas*
Ictaluridae	
Channel Catfish (introduced) [1]	*Ictalurus punctatus*
Brown bullhead (introduced)	*Ameiurus nebulosus*
Centrarchidae	
Sacramento perch (introduced)	*Archoplites interruptus*
Largemouth bass (introduced) [1]	*Micropterus dolomieui*
Green sunfish (introduced)	*Lepomis cyanellus*
Bluegill (introduced)	*Lepomis macrochirus*

1. Found in historical fish collections from the study area (see Tables 4-7), but not encountered in this survey.

Table 2. Species recorded from the upper Pit River. Species recorded from historical collections are included for comparative purposes; not all were caught during the present survey.

Main stem Alturas to north of Lookout | N.F. Pit River | S.F. Pit River

SAMPLING SITE:	1	2	3	4	5	6	7	8	9	10	11	12
NATIVE SPECIES:												
Petromyzonidae												
Pit brook lamprey	9	-	-	-	-	1	-	11	-	4	29	17
Salmonidae												
Redband/rainbow trout	-	-	-	-	-	-	-	-	-	8	6	-
Cyprinidae												
Sacramento pikeminnow	46	>22	47	69	11	39	73	-	3	17	6	15
Hardhead	9	9	13	26	15	13	-	-	-	-	-	-
Tui chub	-	-	1	1	6	27	-	-	1	-	2	10
Speckled dace	-	-	-	-	-	-	-	300	-	-	-	1
Pit Roach [1]	-	-	-	-	-	-	-	-	-	-	-	-
Catostomidae												
Sacramento sucker	116	22	47	91	50	98	76	-	-	62	10	27
Cottidae												
Pit sculpin	-	-	-	-	-	-	-	-	-	7	38	2
INTRODUCED SPECIES:												
Salmonidae												
Brown trout	-	-	-	-	-	-	-	-	-	2	7	1
Cyprinidae												
Golden shiner	-	1	-	-	3	-	-	-	-	-	-	-
Ictaluridae												
Channel Catfish [1]	-	-	-	-	-	-	-	-	-	-	-	-
Brown bullhead	-	-	-	5	16	-	4	-	8	-	-	-
Centrarchidae												
Sacramento perch	-	-	-	-	-	1	5	-	2	10	-	-
Largemouth bass [1]	-	-	-	-	-	-	-	-	-	-	-	-
Green sunfish	21	39	-	16	58	7	13	-	8	-	-	-
Bluegill	-	4	-	-	-	4	-	-	-	-	-	-

1. Found in historical fish collections from the study area (see Tables 4-7), but not encountered in this survey.

Table 3. Catches by Site for fish caught during the 2002 survey of the upper Pit River. Species recorded from historical collections are included for comparative purposes; not all were caught during the present survey. Note that collections were not standardized by sampling effort and different species have different catchability, such that numbers caught may not reflect actual relative abundance.

Common Name	Rutter 1898 [1]	Snyder 1904 [2]	Miller 1961 [3]	Moyle & Daniels 1973-74 [4]	Cooper 1978 [5]	Present Survey 2002 [6]
Petromyzonidae						
Pit brook lamprey	-	-	-	-	X	X
Salmonidae						
Redband/rainbow trout	-	-	-	-	-	-
Brown trout (introduced)	-	-	-	-	-	-
Cyprinidae						
Sacramento pikeminnow	X	-	X	X	X	X
Hardhead	X	X	X	X	X	X
Tui chub	X	X	-	-	-	X
Speckled dace	? [6]	-	-	-	x [7]	-
Pit roach	-	-	x [8]	-	-	-
Golden shiner (introduced)	-	-	-	-	-	X
Catostomidae						
Sacramento sucker	X	X	X	X	X	X
Ictaluridae						
Channel catfish	-	-	-	-	X	-
Brown bullhead (introduced)	-	? [9]	X	X	X	X
Centrarchidae						
Sacramento perch (introduced)	-	-	-	-	-	X
Largemouth bass (introduced)	-	-	X	X	X	-
Green sunfish (introduced)	-	-	X	X	X	X
Bluegill (introduced)	-	-	X	X	X	X
Cottidae						
Pit sculpin	X	? [10]	X	X	X	-

1. Rutter (1908): Pit River, near Canby.
2. Snyder (1908): Pit River, near Canby.
3. Miller et al.(1961): Pit River, at bridge just S. of Canby (Field no. M61-69). From notes and collections at Univ. Michigan.
4. Moyle and Daniels (1982): Throughout upper Pit from Alturas to Rose Canyon.
3. Cooper et al. (1978, 1983): Pit River in canyon from Stone Coal Creek to Rose Canyon Creek (Stations 28, 45-48).
5. Sites 1- 7, Alturas to Rose Canyon.
6. Specimens not recorded at Nation Museum with remainder of Rutter's collections.
7. Single individual caught near mouth of Stone Coal Creek (Station 48, Cooper et al. 1978).
8. Single specimen collected by Miller (UMMZ 179599).
9. Possibly collected and not reported in Snyder (1908), considered an introduced species (noted in museum jar). Specimens collected by Snyder in the Smithsonian are in two lots, both with tags saying "Sta. 23, Pit River, Alturas" (NMNH 058200, 058213; one and two specimens, respectively; S. Reid Pers. Obs.). One could be from a different Pit River locality.
10. Apparently collected and not reported in Snyder (1908). Preserved specimen collected by Snyder at Canby in Smithsonian (NMNH 058207).

Table 4. Historical Comparisons - Mainstem Pit River. Species caught within the mainstem upper Pit River, from Alturas downstream to Rose Canyon, during principal historical fish collections and the present survey.

Common Name	Rutter 1898 [1]	Snyder 1904 [2]	Hubbs et al. 1934 [3]	Murphy & Riddell 1940 [4]	Moyle & Daniels 1973-74 [5]	Present Survey 2002 [6]
Petromyzonidae						
Pit brook lamprey	-	X	-	-	-	-
Salmonidae						
Redband/rainbow trout	X	X	-	-	-	-
Brown trout (introduced)	-	-	-	-	-	-
Cyprinidae						
Sacramento pikeminnow	X	X	X	-	X	X
Hardhead	X	X	X	-	-	-
Tui chub	-	X	X	X	-	-
Speckled dace	X	-	X	X	-	-
Pit roach	x [7]	-	X	-	-	-
Golden shiner (introduced)	-	-	-	-	-	-
Catostomidae						
Sacramento sucker	X	X	X	X	X	X
Ictaluridae						
Channel catfish	-	-	-	-	-	-
Brown bullhead (introduced)	-	X [8]	-	-	-	X
Centrarchidae						
Sacramento perch (introduced)	-	-	-	-	-	X
Largemouth bass (introduced)	-	-	-	-	X	-
Green sunfish (introduced)	-	-	-	-	X	X
Bluegill (introduced)	-	-	-	-	-	-
Cottidae						
Pit sculpin	-	-	X	-	X	-

1. Rutter (1908): North Fork Pit River near Alturas.
2. Snyder (1908): Pit River "near Alturas".
3. Hubbs et al. (1934): N. Fork Pit River, E. of Alturas (T42N R13E; Field no. M34-116). Apparently at junction of Hwys. 299/395, based on route, just upstream of Parker Creek. From notes and collections at Univ. of Michigan.
4. Murphy, G. and F. Riddell (1940): Slough just E. of Alturas, trib. to N. Fork Pit (Field Nos. G*M40-47). From field notes and museum collections at Univ. of Michigan.
5. Moyle and Daniels (1982): Various sites in upper North Fork Pit River in the vicinity of, or below, Parker Creek.
6. Site 7: North Fork Pit, in town of Alturas.
7. The combined catch from the North Fork near Alturas and at the mouth of Joseph Creek was described by Rutter as "a few small specimens" (1908, p. 139). There are no specimens from either site collected by Rutter in the National Museum.
8. Collected and not reported in Snyder (1908), because they were assumed to be an introduced species (noted in museum jar). Specimens collected by Snyder in the Smithsonian are in two lots, both with tags saying "Sta. 23, Pit River, Alturas" (NMNH 058200, 058213; one and two specimens, respectively; S. Reid Pers. Obs.). One could be from a different Pit River locality.

Table 5. Historical Comparisons – North Fork Pit River (lower). Species caught in the lower North Fork of the Pit River, from the vicinity of Parker Creek down to the confluence with the South Fork just below Alturas.

Common Name	Rutter 1898 [1]	Snyder 1904 [2]	Moyle & Daniels 1973-74 [3]	Present Survey 2002 [4]
Petromyzonidae				
Pit brook lamprey	-	-	X	X
Salmonidae				
Redband/rainbow trout	X	-	X	-
Brown trout (introduced)	-	-	-	-
Cyprinidae				
Sacramento pikeminnow	X	-	X	-
Hardhead	-	-	-	-
Tui chub	-	-	-	-
Speckled dace	X	X	X	X
Pit roach	x [5]	-	-	-
Golden shiner (introduced)	-	-	-	-
Catostomidae				
Sacramento sucker	X	-	X	-
Ictaluridae				
Channel catfish	-	-	-	-
Brown bullhead (introduced)	-	-	-	-
Centrarchidae				
Sacramento perch (introduced)	-	-	-	-
Largemouth bass (introduced)	-	-	-	-
Green sunfish (introduced)	-	-	X	-
Bluegill (introduced)	-	-	-	-
Cottidae				
Pit sculpin	X	-	X	-

1. Rutter (1908): North Fork Pit River near mouth of Joseph Creek.
2. Snyder (1908): Pit River "near Joseph Creek".
3. Moyle and Daniels (1982): Various sites in the upper North Fork Pit River above Chimney Rock.
4. Site 8: North Fork Pit, just downstream of Joseph Creek.
5. The combined catch from the North Fork near Alturas and at the mouth of Joseph Creek was described by Rutter as "a few small specimens" (1908, p. 139). There are no specimens from either site collected by Rutter in the National Museum.

Table 6. Historical Comparisons – North Fork Pit River (upper). Species caught in the upper North Fork of the Pit River, during principal historical fish collections and the present survey.

Common Name	Rutter 1898 [1]	Murphy & Riddell 1940 [2]	Hubbs 1942 [3]	Miller 1963 [4]	Moyle & Daniels 1973-74 [5]	Present Survey 2002 [6]
Petromyzonidae						
Pit brook lamprey	X [a]	-	X	X	-	X
Salmonidae						
Redband/rainbow trout	X [a]	-	-	-	X	X
Brown trout (introduced)	-	-	-	-	X	X
Cyprinidae						
Sacramento pikeminnow	-	X	X	X	-	X
Hardhead	-	-	-	-	-	-
Tui chub	X [a]	X	X	-	-	X
Speckled dace	X [a]	X	X	-	-	X
Pit roach	-	X	X	X	-	-
Golden shiner (introduced)	-	-	-	-	-	-
Catostomidae						
Sacramento sucker	X [a]	X	X	X	-	X
Ictaluridae						
Channel catfish	-	-	-	-	-	-
Brown bullhead (introduced)	-	-	-	-	X	-
Centrarchidae						
Sacramento perch (introduced)	-	-	-	-	-	-
Largemouth bass (introduced)	-	-	-	-	-	-
Green sunfish (introduced)	-	-	-	-	-	-
Bluegill (introduced)	-	-	-	-	-	-
Cottidae						
Pit sculpin	X [b]	-	X	X	X	X

1. Rutter (1908): South Fork Pit River at: a) South Fork Post Office (Likely) and b) Jess Valley.
2. Murphy, G. and F. Riddell (1940): S. Fork Pit from Likely to 5 mi upstream of Likely (Field Nos. G*M40-43 to 46). From field notes and museum collections at Univ. of Michigan.
3. Hubbs,C.H. et al (1942): S. Fork Pit, at Likely (Field No. H42-64). From field notes and museum collections at Univ. of Michigan.
4. Miller, R.R. et al (1963): S. Fork Pit, 3.6 mi upstream of Likely (Field No. RRM63-22). From field notes and museum collections at Univ. of Michigan.
5. Moyle and Daniels (1982): South Fork Pit River at Likely and Jess Valley.
6. 2002 survey: Sites 10- 12, S. Fork Pit from about 5 mi upstream of Likely to Jess Valley.

Table 7. Historical Comparisons – South Fork of the Pit River. Species caught within the upper South Fork of the Pit River, from Likely to Jess Valley bridge, during principal historical fish collections and the present survey.

Species Accounts

Sacramento sucker: Sacramento suckers were the most common species encountered and were abundant at most sites. The only sites without suckers were the small, higher gradient section of the upper North Fork (Site 8) and the Talbot Ranch (Site 9) on the lower South Fork just south of Alturas, which had apparently been nearly dry a few weeks earlier. Juveniles (<200mm) were caught at all sites, including the South Fork (App. B-9). Adults were caught in all deeper pool sites on the mainstem Pit (Sites 1-2 and 4-6), with highest abundance at the two sites in Warm Springs Valley, Canby and Clark's Ranch (Sites 5-6), and the Highway 395 bridge (Site 4).

Sacramento suckers have generally been caught by all surveys at all sites. However, they were not caught from the upper North Fork in 2002, and they were apparently not caught by Moyle and Daniels in the upper South Fork in 1974.

Examination of dorsal ray counts (Table 8) and preliminary genetic analysis of suckers from all sites provided no indication that a resident population of Modoc suckers was present in the mainstem Pit River (Topinka et al. in prep). With the exception of a single individual (from Site 2, at Stone Coal Creek) which exhibited one of five Modoc genetic markers, all suckers from the mainstem Pit and vicinity of Alturas had all three Sacramento markers and no Modoc markers. Three individuals from the cascade reach above Stone Coal Creek (Site 3) had some meristic characters generally within the ranges for both Modoc and Sacramento suckers, with 11 dorsal rays and lateral line counts of 78, 79 and 83. However, they had post-weberian vertebral counts of 43-45, which are outside the range for Modoc suckers (40-42) and within the range of Sacramento sucker (43-46) based on recent studies (Kettratad 2001; Reid, unpub. data). They also showed none of the five Modoc sucker genetic markers currently available (Topinka et al. in prep).

However, suckers from the upper South Fork sites (Sites 10-12) contained relatively high frequencies of Modoc markers along with at least two of three Sacramento markers. Five of 34 individuals were missing a single Sacramento marker (Sac 3). The occurence of Modoc sucker genetic markers in the South Fork of the Pit River suggests that either a previously resident population has been genetically swamped and replaced by Sacramento suckers, or that an extant source population of Modoc suckers occupies a tributary to the South Fork (or a reach upstream of the 2002 sampling). The South Fork population is the subject of an ongoing assessment to clarify its phenotypic and genetic character and to survey for possible source populations of Modoc suckers in tributaries to the South Fork (contact S. Reid, USFWS Klamath Falls, for further information).

	Fish Examined (#)											
Site:	1	2	3	4	5	6	7	8	9	10	11	12
Dorsal Rays												
10	-	-	-	-	-	-	-	-	-	-	-	-
11	1	2	7	5	6	7	2	-	-	4	-	4
12	11	16	45	22	37	54	24	-	-	31	1	5
13	-	3	5	3	7	14	4	-	-	3	-	2
Total:	12	21	57	30	50	75	30	0	0	38	1	11

Table 8. Dorsal fin ray counts in Sacramento suckers caught at the twelve sampling sites.

Pit brook lamprey: Pit brook lamprey, the only lamprey currently known from the upper Pit River (excluding Goose sub-basin), were caught in the deeper mainstem Pit River as well as in the more stream-like reaches of the North and South Forks. Both adults and ammocoetes (larvae) were collected together, except at Clark's Ranch on the Pit (Site 6), where only a single adult was caught. A sucker (112mm SL) with an apparent lamprey wound (approx. 8mm diameter) was caught at the Highway 395 bridge (Site 4); this is the first possible evidence of parasitic behavior in a lamprey from the upper Pit River.

Lampreys are often missed or underestimated during electroshocking surveys, especially in turbid water, due to their relatively small size, cryptic brown coloration, tendency to burrow in the substrate, and ability to wriggle through net mesh (S. Reid, pers. obs.). Therefore, their absence at any site is not particularily informative. The presence of lampreys in both the North and South Forks, as well as at mainstem Pit River sites during the present survey, suggests that they probably occur throughout the drainage, and their scattered occurence in historical collections is probably not indicative of variability in their range.

Redband/rainbow trout: Trout exhibiting both native redband coloration (intense color and parr marks retained into maturity) and potential hatchery rainbow trout (indefinite parr marks and pale pink lateral stripe) were caught only in two of the upper South Fork sites.

The absence of trout in the present surveys was consistent with historical collections made during July-September in the mainstem Pit, as well as summer surveys in the vicinity of Alturas since 1904. Both Rutter (1908) and Snyder (1908) caught trout in the immediate vicinity of Alturas circa 1900 (1898 and 1904, respectively). Although both Rutter (in 1898) and Moyle and Daniels (in 1974) caught trout in the upper North Fork, habitat conditions during the 2002 North Fork sampling, which included very low flows and shallow, warm water, probably excluded trout from the area; although potential refugial areas may have been present in the cooler mouths of nearby Thoms and Joseph Creeks. The 2002 catches of trout in the upper South Fork were consistent with Moyle and Daniels collection in the early 1970's. The collections from 1940-1963, which did not encounter trout, were from the lower reaches of the stream, in the vicinity of Likely.

Brown trout (introduced): Brown trout were caught only in the three upper South Fork sites (Sites 10-12). Similarly, in their Pit River collections, Moyle and Daniels caught brown trout only in the upper South Fork. Brown trout have been in the upper Pit drainage since about the 1930's (Moyle and Daniels 1982).

Sacramento pikeminnow: Pikeminnow were abundant at most sites, except the small, higher gradient section of the upper North Fork (Site 8; none caught) and the Talbot Ranch (Site 9; 3 juveniles) on the lower South Fork just south of Alturas, which had apparently been nearly dry a few weeks earlier. The observed length frequencies suggest a young of the year (YOY) size-class centered near 60mm, which was present at all sites except the upper North Fork (App. B-4). Larger juveniles and subadults (100 – 220mm) were present at most sites, but adults (220-400mm) were caught at only two sites in Warm Springs Valley, Canby and Clark's Ranch (Sites 5-6). Both sites contained large deep pools with relatively low flow and gradient.

With few exceptions, pikeminnow have been collected consistently throughout the mainstem and vicnity of Alturas. Their absence from the upper North Fork in the 2002 surveys and absence from the upper South Fork in the 1973-74 surveys are perhaps notable. However, these diffences may be due to local site conditions at the specific times of the surveys or collecting methodologies, and they should not be necessarily taken to indicate complete absence within those streams.

Hardhead: Hardhead of all size-classes were caught only in the mainstem Pit River (App. B-5), and individuals over 200mm, presumably adults, were caught only at the two sites in Warm Springs Valley, Canby and Clark's Ranch (Sites 5-6).

Hardhead have been caught consistently in surveys sampling larger pools of the mainstem Pit River. Their presence in the early surveys in the vicinity of Alturas, probably represent changes in habitat post-channelization of the North Fork through Alturas and/or differences in specific collection sites for the different surveys. Larger pool habitat is still present during the summer in the vicinity of Parker Creek and the Hwy. 395 crossing to Lakeview, but it was not sampled in 2002. Moyles and Daniels (1982) did report hardhead from the mouth of Parker Creek in 1974, though not from their lower North Fork Pit River sites.

Tui chub: Tui chubs were generally not a substantial part of the catch and were absent or represented by only 1-2 individuals at most sites. However, higher catches occured in two areas: at the two sites in Warm Springs Valley, Canby and Clark's Ranch (Sites 5-6), and at the entrance to Jess Valley on the South Fork (Site 12). Most chubs caught appeared to represent a YOY size-class (centered near 50mm) and year-one class (centered near 100mm). The largest chub was collected at Canby and measured 180mm (App. B-6).

Tui chubs were collected in 2002 from most reaches where they had been collected historically, with the exception of the vicinity of Alturas. Habitat conditions at the 2002 site (in the constructed channel at Alturas), were extremely shallow without large pool habitat similar to other sites with tui chubs. Therefore it is not surprising that none were caught; selection of a deeper water site just upstream of town might have produced chubs, as it did for Hubbs and Murphy in the 1934 and 1940 surveys, respectively.

Speckled dace: Dace were absent in the mainstem Pit River, and only occurred in the uppermost sites of the North and South Forks. They were abundant only at the upper North Fork site (Site 8), where they were the only fish besides lampreys in the sample; one individual was caught at the entrance to Jess Valley on the South Fork (Site 12).

Dace were caught only in the shallower stream reaches (upper North and South Forks) in the 2002 surveys, which is generally consistent with earlier surveys. Some earlier surveys also contained catches in the vicinity of Alturas. Whether these catches were due to habitat conditions or site specific differences can not be assessed. While Rutter (1908) reported dace from the Pit River at Canby in his report, there are no specimens from this locality in the National Museum, which contains the remainder of his specimens. Cooper et al. (1978) caught a single dace in the Pit River, near the mouth of Stone Coal Creek.

Pit roach : Pit roach were not caught from the mainstem Pit or the North and South Forks during the 2002 surveys. A single specimen was caught by Miller at the Canby bridge in 1961, and otherwise Pit roach were caught in very low numbers by Rutter ("a few small specimens"; 1908, p. 139) and Hubbs (19 specimens) in the North Fork. Roach were also caught historically in the South Fork near Likely, a reach which was not sampled in 2002.

Golden shiner (introduced): Golden shiner, an introduced species frequently used for bait, was rarely encountered. A single individual was caught at the Stone Coal confluence pool (Site 2) and three were caught at Canby (Site 5). Moyle and Daniels (1982) reported golden shiners to be common in the Big Valley section of the Pit River (downstream of the 2002 survey area), but in the upper Pit Drainage caught the species only in low numbers from Rattlesnake Creek (downstream of Big Sage Reservoir).

Brown bullhead (introduced): Brown bullheads were caught in relatively low numbers from the Hwy. 395 bridge (Site 4) on the mainstem Pit to the Talbot Ranch (Site 9) on the lower South Fork just south of Alturas. Most were smaller juveniles (<100mm), with only a few adults (140-200mm) caught (App. B-10).

Brown bullheads were introduced to California in 1874, and were caught from the mainstem Pit by Snyder in 1904 (Dill and Cordone 1997). They have not been caught in the upper North Fork, probably due to its rocky stream habitat.

Sacramento perch (introduced): Sacramento Perch, a species native to the Sacramento Valley, occurred only as small numbers of juveniles (29-69mm), with the largest catch (10) in the South Fork (Site 10), just below the outlet of West Valley Reservoir (App. B-11).

Sacramento perch were apparently introduced to West Valley Reservoir (tributary to the South Fork Pit) in 1972 (Moyle and Daniels 1982). There are no records from the mainstem Pit or North and South Forks in the historical surveys. The juveniles encountered in the 2002 surveys may be waifs from this population, and the lack of adults in any collections suggest that the species is not established as a reproducing population in the mainstem Pit or North and South Forks.

Green sunfish (introduced): Green sunfish were generally caught throughout the mainstem Pit, lower North Fork and lower South Fork in low-energy reaches. The only mainstem site where green sunfish were not caught was in the high-energy cascade reach (Site 3) immediately above the Stone Coal confluence pool (Site 2), where they were relatively abundant. They were also absent from the upper reaches of the North and South Forks. While small green sunfish were moderately abundant at some sites and were the most abundant exotic species encountered, they never represented a large component of the biomass, since they were generally young juveniles (<50mm) and rarely exceeded 100mm (App. B-12).

Green sunfish were first recorded in fish surveys by Miller in 1961 (Pit River at Canby bridge) and have been recorded from the mainstem Pit and vicinity of Alturas in all subsequent surveys. Moyle and Daniels also caught them in the North Fork Pit, but they were not encountered at the single 2002 site. The species seems to be broadly present throughout the lower elevations of the upper Pit Drainage (Moyle and Daniels 1982, Reid pers. obs.).

Bluegill (introduced): Bluegill were caught at only two sites: the Stone Coal confluence pool (Site 2) and Clark's Ranch (Site 6). Each site had only four, relatively small (63-110mm) individuals apiece (App. B-13).

Bluegill were first recorded in fish surveys by Miller in 1961 (Pit River at Canby bridge) and have been recorded, in at least low numbers, from the mainstem Pit in all subsequent surveys. They have not been recorded from other sections of the North or South Fork, but may be present.

Pit sculpin: Pit sculpin were caught only in the three relatively high gradient upper South Fork sites (Sites 10-12). In historical collections, Pit sculpin have been recorded from throughout the upper Pit system. The absence of sculpin from the 2002 mainstem Pit River collections may be due, in part, to sampling artifacts. Sculpin are cryptically colored and are often missed by netters following electroshockers in turbid streams, while they are trapped in seines regardless of visibility. Sculpin were observed in the mainstem Pit River just upstream of Stone Coal Creek in late summer 2001 (Reid pers. obs.), so they were probably missed during the 2002 collections, rather than absent.

Conclusions

The 2002 Pit River fish surveys were intended to: 1) explore the possibility that unrecognized populations of the federally endangered Modoc sucker might be present in the mainstem rivers, and 2) provide a current fish survey that could be compared with historic collections in order to assess changes in the species composition of the mainstem Upper Pit River fish fauna over the last century (1898-2002). The results of the 2002 surveys will be incorporated into a current status review by the USFWS to determine whether the Modoc sucker has recovered to a point where downlisting or delisting under the Endangered Species Act is appropriate.

The surveys also provide a baseline and record of fish species composition at the various Upper Pit River sites monitored by the Pit River Watershed Alliance for water quality, habitat, and macroinvertebrate composition, and provide faunal information for assessing potential effects to aquatic resources as a result of water and fisheries management in the Pit drainage. These survey results will be provided to the Pit River Watershed Alliance for incorporation into its ongoing assessment of watershed conditions and needs.

The present survey provided valuable information regarding the distribution of Modoc suckers and faunal characteristics of the mainstem upper Pit River, the North and the South Forks over the last century, including:

1) The 2002 survey found no indication of a resident population of Modoc suckers in the mainstem Pit River downstream of Alturas.

2) The occurence of Modoc sucker genetic markers in the Sacramento sucker population in the upper South Fork of the Pit River (above Likely) suggests that either a previously resident population of Modoc suckers has been genetically swamped and replaced by Sacramento suckers, or that an unrecognized source population of Modoc suckers occupies a tributary to the South Fork (or a reach upstream of the 2002 sampling) well outside the previously known range of Modoc suckers in the Pit Drainage. The South Fork population is the subject of an ongoing assessment to clarify the its phenotypic and genetic character and to survey for possible source populations of Modoc suckers in tributaries to the South Fork (contact S. Reid, USFWS Klamath Falls, for further information).

3) The native fish fauna of the upper Pit River has remained relatively stable throughout the last century at the sites surveyed. Possible exceptions include the summer distribution of redband trout in the North Fork, from Alturas upstream, and the localized exclusion of, or reduction in, fishes in river reaches subject to dewatering and/or stagnation.

4) Exotic fishes formed a relatively minor component of the fish communities at the sites surveyed. The most consistently present exotic species were green sunfish and brown bullheads in the mainstem Pit and vicinity of Alturas, and brown trout in the upper South Fork. All three species have been present in the drainage for at least seventy years.

5) Two exotic species, largemouth bass and channel catfish, were caught during historical surveys from the 1960-70's but were notably absent in the 2002 survey. The decline and disappearance of bass and channel catfish was supported by numerous comments by local residents and fishermen during the 2002 survey.

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Appendix A: Survey Sites - Sampling Methods and Habitat Notes

Site 1: Location: Rose Canyon - Pit River, confl. Rose Canyon, at Shaw Ranch bridge.

Site 1:	Location:	Rose Canyon - Pit River, confl. Rose Canyon, at Shaw Ranch bridge.
	Township:	T 41N R 7E Sec 35 (Modoc Co.)
	Date:	12 Sept. 2002, 1030-1400 hrs.
	Depth sampled:	0.1 - 2.0 m in pools, max depth ca 2.0 m under bridge
	Visibility:	ca. 0.3 m
	Water temp.:	16.6 °C
	Conductivity:	226µmhos/cm
	Shocker time:	Raft shocker in pools = 1158 secs (377, 781 secs)
		Backpack shocker in riffles = not recorded
	Notes:	Moderate flow [1].

[1]. Current was characterized as 1) "weak", if water was flowing but hardly noticeable, 2) "moderate", if there was noticeable flow, but it was not strong enough to affect waders in the water, and 3) "strong", if the current resulted in notably turbulent flow and/or was difficult to wade against, control raft, or net fish.

Site 2: Location: Stone Coal Pool - Pit River, large pool at confluence with Stone Coal Creek, just below County Road 85 bridge

Township: T 41N R 8E Sec 27 (Modoc Co.)

Date: 13 Sept. 2002, 0900-1230 hrs.

Depth sampled: ca. 1.0 - 5.0 m

Visibility: ca. 2.0 m

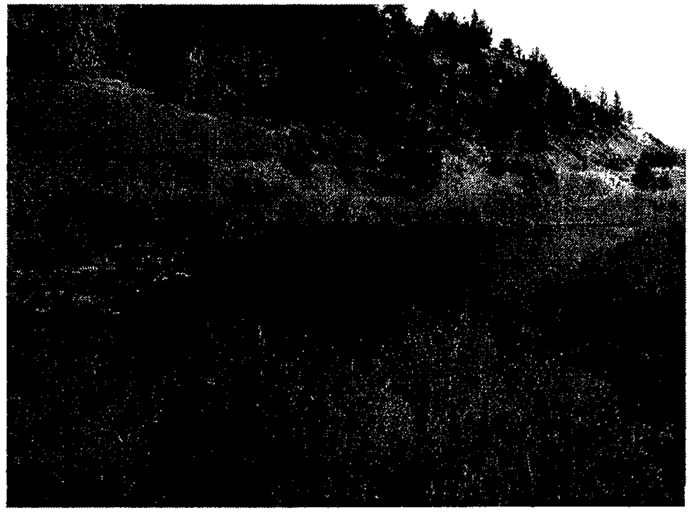
Water temp.: 15.2 °C at surface, 14.0 °C at 3.2 m

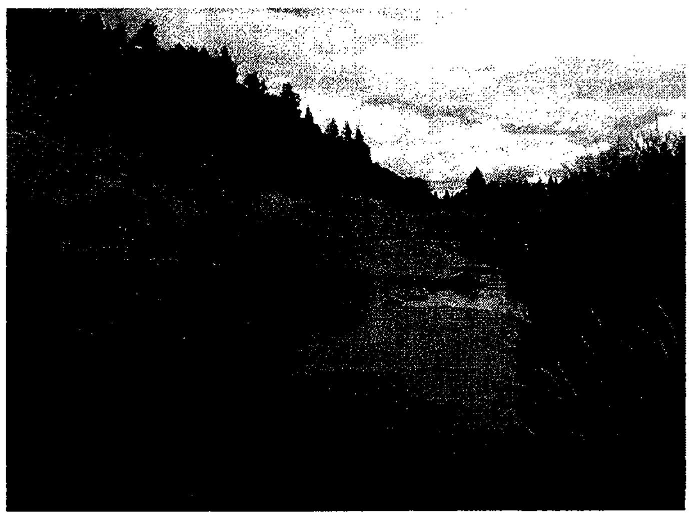
Conductivity: 220µmhos/cm at surface, 215µmhos/cm at 3.2 m

Shocker time: Raft shocker = 2462 secs (1155, 1307 secs); Backpack = 30 mins

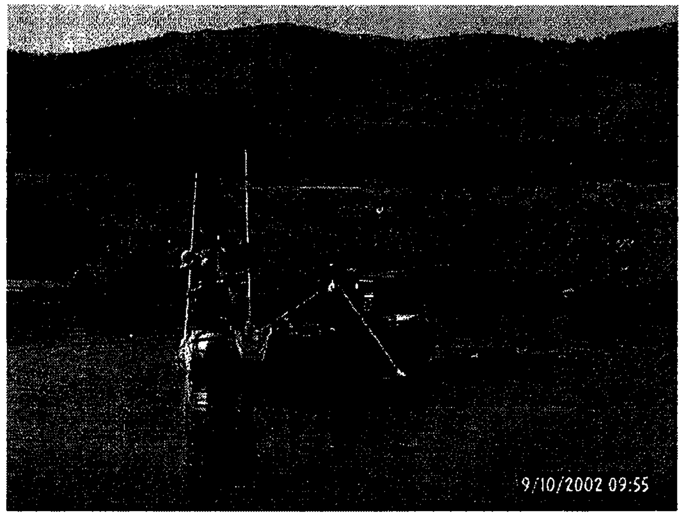
Notes: Large pool at confluence sampled with boat shocker, about 30m of shallow riffles below pool sampled by backpack. Small YOY pikeminnow (< 50 mm) were common in riffles, one larger (120 mm), also caught four small suckers (< 10 cm, all with 12 DR) in riffles.

Site 3:	Location:	Stone Coal Rapids - Pit River, rapids reach just above confluence Stone Coal Creek, at County Road 85 bridge
	Township:	T 41N R 8E Sec 27 (Modoc Co.)
	Date:	12 Sept. 2002, 1450-1900 hrs.
	Depth sampled:	ca. 0.5 - 2.0 m
	Visibility:	ca. 2.0 m
	Water temp.:	21.9 °C
	Conductivity:	241 µmhos/cm
	Shocker time:	Total time (backpack shocker) = not recorded
	Notes:	Rapids reach, large rock and cobble pools with short rapids between.

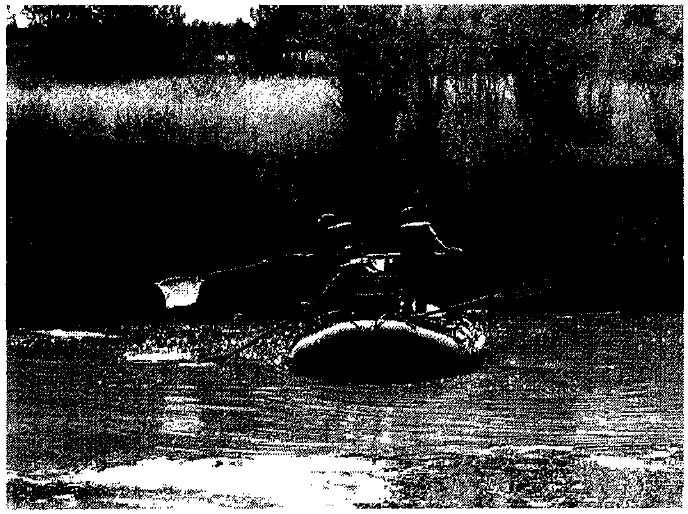


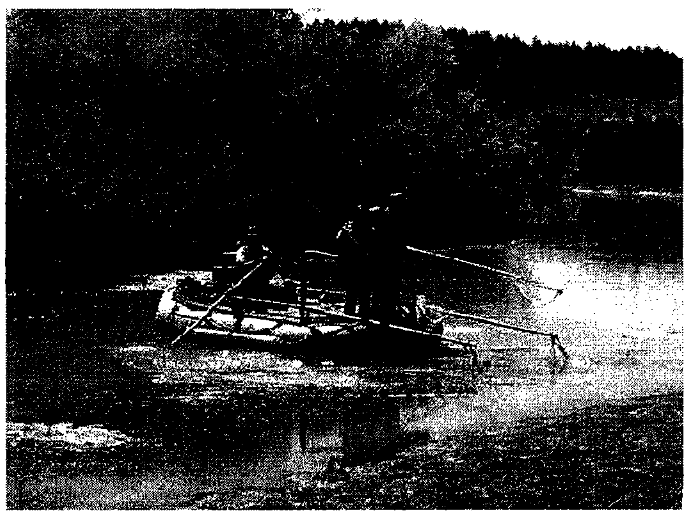


Site 4:	Location:	Hwy. 139 Bridge - Pit River, just downstream of Hwy. 139 bridge at public access, about four miles down from Canby.
	Township:	T 41N R 9E Sec 9 (Modoc Co.)
	Date:	17 Sept. 2002, 0915-1015 hrs.
	Depth sampled:	ca. 0.5 - 1.3 m
	Visibility:	ca. 1.0 m
	Water temp.:	16.5 °C
	Conductivity:	241 μmhos/cm
	Shocker time:	Total time (boat shocker on raft, single pass) = 1423 secs
	Notes:	Slight flow. Sampled rocky bottom, deeper pool, vegetated shorelines and aquatic vegetation.

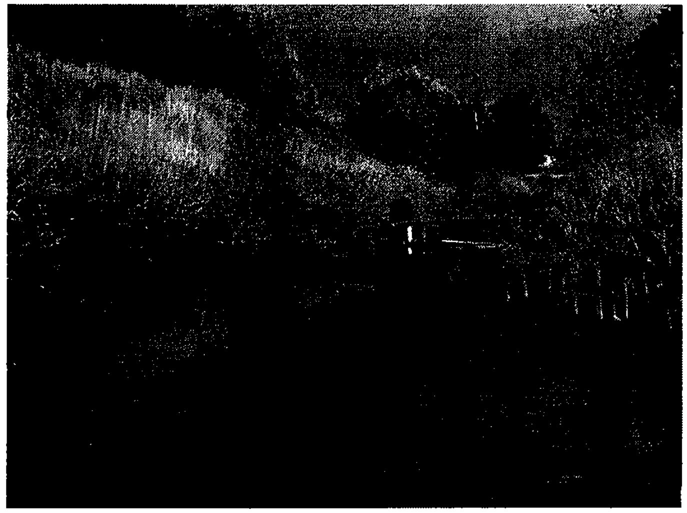


Site 5:	Location:	Canby - Pit River at County Road 54 bridge (Modoc Co.)
	Township:	boundary of T 42N R 9E Sec 36/ T 42N R 10E Sec 31
	Date:	10 Sept. 2002, 0800-1575 hrs.
	Depth sampled:	0.6 - 3.2 m
	Visibility:	ca. 1.0 m
	Water temp.:	15.3 °C
	Conductivity:	147μmhos/cm
	Settings:	Pass 1: High, 30 pd, 50% Pass 2-5: High, 30 pd, 100% - relocated anodes shallower (1.5 m) bow
	Shocker time:	Boat shocker = 8109+ secs ("short", 2188, 1412, 1734, 2775 secs.)
	Notes:	Moderate flow. Three Sacramento suckers (372, 375, 385 mm SL) and three pikeminnow (370, 385, 390 mm SL) frozen for tissue analysis of mercury. Proposed outfall site for ISOT hydrothermal.





Site 6:	Location:	Clark's Ranch - Pit River ca. 5 miles west of Alturas
	Township:	T 42N R 11E Sec 13-14 (Modoc Co.)
	Date:	11 Sept. 2002, 1000-1445 hrs.
	Depth sampled:	0.3 - 1.7 m, mostly < 0.8 m
	Visibility:	< 1.0 m
	Water temp.:	15.2 °C
	Conductivity:	209µmhos/cm
	Shocker time:	Boat shocker = 4418 secs (2051, 1345, 1022 secs)
	Notes:	Moderate flow. Three pikeminnow (340, 350, 400 mm SL) frozen for tissue analysis of mercury concentrations.

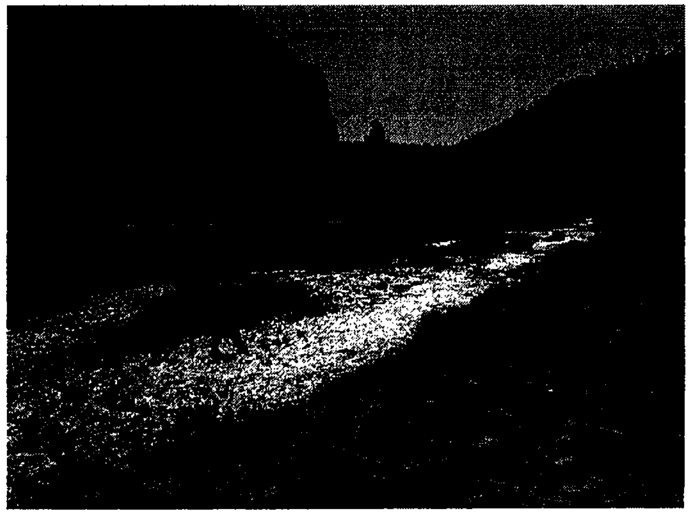


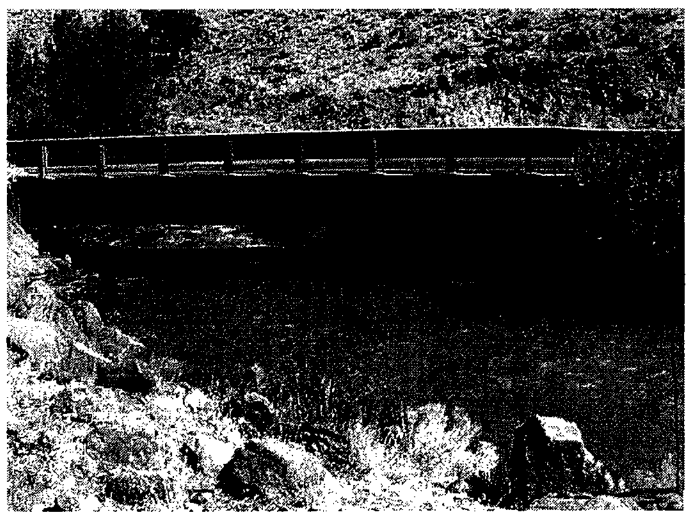
Site 7:	Location:	Alturas - North Fork Pit River, in Alturas, behind River Center.
	Township:	T 42N R 12E Sec 14 (Modoc Co.)
	Date:	17 Sept. 2002, 1700-1830 hrs.
	Depth sampled:	ca. 0.2 - 1.0 m
	Visibility:	ca. 0.5 m
	Water temp.:	19.6 °C
	Conductivity:	472µmhos/cm
	Shocker time:	Total time (backpack shocker) = 1307 secs
	Notes:	Slight flow.

Site 8:	Location:	North Fork - North Fork Pit River, at confl. with Thoms Creek, 1.4 miles downstream of Joseph Creek.
	Township:	T 43N R 13E Sec 1 (Modoc Co.)
	Date:	17 Sept. 2002, 1330-1515 hrs.
	Depth sampled:	ca. 0.2 - 1.0 m
	Visibility:	ca. 1.0 m
	Water temp.:	17.1 °C
	Conductivity:	270µmhos/cm
	Shocker time:	Total time (backpack shocker) = 2442 secs
	Notes:	Slight flow. Dace abundant. Lamprey also present, no other fish.

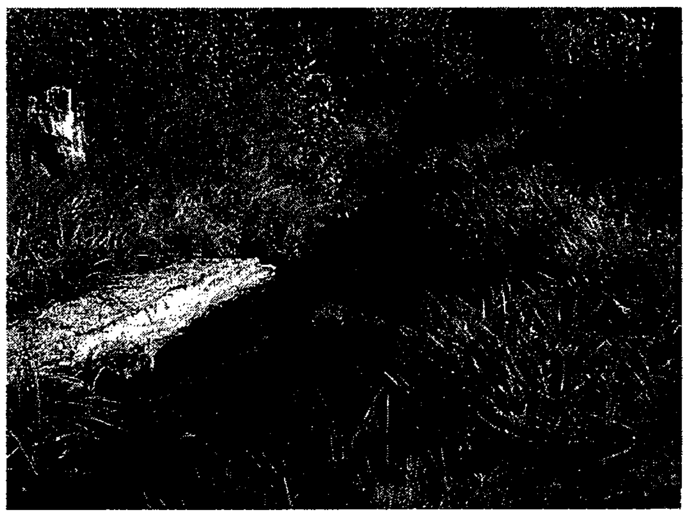
NO PHOTOS AVAILABLE

Site 9:	Location:	Talbot Ranch - S. Fork Pit River, ca. 1 mile south of Alturas
	Township:	T 42N R 12E Sec 23 (Modoc Co.)
	Date:	11 Sept. 2002, 1630-1800 hrs.
	Depth sampled:	0.3 - 1.2 m, mostly ca 1.0 m
	Visibility:	ca. 1.0 m
	Water temp.:	22.0 °C
	Conductivity:	410^{+}µmhos/cm
	Shocker time:	Total time = 1152 secs (boat shocker on raft)
	Notes:	Slight flow. Site had been near dry two weeks earlier (pers. com. Mr. Talbot). Water depth 30-120 cm, dense aquatic vegetation and algae, water clear and red, bottom solid with sod or caliche.

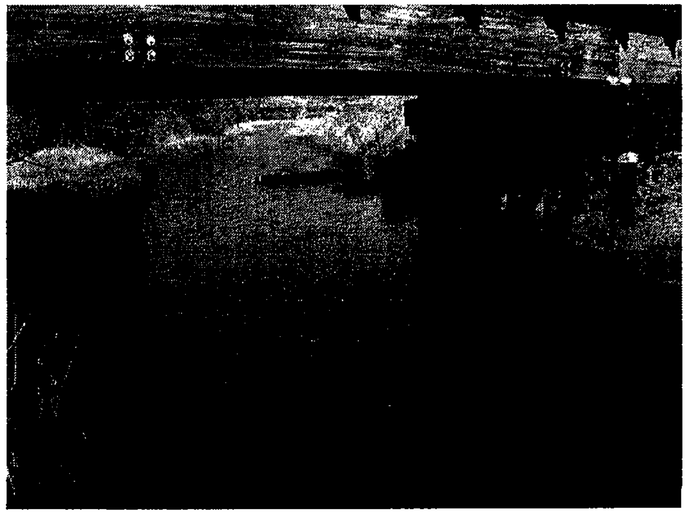


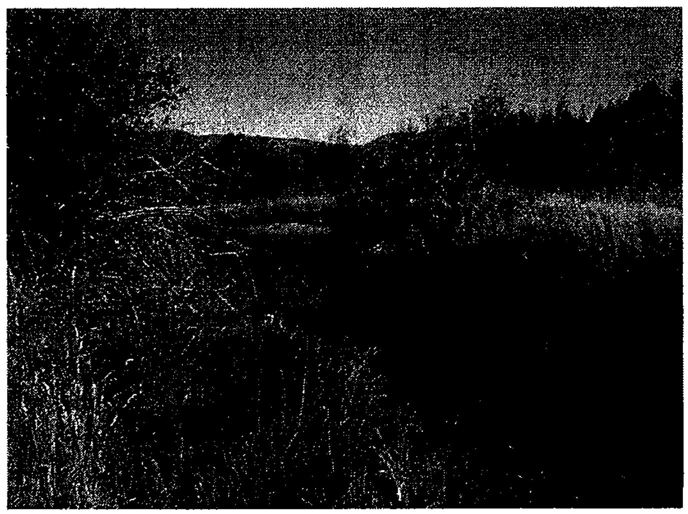


Site 10:	Location:	South Fork Bridge - South Fork Pit River, at bridge one mile below confluence with West Valley Creek.
	Township:	T 39N R 13E Sec 11 (Modoc Co.)
	Date:	18 Sept. 2002, 0800-0940 hrs.
	Depth sampled:	ca. 0.5 - 1.5 m
	Visibility:	ca. 0.2 m, turbid with West Valley Reservoir water
	Water temp.:	14.7 °C
	Conductivity:	139µmhos/cm
	Shocker time:	Total time (boat shocker on raft) = 988 secs
	Notes:	Strong current.

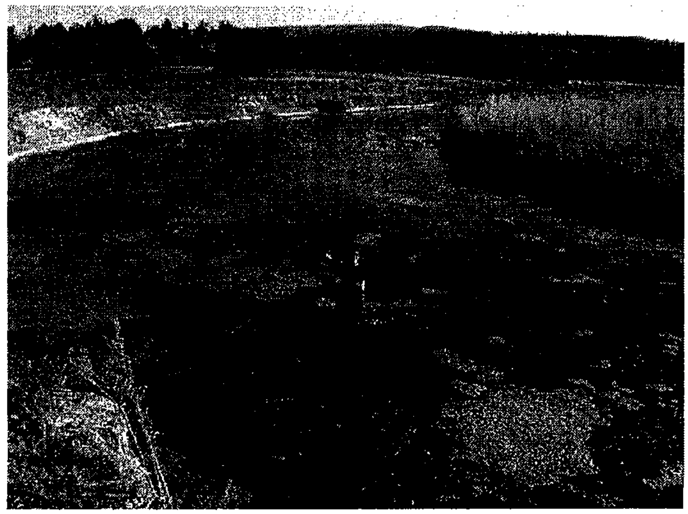


Site 11:	Location:	South Fork Diversion - South Fork Pit River, at irrigation diversion above confluence with West Valley Creek.
	Township:	T 39N R 14E Sec 8 (Modoc Co.)
	Date:	18 Sept. 2002, 1155-1400 hrs.
	Depth sampled:	ca. 0.3 - 1.5 m
	Visibility:	ca. 1.0 m, red with Jess Valley water
	Water temp.:	13.4 °C
	Conductivity:	97µmhos/cm
	Shocker time:	Total time (backpack shocker) = 1680 secs
	Notes:	Moderate current.





Site 12: Location: Jess Valley - South Fork Pit River, just below Jess Valley Bridge.
Township: T 39N R 14E Sec 10/11 (Modoc Co.)
Date: 18 Sept. 2002, 1430-1600 hrs.
Depth sampled: ca. 0.3 - 1.5 m
Visibility: ca. 1.0 m, red with Jess Valley water
Water temp.: 15.9 °C
Conductivity: 95µmhos/cm
Shocker time: Total time (backpack shocker) = 1989 secs
Notes: Moderate current. Relatively low gradient, silt and cinder bottom, with woody debris, branches and vegetation in water.



Site X - Pit River at Kelley Hot Springs outflow channel on September 10th, 2002 – not sampled. Water quality conditions and handnetting indicated the site did not contain many, if any, fish.

Appendix B: Length Frequencies by Species

Pit Brook Lamprey (adults)

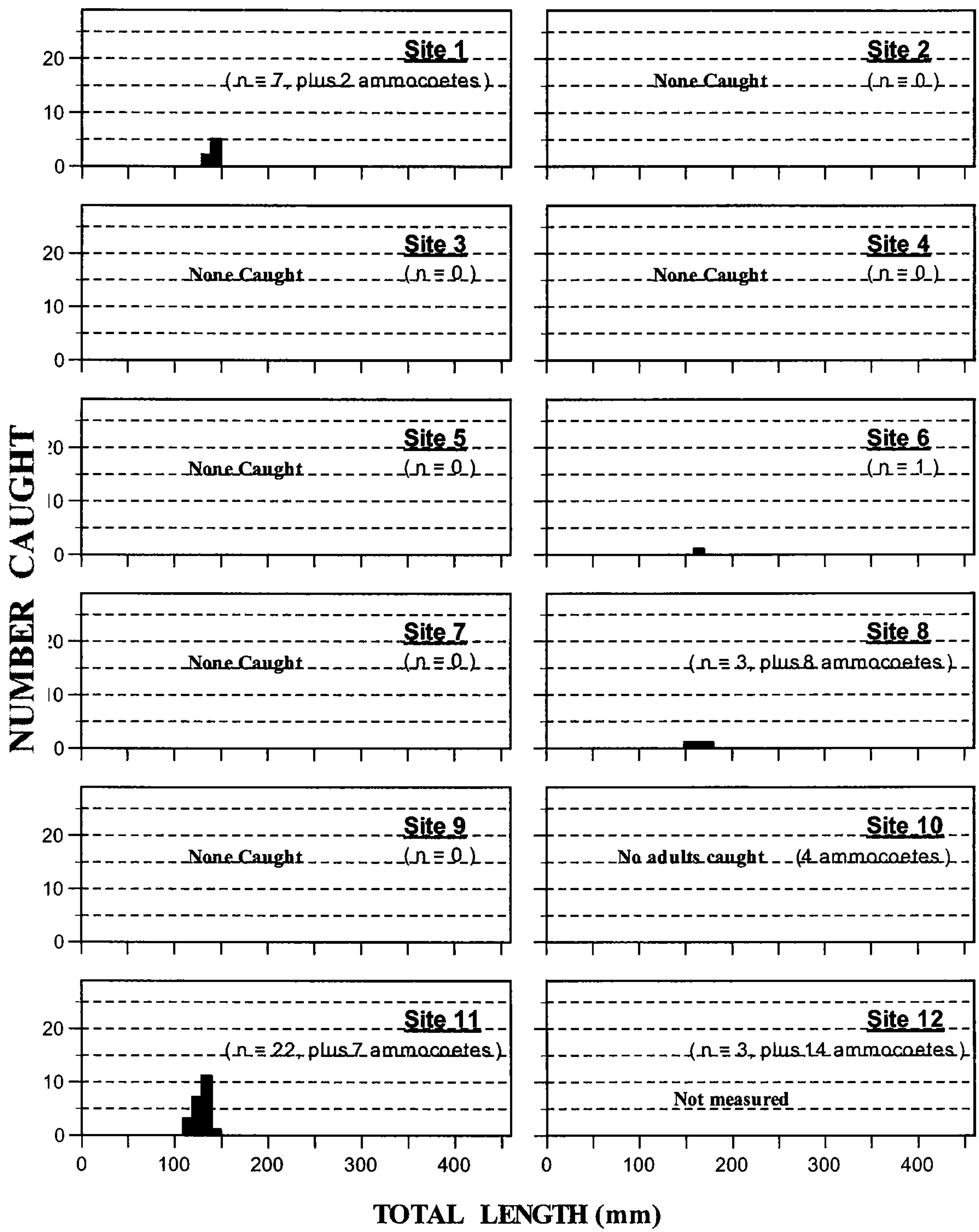


Figure B-1. Pit Brook Lamprey - Length Frequencies and numbers of all adults caught at the various sampling sites. For size distribution of ammocoetes see text (Results).

Redband Trout

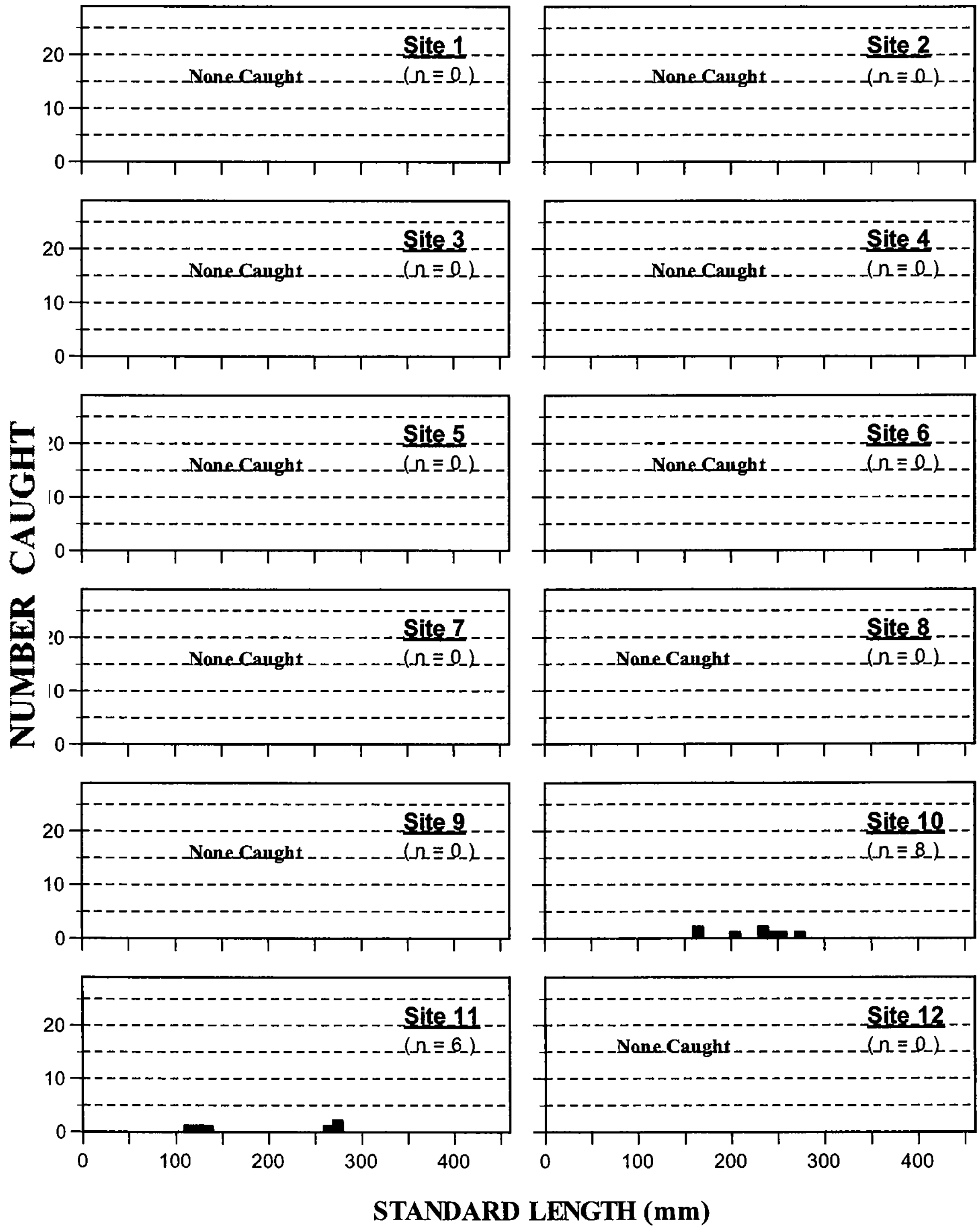


Figure B-2. Redband Trout - Length frequencies and specimens caught at the various sampling sites.

Brown Trout

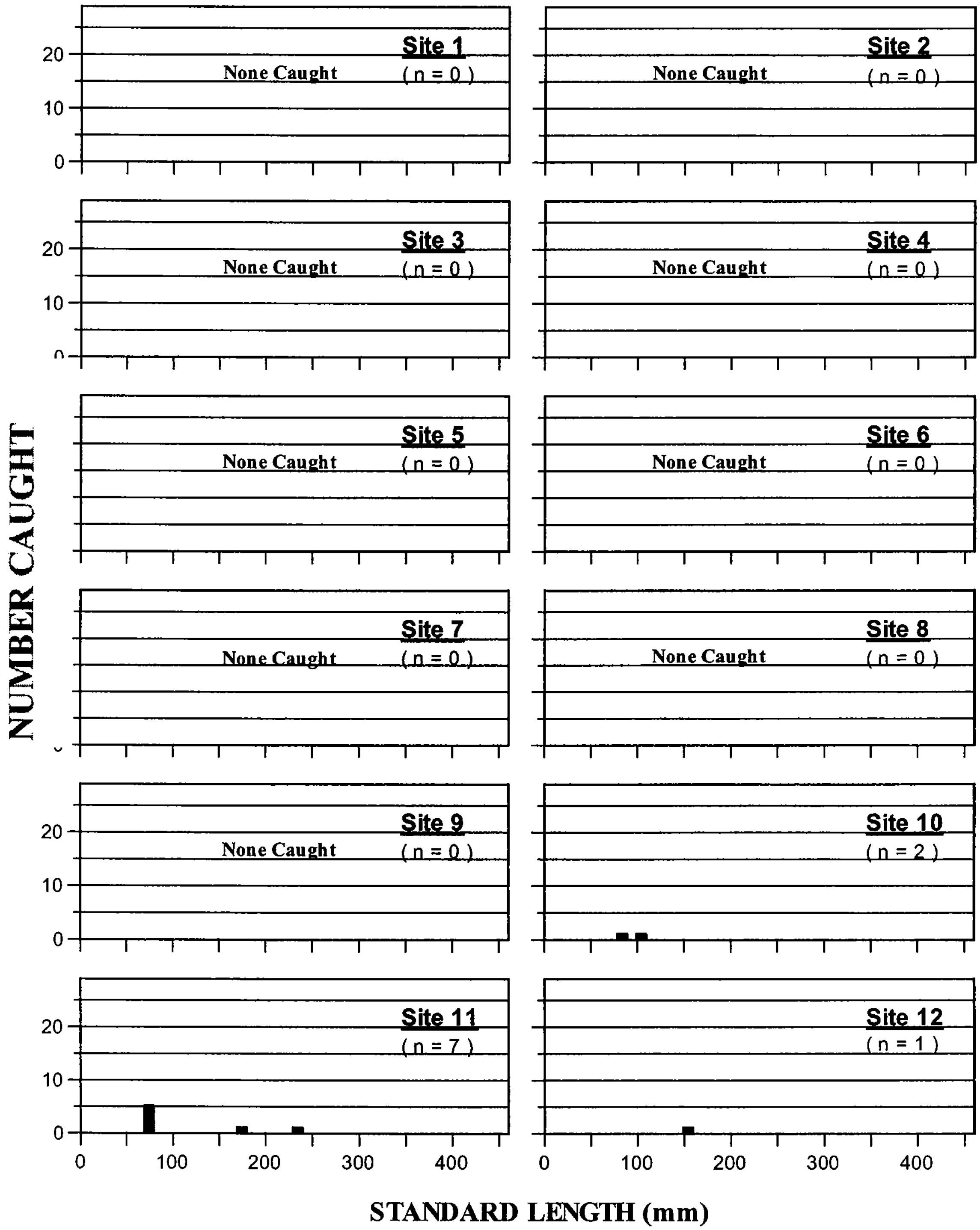


Figure B-3. Brown Trout - Length frequencies and specimens caught at the various sampling sites.

Sacramento Pikeminnow

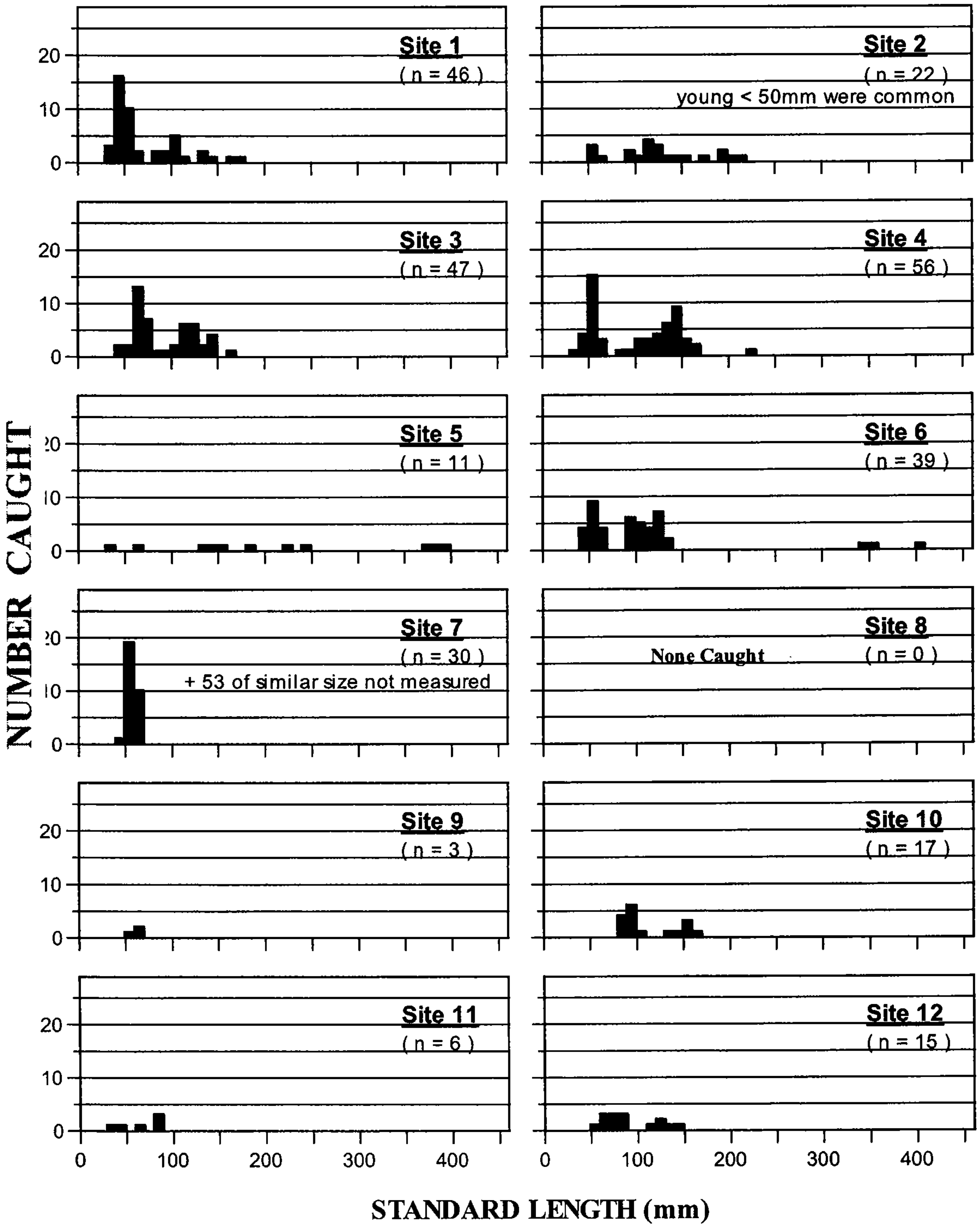


Figure B-4. Sacramento Pikeminnow - Length frequencies and specimens caught at the various sampling sites.

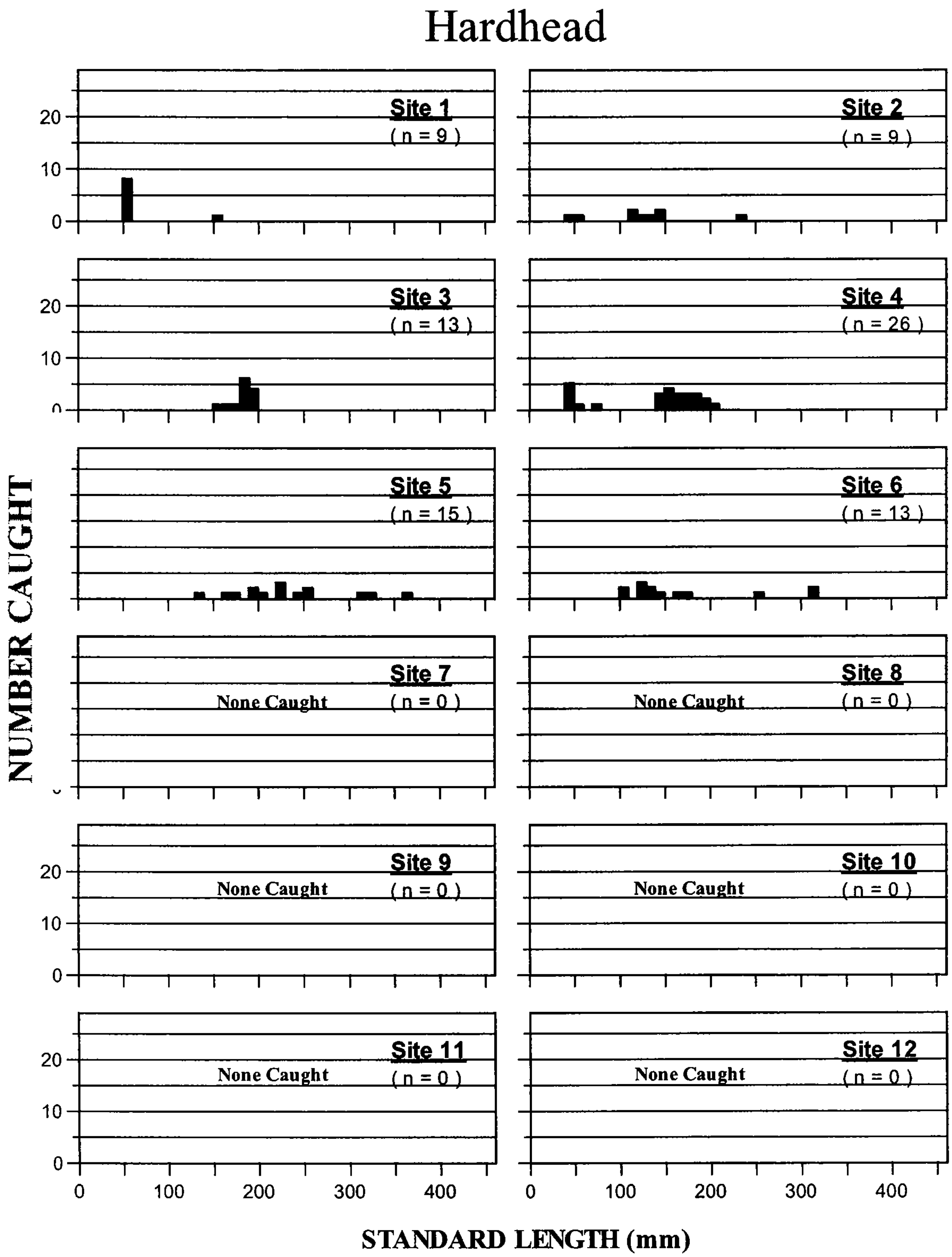


Figure B-5. Hardhead - Length frequencies and specimens caught at the various sampling sites.

Tui Chub

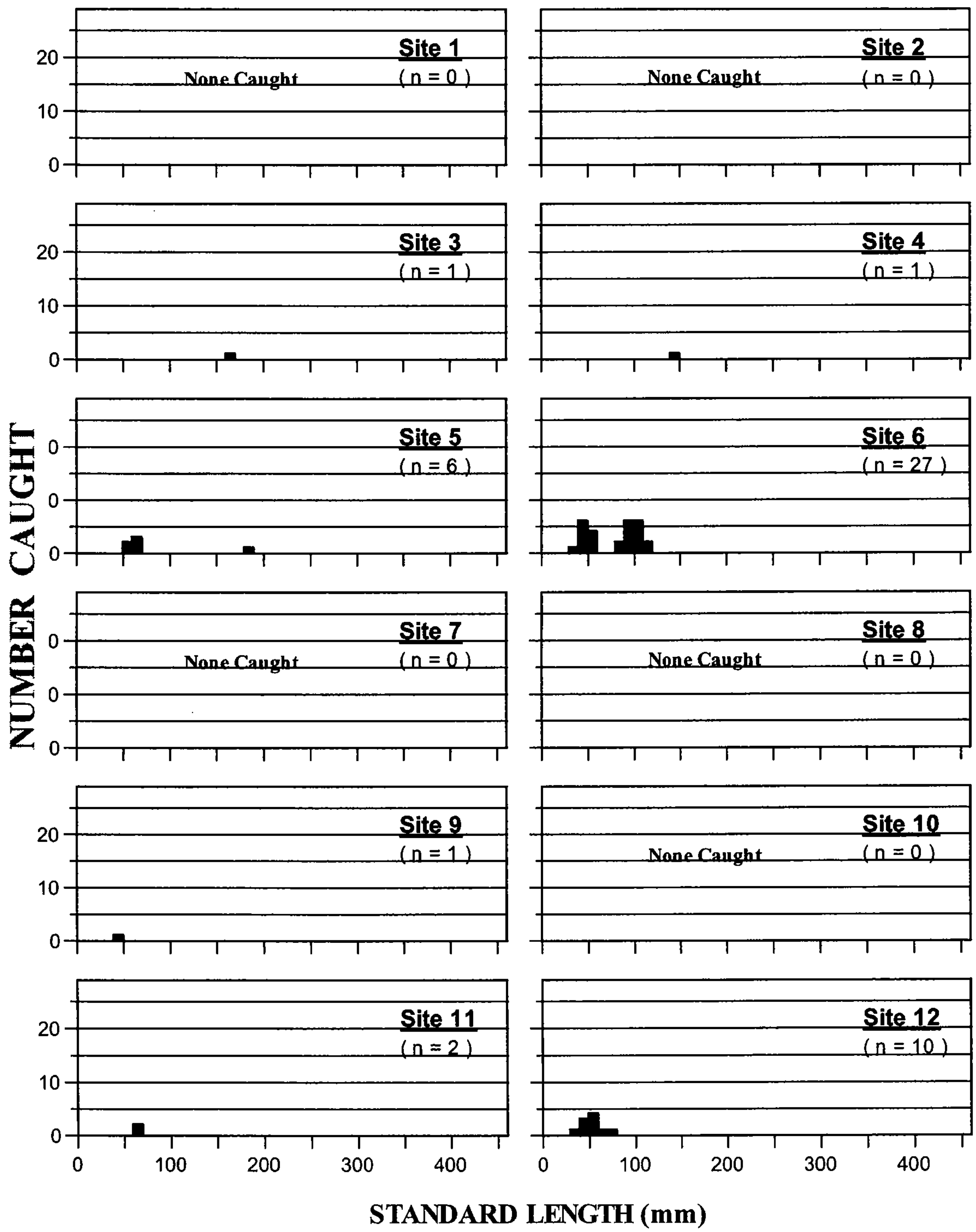


Figure B-6. Tui Chub - Length frequencies and specimens caught at the various sampling sites.

Speckled Dace

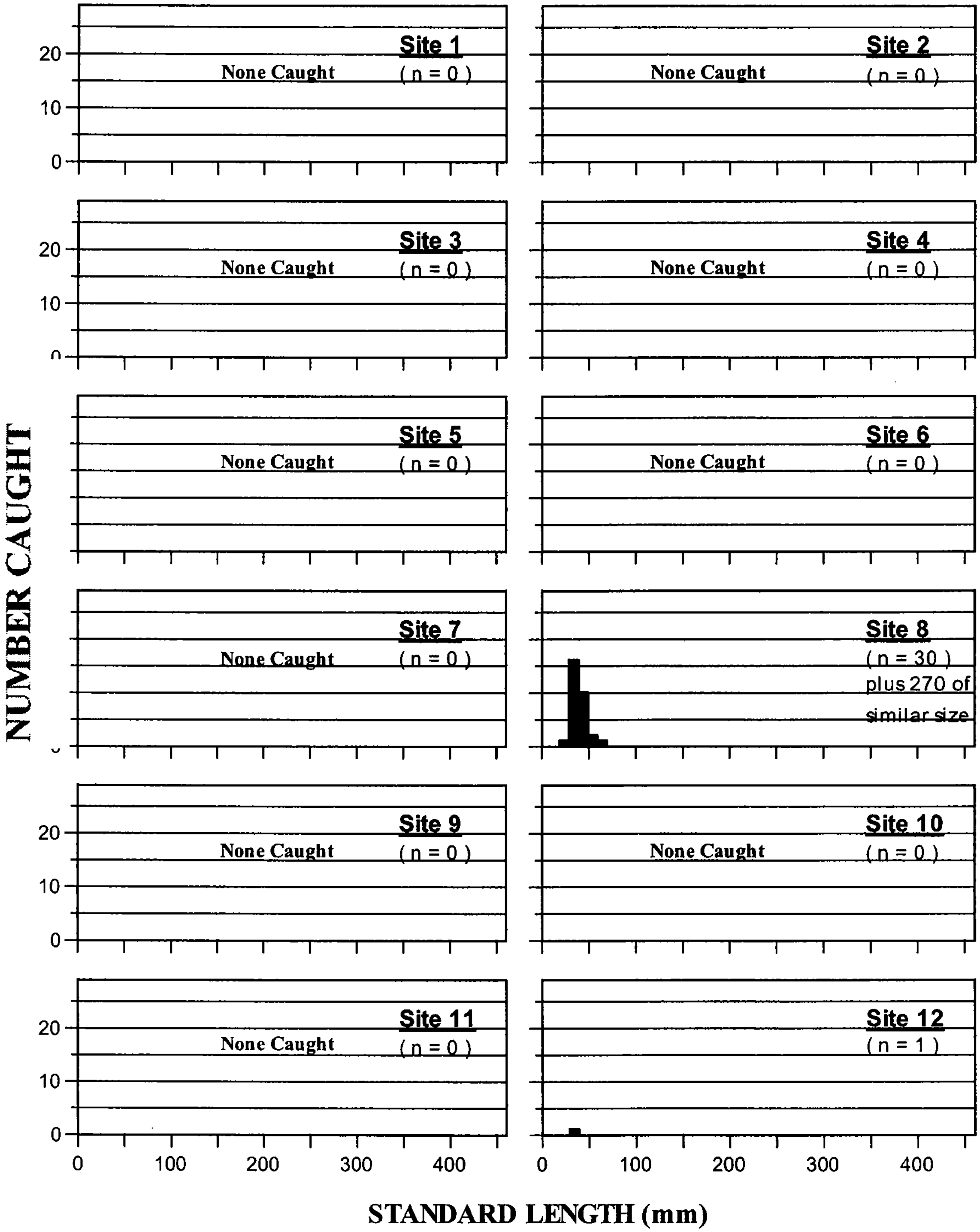


Figure B-7. Speckled Dace - Length frequencies and specimens caught at the various sampling sites.

Golden Shiner

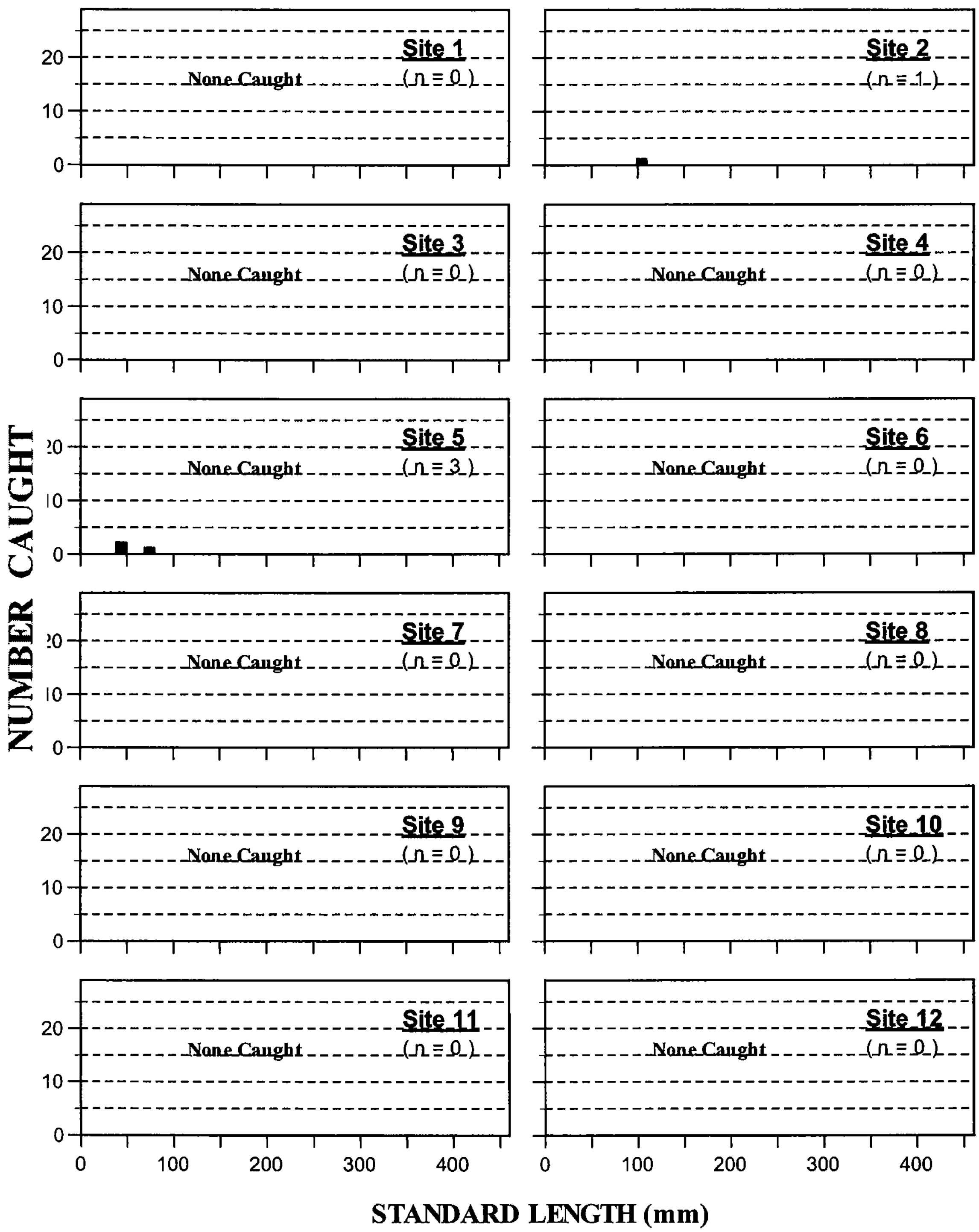


Figure B-8. Golden Shiner - Length frequencies and specimens caught at the various sampling sites.

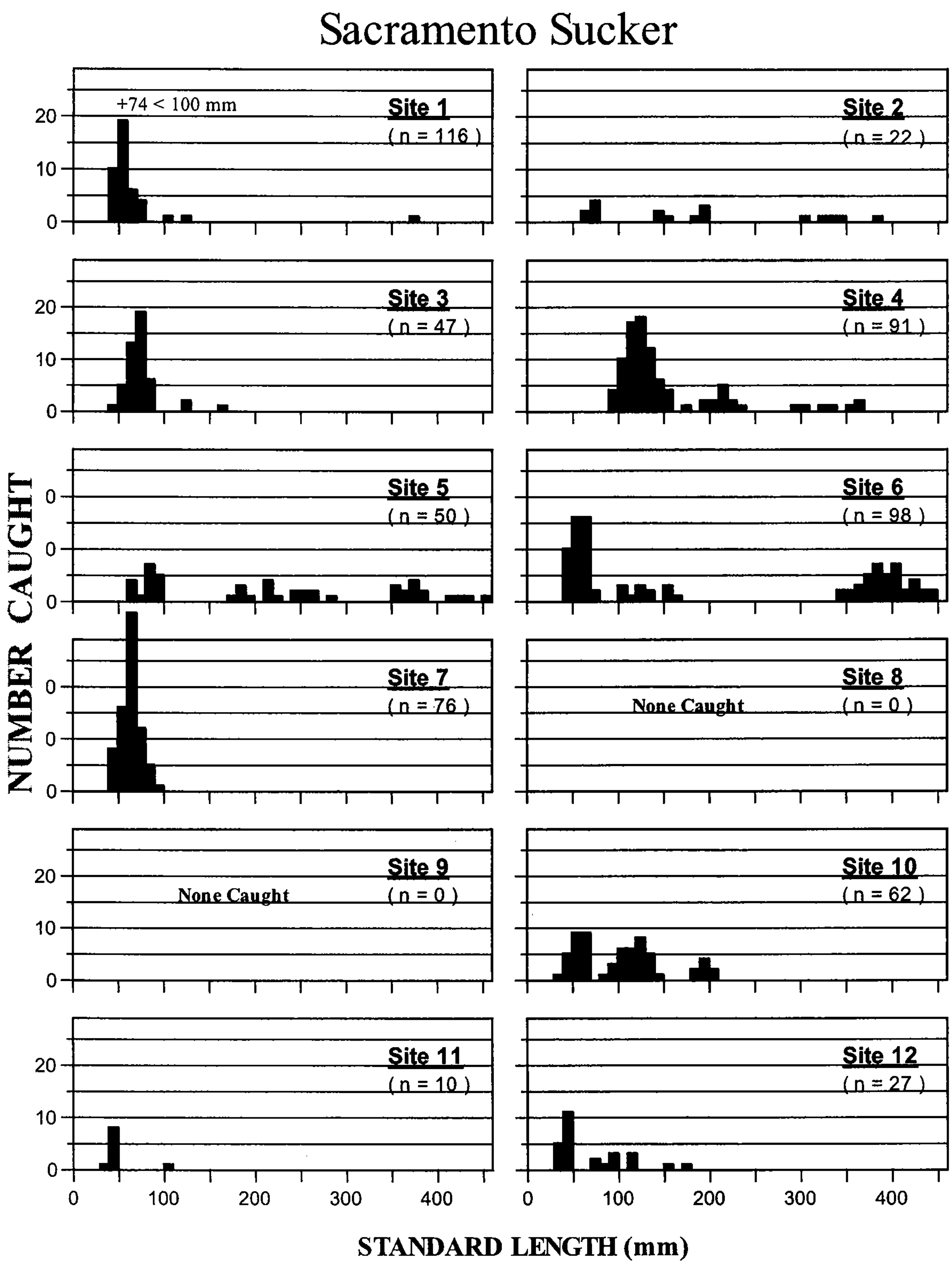


Figure B-9. Sacramento Sucker - Length Frequencies and specimens caught at the various sampling sites.

Brown Bullhead

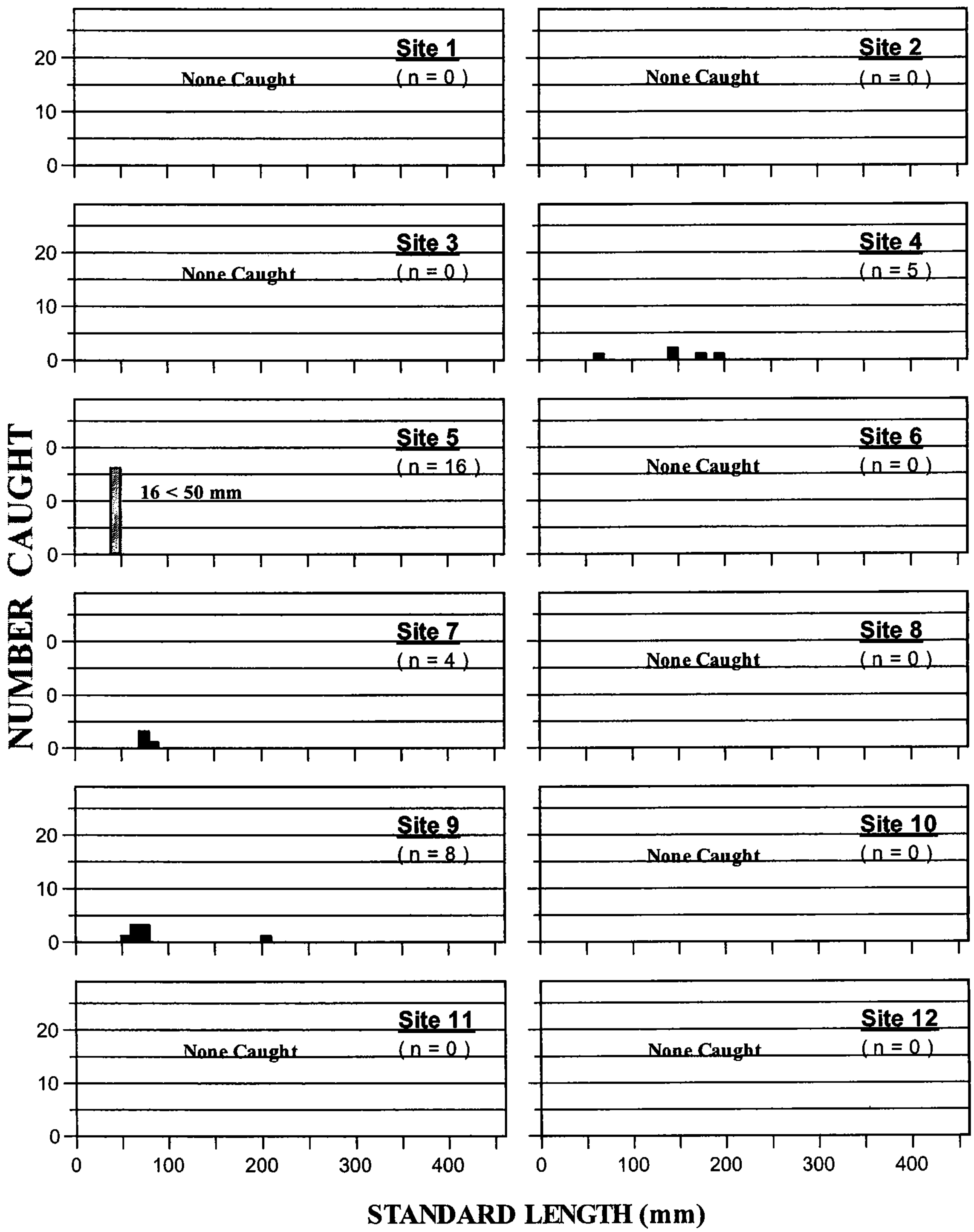


Figure B-10. Brown Bullhead - Length frequencies and specimens caught at the various sampling sites.

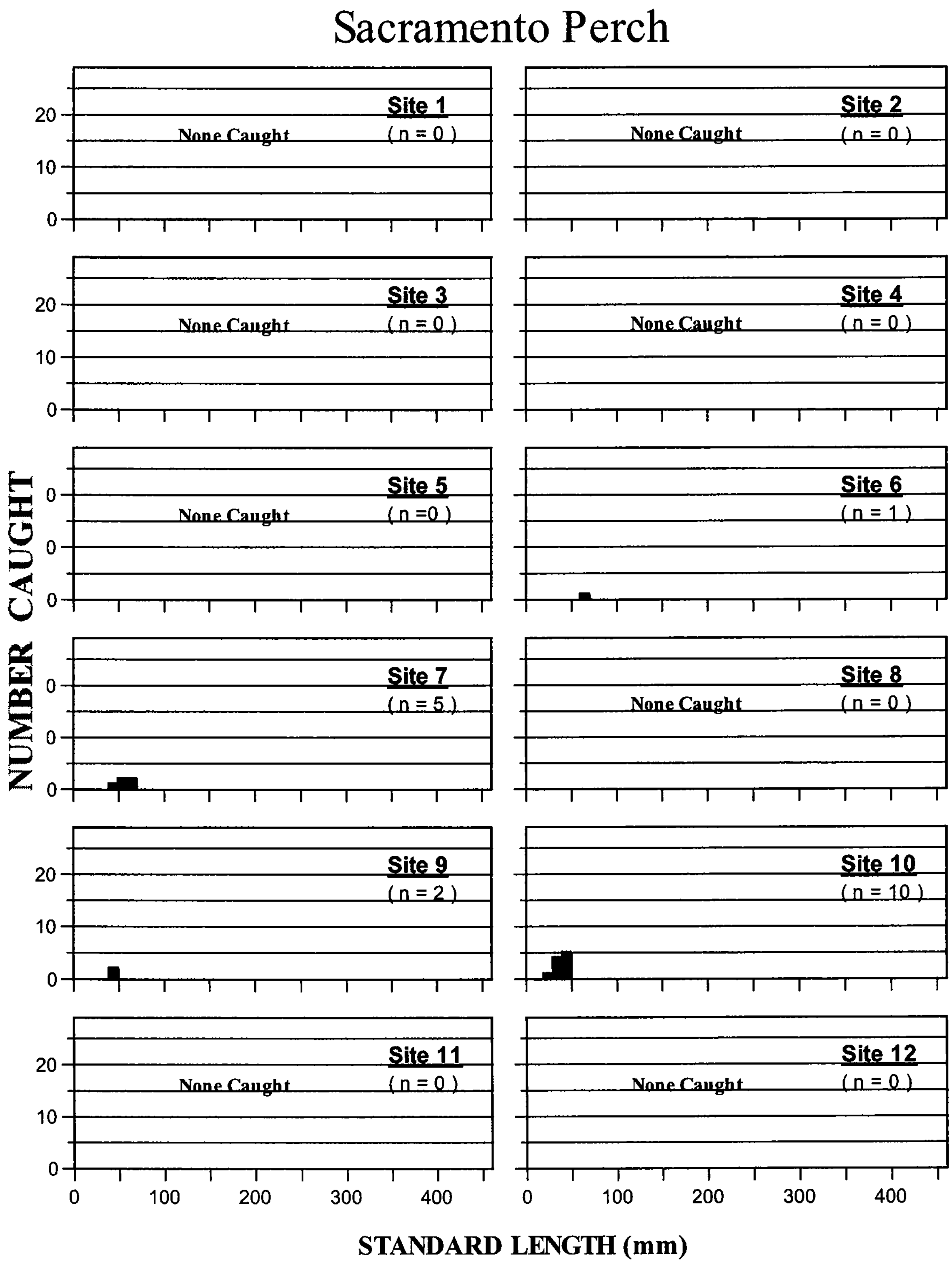


Figure B-11. Sacramento Perch - Length frequencies and specimens caught at the various sampling sites.

Green Sunfish

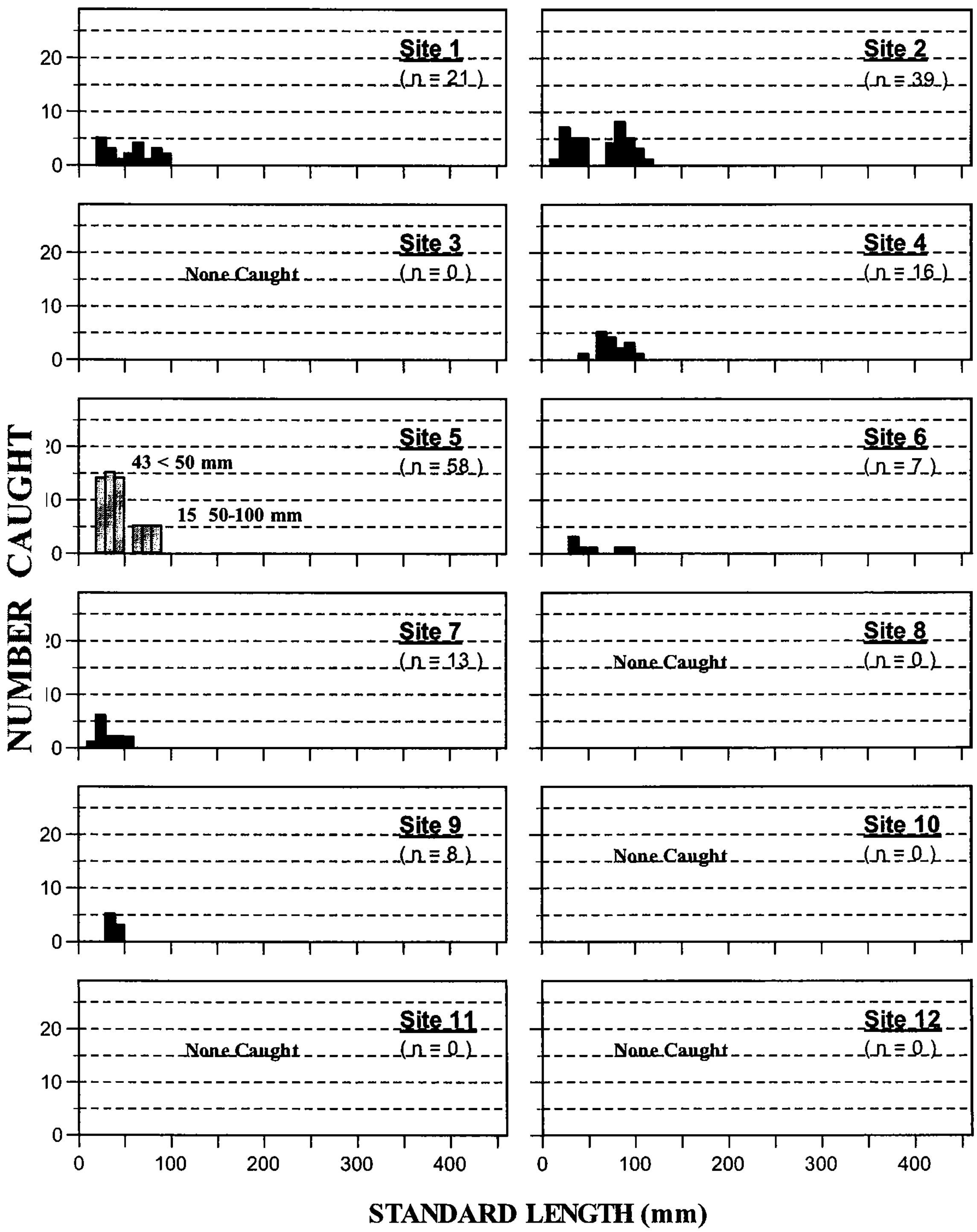


Figure B-12. Green Sunfish - Length frequencies and specimens caught at the various sampling sites.

Bluegill

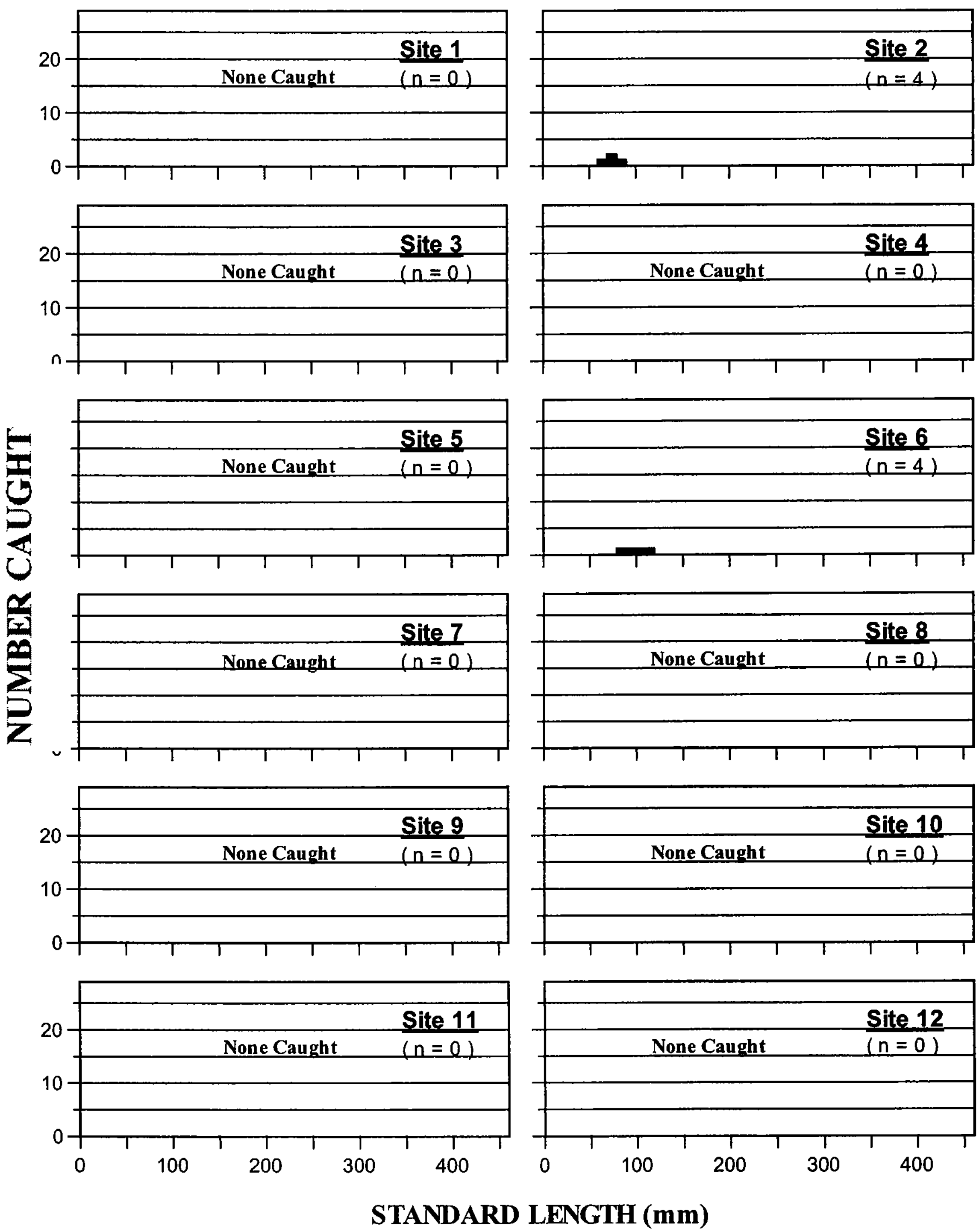


Figure B-13. Bluegill - Length frequencies and specimens caught at the various sampling sites.

Pit Sculpin

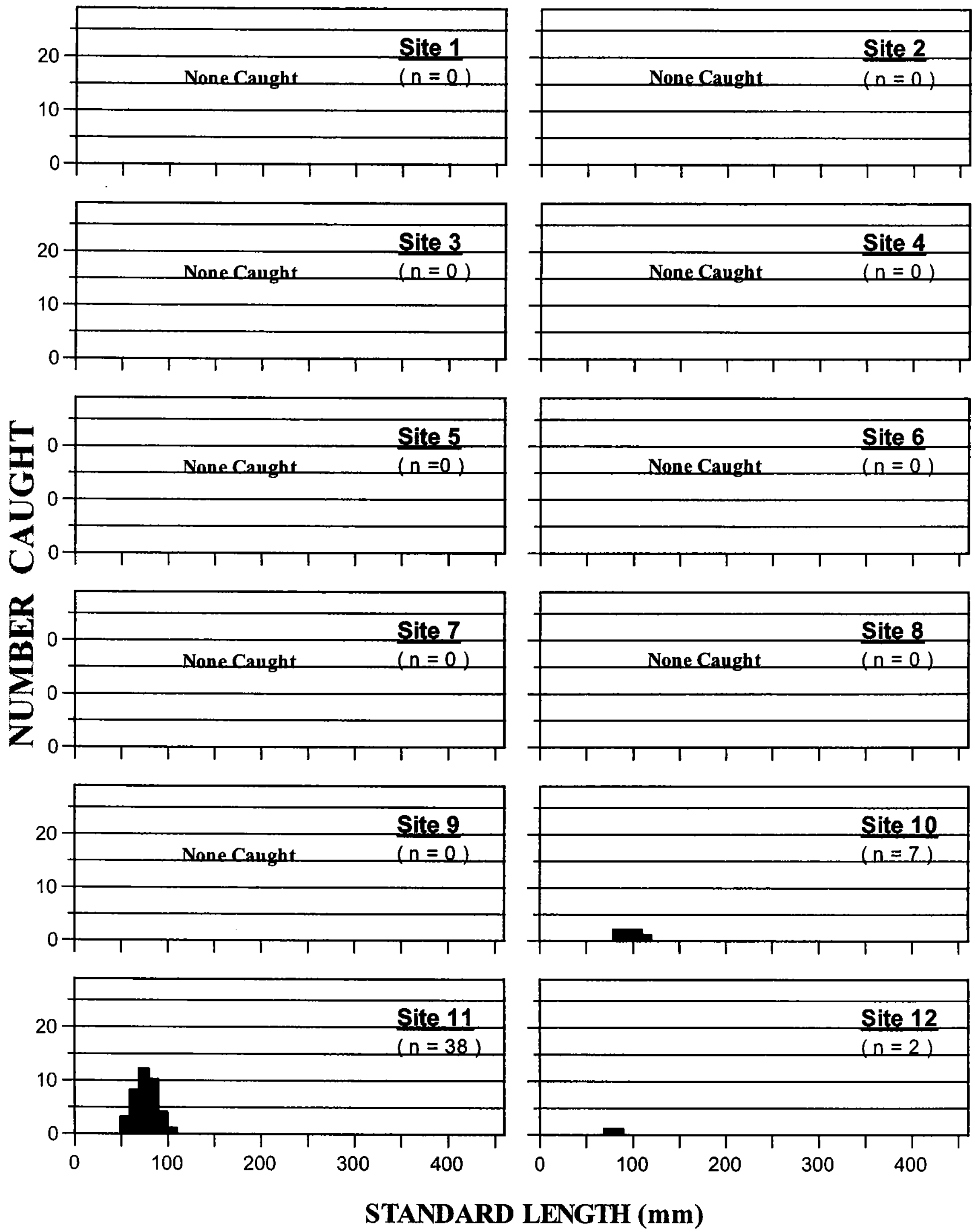


Figure B-14. Pit Sculpin - Length frequencies and specimens caught at the various sampling sites.

Section 10

Section 10
CULTURAL RESOURCES

TABLES

FIGURES

Section 10

CULTURAL RESOURCES

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Wendy Johnston *VESTRA Resources, Inc.*

With contributions from:
Carol Golsh *VESTRA Resources, Inc.*

Much of the historic culture of the early inhabitant on the watershed has been addressed previously in other sections of this report. Historic Native American resource management techniques and general history will not be repeated. As such, this section will focus on current cultural issues and relationships between Native American tribal interests and modern resources use decision. The goal of the section is to provide an introduction to the legal standing of the tribal governments and the precedent for their modern involvement in resource management decisions. Federal law mandates the active participation of tribal governments in resource and land use planning. The tribes are not simply "special interest groups" they are part of the legal government recognized by the United States of America. As such they must be considered separately from the general population under a wide variety of legal mandates addressing environmental analysis, religious freedom, archeological sites and protection of Native American human remains. Because the federally recognized tribes have government-to-government relationships with the United States, the relationship is generally poorly understood by the public. The section will present a brief description of tribes likely involved in the watershed and will attempt to present the basis for development of Indian policy and rights that may affect resource management decisions in the watershed.

An important non-legal consideration is that the Native American people, in many cases, retain a spiritual connection to their ancestral lands, whether or not they are current inhabitants, that derives from traditional culture and teaching about the use of the land and management of nature (Reynolds, 1996).

SOURCES OF DATA

Cultural Resource data on tribal information and organization was not readily available. Rancherias were contacted, but were unable to provide other digital or non-digital data on boundaries, plans, and related resources. In addition, much of the information concerning the archeological resources is confidential and site locations cannot be revealed. There is also significant concern that the identification of specific sites in the assessment will encourage site disruption. Individuals from the USFS, BLM, CDF, State Office of Historic Preservation, EPA, the Pit River Tribe, and the National Park Service were contacted to assist in contributing to issues relevant to the cultural resources of the watershed. Specific contact information is available in the contacts portion of this section. The best available summary of information, and a primary reference for the section development, is Chapter 10 from the Sierra Nevada Ecosystem project prepared by Linda A Reynolds. Ms. Reynolds work makes up a large portion of the section herein entitled Definition and Policies Affecting Tribal Lands. Please see reference list for full references to the section.

TRIBAL AREAS

Ajumawi (Pit River) and Atsugewi

The territory of the Ajumawi comprised the drainage of the Pit River. The Ajumawi were generally a river or stream dependant culture. Most villages were located on the Pit River itself or on its tributaries. The upland areas of their territory were likely used and visited in the summer, but not settled year around. A detailed summary of historical culture is included in Section 2, "General Watershed History." There are eleven recognized bands of the Pit River Tribe. Aboriginal territories of eight bands are found within the Upper Pit River Watershed. These include

- Atsugewi (along Burney Creek)
- Aporige (east of the Atsugewi to Eagle Lake)
- Ajumawi (near Saddle Mountain)
- Atwamsini (in lower Hot Springs Valley)
- Astarawi (in upper Hot Springs Valley)
- Hewise (in the northeast corner)
- Kosealekte (along the North Fork of the Pit River)
- Hammawi (on the South Fork of Pit River)

The aboriginal boundaries of the Ajumawi and Atsugewi are shown on Figure 10-1.

Today there are approximately 1,500 Ajumawi tribal members living in the watershed (Four Directions Institute, 2003). A large number live on tribal lands within the Upper Pit River Watershed including: The Alturas Rancheria in Alturas; Big Bend Rancheria in Big Bend; Lookout Rancheria in Lookout; Montgomery Creek and Roaring Creek Rancherias in Montgomery Creek; and the XL Ranch Reservation in Alturas. Additional tribal members are located on the Round Valley Reservation in Covelo and Susanville Rancheria in Susanville outside the watershed study area.

The Atsugewi were a small closely related sub-group of the Ajumawi. They are reported to have lived to the south of the Ajumawi territory along three medium-sized streams, draining northward into the Pit River. The Atsugewi band lived along the banks of Burney and Hat Creeks to the west and the Aporige band resided in Dixie Valley and along Horse Creek. The current population of Atsugewi Indians is estimated at approximately 50 (Four Directions Institute, 2003). Today no Atsugewi people are listed as living in the Upper Pit River Watershed, but can be found in two locations outside the watershed near Lassen Volcanic National Park in Mineral and Susanville Rancheria in Susanville.

Modoc

The Modoc Indians inhabited a large territory north of the Ajumawi. They lived near Little Klamath Lake, Modoc Lake, Tule Lake, Clear Lake, Goose Lake, and in the Lost River Valley. The boundary between the Modocs and the Ajumawi territories was ill defined. The watershed's most northeastern section would have been considered Modoc territory. Prior to the Modoc War, discussed later in this section, there were 22 known villages in the territory. At the conclusion of the war, 155 Modocs were moved to the Quapaw Agency in Oklahoma as prisoners of war.

Northern Paiute

The northeastern most corner of California was inhabited by a Shoshonean people commonly known as the Paiute. It is not known if the historic territory of the Northern Paiute truly extended into the Upper Pit River Watershed. The Northern Paiute were commonly found in the area of Surprise Valley and the Upper, Middle, and Lower Alkali Lakes, but just as the boundaries of the Modoc and Ajumawi are non-distinct so is the western boundary of the Northern Paiute. The generalized western boundary is defined as the crest of the Warner Mountains through Fandango Valley, but their land may have extended into the eastern portion of the watershed. The current estimated population of Northern Paiute in California is 3,500 (Four Directions Institute, 2003). Most of the current population resides in Fort Bidwell and Cedarville Rancheria in Cedarville and the Susanville Rancheria in Susanville.

Current Rancherias

Tribal Land ownership is summarized on Figure 10-2. Current Rancherias and related tribal lands within the Upper Pit River Watershed are summarized in Table 10-1.

DEFINITIONS AND POLICIES AFFECTING TRIBAL LANDS

As stated previously, this summary was extracted from the Sierra Nevada Ecosystem Project Report. This work by Reynolds was found to be the best available summary of key elements relating to Native American land use policy.

Definitions

Allotments

Allotments are holdings of individuals or families outside a reservation; some in trust, some in fee simple. These are scattered throughout the study area. Within reservations, the tribal government makes assignments of tribal land, as opposed to allotments, to individuals and/or families. The land so assigned remains tribal trust land.

California Indians

The term *California Indians* refers to indigenous peoples in the land now known as California. Today they continue to maintain their separate cultural identities while participating in the social and economic activities of non-Indian communities. The Indian Claims Commission defined the "Indians of California" to whom Congress has a fiduciary duty as all Indians who were residing in the State of California on June 1, 1852, and their descendants now living, as set forth by the Act of May 18, 1928…This identifiable group includes the descendants of members of what have sometimes been loosely described as tribes, bands, rancherias, and villages of Indians of California, and other individual Indians, who resided in California at the time of the promulgation of the Treaty of Guadalupe Hidalgo in 1848. Members of the group who were born prior to May 18, 1928, were enrolled as Indians of California by direction of the Act of Congress approved May 18, 1928. Members of the group who were born subsequent to May 18, 1928, are to be enrolled by direction of the Act of Congress approved June 30, 1948.

Table 10-1
RANHERIAS AND RELATED TRIBAL LANDS WITHIN THE UPPER PIT RIVER WATERSHED

Tribe	Tribal Affiliation	Reservation	Land Base	Tribal Office	Remarks
Within watershed area:					
Pit River Tribe of California	Pit River	Likely Rancheria	1.32 Acres Cemetery	None	See Pit River Tribe of California, Shasta County.
Pit River Tribe of California	Pit River – Ajumawi-Atsugewi	Lookout Rancheria	40 Acres	None	See Pit River Tribe of California, Shasta County.
Alturas Rancheria of Pit River Indians	Pit River-Ajumawi – Atsugewi	Alturas Indian Rancheria	20 Acres	P.O. Box 340, Alturas, CA 96101	Rancheria established by act of June 21, 1906, appropriating funds for purchase of lands for California Indians. Rancheria purchased by provisions of act of January 24, 1923 (*43 Stat*. L 1188); purchase date: September 8, 1924.
Adjoining or likely to have interest in watershed area:					
Cedarville Rancheria of Northern Paiute Indians	Northern Paiute	Cedarville Rancheria	20 Acres	200 S. Howard St., Alturas, CA 96101	Rancheria established under the authority of acts of June 21, 1906, and later, appropriating funds for purchase of lands for California Indians. Purchased October 19, 1915.
Susanville Indian Rancheria	Paiute-Maidu-Pit River-Ajumawi-Atsugewi-Washoe	Susanville Indian Rancheria	150.53 Acres	P.O. Drawer U, Susanville, CA 96130	Original rancheria purchased August 15, 1923, for homeless California Indians, deed in the name of United States of America. Public Law 95-459 approved October 14, 1978, provided for the United States of America to hold 120 acres in trust for the rancheria.
Fort Bidwell Indian Community of Paiute Indians	Paiute	Fort Bidwell Reservation	3,334.97 Acres	P.O. Box 129, Fort Bidwell, CA 96112	A joint resolution of January 30, 1879, authorized the secretary of the interior to use the abandoned Fort Bidwell Military Reserve for an Indian Training School. An act of January 27, 1913, granted land to the People's Church for a cemetery and right-of-way over the Fort Bidwell Indian School Reservation, the Indians to have right of internment therein (*37 Stat*. 652, c. 15). Executive Order 2679 of August 3, 1917, enlarged the reservation.
Pit River Tribe of California	Eleven Autonomous Bands-Ajumawi, Porige, Astarawi, Atsugewi, Atwamsini, Hammawi, Hewisedawi, Ilmawi, Itsatwi, Kosalektawi, Madesi	Ajumawi-Atsugewi Nation	9,567.18 Acres	37014 Main St., Burney, CA 96013	The Pit River Nation comprises eleven autonomous bands. Band members elect each band head. The chairperson and vice-chairperson are chosen through a general election.
Pit River Tribe of California	Pit River-Ajumawi-Atsugewi-Wintun	Big Bend Rancheria	40 Acres	None	See Pit River Tribe of California, earlier.
Pit River Tribe of California	Madesi Band of Pit River Indians	Montgomery Creek Rancheria	72 Acres	None	See Pit River Tribe of California, earlier.
Redding Rancheria	Wintun-Pit River-Yana	Redding Rancheria	30.89 acres	2000 Rancheria Road, Redding, CA 96001-5528	Federal recognition restored on December 15, 1985, as a result of class action suite *Tille Hardwich versus United States of America*.
Pit River Tribe of California	Pit River-Ajumawi-Atsugewi	Roaring Creek Rancheria	Unknown	None	See Pit River Tribe of California, Shasta County.

Notes: The previous information is taken from Bureau of Indian Affairs *1990 Field Directory* and *1993 Tribal Directory*.

Federal Recognition
A tribe is federally recognized if "(1) Congress or the executive created a reservation for the group whether by treaty (1871), by statutorily expressed agreement or by executive order or other valid administrative action and (2) the United Sates has some continuing political relationship with the group, such as providing services through the BIA [Bureau of Indian Affairs]" (AIRI 1988).

Indian
An Indian is a person with some amount of Indian blood who is recognized as an Indian by the person's tribe or community…While membership in a federally recognized tribe is the general criteria used by the BIA for participation in most federal programs, a blood standard also is used alternatively for eligibility for some programs. In recent years Congress has not allowed the BIA to rely solely on a blood standard for federal program eligibility (AIRI, 1988).

Indian Country
The Indian Country Statute of 1948 (18 U.S. Code sec. 1151) defines Indian Country as "all land within the limits of any Indian reservation under the jurisdiction of the United States Government…all dependent Indian communities within the borders of the United States…all Indian allotments, the Indian titles to which have not been extinguished."

Indian Reservation
Federal reservations exist for several purposes. An Indian reservation is that land over which a tribe is recognized by the United States as having governmental jurisdiction (25 Code of Federal Regulations part 151). Some reservations in California have also been call *rancherias* or colonies.

Reserved Rights
"Tribal rights, including rights to land and to self-government, are not granted to the tribe by the United States. Rather, under the reserved rights doctrine (*United States versus Winans, 1905*), tribes retained ("reserved") such rights as part of their status as prior and continuing sovereigns" (AIRI, 1988). Reserved rights are those that were not specifically extinguished by treaty or lands claim cases. In addition to land and self-government, these include hunting and fishing rights, the right to gather traditional materials, and water rights. These are many unanswered questions about reserved rights, and they are a source of conflict in many areas between states and tribes and between tribes and local communities (AIRI, 1988).

Restoration
Tribes once federally recognized were terminated from federal recognition during the termination era. Such tribes may seek to be "restored" to their former status. One other use of the term *restoration* is as the alternative preferred by many Indian people to the term *land acquisition*. In that context herein, the phrase used is *land acquisition/restoration*.

Sovereignty
The special status of Indian tribal governments was defined by a series of United States Supreme Court decisions of the 1830s referred to as the "Marshall Trilogy" after their author, Chief Justice John Marshall. Key elements identified tribes as (1) independent nations and (2) wards or guardians of the United States.

Tribal sovereignty is the third source of sovereignty in the United States, the other two being federal and state. Indian tribes, regardless of size, are internally sovereign; external relationships with other countries are reserved to the federal government. Each tribe has a government-to-government relationship with the United States, including all agencies and bureaus, as will be discussed in the "Contemporary Federal Policy" section.

Powers that are not limited by federal law or treaty remain with tribes. These include the power to establish a form of government and to determine membership, some police powers, and the power to administer justice, to exclude persons from the reservation, to charter business reorganizations, and to exercise sovereign immunity. In general, state law and local law do not apply in Indian country without congressional consent. The degree to which federal statutes apply in Indian Country has been adjudicated in federal courts on a case-by-case basis.

Environmental laws, such as the National Environmental Protection Act (NEPA), apply in only some situations. These include any so-called federal action, such as the transference of other federal or private land to tribal trust, or the use of Housing and Urban Development monies for construction. Environmental laws also apply on tribal land that is held in fee simple. For example, the Big Pine Tribe of Owens Valley acquired private land from the Los Angeles Department of Water and Power. Construction of an industrial park on the land required compliance with NEPA and other federal laws because the tribe, not held in trust for the tribe by the federal government, owned that land.

Tribe

The term *tribe* has several meanings, depending upon the context. The legal meaning is discussed here. Historically, the federal government has determined that it will recognize particular groups of Indians as Indian tribes pursuant to its authority under the Indian Commerce Clause of the United States Constitution. Thus reservations variously have been set aside for ethnologically defined tribes, for bands or other subgroups of tribes, and for confederations of several tribes or bands. All are considered as tribes for legal purposes…Indian groups not recognized under federal law may seek recognition through litigation, through the administrative procedures established by the BIA, or through congressional statute (AIRI, 1988).

This is codified in Code of Federal Regulations, Title 25, part 150, where *tribe* is defined as a tribe, band, nation, community, rancheria, colony, pueblo, or other federally recognized group of Indians. "Tribal membership requirements can be established by usage, written law, treaty, or international agreement. Today, membership typically is defined by a tribal constitution, tribal law, or a tribal roll; varying degrees of blood quantum are required by different tribes" (AIRI, 1988).

Trust

As stated earlier, the trust relationship derives from the concept of tribal sovereignty. Congress has broadly construed authority over Indian tribes based on the Indian Commerce Clause of the Constitution. The executive branch has much more narrowly construed power in its relationship with Indian tribes, but, as with Congress, it has a fiduciary, that is, trustee role. Beneficiaries of the trust relationship include tribes and individual Indians.

Perhaps the most important aspect of the trust relationship is the protection of Indian landownership. The Trade and Intercourse Acts prohibited the sale of Indian land without federal consent. Indians, although not citizens at that time, held land and other property as trust beneficiaries of the United States. This arrangement, in theory at least, protected Indian landownership and allowed the federal government rather than the states to control the opening of

Indian lands for non-Indian settlement. The trust relationship, therefore, enhanced federal power, but it also created federal duties relating to Indian lands and other natural resources (AIRI, 1988).

The trust relationship also includes legal representation: 25 U.S. Code states, "In all states and territories where there are reservations or allotted Indians, the United States Attorney shall represent them in all suites at law and in equity."

Finally, we need to acknowledge that the trust relationship has been defined over time through federal court decisions, congressional actions, and executive orders

> The trust relationship has proved to be dynamic and ongoing, evolving over time. One question that constantly arises is whether the trust relationship is permanent. Is it a perpetual relationship, or is it one that can or ought to be "terminated?" Is the purpose to protect Indian landownership and self-governing status? Or is it to give the federal government power to assimilate Indians into the larger society, to rehabilitate them as "conquered subjects" or to "civilize" them?
>
> Different eras have provided different answers to these questions. At the turn of the century the trust relationship was seen as short term and transitory. Indian land was to be protected for a brief transition period while Indians were assimilated into the "mainstream." The trust relationship was seen as the basis for congressional power to pass legislation breaking up tribal landholdings into individual allotments.
>
> More recently, the view has broadened. The trust relationship now is seen as a doctrine that helps support progressive federal legislation enacted for the benefit of Indians, such as the modern laws dealing with child welfare, Indian religion, and tribal economic development. The trust also controls contemporary interpretations of time-honored treaties and statutes. The once transitory trust relationship apparently has developed into a permanent doctrine that will serve as a benevolent influence in the future of Indian law. (Geary, 1994)

Manifest Destiny

With the signing of the Treaty of Guadalupe Hidalgo on July 4, 1848, Mexico ceded the territory occupied by the United States during the Mexican-American War. In return, the United States guaranteed protection of the property rights and civil liberties of former Mexican citizens, including native peoples. In California this commitment was jeopardized that same year with the discovery of gold and was abrogated the following year when delegates to the California constitutional convention voted to deny citizenship to California Indians.

The difficulty of dealing with the inevitable conflicts between the gold seekers and Indian people led to protracted debate in Congress. After California was admitted to the Union on September 9, 1850, Congress authorized President Fillmore to make treaties with Native Californians; three Indian agents were named and sent to California in 1851. Between 1851 and 1852, eighteen treaties were drawn up with 138 tribes, designating land to be ceded and reservations to be established. Under urging from the California delegation, however, none of these treaties was ever ratified, and in 1852 Congress took the extraordinary measure of sealing them until 1906 (Heizer, 1978b; Stewart, 1978).

The Indians of California

California is thus in the unique position of being a non-treaty state; federal recognition has been gained through other actions. In the 1850s, groups of Indian people were gathered onto seven former military reservations to protect them from violence by non-Indians (Heizer, 1978b). Beginning in 1864, reservations were established for dispossessed Native Californians by executive order. Ultimately, 117 communities were established by the federal government on lands set aside from the public domain or purchased for the "homeless Indians of California." The tribes who have been federally recognized by executive order have all the rights that treaty tribes have, including sovereignty and a trust relationship with the United States. Unfortunately, other tribes remain unacknowledged.

The historical circumstances in California have created a situation today in which several groups may be included in one tribe and several tribes may be located on one reservation. An individual tribe may also have several reservations intermingled with other land. In some tribes, tribal members may retain their tribal affiliation and participate in tribal affairs but reside off the reservation. Tribes and their members may also retain an interest in their aboriginal territories even if they no longer reside in the area.

California Indians have been treated as one group by the federal government since the Treaty of Guadalupe Hidalgo. In 1850, Congress passed the California Indians Act. This act was followed by a series of statutes and actions designed to provide homes, education, and other services for the "Indians of California," regardless whether the groups that benefited were federally recognized tribal governments.

In 1928, the California Indians Jurisdictional Act was passed, enabling California Indians with notice of the act to sue the federal government for the uncompensated taking of land. California Indian land claims were settled in 1950 at the 1850 price of 47 cents per acre. This rate was raised in 1968 to $1.50 per acre. Where the money was taken, land claims were extinguished; however, it is not widely recognized that the settlement was for land, not resources, so the issue of reserved rights may still be open. For those tribes and individuals who did not settle, there are still outstanding claims and questions of aboriginal rights.

The Indian Reorganization Act of 1934

The Indian Reorganization Act was passed in response to the influential Merriam Report of 1928, which detailed the terrible living conditions on many reservations. One major facet was to end the parceling out of tribal lands as allotments and extend the trust period of existing allotments. Another thrust was promotion of tribal self-government. Not all tribes accepted the act, but many did and formed constitutions and corporations under its provisions (AIRI, 1988).

Termination

After World War II, the federal government embarked on a policy of "mainstreaming" reservation Indians, as embodied in the Termination Act of 1953. Termination in this sense is the revocation of federal recognition. In California, this policy was implemented through the California Rancheria of 1958, which resulted in the termination of 41 tribes statewide. Within ten years, 60 percent of the land processed for termination went to non-Indians. Another result of termination was the relocation movement, under which terminated people from all over the United States were relocated to urban areas, placing an additional burden on state services.

Several tribes sued individually for restoration of federal recognition in the 1970s, and then a class action suite, *Tille Hardwick versus United States* (1978), was filed on behalf of all terminated tribes who wished to participate. Seventeen tribes, including six in the Sierra Nevada Ecosystem Project study area, were restored to federal recognition under this lawsuit and are consequently known as *Tille Hardwick* tribes. Tribes that were dismissed from the lawsuit may still file their own suits to regain federal recognition (AIRI, 1988).

Environmental Justice
The concept of Environmental Justice is associated with the misuse of Native American lands and other minority communities for landfills, waste sites or related urban growth problems difficult to site on other public lands. There does not appear to be any significant toxic problems on Rancheria Lands area. An important concern is protection of watersheds of all the tribes, including underground water for those reservations with no surface water. Without protection, reservation growth and development would be affected in the future.

Gaming
In a 1987 decision, the U.S. Supreme Court ruled that the tribe, not the state, has authority over gaming on reservations. The Indian Gaming Regulatory Act of 1989 created three classes of reservation gaming with varied jurisdiction

> *Class 1*: Traditional gaming, such as hand game, which is the exclusive jurisdiction of the tribe
>
> *Class 2*: Bingo and some other games, which are jointly regulated by the tribe and the federal government
>
> *Class 3*: High-stakes gambling, which requires a tribal compact with the state

At present, there is a case before the Supreme Court on the issue of whether the state is obligated to enter into a gaming compact when requested to by a tribe. In the Pit River study area there is one tribal government that has applied for Class 3 compacts: Alturas Rancheria. Other governments have applied for Class 2 gaming. Native American gaming is controversial, and the positive or negative impacts to the communities where it occurs are often contested.

Federal Agency Policy Summary

On April 29, 1994, President Clinton issued an executive order to the heads of departments and agencies outlining the principles involved in working with federally recognized tribes as sovereign tribal governments. He emphasized that each executive department and agency, "including every component bureau and office," is responsible for developing a government-to-government relationship with federally recognized tribes, consulting with tribes on the effects of federal actions on the tribe and tribal trust resources, removing obstacles to developing a working government-to-government relationship, and developing methods to deal with specific tribal issues and needs. In California, the federal agencies formed an Interagency Indian Policy Group with representation from the U.S. Forest Service (USFS), the Bureau of Land Management (BLM), and the National Park Service (NPS).

The United States Forest Service

The laws that affect the management of National Forest System lands and the rights and programs affecting American Indians are still evolving. The challenge facing the USFS is to reconcile many requirements of law so that National Forest System lands can be administered in a way that meets public needs while recognizing the rights of Native American tribes.

The *Forest Service Manual* Section 1563 (1994) describes the relationship between tribal governments and communities. The USFS is to:

1. Maintain a government-to-government relationship with Federally recognized Tribes.

2. Ensure that Forest Service employees are familiar with the rights and interests of Tribes as defined by the Constitution, treaties, statutes, Executive orders, and judicial rulings, through training and other efforts.

3. Implement Forest Service programs and activities consistent with and respecting Indian treaty rights and fulfilling the Federal government's legally mandated trust responsibility with Tribes.

4. Manage Forest Service administered lands and resources on which tribal treaty rights exist in coordination with Tribes.

5. Coordinate Forest Service land and resource management plans and actions with tribal land and resource management plans and actions to promote the health of ecosystems.

6. Administer programs and activities in a manner that is sensitive to traditional American Indian and Alaska Native spiritual beliefs and practices and assist tribal members in securing ceremonial and medicinal plants, animals, and the use of specific geographic places, consistent with Federal policy under AIRFA and E.O. 13007 (FSM 1563.01e).

7. Protect the confidentiality of tribal information (including information regarding repatriation and reburials) received by Tribes to the extent practicable under the law.

8. Assist American Indian and Alaska Native Tribal Governments by providing technical, educational, financial, and other information, and establish information exchanges where mutually agreed to and authorized by law.

9. Work to reduce or remove legal or administrative program impediments that inhibit the agency's and Tribes' capacity to work directly and effectively with each other.

10. Consult with Tribes on matters that may affect tribal rights and interests, utilizing the following principles:

    a. Comply with laws and regulations in a manner consistent with the special and unique legal and political relationship with Tribes. Government-to-government consultation generally involves more than the rights of tribal officials, as members of the general public, to comment on proposed policies or actions under other Federal laws of general applicability.

b. Collaboratively involve Tribes, as early as possible, in the development of regulatory and management policies, resource and land management plans, study plans and actions that may have tribal implications. Work with Tribes to determine whether a proposed Forest Service policy or action has implications for their rights or interests that may warrant consultation and where consultation is necessary work with Tribes to establish an effective consultation process.

c. Respond in a timely manner to all requests for consultation by Tribes and maintain confidentiality of information to the extent authorized by law as may be implemented through Executive order.

d. Coordinate with other Federal and State agencies and local governments during consultation with Tribes.

11. Ensure that the repatriation of Native American human remains and associated funerary objects, unassociated funerary objects, sacred objects, and objects of cultural patrimony are consistent with the requirements of the Native American Graves Protection and Repatriation Act (FSM 1563.01e, para. 4).

12. Support reburial of American Indian and Alaska Native human remains and funerary objects on Forest Service administered lands. Consider reburial requests for specific locations and provide explanation for requests that are denied.

Following the president's executive order, many of the national forests have developed forest-specific handbooks. The Modoc, Lassen, and Shasta National Forests have sections in their respective Land and Resource Management Plans to address the Native American populations of the area. As part of the USFS normal compliance procedures, and in accordance with the American Indian Religious Freedom Act, the Native American Heritage Council, and local Native American groups are consulted on most large-scale projects.

The Bureau of Land Management

The BLM is similar to the USFS in that both are multiple-use land-management agencies responsible for the management of millions of acres of formerly tribal land. Both have many opportunities to work with Indian people and tribes as partners. The BLM has established a National Native American Program Office in Santa Fe, NM. While each Region is developing policies that meet particular needs, the office in Santa Fe has recently issued national guidelines for working with tribes. It is the policy of the BLM to (BLM Manual, 1994)

- Recognize traditional Native American Cultural and religious values as an important, living part of our Nation's heritage, and develop the capability to address adequately any potential disruption of the traditional expression or maintenance of these values that might result from BLM land use decisions.

- Coordinate and consult regularly with appropriate Native American groups to identify and consider their concerns in BLM land use planning and decision making, and document fully all coordination and consultation efforts.

- Review proposed land use planning decisions and other major BLM decisions for consistency with tribal land use and resource allocation plans.

- Participate in developing consistent interagency guidance, procedures, and expertise to address Native American and tribal government policies and programs.

- Avoid unnecessary interference with Native American religious practices.

- Protect sensitive and confidential information about Native American values, practices, and specific locations with which they are associated from disclosure to the public, to the greatest degree possible under law and regulation.

The reasons for Native American consultation is to identify the cultural values, the religious beliefs, the traditional practices, and the legal rights of Native American people, which could be affected by BLM actions on Federal lands. Another important difference is that the BLM has identified "surplus lands" available for transfer to recognized tribes through the BIA. Transference may be accomplished by administrative action of the Secretary of the Interior or through legislation.

The National Park Service

The Department of the Interior (DOI) administers the NPS. It is the policy of the DOI to recognize and fulfill its legal obligations to identify, protect, and conserve the trust resources of federally recognized Native American tribes and tribal members, and to consult with tribes on a government-to-government basis whenever plans or actions affect tribal trust resources, trust assets, or tribal health and safety. It is the responsibility of the NPS to (Dept. of the Interior Manual, 1995)

- Establish procedures to ensure that the activities of DOI organizations impacting upon Indian trust resources are explicitly addressed in planning, decision, and operational documents.

- Ensure the bureaus and offices consult with the recognized tribal government whose trust resource, asset, or health and safety is potentially affected by the proposed action, plan, or activity.

- Remove procedural impediments to working directly and effectively with tribal governments.

- Provide drafts of all procedures or amendments to procedures developed pursuant to this Chapter to the Office of American Indian Trust for review and comment.

- Designate a senior staff member to serve as liaison between the bureau or office and the Office of American Indian Trust.

The Office of American Indian Trust is a department of the NPS with the responsibility of improving relations between tribal members and the NPS through consultation, outreach, technical assistance, education, and advisory services.

CULTURAL RESOURCE REGULATIONS

Many laws and regulations govern the manner in which historical, archaeological, and sites of cultural significance on both public and private lands are managed on the federal, state, and county level. This section presents the laws most relevant to the watershed and potential resource projects. This is not an all-inclusive list and the reader is cautioned to not use the following as legal or regulatory advice.

Federal

- American Antiquities Act of 1906, as amended (16 USC 431-433)
- American Battlefield Protection Act of 1996 (16 USC 469k)
- American Indian Religious Freedom Act of 1978, as amended (42 USC 1996 and 1996a)
- Archaeological and Historic Preservation Act of 1974, as amended (16 USC 469-469c-2)
- Archaeological Resources Protection Act of 1979, as amended (16 USC 470aa-mm)
- Bald Eagle Protection Act of 1940 (16 USC 668-668d)
- Department of Transportation Act, as amended (49 USC 303)
- Disposal of Records (44 USC 3301 et seq.)
- Endangered Species Act of 1973, as amended (16 USC 1531-1543)
- Federal Property and Administrative Services Act of 1949, as amended (40 USC 484(k)(3) and (4))
- Federal Records Act of 1950, as amended (Records Management by Federal Agencies, 44 USC 3101 et seq.)
- Freedom of Information Act of 1982 (5 USC 552)
- National Trust for Historic Preservation, as amended (16 USC 468)
- Native American Graves Protection and Repatriation Act of 1990, as amended (43 USC 10 et seq.)
- Preservation, Arrangement, Duplication, Exhibition of Records (44 USC 2109)
- Reservoir Salvage Act of 1960, as amended (16 USC 469-469c)
- National Historic Landmarks Program (36 CFR 65)

- National Historic Preservation Act (36 CFR 800), known as "Section 106"
- National Register of Historic Places (36 CFR 60)
- Preservation of American Antiquities (43 CFR 3)
- Procedures for State, Tribal, and Local Government Historic Preservation Programs (36 CFR 61)
- Protection of Archaeological Resources (43 CFR 7)
- Cultural Resource Management Guideline, NPS-28
- Executive Order No. 13007 Indian Sacred Sites (1996)

State of California

Public Resources Code

- 5020. – 5020.7 State Historical Resources and Commission
- 5021. – 5022.6 Registration of State Landmarks and Points of Interest
- 5023. Landmark and Point of Interest; duty to maintain
- 5024.– 5024.6 State Owned Historic Resources and the Office of Historic Preservation
- 5025.11-5025.12 State Historic Resources Commission
- 5026. -5029. Nomination, Transfer, Demolition, and Designation of State Historical Resources
- 5031. – 5033. Qualified Historical Property
- 5079. – 5079.65 Heritage Fund
- 5097. – 5097.6 Archeological Sites
- 5097.9 – 5097.991 Native American Heritage
- 21083.2 – 21084.1 CEQA

Government Code

- 6254. – 6254.10 Public Records
- 15399. – 15399.8 California Main Street Program
- 25373. & 27288.2 Local Government
- 37361. – 37361.1 City Property

- 50280. – 50290.0 Mills Act: historical Property Contracts
- 65303. Authority for Preservation in General Plans

Health and Human Safety Code
- 7050.5 Removal of Human Remains
- 17922.2 Hazardous Buildings
- 18950 – 18961 State Historic Building Code
- 37600. – 37662. Marks Act: Historic Rehabilitation

Civil Code
- 815. – 816. Easements

Revenue and Taxation Code
- 439. – 439.4 Historic Property Restriction

Penal Code
- 6221. – 6222. Destruction or Defacement of Historic Property

California Code of Regulations
- Title 14, Chapter 11.5, Section 4850. – 4858. California Registration of Historical Resources
- Title 14, Chapter 3, Section 15064.5 – 15331. CEQA Guidelines
- Title 24, Part 8 State Historic Building Code Regulations

ARCHAEOLOGICAL RESOURCES

Archaeology is the study of man's past. Around the world, this study is usually divided into either prehistoric archaeology or historic archaeology, depending upon the time period involved. In California, historic archaeology generally begins in 1542, and therefore incorporates only the last four or five hundred years. Prehistoric archaeology incorporates everything earlier, and extends backwards in time for at least 12,000 years, believed to be the time of earliest human arrival within what is now California (McGuire and Saechter, 2001).

Archaeological science, discussion, and writing relates either to ***archaeological evidence*** or to ***archaeological interpretation***. Archaeological evidence is the physical remains of past activities, while archaeological interpretation is the explanation of such physical evidence in the attempt of reconstructing past life ways.

Unlike standing timber, an acre of pastureland, or a head of cattle, it is difficult to put a dollar value on an archaeological site. It is equally hard to assess the value of other cultural intangibles such as art, music, but these are the things that enrich our lives in modern society. The understanding of our past is one of those priceless things. Archaeological sites contain the irreplaceable evidence to reconstruct the past. Without archaeological sites, it would be difficult or impossible to develop the long and diverse archaeological record that helps write California pre-history.

California's archaeological record is unique, varied, and as old as anywhere else in North America. Hundreds of different prehistoric cultures have been found within our state through archaeological methods. Many of the archaeological records are the fragile traces left behind by these earlier peoples and require steps to protect and preserve their information

The Upper Pit River Watershed is rich in archaeological resources. Native Americans, either called the watershed home or traveled through the area for trade and hunting. The Devil's Garden and Crooks Canyon have some of the most extensive archaeological sites in the watershed. Archaeological investigations done by the Far Western Anthropological Research Group have determined at least a 12,000-year span of human occupation in the region (McGuire and Saechter, 2001).

Human settlements, recognized now as surface scatters of stone tools and chipping debris, tended to be concentrated along the shores of current and historic streams, lakes, and marshes. The high frequency of spear and dart points in the region, have lead archaeologists to believe the people of the Early Holocene (10,000-5,000 B. C.) relied mostly on hunting. Stone tools found at these sites are often fashioned from obsidian obtained from a wide range of source locations (Howe, 2002). Throughout the watershed, small hunting camps dating back to the Early Archaic (5,000-1,500 B.C.) often contain a distinctive dart point type known as Northern Side-notched. These dart points are one of the most common items found in archaeological sites in the watershed and throughout California. Within the Upper Pit River Watershed, obsidian was generally the preferred material for the manufacture of stone tools (McGuire and Saechter, 2001). At Crook's Canyon alone, obsidian from 22 different source locations in Oregon, Nevada, and northeastern California have been identified in archaeological collections. A timeline showing arrowhead development is shown in Figure 10-3.

By the Late Archaic (A.D.700–1350), archaeological evidence suggests the elaborate villages and residential sites characteristic of the Middle Archaic (1,500 B.C.–A.D. 700) were mostly abandoned. Climate change, increasing population, or scarcity of resources may have been some of the reasons native peoples' diet base changed from hunting to gathering. Evidence of this can be found in a profusion of millstones and plant processing tools found at sites on the valley floor.

Artifacts other than spear points are found throughout the watershed in the form of animal bone and tooth fragments (McGuire and Saechter, 2001). Thousands of individual animal bones and tooth fragments have been recovered from housing structures and campsites. Most of these bones are the discarded remains of food items such as mule deer, jackrabbits, and bobcats. Several fragments of cow and sheep bone attest to the rising importance of introduced Euro-American animal foods. Animal bone was often used to fashion a variety of tools and ornaments. Rabbit and bird bone made good beads and other adornments. Also common are bone awls, which were used for piercing rawhide, and weaving baskets. At several locations in the watershed, including Crooks Canyon Creek, Fairchild Swamp, and Boles Creek, ancient artisans etched designs into the basalt rock near caves or mudstone lining the ancient lakes. Chipping the weathered surface of the basalt with a rock hammer or chiseling into the softer mudstone material makes these designs. Most of the petroglyph panels contain abstract designs such as meandering lines, circles, dots, and line sequences. Their meaning is difficult to interpret, although many archaeologists believe they may have been associated with the rituals and spirit world surrounding the hunting of large game. These petroglyphs are thought to be very old, perhaps dating back to the Middle Archaic Period (Burton, 1998). An example of a petroglyph is shown in Figure 10-4.

Recent archaeological resources consist of houses, camps, and villages occupied within the last 500 to 600 years, many of them within the last few centuries. Many of the artifacts found are from the period when items of Euro-American origin begin to be seen in the Pit River area. Items found at archaeological sites include glass trade beads from Italy, bottle glass, buttons, bullet shell casings, nails, and wire. By the late 1800s, European goods had largely supplemented many native foods, hunting, food processing tools, apparel, and household items. Native American archaeological sites reflect this transition.

ARCHAEOLOGICAL RESOURCE INVENTORY AND EVALUATION

Public Land

The USFS and BLM are in the process of the inventorying, describing, and evaluating of the prehistoric and historic cultural resources located on federal property within the watershed. The Bureau of Reclamation and the Army Corps of Engineers inventory and evaluate cultural resources encountered during planned projects or existing facilities. Direction for these activities is outlined in the National Historic Preservation Act of 1966 and Executive Order 11593. All State and federal representatives consult with the State Historic Preservation Officer, and the Advisory Council on Historic Preservation, and reviews State and federal registers when applicable.

Cultural resource sites are managed in several ways. The level or intensity of management has the following range

- Preservation – sites are protected by excluding incompatible land management activities.

- Conservation – when preservation is not feasible, scientific information is recovered from sites so that other land use activities can occur.

- Interpretation – sites are developed for public enjoyment and education through signs, trails, and public information kiosks.

- No Management – sites are not preserved in any way. These sites are not the quality suitable for nomination to the National Register. They contain little scientific information or Native American cultural heritage value.

As of 1983, about 254,000 acres (16 percent) of USFS lands had been inventoried for cultural resources and approximately 2,600 properties identified (USFS, 1991). Of these, seven are on the National Register of Historic Places and over 500 sites have been evaluated as potentially eligible for nomination. An estimated 26,800 cultural properties have not yet been identified.

About 83 percent of the recorded cultural resource sites are managed at the preservation level and less than 2 percent at the conservation level. No sites have been interpreted, and about 15 percent are not managed. Most prehistoric and historic sites are in the preservation category. Sites not managed are small, surface lithic scatters with little scientific or heritage value.

Many pieces of the archaeological puzzle are missing because inventories are primarily conducted on a project-by-project basis, rather than area-wide. Areas with no associated projects are the last to be inventoried. Because no major archaeological excavations have been conducted, the USFS has little information on the time periods of occupation in the area. Evaluation of sites is difficult due to these deficiencies in the cultural resource database.

As of 2003, approximately 25,000 acres of BLM land in the Alturas Resource area had been inventoried (Foster-Curley, 2003). Table 10-2 gives a general summary of the archeological resources that have been inventoried on BLM lands.

The Pit River generally runs adjacent to BLM lands with a few exceptions, most notably that of the Pit River Canyon Wilderness Study Area located approximately 6 miles southeast of McArther. In that area, little to no survey has been conducted due to the rugged and isolated nature of the wilderness area.

Hat Creek does not run through any BLM lands under the Alturas Field Office Jurisdiction, however given the ethnographic information available, and the number of surveys done by PG&E and other contract crews, approximately 60 percent of the drainage has been surveyed, with at least 30 sites recorded, and a moderate to high sensitivity for the area.

Table 10-2
BLM ARCHAEOLOGICAL SITES

Drainage	% of Basin Surveyed	# Sites	Site Density	Sensitivity
Fitzhugh Creek	60%	100 +	6–10 sites/mile	High
Noble Creek	10%	20	1–5 sites/mile	Moderate
Clover Swale	10%	15	1–5 sites/mile	Moderate
Canyon Creek	25%	5	1–3 sites/mile	Low
Juniper Creek	60%	35	3–5 sites/mile	Moderate/High
Horse Creek	20%	15	3–5 sites/mile	Moderate/High
Beaver Creek	60%	20 +	2–4 sites/mile	Moderate
South Fork of the Pit River	10%	15	2–4 sites/mile	Moderate
Crooks Canyon	25%	20	2–6 sites/mile	Moderate/High

Source: BLM Archaeologist Cheryl Foster-Curley
Please note that the figures listed in the table are approximate, and that site density should be considerably higher in the areas that have not had greater than 50% survey.

Private Land

The NRCS is responsible for many of the inventory, description, and evaluation of the prehistoric and historic cultural resources in the watershed in association with range management and agricultural programs located on private property. NRCS considers cultural resources in its conservation planning along with the soil, water, air, plants, and animals on your property.

Archaeological review is required prior to harvest of timber on private lands through the California Forest Practice rules.

Several Federal, state, and local laws have been enacted to preserve cultural resources. The most important of these is the National Historic Preservation Act of 1966. Under this and other legislation, Federal agencies, including the U.S. Department of Agriculture's Natural Resources

Conservation Service, are required to protect cultural resources. If potential cultural resources are located on your property, the California Cultural Resource Specialists have been listed in the contacts of this section for your convenience.

HISTORIC LANDMARKS

The Office of Historic Preservation offers four different registration programs: California Historic Landmarks, California Points of Interest, California Register of Historic Resources, and National Register of Historic Places. Each is unique in the benefits offered and documentation procedures required. If a resource meets the criteria for registration, it may be nominated to any program at any time. The specific criteria needed for each designation are shown in Table 10-5.

Two of those categories are found in the Upper Pit River Watershed, California Historical Landmarks and National Register of Historic Places. Tables 10-3 and 10-4 list the current landmarks and historical places found in the Upper Pit River Watershed.

Many of the historical landmarks are associated with two major historic events in the watershed. These events are summarized below.

Table 10-3
CALIFORNIA HISTORIC LANDMARKS

Name	Address	City
Chimney Rock	Along Hwy 395	77 miles N of Alturas
Old Emigrant Trail	County Road 84	9 miles NW of Canby
Evans and Bailey Fight, 1861	Centerville Road	5 miles SE of Canby
Infernal Caverns Battleground, 1867	Ferry Ranch, County Road 60	6.5 miles NW of Likely
Lassen Emigrant Trail	Veterans Ln. and Bridge St.	Bieber
First School in Fall River Valley	Hwy 299	0.4 miles east of McArther
Source: State Office of Historic Preservation		

Table 10-4
NATIONAL REGISTER OF HISTORIC PLACES

Name	Address	City
Adin Supply Company	West side of Main Street	Adin
Anklin Village Archeological Site	Address Restricted	Canby
Black Crow Spring	Address Restricted	Canby
Core Site	Address Restricted	Canby
Cuppy Cave	Address Restricted	Canby
Jess Valley Schoolhouse	County Road 64	Likely
Mildred Ann Archeological Site	Address Restricted	Canby
NCO Railroad Depot	East and Third Street	Alturas
Nelson Springs	Address Restricted	Likely
NCO Railway General Office Building	619 N. Main Street	Alturas
Sacred Heart Catholic Church	507 E. Fourth Street	Alturas
Seven Mile Flat Site	Address Restricted	Devil's Garden Ranger District
Skull Ridge	Address Restricted	Canby
Skull Spring	Address Restricted	Canby
Source: National Park Service		

Table 10-5
HISTORIC REGISTRATION CRITERIA

	California Historical Landmarks	California Points of Historical Interest	California Register of Historical Places	National Register of Historic Places
Criteria	The first, last, only or most significant of its type in the state or large geographic area. Assoc. with an individual or group having a profound influence on the history of CA. A prototype or outstanding example of a period, style, or architectural movement.	Same as those for landmarks, but directed to local (city or county) regions.	Associated with events that have made a significant contribution to the broad patterns of local or regional history or the cultural heritage of California. Associated with the lives of persons important to local, CA, or national history. Embodies the distinctive characteristics of a type, period, region, or method of construction or represents the work of a master artist. Has yielded, or has the potential to yield information important to pre-history or history of the local area, California, or the nation.	Associated with events that have made a significant contribution to the broad patterns of our history. Associated with the lives of persons significant in our past. Embodies the distinctive characteristics of a type, period, region, or method of construction or represents the work of a master artist, or possesses high artistic values, or represents a significant and distinguishable entity whose components may lack individual distinction. Has yielded, or has the potential to yield information important to pre-history or history of the nation.
Relation to other registration programs	Resources listed as California Historical Landmarks are automatically listed in California Register.	Resources listed as points of Historical Interest are concurrently listed in California Register.	Resources listed in National Register or as California Historical Landmarks or Points of Interest are also listed in California Register.	Resources listed in National Register are automatically listed in California Register.
Owner Consent	Written consent of property owner(s) is required.	Written consent of property owner(s) is required.	Consent of property owner(s) not required, but cannot be listed if owner(s) objects.	Consent of property owner(s) not required, but cannot be listed if owner(s) objects.
Local Government Notification	Local government must be given 60 days to comment on application before public hearing is held.	Local government must be given 60 days to comment on application before public hearing is held.	Clerk of local government must be given 90 days to comment on application before it is sent to OHP.	Local government must be given 60 days to comment on application before public hearing is held.
Effects of Designation	Local building inspector must grant code alternatives provided under State Historic Building Code. Local assessor may enter into contract with property owner for property tax reduction (Mills Act). Limited protection (environmental review may be required under CEQA if property is threatened by a project). Contact local planning agency for further information. Bronze plaque (with text) at site and highway directional marker (no text).	Local building inspector must grant code alternatives provided under State Historic Building Code. Local assessor may enter into contract with property owner for property tax reduction (Mills Act). Limited protection (environmental review may be required under CEQA if property is threatened by a project). Contact local planning agency for further information. Highway directional marker (no text). Owner may place own plaque or marker.	Local building inspector must grant code alternatives provided under State Historic Building Code. Local assessor may enter into contract with property owner for property tax reduction (Mills Act). Limited protection (environmental review may be required under CEQA if property is threatened by a project). Contact local planning agency for further information. Owner may place own plaque or marker.	Tax incentives, in some cases, for rehabilitation of depreciable structures. Tax deduction available for donation of preservation easement. Local building inspector must grant code alternatives provided under State Historic Building Code. Local assessor may enter into contract with property owner for property tax reduction (Mills Act). Preservation consideration in federally funded or licensed undertakings (Section 106, National Historic Preservation Act). Limited protection (environmental review may be required under CEQA if property is threatened by a project). Contact local planning agency for further information. Owner may place own plaque or marker.

Source: California Department of Parks and Recreation, Office of Historic Preservation, 1998.

Modoc Indian War

The events leading up to the Modoc Indian War (1872–1873) were much the same as every other white/Indian conflict during that time. Settlers began moving into the Lost River area on the border of southern Oregon and northern California during the 1850s. The encroachment of the white man on Indian lands and their way of life threatened the Modoc's very existence.

Roots of the war go back to 1846, when a band of Klamath Indians attacked a group of explorers lead by Captain John Charles Fremont, killing three men. Fremont assumed the Modoc Indians were to blame and exacted his revenge by raiding a Modoc village as he traveled south. In 1852, Indians slaughtered between 36 and 65 whites in wagon trains traveling along the eastern shore of Tule Lake later known as Bloody Point. Accounts of the events vary and the exact number of travelers killed is unknown. The prevailing attitude among whites that all Indians should be exterminated was greatly reinforced and retaliation by settlers continued through the years.

By 1860, the Modoc made a considerable effort to assimilate into American culture and began cultivating relations with the whites in and around Yreka, but white settlers in both Oregon and California were arguing that the Klamaths and Modocs should be placed on a reservation and the rest of their traditional homelands be made available for settlement. In 1864, the Klamaths signed a treaty establishing the Klamath reservation, which entitled them to most of the land they claimed as theirs. J.W. Perit Huntington, Superintendent of Indian Affairs in Oregon, assumed the Modocs would also sign the treaty. This would require the Modoc to surrender all their land and move to the Klamath reservation to coexist with their historic enemies.

Within months of their arrival to the reservation, tensions were so high between the two tribes that before the end of 1865 a group lead by Kientpoos (Captain Jack) decided to leave the reservation and return to the Lost River. When Jack's band returned to Lost River just north of Tule Lake, white settlers had already moved in with their herds and erected cabins. For the next four years, the two groups lived warily side-by-side. Considering that each thought of the other as trespassers, relations were good, only marred by the occasional misunderstanding concerning property "rights." As time passed and the settlers invested more in their claims, they became more concerned about the Modocs presence. While attempting to put on a show of friendliness to the Indians, they demanded that the Oregon Superintendent move the Indians back to the reservation. Several attempts were made with no success, until December 1869 when Captain Jack was finally persuaded to move his people back to the reservation. Life was no better the second time around and made worse by antagonism by the Klamaths and the Modocs lack of food. By April 1870, Jack and his group fled again to the lower Lost River Area.

During the years, 1870 – 1872, Captain Jack appealed for assistance to his white friends in Yreka, particularly two lawyers, Steele and Rosborough. Both men advised him not to resist the authorities and at the same time, offered to give their legal expertise to help the Modocs obtain a separate reservation on Lost River. From these contacts came rumors of Yreka whites of low character, advising the Modocs to resist any relocation efforts forcibly.

All the speculation lead to an increased concern over what the Modocs would do to remain on their land. Communication between the Superintendent of Indian Affairs and General Canby of Fort Klamath, lead to the dispatch of 50 soldiers to patrol the Lost River area. Tension was mounting, settlers were lying, and politicians in Washington were getting nervous. By July 1872, all of these factors lead to the Secretary of the Interior Delano to order the Superintendent to remove the Modocs (Thompson, 1971).

On November 28, 1872, Major Green sent troops from Fort Klamath to move the Modocs, "by force if necessary," back to the reservation. In the early morning of November 29th, the Army surprised the Modoc camp and with the use of a translator commanded the Modocs to surrender and for their leaders to come forward. The officers tried to arrest a group of men in the village. Realizing the Indians were not going to go quietly the officers raised their pistols prepared to fire. This in turn caused Scarface Charley to retaliate by firing back thus began the Modoc Indian War.

The three bands of Modocs along the Lost River quickly fled their villages during the first battle. One group, under the leadership of Hooker John, proceeded east around Tule Lake killing 14 male settlers along the way in retaliation for the attack by the troops. Captain Jack and the rest of the Modocs headed across Tule Lake by boat and entered the lava beds. They were later joined by Hooker Jim's band. Captain Jack reluctantly accepted them, fearing he may be placing the other Modocs' lives in danger by allowing those who had murdered the settlers to stay. Another band of Modocs, the Hot Creeks, eventually joined them after they had been tricked by the settlers into thinking they would all be hung for being Modocs.

Along the shores of Tule Lake, lava flows have formed a rugged, uneven terrain. This place is known as the lake of frozen fire by the Modoc people (Thompson, 1971). The area is cut with deep lava trenches and dotted with small habitable caves, creating a natural fortification and a seemingly endless variety of places where one could move unnoticed. Over 500 troops and volunteers (Report from Major Gillem to General Canby, Feb. 9, 1873, in Hagen) were organized to drive approximately 150 Modoc men, women, and children from the Stronghold. On the foggy morning of January 16, 1873, the troops headed over what they believed was flat land, confident of a Modoc surrender. The Modocs inflicted heavy losses from the cover of their rough terrain. Confused by the fog and exhausted by the bitter cold and terrain, the troops retreated, leaving their weapons, ammunition, and wounded. The Modocs had won a decisive victory and now had a bargaining advantage.

Many meetings took place between Army leaders and Captain Jack. Each meeting found Captain Jack still requesting a Lost River reservation. To avert further fighting, President Grant organized a Peace Commission to meet unarmed with the Modoc leaders. Captain Jack was willing to negotiate for a peaceful settlement, but Hooker Jim, indicted for murder, had little to gain from a peaceful ending. Together Hooker Jim and Curly-headed Doctor (a shaman, jealous of Captain Jack's power) shamed Captain Jack into a plot to kill the Peace Commissioners.

The night before the meeting, Modocs Barncho and Slolox, laden with rifles, hid among the rocks near the peace tent. On the morning of April 11, 1873, General Canby, Reverend Thomas, Commissioner Head Alfred Meacham, and Indian Agent Leroy Dyar left for the meeting. It was arranged that five unarmed Modocs would meet with the commissioners. Upon reaching the peace tent, the commissioners found not five but eight Modocs, two of which were obviously armed. Captain Jack, Schonchin John, Boston Charlie, and Black Jim were among the eight, and again requested a Lost River reservation. When this was not granted Captain Jack drew a pistol and killed Canby. Boston Charlie killed Thomas. Meacham was wounded and Dyar escaped unharmed.

Reinforcements were hastily called and four days later the second attack on the Stronghold began. The plan to surround the Stronghold was not completed but the Modocs were cut off from water. On April 17, the troops captured the Stronghold only to find it empty. Captain Jack and the other Modocs had escaped south to the Schonchin Lava Flow through an unguarded trench. Here they obtained water for the men, women, and children from the nearby ice caves.

On the morning of May 10, the Modocs were defeated in their surprise attack on troops camped at Dry Lake, leaving most of their horses and supplies in a hasty retreat. Ellen's Man George, a shaman who was well liked by all three bands of Modocs, was killed during the attack, devastating the entire group. The protection guaranteed by the shaman was no longer effective and as the Modocs began to quarrel, they dissolved into smaller groups.

Hooker Jim left with three men from his band, and ten of the Hot Creek band, along with their women and children. They headed west toward the present-day town of Dorris. Captain Jack and his followers left for Big Sand Butte.

As troops headed west, expecting to find Captain Jack, they found Hooker Jim and his followers who quickly surrendered. Hooker Jim offered to track down Captain Jack, in an attempt to save his own skin. Captain Jack finally surrendered at Willow Creek on June 1, 1873, ending the Modoc War.

Amnesty was granted to Hooker Jim and his followers (who had murdered the 14 settlers at Tule Lake) for their assistance in the capture of Captain Jack. Those who attacked the peace commissioners were placed on trial at Fort Klamath and convicted of murder. At the last moment, President Grant awarded amnesty to Barncho and Slolux who were sent to Alcatraz. Boston Charlie, Black Jim, Schonchin John, and Captain Jack were hung on October 3, 1873. The surviving Modocs were taken to the Quapaw Agency in Oklahoma. Today the Modoc Tribe of Oklahoma is comprised of some 200 people, descendants of only seven of the original 155 prisoners of war.

The Modoc War cost over half a million dollars, the lives of 83 whites and 17 Indians (Beck and Hasse, 1999). This was the only major Indian War fought in California and one of the first wars to be covered by all the major publications of the day.

The Battle of Infernal Caverns

This locally famous battle occurred over three days in September of 1867, with 110 soldiers and approximately 15 Warm Springs Indian scouts fighting a group of Paiute, Pit River and Modoc Indians, lead by chief Si-e-ta. The encounter left at least 20 Native people dead, including a number of women and children. Eight U.S. Army soldiers also died in the attack.

General George Crook, who had been sent after the Civil War to battle Indian groups in the west, arrived in the Goose Lake area on September 22, specifically looking for "some particularly bad Indian bands to the south." Once in California, the general and his troops saw signal fires and other, unspecified "Indian signs." On September 26, they found a large group of Indians concentrated at a series of natural caves interspersed with deep ravines. This area is located near the top of a precipitous rimrock, which rises abruptly some 600 feet above the valley floor of the South

Fork of the Pit River. When they heard the soldiers approaching, some of the Indians scattered into the tules near the river, and others ran up the rocky slopes to the caves.

Thus began what was to be a three-day siege, during which the Indians, "poured a regular hail of arrows and bullets on the advancing soldiers, who promptly took cover and returned the fire (taken from Liet. William Parnell's journal)." On the second day, Crook's men stormed the fortification and began to climb the vertical boulders to where the Indians were ensconced. They reached the main level and drove the Indians out or deeper into the caverns.

During this part of the fighting, Crook is said to have shot Chief Si-e-ta. On the morning of the third day, the soldiers discovered that the Indians who had still been in the caverns had escaped during the night, via the deep crevices and underground passages. The soldiers retrieved their dead and left the battle site, but not before searching the caverns and noting several dead Indians.

One of the more enduring questions about the Battle of the Infernal Caverns is why many previously hostile tribes; the Pit River, Modoc, and Paiutes were apparently camped together as the attack began. Hammawi (sub-tribe of the Ajumawi) accounts indicate General Crook attacked a "Big Time." This is when neighboring tribes not normally allowed within the Pit River territory were invited for games, feasting, trade, and marriage exchanges. These yearly gatherings, even among traditional enemies, were common in California prior to the arrival of Euro-Americans. This practice continues today in the form of the Pow-Wow. In the Native peoples' eyes, had they been at Infernal Caverns to fight they would not have brought their women and children. Yet, their presence and that of the tribal neighbors played a role in the decision to make a stand.

CONTACTS

The contacts section has been divided into two sources of contacts for the watershed area

- Information Sources
- Native American Sources

These are summarized below.

The following individuals are considered experts on cultural resources of the Upper Pit River Watershed and were contacted for information concerning this assessment.

Information Sources

United States Forest Service (USFS)
Gerry Gates, Archaeologist
Modoc National Forest
800 West 12th Street
Alturas, California 96101
Phone: (530) 233-5811
TDD: (530) 233-8708
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Bureau of Land Management (BLM)
Cheryl Foster-Curley – Archaeologist
Alturas Field Office
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Alturas, CA 96101
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Cheryl_Foster-Curley@ca.blm.gov

California Department of Forestry and Fire Protection (CDF)
Richard Jenkins – Archaeologist
CDF Archaeology Office
6105 Airport Road
Redding, CA 96002
(530) 224-4749 (office)
(530) 949-8822 (mobile)
(530) 242-7170 (pager)
rich.jenkins@fire.ca.gov

Natural Resources Conservation Service (NRCS)
Jerry Reioux, Staff Forester
Cultural Resources Coordinator
NRCS/USDA
California State Office
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Office of Historic Preservation
Dr. Knox Mellon, State Historic Preservation Officer
Stephen Mikesell, Deputy State Historic Preservation Officer
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1416 Ninth Street
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Sacramento, Ca 94296-0001
Phone: (916) 653-6624
Fax: (916) 653-9828
calshpo@ohp.parks.ca.gov

Advisory Council Historic Preservation
Denver Office
12136 West Bayaud Avenue, Suite 330
Lakewood, CO 80228
Phone: (303) 969-5110
Fax: (303) 969-5115

Washington Office
The Old Post Office Building
1100 Pennsylvania Avenue NW Suite 809
Washington, DC 20004
Phone: (202) 606-8503
Fax: (202) 606-8647 or (202) 606-8672
achp@achp.gov

National Park Service (NPS)
NPS Pacific Great Basin Support Office
Suite 700
1111 Jackson Street
Oakland, California 94607
Phone: (510) 817-1396
Fax: (510) 817-1484
http://www.cr.nps.gov

National Center for Cultural Resources
National Historic Landmarks Survey
1849 C Street, NW (Org. 2280)
Washington, D.C. 20240
Phone: (202) 354-2216
Fax: (202) 371-2229

Native American Sources

Native American contacts identified in the Upper Pit River Watershed include:

Western Division – Siskiyou County Line to Canby
Native American Heritage Commission
915 Capitol Mall, Room #364
Sacramento, CA 95814
Attn: Rob Wood
(916) 653-4040

Ajumawi Band Cultural Resources Representative*
Office of Tribal Chairperson
P.O. Box 1253
Burney, CA 96013
Tribal Affiliation: Pit River - Ajumawi

Pit River Tribe of California*
(This includes XL Rancheria, Lookout Rancheria & Likely Rancheria)
Office of Tribal Chairperson
37014 Main Street
Burney, CA 96013
Tribal Affiliation: Pit River – Achomawi – Atsugewi, Wintun
(530) 335-5421 / (530) 335-3140 Fax

Pit River Tribe Environmental Office*
Cultural Information Officer
37014 Main Street
Burney, CA 96013
Tribal Affiliation: Pit River – Achomawi – Atsugewi, Wintun
(530) 335-5062

Shasta Nation
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Eastern Division - Canby to Nevada State line
Native American Heritage Commission
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Hammawi Band*
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(530) 604-9639

Alturas Rancheria*
Office of Tribal Chairperson
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Alturas, CA 96101
Tribal Affiliation: Pit River, Acomawi-Atsugewi
(530) 233-5571 / (530) 233-4165 Fax

Cedarville Rancheria of Northern Paiute*
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200 South Howard Street
Alturas, CA 96101
Tribal Affiliation: Northern Paiute
(530) 233-3969

Illmawi Band
Cultural Resources Representative
P.O. Box 48
Fall River Mills, CA 96028
Tribal Affiliation: Pit River – Illmawi
(530) 335-2777

Sample Tribal Contact letters for projects in the watershed can be downloaded from
http://www.indiana.edu/~e472/cdf/contacts/letters.html

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Section 11

Section 11
FIRE AND FUELS MANAGEMENT

TABLES

FIGURES

Section 11
FIRE AND FUELS MANAGEMENT

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INTRODUCTION

Fire has dominated the California landscape for as long as there has been vegetation to burn. The States combination of climate, terrain, and vegetation produces one of the most combustible natural fire environments on earth (CDF, 1995). A combination of heavy forest floor fuels and dense sapling thickets acting as ladder fuels, coupled with the normally dry climate, frequent lightning and human cause ignitions, has resulted in a dramatic increase of severe wildfires.

Fire suppression efforts and resource management activities over the last 100 years have increased the fire hazard in many California's ecosystems. These land management practices have resulted in extensive forest areas dominated by dense stands of small trees that are predominantly shade-tolerant and fire-sensitive species. The result is a significant increase in the volume and continuity of live and dead woody fuels near the forest floor, which provide a ladder for connecting surface fuels with the cores canopy (McKelvey et. al, 1996). The increased competition for available water and sunlight in these dense stands often weakens or kills trees, increasing fire severity.

Simultaneously, fire exclusion practices have allowed brush, juniper and other non-native species to invade lowland and coniferous communities. The risk of catastrophic fire has increased dramatically. At the same time, encroaching developments and increasing property values have moved human populations into ever-increasing risk of loss. Fire suppression activities have shifted the fire regime away from numerous smaller fires, toward fewer, larger fires under more severe weather conditions. Fire suppression activities and historic forest management practices, have combined to increased fuel loading in conifer forest, and develop stands that are younger, denser and at a higher risk to loss by fire (CDF, 1995).

Prior to European settlement, reports of the forest and woodlands were described as generally open. By the turn of the century they were altered by intense grazing and associated burning pattern in the late 1800s (McKelvey et. al, 1996). Current forests when compared to pre-settlement conditions are younger, denser, not as large in diameter and generally more homogenous (McKelvey et. al, 1996).

SOURCES OF DATA

Information used in this section was obtained primarily from the following sources:

- National Fire Plan
- California Fire Plan, 1999, California Department of Forestry and Fire Protection (CDF)
- Data from Lassen and Modoc National Forests

- Data from Bureau of Land Management (BLM)
- California Department of Forestry and Fire Protection, Fire and Resource Assessment Program (FRAP)

References included at the end of this section provided other sources of information.

FIRE HISTORY

Pre- European Fire

Changes in climate and fire frequency are likely the two most significant contributors to ecosystem development of the watershed ecosystems evident today. The 200 or more years of dry, cool weather preceding the arrival of European man, (see Section 1, "Introduction") coupled with Native American fire use resulted in many frequent low-intensity fires. The hot, dry summer climate provided suitable weather conditions and dry fuels for burning. Lightning provided a ready ignition source, supplemented by Native Americans, who used fire for a variety of purposes. Fires could spread until weather conditions or fuels, or both, were no longer suitable.

Fire-scar records in tree rings have shown variable fire-return intervals in pre-settlement times. Median values are consistently less than twenty (and as low as four) years for the ponderosa pine and mixed conifer zones of the Sierra Nevada. Only one study, in high-elevation red fir, found a median fire-return interval greater than thirty years (see Table 11-1).

Table 11-1
HISTORIC FIRE-RETURN INTERVALS
COMPARED WITH TWENTIETH CENTURY PATTERNS

Forest Type	Fire-Return Period (Years)	
	Pre-1900	Twentieth Century
Red fir	26	1,644
Mixed conifer-fir	12	644
Mixed conifer-pine	15	185
Ponderosa pine	11	192
Blue oak	8	78

The variable nature of pre-settlement fire helped create diverse landscapes and variable forest conditions. In many areas frequent surface fires are thought to have minimized fuel accumulation, keeping understories relatively free of trees and other vegetation that could form fuel ladders to carry fire into the main canopy. The effects of frequent surface fires would largely explain the reports and photographs of those early observers who described Sierran forests as typically "open and parklike". However, such descriptions must be tempered by other early observations emphasizing dense, impenetrable stands of brush and young trees.

Almost all scientists agree that fire has played a significant if not dominant role in shaping the vegetative patterns and systems of California vegetation. There is a significant divergence of views as to fire

frequency and vegetative composition of pre-settlement fire. This point of difference in views centers on the belief that there were probably many variations in the return frequencies and fire intensity patterns that contributed to the mosaic of vegetation patterns on the landscape today.
A second major point of difference relates to the relative "openness" of forests before the disturbances caused by settlers. Alternative views conclude that forest conditions were not largely "open or parklike," as in the words of John Muir; rather they were a mix of dark, dense, or thick forests in unknown comparative quantities. Select early accounts support an open, parklike forest, but there were many similar accounts that describe forest conditions as dark, dense or thick. J. Goldsborough Bruff, a forty-niner who traveled the western slopes of the Feather River drainage between 1849 and 1851, kept a detailed diary. He clearly distinguished between open and dense forest conditions and recorded the dense condition six times more often than the open. Many other accounts of early explorers (e.g. John C. Fremont, Peter Decker, William Brewer) identify dark or impenetrable forest; the pre-settlement forest was far from a continuum of open, parklike stands. From these records, it seems clear that Sierran forests were a mix of different degrees of openness and an unknown proportion in dark, dense, nearly impenetrable vegetative cover with variations from north to south and foothill to crest.

A third point of departure has to do with the frequency of stand-terminating fires in pre-settlement times. One group concludes that such events were rare or uncommon. The alternative view is that stand-threatening fires were probably more frequent. They were heavily dependent upon combinations of prolonged drought, an accumulation of dead material resulting from natural causes (e.g., insect mortality, wind-throw, snow breakage), and severe fire weather conditions of low humidity and dry east winds couples with multiple ignitions, possibly from lightning associated with rainless thunderstorms. Such fires were noted during the last half of the nineteenth century by newspaper accounts, official reports (U.S. Geological Survey, 1902), and diaries; most were apparently caused by settlers, stockmen, or miners. Fuel loads were obviously sufficient at that time, thus strongly suggesting that similar conditions existed in earlier times with unknown frequencies (discussion taken from SNEP Volume 1, Chapter 4).

The purpose of fire to the Native American Indians was to shape the ecosystem to benefit tribal survival and sustain thriving, growing societies (Williams, 1999). Great variations have been found for intentional burning of the forest and wildlands by the Native Americans. Native peoples had a least 70 different reasons for burning vegetation (Kay, 1994). In doing so, burning their ecosystem was dependent upon what resources were being managed, setting fires that, for the most part were not destructive of entire forest or ecosystem, relatively easy to control, and designed to encourage new growth of plant species (Williams, 1999). Lightning and Native Americans ignited forests and early Spanish explores and missionaries documented the use of fire by the Native Americans to increase the amount of oaks to increase acorn harvesting (Ainsworth et al, 1995). Fire was also used in ancient European times to control various agricultural insect pest in crops, field borders, and to some extent on range and pasture lands (Ahlegren and Kozlowski, 1974).

Post-European Fire

Conservation, since it's beginning with Gifford Pinchot in the late 1890s, came to believe that fire was the bane of the forest (Williams, 1999). The national firestorms of 1910 cemented the exclusion of fire from national forests. Fire should be suppressed and eliminated to allow the forest to grow and thrive. The understanding that humans influenced ecosystems through the use of fire, shifted after European settlement in North America, when it was believed that fire should and could be controlled to protect both public and private land (Williams, 1999).

At the turn of the century, some settlers began to use "light-burn" as a farm management tool. The U.S. Forest Service (USFS) experimented with the same theory in the 1910s, but determined that it was too damaging to young seedlings needed for regeneration (Williams, 1999). By 1933, with the advent of the Civilian Conservation Corps (CCC), fire fighting had become and the suppression of wildfires became a fulltime occupation. Thousands of men were trained to fight fire on public and private lands. The primary fire-related mission of land management agencies was to stop fires whenever possible, and to prevent large fires from developing (Moore, 1974).

Indiscriminate use of fire by sheep men and miners from approximately 1870 to 1900 (see Section 2, "General Watershed History") resulted in significant environmental damage and furthered the developing cause for fire suppression.

By 1950s controlled burns to reduce fuels and improve habitat for wildlife had become commonplace in much of California rangelands, but all other fires were vigorously controlled. In 1963, Leopold and others published a report on the ecological conditions of the National Parks in the United States, and as a result, managers and the public began to see the benefit of fires in the wildlands (Lyon et al, 2000). Leopold's report stated that wildlife habitat is not a stable entity that persists unchanged, but rather a dynamic entity. Suitable habitat for many wildlife species and communities must be renewed by fire, and as a result of the Leopold Report, by 1968, the fire policy of the National Park Service (NPS) changed as managers began to adopt the recommendations of the report (Lyon et al, 2000).

Today wild fire suppression is a full time occupation. Many agencies are involved coordinating, controlling, and fighting the fire including USFS, BLM, NPS, U.S Fish and Wildlife Services (USFWS), Native American tribes, state forestry departments, and many local fire-fighting agencies.

As agencies and the general public have sought to "protect" the forest from fire, a consequence has been the increased levels of fuel loads, setting the stage for larger and more devastating wildfires. The Pit River has experienced this over recorded history, where more, smaller fires have changed to fewer larger fires. In order to get the watershed vegetation back to a more "natural" fire regime, landowner, timber companies, and agencies have conducted several prescribed burns with in the watershed, under the California Vegetation Management Plan (CVMP). Acreage is burned to dispose of logging and thinning slash, prepare areas for timber or range regeneration, reduce hazardous brush accumulations, improve wildlife habitat and livestock forage, or to improve water yield. Additionally, burning programs occur on federal lands administered by the USFS and BLM.

Wildfire History

Fire was a common influence on the structure and function of California's ecosystem in prehistoric times with as much as 5.5 to 13 million acres burning annually on average (CDF, 1999). During the period of 1987 to 1997 California averaged over 300,000 acres burned by wildfire, second only to Alaska (Lyon et al, 2000). As a result, many plants exhibit specific fire-adapted traits such as thick bark and fire-simulated flowering, sprouting, seed release, and/or germination (McKelvey et al., 1996).

The relative impact of topography and spatial variations in fuels on fire behavior depends on weather conditions and fuel moisture. At moderate-to-high fuel moisture, variations in vegetation structure and localized landscape fragmentation (due to past fire history), may determine burning pattern. However, when fuel moisture drops below threshold levels and weather conditions are extreme (such as hot, dry winds), fire behavior may be regulated primarily by larger-scale topographic features (Christensen, 1994). Figure 11-1 ranks fuels in the watershed based on expected fire behavior for unique combinations of topography and vegetative fuels under a given severe weather condition (i.e. wind speed, humidity, and temperature).

As indicated in Figure 11-1, the Upper Pit River Watershed is dominated by high rankings with several severe areas indicating that during summer and fall times there is an increased likelihood of fire.

There is considerable variability in the seasonality of fires in the Upper Pit River Watershed. Fuels are driest and ignited sources are most frequent in the summer. Thus, the vast majority of fires occur in summer; winter and early spring fires are relatively uncommon. Part of the Upper Pit River Watershed is located in an area with large amount of lightning strikes, which increases the likelihood of wildfire. Historical fires (CDF data) and causes in the Pit River area from 1910 to 2001 are included on Table 11-2.

Table 11-2
CDF HISTORICAL FIRE IGNITION SOURCES: 1910–2001

Cause	Number of Fires	Number of Acres	Percent of Total Fires	Percent Acres
Unidentified	44	130,849	13.66%	28.30%
Lightning	113	217,858	35.09%	47.12%
Use of Equipment	1	573	0.31%	0.12%
Garbage or Debris	1	391	0.31%	0.08%
Playing with Fire	1	13	0.31%	0%
Miscellaneous	2	2,221	0.62%	0.48%
Human (USFS)	113	89,445	35.09%	19.35%
Prescribed	47	20,984	14.60%	4.54%
TOTALS	**322**	**462,334**		

Miscellaneous fires are considered a catchall group, i.e. fires because of a car on fire along side of a road or due to the railroad, and human related fires listed in Table 11-2 could be a result of a campfire for example.

Lightning related fires make up over 35 percent of all fires in the Upper Pit River Watershed and consumed almost as much acreage as all other source of fires combined. The largest lightning fire was the Glass Mountain Fire in 1910 that burned 107,912 acres, and the largest fire in the 1990s was the Damon/Long Fire of 1996 that burned 11,947 acres. The Blue Fire, 2001, burned over 34,000 acres. In 2003, the Modoc National Forest reported 69 total fires, four of which were human caused and 65, which were caused by lightening.

Historical wild land and prescribe fires are shown on Figure 11-2. The Upper Pit River Watershed acreage burned since 1910 is summarized in Table 11-3.

Table 11-3 ACERAGE BURNED 1910–1999			
	Fire Type		
Date	CVMP	Wildfire Acres	% Watershed Burned
1910–1919		119,153	5
1920–1929		19,823	1
1930–1939		17,304	1
1940–1949		18,950	1
1950–1959		55,915	3
1960–1969		7,609	0
1970–1979		107,905	5
1980–1989	1,523	18,619	1
1990–1999*	19,430	29,845	2
Total	**20,953**	**395,123**	**19%**
*Last complete year of records.			

ENVIRONMENTAL CONSEQUENCES OF UNCONTROLLED FIRE

Uncontrolled stand replacing wildfire is detrimental to both the watershed function and quality and can negatively impact all aspects of the watershed. In uncontrolled wildfire, typically all vegetation is removed or damaged, including seeds, soil microorganisms, minerals, and nutrients.

Fire and the environmental damage they cause is a function of frequency, season, size, and prominent, immediate effects. There are four generally recognized fire regimes:

1) Understory fire regime – Applied to forest and woodland vegetation types. Fires are generally non-lethal and do not substantially change the structure to dominate vegetation.

2) Stand-replacement regime – Applies to forests, shrublands, and grasslands. Fires kill or topkill aboveground parts of the dominant vegetation, changing the aboveground structure substantially. Approximately 80 percent or more of the aboveground dominant vegetation is destroyed.

3) Mixed-severity regime – Applies to forests and woodlands. Severity of fire either causes selective mortality in dominant vegetation, depending on different specie's susceptibility to fire, or varies between understory and stand replacement.

4) Nonfire regime – Little or no occurrence of natural fire.

Soil

The frequency and severity of wildfire affects the magnitude of accelerated erosion. The potential for accelerated erosion is primarily through its effects and removal of vegetation. During an intense surface wildfire, all vegetation may be destroyed, and organic material in the soil may be burned away or decomposed into a water-repellent substance that prevents water from percolating into the soil (hydrophobic soils). The potential for fire to increase erosion increases with fire severity, soil erodibility, steepness of slope, and intensity or amount of precipitation. The amount and duration of such change in erosion rate vary widely among sites as a consequence of fire intensity soil infiltration capacity, topography, climate, and patterns of vegetation recovery (Christensen, 1994). Post fire erosions rates may be more then 50 to 100 times greater than on a well-vegetated watershed (Sanberg, et al, 2002). In experiments using the clearing actions of wildfires, changes were found in both overland flow and infiltration after wildfires in a Mediterranean scrubland. Simulated rainfall was used, and overland flow decreased from 45 percent immediately after the fire, to 6 percent after five years, due to the recovery of vegetation (Sanberg et al, 2002). With increased overland flow with the loss of root systems may result in the increased rill and sheet erosion as well as the facilitation of debris flows in rivers and streams decreasing water quality (Christensen, 1994).

Temperatures at ground level during a wildfire, may reach to 600 to 700ºC. Oil resins and waxes that are stored in plants are vaporized due to the intense heat. Despite high surface temperatures, just centimeters below the surface remain cooler, allowing the oil resins and waxes to condense and form the hydrophobic layer (Ainsworth et al, 1995). The hydrophobic layer slows water infiltration, increasing erosional rates and minimizing evaporation into the root zone (Ainsworth et al, 1995).

As temperatures of the wildfire increases quality of soil decreases. Minerals and nutrients at temperatures 220 to 460 ºC begin to mineralize and nitrogen vaporizes, organic materials are oxidized and more sand size particles are formed. At temperatures greater than 460 ºC, permanent changes in structure, texture, porosity, plasticity, and elasticity occur.

Soil pH may increase after a wildfire. This is due to the addition of ash minerals leaching out after precipitation events. Many fungi and bacteria thrive in basic conditions and with the increase pH levels and the scarring effect of fire may increase the likelihood of disease to the forest (Ahlegren and Kozlowski, 1974).

Wildfires result in the net loss of nutrients from the ecosystem. Although there are few estimates of such loss, Christensen (1994) proposed five mechanisms to account for these losses:

1) Oxidation of compounds to a gaseous form (gasification), nitrogen and sulfur, easily oxidized, are directly proportional to the loss of organic matter.

2) Vaporization of compounds that were solid at normal temperatures, nitrate.

3) Convection of ash particles in fire generated winds, loss of important plant development nutrients.

4) Leaching of ions in solution out of soils.

5) And as previously stated erosion following the fire.

The relative importance of these mechanisms varies for each nutrient and is consequence of variations in fire intensity, site soil and topography, and climatic pattern.

During prescribed burning, physical changes in soil features such as texture or mineralogy are negligible. Where parent rock is exposed, weathering may be accelerated as a consequence of spalling (Christensen, 1994). Impacts of any particular fire regime on soils and biogeochemical process depends on basic site characteristics such as slope, parent rock material and soil properties (Christensen, 1994).

Water

The increase of river sediment in rivers one of the most dramatic responses associated with fire. Loss of ground cover such as needles and small branches, and the chemical transformation of burned soils, makes watersheds more susceptible to erosion from precipitation events. Runoff, where at least 75 percent of the vegetation has been removed, can increase discharge to the basin ranging at a low of 0.1 acre-foot per acre to a high of 0.8 acre-foot per acre of burned forest, dependent upon amount of precipitation. Additional sediment storage can alter a stream's form and function in a deleterious manner. Studies in the Stanislaus National Forest indicates large, intense fires produce an average of 20 to 50 tons per acre per year of erosion for the first two years (CDF, 1995).

Sediment transported from a recent wildfire after a recent precipitation event into local waterways can be detrimental to aquatic organism and many fish species. After the rivers and streams settles, sediment fills voids in the streambeds eliminating essential habitat, covering food sources and spawning sites and smothering bottom-dwelling organisms. Sediment deposition also reduces the capacity of stream channels to carry water and of reservoirs to hold water. This decreased flow and storage capacity can lead to increase flooding and decreased water supplies (Golden et al, 1984). Sediment entering the stream channels from increased runoff can be deposited on spawning gravel preventing the emergence of fry and the deposition of eggs. Sediment can also fill pools, widening and flattening the stream channel removing summer and winter rearing habitat for small fish.

An increase in suspended sediment results in an increase turbidity, limiting the depth to which light can penetrate and adversely affecting aquatic vegetation photosynthesis. Suspended sediments can also damage the gills of some fish species, causing them to suffocate, and can limit the ability of sight-feeding fish to find and obtain food. Immediate effects are those that arise directly from the fire, such as changes in water chemistry due to ash deposition and abrupt changes in food quality. In certain instances, where severe burns have occurred, elevated levels of manganese and phosphates have been detected in surface water up to two years after fires. Changes in water quality due to wildfire are thought to be minimal and short-lived. However, in some cases increases in ions or pH following fire can cause fish mortality. Large woody debris jams will likely increase post-fire because of fire-killed snags, but new recruitment of debris will be reduced in subsequent years. In addition, retention of woody debris (which create pools and habitat for fish) may be decreased post-fire because of increased flow.

Turbid waters tend to have higher temperatures and lower dissolved oxygen concentrations. A decrease in dissolved oxygen levels can kill aquatic vegetation, fish, and other aquatic organisms. Increases (or decreases) in water temperature outside the tolerance limits can be detrimental to aquatic organisms, especially cold-water fish such as trout and salmon, can also be lethal (Brown et al, 2000).

Large, intense fires will have a much greater effect on stream ecology than smaller, less-intense fires. In addition, the size of the watershed burned and the proportion of the burned area within the watershed will also influence the effects of the fire on stream ecology. Tree removal reduces evapotranspiration, which increases water availability to stream systems. Increased streamflows can scour channels, erode streambanks, increase sedimentation, and increase peak flows.

Air

Air quality is a particular concern in California and within the Upper Pit River Watershed. Residents generally seek out rural lifestyles because of high quality of life, low population densities, and closeness to "nature." Poor air quality is generally associated with urban environments and smoke is generally an unwanted intrusion. Suppression of wildfires provides a short-term benefit to air quality by reducing the amount of vegetation consumed, and reducing smoke emissions. However, delaying a natural event to a later date, poor air quality is simply pushed to a future time. Estimating the impacts from air pollutants is difficult in general, and more complex in a wildland setting. Wildfire smoke, and in some cases prescribed burning, can affect visibility, human health, vegetation, and pollution rights. Overall air quality impacts of smoke are important, especially given the fact that the Sacramento Valley Air Basin in a non-attainment status. Wildland fires are categorized as an "area source" by many pollution agencies, since they tend to release pollutants over large areas (CDF, 1999). A single wildfire that consumes 100 acres of heavy forest fuels can emit as much as 90 tons of particulate matter into the atmosphere. Wildfires generally occur during the time of year, summer and fall, when smoke and particulate matter is trapped in lower lying areas, increasing exposure to the effects of smoke and reducing visibility. A reduction of visibility may result in a reduction of recreational activities and tourism. Visibility can also be utilized to estimate human health as seen in Table 11-4.

Health issues contributed to prescribed burns and wildfires affect the younger and older generations, as shown in the previous table. Reactions to smoke exposure range from itchy and scratchy throat to more serious reactions such as asthma, emphysema, and congestive heart failure (Department of Environmental Quality, 2003).

National ambient air quality standards (NAAQS) are defined in the Clean Air Act as amount of pollutants above the standard whose effects are detrimental to public health or welfare may result. NAAQS has established criteria for particulate matter (PM) or called total suspended solids (TSP), based upon size. PM10 is particulate matter less than 10 microns in diameter and PM2.5 is less then 2.5 microns in diameter. The major pollutant for wildfire in smoke is fine particulate matter, PM10 and PM2.5. Studies show that 90 percent of all smoke particles emitted during wildland burning is PM10, and 90 percent of PM10 is PM2.5 (Sandberg et al, 2000). Further studies have shown that PM2.5 are largely responsible for the health effects including mortality, exacerbation of chronic disease and increased hospital admissions (Sandberg et al, 2000). The 1988 Yellowstone National Park wildfire impacted communities in three states due to the exceeded the NAAQS of PM10 triggering public health alerts and advisories.

Ozone, a product of biomass combustion, is a precursor to greenhouse gases. Although ozone produced by prescribed fire usually is quickly diluted and dispersed into the air, it may bring wildland fire under scrutiny as a contributor to the greenhouse effect. Additionally wildland fires contribute approximately one fifth of the total global emissions of carbon dioxide (Sandberg et al, 2000).

Wildlife

Assessing the economic implication of fire on wildlife without a recognized valuation technique makes quantifying problematic. However, wildlife can be generally expressed in terms of the value of a consumptive use (i.e. hunting) or non-consumptive use (viewing, bird watching). Loss of revenue may

Table 11-4 HEALTH EFFECTS BASED ON VISIBILITY			
Visibility Range	**Health Category**	**Health Effects**	**Cautionary Statements**
10 miles and up	Good	None	None
6–9 miles	Moderate	Possibility of aggravation of heart or lung disease among persons with cardiopulmonary disease and the elderly	None
3 to 5 miles	Unhealthy for sensitive groups	Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly.	People with respiratory or heart disease, the elderly and children should limit prolonged exertion.
1 ½ to 2 ½ miles	Unhealthy	Increase aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in general population.	People with respiratory or heart disease, the elderly and children should avoid prolonged exertion; everyone else should limit prolonged exertion.
1 mile	Very unhealthy	Significant aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; significant increase in respiratory effects in general population.	People with respiratory or heart disease, the elderly and children should avoid any outdoor activity; everyone else should avoid prolonged exertion.
Under ¾ mile	Hazardous	Serious aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; serious risk of respiratory effects in general population.	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly and children should remain indoors.
Source: Air Quality: Department of Environmental Quality, Oregon			

be seen in hotels, restaurants, gasoline stations, and grocery stores due to wildland fires and patrons not visiting the area.

The major impact of wildfire on wildlife centers is its influence on vegetation structure and composition. The loss of down and dead woody material, during wild and prescribed burns, removes essential structural habitat components for a variety of wildlife and reduces species diversity. Loss of brush fields and forestlands restrict the ability of wildlife to forage for food and find shelter. Fire has the potential to accentuate impacts to fish and wildlife associated with other landscape fragmentation and development (timber harvesting, road building, forest management practices). For fish, the primary concerns relative to fire are increases in water temperature, sediment loading, stream cover, and the long-term loss of woody debris from stream channels. Loss of vegetation also increases the rate of erosion along stream banks.

Change in species composition from intense wildfire favor early successional habitat and its assorted wildlife populations. Significant increase in browsing species population (such as deer) is common following severe fire. Physical movement of animals is also enhanced after wildfire. However, in chaparral, mountain lions are attracted to the edges of the burned area where deer tend to congregate (Lyon et al, 2000). Low intensity fires do not generally results in significant changes to vegetation composition and resulting wildlife species, but may have similar benefit by increasing the diversity of vegetation mosaics providing better food and cover border areas.

Bird populations generally respond to changes in food, cover, and nesting caused by fire. Fire effects on insect and plant eating bird population depend on alterations in food and cover. Some species of birds may increase in numbers after a fire, such as the swallow, swifts, and flycatchers, allowing greater access to forage. Several species such as the California gnatcatcher require structure and cover provided by mature scrub (Lyon et al, 2000). Bird nest site selection, territory establishment, and nesting success can be affected by season of fire. Spring burns may destroy active nest (Lyon et al, 2000).

Direct effects on wildlife population due to wildfires vary depending on body size, mobility of the specie, and intensity of the fire. Most animals move away form wildfires, but some (insectivorous birds, raptors) may be attracted, to take advantage of available prey (Lyon et al, 2000). Large mammal mortality is most likely when fire fronts are wide and fast moving, fires are actively crowning, and thick ground smoke occurs (USDS, 2000). Although few studies have been conducted, it is believed that losses to wildlife due fire is negligible. The large fires of 1988 in the Greater Yellowstone Area killed about one percent of the elk population, further more, most of the larger animals died of smoke inhalation (Lyon et al, 2000). However, like birds, spring fires may impact mammal population due to limited ability to produce offspring, find cover, and availability of food. Carnivores and omnivores are opportunistic species and although little increase in species occurs, they tend to thrive in areas where their preferred prey or forage is most plentiful, often in recent burn areas (Lyon et al, 2000).

Indirect effects on the wildlife population come in the form of preference of certain forest structural attributes characteristics of plant communities indirectly lost through habitat modification. For example, a major concern is fire risk to preferred habitat of the California spotted owl (CDF, 1995).

Rangeland

Rangelands in Upper Pit River Watershed play an important role in the state's overall production of range livestock. Sagebrush Steppes and their associated bunch grasses were the primary rangelands of the Upper Pit River Watershed. The sagebrush scrub continues to play and important role in rangeland uses of the Upper Pit River Watershed. In addition, sagebrush rangelands provide important winter range habitat to mule deer and pronghorn antelope (California Department of Fish and Game, 2002). Wildfire impacts or the lack of wildfire is believed to have had a significant impact on these important local rangelands. Cheatgrass (*Bromus terctorum*), medusahead (*Taeniatherum caput-medusae*), and other exotic annual plants have displaced many of the native bunchgrasses present on the sagebrush steppe and, more importantly, the encroachment of western juniper has resulted in significant reductions in carrying capacity.

Western juniper is now the dominant species on as much as 20 percent of the Upper Pit River Watershed. It is rapidly expanding into another 20 percent of the area. Over the last 130 years, western juniper has spread by ten fold in northeastern California (Bureau of Land Management, 2003). Analysis of the BLM data for the Upper Pit River Watershed gives an estimate that 43 percent of the area currently has juniper cover above 5 percent, 21 percent of the area has cover juniper cover above 20 percent, and 6 percent of the area has juniper cover above 30 percent. The distribution of juniper is variable; it is most concentrated in the northeastern half of the Upper Pit River Watershed. (For a more detailed discussion see Section 7, "Vegetation.")

Although a direct cause and effect connection has not been established, the reasons for the expansion of juniper likely pertain to climate, fire suppression, and overgrazing. The concurrent histories of overgrazing and fire suppression have likely facilitated the spread of juniper. The eating down of grasses by livestock reduced fine fuels and the frequency of fire in the sagebrush-juniper interface. Juniper regeneration is particularly susceptible to fire until it reaches about 50 years of age (Young and Evans, 1981), and natural fire return intervals in sagebrush were historically on the order of 15 to 25 years (Miller and Rose, 1995).

There appears to be a fair amount of controversy surrounding the issue of the possible ecological effects of juniper encroachment and proposed management options (Belsky, 1996). The disputed effects include alteration of the fire disturbance and hydrological regimes, displacement of sagebrush and other vegetation, and adverse impacts to wildlife habitat for some species including the sage grouse (*Centrocercus urophasianus).* Miller et al. found a significant relationship between increased juniper densities and decreased big sagebrush, perennial herb, and aspen densities. For example, they report that when juniper canopies reached 50 percent of maximum woodland cover, the shrub layer declined to 80 percent of maximum potential in the big sagebrush communities they examined.

Studies have indicated that through controlled burning, range livestock can benefit. Early setters of the Flint Hill region of Kansas discovered that cattle selected forage from burned range more readily than from unburned range. This discovery lead to the observation that steers gained weight faster by grazing on burned range (USGS, 2000).

Recreation

While concentrated recreation within the watershed is limited, the watershed does provide for considerable dispersed recreation (hunting, fishing, hiking, sight-seeing). Wildfire impacts recreation values through loss of use, reduced wildlife habitat and change in species mix of vegetation. Areas burned that attract visitors for hunting and fishing will diminish in value after wildfire, as visitors are not attracted to burned forests. Wildlife that loose habitat and forage will disperse to other locations, resulting in lower hunter numbers for several years. Additionally, wildfires that significantly change the vegetation composition (forest to brush) result in visitors' by passing these areas.

While direct economic loss from land use can be measured, it is more difficult to estimate losses to recreational activities Recreation use numbers tend to display visitors in terms of users per day and are detailed towards specific attractions (campgrounds, park, forests). Three National Park Service (NPS) studies determined that air quality conditions affected the amount of time and money visitors' area willing to spend at NPS units (USDA, 2000). In the Upper Pit River Watershed, the loss in recreational value can be similar to these other locations, but the economic loss more subtle. This may equate to reduction in tourist traffic at local stores, restaurants, and gas stations that is masked by other overriding economic factors, such as the increase in gasoline costs.

Timberland

Timberland loss can be significant during wildfire. The most noticeable direct effect is loss of timber and its economic value. Catastrophic stand replacing fires tend to remove much of the usable wood fiber from the landscape due to the intense fire conditions. Any remaining timber is generally of low quality, low value, scattered over the fire area, and has a reduced economic value. Reforestation efforts are expensive and time consuming, generally in excess of $500 per acre. The resulting forests require periods of intensive management with no economic return for up to 60 years. Indirect effects of fire include loss in soil productivity, changed forest successional characteristics, reduced forest health and increased risk of insect and disease infestation.

Human Resources

Wildfire poses a significant risk to human health and property and fire fighter safety. Population growth has climbed steadily in the areas outlining population centers. Human-caused ignitions generally tend to increase with population. Losses are both economical and social, as many non-renewable in the form of historical buildings and site, as well as memories of family.

FUEL LOADING AND CONDITIONS

Fire behavior is a function of fuels, weather, and topography. Of these components, referred to as the fire triangle, only fuel conditions can be influenced by human activity. Fuel parameters important to fire behavior that affect intensity, speed of spread, and behavior include, loading, size and shape, compactness, horizontal continuity, vertical continuity and species.

Fuels

In the Mediterranean climate of California, decomposition rates are low, due to low temperatures during the winter and little to no moisture in the summer months. Rates for decomposition maybe greater than in the past due to: 1) this century has been warmer and wetter, 2) the generally denser stands during this century have provided more mesoic microclimates that favor decomposition, and 3) more forest floor biomass has been available for decomposition because it has not been removed regularly by fire in the twentieth century (Skinner and Weatherspoon, 1996). Although decomposition may have increased, it is at a rate not nearly sufficient to compensate for the increasing fuel load due to logging slash and natural (not produced by management activities) fuels (Skinner and Weatherspoon, 1996). CDF data on fuel loading and risk is included as Figure 11-3. The USFS fuel inventory data and SPI fuel inventory data were not available.

Weather

The weather in the Upper Pit River Watershed is variable by season, but during the fire risk period of summer, the dominant wind condition is usually from the southwest to northeast and often driven by thunderstorms. Generally, the fires that have occurred in the watershed have progressed from southwest to northeast.

Precipitation for the Upper Pit River Watershed ranges between 4.94 inches to 20.80 inches per year with and average annual precipitation of 12 inches. Average temperature for the area during daytime during the summer months is 89ºF with a low of 42ºF. Winter daytime high is 46ºF. Winter nighttime low is 20ºF. Low precipitation increases wild fires potential during summer months.

Topography

Topography is a key element to the direction, intensity and rate of speed of fire. Aspect, steepness of slope elevation and shape all contribute to how a fire behaves once ignited. Surface fires are very dependent on topography and generally move more quickly upslope than down slope and may slow significantly over ridges. A fire will spread faster and have longer flame lengths as the slope becomes steeper. The fire heats and dries fuel above it, causing the fuel to burn. For this reason, CDF commonly uses ridges for fuel breaks and protection areas.

FIRE PROTECTION

Prevention, detection, pre-suppression, suppression, and fuels management are the five programs in fire protection on high fire risk lands. These activities are carried out under both separate federal and state fire policies. The Policy for federal and state programs is summarized in this section.

Fire Policy

Federal

The average number of annual recorded fires on the Modoc National Forest has not changed significantly. USFS Land and Resource Management Plans from 1910 to 1979 show that more than 6,094 fires burned 705,334 acres of forest. Twenty-three percent of these fires were caused by people, and 77 percent were started by lightning. In the last 25 years, the number of human-caused fires has decreased dramatically as a result of intensive public education programs.

Acreage burned has varied widely. From 1910 through 1969, an average of 9,607 acres burned annually. From 1970 through 1979, the average number of acres burned rose to 12,890 while the average annual acres burned decreased to 1,393 from 1980 to 1985. Cooler, moister weather than normal, as well as fewer lightning-caused fires, account for the dramatic drop in burned acres. The 1997 drought and dry lightning resulted in one 100,000-acre fire that year.

Prior to 1996, fire and fuel management activities were governed by the Forest Land and Resource Management Plan. Changes in the Federal Wildland Fire Management Policy established the National Fire Plan. After the record-breaking wildfire season of 2000, the President requested a national strategy for preventing the loss of life, natural resources, private property, and livelihoods in the wildland/urban interface. Working with Congress, the Secretaries of Agriculture and Interior jointly developed the National Fire Plan (NFP) to respond to severe wildland fires, and reduce their impacts on communities, and assure sufficient firefighting capabilities for the future. The NFP includes five key points:

- Firefighting preparedness
- Rehabilitation and restoration of burned areas
- Reduction of hazardous fuels
- Community assistance
- Accountability

As part of the community assistance, the USFS, BLM, and tribes identified "at risk" communities. Eventually, all towns in the Upper Pit River Watershed have been identified as a community at risk in the Federal Register.

The USFS and the BLM are in the second year of the NFP implementation. Significant headway has been made since 2001 to meet both the intent and specific direction from Congress in the 2001 Interior and Related Agencies Appropriations Act. There are also tracking and reporting mechanisms in place to provide accountability as accomplishments are made in firefighting, rehabilitation, and restoration; hazardous fuels reduction; community assistance; and research.

The NFP is a long-term investment that will help protect communities and natural resources, and most importantly, the lives of firefighters and the public. It is a long-term commitment based on cooperation and communication among federal agencies, states, local governments, tribes, and interested public. To date, the Modoc National Forest has conducted over 5,000 acres of fuel reduction activities.

In addition to the NFP, the Sierra Nevada Forest Plan Amendment, Record of Decision (ROD) jointly amends the planning documents of nineteen National Forests to implement conservation measures for late successional stage and old growth forests for the purpose of spotted owl management. The ROD consists of extensive standards and guidelines that comprise "a comprehensive ecosystem management strategy" which supercedes other federal land management plans. To accomplish this, the ROD divides federal lands into land allocation categories with specific "standards and guidelines" for management of each category. The land allocation associated with fire included:

- South Warner Wilderness Area – South Warner Wilderness Fire Management Plan

- Inventoried Roadless Area – "Fuel treatments in inventoried roadless areas may be considered stewardship treatments and therefore permissible under the Roadless Rule."

- Old Forest Emphasis Area – "Management in old forest emphasis areas to emphasize protecting the highest quality remaining old forest landscapes, increasing old forest conditions, using prescribed fire to reduce hazardous fuel conditions, and re-introducing fire as an ecosystem process. Mechanical treatments will be avoided in old forest emphasis areas except in areas with (1) air quality concerns, (2) high risk of prescribed fire escapes, (3) excessive surface and ladder fuels, (4) unacceptable risks to old forest characteristics, or (5) prohibitive implementation costs."

- Wildland Urban Interface – (WUI) "The highest priority has been given to fuel reduction activities in the WUI. Fuel reduction treatments protect human communities from wildfires as well as minimize the spread of fires that might originate in urban areas." "Management direction for the urban wildland intermix zones is to: (1) design fuel treatments to provide a buffer between developed areas and wildlands; (2) design and distribute treatments to increase the efficiency of firefighting efforts and reduce risks to firefighters, the public, facilities and structures, and natural resources; (3) determine the distribution, schedule, and types of fuel reduction treatments through collaboration with local agencies, air regulators, groups, and individuals; and (4) place the highest density and intensity of treatments in developed areas within the urban wildland intermix zone.

- Strategically Placed Area Treatments (SPLATs) – These are areas that have been treated to reduce fuel loading. "The treatment areas are placed so that a spreading fire does not have a clear path of untreated fuels from the bottom of the slope to the ridge top." "The SPLAT strategy treats a relatively large proportion of the landscape and this strategy facilitates fire reintroduction."

- General Forest – "Management direction is to reduce hazardous fuels to effectively modify wildland fire behavior to reduce uncharacteristically severe wildland fire effects; and increase the numbers of large trees and the distribution and connectivity of old forests across landscapes."

"The Amended Forest Plan" (page A-10) applies a strategic approach for locating fuels treatments across broad landscapes. WUI have the highest priority for fuel treatments. Fuels treatments for landscape fuels management are designed to limit wildland fire extent, modify fire behavior, and improve ecosystems (USDA, 2001s).

A WUI is an area where human habitation is mixed with areas of flammable wildland vegetation. In order to protect human communities from wildland fires and minimize the spread of fires that might originate in the WUI, the highest priority has been given to fuel reduction treatment activities within the WUI. A WUI contains an "inner defense zone" that is located within quarter-mile from the inner defense zone outward for 1.25 miles. Fuels are treated less intensively within the threat zone than in the inner defense zone.

The desired condition for WUI is that fuel conditions allow for efficient and safe suppression of all wildland fires. Fires are controlled through initial attack under all but the most severe weather conditions. Under high weather conditions, wildland fire behavior in treated areas is characterized as follows:

- Flame lengths at the head of the fire are less than four feet

- The rate of spread at the head of the fire is reduced to at least 50 percent of pre-treatment level for a minimum of five years

- Hazards to firefighters are reduced by keeping snag levels to two per area and production rates for fireline construction are doubled from pre-treatment levels

In general, landscape-level fuels treatment strategies are designed to limit wildland fire extent, modify fire behavior, and improve ecosystems. These strategies allow fire managers to control fires and set priorities that protect fire fighters, the public, property, and natural resources. SPLATs are one of those strategies. SPLATs are blocks of land ranging from 50 to 1,000 acres where the vegetation has been modified to reduce fuel loading. The spatial pattern of the treated areas reduces the rates in which fires spread and intensify at the head of the fire. The SPLAT strategy treats a relatively large portion of the landscape that facilitates fire reintroduction. SPLATs are designed to burn at lower intensities and slower rates of spread during wildfires than comparable untreated areas. Hence, wildfires are expected to have lighter impacts and be less damaging in treated areas.

The desired future condition is embodied in the Modoc Land and Resource Management Plan mission and goals, forest standards and guidelines, management prescriptions, and land allocation area direction. The desired condition will result in integrating fuels objectives with other natural resource objectives that address the role of fire as well as maintaining a level of resource protection commensurate with values.

Fuel management strategies are designed to reintroduce fire, reduce fuels, and mitigate the consequences of large damaging fires. In general such landscape level treatment is designed to limit fire extent, modify fire behavior, and improve ecosystems.

Throughout the forest a strategic approach for fuel treatment is to be used. Priority for fuel treatment will be areas of urban intermix, old forest emphasis, and general forest. The primary strategies to use include a combination of treatments in strategically placed locations, wildland fire use, defensible fuel profile zones, and priority setting mechanisms established in the National Fire Strategy. The Modoc Forest Land and Resource Management Plan, as amended by the Sierra Nevada Forest Plan Amendment-Record of Decision provides further Standards and Guidelines for fuel treatments. The following discussions display applicable direction from these plans.

WUIs are designed to protect human communities from wildland fires as well as minimize the spread of fires that might originate in urban areas. The management objective in the urban intermix is to enhance fire suppression capabilities by modifying fire behavior inside the zone and provide a safe and effective area for possible future suppression activity. The intent here is to provide a buffer between developed areas and wildlands. The intermix zones are broken into two categories with differing treatment standards:

- Defense Zone – This is a quarter mile buffer zone around the urban development itself. In this zone where canopy cover is less than 40 percent, desired flame lengths are under 4 feet, crown bulk densities are at .05 kg/m^2, and live crown base are at an average of 15 feet high. Snag levels are kept under two snags/acre for firefighter safety. The predicted rate of spread of the fire is 50 percent of pre-treatment levels and line construction accomplishment rates are doubled.

- Threat Zone – This is a 1.25 miles buffer zone beyond the defense zone. In this zone where canopy cover is less than 40 percent, desired flame lengths are under 6 feet with crown bulk densities and live crown base levels the same as the defense zone.

The desired condition here is to provide for efficient and safe suppression of all wildland fire starts in the hopes of controlling them under even the most severe weather conditions. These zones include not only the sites themselves but also the continuous slopes and fuels that lead directly to the urban sites in need of protection thus the modification of the fuel profile around them.

Desired Condition-Old Forest Emphasis and General Forest

Land management objectives for both of these allocations are to focus treatment priorities on areas of high hazard and high risk. Primary locations for treatment of fuels would be in lower elevations that are pine/mix conifer dominant, typified in eastside pine, which are low intensity regimes historically, Also of prime concern is the upper two-thirds of slopes with south and west aspects as these areas typically burn more often due to exposure and slope. Desired conditions are that 75 percent of the area will have flame lengths less than six feet during weather variables described as 90th percentile conditions. While this flame length is only recommended for Old Forest Emphasis areas it applies as well to General Forest as a regionally recognized acceptable fire behavior measurement level.

Big Sage Fire Management Unit (BSFMU) – In 1980, the Forest developed the BSFMU. This 430,000-acre area on the Devil's Garden and Doublehead Ranger Districts is designed to save suppression costs and personnel for fires that threaten higher resource values. Vegetation in the BSFMU is so sparse and the ground so rocky that fire does not easily spread, even under dry, windy conditions. Most fires in the BSFMU involve single juniper trees. The fire plan for the Unit allows lightning-caused fires to burn under a confine, contain, and control strategy.

Wilderness Fire Suppression – The South Warner Wilderness Fire Management Plan provides a working guide for implementation of a Wildland Fire Use program for wilderness resource benefit within the South Warner Wilderness. The plan is divided into two major sections: 1) Environmental Assessment Summary, and 2) Operations. Included in the Environmental Summary are fire use management objectives for the South Warner Wilderness and descriptions of the fire use management area. The Operation section provides detailed guidance and direction for Wildland Fire Use within the South Warner Wilderness. General objectives of the plan include:

1. Permit lightning caused fires to play, as nearly as possible, their natural ecological role in the South Warner Wilderness.

2. Reduce, to an acceptable level, the risks and consequences of a wildfire within the South Warner Wilderness or escaping from the South Warner Wilderness.

The elements of fire management on the Modoc National Forest are prevention, detection, suppression, and fuels management.

Prevention – Prevention includes public contacts, law enforcement, building inspection, and patrols. Prevention has a low priority because the Modoc National Forest averages 100 lightning fires annually.

Suppression – Suppression includes the customary firefighting activities with hand crews, engines, helitack, and retardant aircraft. With its own suppression forces, the Modoc National Forest cooperates with the CDF, BLM, Lava Beds National Monument (LBNM), and the USFWS to protect mutual boundaries for cost efficient fire suppression. In addition, local rural fire departments protect structures on some federal and state lands. Altogether, the Modoc National Forest is responsible for protecting 1,805,069 acres.

State

The State Board of Forestry and the CDF have drafted a comprehensive update of the fire plan for wildland fire protection in California. The planning process defines a level of service measurement, considers assets at risk, incorporates the cooperative interdependent relationships of wildland fire protection providers, provides for public stakeholder involvement, and creates a fiscal framework for policy analysis.

The overall goal is to reduce total costs and losses from wildland fire in California by protecting assets at risk through focused pre-fire management prescriptions and increasing initial attack success.

The California Fire Plan has five strategic objectives:

- To create wildfire protection zones that reduces the risks to citizens and firefighters.
- To assess all wildlands, not just the state responsibility areas. Analyses will include all wildland fire service providers – federal, state, local government, and private. The analysis will identify high risk, high value areas, and develop information on and determine who is responsible, who is responding, and who is paying for wildland fire emergencies.
- To identify and analyze key policy issues and develop recommendations for changes in public policy. Analysis will include alternatives to reduce total costs and losses by increasing fire protection system effectiveness.
- To have a strong fiscal policy focus and monitor the wildland fire protection system in fiscal terms. This will include all public and private expenditures and economic losses.
- To translate the analyses into public policies.

Five major components form the basis of an ongoing fire planning process to monitor and assess California's wildland fire environment.

Wildfire protection zones – A key product of this Fire Plan is the development of wildfire safety zones to reduce citizen and firefighter risks from future large wildfires.

Initial attack success – The fire plan defines an assessment process for measuring the level of service provided by the fire protection system for wildland fire. This measure can be used to assess the department's ability to provide an equal level of protection to lands of similar type, as required by Public Resources Code 4130. This measurement is the percentage of fires that are successfully controlled before unacceptable costs are incurred. Knowledge of the level of service will help define the risk to wildfire damage faced by public and private assets in the wildlands.

Assets protected – The plan will establish a methodology for defining assets protected and their degree of risk from wildfire. The assets addressed in the plan are citizen and firefighter safety, watersheds and water, timber, wildlife and habitat (including rare and endangered species), unique areas (scenic, cultural, and historic), recreation, structures, and air quality. Stakeholders (national, state, local, a private agencies, interest groups, etc.) will be identified for each asset at risk. The assessment will define the areas where assets are at risk from wildfire, enabling fire service managers and stakeholders to set priorities for pre-fire management project work.

Fiscal framework – The Board of Forestry and CDF are developing a fiscal framework for assessing and monitoring annual and long-term changes in California's wildland fire protection systems. State, local, and federal wildland fire protection agencies, along with the private sector, have evolved into an interdependent system of pre-fire management and suppression forces. As a result, changes to budgeted levels of service of any of the entities directly affect the others and the services delivered to the public. Monitoring system changes through this fiscal framework will allow the Board and CDF to address public policy issues that maximize the efficiency of local, state, and federal firefighting resources.

Fire Safe Councils

Fire safe councils are an outgrowth of the National Fire Policy Firewise program. Most are funded through the National Fire Policy grant funds to initiate and develop community based outreach and education programs. The Modoc Fire Safe Council is active and can be contacted at:

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FIRE MANAGEMENT TOOLS

In addition to the suppression of fire, many other tools are available to resource managers to reduce wildfire risk and impact.

Defensible Fuel Profile Zones (DFPZs)

DFPZs are strategically located lineal fuel reduction and fire protections areas that are generally construction a quarter mile wide along public and private roads that traverse communities, watersheds, and areas of special concern. Within the DFPZ, the hazardous surface, ladder, and canopy fuels are mechanically reduced to historic levels that allow fire fighters quicker and safer access to the DFPZ for attacking and suppressing oncoming forest fires. The lineal connectivity of the DFPZ network allows various property owners within a watershed the opportunity to connect fuel reduction projects to adjoining properties through local County Fire Safe Councils. The DFPZ network is the starting point for addressing the scale of the existing hazardous fuel problem at the appropriate pace of annual acres treated.

DFPZ fuel reduction treatments should be designed to address the specific local issues (e.g. establishing a community defense zone, or breaking up areas of continuous high-hazard fuels, or designating a strip or block of land to form a zone of defensible space where both live and dead fuels are reduced, also referred to as shade fuel breaks.

Such DFPZs are best initially placed primarily on ridges and upper south and west slopes and, where possible, along existing roads. They also should be located with respect to urban-wildland intermix and other high-value areas (such as old-growth or wildlife habitat areas), areas of high historical fire occurrence, and/or areas of heavy fuel concentration. Thinning from below and treatment of surface fuels can result in fairly open stands, dominated mostly by larger trees of fire-tolerant species.

DFPZs need not be uniform, monotonous areas, however, but may encompass considerable diversity in ages, sizes, and distributions of trees. The key feature should be the general openness and discontinuity of crown fuels, both horizontally and vertically, producing a very low probability of sustained crown fire.

DFPZs should offer multiple benefits by providing not only local protection to treated areas (as with any fuel-management treatment) but also safe zones within which firefighters have improved odds of stopping a fire, interruption of the continuity of hazardous fuels across a landscape, and various benefits not related to fire, including improved forest health, greater landscape diversity, and increased availability of relatively open forest habitats dominated by large trees.

DFPZ and fuel break locations in the Upper Pit River Watershed are shown on Figure11-4. Typical DFPZ density is included on Figure 11-5.

Prescribed Fire

Prescribed fire is the controlled application of fire to the land to accomplish specific land management goals. These goals can vary from annual burning around residences to clear grass and weeds, to agricultural field burning for preparation of crop planting, burning of brush piles, and landscape burning of forest to remove brush and accumulation of forest fuel. Forestlands can benefit from prescribed fire by attempting to regulate or moderate the frequency and intensity of wildfires. The advantages of using fire and improvement cuttings to restore and maintain seral, fire-resistant species include:

1) Resistance to insect and disease epidemics and severe wildfire.
2) Providing continual forest cover for esthetics and wildlife habitat.
3) Frequent harvests for timber products.
4) Stimulation of forage species.
5) Moderate site disturbance that allow for tree regeneration (Arno, 2000)

By returning to regular burning, forest can achieve a measure of protection from catastrophic loss by reducing the amounts and concentration of brush and other forest fuels.

Historical land-use changes in the upper watershed make a return to the pre-historical fire regime infeasible. Not only are structures, infrastructures, and managed forest at risk of fire damage too expensive to permit burning at the pre-settlement rate, but regulatory constraints and social costs of fire and its effects (e.g., low air quality) also prohibit burning at pre-European scales (SAF, 1997). Although fire will remain an essential element of these wildland ecosystems, it must be controlled and used in conjunction with other techniques to reduce fuel loads to levels consistent with maintaining healthy forests (McKelvey et al, 1996).

Mechanical fuel management can reduce fire hazard. Recent studies of the behavior of fires immediately following harvesting found that harvesting, or biomass fuel reduction with slash and landscape treatments followed by prescribed burning, produced fuels structures that minimize average fire intensities, heat per unit area, rate of spread, area burned, and scorched heights. In contrast, sanitation-salvage harvest without biomass reduction and just lopping and scattering of slash resulted in higher fire intensities. The latter treatments probably result in less severe fires relative to untreated stands, especially after sufficient time has passed to allow the slash to decompose (SAF, 1997). In addition, wildfires burn into areas where fuels have been reduced by prescribed burning cause less damage and are much easier to control.

Prescribed fire can also be an effective tool for managing fuels. In most forested areas, however, fuel structures are currently too hazardous to safely attempt prescribed ignitions without pre-treating the stand mechanically. Planned non-suppressions fires are fires resulting from unplanned ignitions (caused by either lightning or humans) in areas for which prescribed natural fire plans have been adopted specifying conditions under which such fires will be allowed to burn. Prescribed natural fire planning following specific fire management activities represents an important opportunity to have wildfire help meet watershed management objectives

A key element to fuel management planning is the initiation of market uses for small trees and biomass removed from wildlands under fuels management programs.

The intensity and temperature of most prescribed fire scenarios are significantly less than catastrophic wildfire and produce positive rather than negative ecosystem impacts. Benefits of prescribed fire include:

- ***Reduction of fuel buildup*** of dead wood, overcrowded, unhealthy trees and thick layers of pine needles and ground vegetation that can contribute to larger in size, intensity and more uncontrollable fires.

- ***Thinning of overcrowded forest***s that have been thinned by fire. These forests are generally healthier and more vigorous, recover faster and more resistant to insect and disease attacks.

- ***Preparation of the site for new growth*** by removing excess vegetation. As the excess vegetation is burned, nitrogen and other nutrients are released, allowing the soil to be receptive for new plants to grow and allowing conifer seeds to germinate. Additionally, some forms of conifers and brush (knobcone pine, lodgepole pine manzanita, deer brush) rely on frequent fire for germination of seeds and new growth development.

- ***Creation of diverse vegetation for wildfire*** by having varying ages and type of plants available for animals to forage on and find shelter in. Wildlife that graze (deer, elk) benefit from new growth as young plants provide more nutrients. Fire can create more open stands that allow predators to be seen and down wood for small mammals and insects.

- ***Increase in water and spring yield by removing*** encroaching chaparral and shade tolerant species and decreasing evapotranspiration, increases occur in local springs and groundwater discharge to creeks. Significant increased flows are common after fires and spring yield may increase as much as 200 percent (R. Bursy, undated).

- ***Increase in nutrients*** such as phosphorus, potassium, calcium, and magnesium in the ash deposits (Ahlegren and Kozlowski, 1974).

California Vegetation Management Plan (CVMP)

The CVMP is a cost-sharing program that focuses on the use of prescribed fire and mechanical means, for addressing wildland fire fuel hazards and other resource management issues on State Responsibility Area lands. If the use of prescribed fire mimics natural processes, it restores fire to a historical role in wildland ecosystems, and provides significant fire hazard reduction benefits that enhance public and firefighter safety. The goals of this program are to:

- Reduce fuel accumulations
- Prepare seedbeds
- Control competition vegetation
- Improve production of grazing and forest lands
- Manage of wildlife habitat
- Thin young trees
- Control of pests and disease
- Increase water yield
- Improve fish habitat
- Improve air quality
- Protect irreplaceable soil resources

CVMP allows private landowners to enter into a contract with CDF to use prescribed fire to accomplish a combination of management goals on both forestlands and grasslands. Since 1981, approximately 500,000 acres (an average of 31,000 acres per year) have been treated with prescribed fire under CVMP in California. Cost of the prescribed burning averages $25 to $30 per acre but can vary based on the number of acres and resources necessary for the prescribed fire project. This cost sharing program with the landowner paying approximately 25 to 30 percent of the total project costs.

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