United States
Department of
Agriculture

Forest
Service

November 2010

Pit Arm Shasta Lake Watershed Analysis

Shasta Unit – Shasta-Trinity National Recreation Area
Shasta-Trinity National Forest

For More Information Contact:
Shasta Lake Ranger Station
14225 Holiday Road
Redding, CA
(530) 275-1587

Table of Contents

List of Tables

List of Figures

List of Photos

Introduction

About This Analysis

This watershed analysis is presented as part of the Aquatic Conservation Strategy adopted for the President's "Northwest Forest Plan" (Record of Decision [ROD] for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl, including Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Related Species; USDA Forest Service and USDI Bureau of Land Management 1994).

The preparation of a watershed analysis for the Pit Arm Shasta Lake watershed follows direction in the Aquatic Conservation Strategy that requires watershed analysis "for roadless areas in non-key watersheds, and riparian reserves prior to determining how land management activities meet Aquatic Conservation Strategy objectives" (ROD, p. B-20).

This document is guided by two levels of analysis:

- Core topics - provide a broad, comprehensive understanding of the watershed.

Core topics are provided in "Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis", Version 2.2 (Regional Interagency Executive Committee and the Intergovernmental Advisory Committee 1995) to address basic ecological conditions, processes, and interactions at work in the watershed.

- Issues - focus the analysis on the main management questions to be addressed.

Issues are those resource problems, concerns, or other factors upon which the analysis will be focused. Some of these issues prompted initiation of the analysis. Other issues were developed from public input in response to scoping or were identified by the team during the analysis process.

Key analysis questions are developed for each issue. These questions are organized by analysis step to help focus the analysis and to provide organization to the document while addressing the issues.

This analysis documents an analysis of the Pit Arm Shasta Lake watershed located in the Shasta Unit of the Shasta-Trinity National Recreation Area in the Shasta-Trinity National Forest. The Pit Arm Shasta Lake watershed was selected for analysis to enable the Forest Service to plan long-term management of the watershed.

The purpose of this analysis is to provide district resource managers with a scientifically based understanding of the ecological processes and interactions occurring within the watershed area and how past and present activities and events interact with the physical, biological, and social environments. This information can then be used as a basis from which to make future decisions about the management of resources in the Pit Arm Shasta Lake watershed. While this document provides management recommendations, it is not a decision document. No direct changes in the management of resources in this watershed will occur without separate documentation, public involvement, and further environmental analysis.

The Analysis Process

This analysis used the six-step process as outlined in the Federal Guide for Watershed Analysis. The six-step process includes the following:

- **Step 1: Characterization** – identifies the dominant physical, biological and human processes or features of the watershed that affect ecosystem function and conditions.
- **Step 2: Identification of Resource Issues and Key Questions** – focuses the analysis on the key elements of the ecosystem that are most relevant to the management objectives, human values or resource conditions within the watershed.
- **Step 3: Description of Current Conditions** – documents the current range, distribution and condition of the relevant ecosystem elements.
- **Step 4: Description of Reference Conditions** – documents how ecological conditions have changed over time as a result of human influence and natural disturbances.
- **Step 5: Synthesis and Interpretation of Information** – compares existing and reference conditions of specific ecosystem elements to explain significant differences, similarities or trends and their causes.
- **Step 6: Recommendations** – brings the results of the previous steps to conclusion, focusing on management recommendations that are responsive to watershed processes identified in the analysis.

The analysis also evaluates conditions in the Pit Arm of Shasta Lake Watershed as they relate to conditions at larger scales. Comparisons were made with information on the larger Pit River Basin and the Shasta-Trinity National Recreation Area (NRA). This analysis also discusses the importance of unique geological and biological features within the watershed with regard to paleontological records and rare flora and fauna on the west coast of the United States.

Watershed analysis is a continuous process. This analysis is a dynamic document and is intended to be revised and updated as new information becomes available.

Step 1. Characterization of the Watershed

Location

The Pit Arm Shasta Lake watershed analysis area is part of the Pit River drainage. The analysis area is bounded by the ridges separating the lower Pit River from Squaw Creek to the northwest and Pit No. 7 watershed to the east, by the national forest boundary line to the south, and by the confluence of the Pit Arm and the Sacramento Arm of Shasta Lake to the west (see figure A-1 in Appendix A).

Watershed Setting

The Pit Arm is the longest of five arms in Shasta Lake. Two of the arms, Squaw Creek and the McCloud Arm, merge into the Pit Arm before the confluence with the Sacramento River. Physical conditions and land use patterns in the Pit Arm between Jones Valley and the Sacramento River confluence are typified by steep hillslopes of varied geology dissected by the

Pit Arm. High-density recreation use occurs on the lake and its shoreline. Much of the remaining area is rugged and inaccessible and is essentially unroaded. Human use along the shoreline upstream of Jones Valley becomes markedly less frequent. Terrain becomes generally less steep in the eastern analysis area and is characterized as rugged with low road density.

Relationship to Larger Scale Setting

Many physical, biological and human processes or features span areas much larger than a watershed. To appropriately characterize and analyze specific aspects of the watershed, the watershed needs to be placed in its logical setting with respect to these larger scales.

Two larger-scale settings need to be considered when addressing the Pit River Watershed:

- The Pit River Basin
- The Shasta-Trinity National Recreation Area

The Pit River Basin

The Pit River Basin drains an area of approximately 5,319 square miles. The Pit River is the longest tributary of the Sacramento River and contributes up to 80 percent of the water volume in Shasta Lake. It is one of three rivers that cross the Cascade Range. Its headwaters begin below Goose Lake; however, during rare high-flow events, overflow from the Goose Lake Basin spills into the North Fork of the Pit River. The Pit River flows through Modoc, Lassen and Shasta Counties. The river flows southwest for approximately 315 miles at its furthest point to its terminus at Shasta Lake (see figure A-2 in Appendix A). The Pit Arm watershed analysis area encompasses the lowermost 30 miles of the Pit River from the PG&E (Pacific Gas and Electric) Pit No. 7 afterbay to the river's confluence with the Sacramento River.

National Recreation Area

The Pit Arm Watershed lies within the Shasta Unit of the Whiskeytown-Shasta-Trinity National Recreation Area (NRA), which includes 212,000 acres on the Shasta Lake and Weaverville Ranger Districts of the Shasta-Trinity National Forests (see figure A-3 in Appendix A).

Geological and Biological Uniqueness

The limestone formation in the area around Shasta Lake is unique in its development, composition and contribution to economic and worldwide paleontological significance. For example, the McCloud limestone contains 36 species of rugose and tabulate corals, 23 of which should form the basis of new species. These fall into 16 genera, 4 of which are probably new to science.

Because of its diverse fossil faunas, the area immediately north of Shasta Lake and between its McCloud and Pit Arms is perhaps California's single most important area for paleontological research (Munthe and Hirschfield circa 1978). Marine invertebrate fauna fossils of Mississippian, Pennsylvanian and Permian age; marine invertebrate and vertebrate faunas of Triassic age; and faunas of Pleistocene age all occur in this small area.

The area immediately northwest of McCloud Bridge has produced several large Mississippian and Pennsylvanian invertebrate fossil records. Since this geologic period is poorly represented on the West Coast, these Shasta Lake faunas are important to understanding the late Paleozoic evolution in this part of the country.

The Permian paleontological record in the area north of Shasta Lake is also unique. Only the Mojave Desert harbors comparable California Permian fauna fossils. Research in the Shasta Lake area can provide an understanding into how West Coast invertebrate evolution compares with that on the rest of the continent.

Shasta Lake limestone formations have provided important Triassic marine invertebrate fossil records. Ichthyosaurs of the area have provided virtually everything known about this group's development during the late Triassic period in North America. Several new species and genera have been described based on collections made by J.C. Merriam and others from the University of California in the early 1900s; this work still stands as some of the most important information on ichthyosaurs. In addition to ichthyosaurs, the area has produced the only remains of *Thallatosauria* ever found in the Western Hemisphere. Ichthyosaurs were the most highly adapted reptiles for an aquatic existence, and thallatosaurs were small aquatic fish-feeding reptiles.

Limestone caves in the Shasta Lake area and tar pit entrapment at Rancho La Brea in Los Angeles have produced most of what is known about a large part of California in the late Pleistocene. Specifically, Potter and Samwell caves constitute virtually the entire knowledge of late Pleistocene vertebrate life in northern California.

The McCloud limestone also provides habitat for unique cave-adapted vertebrates and invertebrates and limestone-associated biota. Examples of flora and fauna associated with limestone formations and known to occur in the watershed include several rare snail species, the Shasta salamander, Shasta eupatorium (*Ageratina shastensis*), Howell's cliff-maids (*Lewisia cotyledon* ssp. *howellii*), and Shasta snow-wreath (*Neviusia cliftonii*).

Physical Features

Dominant Physical Features

The dominant physical feature of the watershed within the analysis area is the Pit Arm of Shasta Lake. Elevations range from 1,065 feet above sea level (the spillway elevation of Shasta Lake) to 3,788 feet on Hogback Mountain.

The only large subdrainage within the watershed is the Potem Creek drainage in the northeast portion of the analysis area. Numerous smaller tributary streams are characteristic the remainder of the Pit River watershed.

Figure A-4 in Appendix A displays the watershed's dominant physical features.

Climate

The Lower Pit Arm watershed is characterized by hot, dry summers and a mild climate during the remainder of the year. Daytime high temperatures commonly exceed 100 °F in the summer. Annual precipitation, mostly in the form of rain, varies from 45 to 75 inches depending on local topography. Approximately 85 percent of this precipitation falls from November 1 through April 30. Summer precipitation occurs predominantly as high-intensity short-duration thunderstorms.

Geology, Geomorphology, and Erosion Processes

As discussed above, the most unique geologic features in the Pit Arm watershed are the multiple limestone terranes, including the McCloud Formation and Hosselkus limestone area. In addition to containing numerous limestone caverns, limestone terranes also provide habitat for many cave-adapted invertebrates and limestone-associated biota.

The analysis area falls within the southeast extent of the Klamath Mountains province. The topography is rugged with prominent peaks and steep dissected drainages. Eroding hillslopes dominate the geomorphology features within the analysis area, although mass wasting features are frequent. Naturally occurring erosion, including mass wasting, is relatively high because of the steep terrain, parent materials and climate.

Several land uses affect erosion in the analysis area including prescribed fire, fire suppression, road- and trail-related activities, recreation, timber harvest, private residences, and wave action that is localized at the fluctuating shoreline. Fire suppression in a fire-dependent ecosystem has multiple interrelated effects (such as increased erosion resulting from higher fire intensity due to decades of fire suppression).

Hydrology

The dominant hydrologic feature in the watershed is the Pit Arm of Shasta Lake. The lower 30 miles of the Pit River constitute the longest of the five arms of Shasta Lake. All tributaries to the Pit Arm of Shasta Lake drain mountainous terrain forested primarily by brushy, understocked hardwood stands and ponderosa pine-dominated conifer stands. Riparian reserves in the Pit Arm consist almost exclusively of stream channels, unstable areas and reservoir buffers. There are no natural lakes, ponds or wet meadows in the watershed.

Immediately upstream of the Pit Arm Shasta Lake Watershed Analysis boundary is the lowermost Pacific Gas and Electric (PG&E) hydroelectric structure on the Pit River. Base flows in the Pit River are completely regulated by the Pit River Hydroelectric Project. Water from the McCloud River is diverted at Lake McCloud and sent through a tunnel to Iron Canyon Reservoir and eventually into the Pit River.

Peak flow events in the Pit Arm watershed occur during the winter months when heavy rains saturate the ground and melt snow at the upper elevations of the watershed.

Stream Channel

The entire main channel of the Pit River within the watershed analysis area has been inundated by the formation of Shasta Lake following the completion of Shasta Dam in 1945.

The morphology of other tributaries in the watershed analysis area reflects natural geologic and fluvial processes and, in some cases, land use activities. Upland channels are generally located within unstable terrain throughout the watershed. Many of the upland channels were formed as a direct consequence of debris flows. The morphology of channels and the unstable slopes associated with them may be affected by fire suppression, high-severity fire and prescribed fire.

See “Step 3 – Current Condition” for more detailed information on the morphology and dynamics of stream channels in the watershed.

Water Quality

The quality of water in the Pit Arm watershed is influenced by both natural processes and land-use activities. Current water quality in Shasta Lake is considered very good, primarily due to the high turnover rate of water in the lake. The Upper Pit River is currently listed under the Clean Water Act, Section 303(d) as impaired for nutrients, temperature and nutrient enrichment;

however, water quality within the analysis area is not considered degraded from these listed reaches.

The potential for water quality degradation in Shasta Lake includes turbidity caused by shoreline erosion and other factors, large concentrations of woody debris and litter left by recreationists. Past concerns for gray water and fuel contamination have largely been resolved through upgrading of substandard underground storage tanks and compliance monitoring by the Regional Water Quality Resources Control Board.

See “Step 3 – Current Condition” for more information related to water quality in the analysis area.

Biological Features

Fire and Fuels

Fire has played a major role in shaping vegetation composition and structure in the watershed analysis area (Agee 2007, Skinner et al. 2006, Taylor and Skinner 1998). The analysis area extends through the montane ecological zones and is characterized by frequent fires of low- to-mixed severity (Skinner et al. 2006, Taylor and Skinner 1998). Lightning, European settlers, and American Indian-ignited fires were the primary factors shaping the vegetation, creating primarily multi-aged stands (Taylor and Skinner 1998).

Stand and vegetation structures, along with severity patterns within this regime, are highly dependent on the complex combination of topography, vegetation composition, and climate (Agee 2007, Skinner et al. 2006). Generally, upper slope positions and south- and west-facing slopes burn at higher frequencies and with higher severities than lower slope positions and north- and east-facing slopes (Weatherspoon and Skinner 1995, Taylor and Skinner 1998, Skinner et al. 2006, Jimerson and Jones 2003). Spatial variation in soil productivity, in conjunction with steep gradients of elevations and aspects, controls the rates of fuel accumulation (Skinner et al. 2006). Disturbance history affects the fuel profile and is linked to patterns of fire severity on the landscape (Miller et al. 2009 and Alexander et al. 2006).

The climate of the analysis area is best described as Mediterranean, characterized by wet, cool winters and dry, warm summers (Skinner 2006). Mean annual precipitation ranges from 45 to 75 inches in the watershed and primarily occurs from November 1 through April 30. Summer thunderstorms are common, and can release significant localized rain. These storms can also be dry with conditions that encourage fire ignition and spread from lightning strikes, with the summer of 2008 being the latest example of this pattern near the analysis area.

The steep and complex landscape creates a unique interaction with fire weather and elevation during the hot, dry summers when a high pressure prevails and smoke does not dissipate; this often results in temperature inversions. While these inversions can lead to benign fire behavior, they can also create public health issues and concerns over high densities of smoke particulates that cover large areas and can persist for many days. When the temperature inversions are broken by high winds, fire behavior can increase significantly, resulting in large areas of high-severity fire.

Numerous fire starts still occur in the watershed analysis area. However, with the onset of fire suppression in the early 1900s and the increased effectiveness of suppressing fires with mechanized equipment (e.g., fire engines, dozers, aircraft, etc.) in later years, most of the fires are kept small. As a result, forest vegetation has changed from a heterogeneous pattern to a more homogeneous pattern of smaller openings in a matrix of denser forest (Skinner et al. 2006). Therefore, one of the most extensive problems related to the health of this watershed is the over-accumulation of vegetation and fuel loading due to a lack of disturbance from fire. Although severity patterns are still largely dependent on physical factors (i.e., slope position, aspect, slope percentage, elevation, etc.), the current vegetation composition and structure have created conditions that increase the likelihood of larger areas of intense and severe fire (Skinner et al. 2006, Taylor and Skinner 2003, Scott and Reinhardt 2001).

Vegetation

Forest Vegetation

Vegetation in the Pit Arm watershed is predominantly mixed conifer/hardwood and conifer stands that reflect a transition from lower elevation foothill to higher montane forest vegetation. Approximately 75 percent of the land base is in forest vegetative cover, while Shasta Lake occupies approximately 12 percent of the watershed. The remaining land base is comprised of chaparral, grassland, barren, and urban areas.

Forest vegetation in the Pit Arm watershed is distributed within the following three categories:

- hardwoods – 30 percent
- mixed hardwood/conifer – 20 percent
- conifer – 50 percent

Hardwood stands are predominantly oak and often contain scattered gray pine and other conifers. Conifer stands are mainly composed of ponderosa pine, Douglas-fir and white fir, other conifer species, and black oak. Mixed stands are transitional between these two and contain varying proportions of hardwoods and conifers.

The majority of forest stands (approximately 88 percent) are dense, with crown canopy of 60 percent cover or more. Most forest stands (approximately 86 percent) have an average overstory tree diameter of 15 to 25 inches, measured as diameter at breast height (d.b.h.). Roughly two percent of the watershed consists of late-successional conifer stands. These older conifer stands occur mostly in the upper reaches of the watershed on north- to east-facing slopes. There are approximately 400 acres of plantations in the watershed dating from 1984-2000.

Riparian vegetation is well developed along perennial streams. Important riparian components include umbrella plant, willow, bigleaf maple, torrent sedge, white alder, western spicebush, California bay, western azalea, and Himalayan blackberry.

Nonforest Vegetation

Chaparral vegetation occurs on approximately 10 percent of the watershed and is characterized by a diversity of flowering shrubs (manzanita and ceanothus species, toyon, snowdrop-bush and California buckeye) and by shrub-sized hardwoods (e.g., black oak and Oregon white oak).

Grasslands in the watershed are small and are intermingled with oak woodlands; species composition is dominated by invasive annual grasses introduced from the Mediterranean region.

Large fires in the late 1800s destroyed vegetation in much of the area. These fires were followed by more than 90 years of fire suppression that have allowed vegetation to develop and fuels to accumulate.

Threatened, Endangered and Sensitive (TES) Plants and Other Species of Concern

Management direction for rare vascular and nonvascular plants and fungi on the Shasta-Trinity National Forest is found in the Land and Resource Management Plan (LRMP) (USDA Forest Service 1995) on pages 4-14 through 4-16 and on page 4-115. These species may include federally listed threatened or endangered species, sensitive and endemic species, and survey-and-manage species (USDA Forest Service and USDI Bureau of Land Management 2001).

According to the Land and Resource Management Plan (LRMP, page 4-5), Forest goals for botanical species include the following:

- “Monitor and protect habitat for federally listed threatened and endangered (T&E) and candidate species. Assist in recovery efforts for T&E species. Cooperate with the State to meet objectives for State-listed species.”
- “Manage habitat for sensitive plants...in a manner that will prevent any species from becoming a candidate for T&E status.”

No threatened or endangered plants are known or suspected to occur on the Forest. No survey-and-manage vascular plants, lichens or fungi are documented in the watershed analysis area. *Viburnum ellipticum* (oval-leafed viburnum) is a California Native Plant Society (CNPS 2009) List 2.3 species (i.e., rare, threatened, or endangered species in California, common elsewhere). While this species is not listed by the Pacific Southwest Region as sensitive, the Forest Service documents occurrences identified during botanical surveys on National Forest System lands and designs project activities to reduce or avoid impacts to documented populations. Refer to the project file for a complete list of TES, survey-and-manage, and other special status vascular plant, bryophyte, lichen and fungus species of concern on the Shasta Trinity National Forest.

The following sensitive and endemic vascular plant species either are documented or are likely to occur in the Pit Arm Shasta Lake watershed, since they are within the geographic range of the species and suitable habitat occurs within the watershed:

- *Ageratina shastensis* (Shasta eupatory)
- *Calystegia atriplicifolia* ssp. *buttensis* (Butte County morning-glory)
- *Clarkia borealis* ssp. *borealis* (Shasta clarkia)
- *Fritillaria eastwoodiae* (Butte County fritillary)
- *Neviusia cliftonii* (Shasta snow-wreath)

Noxious and Undesirable Weed Species

The LRMP directs the Forest to ensure that “the spread of weed plant populations has been arrested and native plants are being reintroduced where suitable”. The following selected noxious weed species are of high concern and are either documented or have the potential to occur in the Pit Arm Shasta Lake:

- *Ailanthus altissima* (tree of heaven)
- *Bromus tectorum* (cheatgrass)
- *Carduus pycnocephalus* (Italian plumeless thistle)
- *Centaurea solstitialis* (yellow star thistle)
- *Cirsium arvense* (Canada thistle)
- *Cirsium vulgare* (bull thistle)
- *Cytisus scoparius* (Scotch broom)
- *Genista monspessulana* (French broom)
- *Rubus armeniacus* (Himalayan blackberry)
- *Rubus laciniatus* (cutleaf blackberry)
- *Torilis arvensis* (hedge parsley)
- *Tribulus terrestris* (puncturevine)
- *Spartium junceum* (Spanish broom)

Refer to the project file for a complete list of invasive plants on the Shasta Trinity National Forest.

Species and Habitat

Terrestrial Wildlife Species

Habitat for terrestrial wildlife species associated with early-, mid- and late-seral mixed-conifer forest occurs within the Pit Arm Shasta Lake watershed. Large overstory ponderosa pines on slopes adjacent to or with lines of sight to Shasta Lake provide excellent nesting, roosting and foraging habitat for the bald eagle; the bald eagle is, therefore, one of the of the major species of special concern in this watershed. Multiple eagle nests and associated territories are located along a relatively narrow strip of trees between the ridgelines and the shorelines of the lake.

Nest and roost trees can be located in late-seral stands of mixed conifer or in younger mid-seral stands that contain only a few residual large overstory trees. Eagle territories generally contain several large snags located in close proximity to the water that are used as perches during foraging. The Forest Service monitors bald eagles in the watershed through annual winter roost and nesting status surveys. Much of the habitat management for the area is focused on bald eagle protection and habitat enhancement.

Photo 1. Bald eagle along the Pit Arm of Shasta Lake

Earl-seral habitat in the watershed is comprised of brush species such as manzanita, chinquapin and various *Ceanothus* species. Terrestrial wildlife species in the area associated with this habitat type include deer, elk and turkey. The current condition of the brush and browse in the watershed is variable, depending on whether the area has received fuels treatments or burned in past wildfires or prescribed burns. Those areas that have been treated or that burned contain a mosaic of new growth and older brush skeletons. Untreated areas contain older, decadent brush that has much reduced palatability as browse.

The Shasta-Trinity LRMP designated late-successional reserves in the watershed. These areas do not all contain habitat that would be classified as late successional; they were designated for the protection of species that can often be associated with late-successional habitat and that were known to occur in the area. Several of these late-successional reserves contain bald eagle territories or peregrine falcon eyries and are managed with standards and guidelines associated with late-successional reserves. The eastern portion of the watershed contains late-successional habitat that would be characterized as suitable for northern spotted owls, though these areas are not currently in late successional reserve land allocations.

In addition, limestone slopes, outcroppings and caves are present in the watershed and contain suitable habitat for bat species, several terrestrial mollusks species, peregrine falcons and Shasta salamanders (see species list below). These areas do not require specific actions other than surveys that identify areas to be flagged and avoided during management actions such as prescribed burning.

Other habitats include numerous snags that emerge from the water along the shorelines and in areas with low water. Many of these water-killed trees have been present since the dam was constructed, while others have emerged only after the water level of the lake was lowered. These snags are valuable habitat for cavity nesting species in the area. Acorn woodpeckers in particular thrive in this setting, due to the presence of oaks near the shoreline combined with the abundance of snags that serve as cache trees and nesting structures.

Photo 2. Snag habitat on exposed shoreline, Shasta Lake

In 2008, the U.S. Fish and Wildlife Service designated critical habitat units (CHUs) for the northern spotted owl, which included a portion of the north end of the watershed. However, only a small portion of this section of the critical habitat unit would be characterized as suitable northern spotted owl habitat, though and it is surrounded by unsuitable habitat.

Aquatic and Riparian-dependent Species and Habitats

The construction of Shasta Dam and subsequent creation of Shasta Lake had a major impact on the surrounding natural aquatic and riparian environment. The dam put an end to the anadromous fisheries resource in the Pit, McCloud, and upper Sacramento Rivers, and inundated many miles of stream and riparian habitat. The storage volume and elevation of Shasta Lake varies annually and seasonally. The upper reach of the Pit River arm of the lake variably shifts from riverine to lacustrine in nature as a result of the releases from Pit No. 7 Dam and reservoir levels in Shasta Lake. The resulting aquatic habitats vary from the deep nonvegetated open water of the lake, to intermittent standing water with varied amounts of vegetation, and permanent, cool water streams with adequate instream cover and surrounding dense riparian vegetation. These habitats support a variety of aquatic and riparian species including fish, freshwater mollusks and other invertebrates, amphibians, and reptiles.

Shasta Lake has both a warmwater and coldwater fishery. The warmwater fishery is dominated by spotted bass, smallmouth bass, black crappie, channel catfish, and bluegill. Habitat for warmwater species is limited by lack of cover and the level of reservoir drawdown. The coldwater fishery is composed of rainbow trout, brown trout and Chinook salmon. Native species such as white sturgeon, Sacramento blackfish, hardhead minnow, riffle sculpin, Sacramento sucker, and Sacramento pike minnow are also present, but these species receive little fishing pressure. Habitat for coldwater species in Shasta Lake is considered good.

Stream habitats are dominated by rainbow trout, but also include hardhead, Sacramento sucker and pit sculpin. Most of the fish found within the lake may also be found within the lower stream reaches, which also serve as spawning sites for lake-run rainbow trout during the spring. Habitat within streams is generally limited by low water flows and steep gradients and, except for spawning, is considered poor. Fish passage barriers caused by reservoir fluctuations include excessive shoreline erosion or deposition, which has filled pool habitats and created steep homogenous channels that limit upstream migration.

Human Uses

The Pit Arm Watershed Analysis (WA) area encompasses the lowermost 30 miles of the Pit River from the PG&E Pit No. 7 afterbay to the river's confluence with Shasta Lake. The Interstate 5 corridor provides vehicle access for the public to Shasta Lake and Pit Arm watershed as it continues north through the Shasta Unit of the Shasta Trinity National Recreation Area. Interstate Highway 5 provides access to the Bridge Bay Resort on Shasta Lake, from the north and south. Shasta Lake provides water for domestic, agricultural and hydroelectric use; it also provides ample recreational opportunities, of which boating and camping are the most popular. The lower southwest portion of the Pit River merges with the McCloud River and Squaw Creek drainages. These three tributaries empty into Shasta Lake. Recreation on the lake is currently managed by the Shasta-Trinity National Forest. Houseboat use is particularly heavy on Shasta Lake, although smaller watercraft also use the lake and upstream tributaries. Campgrounds for recreational vehicles are the most frequent lakeside development, followed by cottage resorts and tent camping areas.

Heritage Resources

Native Americans occupied the Pit Arm Shasta Lake Watershed drainage for thousands of years, and their descendants today retain an active interest in protecting their patrimonial heritage. Ethno-historical records reveal that the watershed lies within the traditional territory of the Wintu and the Pit River people (Dubois 1935, Theodoratus 1981). The boundary between the groups was an area of land just east of Squaw Creek referred to as no man's land and used as hunting and gathering grounds by both. Prehistoric sites are concentrated along the waterways and drainages, especially Jones Valley, but a few are located on ridgelines and other landforms.

Recreation Resources

Four commercial marinas with private boat ramps operate within the watershed, providing service to the public with paved ramps, lighted parking areas, restrooms and garbage disposal facilities, boat rentals, and fuel sales. All four marinas operate under special use permits administered by the Forest Service. In addition, the Forest Service maintains several designated public boat ramps in the Jones Valley area.

There are six designated camping areas and facilities in the watershed. Two very popular trail systems totaling about eight miles provide access along the lake's shoreline and to some upland areas within the watershed. There are approximately 34 miles of trails in the watershed. In addition, several miles of authorized and unauthorized OHV trails occur in the watershed.

Other Special Use Permits

Several power transmission lines follow the ridge from Brush Patch, predominately on private property. They are associated with Dam Pit No. 7, and both are operated under special use permits. A new road and powerhouse with a small turbine are scheduled to be constructed as part of the dam relicensing with PG&E in 2010.

Mining Resources

Copper mining within the watershed boundaries began in the 1890s but had dwindled by the 1950s. A copper smelter began operation in 1901 in the adjacent Squaw Creek Arm, but closed due to difficulties in treating smelter fumes. Currently, there are very few mining claims with minimal activity occurring on National Forest System lands in the watershed.

Timber Resources

There are no active timber sales within the Pit Arm watershed. Past timber harvest was sporadic. The most recent timber harvest occurred under the Bear Fire Heli Salvage Project that covered approximately 274 acres (completed in 2005), and as part of a commercial thinning project on 45 acres (completed in 2006).

Transportation System and OHV Routes

The transportation system in the watershed consists of approximately 212 miles of private and National Forest System roads. Current road density is approximately two miles of road per square mile of land. Roads are mostly related to past timber activities and recreation uses. In the lower section of the watershed, they are concentrated near campgrounds and trails. In the upper section, they consist of power utilities access and other low-standard roads and jeep trails.

Most roads were constructed for timber harvest and mining activities. Authorized and unauthorized off-highway vehicle (OHV) use occurs in the watershed. Recent wildfires (the Jones Valley area in particular) exposed additional off-road areas to proliferation of unauthorized user-created trails.

Figure A-5 in Appendix A displays the watershed's transportation system, trails and OHV routes.

Visual Resources and Scenery

The current visual condition of the watershed varies from apparently unaltered to large-scale physical alteration, due to wildfires and to the development of roads and trails and other human-caused disturbances.

Fire and Fuels as Related to Human Uses

Increased vegetation densities and fuel loading over time have led to concerns over fire behavior within and adjacent to the wildland-urban interface and over fire effects to other resources (e.g., wildlife habitat, soil stability, recreation, hydrology, air quality, etc). Recreation activities at the bottom of slopes tend to pose the most threat for high-severity human-caused fires, as such fires tend to be carried uphill by prevailing winds. See the Fire and Fuels discussion in this watershed analysis for a detailed discussion of fire behavior and characteristics.

Land Allocations and Management Direction

Management direction for the Pit Arm Shasta Lake Watershed is found in the Shasta-Trinity National Forests Land and Resource Management Plan (LRMP); the LRMP incorporates direction from the Northwest Forest Plan.

Figure A-6 in Appendix A displays both public and private ownership within the Pit Arm Shasta Lake Watershed Analysis area. Figure A-7 in Appendix A displays the land allocations within National Forest System lands in the analysis area, as designated in the Shasta-Trinity National Forest LRMP. Figure A-8 in Appendix A displays the management areas and prescriptions for National Forest System lands in the analysis area, as described in the LRMP.

Matrix Land Allocation

Within the watershed analysis area, approximately 48,390 acres lie within the matrix land allocation. Per the Shasta-Trinity LRMP, management prescriptions for this land allocation fall within three categories, with the following objectives:

Management Prescription III – Roaded Recreation: The purpose of this prescription is to provide for an area where there are moderate evidences of the sights and sounds of humans. Modifications are evident and may appear moderate to observers in the area but will be unnoticed or visually subordinate from sensitive travel routes. This prescription emphasizes recreational opportunities associated with developed road systems and dispersed and developed campsites. Fish and wildlife management, which supports the recreational use of wildlife species (hunting, fishing and viewing), is also emphasized. The emphasis of vegetation management activities will be to meet recreation, visual, and wildlife objectives while maintaining healthy and vigorous ecosystems.

Management Prescription VI – Wildlife Habitat Management: The primary purpose of this prescription is to maintain and enhance big game, small game, upland game bird and nongame habitat, thereby providing adequate hunting and viewing opportunities. Habitat management for species that are primarily dependent upon early and mid-seral stages is an important consideration. While this prescription does not emphasize those wildlife species dependent on late seral stages, habitat favorable to these species will occur within this prescription. Vegetation is manipulated to meet wildlife habitat management objectives and to maintain healthy, vigorous stands using such tools as silviculture and prescribed fire. Roaded natural recreation opportunities will be maintained.

Management Prescription VIII – Commercial Wood Products Emphasis: The purpose of this prescription is to obtain an optimum timber yield of wood fiber products from productive forest lands within the context of ecosystem management. Investments will be made in road construction, fuels management, reforestation, vegetation management, and timber stand improvement...Vegetative manipulation will provide habitat for those wildlife species primarily dependent on early and mid-seral stages.

Management prescriptions for the matrix land allocation are found in the LRMP on pages 4-64 through 4-67.

Administratively Withdrawn Areas

Approximately 22,186 acres within the watershed analysis area are classified as administratively withdrawn; these acres are within the Whiskeytown Shasta-Trinity NRA and the Rock-Hosselkus RNA. Per the Shasta-Trinity LRMP, management prescriptions for this land allocation fall within five categories, with the following objectives:

Management Prescription I – Unroaded, Nonmotorized Recreation: The purpose of this prescription is to provide for semiprimitive nonmotorized recreation opportunities in unroaded areas outside existing wildernesses while maintaining predominantly natural-appearing areas with only subtle modifications. Special recreational and visual values, fisheries, and riparian resources are emphasized. Also emphasized in this prescription is retention of old-growth vegetation and management of wildlife species requiring late seral stage conditions.

Management Prescription II – Limited Motorized Recreation: The purpose of this prescription is to provide for semiprimitive motorized recreation opportunities, while maintaining predominantly natural-appearing areas with some modifications. Recreational and visual resources are important values; semi-primitive activities are emphasized. Managing for old-growth vegetation and wildlife species requiring these late seral stages is also an important consideration.

Management Prescription IV – Roaded, High-Density Recreation: The purpose of this prescription is to provide for areas that are characterized by a substantially modified natural environment. Sights and sounds of humans are readily evident, and the interaction between users is often moderate to high. Facilities are designed for use by a large number of people. Recreational and visual resources are important values with rural recreation emphasized.

Management Prescription X – Special Area Management: This prescription provides for protection and management of special interest areas (SIAs) and research natural areas (RNAs). Protection and management of associated amenity values, including unique plant, animal, and aquatic systems, will be consistent with special area objectives. These standards apply to all special areas. If the special area is located in an allocation more restrictive than an Administrative Withdrawal, the additional restrictions also apply.

Management Prescription XI – Heritage Resources: The primary theme of this prescription is to protect designated cultural resource values, interpret significant archaeological and historical values for the public, and encourage scientific research of these selected properties. Visual resources, water quality, wildlife habitat, and vegetation will be protected.

Pages 4-45 through 4-51 of the LRMP detail the management prescriptions for Administratively Withdrawn Areas.

Late-successional Reserves and Managed Late-successional Areas

Approximately 3,770 acres within the watershed analysis area are designated as late-successional reserves, and 137 acres are managed late-successional areas. Objectives for late-successional reserves as described in the LRMP on page 4-37 are as follows:

Late-successional reserves are to be managed to protect and enhance conditions of late-successional and old-growth forest ecosystems, which serve as habitat for late-successional and old-growth related species including the northern spotted owl. These reserves are designed to maintain a functional, interacting, late-successional and old-growth forest ecosystem.

This land allocation contains a single management prescription category, with the following objectives:

Management Prescription VII – Late-Successional Reserves and Threatened, Endangered and Selected Sensitive Species: The purpose of this prescription is to provide special management for late- successional reserves and threatened and endangered species. It also includes special, selected sensitive wildlife species, which are primarily dependent on late-seral stage conditions. This prescription also emphasizes retention and enhancement of sensitive plant species, old-growth vegetation, and hardwoods. Sensitive fish and wildlife species, which are dependent on riparian areas, will be managed in accordance with the standards and guidelines in riparian reserves.

Specific standards and guidelines for late-successional reserves and managed late-successional areas (LRMP. p. 4-44) are designed to maintain, enhance and protect these areas.

Riparian Reserves

The Northwest Forest Plan contains an Aquatic Conservation Strategy, which was designed to restore and maintain the ecological health of watersheds and aquatic ecosystems within the range of the northern spotted owl. The Aquatic Conservation Strategy directs the Forest Service to provide an area along streams, wetlands, ponds, lakes, and unstable and potentially unstable areas where riparian-dependent resources receive primary emphasis. Riparian reserves are important to the terrestrial ecosystems as well, serving, for example, as dispersal habitat for certain terrestrial species (USDA Forest Service and USDI Bureau of Land Management 1994, as amended).

Riparian reserves overlay all other land allocations. The riparian reserve widths prescribed in the Aquatic Conservation Strategy apply to all watersheds until watershed analysis is completed, a site-specific analysis is conducted and described, and the rationale for final riparian reserve boundaries is presented through the appropriate NEPA decisionmaking process.

Currently designated riparian reserves in the watershed total approximately 32,182 acres, including Shasta Lake, streams within the watershed and geomorphological features such as inner gorges and slides and other unstable areas. Riparian reserves, excluding the waters of Shasta Lake, total approximately 22,944 acres.

Standards and guidelines for riparian reserves prohibit or regulate activities in riparian reserves that retard or prevent attainment of the Aquatic Conservation Strategy objectives. Specific standards and guidelines for riparian reserves are found in the LRMP on pages 4-53 through 4-60.

National Recreation Area (NRA)

Whiskeytown-Shasta Trinity National Recreation Area comprises 35,378 acres of the Pit Arm Shasta Lake Watershed Analysis area (see figure A-3 in Appendix A). Desired conditions of the Shasta Unit of the NRA (which encompasses the Pit Arm watershed) are described on page 4-111 of the LRMP. Pages 4-114 and 4-115 of the LRMP describe management direction for the entire NRA. Management prescriptions for the NRA are as allocated for late-successional reserves, administratively withdrawn areas, riparian reserves, adaptive management area, and matrix (LRMP, table 4-11, p. 4-114).

Research Natural Area (RNA)

Approximately 3,963 acres of the Devils Rock-Hosselkus Research Natural Area lie within the watershed analysis area. The LRMP on page 4-26 directs the Forest Service to manage research natural areas to maintain unmodified conditions and natural processes as set forth in Forest Service Manual (FSM) 4063.3.

Step 2. Issues and Key Questions

Identification of issues and key questions related to resources in the watershed serves to focus the watershed analysis on those key elements that are relevant to management objectives, human values and resource conditions within the watershed.

Hydrology, Geomorphology, Erosion Processes and Water Quality

At this time, issues and key questions relevant to hydrology, geology and soils in the watershed are directly related to issues and key questions described for human uses and fire and fuels (see the Human Uses and Fire and Fuels discussions in this watershed analysis).

Fire and Fuels

Past forest management practices and disturbance history have changed the character of the vegetation within the analysis area from historic periods. Current concerns have revolved around fire hazard (defined by fuel loading and vegetation densities) and a high fire risk (defined by fire start occurrence) over time. Fire risk and associated fire hazard have led to concerns over fire behavior within and adjacent to the wildland urban interface and over fire effects to other resources (e.g., wildlife habitat, soil stability, recreation, hydrology, air quality, etc). Many of these concerns have been validated by relatively recent wildfires (e.g., the 2008 Stein, Murphy and SHU Lightning Complex fires; the 2004 Bear fire; the 1999 Jones fire; the 1992 Fountain fire and others) near or within the analysis area. Weather conditions, poor access for firefighting forces, rugged terrain and many other factors contributed to large fire growth in most of these recent fires.

In addition, smoke from large fires that does not disperse has the potential to negatively impact the recreation experience in the watershed. See the Human Uses discussion for a detailed description of the recreation resource.

This analysis will evaluate current and reference vegetation conditions and fire regimes in the context of the key questions described below.

Issue: Fire and Fuels

The overriding issue concerning fire and fuels revolves around fire hazard and fire risk. Past management activities have resulted in areas with dense vegetation and fuel loading conducive to large fire growth, extreme fire behavior, and large areas of severe and intense wildfire. Accumulated fuels through time heighten concerns over fire effects to resources (e.g., wildlife habitat, soils, human uses, hydrology, and air quality), public and firefighter safety, and fire behavior potential within and adjacent to the wildland-urban interface. Numerous fire starts occur every year (160 starts from 1987 to 2008), and are primarily human caused. The combination of high fire risk and fire hazard in the watershed analysis area is, therefore, a major issue for the Pit Arm Shasta Lake Watershed Analysis.

Key Questions

1. What is the current fire hazard and risk in the analysis area, including the threat to the wildland-urban interface?
2. How does the current fire regime impact vegetation within the analysis area?
3. How might future high-severity fires affect other resources (i.e., air quality, erosion processes, soil fertility, water quality, fisheries habitat and human uses)?
4. What are current fire suppression concerns in the analysis area?

Vegetation

Forest and Nonforest Vegetation

Issues of vegetation conditions are reflected in the discussion of fuels and fire. Current trends of forest stand densification and fuel accumulation indicate an increasing likelihood of fire disturbance that could dramatically shift vegetation to predominantly early seral conditions of brush, grass, and open forest stands.

Threatened, Endangered and Sensitive Plants

Issue: The Effects of Management Activities and Natural Events on Rare Plants and Rare Plant Habitat in the Watershed

Suitable habitat for rare vascular and nonvascular plant, lichen, bryophyte and fungus species has likely declined in recent decades due to both anthropogenic (e.g., fire suppression, recreational impacts) and natural alterations (e.g., wildfire, drought) of the landscape. Botanical species diversity contributes to healthy ecosystems through genetic, functional, and structural aspects. An assessment of rare botanical species populations and suitable habitat within the watershed and the impact of past management on these species is the focus of this issue.

Key Questions

1. What is the current status and distribution of documented rare plant occurrences and/or suitable rare plant habitat in the watershed?
2. How have past activities and events impacted rare plant populations and/or suitable rare plant habitat?
3. How can future management practices help maintain or restore rare plant habitat in the watershed?

Noxious Weeds

Past and current management practices were assessed to determine their impacts on noxious weed populations within the watershed.

Issue: The Effects of Management Activities and Natural Events on Noxious Weeds

1. How have past activities or events influenced noxious weed populations in the watershed?
2. How can future management practices reduce the potential for noxious weed introduction and spread?

Issue: The Effects of Noxious Weeds on Ecological Processes in the Watershed

Noxious weeds are strong competitors with native species. They have the potential to displace rare plants, possibly leading to their extirpation from the landscape, and to prevent native species from establishing. Additionally, large infestations of some noxious weed species have been shown to alter fire behavior (Brooks et al. 2004).

Key Questions

1. What are the potential effects of current or future potential noxious weed infestations on rare plants and on ecosystem function and integrity in general?

Terrestrial Wildlife Species

Issue: Bald Eagle Viability and Habitat Integrity

Due to the abundance of bald eagle nesting, roosting and foraging habitat, multiple eagle territories are located throughout the watershed. The Pit River arm of Shasta Lake has the highest density of known nests on the lake, thereby placing an increased importance on maintaining and protecting this high-value habitat. The loss of large overstory trees and snags located on slopes with lines of sight to the lake would have measurable and meaningful impacts to the eagle population at Shasta Lake. Habitat throughout the watershed plays a major role in the viability of the eagles that use the area for wintering as well as for nesting. In addition to protecting the large overstory trees and snags, it is also necessary to plan and provide for the future of the habitat by ensuring that a sufficient number of trees - ponderosa pine in particular - are recruited and brought to maturity for future use.

Bald eagle viability can be threatened by human use such as houseboaters and other recreationists during times of high sensitivity (i.e., nesting and hatching) in areas most susceptible to disturbance (i.e., a nest located within a cove or camping area). Eagles construct nests and begin laying eggs in winter and early spring when human use levels are the lowest;

however, by the time they have committed to a nesting effort and have begun laying eggs, a dramatic increase in human use occurs, such as during spring break and Memorial Day, Fourth of July and Labor Day holidays. These sudden periods of high use can be major sources of disturbance for nesting eagles and may require protection or mitigation efforts in order to prevent nesting failure.

Key Questions

1. How are current conditions influencing the potential for high-severity wildfire to consume stands with large overstory trees?
2. Is there currently enough recruitment of younger ponderosa pine stands for future eagle habitat?
3. How have past management actions influenced current and future eagle habitat?
4. What is the current distribution of bald eagle nests, territories and winter roosts?
5. What management actions and protection measures can be undertaken to provide the most benefit for eagles in the watershed?

Issue: Management of Late-successional Habitat

Late-successional habitat, which is underrepresented in the Pit River watershed, has the potential to support several Forest Service sensitive and federally listed species, such as the northern spotted owl. There is a need to manage and protect what currently exists and to recruit additional habitat of this type for the future.

Key Questions

1. What is the current distribution and location of late-successional habitat in the area?
2. What is the current risk to these areas and how can the risk be alleviated?
3. How are current conditions influencing the potential for high-severity wildfire to impact late-successional habitat?

Issue: Management of Early Seral Brush and Browse Habitat

Early seral brush habitat in the Pit River watershed provides browse for numerous species on National Forest System lands such as black-tailed deer, elk and prey species that support raptors and forest carnivores. These areas provide cover and forage when the habitat is in a well-maintained condition with a mosaic of new growth for forage, intermixed with older patches, which serve as cover and potential fawning areas. Species that rely on these areas may be negatively impacted if browse condition becomes decadent and dominated by older, less palatable forage and brush skeletons.

Key Questions

1. What is the current distribution early seral browse habitat in the area?
2. What is the current condition of the browse?
3. How have past management actions impacted the current conditions?
4. What management actions can be undertaken to improve conditions where they are not in the desired condition?

Aquatic and Riparian-dependent Species and Habitats

The analysis area provides habitat for Forest Service sensitive and other aquatic and riparian species of concern. These species and their habitats are directly affected by management activities that also influence hydrology, geomorphology, erosion processes, and water quality. As mentioned above, these in turn are directly related to issues surrounding human uses and fire and fuels in the Pit Arm Shasta Lake watershed. Riparian area disturbances, including roads, wildfire, timber harvest, and mining may have compounded and contributed to aquatic habitat impacts. As a result, instream habitat conditions are of concern as well as the condition of streamside vegetation. Riparian reserves are a National Forest land allocation intended to protect riparian areas, and many species use riparian corridors to travel across the landscape. Minimizing the impacts in riparian areas from past and future disturbances, including additional riparian area disturbance from future wildfires, are concerns.

Key Questions

1. What is the status and distribution of aquatic and riparian-dependent species of concern in the watershed?
2. What areas are critical for maintenance, protection, and recovery for aquatic and riparian dependent species of concern?
3. How do the current riparian habitats compare to optimum habitats, and how can riparian areas be protected and/or restored?
4. Are riparian reserve widths adequate for riparian habitat and travel corridors?

Human Uses

Issue: The Status and Condition of Heritage Resources in the Watershed

In recent years, drought has caused the water level in Shasta Lake to drop by up to 100 feet. As a result, several archaeological sites that were once underwater are now exposed. Many of these sites were visited in 1986 to assess the impacts of the reservoir drawdown on them (Henn and Sundahl 1986). The study found that many sites maintained significant research potential but that sites were also being significantly impacted by erosion, siltation, and recreation, especially off-road vehicle use. The negative impacts associated with the drawdown are likely to continue during drought-induced low water conditions. Many of the exposed sites have not been revisited since 1986; consequently, their current conditions have not been assessed, associated records have not been updated, locations have not been recorded by GIS, and sites with research potential have not been nominated for listing on the National Register of Historic Places. Other archaeological sites are - and will continue to be - exposed during annual lake level fluctuations.

Key Question

1. Are archaeological sites with significant research potential losing that potential due to the negative effects associated with management activities in the watershed?

Issue: The Effects of Recreation and Human Uses on other Resources in the Watershed

Recreation and other human uses within the watershed have impacted or have the potential to impact other resources. For example, private houseboat mooring has the potential to disturb eagles nesting on the shores of Shasta Lake, and watercraft with internal combustion engines can contribute to water quality degradation in the lake. OHV traffic at low water markings has the potential to impact visual, audio, soil, air, and water quality resources. Peak season usage of recreation facilities, trails and watercraft has the potential to affect other resources within the watershed. Finally, heavy recreation usage during periods of high fire danger increases the potential for human-caused fire starts.

Key Questions

1. How has the use of the lake by boaters affected wildlife? How might an increase in other human uses impact other resources (e.g., water quality, fire and fuels, and botanical resources)?
2. How does OHV traffic affect the integrity of watershed resources and impact other recreation experiences?
3. What management practices might alleviate some of the problems associated with peak season usage (i.e., trash, litter and debris and wildlife protection)?
4. How does human use within the watershed increase the potential for high-severity fire and the resulting effects on other resources (i.e., caves, scenery, recreation, and public utilities)?

Issue: The Effects of Activities and Events in the Watershed on Recreation and other Human Uses

In addition to the effects of human uses on other resources in the watershed, past, current and future management practices and events have affected, or have the potential to affect, the recreation experience. For example, prescribed burning may cause smoke that could affect recreation activities. Major wildfires may cause trails and campgrounds to be closed. Air quality and smoke inversion may affect the recreation experience during wildfires. Conversely, past road and trail construction has increased accessibility and, therefore, recreational use within the watershed.

Key Questions

1. How have past management practices (e.g., mining, road construction, logging and prescribed fire) and events (e.g., wildfire) affected recreation and other human uses in the watershed?
2. What future management practices and events might adversely affect the recreation experience?
3. How might future management practices reduce the potential for adverse effects to the recreation experience?

Step 3. Current Conditions

The purpose of this chapter is to develop information relevant to the issues and key questions identified in Chapter 2. The current range, distribution, and condition of the relevant ecosystem elements are discussed.

Physical Features

Geology, Geomorphology and Erosional Processes

Geology

The erosional characteristics of the watershed are influenced by rock types and landforms. The geology and geomorphology of the analysis area, typical of the Klamath Mountains, is a complex of intrusions, contact and shear zones, dormant slides, moderate to steep mountain slopes, stream terraces, and valley inner gorges. An array of rock types has been identified by multiple geologic surveys. For simplicity, the lithology - the characteristics of the rock - will be described by six types (see Table 1). A description of the six rock types is in the Physical Sciences discussion. Figure A-9 in Appendix A displays a map of geological features in the watershed analysis area.

Table 1. Lithology of the Pit Arm Shasta Lake Watershed Analysis area

Lithology	Acres	Percent land base
Clastics	167,337	25
Klamath volcanics	75,909	11
Limestone/Marble	27,145	4
Metamorphics	247,653	37
Plutonic	133,870	20
Cascade volcanics	11,916	2

The Hosselkus Limestone formation, part of which comprises the Hosselkus Research Natural Area, is located in both the Pit Arm and Squaw Creek watersheds. The geologic/paleontologic significance of this and other limestone formations was discussed above in Step 1 - Characterization.

On March 30, 2009, the Paleontological Resources Preservation Act became law when President Barack Obama signed the Omnibus Public Lands Management Act of 2009. This law requires the Secretaries of the Interior and Agriculture to manage and protect paleontological resources on Federal land using scientific principles and expertise. The new law affirms the authority for many of the policies the Federal land managing agencies already have in place for the management of paleontological resources such as issuing permits for collecting paleontological resources, curation of paleontological resources, and confidentiality of locality data.

Geomorphology and Erosional Processes

The geomorphology of the analysis area is mapped predominantly as eroding hillslopes. The primary mass wasting process is colluviation, although rotational (slumps), translational and undifferentiated slides and debris flows are also documented. Thirteen active mass wasting events are documented within the analysis area. Human landforms mapped within the area include the Shasta Lake reservoir and a borrow pit. Figure A-10 in Appendix A displays a map of the geomorphology of the watershed analysis area.

Table 2. Geomorphology and erosional processes within Pit Arm Shasta Lake Watershed Analysis area

Land Form/Erosional Process	Acres	Percent in analysis area
Fluvial	58,648	78
Human	8,631	11
Land Form	399	< 1
Mass Wasting	7,946	11

Surface erosion occurs much more frequently than mass wasting, typically several times a year during measurable precipitation events. Soils in the area are predominantly loamy-skeletal (57 percent), fine-loamy (30 percent), or loamy (10 percent). Roughly 30 percent of the soils have an erosion hazard rating of high or very high. Over half of the soils (56 percent) in the analysis area have a moderate erosion hazard rating, and 14 percent of the soils are mapped with a low erosion hazard rating. Slope is a factor in determining soil erodibility. Approximately half of the analysis area is characterized by steep or very steep terrain, and 93 percent of the land base is considered moderately sloped or steeper (see Table 3). Figure A-11 in Appendix A displays a map of slopes in the watershed analysis area.

Table 3. Acres and percent of analysis area, by slope, in the watershed analysis area

Slope	Percent in analysis area
Flat – gently sloped (0-10%)	6.4
Moderately sloped (10-35%)	42.6
Steep (35-60%)	41.2
Very steep (over 60%)	9.8

Erosion control measures are considered for activities that substantially reduce or eliminate ground cover. Surface erosion rates can accelerate when soil duff, litter, and vegetation is removed by disturbances such as wildfire, road construction and maintenance, prescribed fire, timber harvest, housing developments, and recreational use.

Erosion in the Jones Valley area is a concern because of the cumulative impacts from high severity fire and recreation use. Portions of the Jones Valley fire burned at high intensity, and the area was denuded of vegetation. OHV use is permitted in the general vicinity; however, it is not permitted off designated trails above the high-water mark of Shasta Lake. Widespread devegetation from the fire exposed the steep hillslopes to unauthorized OHV access (primarily dirt bikes). User-created trails have consequently proliferated on the hillslopes with a resulting increase in surface rills and gully erosion.

The type and extent of disturbance, primarily from land use is varied within the analysis area. Recreation is concentrated around the I-5 corridor and Shasta Lake. Road densities are limited by the accessibility of terrain and land use designations.

Hydrology

Most precipitation falls between November and April; primarily as rain. Snowfall may blanket the entire area infrequently; however, persistent snow below 4,000 feet elevation is rare. Rain-on-snow events between 4,000 and 6,000 feet are common during winter months. Snow may accumulate in this zone and then be partially or completely melted by mid-winter rains, resulting in high peak flows in the Pit River upstream of the analysis area. Peak flow events in the Pit Arm watershed occur during the winter months when heavy rains saturate the ground and melt snow at the upper elevations of the watershed. Natural processes that controlled peak and base flows in the Pit River Basin prior to European settlement (see Step 4 – Reference Conditions for hydrology) have not changed from reference to current conditions.

Maximum recorded inflow to Shasta Lake on the Pit Arm was 73,000 cubic feet per second (cfs) on January 24th, 1970. Annual peak discharge generally varies from 8,000 cfs to 30,000 cfs. Annual peak flows most commonly occur in January or February; however, annual peak flows have been recorded in every month except June. Stream discharge has been recorded at Montgomery Creek confluence since 1944. Approximately 30 percent of the soils within the analysis area exhibit high runoff potential. Except for the Clikapudi-Pit 7th-level watershed, most of these soils have low road densities in minimally developed, non-residential areas (see figure A-4 in Appendix A).

The dominant hydrologic feature in the watershed is the Pit Arm of Shasta Lake. The lower 30 miles of the Pit River constitute the longest of the five arms of Shasta Lake. Shasta Dam has completely altered the hydrology of the Pit River within the analysis area. The Pit Arm watershed within the analysis is long and narrow. Tributaries are typically low order, high gradient streams. Potem Creek, which is located at the eastern edge of the analysis area, is the longest tributary to the Pit Arm and exhibits a wide range of stream types ranging from waterfalls and cascade-boulder to low-gradient gravel/fine substrate channels. Dense riparian vegetation is common along the creek. A 2006 process paper on prioritization of watersheds on the Shasta-Trinity NF identified Potem Creek as 2nd priority for restoration because of moderate-high risk to cumulative watershed effects and existing beneficial uses (USDA Forest Service 2006a).

Immediately upstream of the Pit Arm Shasta Lake Watershed Analysis boundary is the lowermost PG&E hydroelectric structure on the Pit River. Base flows in the Pit River are completely regulated by the Pit River Hydroelectric Project. Water from the McCloud River is diverted at Lake McCloud and sent through a tunnel to Iron Canyon Reservoir and eventually into the Pit River.

Groundwater pools are present in several of the existing caves. These caves are at risk of dewatering from water diversion. Forest Service personnel discovered nearby caves had been dewatered by diversion of flow from illegal cultivation of marijuana. The potential for this situation to recur exists, and local personnel continue to monitor the area for unauthorized water use.

Sediment inflows from the Pit River and other tributaries are slowly decreasing the size and storage capacity of Shasta Lake. The U.S. Department of Interior, Bureau of Reclamation, in conjunction with California Department of Water Resources, is currently studying the possible modification of Shasta Dam. Three alternatives under consideration include raising the height of the dam from between 6.5 feet and 18.5 feet (USDI Bureau of Reclamation 2004).

Stream Channel

The hydraulics of the main Pit Arm have been completely altered as a result of construction of the Shasta Dam (1938 – 1945). The two primary tributaries to the Pit Arm within the analysis area, McCloud Arm and Squaw Creek, have also been altered by the presence of Shasta Lake Dam. Interbasin transfers from the McCloud River to the Pit River occur upstream of the analysis area. The morphology of other tributaries in the Pit Arm Watershed reflects natural geologic and fluvial processes and, in some cases, land use activities. Channel morphologies throughout the watershed differ because channels have formed in different geologic parent materials. Typically, channels are high-gradient transport reaches. Many streams are deeply incised with reaches susceptible to mass wasting.

Upland channels are generally located within unstable terrain throughout the watershed. Past geologic analyses (see the project file) indicate that most upland channels have been affected by debris flows and that landslide activity occurred throughout the Holocene Epoch. Many of the upland channels were formed as a direct consequence of debris flows.

The morphology of channels and the unstable slopes associated with them may be affected by fire suppression, high-severity fire and prescribed fire. Effective fire suppression over the past several decades has allowed vegetation and fuels to accumulate in the watershed. Increased vegetation cover and a decrease in the return intervals of natural fires may be affecting erosion processes and sediment delivery to the channel network.

Riparian reserves in the analysis area consist almost exclusively of stream channel buffers, unstable or sensitive areas (valley inner gorges) and reservoir buffers. Together these riparian reserves account for approximately 36 percent of the total land base in the analysis area. Figure A-12 in Appendix A displays a map of riparian reserves in the watershed analysis area.

Water Quality

Information on current and historical water quality in the Pit Arm Watershed analysis area is derived from water quality studies conducted by the California Regional Water Quality Control Board (see the References section), historical documents and local knowledge.

As mentioned in Step 1 – Characterization, the quality of water in the analysis area is influenced by both natural processes and land use activities. Beneficial uses dependent on high-quality water include fish and aquatic life (including riparian vegetation), domestic and municipal water supply, industrial and agricultural supply, hydropower generation, water contact and noncontact recreation, aesthetic enjoyment, freshwater habitat, fish spawning, wildlife habitat, and preservation and enhancement of fish, wildlife, and other aquatic resources.

The quality of water in Shasta Lake is considered very good. The high turnover rate of water in Shasta Lake is the main factor that ensures good water quality. Inflows from Shasta Lake's major tributaries continually replenish the lake with fresh, high-quality water. The total annual inflow to Shasta Lake is approximately half the total storage capacity of the lake. No bodies of water within the analysis area are currently listed under the Clean Water Act Section 303(d) as impaired.

At times, turbidity levels in Shasta Lake become notable. Shoreline erosion by wave action, high peak flows carrying sediment, and water level fluctuations in the reservoir are contributing factors. Abundance of fine-textured clay particles in suspension result in turbidity persisting for long periods.

Gray water was at one time identified as a concern on Shasta Lake. Past sampling of gray water holding tanks and marinas where houseboat use is concentrated reported elevated levels of pollutants and pathogens consistent with human sewage. As of 2006, discharge of gray water from houseboats into Shasta Lake is no longer permitted. The Regional Water Quality Resources Control Board continues compliance monitoring, but reports no current concerns.

The need for fuel to support the high level of motorized use on Shasta Lake introduces a risk of water quality degradation. As a result, substandard underground storage tanks have been upgraded to reduce potential for contamination from leak and spills. Most tanks are now double-walled floating gas tanks. These facilities are monitored by the California Regional Water Quality Control Board.

Large concentrations of woody debris provide increased habitat for aquatic organisms but also present a hazard to boaters on the lake. Woody debris that accumulates in the reservoir after large floods, such as the 1997 event, is mapped on an annual basis and removed when water levels are at their lowest.

High recreational use, particularly during warm-season holidays, results in large amounts of litter left in the lake and around the shoreline. The Forest Service engages in regular cleanup activities to remove the trash.

Biological Features

Fire and Fuels

Methodology

Fire behavior modeling was conducted using Flammap. Flammap is a fire behavior mapping and analysis program that computes fire behavior characteristics over a landscape of constant inputs of weather and fuels moisture conditions. Outputs consisted of crown fire potential and flame length potential using Rothermel (1972) and Finney (1998). In addition, all fire model runs were calculated using the California Fuels Landscape, which uses the vegetation layer to obtain fuel models.

Weather and fuel moisture conditions were calculated for three scenarios, all obtained by a climatology program (Fire Family Plus) that collects historical weather data for analysis. The scenarios were used to evaluate moderate to extreme weather conditions that have been experienced in the past within the analysis area.

The first scenario calculated fire behavior under 90^{th} percentile weather conditions or severe weather conditions. Fires under 90^{th} percentile weather conditions have demonstrated significant fire growth and fire effects in the past. Fuel moistures under such conditions are very dry.

The second scenario calculated fire behavior under 50^{th} percentile weather conditions or moderate weather conditions. According to the Shasta Trinity National Forest Pocket Cards, this is when growth of fires or when fire suppression concerns starts to occur. Fuel moistures under such conditions are dry.

The third scenario calculated fire behavior conditions under increased wind, to show potential fire behavior and effects under extreme weather conditions. This scenario looked at past fires and fire weather (i.e., the Jones Fire of 1999 and the Bear Fire of 2004) to mimic a similar situation in places in and around the analysis area.

For the watershed analysis, only 90th percentile conditions are displayed. These conditions served as somewhat of an overall average of the three conditions mentioned. In addition, areas of concern did not change over the three scenarios, but were less or more prominent depending on weather and fuel moisture inputs.

The Shasta-Trinity National Forest Fire Management Plan updated the fuels situation in May of 2010 in terms of fire hazard, risk and value (USDA Forest Service 2010b). The following analysis will be similar in process and assumptions but will be more site-specific to the analysis area.

Fire Hazard

Fire hazard can be characterized by how a fire will burn or fire behavior. Fire behavior is the product of the natural environment or the unique combination of topography, weather and fuels (Countryman 1972). Topography and weather are factors on which humans have little effect. Fuels can be altered through human intervention or natural processes such as fire (rapid) or decomposition (very slow). Therefore, when assessing fire hazard, the focus can be on fuels and the associated fire behavior.

Fuels

Table 4 displays the fuel models in terms of description, acres, and percentage of each category of fuels in the watershed analysis area. These fuels models are derived from the vegetation layer and can describe fire behavior based on weather, topography, and weather characteristics.

Fire Behavior

Flame lengths, a measure of how intense or severe a fire may become and a proxy for ease of fire suppression, were used to model and predict fire behavior. Flame lengths are described in the Fire Management Plan and Appendix B of the Fireline Handbook as follows:

Low – Flame lengths 0 to 4 feet. Persons using hand tools can generally attach fires at the head or flanks of the fire.

Moderate – Flame lengths 4 to 8 feet. Fires are too intense for direct attack on the head of the fire by persons using hand tools. Equipment such as dozers, engines and retardant aircraft can be effective.

High – Flame lengths greater than 8 feet. Fires may present serious control problems such as torching, crowning, and spotting. Control efforts at the head of the fire will probably be ineffective.

Table 5 displays potential flame lengths for the analysis area. Figure A-15 in Appendix A displays a map of flame length potential in the analysis area.

Table 4. Fuel models within the watershed analysis area in acres and percentage of area

Fuel model and category	Description	Percent within analysis area / acres
Nonflammable fuel models 91, 97, 98, 99	Nonflammable. For example, open water, urban development, or bare ground	13% / 9,951
Grass-shrub fuel models 121 -- GS1	The primary carrier of fire in GS1 is grass and shrubs combined. Shrubs are about 1 foot high, grass load is low. Spread rate is high; flame length moderate.	2% / 1,719
Shrub fuel models 142 -- SH2	The primary carrier of fire in SH2 is woody shrubs and shrub litter. Moderate fuel load (higher than SH1), depth about 1 foot, no grass fuel present. Spread rate is moderate; flame length moderate.	6% / 4,600
Timber-understory fuel models 165 - TU5	The primary carrier of fire in TU5 is heavy forest litter with a shrub or small tree understory. Spread rate is moderate; flame length high.	11% / 8,376
Timber-litter fuel models		
181 -- TL1	The primary carrier of fire in TL1 is compact forest litter. Light to moderate load, fuels 1-2 inches deep. Spread rate is very low; flame length very low. May be used to represent a recently burned forest.	3% / 2,419
182 -- TL2	The primary carrier of fire in TL2 is broadleaf (hardwood) litter. Low load, compact broadleaf litter. Spread rate is very low; flame length very low.	1% / 1,104
183 -- TL3	The primary carrier of fire in TL3 is moderate load conifer litter, light load of coarse fuels. Spread rate is very low; flame length very low.	12% / 9,266
184 -- TL4	The primary carrier of fire in TL4 is moderate load of fine litter and coarse fuels. Includes small diameter downed logs. Spread rate is low; flame length low.	14% / 10,637
187 -- TL7	The primary carrier of fire in TL7 is heavy load forest litter, includes larger diameter downed logs. Spread rate low; flame length low.	2% / 1,383
188 -- TL8	The primary carrier of fire in TL8 is moderate load long-needle pine litter, may include small amount of herbaceous load. Spread rate is moderate; flame length low.	23% / 17,399
189 -- TL9	The primary carrier of fire in TL9 is very high load, fluffy broadleaf litter. TL9 can also be used to represent heavy needle-drape. Spread rate is moderate; flame length moderate.	5% / 4,075
Other fuel models	Other fuel models within the analysis boundary less than 1,000 acres and make up a small percentage of the total area.	6% / 4,647

Descriptions based on Anderson 1982 and Scott and Burgan 2005. Fuel models derived from the California Fuels Landscape created by the Region 5 Stewardship and Fireshed Analysis Team and clipped to the analysis area in GIS.

Table 5. Fire behavior potential based on flame lengths under 90th percentile weather

Flame Lengths	Acres	Percent Total Area	Percent Flammable Area
Non-flammable	9,939	14%	N/A
Low 0-4 feet	35,032	46%	53%
Moderate 4-8 feet	12,331	16%	19%
High > 8 feet	18,325	24%	28%
Total	75,627	100%	100%

Crown fire potential is a measure of how severe a fire may become under specified conditions. Canopy characteristics, ladder fuels and fuel loading are all factors that determine crown fire potential. Model limitations include the transition of passive and active crown fire and poor parameterization of canopy fuels; as a result, under-prediction of active crown fire compared to observations is common (Fule et al. 2001, Scott and Reinhardt 2001, Cruz et al. 2003, and Stratton 2004). Crown fire measures are defined as the following:

Surface fire -- The fire remains on the forest floor. The combination of surface fire intensity and ladder fuels is not sufficient to move a fire into the crowns under the defined burning conditions.

Passive Crown Fire -- Individual tree or group torching occurs. The combination of surface fire intensity and ladder fuels allows for movement into the crowns under the defined burning conditions, but canopy bulk density is too low for fire to spread through the crowns under the projected wind speeds.

Active Crown Fire -- The combination of surface fire intensity, ladder fuels and canopy bulk density allows fire to move into, and spread through, the crowns under the defined burning conditions.

Table 6 displays crown fire potential in the analysis area. Figure A-16 in Appendix A displays a map of crown fire potential in the analysis area.

Table 6. Crown fire potential under 90th percentile weather

Crown fire potential	Acres	Percent total area	Percent flammable area
Nonflammable	9,939	14	N/A
Surface fire	37,379	49	57
Passive crown fire	22,699	30	34
Active crown fire	5,610	7	9
Total	**75,627**	**100**	**100**

Fire Risk

Fire risk is defined in the Fire Management Plan as the probability of a fire start occurring over a 10-year period for a given thousand-acre area. Fire risk is based on the Shasta Trinity National Forest GIS layers for fire occurrence records within the analysis area. The risk classification within the Fire Management Plan is as follows:

Low Risk = 0 to 0.49: Less than 0.5 fires expected to occur per decade for every thousand acres in the area being analyzed.

Moderate Risk = 0.50 to 0.99: Between 0.5 and 0.99 fires expected to occur per decade for every thousand acres in the area being analyzed.

High Risk = At least one fire expected to occur per decade for every thousand acres in the area being analyzed.

Within the project boundary (75,576 acres) 160 fire starts occurred over a 21-year period analyzed (1987 to 2008). The risk value formula is R = {(*x*/*y*) 10}/*z* where:

x = fire starts (160)
y = period analyzed (21 years)
z = number of acres analyzed (75,576 displayed in thousands = 75.6)
Risk rating = {(160/21) 10}/75.6 = 1.01 (high risk)

The analysis area has a high fire risk value. The primary source of ignition (approximately 82 percent from 1987 to 2008) has been human-caused ignitions, while approximately 18 percent has been lightning-caused. The majority of the human-caused fires are in the Interstate 5 corridor and adjacent to Shasta Lake.

Wildland-urban Interface Threat

The wildland-urban interface for the analysis area is primarily on the west and south sides of Shasta Lake. The threat comes primarily from human-caused fires; however, lightning-caused fires have posed a threat to communities in recent years. Recent fires threatening communities include the 2008 SHU Lightning Complex fires; the 2004 Bear fire; the 1999 Jones fire; the 1992 Fountain fire and others. Weather conditions, poor access for firefighting forces, rugged terrain, fuel conditions, and many other factors contributed to large fire growth in most of these recent fires. Table 7 displays the results of analysis of fire behavior potential (flame lengths) within the wildland-urban interface and analysis area.

Table 7. Flame length potential (acres) under 90th percentile weather conditions in the wildland-urban interface within the Pit Arm Shasta Lake Watershed Analysis area

Wildland-urban interface	Nonflammable	Low (0-4 ft.)	Moderate (4-8 ft.)	High (> 8 ft.)	Total
Frendiman	0	5	6	9	20
Shasta Lake	236	17,375	5,690	6,482	29,783
Jones Valley	171	6,855	1,216	2,134	10,376
Mountain Gate / Shasta Lake	403	2,695	1,262	1,794	6,154
O'Brien	55	369	391	961	1,776
Total	865	27,299	8,565	11,380	48,109

The wildland-urban interface GIS layer comes from the most recent analysis of the area (2009).

Impact of the Current Fire Regime on Vegetation within the Analysis Area

Methodology

Fire behavior potential under 90th percentile weather conditions was used for this analysis. Dominant vegetation types and size classes were from the Shasta Trinity National Forest vegetation layer. It is important to note that the vegetation layer did not cover portions of private lands; therefore, the analysis was done for areas covered by the vegetation layer.

Current Fire Regime Impacts to Vegetation

The fire regime is the most widespread and dynamic disturbance regime affecting the analysis area. Numerous fire starts occur within the analysis area every year. Fires occurring in the area affect vegetation communities with varying severities. Patterns of fire severity can be attributed to vegetation type, solar radiation, weather patterns, and slope positions. Upper slopes, ridgetops, and south- and west-facing aspects typically experience higher fire severity. As a result, shrubs and fire-adapted species such as knobcone pine and other even-aged trees dominate such areas. Lower slopes and north- and east-facing aspects typically experience lower fire severity. These areas typically have multi-aged stands and burn with less frequency. With lower fuel loadings, landscape features such as streams and ridgetops are often sufficient to impede fire spread.

Current vegetation patterns are also attributed to disturbance history. Much of the analysis area (approximately 80 percent of the area not including Shasta Lake) has been fire free over the past 20 years. As a result, the buildup of ladder and surface fuels has increased the probability of high-severity stand-replacing fire. Although current vegetation and severity patterns are largely dependent on factors mentioned above, large patches of high-severity fire have been observed in areas that typically burned at low severity. As a result of areas burning at uncharacteristically high severities and other areas being fire free, current vegetation patterns and seral stage distribution has changed significantly since the onset of the fire suppression era approximately 100 years ago.

An analysis was conducted to determine current fire behavior potential on dominant vegetation communities (Table 8) and size class (Table 9). This was done to get a better understanding of fire effects on current vegetation types and size class distribution within the analysis area.

Table 8. Fire behavior potential (in acres) by dominant vegetation type

Dominant vegetation type	Low	Moderate	High
Annual grass	751	41	210
Barren	309	0	0
Blue oak - foothill pine	200	255	758
Blue oak woodland	318	5	12
Closed-cone pine-cypress	33	188	374
Douglas-fir	2,806	32	79
Lacustrine	9,333	0	0
Mixed chaparral	2,311	578	4,563
Montane chaparral	24	8	319
Montane hardwood-conifer	5,163	1,921	1,638
Montane hardwood	9,715	3,298	3,633
Ponderosa pine	926	2,399	3,993
Sierran mixed conifer	12,455	3,440	2,602
Urban	271	7	13

The dominant WHR type from the EVEG GIS layer was used for this analysis.

Table 9. Fire behavior potential (acres) by tree size class

Size class (dbh)	Low	Moderate	High
1 - 5.9 in.	400	116	357
6 - 10.9 in.	3,664	1,127	1,968
11 - 23.9 in.	14,957	4,655	4,005
> 24 in.	12,587	5,627	6,754

GIS data for size class were obtained from the EVEG layer.

Impacts of Fire on other Resources

Air Quality

Air quality can be evaluated in terms of visibility and the concentration of pollutants. Wildfire, residential wood and trash burning, agricultural and prescribed burning, asbestos from asbestos containing rock and road construction can create smoke or dust. Smoke and dust have the potential to affect air quality. Fire produces carbon monoxide, suspended particulate matter (PM_{10} and below) and polycyclic hydrocarbons as pollutants. The smoke produced by fires can affect visibility as well as other air pollutant standards.

Smoke- and/or dust-producing activities on National Forest lands are regulated by the Federal Clean Air Act, the Shasta-Trinity National Forest LRMP and the California Air Resources Board. Standards established therein are also useful in measuring the impact of wildfires on air quality.

Air quality was noticeably poor at various times in Northern California from August through October of 1999 and 2008 due to large wildfires on the Shasta Trinity and Six Rivers National Forests. Monitoring at the community of Hoopa, California indicated that, as a result of the Big Bar Complex fires, California 24-hour PM_{10} standards were exceeded on 19 days and the federal standard was exceeded on 12 days. During several days, average PM_{10} standards were greater than 420 ug/m^3, which is considered hazardous. The smoke from the fires precipitated the first declared state of emergency in a California county due to air pollution (Herr 1999).

As fire risk and high fire behavior potential in the analysis area increase, periods of poor air quality during wildfires are likelier to occur.

Erosion Processes and Soil Productivity

Fires may affect soil properties and erosion processes. Areas that burn with a moderate to high intensity often lose their duff layer. The duff layer provides protection from erosion processes, a supply of nutrients to the soil, and a natural reserve of nutrients for long-term soil productivity needs. Areas burned with high intensity also lose nitrogen by volatilization processes in the surface inch of soil. The loss of soil nutrients from fire volatilization of above- and below-ground organic material and from accelerated erosion processes impacts soil and site productivity. Erosion in the Jones Valley area is a concern because of the cumulative impacts from high severity fire and recreation use. Portions of Jones Valley burned at high intensity in the Jones Fire of 1999 and the Bear Fire of 2004 and the steep slopes were de-vegetated, which increased erosion potential.

See the Physical Sciences discussion for a more detailed description of erosion processes in the watershed.

Water Quality and Aquatic Species Habitat

Water quality is directly related to aquatic species habitat needs. Increased delivery of sediment to streams from upland erosion and elevated stream temperatures from loss of overstory canopy shade in the wake of high-intensity fires may reduce water quality and degrade habitat for local fish populations.

See the Physical Sciences and Aquatic and Riparian-Dependent Species discussions for a more detailed description of water quality and aquatic species habitat in the watershed.

Terrestrial Wildlife Habitat

Fire effects to vegetation, as discussed above, also influence wildlife habitat and populations. Wildfire can potentially limit foraging resources, as well as predator protection and thermal protection for Northern spotted owls. Conversely, fire can improve browse for elk, bear and other species and increase snag habitat for snag-dependent species. See the Wildlife discussion for a more detailed description of the inter-relationship between fire and wildlife habitat and populations.

Human Uses

Fire effects to the above resources in turn impact the recreation experience and other human uses in the analysis area. Such impacts include - but are not limited to - effects to scenery from large areas of burned landscape, restrictions on motorized and non-motorized recreation and poor air quality during wildfire events, and degradation of water quality. See the Human Uses discussion for a detailed description of other uses in the analysis area that may be impacted by fires.

Fire Suppression Concerns within the Analysis Area

Fire suppression is a major concern within the analysis area. Numerous fire starts coupled with steep terrain, poor access for fire suppression forces, dense fuels conditions and weather patterns conducive to large fire growth have created fire-suppression concerns in the past and continue to drive the concerns of suppressing future wildfires. These factors will be discussed in more depth below.

Human use is high within the analysis area (see the Human Uses current conditions above), and as described above, the numerous fire starts that occur every year are primarily human-caused (see figures A-25 and A-26 in Appendix A). The major concern of human-caused starts is that they typically occur under weather conditions conducive to large fire growth. Extreme fire weather conditions occurred during the 2004 Bear and 1999 Jones fires. Such recurring weather conditions and the potential for human-caused fire starts are an ongoing concern.

Portions of the analysis area have steep terrain and poor access for fire suppression forces. The north side of Shasta Lake and other portions of the analysis area have limited road access (see figure A-5 in Appendix A) for fire-suppression forces, making it difficult for ground forces to reach the fires. Heavy fuel loading and steep terrain also make it more difficult to suppress fires in the analysis area. These factors delay adequate response times to fire starts, increasing the likelihood of a fire getting larger.

Another concern revolves around the wildland-urban interface within and adjacent to the analysis area. Ingress and egress of public and fire-suppression forces lead to concerns of firefighter and public safety. In addition, Table 7 above identifies approximately 19,945 acres of moderate-to-high fire behavior potential in the wildland-urban interface under current conditions. The wildland-urban interface falls primarily within the CalFire direct protection agency zone, included in this area is a small percentage of National Forest System lands.

Vegetation

The analysis area falls within the southeast extent of the Klamath Mountains Geological Province. Vegetation communities in the Pit Arm watershed are strongly influenced by climate, land surface morphology and past management practices. Vegetation diversity tends to be high due largely to favorable climate and varying geology.

Methodology

Current and past vegetation types and conditions were analyzed using vegetation mapping obtained from the Forest Service Region 5 Remote Sensing Lab (see the project file). Historical activities and vegetation conditions were also researched and analyzed using published historical documentation (see the project file). Current and historical spatial polygons of vegetation types in Geographical Information Systems (GIS) maps were compared and analyzed to determine vegetation types, distribution and change over time.

Current vegetation conditions were also assessed by onsite observations (September 2009) to determine overall conditions and trends within the watershed. Spatial queries and analysis were conducted using corporate GIS data including soil types, topography, water features and land management allocations.

Climate

The climate regime is described as Mediterranean and typified by hot dry summers and cool wet winters. Annual precipitation within the watershed averages from 45 to 75 inches and falls primarily as rain from November 1 through April 30. Average temperatures range from the mid-40s Fahrenheit in the winter months to near 80 degrees in the summer months, with summer days typically reaching near or above 100 degrees. Weather data from Shasta Lake in 2008 recorded a total of 27 days of below freezing temperatures with a lowest recorded temperature of 24 degrees. High summer temperatures combined with low humidity and limited rainfall are perhaps the strongest climatic influence on local plant communities, favoring drought-tolerant species that can limit evapotranspiration loss.

Physical Characteristics

Land characteristics that most strongly influence the vegetation communities include aspect, slope position, elevation, and soil characteristics. The terrain within the watershed is rugged and predominantly composed of steep dissected drainages with slopes typically between 40 and 60 percent or greater. Elevations within the analysis area range from near 900 feet to over 3,600 feet, with an average elevation of approximately 2,000 feet. Two vegetation transition zones occur within the watershed based on elevation: (1) valley (less than 1,500 feet) and lower montane (foothill) vegetation types and (2) lower montane (1,000 to 3,500 feet), and montane (greater than 3,000 feet) vegetation types.

Soils are quite varied within the watershed but are predominantly derived from ultramafic, Pre-Cretaceous metamorphic and Pre-Silurian metavolcanic rock (Lanspa 1993). Figure A-17 in Appendix A displays a map of soil families in the watershed. Most of the soils fall within six different Order 3 soil families, which are further described in Table 10.

Forest soil surveys further classify Order 5 soil taxonomic units and indicate commonly occurring vegetation types, estimated forest productivity (forest survey site class), and conifer seedling survival potential. Forest survey site class is tied to estimations of maximum annual timber biomass accumulation and as such is used to indicate soil productivity in terms of timber yield. Seedling survival potential is based primarily on the plant-available water capacity (AWC) of a soil, which relates to soil depth and texture.

Table 10. Predominant Order 3 soil families within Pit Arm watershed

Soil Family	Description	Taxonomic Class
Holland	Moderately deep and deep, well-drained soils formed in material weathered from metasedimentary, volcanic and diorite or granitic rocks.	Fine-loamy, mixed, mesic Ultic Haploxeralfs
Marpa	Moderately deep and deep, well-drained formed in material weathered from metavolcanic and metasedimentary and sedimentary rock.	Loamy-skeletal, mixed, mesic Ultic Haploxeralfs
Goulding	Shallow, well drained that formed in material weathered from metavolcanic and metasedimentary rocks.	Loamy-skeletal, mixed, mesic Lithic Xerochrepts
Millsholm	Shallow, well-drained soils that formed in material weathered from sedimentary rocks such as sandstone, shale and siltstone.	Loamy, mixed, thermic Lithic Xerochrepts
Neuns	Moderately deep and deep, well-drained soils that formed in material weathered from schist, metavolcanic and metasedimentary rocks.	Loamy-skeletal, mixed, mesic Dystric Xerochrepts
Washougal	Moderately deep and deep, somewhat excessively drained soils that have formed in volcanic ash deposited over lava flows.	Medial-skeletal, mesic Andic Xerumbrepts

Table 11 lists the most prevalent forest soils (Order 5) in the watershed. Table 12 lists associated WHR (wildlife habitat relationship) vegetation types and characteristics. In general, soils are typically well drained with moderate to moderately high levels of gravel content. Soil depth and parent material strongly influence vegetation composition and distribution.

Table 11. Predominant Order 5 soils within forested vegetation types

Soil Map Unit	Order 5 Taxonomic Unit Description	Percent of forested watershed
183/182	Marpa-Holland, deep families complex, 40- 60 % slopes / 20-40% slopes	14%
105	Holland-Holland family, deep complex, 40- 60 % slopes	9%
179	Marpa-Goulding families association, 40- 60 % slopes	8%
195	Millsholm family, 20 TO 60 percent slopes	8%
219	Neuns-Marpa families complex, 60 TO 80 percent slopes	6%
114	Holland, ashy-Washougal families complex, 25-65 % slopes	6%
204	Neuns family, 60 TO 80 percent slopes	4%
102	Holland-Goulding families association, 40- 60 % slopes	4%
80	Goulding family, 40- 60 % slopes	4%
120	Holland family, deep - Holland family complex, 40- 60 % slopes	4%
180	Marpa-Goulding families association, 60-80% slopes	4%
109	Holland family, ashy, 0 TO 20 percent slopes	3%
83	Goulding-Marpa families association, 40- 60 % slopes	3%

Table 12. Predominant forest soils and their characteristics

Soil Map Unit	Associated WHR Vegetation Types	Forest survey site class	Seedling survival
183/ 182	DFR, SMC	5 / 3-4	low-high
105	SMC, BOP	4-5 / 3-4	moderate-high
179	DFR, SMC / MCH	5	low-high / v. low-low
195	BOW, MCH, MCP	7	low-moderate
219	DFR, SMC	5	low-high
114	SMC, MCP	3-4 / 5	moderate-high / low-mod
204	DFR, SMC	5	low-mod
102	DFR / BOW, MCH, MCP	4-5 / 7	mod-high / v. low-low
80	BOW, MCH	7	v. low- low
120	DFR, SMC	3-4 / 4-5	mod-high
180	DFR, SMC / BOW, MCH	5 / 7	low-high / v. low-low
109	SMC, PPN	3-4	mod-high
83	BOW, MCH / SMC	7 / 5	v. low-low / low-high

Forest Survey Site Class:	Mean Annual Increment (MAI) (cubic feet of wood volume growth):
3	120-164
4	85-119
5	50-84
6	20-49
7	<20

Vegetation Types

DFR – Douglas-fir
SMC – Sierran mixed conifer
BOP – blue oak foothill pine
MCH – mixed chaparral
MCP – montane chaparral
BOW – blue oak woodland
PPN – ponderosa pine

Vegetation Types

Vegetation is classified into wildlife habitat relationship (WHR) types that identify predominant species as well as size classes and canopy cover classes in vegetation types that are tree dominated. WHR types provide an ecological classification of groupings of vegetation that commonly occur together within geographic areas and elevation zones, and share a common developmental pattern of seral stages (Mayer and Laudenslayer 1988). Vegetation types in the lower elevations are predominantly chaparral and hardwoods with a minor component of annual grassland. Vegetation transitions to contain both a chaparral/hardwood mix and a conifer component (predominantly pine) with increasing elevation. At higher elevations, sites are dominated by mixed-conifer overstory with brush in the understory, primarily in open areas. Riparian corridors are an exception where conifers can span from lower to upper elevations due to a conducive microclimate. Montane riparian vegetation is located in narrow belts along many of the tributaries. Table 13 lists the total acres by WHR vegetation type found within the watershed. Figure A-18 in Appendix A displays a map of these vegetation types in the watershed.

WHR tree size and canopy cover classes are used to identify seral stage in forest stands. Seral stages are used to describe a sequential, directional change of vegetation development through time from bare ground (early seral) to a climax community (late seral). Under this concept, stands grow and shift along a continuum of development based on disturbance events. As such, a climax community is not a "final" or steady-state condition. Viewed as a continuum through time, late-seral stands can be considered the farthest vegetation stage from a prior stand disturbance event.

Table 13. WHR vegetation types within the watershed

WHR Vegetation Type	Description	Category	Acres
AGS	Annual Grassland	non-forested	602
BAR	Barren	non-forested	305
LAC	Lacustrine - Water	non-forested	9,333
URB	Urban	non-forested	291
		Subtotal	*10,532*
MCH	Mixed Chaparral	brush	7,452
MCP	Montane Chaparral	brush	351
		Subtotal	*7,803*
MHW	Montane Hardwood	hardwood	16,646
		Subtotal	*16,646*
BOP	Blue Oak-Foothill Pine	hardwood/conifer	1,213
BOW	Blue Oak Woodland	hardwood/conifer	335
CPC	Closed-Cone Pine-Cypress	hardwood/conifer	595
MHC	Montane Hardwood-Conifer	hardwood/conifer	8,721
		Subtotal	*10,864*
DFR	Douglas-Fir	conifer	2,917
PPN	Ponderosa Pine	conifer	7,318
SMC	Sierran Mixed Conifer	conifer	18,497
		Subtotal	*28,732*
		Subtotal - all forested vegetation	*56,243*
		Total	74,577

Currently, with the exception of recently burned areas, much of the forest vegetation is typed as late seral. This is due much in part to fire suppression activities that began in the early 1900s. Historic vegetation conditions and their change through time are further discussed in the next chapter. Table 14 lists the WHR size class, canopy class and seral stage of forested stands in the watershed. Figures A-19, A-20 and A-21 in Appendix A display maps of WHR vegetation type seral stages, size classes and canopy density class, respectively.

Table 14. WHR size, seral stage and canopy cover in forested vegetation types

WHR size class (dbh)	Seral stage	WHR density class (% Canopy)				Total Acres	% Per Size Class
		S (10-24%)	P (25-39%)	M (40-59%)	D (60-100%)		
1: < 1"	Early seral	0	0	2	23	25	0%
2: 1"-6"		142	190	135	406	874	2%
3: 6"-11"	Mid seral	199	594	1,186	4,780	6,759	12%
4: 11"-24"		309	938	2,410	19,959	23,617	42%
5: > 24"	Late seral	110	197	474	24,187	24,968	44%
Total Acres (forested)		761	1,919	4,207	49,355	56,243	100%

As shown in Table 14, over 80 percent of the current forest vegetation is WHR sizes 4 and 5 (mid- and late seral) and nearly all stands (88 percent) have 60 percent or more canopy cover. Overall, most forested stands are quite dense with continuous canopies. Understory vegetation is highly variable but present in most stands, particularly in small openings. Shrubs, oak and young/suppressed Douglas-fir and ponderosa pine are common understory and midstory components. Highly dense mixed conifer, pine and Douglas-fir stands (WHR 5D) generally have little to no live understory but often have skeletal remains of brush and small trees that have been shaded out and died.

Table 15 displays the WHR size classes by vegetation type. While WHR size class 5 is described as late seral, the various vegetation types within this size class (for example blue oak - foothill pine) are not necessarily considered late-successional habitat for wildlife species. Late-successional habitat is further described in Wildlife – Current Conditions.

Table 15. WHR size class, seral stage and canopy cover in forested vegetation types

WHR Type	WHR size class						Total acres
	X	1	2	3	4	5	
Blue Oak-Foothill Pine			22	175	774	243	1,213
Blue oak woodland		10	58	266	2		335
Closed-cone pine-cypress			13	136	164	282	595
Montane hardwood-conifer			83	328	5,360	2,949	8,721
Montane hardwood		15	561	4,958	10,876	237	16,646
Douglas-fir			3	30	310	2,574	2,917
Ponderosa pine			60	260	955	6,044	7,318
Sierran mixed conifer			74	608	5,177	12,638	18,497
Mixed chaparral	7,452						7,452
Montane chaparral	351						351
Total acres (forested)	**7,803**	**25**	**874**	**6,759**	**23,617**	**24,968**	**64,046**

Pure chaparral is found on approximately 10 percent of the watershed; however, it is also present in many if not most openings within forested stands. A patchy to virtually continuous understory of chaparral is also present in most early seral stands and open-canopied stands (WHR density "S" and "P"; see Table 14). Chaparral stands and patches generally range from 5 to 10 feet or more in height and have fairly high accumulations of leaf litter and standing dead material due to their age.

Riparian vegetation within the watershed is generally limited to narrow strips adjacent to stream channels in steep draws and includes species such as wild grape (*Vitus californica*), wild rose (*Rosa* spp.), dogwood (*Cornus* spp.), black cottonwood (*Populus trichocarpa*) and bigleaf maple (*Acer macrophyllum*). Riparian vegetation occurs beneath or as a minor component of a forest overstory, and as such is mapped by location rather than as a distinct WHR classification.

The photographs on page 39 show examples of vegetation types within the watershed.

Late seral mixed-conifer stand (WHR 5D)

Montane chaparral next to mixed-conifer stand (WHR 4D)

Chaparral with grey pine

Mixed hardwood stand with shrub understory

Photo 3. Examples of vegetation conditions within the Pit Arm watershed

Threatened, Endangered and Sensitive (TES) Plants and Other Species of Concern

Methodology

Current habitat conditions of TES plants, survey-and-manage plants, and botanical species of interest occurring in the Pit Arm Shasta Lake watershed were assessed using Natural Resources Information Systems (NRIS) and California Natural Diversity Database (CNDDB) Element Occurrence Records, results of past floristic and rare plant surveys, the CNPS online Inventory of Rare and Endangered Vascular Plants of California, current vegetation information (Lindstrand and Nelson 2006), and site observations (September 2009). Rare plant occurrence polygons were overlain with the watershed boundary in a GIS (geographical information system) database and species occurring within the boundary were considered for further analysis. Queries were also run in the GIS using soils, elevation, and existing vegetation layers to assess potential suitable habitat in the watershed. The amount of suitable rare plant habitat is often overestimated because queries rely on somewhat generalized vegetation layers. Conversely, small microsites of suitable habitat may be overlooked during coarse-scale analysis.

Documented Rare Plant Occurrences and Suitable Rare Plant Habitat

Documented rare plant surveys in the watershed have been intermittent. Recent surveys related to forest activities include the Pit 3 and 4 Hydroelectric Project (2003), Green Mountain Prescribed Burn (2006), Bear Hazardous Fuels Reduction (2006), and PG&E McCloud-Pit Federal Relicensing (2007, 2008) projects. These surveys identified new occurrences of *Fritillaria eastwoodiae* and suitable habitat (but no occurrences) for *Arnica venosa, Clarkia borealis* spp. *borealis, Cypripedium montanum*, and *Neviusia cliftonii*.

The following rare vascular plant species are documented as occurring in the Pit Arm watershed:

- ***Ageratina shastensis* (Shasta eupatory):** This perennial subshrub is classified as a CNPS List 4.2 species (i.e., limited distribution [watch list]; fairly endangered in California). It is limited to Shasta County and typically occurs on limestone substrates (Hickman 1993) in chaparral and lower montane coniferous forest at elevations from 1,300 to 5,900 feet (CNPS 2009). There are two documented populations of *A. shastensis* (1975, 1993) in the watershed. Both populations occur in the Devil’s rock region, on a limestone substrate, and in mixed vegetation types (Douglas-fir, montane hardwood, mixed chaparral, Sierran mixed conifer).
- ***Calystegia atriplicifolia* ssp. *buttensis* (Butte County morning-glory):** This perennial rhizomatous herb is classified as a CNPS List 1B.2 species (i.e., rare, threatened, or endangered in California and elsewhere; fairly endangered in California), Forest Service sensitive species, and BLM sensitive species. It is endemic to California and occurs in chaparral, open areas in lower montane coniferous forests, and occasionally along roadsides at elevations from 1,970 to 5,000 feet. There are two documented populations in the watershed (2004) – one roadside in an annual grass vegetation type and one hillside in Sierran mixed conifer and mixed chaparral vegetation types. Both populations occur on private land adjacent to the Shasta-Trinity National Forest.
- ***Clarkia borealis* ssp. *arida* (Shasta clarkia):** This annual herb is classified as a CNPS List 1B.1 (i.e., rare, threatened, or endangered in California and elsewhere) and BLM sensitive species. It occurs in cismontane (i.e., situated on the coastal side of mountains) woodlands, chaparral, and gaps in lower montane coniferous forest from 1,640 to 1,970

feet in elevation (CNPS 2009). There is one documented occurrence (1996) in the watershed.

- ***Clarkia borealis* ssp. *borealis* (northern clarkia):** This annual herb is classified as a CNPS List 1B.3 species (i.e., rare, threatened or endangered in California and elsewhere; not very endangered in California), Forest Service sensitive species, and BLM sensitive species. It is endemic to California, and locations are known only in Shasta and Trinity counties (CNPS 2008). *C. borealis* ssp. *borealis* prefers cismontane and foothill woodlands, chaparral, and lower montane coniferous forest habitats between elevations of 1,300 and 4,400 feet. There are four documented populations in the watershed (1932, 1987 and 1995) occurring primarily in the montane hardwood vegetation type.
- ***Fritillaria eastwoodiae* (Butte County fritillary):** This perennial herb is classified as a CNPS List 3.2 species (i.e., more information needed about this plant [review list]; fairly endangered in California). Its distribution is limited to the Cascade Range, specifically Tehama, Butte and Shasta Counties (Hickman 1993). It is found in chaparral and cismontane woodland on dry benches and slopes and openings in lower montane coniferous forest from 164 to 4,920 feet (CNPS 2009). There is one documented occurrence of *F. eastwoodiae* within the watershed (2008) in the Sierran mixed conifer vegetation type.
- ***Neviusia cliftonii* (Shasta snow-wreath):** This shrub is classified as a CNPS List 1B.2 species (i.e., rare, threatened, or endangered in CA and elsewhere), Forest Service sensitive species and BLM sensitive species. It is found in cismontane woodlands, lower montane coniferous forest and riparian woodlands along streamsides. This species was previously considered associated with limestone substrates (CNPS 2009, Hickman 1993); however, newer information indicates that nearly half the documented occurrences in Shasta County grow on non-limestone substrates (Lindstrand and Nelson 2006) between 984 and 1,640 feet. There are six documented occurrences (1994, 1996, and 2003) in the watershed primarily on north-facing slopes in a variety of vegetation types.
- ***Thermopsis gracilis* var. *gracilis* (slender false lupine):** This herb is a CNPS List 4.3 species (i.e., limited distribution [watch list]; not very endangered in California). It is often found on dry sites, between 328 and 4,500 feet elevation, in cismontane woodlands, lower montane coniferous forest, or north coast coniferous forests. There are four documented occurrences (2007, 2008) of *T. gracilis* var. *gracilis* in the northeast portion of the watershed. All occurrences are at approximately 1,250 feet in elevation and are found within Sierran mixed conifer or ponderosa pine vegetation types.
- ***Viburnum ellipticum* (Oval-leafed viburnum):** This shrub is a CNPS List 2.3 species (i.e., rare, threatened, or endangered in CA; common elsewhere). This plant grows in chaparral, cismontane woodland, and lower montane coniferous forest communities at elevations ranging from 700 to 4,600 feet. There is one documented occurrence of *V. ellipticum* within the watershed (2007), in the chaparral vegetation type.

The GIS query results indicate that approximately 64,648 acres of the watershed (or approximately 87 percent) are potential habitat for one or more TES plants. As noted above, this amount of potential rare plant habitat is likely overestimated.

Several rare plant species are endemic to either serpentine or limestone bedrock, of which there are respectively 208 and 2,714 acres in the watershed. Additional rare plant species occurring within 10 miles of (but not within) the watershed boundary include *Arnica venosa, Smilax jamesii,* and *Streptanthus longisiliqus.*

Although no populations of bryophyte, lichen, or fungi species are documented in the watershed, potential habitat may exist in microsite environments (e.g., caves, down or decaying large-diameter logs, vernally mesic areas).

Noxious and Undesirable Weed Species

Methodology

Current habitat conditions of noxious weeds occurring in the Pit Arm Shasta Lake watershed were assessed using information from Natural Resources Information Systems (NRIS) Element Occurrence Records, results of past floristic surveys, California Invasive Plant Council (Cal-IPC), California Department of Food and Agriculture (CDFA), and current vegetation information supplied by the Forest.

Documented Weed Infestations

Documented noxious weed surveys in the watershed have been intermittent. Recent surveys related to forest activities include the Pit 3 and 4 Hydroelectric Project (2003), the Green Mountain Prescribed Burn (2006), the Bear Hazardous Fuels Reduction, and the PG&E McCloud-Pit Federal Relicensing (2007, 2008) projects.

The following noxious weed species are documented in the Pit Arm Shasta Lake watershed:

- ***Ailanthus altissima* (tree of heaven)** – This deciduous tree is considered moderately invasive by Cal-IPC. This fast-growing species spreads rapidly either by seed or by root sprouts and may appear in disturbed urban and semi-natural environments and waste areas (Hickman 1993, Cal-IPC 2009). Three occurrences, covering approximately 1.6 acres, of *A. altissima* were documented in the watershed in 2003 and 2007.). This species is displacing native riparian vegetation along the nearby Lower McCloud River but is not expected to have major impacts in conifer stands (USDA Forest Service 1998). *A. altissima* has been observed along roads and recreation sites in and around the Pit Arm watershed.
- ***Bromus tectorum* (cheatgrass)** – This annual grass is considered highly invasive by Cal-IPC. It is relatively rare in annual range communities but may be found in open, disturbed areas below 7,200 feet (Hickman 1993). The only documented occurrence in the watershed of *B. tectorum* occurs along a roadside near the Pit 7 Dam.
- ***Carduus pycnocephalus* (Italian plumeless thistle)** – This annual herb is rated as moderately invasive by Cal-IPC. *C. pycnocephalus* grows along roadsides, pastures, and waste areas below 3,280 feet (Hickman 1993). Plants can reach nearly 100 percent cover over large areas inhibiting seedling recruitment and survivorship (Cal-IPC 2009).
- ***Centaurea solstitialis* (yellow star thistle) –** Yellow star thistle invades 12 million acres in California, is considered highly invasive (Cal-IPC 2009), is on the Noxious Weed List C (control required in nurseries, not required elsewhere) by CDFA, and is of very high concern on the Shasta-Trinity National Forest. This species occurs throughout the Pit Arm watershed as well as the larger Shasta-Trinity National Forest. Currently there are 36 documented occurrences in the watershed, totaling approximately 18 acres of infestation, along roadsides and transmission lines. Yellow star thistle is a species of very high concern in the watershed as well as adjacent watersheds. In the Clikapudi

subwatershed *C. solstitialis* occupies most natural openings and has replaced native grasses (USDA Forest Service 2000).

- ***Cirsium arvense* (Canada thistle)** – This perennial thistle is rated as moderately invasive by Cal-IPC. It is common below 5,900 feet throughout California (Hickman 1993, Bossard et al. 2000) on a variety of soil types. *C. arvense* invades prairies, riparian zones, and roadsides. It is intolerant of shade and therefore colonizes well in recent burned or cut areas. There are no documented occurrences of *C. arvense* in the watershed; however, it has been observed in the area.
- ***Cirsium vulgare* (bull thistle) –** This biennial forb is considered a moderate invasive (Cal-IPC 2009). It is common below 6,900 feet throughout California (Hickman 1993, Cal-IPC 2009) on disturbed sites, roadsides, coastal grasslands, wetlands, forest openings, or rangelands and pastures (Bossard et al. 2000). Currently there are 14 documented occurrences in the watershed, totaling approximately 2.3 acres of infestation, along roadsides, ditches, and open forested areas.
- ***Cytisus scoparius* (Scotch broom) –** This perennial shrub is rated as highly invasive by Cal-IPC and as class C by CDFA. *C. scoparius* is common below 3,280 feet throughout northern California (Hickman 1993). It spreads through prodigious seed production and may be commonly found in disturbed areas such as road cuts and forest clear cuts but may also reside in undisturbed communities such as oak woodlands, or grasslands. Currently there is a documented occurrence along NFS road 34N27 near Packer's Bay on Shasta Lake.
- ***Genista monspessulana* (French broom)** – CDFA classifies this perennial shrub as a Noxious Weed List C and Cal-IPC considers it highly invasive. *G. monspessulana* is a strong competitor with other plants and may form dense, monospecific stands (Bossard et al. 2000). There are documented occurrences along NFS roads 33N85A and 34N27.
- ***Rubus armeniacus* (Himalayan blackberry)** – This perennial plant is rated as a highly invasive species by Cal-IPC. *R. armeniacus* is common below 5,250 feet throughout California; habitat types include wetlands and disturbed moist areas either manmade or natural (Hickman 1993, Bossard et al. 2000). Fifty occurrences, totaling 45 acres, are documented in the northeastern portion of the Pit Arm watershed; however, this species has been observed throughout the entire watershed and is competing aggressively with native species.
- ***Rubus laciniatus* (cutleaf blackberry*)*** – This perennial plant is found in generally moist, disturbed areas throughout northern and central California below 6,230 feet (Hickman 1993, CNPS 2010). It is listed as introduced to Canada and the lower 48 states (USDA Natural Resources Conservation Service 2010). There are no documented occurrences of *R. laciniatus* in the watershed; however, it has been observed in the area.
- ***Spartium junceum* (Spanish broom)** – This perennial shrub is rated as highly invasive by Cal-IPC. It is common in disturbed areas such as roadsides, pastures, eroding riverbanks and slopes; however, it may also invade undisturbed grasslands, coastal scrub and chaparral ecosystems (Bossard et al. 2000). Currently there is a documented occurrence along NFS road 34N27 near Packer's Bay on Shasta Lake.
- ***Torilis arvensis* (hedge parsley)** – This annual herb is considered a moderate invasive (Cal-IPC 2009). It occurs throughout California in disturbed site, urban areas and woodlands below 5,250 feet (Hickman 1993). It is especially common in foothill oak woodlands and grasslands east and west of the Central Valley (Cal-IPC 2010). There are

several occurrences of *T. arvensis* along the road near the Pit 7 Dam in the northeastern section of the watershed.

- ***Tribulus terrestris* (puncturevine)** – This annual herb is on the Noxious Weed List C (control required in nurseries, not required elsewhere) by CDFA. *T. terrestris* grows below 3,280 feet elevation, in disturbed areas (e.g., roadsides, railways, vacant lots), throughout California. The only documented occurrence of *T. terrestris* in the watershed occurs in an open, sandy area by the Pit No.7 afterbay dam fence.

Additional weed species of concern observed in the watershed include *Bromus tectorum, Lathyrus latifolius, Torilis arvensis,* and *Tribulus terrestris*.

Many noxious weeds establish or are spread along roads, trails or fuelbreaks via human or mechanical vectors. Several of these species may also colonize nearby off-road areas following a disturbance such as fire or logging (Bossard et al. 2000). This may be particularly true of species with high seed dispersal capabilities such as *Ailanthus altissima* (Landenberger et al. 2007) or *Cirsium vulgare* (Parendes and Jones 2000). The Pit Arm watershed contains approximately 212 miles of roads and OHV routes and 34 miles of trail. Additionally, there are many high-use recreation areas within the watershed (e.g., camping, mountain biking and hiking) where noxious weeds occur or have the potential to occur. Private lands adjacent to the watershed have several documented noxious weed occurrences that pose a threat for further forest infestation. Wind, water and wildlife also transport noxious weeds into, out of and within the watershed.

Current Weed Treatment Activities

An invasive plant species removal project has been proposed in the Packers Bay area of the watershed along NFS road 34N27 (Johnson 2009 personal communication). This project proposes to use a combination of hand cutting, piling and burning and herbicide application for the control of invasive broom species (*Cytisus scoparius*, *Genista monospessulana,* and *Spartium junceum*) in the 112-acre area. This particular broom infestation threatens to encroach upon a population of the rare plant *Neviusia cliftonii*. Past attempts have been made to control these species in the watershed with little success (Johnson 2009 personal communication).

Pokeweed (*Phytolacca americana*) removal has successfully taken place in a nearby recreation area (Bailey’s Cove) just outside the watershed boundary.

Additionally, at least one private landowner within the watershed, PG&E, manages for invasive species occurring on their property in compliance with relicensing conditions. These control measures include manual (pulling or cutting), mechanical (mowing or discing), chemical (herbicides), and biological (insect or pathogens) strategies.

Species and Habitats

Terrestrial Wildlife Species

Methodology

Wildlife species were divided into three main categories for the purposes of this analysis. These include the following:

- Federally listed by the U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act (1973) as threatened, endangered, proposed or candidate

- Forest Service sensitive
- Other species of interest
    - Survey-and-manage species
    - Neotropical migratory birds
    - Game species

Each of these categories and subcategories contain species that have a variety of habitat associations. Habitat descriptions and associations are described in more detail below. Figure A-22 in Appendix A displays the various wildlife habitats that occur in the Pit Arm Shasta Lake watershed analysis area.

Current information for known locations of these wildlife species, survey-and-manage wildlife species, and species of interest occurring in the Pit Arm watershed of Shasta Lake were assessed using district GIS data layers for species' locations compiled from past surveys, incidental sightings and known historical detections. In addition, data were gathered from the California Natural Diversity Database (CNDDB), Natural Resources Information Systems (NRIS), and the USFWS website that provides lists of threatened, endangered, proposed or candidate species known to occur in given geographic areas.

Habitat descriptions and condition were initially analyzed using CALVEG and Remote Sensing Lab (RSL) data in conjunction with National Agriculture Imagery Program (NAIP) imagery and district vegetation GIS layers (see the project file). On-the-ground conditions were then assessed during field visits.

Federally Listed Species

One federally listed species – northern spotted owl - has the potential to occur in the watershed, based on potential suitable habitat availability.

Forest Service Sensitive Species

Forest Service sensitive terrestrial wildlife species known or expected to occur or with suitable habitat in the Pit Arm watershed; based on either known location data or suitable habitat availability include the following (an asterisk [*] denotes species also categorized as survey-and-manage species):

- Bald eagle
- Late-successional mixed-conifer habitat
    - Northern goshawk
    - Pacific fisher (also a candidate species for federal listing)
    - American marten
    - California wolverine
- Early/mid-seral and oak woodland habitats
    - Pallid bat
    - Townsend's big-eared bat
    - Western red bat
- Terrestrial riparian-associated species
    - Northwestern pond turtle
    - Foothill yellow-legged frog
    - Southern torrent salamander
- Limestone-associated species
    - Shasta salamander*
    - Shasta sideband snail*
    - Wintu sideband snail*
    - Shasta chaparral snail*
- Species with limited suitable habitat in the watershed
    - Willow flycatcher

Bald Eagle Habitat and Viability

The bald eagle was listed in 1967 under legislation that preceded the Endangered Species Act, and was officially listed as endangered when the Act was signed into law in 1973. It was listed as endangered in the lower 48 United States because of a severe decline in numbers. This decline was primarily attributed to the use of certain pesticides that caused reproductive dysfunction and eggshell thinning. Habitat loss and disturbance at nest and roost sites were also major factors. Eagle populations have rebounded since the banning of DDT and the increased protection for nesting and winter roosting habitat. The bald eagle was removed from the Endangered Species List by the USFWS on July 9, 2007 and is now managed as a Forest Service sensitive species. Viability of this species on the Forest is expected to be provided through implementation of the National Bald Eagle Management Guidelines (USDI 2007), the Bald and Golden Eagle Protection Act, the Migratory Bird Treaty Act, and implementation of LRMP standards and guidelines for bald eagles.

Nesting territories are generally associated with lakes, reservoirs, rivers, or large streams. Nest trees are generally large-limbed, mature overstory conifers (generally pine) located within close proximity (2 miles or less) to large bodies of water that provide fish and water fowl for foraging.

Bald eagles have a very high fidelity to their established nests. A pair will remain in the same nest area year after year if left undisturbed. Around Shasta Lake, the nests are generally found in larger trees at a distance of 50 to 300 meters from the water's edge. Nests of adjacent territories are found only at 3- to 5-mile intervals, except for the Pit Arm of the lake where territories appear to be closer but are separated topographically from each other. This higher density of nests is believed to be the result of higher quality habitat in the Pit Arm of the lake. Most of the Pit Arm was not logged before construction of the dam and supports numerous snags, which provide foraging perches and better fish habitat than is found in the other arms of the lake (USDA Forest Service 1998a).

Bald eagles are present in the watershed year-round. The number of known bald eagle nests on Shasta Lake has increased dramatically since record keeping began: from 1970 with one known nest, to 1980 with 12 nests, and to 2009 with 23 nests (though not all are actively nesting on any given year; see Figure 1). Fifteen nests are known to be active in the Pit Arm watershed and to have fledged young in recent years. In the mid-1990s, prior to delisting, nest productivity had been a concern for the management of eagles on the lake due to a lack of nesting success of many of the eagle territories. Except for the 1994 productivity of 1.2 chicks per nest, eagles at Shasta Lake had not met the management objective of 1.0 young per nest as outlined in the Pacific Bald Eagle Recovery Plan (1986) since 1987. Concerted efforts to monitor fledging success and overall productivity of each territory were made. Multiple studies were conducted to establish possible reasons for a lack of productivity of the nests, and many possible reasons were cited including increased disturbance from recreationists on the lake during sensitive breeding periods, older females still producing thin-shelled eggs affected by pesticide exposure, changing water levels, drought, and availability of prey.

Since delisting, nesting and fledging success is still monitored, though only on a subset of the lake’s eagle population. Concerns related to eagle productivity center on disturbance-related issues associated with high-use recreation areas, especially during periods of dramatically increased use such as spring break, Memorial Day, Fourth of July and Labor Day vacations. Surveys for eagles and eagle nests are conducted along the entire shoreline of Shasta Lake on annual basis by Shasta Lake district biologists. In addition, annual helicopter surveys are conducted by PG&E biologists along the entire length of the Pit River, for Federal Energy Regulatory Commission licensing compliance.

Management of bald eagles on Shasta Lake is directed by individual territory management plans. Each known territory has a plan that determines management zones and directs which activities are permitted during different times of the year. Activities permitted on the lake within these zones may be restricted to assure that they will not have a negative effect upon bald eagles. Currently, booms, buoys and/or "Critical Wildlife Area" signs are placed seasonally in coves that receive high recreational activity from either houseboats or campers, where nesting eagles have been identified. Coves that have a potential for closure include the mouth of the Squaw River territory, Hirz Bay, Reno Canyon, and Mariner's Point. Each year, protective closures are in place from January 1 to July 31 in those coves that are determined to need protection from disturbance (USDA Forest Service 1998b).

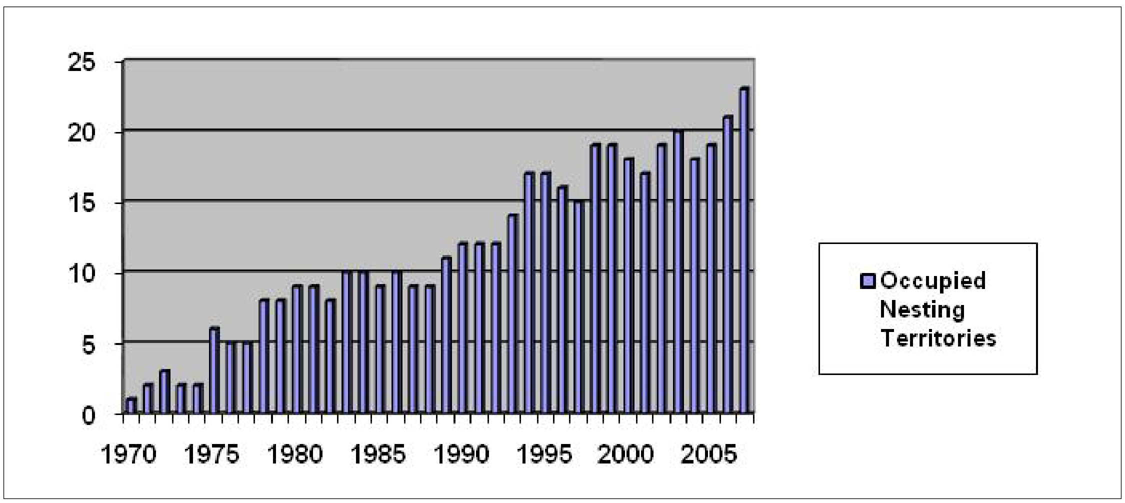

Figure 1. Number of occupied bald eagle nest territories at Shasta Lake

Late-successional Mixed-conifer Habitat

Of the species listed above, those with the potential to occur within late-successional mixed-conifer habitat are the northern spotted owl, American marten, Pacific fisher, northern goshawk, and California wolverine (though the probability of wolverine in the watershed is extremely low).

Northern Spotted Owl

Northern spotted owls are strongly associated with late-successional coniferous forests. Suitable habitat for the species is described as multi-layered, multi-species coniferous forest stands with more than 60 percent total canopy cover for nesting and roosting, a minimum of 40 percent canopy cover for foraging; large (greater than 18 inches dbh) overstory trees, large amounts of down woody debris, presence of trees with defects, or other signs of decadence in the stand (USDI Fish and Wildlife Service 2008). Figures A-19 and A-23 in Appendix A display WHR vegetation type seral stages and conifer seral stages, respectively, in the Pit Arm Shasta Lake watershed analysis area.

Determinations of suitability also consider size of stand and adjacency to other habitat types that owls can utilize. Forested stands with reduced acreage due to past land management activities or natural occurrences such as wildfire can create limiting habitat attributes essential to individual owl viability. Wildfire can potentially limit foraging resources, as well as predator protection and thermal protection. These foraging resources are prey abundance and essential cover for protection during foraging endeavors; both are depreciated or lost when intense wildfire moves through a forested stand. Suitable northern spotted owl habitat was identified using these definitions, in conjunction with “Suitable Spotted Owl Habitat Definitions using GIS” (USDA Forest Service 2010a), aerial photos and ground verification.

The figures in Table 16 indicate a higher number of suitable acres than was determined from ground verification. The amount of suitable nesting, roosting, and foraging habitat in the analysis area was ground verified due to an inherent overestimation from the GIS layer, and was determined to be approximately 50 percent less than the initial GIS acres had shown. This is likely due to the large hardwood component present in stands, but which precludes suitability for nesting and roosting when present in high (greater than 50 percent) proportions. In addition, the smaller, younger trees and the inclusion of grey pine as a conifer species that would provide suitable habitat were also factors in the GIS analysis that indicated more suitable northern spotted owl habitat than was actually present on the ground. Acre figures above will be modified to more accurately reflect on-the-ground conditions as more accurate habitat information is available for use with GIS.

Table 16. Acres of suitable northern spotted owl habitat within the Pit Arm watershed of Shasta Lake, based on GIS analysis (see the project file)

Type of northern spotted owl habitat	Acres
Nesting and roosting	1,689
Foraging	7,191

The Whiskeytown Shasta-Trinity National Recreation Area (NRA) Guide (1998) concluded that the northern spotted owl is not known to inhabit the NRA and that the area supports very little suitable habitat for this species. It also concluded that the drainages of this unit may provide dispersal corridors between suitable habitat areas west and east of the NRA.

Northern Spotted Owl Critical Habitat - In 2008, the USFWS designated new areas of critical habitat for the northern spotted owl, which included a portion of the north end of the watershed. This critical habitat unit (CHU 28) does not, however, contain much currently suitable spotted owl habitat. A large portion of the area is rock and brush, grey pine and manzanita or limestone outcropping. Only a small portion in the far northern section of the critical habitat unit would be characterized as suitable northern spotted owl habitat, though it is surrounded by unsuitable habitat. The rationale for the designation is unknown at this time. No special management concerns are present at this time for this designation. Figure A-22 in Appendix A displays the location of CHU 28 within the watershed analysis area.

Northern Goshawk

Northern goshawks can be found in middle and higher elevation mature coniferous forests; usually with little understory vegetation and flat or moderately sloping terrain. Moderate and high-quality habitats contain abundant large snags and large logs for prey habitat and plucking posts (Squires and Reynolds 1997). Goshawks generally breed in mature coniferous, mixed, and deciduous forest habitats. Suitable nesting habitat contains large trees for nesting, a closed canopy for protection and thermal cover, and open spaces allowing maneuverability below the canopy. Territories associated with large contiguous forest patches are more consistently occupied compared to highly fragmented stands.

On the Shasta-Trinity National Forest, goshawk habitat consists of mid- and late-successional mixed-conifer forest with scattered harvested and natural openings. Foraging habitat is variable and includes mid- and late-successional forest, natural and man-made openings, and forest edges.

There are no known northern goshawk territories in the Pit Arm watershed. Very few goshawk surveys have been conducted in the Shasta Lake area and none recently. The NRA Guide (1998) concluded that a small amount of suitable habitat was present in the NRA, but none of it was located immediately adjacent to Shasta Lake. A small amount of nesting habitat may be located where suitable spotted owl habitat was identified.

Pacific Fisher

The fisher is a forest carnivore that occupies late-seral stage habitat in mature and old growth mixed-conifer stands with a home range that can be very large (up to 11,000 acres in low quality habitat; CDFG 2003). In the western mountains, fishers prefer late-successional forests (especially for resting and denning) and occur most frequently where these forests have the fewest non-forested openings. Historically, fur trapping reduced populations.

Drainage bottoms are generally used more often for resting compared to ridgetops and mid-slope locations possibly due to increased access to water, increased prey abundance, larger trees, and denser canopy cover (Yeager 2005). Riparian areas provide concentrations of rest site elements, such as broken-top trees, snags, and coarse woody debris. Whether for prey availability, water access, riparian vegetation or microhabitat conditions, fisher may selectively use rest sites within 500 feet of water, and rarely farther than 1,100 feet from water. Fisher tend to use large live trees with cavities, particularly oak species, and logs for rest structures.

Populations of fisher currently occur in the North Coast Ranges of California and the Klamath-Siskiyou Mountains of northern California and southern Oregon. Additionally, surveys and sightings in California place fisher throughout much of the Sierra Nevada range. There are over 30 sightings of fisher in Shasta county in the CNDDB database (CNDDB 2010) dating back to 1968, several near Shasta Lake, though none directly within the watershed boundary. Other data sources also show fisher on the NRA, but not within the Pit Arm watershed specifically. Habitat for fisher exists in the watershed and it is possible that the area contains fisher.

American Marten

American marten tend to use high elevation (greater than 5,000 feet), multi-storied mature and old growth conifer (white fir/red fir) forests with moderate to dense canopy closure. Preferred habitat consists of a dense overstory exceeding 70 percent with minimum tree size of 24 inches dbh and sufficient understory including slash, rotten logs and stumps to provide hiding cover and denning areas. In most studies of habitat use, martens were found to prefer late-successional stands of mesic coniferous forest, especially those with complex physical structure near the ground (Buskirk and Powell 1994). Martens generally occupy stands that are located within ¼ mile from water with forest openings less than 1 acre in size. They are most abundant in forested areas adjacent to meadows or riparian corridors, but use travelways comprised of closed canopy forests to move between foraging areas. Martens generally avoid habitats that lack overhead cover, and tend to avoid crossing large openings (larger than 980 feet), especially in winter.

Because of the low elevation of the watershed (less than 1,500 feet) combined with the small amount of mature and old-growth forested areas, it is unlikely that marten occupy the area. There are no records of sightings in the district files, CNDDB, or other data sources.

California Wolverine

Wolverines are generally considered a solitary species, with adults associating only during the breeding season. The species occurs at low densities and is highly secretive, making estimation of population trends difficult (Banci 1994). Historical trapping reduced populations in various parts of the United States range, including California. Limiting factors for this species include habitat fragmentation and human disturbance, which have prevented population recovery since the days of trapping.

Distribution in California includes the North Coast mountains and the Sierra Nevada mountains. A scarce resident in California, known habitat distribution occurs from Del Norte and Trinity Counties east through Siskiyou and Shasta Counties, and south through the Sierra Nevada to Tulare County. Most sightings in the North Coast mountains of California and the southern Sierra Nevada fall within the 1,600-4,800 feet elevation range in Douglas fir and mixed-conifer habitats. Wolverines likely also use red fir, subalpine conifer, alpine dwarf-shrub, lodgepole, wet meadow, Jeffrey pine, and montane riparian habitats. Wolverines are highly dependent upon mature, late-successional conifer forests for survival in winter, and generally move downslope in winter into heavier timber where food is available.

Similar vegetation types occur in the watershed, though in small quantities. Wolverines are known to inhabit large, sparsely inhabited wilderness areas, and are considered rare in California. A small amount of possible wolverine habitat exists in the area. However, due to the level of fragmentation and the existing level of human disturbance within the watershed, this species is not expected to occur within or adjacent to the area.

Early Seral Brush and Browse Habitat

Terrestrial wildlife species of management concern associated with early- seral brush and browse habitat - as well as mid-seral oak woodland habitat - in the watershed are generally game species, bat species, and a wide variety of neotropical migratory and resident birds.

Game Species

Most of the watershed serves as winter range for the Columbian black-tailed deer, which migrate down from the surrounding higher elevations. Nearly all the land surface is below 3,000 feet elevation, and normally snow free. Important winter range is located on most of the south-facing slopes, especially on the east side of the lake. The herds utilize the area as a migratory travel route, from winter to summer ranges. The shrub lands, hardwood stands, and hardwood/conifer mixed stands provide for a moderate to high level of forage and cover. The area receives moderate year-round use, receiving the highest use when mast crops are plentiful and as winter range. Road density and closure status play a major role in habitat use and distribution of black-tailed deer as a result of the disturbances that occur.

Fifty-one Rocky Mountain elk were introduced to the area in 1911 from Yellowstone National Park into the Squaw Creek drainage. Herds of over 80 animals currently range over the eastern portion of the Whiskeytown Shasta-Trinity NRA during all seasons, though they tend to extend into the higher elevations to the north and east of the lake during the summer months.

Black bears are also common during all seasons. They forage on a diversity of grasses, berries, forbs, browse, insects, and carrion. Road density and closure status play a major role in habitat use and distribution of black bear.

The area also supports populations of additional harvest species such as wild turkey, California quail, mountain quail, western gray squirrel, band-tailed pigeon, ruffed grouse, mourning doves, a wide variety of waterfowl, and a few feral pigs.

Bats

A wide range of habitats is required by the various bat species present in the watershed. The Forest Service sensitive Townsend’s big-eared, pallid, and western red bats can utilize multiple different habitats in a given day. Suitable habitat for each of these species occurs in the watershed.

Pallid bats are usually found in low to middle elevation habitats below 6,000 feet. Varieties of habitats are used, including grasslands, shrublands, woodlands, and coniferous forests. Pallid bats most often occur in open, dry habitats that contain rocky areas for roosting. They are a yearlong resident in most of their range and hibernate in winter near their summer roost. Day roosts may vary but are commonly found in rock crevices, tree hollows, mines, caves, and a variety of human-made structures. Tree roosting has been documented in large conifer snags, inside basal hollows of redwoods and giant sequoias, and bole cavities in oaks (Pierson and Rainey 2007). Cavities in broken branches of black oak are very important and there is a strong association with black oak for roosting. The site must protect bats from high temperatures, as this species is intolerant of roosts in excess of 104 ºF. Night roosts are usually more open sites and may include open buildings, porches, mines, caves, and under bridges. Pallid bats are very sensitive to roost site disturbance.

Townsend’s big-eared bats are distributed broadly throughout western North America. They also occur in two disjunct, isolated populations in the central and eastern United States. In the West, this species’ range extends from the Pacific coast north to southern British Columbia, south to central and southern Mexico and the Baja Peninsula (Gruver 2006). This species is found throughout California from low desert to mid-elevation montane habitats. The roost sites for this species are cavernous sites associated with caves, mines and buildings (Sherwin et al. 2000). It also roosts in hollow trees and certain types of bridges (Sherwin et al. 2000). The Townsend’s big-eared bat has been documented in the nearby Sacramento watershed and a roost is known to exist in a cave to the northeast of the Pit Arm watershed on the McCloud Ranger District.

Western red bats are locally common in some areas of California; occurring from Shasta County to the Mexican border, west of the Sierra Nevada/Cascade crest and deserts (Zeiner 1990). Red bat winter range includes western lowlands and coastal regions south of San Francisco Bay. The western red bat is typically solitary, roosting primarily in the foliage of trees or shrubs (Bolster 2005). Day roosts are commonly in edge habitats adjacent to streams or open fields, in orchards, and sometimes in urban areas. Red bats require water and there may be an association with intact riparian habitat, particularly willows, cottonwoods, and sycamores. In 1997, the Shasta-Trinity National Forest began surveys in areas where proposed activities could affect potential roost sites. During the course of a four-year survey period (June through September 2005-2008) with 64 nights of bat mist net monitoring at the Trout Creek watershed area, one red bat was found. The bat was captured in late August during migration. There are no known locations in the Pit Arm watershed, though habitat exists.

Neotropical Migratory Birds

Neotropical migratory birds are associated with a wide variety of habitat types within the Pit River watershed, including oak woodland, mid and late seral mixed conifer, riparian, open water, cliff and talus slopes, grassland, and chaparral/brush. These areas provide potential breeding habitat and migration corridors for over 215 different species of birds.

Other Wildlife Species and Habitats

Terrestrial Riparian-Associated Species

Northwestern Pond Turtle - Northwestern pond turtles are associated with permanent or nearly permanent water from sea level to 6,000 feet in elevation. Western pond turtles (species *Clemmys marmorata*) can be found in the United States from Washington to Baja, California, though the subspecies, the northwestern pond turtle (species name *Clemmys marmorata marmorata*) is only found in Washington through northern California, including some aquatic habitats on the Shasta-Trinity National Forest and the Pit Arm watershed.

They prefer quiet stretches of moving water of ponds, lakes, major rivers, and streams. Important habitat elements such as partially submerged logs, rocks, mats of floating vegetation, or open mud banks, are used as basking sites and refuge from predators. Nest sites generally occur within ¼ mile of water sources, and are usually characterized as open areas dominated by grasses and herbaceous annuals with a southern exposure. Causes of population decline include habitat loss and alteration (both aquatic sites used for feeding and basking, and nest sites), population fragmentation, predation on young, especially by raccoons and introduced predators (e.g., bullfrog), and commercial harvest for the pet trade.

Distribution of northwestern pond turtles on the Forest is not well known due to a lack of survey information. Data records from the district include sightings within the watershed, though no systematic, structured surveys are conducted.

Foothill Yellow-legged Frog - Historic distributions of this species ranged through most Pacific drainages west of the Sierra/Cascade Crest, from southern Oregon to southern California. Current distribution and abundance of this species has been reduced drastically in the southern portion of its range but it still occurs throughout coastal drainages in the northern portion of its range. The foothill yellow-legged frog frequents the rocky, sunny banks of riffles along streams and rivers of all sizes in woodland, chaparral and forest. The species occurs west of the Cascade crest, Sierra foothills, and coast range from Oregon to Baja California. They occur from sea level to approximately 7,000 feet, although they are rare over 4,800 feet.

The foothill yellow-legged frog is at risk due to various anthropogenic and environmental threats throughout its range. Among some of the larger rivers in California, predation from introduced bullfrogs has been implicated as a cause of their decline. In addition, increased sediment loads in breeding streams have a potential to reduce survival of eggs.

No formal surveys have been conducted in the Pit Arm watershed. Habitat for this species is present in the watershed along intermittent and perennial streams, though no detection information was found in district records or the CNDDB database.

Southern Torrent Salamander - This species occurs from northwestern California to the Coast Range of Oregon in mid to low elevations. Habitat elements considered critical for survival include riparian vegetation, cool water present year round, and stream shade and require water for all stages of their life cycle. They are often associated with cold mountain streams, springs, and/or seepages that are well shaded and are seldom more than a few feet from free-running water. Declines of torrent salamanders have been attributed to increased amounts of sediments and increased water temperatures as a result of timber harvesting within their preferred habitat. Changes in forest canopies and the hydrology of seeps and streams can have negative impacts to southern torrent salamanders.

Management of riparian reserves through the Aquatic Conservation Strategy is expected to provide for or minimize impacts to aquatic and riparian associated species, including this species. While systematic surveys targeting southern torrent salamander have not been conducted within the watershed, personnel responsible for past stream and wetland surveys have looked for the species. According to district records and CNDDB database, no detections have been made in the Pit Arm watershed or around Shasta Lake.

Limestone-associated Species

Shasta Salamander - The Shasta salamander is listed as both a Forest Service sensitive species and a survey-and-manage species. It primarily inhabits isolated limestone formations in the Shasta Lake area, though recent surveys have confirmed that it may also inhabit non-limestone habitats near the McCloud Reservoir. Currently, there are 61 known sites representing 16 to 17 population centers, most of which are on National Forest System land surrounding Shasta Lake. Habitat includes moist limestone fissures and caves, volcanic and other rock outcroppings, and under woody debris and duff in mixed pine-hardwood stands found near moist caves, rock cracks, and cliff faces.

A survey protocol and management plan has been developed for this species on the Shasta-Trinity National Forest. It is regularly surveyed for as part of the assessment process prior to ground disturbing activities. Primary threats listed in California Department of Fish and Game nongame species assessments include increased recreation around Shasta Lake, limestone quarrying, and raising of lake water levels. In addition, timber harvest can cause a loss of habitat and possible direct mortality, due to moisture loss via canopy reduction and ground disturbance. Highways can act as barriers to dispersal, and rock quarries can remove or disrupt habitat.

Terrestrial Mollusks - The Shasta sideband snail, Wintu sideband snail, and Shasta chaparral snail are all associated with limestone and/or talus rock outcroppings near Shasta Lake.

The Shasta sideband and Wintu sideband snails are both strongly associated with the Pit Arm of Shasta Lake. Habitat for both species includes limestone areas, including caves, talus slopes, and other rocky areas that can be open, brush-covered, or associated with pine-oak woodlands.

The Shasta chaparral snail is an endemic species of Shasta County. It is found within 100 meters of lightly to deeply shaded limestone rockslides, draws, or caves with a cover of shrubs or oak and is strongly associated with Shasta Lake.

Multiple protocol surveys have been conducted along Shasta Lake since the designation of these species within the Northwest Forest Plan. There are several known locations of each of these mollusks in the Pit Arm watershed and nearby Squaw and McCloud Arms of Shasta Lake. Location specific data is available within the district GIS layers and the NRIS database (described above).

Willow Flycatcher

The willow flycatcher is a common migratory species that breeds in a variety of usually shrubby, often wet habitat from Maine to British Columbia and as far south as southern Arizona and California (Sedgwick 2000). In general, the willow flycatcher prefers moist, shrubby areas, often with standing or running water. In northern California, they are strongly tied to thickets of willows, whether along streams in broad valleys, in canyon bottoms, around mountainside seepages, or at the margins of ponds and lakes. There are no willow flycatcher sightings recorded in district files or within the CNDDB database for the Pit Arm watershed. Because of their strong link to relatively large willow patches and the lack of such patches, habitat for this species is very limited in the watershed.

Snag Habitat Specific to Shasta Lake

The purple martin is a species of special interest because it is very uncommon in the western states. One of the few known nesting colonies of this species in the west occurs along the Pit River Arm of Shasta Lake in snags that are submerged at full pool. Approximately 25 pairs are known to nest on the Pit Arm of Shasta Lake. This number will fluctuate depending upon lake levels during early spring.

Numerous snags emerge from the water along the shoreline of the Pit Arm of Shasta Lake, and in areas with low water. Many of these water-killed trees have been present since the dam was constructed, while others have emerged only after the water level of the lake was lowered. These snags are valuable habitat for the cavity nesting species in the area. Acorn woodpeckers in particular thrive in this setting due to the presence of oaks near the shoreline in combination with the abundance of snags that serve as cache trees and nesting structure.

Aquatic and Riparian-Dependent Species and Habitats

Aquatic and Riparian-Dependent Species of Concern

Aquatic species that are federally listed as threatened or endangered include anadromous salmon and steelhead, which were blocked from their historic range in the Pit River by Shasta Dam. Although remnant populations of these species once were trapped upstream of the dam, they were not self-perpetuating and are no longer a part of the watershed's aquatic fauna. Hatchery raised Chinook salmon planted in Shasta Lake are not considered a federal species of concern.

Other aquatic species of concern include Forest Service Region 5 Sensitive species and Survey and Manage species. There are two aquatic Management Indicator Species on the Shasta-Trinity National Forest – rainbow trout and largemouth bass. Sensitive aquatic species and Survey and Manage aquatic species known to occur or that may occur within the analysis area are listed in Table 17. Most of these species are aquatic mollusks.

Forest Service Sensitive Species

Hardhead Minnow - Hardhead minnows are typically found in relatively undisturbed low-elevation streams. They are omnivores that forage on drifting invertebrates and aquatic plant material, and on zooplankton in reservoirs. This species prefers moderate velocity water and is mostly observed in runs or pools in stream systems or associated with surface waters in reservoirs. Hardhead minnows migrate to tributaries in April and May and spawn by broadcasting eggs over gravel riffles or runs (Moyle 2002). They are abundant in Pit River reservoirs and are found within analysis area stream and lake waters.

Table 17. Aquatic species of concern in the Pit Arm watershed

Common Name	Scientific Name	Type	Known Locations
R5 Regional Forester Sensitive Species			
Hardhead minnow	*Mylopharodon conocephalus*	fish	Shasta Lake, Pit Arm watershed
CA floater	*Anodonta californiensis*	mussel	Pit River
Nugget pebblesnail	*Fluminicola seminalis*	snail	Pit River
Scalloped juga	*Juga (Calibasis) occata*	snail	Unimpounded portion of the Pit River
Montane peaclam	*Pisidium (Cyclocalyx) ultramontanum*	mussel	Middle Pit River upstream from Pit Arm watershed
Survey and Manage Species			
Potem pebblesnail	*Fluminicola n*. sp 14	snail	Pit River Basin
Globular pebblesnail	*Fluminicola n*. sp 18	snail	Pit River Basin
Canary duskysnail	*Lyogyrus n*. sp 3	snail	Pit River upstream from Pit Arm watershed

California Floater - The California floater is a mussel that lives in shallow areas of clean, clear lakes, ponds and large rivers. They prefer lower elevations and soft, silty substrates. Their life cycle includes a parasitic larval stage, which is dependent on host fish for food and dispersal. The decline of native host fish species, as well as other factors, has been identified as likely causes of their decline. Currently in Shasta County, it is believed that they have been eradicated from the Sacramento River system and persist only in the Fall and Pit Rivers (Frest and Johannes 1995 in Furnish 2005).

Nugget Pebblesnail - The nugget pebblesnail is a rare snail that prefers cool, clear, flowing water and gravel-cobble substrates. It is typically found in larger creeks and rivers, but also occurs on soft, mud substrates in large springs. Presently, this species occurs in the Pit and McCloud River basins, and is known from only two sites on the Shasta-Trinity National Forest (Furnish and Monthey 1998).

Scalloped Juga - The scalloped Juga is a Sacramento River endemic species that was once widespread in the lower Sacramento River, but is now believed to be extirpated (Frest and Johannes 1995 in Furnish 2005). It is a large river form found generally under loose but stable boulders and cobbles in cold swift water. The species has been found at a few sites in the unimpounded portions of the Pit River, upstream from the Pit Arm watershed.

Montane Peaclam - The montane peaclam occurs within portions of the Pit River system and its tributaries. This clam generally inhabits larger permanent lakes and rivers. It is found in spring-fed areas often on gravel substrate, generally in high diversity mollusk communities. According to Furnish (2005), current populations are found in the middle Pit River, upstream from this analysis area. Occurrences on the Shasta side of the Shasta-Trinity National Forest are suspected (possibly Pit River); however, populations at known historic sites appear to be extirpated.

Survey-and-manage Species

The Potem pebblesnail and globular pebblesnail are associated with cold-spring complexes in the Pit River system and have been found on National Forest System lands during surveys (Frest and Johannes 1995 in Furnish and Monthey 1998). These two species are considered spring snails, meaning they prefer small, perennial, coldwater spring habitats. The canary duskysnail is currently known to occur in a large spring complex and spring-fed portion of the Pit River upstream from the analysis area (Furnish and Monthey 1998), but could be present within the Pit Arm watershed.

Aquatic and Riparian Habitats

Optimal aquatic and riparian habitats and standard thresholds adequate to assess their conditions are difficult to describe in terms of specific habitat parameters. One set of criteria cannot fit all streams. One of the most difficult aspects is how to scale habitat parameters to the size of a stream and to the geologic morphology of its watershed. Pools in smaller streams tend to be shallower than pools in larger streams. Streams in a watershed having large areas of decomposed granitic soils generally have a higher percentage of fines in substrates than streams within watersheds composed mostly of competent bedrock. Within the Pit Arm watershed, there is very little information available on optimal stream habitat conditions. More thorough analysis of existing data and surveys of relatively undisturbed streams could help refine appropriate ranges of conditions for determining the quality of current aquatic and riparian habitats.

Cool, clear, flowing water with high levels of dissolved oxygen, a variety of pool habitats, deposited gravel in pool tailouts, intact riparian areas with vegetative and topographic shade, and woody debris are important habitat parameters to maintain for healthy aquatic populations. Maintaining or improving these habitat conditions in Potem, Ripgut, and Flat Creeks would contribute to providing high quality habitat, critical for maintaining populations of sensitive hardhead minnows. Localized cold spring complexes and spring-fed cold, clear waters with low amounts of fine sediments are critical for maintaining populations of other sensitive and survey and manage mussel and snail species.

Shasta Lake

Shasta Lake is a two-story impoundment that provides habitat for both warmwater and coldwater fishes. Fish species within the lake are varied and abundant. The California Department of Fish and Game surveyed the Pit Arm of Shasta Lake in 2000 and 2001 to characterize fish species composition using boat electrofishing techniques. Fish surveys occurred within approximately seven miles of the middle and lower reaches of the Pit Arm. The results included bluegill, brown bullhead catfish, white catfish, channel catfish, black crappie, hybrid bass (spotted bass crossed with smallmouth bass), largemouth bass, smallmouth bass, spotted bass, rainbow trout, threadfin shad, goldfish, and green sunfish. Spotted bass were the dominant fish species at about 85% of the total fish captured (PG&E 2009). Other species known to inhabit the lake in the analysis area include brown trout, Chinook salmon (planted), carp, Sacramento sucker, Sacramento pike minnow, riffle sculpin, black fish, hardhead minnow, white sturgeon, tui chub, tule perch and golden shiner.

Habitat for coldwater fish species within the lake is considered good; however, habitat for warmwater fish species is limited by steep-sided lake banks, water level fluctuations, and a lack of shoreline cover and shallow water cover for juvenile fish (USDI Bureau of Reclamation 2003). Habitat improvement projects implemented within the Pit Arm have improved fish habitat conditions for warmwater fish species in some areas. Bass and trout species are most frequently caught by anglers and the Pit Arm is a popular fishing area, mostly accessed by boat. Even though there is some natural reproduction, the coldwater fish populations within the lake are largely maintained through annual stocking by the California Department of Fish and Game. The warmwater fish populations are self-perpetuating.

Fish-bearing Streams

Within the Pit Arm watershed are approximately 19 miles of fish-bearing streams, as shown in Table 18. Larger fish-bearing streams within the analysis area include Brock Creek, Potem Creek, Ripgut Creek, and Flat Creek. These are located on the eastern side of the watershed near the Pit No. 7 afterbay. Rainbow trout dominate these stream habitats, but other lake fish species such as smallmouth bass, Sacramento sucker and Sacramento pike minnow, may be found in the lower stream reaches depending on lake water levels.

Table 18. Fish-bearing streams and miles of suitable habitat

Stream Name	Miles of Habitat
Brock Creek	0.5
Flat Creek	3.8
Ripgut Creek	4.4
No Name 1	1.7
Potem Creek	6.2
No Name 2	2.3
Total	**18.9**

Other perennial streams in the analysis area include Stein Creek, Bear Canyon, Constant Flow Gulch, Susanville Canyon, and several smaller spring-fed streams. There are also many intermittent stream channels such as Clikapudi, Deadhorse, Arbuckle and Painter Creeks that may provide habitat for aquatic species during the rainy season or when Shasta Lake is full. Figure A-24 in Appendix A displays the stream types and distribution of fish populations within the analysis area.

The perennial fish-bearing Pit River tributaries within the analysis area generally provide good fish habitat. These streams are in dynamic equilibrium with respect to flow, bedload and the delivery of woody material, which has resulted in the formation and maintenance of habitat features such as pools and runs that are critical to the production of trout. Many of these streams also provide spawning habitat for adfluvial trout runs from the lake. The smaller tributaries in general are also functioning well, but are limited for fish habitat because of their small size, steep gradients and intermittent flows.

Riparian Reserves

Meeting any given management imposed habitat standard may or may not reflect the health of a stream or spring system. Maintenance of critical stream processes such as the regimes of water, sediment, woody material delivery, and riparian vegetation are more likely to result in the successful conservation of aquatic and riparian-dependent species. Riparian reserve designations and the aquatic conservation strategy were designed to protect these critical stream processes.

Within the analysis area, riparian reserves have been designated along all perennial and intermittent streams, and along all ephemeral channels with annual scour. Also included are mapped hydrologic features such as reservoirs, springs, seeps and wetlands and unstable or potentially unstable areas. Approximately 22,944 acres in the Pit Arm watershed are designated as riparian reserves (excluding the waters of Shasta Lake). Riparian reserves are intended to provide special protection to areas, where changes likely to occur in the absence of that protection would significantly affect on-site or downstream aquatic and riparian values (USDA Forest Service and USDI Bureau of Land Management 1994). Management of riparian reserves through the Aquatic Conservation Strategy is expected to provide for or minimize impacts to aquatic and riparian associated species. Established widths for riparian reserves are described in the Shasta-Trinity LRMP on pages 4-53 and 4-54. Riparian reserves not only provide protection of aquatic-dependent species; they also provide late-seral connectivity and dispersal corridors across the watershed for riparian-dependent and terrestrial species. Late-seral vegetation is generally associated with north-facing slopes and riparian reserves. The bands of conifer-dominated forest adjacent to intermittent and perennial streams are key areas in providing corridors; of lesser importance are areas dominated by chaparral vegetation types. Within the Pit Arm watershed, approximately 35 percent of late-seral habitats are found within riparian reserves (excluding the waters of Shasta Lake). Due to the high density of riparian reserves, there should be ample travel corridors for connectivity and dispersal. Riparian reserve interim widths described in table 3 above are considered adequate for serving as travel corridors and providing protection to aquatic habitats.

Human Uses

Methodology

Current human and recreational uses in the watershed were assessed using a variety of GIS queries, including road density layers for transportation and OHV routes, vegetation and timber mapping, National Forest and watershed boundaries and land allocations. Discussions with district and Forest personnel (Bachmann 2010, Beres 2009 and Valenzuela 2009), historic documents, the Shasta-Trinity National Forest website for Recreational Activities, the Shasta Unit-Whiskeytown-Shasta Trinity NRA guide to Recreation Facilities, the Shasta-Trinity Travel Management Plan, the Shasta-Trinity LRMP, NRA Guide, Water Recreation Opportunity Spectrum, and other and available research literature were also used to determine the current conditions related to human activities and recreation.

The purpose of the Water Recreation Opportunity Spectrum was to inventory, classify, map, and document the current recreation situation for Shasta Lake. The data were collected by site visits as part of a regional comparison of recreation opportunities at several reservoirs across the State of California. The information derived from this inventory has been beneficial in assessing the current conditions; it may also be of value for planners and managers at Shasta reservoir. The Water Recreation Opportunity Spectrum was developed to provide site-to-site comparison as well as individual site evaluation.

Heritage Resources

Since the earliest archaeological investigations in the 1940s, heritage management has focused on those areas impacted by other land-use activities on National Forest System lands, especially land inundation associated with the reservoir, recreation management and prescribed burns. The predominance of project-driven archaeology, in combination with probability models that predict sites to be located where resources were historically more abundant and terrain more easily navigated, has resulted in a significant bias in survey intensity in the Pit Arm watershed that favors river valleys over the surrounding steep hillsides. In addition, project-driven archeological surveys fail to consistently protect heritage sites that may be impacted by processes and activities outside the scope of a given project.

Previous work in the Pit Arm watershed has identified 86 prehistoric and historic properties. Of these sites, four are historic, two are multi-component, and the rest are prehistoric. The sites are concentrated along the waterways and drainages, especially Jones Valley, but a few are located on ridgelines and other landforms. Prehistoric site types include lithic scatters, middens and village sites. To date, 61 of the 86 sites have been plotted in GIS, with most of the unplotted sites lying below the high waterline. Investigations at a limited number of sites, primarily in Jones Valley and along Clikapudi Creek, provide a basic understanding of the chronology, culture history, and subsistence economy of the area (Clewett and Sundahl 1979; Sundahl 1986, 1994).

Research driven archaeology has been limited in northeastern California, including the Pit Arm watershed, relative to the rest of the state (Moratto 1984). However, investigations at a limited number of sites in Jones Valley and along Clikapudi Creek provide a basic understanding of the chronology, culture history, and subsistence economy of the area (Clewett and Sundahl 1979; Sundahl 1986, 1994). Despite the research potential exemplified by these studies and identified at other sites (Henn and Sundahl 1986), none of the sites within the watershed has been nominated for listing on the National Register of Historic Places.

Heritage resources within the watershed have been impacted by a series of factors. The greatest impact was the inundation of land to form the Shasta Reservoir. During the drawdown in 1986, archaeological sites within the Shasta Lake pool area were revisited and assessed for research potential and site integrity (Henn and Sundahl 1986). At least 115 archaeological sites are partially or entirely within the Shasta Lake pool area (Henn and Sundahl 1986), including at least eight within the Pit Arm watershed. In 1986, the eight sites within the watershed were identified as having unknown or high research potential (Henn and Sundahl 1986). The sites had been negatively impacted by the initial inundation; negative impacts caused by subsequent lake level fluctuations have continued (Henn and Sundahl 1986). Inundation and lake level fluctuation have caused erosion and siltation. Recreation activities, including development of boat ramps, temporary access roads and parking, OHV use in sites, and collection of artifacts, further impact low-water sites when exposed and higher elevation sites year round.

Recreation Resources

The Shasta Lake Visitor Information Center is located 10 miles north of Redding in the community of Mountain Gate and within the interface area of the watershed. The visitor center specializes in information about the Whiskeytown-Shasta-Trinity National Recreation Area and National Forest information, including fuelwood, campfire and Christmas tree permits. It is also a resource for the public to acquire Golden Age and Access Passports.

National Recreation Area (NRA)

According to the Shasta Lake West Watershed Analysis (USDA Forest Service 2000), some of the human uses occurring in the NRA include boating (motorboats and houseboats), swimming, jet skiing, waterskiing, fishing, sightseeing, and hunting. Approximately 35,378 acres of the NRA are within the watershed boundary and are managed by the Forest Service (see Figure A-3 in Appendix A). Management direction for the Shasta and Trinity units of the Whiskeytown-Shasta-Trinity NRA was last revised and approved in 1998. The management guide for the Shasta and Trinity Units of the Whiskeytown-Shasta-Trinity National Recreation Area provides direction to integrate past decisions that are still pertinent for managing the NRA with standards, guidelines and management prescriptions incorporated from the April 1995 Forest LRMP. Direction from the NRA guide as it relates to proposed open areas below the high-water marks on Shasta Lake is as follows:

> "The feasibility of developing recreational facilities to increase recreation opportunities with fluctuating lake levels, such as floating picnic and/or camp sites will be explored (NRA Guide, p. IV-9)."
>
> "Use will be monitored at dispersed camping locations below high water to see if sanitation problems suggest closing of the areas. The feasibility of providing Level 1[1] facilities at traditional dispersed camping areas below high water at Jones Valley will be explored (NRA Guide, p. IV-10)."

The Shasta-Trinity National Forest is conducting a facility analysis under the LRMP and has considered the possibility of reducing recreation activities within certain high-use areas in the watershed as a possible management action. This may include special use permits, hiking and camping.

Special Use Permits for Recreation Facilities

Several recreation facilities in the watershed analysis area operate under special use permits administered by the Forest Service. Jones Valley Marina is permitted to have 31 commercial houseboats but has often been granted a temporary increase of at least 8 additional houseboats on a yearly basis. However, the marina is in the process of consolidating with another marina on Shasta Lake as well as beginning the process of developing a master development plan for the Jones Valley Marina. Both the consolidation and master development plan processes have the potential to increase the number of permitted houseboats. The marina currently has 10 private houseboats moored there with room for 40 more. High-density recreation use occurs on the lake and its shoreline. Along the shoreline upstream of Jones Valley, human use becomes markedly less frequent.

Silverthorn Marina is permitted to have 35 houseboats but is often allowed to increase that number to an additional 15 on a temporary yearly basis. Silverthorn Marina currently has 94 private houseboats or patio boats permitted and moored at the marina with 32 additional moorage spaces available for (usually) smaller boats (e.g., power boats). Silverthorn also has a restaurant and eight rental cabins. The area is frequented by different types of boats, some of which pass through at high speeds and create choppy water and noise (USDA Forest Service 2006b).

The Bridge Bay Resort Marina on Shasta Lake is south of the Pit River Bridge and Interstate 5. The largest inland marina on the West Coast, the resort offers a motel, boat rentals, ramp, store, and fuel, and is currently permitted to have 92 commercial houseboats. This number can change from year to year. Bridge Bay is a staging area for people launching at the marina and a transition zone for boats trying to reach different arms of the lake (USDA Forest Service 2006b). Figure A-13 in Appendix A displays a map of facilities within the Interstate 5 corridor in the Bridge Bay subwatershed.

Packers Bay Marina has 26 commercial houseboat allocations and is adjacent to the public Packers Bay boat ramp. The ramp is maintained by the Forest Service and is paved with four lanes available until 50 feet of drawdown, and then has two lanes available until 115 feet of drawdown. Open all year, this ramp is very busy during holidays. There is a lighted parking lot with 188 spaces and offers an accessible loading platform in addition to the ramp. Adjacent to

[1] There are five levels of recreation development that are described in increments from primitive to highly modified. Level 1 is at the primitive end of the scale, while level 5 is most developed. Within the NRA recreation development and construction, most are managed at levels 3 through 5.

this boat ramp facility are four trails of varying distances: the Waters Gulch, Fish Loop, Overlook, and Eastside trails (see Figure A-13 in Appendix A).

In addition to the launching facilities at the commercial marinas, the Forest Service maintains several designated public boat ramps in the Jones Valley Area, with a daily use fee required. All of the designated Forest Service ramps are public ramps with parking areas, restrooms and garbage disposal facilities. The ramps are usually open all year; however, they may be closed when the parking lots fill up, when lower lake levels cause ramps to slope beyond 15 percent, or when lake debris makes launching hazardous (Luzietti 2009 personal communication).

The special use permits regulate the number of houseboats allowed on the lake. During the high peak usage period in the spring and summer months, the number of recreationists on the lake greatly increases. Trash blowing off boats, and littering from these activities results in large amounts of litter left in the lake and around the shoreline. The Forest Service engages in regular cleanup activities to remove the debris.

The Shasta-Trinity National Forest is considering reducing the season of use, is conducting a facility analysis within the forest management plan, and has considered the possibility of reducing the period of time for recreation activities within certain high-use areas in the watershed as a possible management action. This may include special use permits, hiking and camping.

Motorized Recreation

Motorized recreation has become the key recreation activity, and most of the watershed is accessible by watercraft. High-use periods for this type of recreation in the watershed have increased since the creation of Shasta Lake. Holiday weekends and the summer season have the highest usage, increasing the number of watercraft (especially houseboats) and people in the area. The entire channel and coves have become inundated and are occupied by large groups during the high activity period, especially Memorial Day and spring break.

Houseboats mooring near the known bald eagle nests situated on the lakeshore or visible from the water pose a concern for disturbance to nesting pairs of eagles. The Forest Service conducts mid-winter eagle surveys to count mating pairs, and periodically monitors new nest sites for breeding young. Critical periods for protection of the nests are during hatching periods, which coincide with the highest usage periods. The Forest Service will buoy off known nest sites periodically between January and June. See the Terrestrial Species and Habitats discussion for reference conditions and current protection measures for bald eagles.

Wave action from motorcraft presents problems with soil disturbance along the shoreline. Debris is also left at these areas from logs, runoff, and litter. Because of water fluctuations with spring runoff and releases from the dam, much of the shoreline is accessible at low water line for pedestrian and vehicle activity.

Smaller watercraft (e.g., fishing boats, wake boards and jet skis) have better access to the upper reaches of the Pit Arm. This is due, in part, to the narrow stretch of water channel at low water levels, making it inaccessible to the larger boats. Consequently, soil disturbance from wave action and potential disturbance of nesting bald eagles can occur upstream of the lake.

Recreation Residences

Silverthorn Recreation Residential Tract is part of recreational facilities developed after completion of Shasta Dam in 1945 and the subsequent filling of Shasta Lake Reservoir (Fryman 2009). Managed under the Special Use Permit System, with 75 cabin lots, it is the largest of the five recreation residence tracts at Shasta Lake (Fryman 2009). The tract is accessed from Highway 299 along approximately 6 miles of paved rural county road through the small community of Sherman and through Jones Valley. It can also be reached from Mountain Gate on Interstate 5 via Bear Valley Road.

Trails and Campgrounds

There are six designated camping areas and facilities within the watershed - Arbuckle Flat Boat-in Campground, located on the Pit Arm of the lake, Jones Inlet shoreline camping, Lower Jones Valley Campground, Mariners Point shoreline camping, Ski Island Boat-in Campground, and Fenders Ferry day use and dispersed campground with boat ramp.

Some developed sites in the watershed are overcrowded and in poor condition. Many campgrounds that were designed and constructed 30 to 50 years ago are frequently filled to capacity and are not suited to today's recreational pursuits. Recreation budgets have not kept pace with facilities maintenance and reconstruction needs are high for those operating below standards (LRMP, p. 3-15).

Many of the trails at the lower end of the watershed at Shasta Lake follow the shoreline. These trails offer opportunities for day hiking, mountain biking, running, fishing, sightseeing, and wildlife viewing. There are numerous footpaths to the lake from area campgrounds. The Clikapudi Trail, completed in 1976, is the most extensively developed trail in the watershed. It is accessed from three trailheads, one at the Jones Valley Campground, one at the Jones Valley boat ramp parking lot, and one halfway between where the trail crosses NFS road 33N03 (Luzietti 2009 personal communication). The trail is 7.5 miles long and is currently undergoing improvements to switchbacks due to problems with erosion in steep sections. The Clikapudi Trail is open to mountain bikers, hikers and horseback riders (Grigsby 2010 personal communication). Potem Falls Trail is a short hike of 0.3 mile from Fenders Ferry Road.

Near the upper end of the arm, the channel becomes very narrow and the canyon walls are extremely steep, making foot traffic difficult. The Bear Creek trail, on the south side of the drainage, about 3.5 miles above Stein Creek Campground, is a short hike that leads to a double waterfall known as Bear Creek Falls. Potem Falls, a larger waterfall, can be found on Potem Creek near Fenders Flat. This waterfall can be reached by trail from the lake or seen from Fenders Ferry Road and is a short hike of 0.3 mile from the road. There are approximately 34 miles of trails in the watershed.

The Fenders Ferry day use and dispersed campground has limited facilities. Access to this area is via Highway 299 and Interstate 5. Most of the roads in the area have been established for Sierra Pacific Industry lands access. The area is fairly remote and is a long drive for recreationists; however, the designated OHV routes do receive some use, mostly by OHV users for hunting (Grigsby 2010, personal communication).

Noxious weeds occur or have the potential to occur in many high-use recreation areas within the watershed (e.g., campgrounds and mountain biking and hiking trails). Several noxious broom species occur in the Packers Bay area (see Current Conditions – Noxious Weeds).

Figure A-14 in Appendix A displays roads, trails and developed and dispersed recreation sites in the high-use Jones Valley, Fenders Flat, and Packers Bay areas.

Other Special Use Permits

In addition to the permitted recreation facilities described above, special use permits authorize facilities and services necessary for public health, welfare, safety, and security, such as communications sites for local 911 radio repeaters to support local law enforcement and emergency response entities. Other special use permits provide basic needs such as power and telephone lines and access to private landowners.

Caves

There is an abundance of cave resources within the Pit Arm Shasta Lake watershed. Many are indiscrete and many are covered with vegetation. Although human use of the caves is minimal, potential looting and dewatering are of concern. Rich in legends, cultural significance, and fossil history, caves are also an important habitat for bats and limestone material. See the Physical Sciences discussion for a more detailed discussion of cave resources.

Mining Resources

Currently, there are very few mining claims with minimal activity occurring on National Forest System lands in the watershed. Little is known of the smaller mining claims at the upper end of the watershed - Pope Joy mine, Slaughter Group mine, and Pit River mine. Two of these smaller claims are located near the confluence of the Squaw and Pit Arm:

Brushy Canyon Group – This group consists of a number of claims, not patented, located in Sec. 34, T. 34 N., R. 3 W., and is owned by E. L. Blowers, James Drennan, and others. The group is under bond by the Bully Hill Company, and employs a small workforce. The claims are developed by a few cuts and tunnels and an 80-foot-deep shaft. A large body of limonite ore (gossan) has been proved, but comparatively little sulphide.

Doedollis (a.k.a. De Dallis on the map) Group – This group consists of five unpatented claims located in Sec. 34, T. 34 N., R. 3 W., and is owned by William Ellis, J. L. Cannon, and others. Comparatively little work done at present (Luzietti 2009 personal communication).

Lehigh Southwest Company has a cement and lime plant outside of Mountain Gate on private land, and some of the spoil piles are on National Forest System lands and are visible from Bailey Cove. A reclamation plan is in place and is overseen by the California Department of Fish and Game for water quality issues. Other than being a visible eye sore, the spoil piles on the lakeside pose no environmental threat to the watershed (Newburn 2009 personal communication). The conveyor system for the plant on is National Forest lands and is operated under a special use permit.

Limestone substrates in the watershed provide habitat for unique cave-adapted vertebrates and invertebrates and limestone-associated flora, including some rare plant species. These substrates and the species they support are vulnerable to disturbance from establishment of quarries to extract the lime for commercial uses. The effects on these species from activities at private quarries such as the Lehigh plant noted above are unknown.

Timber Resources

There are no active timber sales within the Pit Arm watershed. Approximately 400 acres of plantations are within the watershed dating from 1984-2000. Management plans occasionally call for units to be maintained for animal-damage control, reforestation, and release and weeding. The last stand maintenance projects were completed in 2007. Silvicultural treatments have occurred in 1,541 stands in the watershed (Newburn 2010 personal communication).

Reforestation will occur as needed after wildfires or timber management. Past activities associated with replanting trees included the use of herbicides, and mechanical and physical site preparation to reduce the competition for soil nutrients and sunlight from grasses and shrubs (release). Existing roads are used for reforestation projects.

Transportation System and OHV Routes

Interstate 5 is an important conduit for travel in and out of the watershed boundaries (see Figure A-13 in Appendix A). It provides access to the Shasta Lake Visitor Information Center in Mountain Gate, to recreation residences in the watershed and to recreational opportunities on Shasta Lake.

Currently, forest planning efforts evaluate proposed projects on a site-specific basis for existing roads that can be used and for the possible decommissioning of roads that are no longer necessary. There may still be a need for temporary road construction and for the reconstruction of existing roads to allow for use of new equipment and for adjusting to specific logging systems required for steeper ground.

As noted in Step 1 – Characterization, approximately 212 miles of routes in the analysis area are designated for vehicle travel (including “street legal” and off-road vehicles). These routes are concentrated in the Silverthorn and Jones Valley Marina areas at the southern portion of the analysis area and the Fender’s Flat area of the upper portion of the watershed.

Permitted motorized access to private lands, communication sites and other special-use sites is exempt from travel management guidelines. Roads to private property, communication sites and other special-use-permitted activities are not necessarily part of the National Forest Transportation System. Those with a valid special use permit will be allowed to continue to access the property and sites. However, these roads may not be open to public access.

Wildfire and associated suppression and rehabilitation measures sometimes require the creation of temporary roads and fuelbreaks that have been used by the public and have become unauthorized routes. The creation and continued use of unauthorized routes has the potential to cause environmental changes to the ecosystem, primarily with regard to soil, water quality, and visual quality issues.

Increasing use of the shoreline by vehicles at low water levels has raised some issues relevant to watershed integrity. The use of roads, trails and other areas on National Forest System lands for public operation of motor vehicles has the potential to affect hydrologic functions through interception of runoff, compaction of soils, and detachment of sediment (Foltz 2006). In addition, there are erosion effects below high waterline in post-fire areas as a result of OHV traffic through burned vegetation.

Vehicles are a major vector in the introduction and spread of noxious weeds and other nonnative invasive species. Motor vehicle travel both on and off of roads and trails has been a part of forest recreation for many years. This activity has created a disturbed condition that greatly increases the vulnerability of the landscape to noxious weed invasion and spread.

The Forest is currently in the draft stages of developing an environmental impact statement to address the Travel Management Rule required of all Region 5 national forests (USDA Forest Service 2009). The resulting Travel Management Plan will address all system roads including vehicle class changes and OHV trails. Unauthorized trails are proposed in various alternatives for inclusion in the transportation system. See Figure A-5 in Appendix A for a map of the main transportation system in the watershed analysis area.

Visual Resources and Scenery

Visual experiences in outdoor recreation settings vary and depend on whether a scene is viewed from a motorized or nonmotorized mode of travel, from the speed at which the traveler is moving, the distance from the viewing area, and topography. For instance, alterations seen in the landscape on steep topography are more visually apparent than on flat topography due to the viewing angle. The ability to identify and discern individual objects, patterns, and their relationship to the whole landscape, become more difficult the faster one travels because the duration of the view is decreased. However, the chances for a hiker to notice deviations on a trail increase, because the viewing period increases dramatically (USDA Forest Service 2009).

The LRMP contains Forestwide management direction in the form of visual quality objectives (VQOs) and specific management area direction for visual resources. Roads and trails create linear alterations in landscapes that can be mitigated through design. If not mitigated, these features present qualities uncharacteristic of forested landscapes. Landscapes with a dense canopy cover and/or sloping terrain have the capability of masking these linear alterations; sparsely covered landscapes have less such capability. The proliferation of unauthorized routes, particularly in sparsely covered landscapes, can adversely affect the forest’s visual resources.

Currently, travel corridors within the watershed are managed for visual guidelines within the direction of the LRMP, National Forest Management Act (NFMA), and the Travel Management Rule. Based on sensitivity levels, VQOs establish minimum acceptable thresholds for landscape alterations from an otherwise natural-appearing forest landscape. Three levels of acceptable thresholds are identified: 1) retention areas expected to retain a natural appearance; 2) partial retention areas with some alterations that remain subordinate to the characteristic landscape; and 3) areas with modifications that do not appear natural.

Within the watershed analysis area, sensitive corridors include Interstate 5 with an adopted VQO of retention from 0.25 to 0.5 mile from a road viewer. This corridor is managed for this rating under the standards and guidelines for VQOs. Route additions proposed for inclusion to the Motorized Travel Management EIS (in progress) and the VQOs can be found in the Effects Analysis portion of that document (USDA Forest Service 2009). Additional current information can be accessed through the National Visitor Use Monitoring report, which determines the popularity of different areas for viewing scenery or driving for pleasure.

As noted above in Step 1 – Characterization, the current visual condition of the watershed varies from apparently unaltered to large-scale physical alteration. The upper extent of the watershed remains in natural or near natural appearance, other than fluctuation in water levels, debris collections, and structures under special use permits.

Fire and Fuels as Related to Human Uses

Although high-density recreation use occurs on the lake and its shoreline, much of the remaining area is rugged and inaccessible and is essentially unroaded. The terrain, which becomes generally less steep in the eastern analysis area, is characterized as rugged with low road density. Large fires in the late 1800s were stand replacing in much of the area. These fires were followed by 90 years of fire suppression that have allowed vegetation to regenerate and fuels to accumulate beyond what would have occurred in the absence of aggressive fire suppression.

Due to fire suppression, increased fuel vegetation has the potential to ignite due to human and natural causes. Portions of the watershed are inaccessible for prescribed burning using ground forces. Air quality and smoke management are of concern for their impacts on recreational uses and on nearby communities. At the same time, high recreation use increases the risk of human-ignited fires. Major wildfires can create widespread heavy smoke and degrade air quality during peak recreation use periods. Major wildfires also have the potential to cause closure of trail systems and restriction of recreational activities for public safety.

Step 4. Reference Conditions

The purpose of this chapter is to explain how ecological conditions have changed over time as a result of human influence and natural disturbances. A reference is developed for later comparison with the current conditions over the period that the system evolved and with key management objectives.

This chapter begins with a historic overview that summarizes the natural processes and land-use activities in the watershed. The remainder of the chapter follows the six core topics that have been presented previously.

Discussions of physical features, biological features and human uses can generally be segregated into three distinct time periods, as follows:

- Before 1900: During this period, significant Anglo-American influences were absent. Although native peoples used the area, the ecosystem was functioning under essentially natural conditions during this time.
- 1900-1945: During this period, human influences began to affect natural processes in the watershed. The area began to experience increased effects from settlement, mining, wildfire suppression, timber harvest, and road construction activities.
- 1945-present: This period began with the completion of Shasta Dam and the subsequent creation of Shasta Lake in 1945, after which major human influence on watershed ecosystem processes has been documented.

Physical Features

Geology, Geomorphology, and Erosion Processes

Before 1900

The Pit Arm watershed was formed by natural processes occurring over hundreds of thousands or even millions of years. The most recent period of mountain uplift began in the early to mid-Pleistocene, approximately 1.7 to 1.5 million years ago, and continues today. Mount Shasta has erupted 13 times in the last 10,000 years. Repeated eruptions and mudflows affected water quality and channel morphology.

The Klamath Mountains are still being uplifted; however, the rate of uplift has been offset by the continuing effects of erosion processes. Erosion rates in the watershed have varied considerably over time in response to long-term changes in climatic patterns. The last major period of erosional activity occurred during the Pleistocene Epoch, 100,000 to 2 million years B.P. (before present). The climate during this period was wetter than it is today. Periodic floods increased erosion by affecting both mass wasting and surface erosion.

The current topography of the Pit Arm watershed has been created almost exclusively by a combination of tectonic uplift, mass wasting, and fluvial and surface erosion processes. The influence of these processes has been continuous from the beginning of the Klamath Mountain uplift. Fluvial processes dominate most of the analysis area.

Native Americans also influenced erosional processes, most notably by lighting periodic fires in the area to control vegetation. In the mid-1850s, land-use activities introduced by European settlers began to influence natural erosion processes in the watershed; during the past 150 years these activities have influenced the rates, frequency, magnitudes and areas of occurrence of natural processes.

The interactions between natural processes and land-use activities are complex. Some land-use activities, such as road building and fire suppression, have significantly altered natural processes throughout the entire watershed while others have had little to no effect. Very little information is available concerning reference conditions for natural processes prior to European settlement. In order to understand how land-use activities affected natural processes, it is necessary to identify the dominant natural processes that occurred in the watershed prior to European settlement and then determine the effects of land-use activities on each natural process.

1900-1945

Between 1900 and 1945, land-use activities introduced by European settlers continued to influence natural erosion processes in watershed. The earliest activities to occur in the watershed included fur trapping, grazing, mining, road and trail construction, and logging. The effects these activities had on erosion processes likely increased steadily throughout this period. However, most of the area remained undeveloped, and the extent and duration of these activities was so limited that their relative influence on the watershed during this period is believed to have been insignificant.

Grazing activity appears to be the exception and likely influenced erosion processes. Direct impacts from cattle and sheep have not been documented; however, grazing activities occurring during the early 1900s probably affected erosion processes. Grazing was reported to be utilized to its maximum capacity, with abundant evidence of localized overutilization (USDI Bureau of Reclamation 1947). Fires were reportedly set in many locations to maximize palatable forage (USDI Bureau of Reclamation 1947, USDA Forest Service 1945). Erosion likely increased in several areas from overutilization, trampling and loss of groundcover from burning; however, the extent of these impacts is not documented. The influence of grazing activities on erosion processes ended with the exclusion of cattle and sheep from the watershed following the completion of Shasta Dam in 1945. The areas of the most past concentrated livestock use were flooded by the reservoir and are now inundated. No impacts from grazing are evident in the watershed today.

The last major mudflow occurred on Mud Creek in 1924. Sediment from this mudflow entered the McCloud River and was observed entering San Francisco Bay. See also “Water Quality” below.

1945-present

Road construction, timber harvest activities, and other developments have accelerated erosion in the western analysis area around the Interstate 5 corridor. Most of the recreation facilities including the Jones Valley Marina, boat ramps and campgrounds were developed and improved from 1950 to the present. From approximately 1965 to present, timber harvest and road construction activities affected erosion processes in portions of the analysis area. Due to the lack of intensive surveys, it is not known if or how many slides have occurred as a direct result of harvest activities. Surface erosion from poorly constructed roads, unmaintained roads, and disturbed hillslopes has increased over the past 30 years. The lack of an observed increase in mass wasting activity may be partly due to the relatively brief period in which road construction and timber harvest activities have occurred in the watershed. A large portion of the analysis area has low road density and experiences a low frequency of ground-disturbing activities.

Fire suppression has reduced the number of large fires and consequently altered the density of vegetation. Soil impacts and fire intensity data are limited for many of the fires; however, recent fire activity indicates that fires that do occur are burning at higher intensities than in the past. For instance, of the soil types found in the Jones Fire area within the watershed, 78 percent have moderate or high potential for soil erodibility; approximately 40 percent of soils became hydrophobic from high-severity burns.

Hydrology

Before 1900

Prior to European settlement, peak and base flows within the watershed were controlled by the prevailing climate (by variations in annual precipitation) and, to a lesser extent, topography. As areas within the Pit River Basin were settled, irrigation depleted base flows in the upper Pit River. Anecdotal information indicates that flow was significantly depleted along reaches of the Upper Pit River during summer months. Although not quantified, the flows on the Pit River within the analysis area would also have been substantially reduced.

Variations in the amounts and distribution of vegetation within the watershed also affected peak and base flows. Wetter periods brought increased rainfall, which reduced wildfire activity and stimulated vegetative growth. Increases in evapotranspiration probably partially offset increases in base flows during these wetter periods. Conversely, dryer periods resulted in lower flows that were offset by decreased evapotranspiration following high-severity fires. Changes in precipitation and evapotranspiration affected peak and base flows in tributary streams to the Pit River but had a lesser effect on base flows in the river itself.

1900-1945

Between 1900 and 1945, peak flows within the Pit Arm watershed were not affected significantly by land-use activities. The scope of logging, road construction and mining activities was very limited, and fire suppression activities were still only partially effective at controlling wildfires. Controlled burns undertaken by grazing permittees to enhance range forage may have affected water flows. Base flows were likely reduced due to water consumption, primarily, irrigation upstream.

1945-present

Hydrologic conditions of the Pit Arm watershed within the analysis area were dramatically altered following the completion of Shasta Dam. Shasta Dam was the cornerstone of the Central Valley Project designed to provide irrigation water to farms, conserve winter runoff, maintain navigation on the Sacramento River and to reduce the threat of flooding in the Central Valley (Cranfield 1984). Approximately 30 miles of the Pit River were inundated with the creation of Shasta Lake. Annual peak flows on the Pit Arm near Montgomery Creek (upstream of the Shasta Lake high water mark) ranged from 8,300 cfs to 73,000 cfs between 1945 and 2008. Flows are affected by regulation and diversion.

Approximately 1,000 cfs was diverted to the Pit River upstream of the analysis area when the McCloud Dam was completed in 1965. The McCloud Dam was one component of the McCloud-Pit Project that was implemented for hydroelectric power generation. Phase I of the project resulted in the creation of the Lake McCloud and Iron Canyon Reservoirs and the construction of two large diversion tunnels (Lake McCloud to Iron Canyon and Iron Canyon to Pit No. 5 Power House).

The effectiveness of fire suppression increased with the introduction of mechanical and aerial suppression methods after 1945, and the natural fire regime in the watershed was altered. No data on the impacts of increased vegetation cover on evapotranspiration and water yield are available during this period; however, it is likely that water yield throughout the watershed decreased as the evapotranspiration increased.

After construction of the dam, development and recreation within the Interstate 5 corridor escalated. The concentration of human use has altered water yield and rates of runoff and has increased erosion.

Stream Channel

Before 1900

Stream channels in the analysis area formed as a result of the uplift of the Klamath Mountains. Lateral movement of the channels was largely controlled by the geomorphology. The main factors influencing channel formation are climate, substrate and stream gradient. Swales, colluvial, bedrock, and cascade channels located in upland areas that burned frequently probably exhibited unstable characteristics as a result of the high sediment inputs and the lack of large woody debris needed for channel stabilization. These upland channel types probably hosted aquatic and terrestrial plant and wildlife species adapted to frequently burned, early seral habitats rather than those adapted to the forested riparian areas found throughout the watershed today.

The channel morphologies of step-pool and pool-riffle channels like Potem Creek were probably similar to those found in the watershed today. Because impacts from burning appear to have affected midslopes and ridgetops more than inner gorge areas, it is believed that the larger channel types such as step-pool and pool-riffle channels probably were not impacted appreciably by wildfires or mass wasting activity. Gravel and fine sediment probably accumulated in step-pool and pool-riffle channels following large wildfires and floods. However, the sediment deposited during these events was probably flushed from the channel network during smaller bankfull flows occurring over the following years. Large woody debris probably played a significant role in controlling the morphologies of smaller step-pool channels; however, most large wood was probably flushed through the larger step-pool and pool-riffle channels.

1900-1945

Little information is available concerning the effects of land-use activities on channel morphologies in the Pit Arm analysis area between 1900 and 1945. Stream channel disturbance was limited due to the relatively low level of human use that occurred in the watershed during this period. Some stream channels may have been impacted by land-use activities such as road construction and mining; however, these impacts were probably insignificant due to the small area in which they occurred. Stream channels and riparian areas were probably impacted by grazing activities in the larger and lower gradient streams with developed riparian areas; however, no long-term impacts from grazing are documented in the analysis area and the degree to which grazing activities affected stream channels and riparian areas is unknown (see p. 67 Geology, Geomorphology, and Erosion Processes section above).

1945-present

The completion of Shasta Dam and subsequent creation of Shasta Lake resulted in the inundation of approximately 30 miles of the Pit River and lower reaches of tributaries. The creation of the lake resulted in changes in the sediment transport capabilities of channels at their confluence with the reservoir. Aggradation of sediment and channel bedload began to occur where channels entered the lake. This reservoir sedimentation process is believed to be slow due to the interception of sediment from upland reservoirs and soil and geologic conditions in the watershed tributaries to Shasta Lake (USDA Forest Service 1997). Continued fire suppression has resulted in relatively dense vegetation levels in stream corridors.

Water Quality

Before 1900

Reference conditions for water quality in the Pit Arm watershed are believed to be similar to current conditions, with the greatest influence from human activities taking place between 1850 and 1900. The quality of water in the streams tributary to the Pit Arm has always been very good. Natural processes that affected water quality in the tributary streams prior to European settlement included climate, fire, peak flows, erosional processes and mass wasting activity, geochemistry, and possibly volcanic eruptions from Mount Shasta. Minor impacts in the form of increased sediment from Native Americans, primarily from periodic fires set in the analysis area, were likely short in duration. The most common impacts to water quality likely occurred for short periods during winter high flows when concentrations of suspended sediments increased. Water quality in all of the tributary streams was probably excellent between high flows and during the summer and fall when base flow conditions prevailed.

Squaw Creek and Mud Creek (a tributary to the McCloud River) experienced debris flows approximately every 75 years that contributed to periodic elevated suspended sediment concentrations in the Pit Arm.

1900-1945

Human disturbances most likely modified water quality by increasing turbidity, increasing water temperatures, and possibly contributing fecal contamination in the Pit River. The Pit Arm was once described as follows: “Less attractive is the Pit Arm which has been more severely treated by fires and its waters discolored and brackish because of its source” (USDA Forest Service 1953). Little to no information concerning the effects of land-use activities on water quality in tributaries to the Pit Arm is available for the early 1900s. Historical accounts of the McCloud

River watershed indicate that the quality of water in the tributaries was very good during this period (Wales 1939). Because of the similarity of the upland characteristics of the Pit Arm and the McCloud Arm, water quality in the tributaries of the analysis area is assumed to have been very good. Water quality was likely impacted by logging, road construction and grazing activities; however, the extent of these impacts is unknown. No other land-use activities have significantly influenced water quality in the Pit Arm watershed.

The large debris flows originating on Mount Shasta during the mid-1920s impacted water quality in the McCloud River, which drains into the lowermost reach of the Pit River. During the largest of these events in 1924, it was estimated that approximately 10,000,000 cubic yards of glacial debris were deposited in a 10-mile stretch of Mud Creek and an unknown amount of this material entered the McCloud River (Wales 1939). During the peak of the debris flow, it is estimated that the solid content of sediment in the McCloud River was approximately 68 percent (Cranfield 1984). The effects to water quality on the Pit River are unknown.

1945-Present

Water quality in the Pit River is believed to have improved since 1945. Reaches of the Pit River within the analysis area have been studied and are not listed as impaired. Reaches of the Upper Pit River above the analysis area are listed as impaired for several water quality parameters; however, the Pit River Alliance is actively engaged in watershed restoration.

Biological Features

Fire and Fuels

Figure A-25 in Appendix A displays a map of large fire history prior to 1987. Figure A-26 in Appendix A displays a map of large fire history from 1987 to 2009.

Before 1900

C. Hart Merriam, Chief of the Division of Biological Survey in 1898, wrote that “of the hundreds of persons who visit the pacific slope in California every summer to see the mountains, few see more than the immediate foreground and a haze of smoke which even the strongest glass is unable to penetrate.” Few forested regions have experienced fires as frequently and with such high variability in fire severity as those in the Klamath Mountains (Taylor and Skinner 1998).

With frequent fire, fuel accumulations over most of the area were historically maintained at low levels. This frequent regime produced overall low to moderate fire severity. Studies of fire scar analysis within the analysis area also show that fire was a frequently recurring event.

A study of fire scar analysis for fire history was conducted in Jackass Creek and Oak Flat, both near the analysis area (Skinner 2006). The study showed a fire return interval of 3 to 38 years (mean 12.75 years) in Jackass Creek and 4 to 16 years in Oak Flat (mean 8.36). Additionally, research shows that lower elevation mixed-conifer forests of the Klamath Mountains historically burned every 5 to 19 years, with riparian areas burning somewhat less frequently (Fry and Stephens 2006, Taylor and Skinner 1998, 2003).

Studies of historical fire regimes also showed that vegetation and topography strongly influence the fire regime. Frequent fires and fire-scarred trees that survived historical fires suggest that the fire regime was characterized by low to moderate severities (Skinner et al. 2006, Taylor and Skinner 1998). Studies also show that upper slope positions, ridgetops, and south- and west-facing aspects burned at higher severities than lower slope positions and north- and east-facing aspects (Alexander et al. 2006, Taylor and Skinner 1998).

Prior to the establishment of the Shasta-Trinity National Forest, suppression concerns were primarily focused on keeping wildfires from spreading to homes and other improvements. These efforts typically did not result in successful wildfire suppression. In other cases, human-caused fires or wildfires were allowed to burn for many reasons.

1900 to 1945

Fire suppression efforts were institutionalized after the establishment of the Shasta-Trinity National Forest. Since the onset of the fire suppression era in the early 1900s, and with the increased effectiveness of mechanized suppression techniques (e.g., fire engines, dozers, aircraft, etc.) in later years, most of the fires have been kept small. Successful fire suppression was noted in early fire protection plans (e.g., USDA Forest Service 1953, which states: “For the period 1929 – 1936 more than 3% of the lands in the immediate Shasta Dam drainage were burned . . . Since 1948 when the Forest Service protected the same area . . . an average of 0.13% of the area burned annually”).

1945 to Present

With successful fire suppression, fuels and vegetation density have increased and fires have become more intense and more difficult to control. Suppression concerns have, therefore, continued to focus on homes and other improvements in the wildland-urban interface. In addition, concerns over fire effects to other resources (e.g., wildlife habitat, soils, human uses, hydrology, air quality, etc.) have increased over time. Accessibility to portions of the analysis area was a concern in early fire protection plans (Burrows 1947 and USDA Forest Service 1953) and is still identified as a current suppression concern.

Shasta-Trinity National Forest GIS layers show fire starts and large fire history within and near the analysis area. Figures A-25 and A-26 in Appendix A display large fire history and fire starts from before 1987 and from 1987 to 2008, respectively. Figure A-27 in Appendix A demonstrates that fire return intervals have not been maintained at the historical levels described above in Reference Conditions.

Vegetation

Forest and Non-forest Vegetation

Pre-1900

Perhaps the largest scale influence to vegetation within the watershed prior to 1900 was recurrent wildfire. Typical fire severity and return intervals are discussed in the Fire and Fuels section of this watershed analysis. Of note is a fire recorded in 1872 that:

> *"...swept 150,000 acres of timberlands on the north slope of the Pitt River, as far east as the divide between Pitt River and Squaw Creek, the entire Squaw Creek drainage and the lower McCloud River as far north as Chatterdown Creek. This fire destroyed about a billion and a half feet of timber, being most of the standing timber on the area." (Barrett, 1935) This same area was reportedly re-burned in 1898: "Fire covered same area as fire of 1872 on Pit River, Squaw Creek, and McCloud River. Complete destruction over the area, especially on the higher slopes."* (Barrett 1935).

Native American burning is also believed to have occurred as a standard practice within the watershed prior to the 1900s. The extent of Native American burning is not clearly known but is included when analyzing historical fire return intervals and fire severity (Taylor and Skinner 2003). Anthropological accounts indicate local Klamath tribes used fire extensively to promote acorn, berry, root, and fiber production and to hunt game (Lewis 1973).

While precise historic vegetation distribution is not known, much can be surmised from fire history and later developing vegetation conditions. Vegetation mapping from the late 1930s and early 1940s indicated much of the watershed was early seral or open canopied stands. Based upon those conditions and a historical fire regime of frequent low to moderate intensity fire, much of the vegetation prior to the 1900s was likely fairly open canopied with brush, forbs and grasses underneath. More dense stands of mixed conifers would have likely been present at higher elevations, along riparian corridors and on north-facing slopes.

Under a natural fire disturbance regime, the Klamath-enriched mixed-conifer communities (WHR type "KMC") are typically 200 years old or younger and often contain old-growth conifers with deep fire scars. Within the eastern Klamath region, these communities are considered stable despite frequent fires and are considered a fire-adapted vegetation type (Benson in Mayer and Laudenslayer 1988).

Timber Harvest and Grazing

The earliest timber harvesting occurred to support mining operations beginning in the mid 1800s While there are no records of concentrated large-scale logging within the Pit River Arm during this era, later accounts describe "all merchantable timber" as having been removed from the Shasta Lake Area (USDI Bureau of Reclamation 1947), which would include the lower portions of the Pit River Arm. Historic records indicate approximately 7,000 head of cattle were grazed within the Pit River, Squaw Creek and McCloud River drainages between 1870 and 1905, when the Shasta Forest was created (USDA Forest Service 1945).

1900-1945

Vegetation descriptions and mapping in the early years was focused on resource availability for human uses. Table 19 lists the vegetation types identified in the watershed from 1934 records (USDA Forest Service Region 5 Remote Sensing Lab).

Table 19. Vegetation descriptions and distribution in 1934

1934 Mapped Vegetation Descriptions	Acres
Deforested lands (potential forest lands)	26,631
Grazing lands	13,379
Pine and pine-fir forested Lands	15,836
Watershed lands (non-forested lands)	18,732
Total acres	74,577

Grazing lands were primarily chaparral and open oak woodlands. Forested lands were identified in the southeast quarter of the watershed along the upper reaches of the Pit River. The upper reaches to the Northeast were mapped as unforested, as was an area south of the confluence with the McCloud River. More localized data from that era for a portion of the watershed are in conflict, and indicate timberland and woodlands in some areas mapped as deforested in1934

(USDA Forest Service 1938). General conditions can be surmised to indicate that much if not most of the watershed vegetation was in early to mid-seral conditions during this period, with late-seral forests generally in the southeast upper reaches of the watershed. Fires from the early 1920s to 1939 were mapped along much of the lower reaches of the Pit River above the confluence with Squaw Creek and indicate an increasing number of human-caused ignitions, including fires set by stockmen to improve grazing. However, fire suppression activities began in that same era and became increasingly effective as equipment and techniques improved.

As early as 1915, local stockman had begun to complain of dwindling forage as brush stands developed (USDA Forest Service 1945). Localized overgrazing and the setting of fires to maximize forage for livestock were common practices in this era (USDI Bureau of Reclamation 1947, USDA Forest Service 1945). Grazing activities declined over time through attrition and ended following the completion of the Shasta Dam in 1945. Areas that were most impacted by livestock grazing were subsequently flooded by the reservoir.

1945 to Present

With increasingly effective fire suppression, vegetation communities grew increasingly dense over the next several decades. Overhead canopies began to close in both hardwood and conifer types. Understory brush persisted in the absence of fire, eventually dying out over time as it was shaded out. At mid and upper elevations, understory brush was slowly replaced by more shade-tolerant fir and Douglas-fir regeneration. After approximately 30 years or more without fire disturbance, mixed chaparral stands become senescent, with increasing amounts of dead leaf litter and standing dead material (A. England in Mayer and Laudenslayer 1988). In the absence of fire, vegetation growth is limited most by precipitation and soil productivity. While soils are variable within the watershed, they are generally moderately to highly productive, with localized exceptions. Current vegetation densities reflect that, overall, the watershed is quite productive and able to develop forest vegetation (biomass) at levels higher than would be seen under a natural regime of more frequent fire.

As vegetation communities developed without fire disturbance, the overall distribution of cover types shifted to become increasingly tree dominated. Table 20 compares the relative distribution of vegetation types from 1945 to present day.

Table 20. Shift in vegetation type distribution - 1945 to present

Vegetation Type	% of Watershed - 1945	% of Watershed - Present
Chaparral	37	10
Hardwood	43*	23
Conifer and Hardwood/conifer mix	13	53
Undefined / non-forest	7	14

* likely includes some stands that would be typed as mixed hardwood/conifer using current standards.

A similar shift in vegetation has been observed in the adjacent Lower McCloud watershed, which shares the same local history of fire suppression. Comparisons of 1944 to 1995 aerial photography showed an increase of late-seral habitat from two percent to 35 percent within the watershed (USDA Forest Service 1998). This comparison also showed that most of the current late-seral habitat (WHR 5M and 5D) arose from what were mid-seral open canopied stands in 1945. Differences in current late-seral habitat were observed to be based on the type of stands they arose from. Stands that were dense canopied mid-seral in 1945 developed into single-layered late-seral stands with little vertical structural diversity. In comparison, late-seral stands that arose from previously open canopied conditions developed as multi-layered stands of scattered large overstory trees with smaller trees growing in the midstory and remnants of brush in the understory (USDA Forest Service 1998).

Timber Harvest and Grazing

Limited sporadic timber harvesting likely occurred within the watershed after the mining days and before the creation of the Shasta Lake reservoir, but records do not note any large-scale harvesting or clearcutting within the watershed during this time. Timber was cut from the lower reaches of the Pit Arm below the reservoir level prior to finishing the Shasta Dam; however, logging operations were halted during World War II. As a result, the upper Pit Arm of Shasta Lake contains many standing dead trees that were inundated when the reservoir filled.

Timber harvesting in recent years has been limited to small amounts of fire and insect salvage and thinning. Some reforestation has also occurred in association with salvage operations and a small range conversion project. Table 21 lists the timber harvesting and reforestation that has occurred in the watershed in recent years. As discussed above, livestock grazing within the watershed discontinued after the mid-1940s when the Shasta Lake reservoir was filled.

Table 21. Recent vegetation management activities within the Pit Arm watershed

Vegetation Management Activity	1983	1984	1991	1992	2005	2006	2007	Total Acres
Precommercial Thin				12				12
Commercial Thin (Reynolds Basin T.S.)						146		146
Insect salvage (clearcut)			45					45
Fire Salvage (Bear fire)					274			274
Range cover type conversion	66							66
Reforestation		66		45	20	10	80	221
Total Acres	66	66	45	57	294	156	80	764

Threatened, Endangered and Sensitive (TES) Plants and other Species of Concern

There is little information pertaining to the historical occurrence and distribution of sensitive plants within the watershed. Although the CNDDB and NRIS databases have entries dating as early as 1932 (*Clarkia borealis* ssp. *borealis*) and 1975 (*Ageratina shastensis*) respectively, this does not indicate whether these species existed in the watershed prior to those database entries. These data simply tell us the first known and documented locations of the selected rare plants.

Habitat for species with serpentine or limestone affinities such as *Ageratina shastensis*, *Ericameria ophitidis* and *Minuartia rosei* exists in small quantities within or adjacent to the watershed analysis area. Several caves in the watershed may contain suitable habitat for rare lichen, fungi, or bryophyte species. Habitat for several other species, however, has likely been reduced by events or activities within the watershed such as high-severity fire, fuels accumulation from fire suppression, timber harvest, mining, road construction, construction of Shasta Dam and the subsequent creation of Shasta Lake, and recreational use such as hiking or

OHV use. Additionally, noxious weed introduction and spread throughout the past century has likely reduced habitat for or displaced rare species such as *Calystegia atriplicifolia* ssp. *buttensis*, *Neviusia cliftonii* and others.

It is difficult to speculate on the historic distribution of rare plants within the overlapping region of Shasta Lake. Two species (*Neviusia cliftonii* and *Viburnum ellipticum*), however, have documented occurrences along the lake's edge and may possibly be displaced if the proposed raising of Shasta Dam occurs.

Noxious Weeds

Most of California's invasive plants originated from the Mediterranean Basin and began establishing as early as the 1730s – initially along the coasts and then spreading inland (Zouhar et al. 2008). Activities such as clearcut logging, prescribed fire or wildfire, grazing, and road building have all been shown to increase the abundance of noxious weeds in the northwest California bioregion.

As discussed in the Fire and Fuels section, the watershed experienced a reduction in fire-return interval during the era of widespread fire suppression era (1900-1945 and 1945-present). Although the buildup of fuels from active fire suppression created some shaded environments where light-loving invasive plants have a difficult time establishing (Keeley 2006), this accumulated fuel load also increased potential wildfire severity. In fact, several high-severity wildfires have occurred in the watershed (see Fire and Fuels section), with the resulting creation of new habitat for several invasive plants that may capitalize on open, bare substrates.

Recreational use of OHVs has increased in the watershed throughout the past 60 years (since construction of Shasta Dam). A concurrent increase in unauthorized OHV trails has likely promoted the introduction and proliferation of non-native and invasive plant species in the watershed.

There is little specific information pertaining to the historical occurrence and distribution of noxious weeds in the watershed. Some information may be gleaned, however, by reviewing these species distributions at a broader scale. The following is a general description of noxious weed introduction and occurrence in California:

- ***Ailanthus altissima* (tree of heaven)**: this native of China was introduced into the eastern U.S. in the late 18th century and was quickly adopted throughout the U.S. as a desirable urban tree (Landenberger *et al*. 2007).
- ***Bromus tectorum* (cheatgrass):** this native of southern Europe, northern Africa, and Asia was introduced to northeastern California in the nineteenth century (Bossard et al. 2000). By 1920, *B. tectorum* could be found along the Klamath River near Yreka, CA.
- ***Carduus pycnocephalus* (Italian plumeless thistle):** this native of the Mediterranean was introduced to California in the 1930s (Bossard et al. 2000).
- ***Centaurea solstitialis* (yellow star thistle):** this native of southern Europe and western Eurasia has occurred in California for over a century. Beginning in the late 1950s, it expanded its range within the state at an exponential rate, increasing from 1.2 to 12 million acres (Cal-IPC 2009).
- ***Cirsium arvense* (Canada thistle):** this native of southeastern Europe was introduced to North America in the 17th century as a contaminant in crop seed (Bossard et al. 2000).

There is no information regarding the vector for introduction of *C. arvense* in the watershed.

- ***Cirsium vulgare* (bull thistle):** this native of Europe, western Asia and North Africa came to the U.S. as a contaminant on ships in seed supplies or ballast. By 1925, it had been reported in several areas of California including the Klamath region (Bossard et al. 2000).
- ***Cytisus scoparius* (Scotch broom)**: this native to southern Europe and northern Africa is another woody species that often increases after prescribed fire. It was introduced to the Sierra Nevada foothills in the 1850s as an ornamental and was later used in erosion control (Bossard et al. 2000).
- ***Genista monspessulana* (French broom):** this native of Europe was first introduced to California in 1871 as an ornamental and was reported widely naturalized by the 1940s (Zouhar et al. 2008).
- ***Rubus laciniatus* (cutleaf blackberry):** this native of Europe was introduced to the U.S. as an escaped cultivar (Hickman 1993).
- ***Rubus armeniacus* (Himalayan blackberry)**: this native of western Europe was introduced to the U.S. as a cultivated crop and by 1945 had become naturalized along the west coast of California (Bossard et al. 2007).
- ***Spartium junceum* (Spanish broom):** this native of the Mediterranean region was introduced as an ornamental in the mid-1800s and by the 1930s was being prolifically planted along highways in southern California. By 1949, *S. junceum* had spread northward to Marin County (Bossard et al. 2007).
- ***Torilis arvensis* (hedge parsley):** this native of Europe has been documented in the San Francisco Bay area for at least 30 years and has recently begun spreading to other parts of the state (Cal-IPC 2010).
- ***Tribulus terrestris* (puncturevine):** this native of the Mediterranean was first collected in California in 1902 (Hickman 1993).

In addition, Klamath weed (*Hypericum perforatum*) was noted as a problem species in the Shasta Lake region as early as 1947 (USDI Bureau of Reclamation 1947).

Species and Habitats

Terrestrial Wildlife Species

Prior to settlement in the mid 1800s, the transportation system consisted of trails associated with hunting, fishing, trading, and other activities of the native inhabitants. Some early explorers and trappers passed through this watershed in the early 1800s (Henery 2008). The gradual extirpation of large carnivores such as the grizzly bear and gray wolf began as settlers moved into the area. Trapping and overhunting resulted in population-level declines of other furbearer species such as fisher, marten, wolverine, beaver, and river otter.

Wildlife species that were restricted to special habitats (cavity nesters, bats) may have been in greater numbers due to large expanses of habitat or the absence of the land-use practices of the Europeans who were to follow. Large expanses of late-successional habitat prior to mechanized timber harvest practices offered habitat for species associated with this habitat type, though the landscape was most likely more open due to more frequent fire and subsequent lack of heavy fuels in the understories.

In the late 1800s, livestock grazing and homesteading began to change the native landscape. Attempts to extirpate wildlife species populations that were considered threats, such as the grizzly bear and wolf, continued. Elk were also extirpated, possibly due to overhunting as occurred with elk in the Trinity Alps (Henery 2008), though elk were successfully reintroduced in 1911.

For other species, habitat changes most likely affected their historical populations and distributions. A major contributor to the change in habitat was fire suppression. Fire suppression practices caused a decrease in populations of deer and other species that utilize early seral habitats. Conversely, fire suppression most likely expanded the population and distribution of many species that utilized late-successional patches found in the watershed (e.g., northern spotted owl, northern goshawk). Increased human activity through construction of roads and timber harvest most likely contributed to a movement out of the watershed or decline in habitat use for some species (e.g., deer and elk) due to disturbance and exposure (Henery 2008). Species that may have proliferated in the human-altered environments are expected to be more common today than before European settlement.

Bald Eagle Habitat and Viability

Before 1900 and 1900-1945

The status and distribution of bald eagles in the time before World War II are poorly understood. Across its range, bald eagle population declines likely began in the late 19th century and continued through the 1940s. Between 1947 and 1970, reproduction in most eagle populations began to decline drastically and the species disappeared entirely from many parts of its breeding range (USFWS 1986).

Within the Pacific Northwest, an abundance of bald eagles was documented in the late 19th century. The beginning of the decline appears to have occurred at the beginning of the 20th century. However, these declines are difficult to quantify due to a lack of intensive surveys until the latter part of the 20th century (USDI Fish and Wildlife Service 1986).

1945-Present

Following the construction of Shasta Dam in 1945, wildlife use of the watershed shifted. Species that rely on or are associated with larger bodies of water were drawn to the lake. In particular, the population of bald eagles grew within the watershed. Because the Pit Arm of the lake did not experience the high level of timber harvest that the other watersheds of the lake had experienced beginning in the 1960s, there was an increase in quantity and quality of bald eagle habitat in the watershed. In addition, the rapid inundation of the lake created an increased level of large snags and an abundance of habitat for snag-associated primary excavator species such as hairy, acorn and pileated woodpeckers. Consequently, habitat for secondary cavity users such as purple martin, swallows, swifts, American kestrels, owls, and bats also increased. Snags from high water and fluctuating water levels along the lakeshore continue to offer excellent cavity nester habitat.

Numbers of bald eagles in the watershed prior to 1970 are unknown due to a lack of survey information. The population around Shasta Lake was low for several reasons. Overall numbers of bald eagles in the United States had severely declined by the 1960s. It was at this time that the bald eagle was listed as Endangered under the Endangered Species Act because of a severe decline in numbers attributed to the use of certain pesticides, disturbance at nesting sites and habitat loss. Eagle populations have since rebounded and it was removed from the Endangered

Species List by the USFWS in 2007. Refer to Figure 1 on p. 47, which displays changes in the number of bald eagle nest territories from 1970 to 2005.

Wildlife management on the NRA has shifted focus over the years. In the early years of the NRA, wildlife managers focused on game species and predatory species. Game species such as deer and elk were emphasized, and control of predatory species such as mountain lions, black bears, coyotes, and bobcats was practiced (USDA Forest Service draft in progress). While providing for the habitat needs of game species continues to be an important aspect of management on the NRA, the conservation of rare species and their habitats has become a high priority. Management now focuses on protection and conservation of species listed under the Endangered Species Act and Forest Service sensitive species (USDA Forest Service draft in progress).

Late-successional Mixed-conifer Habitat

Before 1900

Late-successional habitat was closely associated with the major tributaries to the McCloud, Pit and Sacramento Rivers. The remaining landscape consisted of open forested habitats (greater than 60 percent canopy closure) with early seral shrub or herbaceous understories, hardwood/conifer, oak woodland and chaparral habitats. Because of the open nature of much of the landscape, late-successional species would have been associated with the stringers and adjacent forested stands.

1900-1945

Settlement in the areas surrounding the Pit, McCloud, and Sacramento Rivers, as well as the introduction of fire suppression techniques initiated habitat changes in old growth visible today. In the beginning, very small quantities of timber were likely harvested as a result of settlement, rather than marketing, as the watershed was not as accessible as surrounding forested land. As fire suppression became more efficient, less of the land was maintained in an early seral or open forested stage. Consequently, the distribution and population levels of late-successional species slowly increased.

1945-present

Though fire suppression may have improved some stands, other stands may have become less suitable for certain species of wildlife as a result of an increase in dead and down wood, dense single-species understories, and the decline of shade-intolerant species. Excessive buildup of dead and down wood on the forest floor could inhibit visibility and accessibility of prey species for avian predators like the goshawk and spotted owl. Dense understory regeneration by shade-tolerant species has the potential to obstruct movement of avian predators and decrease the overall species composition. Increased canopy closure could have led to a decline of oaks and other shade-intolerant species in the understory and, therefore, to a decrease in structural diversity as well as forage (such as mast and herbaceous vegetation) important to many wildlife species.

With the increase in timber harvest in the 1960s, much of the late-successional habitat was fragmented, mostly in the easternmost section of the watershed, on both National Forest lands in the eastern sections of the watershed and on the private lands in the southern portions. Some clearcut areas could have mimicked natural openings of early seral habitat utilized by predatory species, but at the cost of fragmentation. Harvest units were much larger than natural openings and were different in overall composition. This fragmentation impacted the late-successional species occurring there, but to what extent is not known, as no surveys were conducted before harvest activities at that time.

Early Seral Brush and Browse Habitat

Before 1900

Open chaparral and oak woodlands supported deer, small mammals (that served as both seed dispersers and prey for larger predators), and a wide variety of wildlife species dependent upon open habitat and early seral stands. Chaparral grew in the southern half of the watershed with patchy distribution elsewhere. Naturally occurring disturbances such as fire would have maintained forage in the form of herbaceous vegetation found amongst the chaparral and open forest understories. As the chaparral recovered, sprouting chaparral provided succulent, palatable forage. In undisturbed areas, mature chaparral produced berries and dense cover.

Oak woodlands supported hardwood-associated species such as the gray squirrel, band-tailed pigeon, acorn woodpecker, pallid bat, deer, turkey and black bear. Wildfires often burned cool and kept the hardwood understory relatively open, stimulated acorn production and vegetative growth, and maintained shrublands in a mosaic of seral conditions.

1900-1945

Settlement was primarily in the north and fire suppression efforts were still developing. Habitat changes incurred from grazing, mining and other human-caused disturbances continued. Wolf and grizzly bears were on the verge of complete extirpation, and dramatic declines in furbearing species and elk continued.

1945-present

As natural fires were suppressed, chaparral became more decadent with time. Browsers were negatively affected as the chaparral became unpalatable and new growth became out of reach. In addition, as the chaparral became decadent, it provided less habitat for small- to medium-sized mammals, as branches near ground level matured or died. The accessibility for birds of prey was also reduced, as less ground was exposed. Other species, though, that feed on berries or use shrubs as cover (e.g., bears, birds and deer) benefited from the maturing chaparral (USDA Forest Service 1998a).

Within the oak woodlands, fire suppression reduced the amount of browse available in the understory in the form of mast, herbaceous growth or early seral shrubs. Herbaceous growth may have been hindered since understory growth of shrubs and oak seedlings, usually tempered by frequent fire, would outcompete the herbaceous plants. Then, as with chaparral, shrub species in the understory would mature and become unpalatable to browsing species (USDA Forest Service 1998a).

Aquatic and Riparian-dependent Species and Habitats

Before 1900

Large runs of Chinook salmon and steelhead ascended the Pit River and its large tributaries. Coho salmon were also likely present in the river, but in much smaller numbers. Rainbow trout, as well as Sacramento sucker, Sacramento pike minnow and hardhead minnow were common year-round river inhabitants (Moyle 2002). Native fish assemblages within the Pit River were used by local Native Americans as an important source of food. Early European settlers began to inhabit the area in the mid to late 1800s, attracted to the area by the discovery of gold in northern

California. Other fish species believed to occur in the Pit River during this time were speckled dace and riffle sculpin. These fish were probably not important dietary staples. White sturgeon, however, were present in the river and were likely an important food source.

Stream processes were likely functioning to provide excellent fish habitat. Bedload movement and large woody debris were in balance with channel functions and most likely provided an abundance of deep pools and runs. Under these conditions, large fish would have been common. Early use before the mining era had little impact on the river and surrounding watersheds or on local fish populations, as human land alterations were small in scope and were associated primarily with homesteading and Native American use.

The gold rush of the mid-1800s attracted thousands of people to Shasta County and the upper Sacramento River basin. These miners and settlers capitalized on the fishery resources, for both personal and commercial consumption. Several fish hatcheries and canneries were built along the Sacramento River and its larger tributaries. The abundant runs of Chinook salmon were most impacted by these ventures. By the late 1800s, diminishing runs of salmon were noticeable in the Sacramento River and its tributaries including the Pit River. In 1888, the Hat Creek fish hatchery in the upper Pit River was abandoned due to insufficient numbers of spawning salmon. Fish declines were also attributed to construction of the railroad line through Redding and continuing north from its prior terminus in Red Bluff (Leitritz 1970).

Wildland fires occurred regularly within the Pit River drainage. They were part of the natural basin ecology and due to their recurrent nature, most likely helped maintain channel processes through the contribution of large woody material.

1900 – 1945

Changes to fish populations and aquatic habitat that began taking place in the late 1800s continued through the early 1900s. These changes were associated with fish hatcheries, fish canneries and commercial fishing, grazing, mining, timber harvest, and recreation. Logging operations were active along portions of the Pit River to supply timbers to mining companies. Timber was floated down the Pit and Sacramento Rivers to Keswick, from about 65 miles upstream of Keswick (Brown 1915).

Copper smelting was extensive in the early 1900s near the mouth of the Pit River. Smelting fumes destroyed large areas of forested vegetation and created a large fire hazard. Approximately 275 fires occurred in the general Kennett area between 1929 and 1936 with several fires north and south of the current Pit Arm of Shasta Lake. High erosion rates from areas with no vegetation delivered large amounts of sediment to analysis area streams. Erosion had become enough of a concern that control efforts were initiated in the 1920s and 1930s through reforestation programs (CDF 2008).

All these activities contributed to destruction of riparian vegetation, erosion of streambanks and accelerated sediment delivery to the Pit River system. These changes in stream morphology likely resulted in degraded aquatic habitat conditions and added to further declines in fish populations.

American shad were introduced into the Sacramento River system between 1871 and 1881. By 1879, they were well established as part of the basin's anadromous fish community. Their presence would have resulted in competition for food and some displacement of native fish species (USDA Forest Service 1999). Shad were probably present within the Pit River. The development of fish hatcheries in Shasta County and the widespread practice of introducing non-native game fish to western waterways likely resulted in the introduction of other non-native fish species such as brown trout. Stocking records during the early 1900s are incomplete and vague.

1945 to Present

The completion of Shasta Dam in 1945 blocked the runs of salmon and steelhead from accessing the upper Sacramento River system including the Pit River. The elimination of anadromous fish runs changed the ecology of the area by removing an important food source, altering the fish community structure, and genetically isolating rainbow trout. The dam resulted in simplifying and destabilizing the native fish community as it effectively blocked upstream and downstream migration patterns.

The creation of Shasta Lake converted the analysis area reach of the Pit River from a stream environment into a lake environment. Fish populations that required stream habitats experienced habitat reduction, which caused local population levels to sharply decrease. The formation of a warmwater lake fishery adversely affected native fish populations even more. Introduced lake species such as bass, catfish, carp, and brown trout moved into the Pit Arm of Shasta Lake where the Pit River once flowed. These introduced species often out-compete and prey on native species, further reducing their numbers.

White sturgeon continued to spawn in the upper Pit River until construction of the Pit No. 6 and Pit No.7 Dams and subsequent higher water levels eliminated the spawning habitat for this species.

During this time, grazing and mining activities ceased. The impacts associated with these activities are largely gone, covered by the waters of Shasta Lake. The completion of Fenders Ferry road in the early 1940s brought an increase in recreational access and use to the area below the Pit No. 7 Dam. This resulted in an increase in fishing and associated riparian use upstream from areas accessible by boat, although uses in this area remain at low levels.

Hydropower developments along the Pit River system upstream from the analysis area profoundly altered flow and sediment regimes and the river’s morphology (see Hydrology section). These impoundments, along with Shasta Dam, have permanently altered aquatic habitats in the analysis area.

In the southern portion of the analysis area, approximately 1,000 acres of riparian habitat were burned at various intensities during the Jones Fire in 1999. Areas that burned at low and moderate intensities had improved habitat conditions for terrestrial species (such as forage habitat). However, shade levels, amount of cover and the large wood habitat component were negatively impacted in areas that burned at high intensities. The Jones Fire negatively impacted seasonal fish habitat in Clikapudi Creek. The fire consumed large woody debris in the creek that resulted in the release of stored sediment. The release of stored sediments increased turbidity, negatively affecting water quality in the stream and in the Clikapudi inlet of Shasta Lake (USDA Forest Service 2000).

Human Uses

Before 1900

Prehistoric Human Uses

Prehistoric use of the Pit Arm Shasta Lake watershed by native peoples is well documented. Archaeological evidence from sites within the Pit Arm watershed indicates that people continuously occupied the watershed for the last 8,000 years (Clewett and Sundahl 1979, Sundahl 1986), although the presence of earlier sites in other parts of northeastern California suggests that people probably utilized the watershed as early as 10,000-12,5000 B.P. (McGuire 2002, Moratto 1984). The local prehistoric material culture evolved over time, reflecting adaptations to changing physical and cultural landscapes.

The Paleo-Indian Period (12,500-10,000 B.P) occurred during the Pleistocene-Holocene transition when the transition to a postglacial climate caused a rapid change in vegetation northeastern California (West et al. 2007). Paleo-Indian sites are identified by the presence of large fluted Clovis-like projectile points (McGuire 2002). Although no Clovis points have been recovered from the watershed, they were recovered from nearby Samwel Cave (Treganza 1964), Mammoth Springs, Eagle Lake, Hat Creek (Dillon 2002), and Sconchin Butte (Morratto 1984:87). In addition, a fire pit in a rock shelter along Tule Lake was radiocarbon dated to 11,300 B.C. (Erlandson et al. 2007). Due to the occasional association of Clovis points with megafauna, and otherwise ephemeral natures of Clovis sites, early populations are assumed to have been organized in highly mobile small groups that focused on large game hunting.

The Early Holocene Period (10,000-7,000 B.P.) was warmer and drier than any other period during the Holocene (West et al. 2007). Early Holocene sites in northeast California are characterized by large lanceolate and stemmed projectile points, core and flake tools, bifaces, and chipped stone crescents (McGuire 2002). However, wide-stemmed projectile points are more common in the Pit Arm watershed area (Clewett and Sundahl 1983; Sundahl 1992; White et al. 1995). The continued abundance of large projectile points suggests a reliance on large game hunting, although ground stone and rabbit, fish and shellfish remains recovered from sites around Honey Lake may indicate the beginnings of intensification (McGuire 2002).

The Post-Mazama Period (7,000-5,000 B.P.) corresponds to a continuation of the warm, dry climate (West et al. 2007). Several lines of evidence suggest that land-use patterns changed significantly during this period. Sites were primarily located on alluvial fans adjacent to what would have been prominent water sources (McGuire 2007). The appearance of semisubterranean houses in Surprise Valley (O’Connell 1975) suggests a decline in mobility. Finally, the emergence and steady increase in milling equipment is evidence of resource intensification (Morratto 1984).

During the Early Archaic Period (5,000-3,500 B.P.), archaeological visibility increased (McGuire 2002), suggesting people were more numerous and/or more conspicuous on the landscape. Several projectile point types were introduced during this period including Houx, Excelsior and McKee (Moratto 1984). At the same time, milling equipment began declining in abundance. This suggests that the subsistence economy began relying more heavily on higher-return faunal resources again.

The Middle Archaic Period (3,500-1,250 B.P.), locally known as the *Squaw Creek Pattern,* coincides with a transition to cooler, wetter conditions (West et al. 2007). Middle archaic sites are recognized by the presence of contracting stem projectile points (Squaw Creek points), the continued use of manos and matates, unifacial tools, awls, wedges, net sinkers, and atlatl weights (McGuire 2007). The period is also characterized by large semisedentary village sites in the valleys and an abundance of temporary camps and hunting features in the uplands (McGuire 2007). This site distribution pattern suggests that people followed a logistical mobility foraging strategy in which small hunting parties left the residential camp for prolonged periods of time to hunt in the uplands (McGuire 2002). The widespread distribution of obsidian suggests that expansive trade and exchange also developed during this time.

The Late Archaic (1,250-500 B.P.) was a period of major change in assemblages, subsistence, and settlement organization (McGuire 2007). These changes may have resulted from the global climatic instability caused by the Medieval Warm Period, a warm, dry interval from ~1050 B.P. to 600 B.P. (Crowley and Lowery 2000; Mann and Rutherford 2002; Moberg et al. 2005). Climate change, in conjunction with increased population density, led to resource intensification. Subsistence studies show declines in large mammal abundances (Carpenter 2002) and increases in the exploitation of freshwater mussels, seeds, Manzanita berries, and upland root crops (Chatters and Cleland 1995; White et al. 2005). Other changes during the Late Archaic include increasing abundances of small projectile points, such as Rose Spring and Gunther points, marking the adoption of the bow and arrow during this period, and a decrease in house complexity (McGuire 2002; Moratto 1984).

The Terminal Prehistoric (500-contact) is identified by the presence of Desert side-notched and cottonwood projectile points (McGuire 2002). The period identifies the expansion of Numic groups from southeastern California into the area (Bettinger and Baumhoff 1982; Madsen and Rhode 1994; Lamb 1958). At this time, small one or two household settlements replaced the larger Late Archaic settlements, and presumably foraging strategies also shifted to focus on local resources that could be returned to the residential camp daily (McGuire 2007). The local expression, referred to as the *Shasta Complex* (1,400 to contact), is an exception to the Numic pattern. The Shasta Complex settlement pattern suggests greater continuity with the Late Archaic occurred locally than in other parts of northeastern California. It is characterized by large villages located near major streams with smaller sites in specialized resource procurement locations (Clewett and Sundahl 1979; Cleland 1995 in McGuire 2007). Artifacts and features from single and multi-family residences reflect a variety of residential activities (Delacorte 2002). Shasta Complex artifact assemblages include Desert side-notched and Gunther points, bipointed blades, hopper mortars and pestles, Olivella beads, and Haliotis pendants (Smith and Weymouth 1952; Clewett and Sundahl 1979).

Ethnohistorical records reveal that the watershed lies within the traditional territory of the Wintu and the Pit River people (Dubois 1935; Theodoratus 1981). The boundary between the groups was an area of land just east of Squaw Creek referred to as no man’s land and used as hunting and gathering grounds by both. At the time of contact, the Wintu and the Pit River people were semi-sedentary foragers, living in permanent winter villages along waterways (Dubois 1935; Theodoratus 1981). Contact with Euro-Americans resulted in pandemics that decimated native populations and conflict over land use (Theodoratus 1981). In 1851, the Cottonwood treaty provided the Wintu with a 35-square-mile parcel of land. The Pit River people avoided efforts by the Federal Indian Commission to negotiate treaties (Theodoratus 1981). Violence between settlers and both the Wintu and Pit River people led to their forced relocation to reservations (Theodoratus 1981).

Historic Human Uses

The first known Euro-Americans to enter the watershed were John Work and Thomas Mckay of the Hudson Bay Company; they led trapping expeditions along the Pit River in the 1830s (Mackie 1997). These expeditions established a route, likely following existing Native American footpaths, which became known as the Siskiyou Trail and stretched from California's Central Valley to the Pacific Northwest.

In 1844, the Mexican land grants led to an influx of settlers, many of whom were ranchers (Jensen and Reed 1979). The watershed was used by early Euroamericans primarily for mining, timber, ranching and grazing. Hunters also built trails for access into the watershed.

Prospectors looking for gold entered the watershed in the mid-1800s with the influx of settlers who arrived to take advantage of the 1844 Mexican land grants. However, it was not until copper mining began in earnest in the 1890s that the mining industry developed in the area (California Office of Mine Reclamation 2000).

The direct north-south leg of the Siskiyou Trail closely paralleled the Sacramento River and took advantage of the valleys and canyons carved by the river through the rugged terrain of Northern California. With the rapid development of California in the 1850s, the same line of communication became a horse trail for pack trains, a wagon road, a rugged turnpike for Concord stagecoaches, and finally the roadbed for the Central Pacific Railroad (later Southern Pacific Railroad), which was extended northward from Redding beginning in 1883. Settlements arose along many of the railroad stops such as Morley, Elmore, Pollack, Antlers, and Delta, many of which are now underwater (USDA Forest Service 2000). River crossings were via ferries.

1900-1945

Recreation Uses

Documentation of recreational use of the watershed prior to construction of Shasta Dam is limited, but such use certainly increased after the early 1900s as road construction in support of other activities began to open the area to more forest visitors.

Mining Resources

Prospectors looking for gold entered the watershed at about the same time as the influx of settlers in 1844 (see Step 1 – Characterization). However, it was not until copper mining began in earnest in the 1890s that the mining industry developed in the area (California Office of Mine Reclamation 2000).

Copper mining is not known to have existed in the Pit Arm; however, according to Aubury (1905), the main copper belt, consisting of a series of deposits, “intersects the Sacramento at about the point where it receives the Pitt, thus ending in the midst of the focal point of the copper mining activity within the Shasta Lake area.” Irelan (1892) reported that “the unconsolidated deposits narrow northward and disappear before reaching Pitt River.”

Directly north of the dam and under about 400 feet of water lies the copper mining town of Kennett founded during the gold rush of the 1850s. Kennett’s population boomed to nearly 10,000 residents in the early 1900s due to the high demand for copper, which was more prevalent than gold in the surrounding hills.

Timber from the Pit Arm was extracted during the copper boom for use in the smelters. Sulphur damage from the town's five smelters destroyed nearly all the vegetation within a 15-mile radius of the town and, combined with declining copper prices after World War I, led to the demise of the town after 1925 and the closing of the smelters.

Timber Resources

Commercial thinning and clearcut logging occurred in the watershed, probably beginning in the mid- to late 1800s to provide timbers for area mine adits, but was likely sporadic until around World War II, when the demand for timber to support the war effort coupled with the increased mechanization of logging practices saw an increase in timber harvest. Even so, the Pit Arm watershed was not logged as extensively as adjacent watersheds. The removal of timber from the Pit Arm in anticipation of elevated water levels following construction of Shasta Dam was interrupted by World War II. As a result, after the dam was constructed and water filled the Pit Arm drainage, a number of unharvested trees were inundated.

Grazing

Grazing activities occurred in the early 1900s, with abundant evidence of localized overutilization documented (USDI Bureau of Reclamation, USDA Forest Service 1945). Fires were reportedly set in many locations to maximize palatable forage for livestock (USDI Bureau of Reclamation 1947, USDA Forest Service 1945). Grazing activities ended with the exclusion of cattle and sheep from the watershed following the completion of Shasta Dam in 1945. The areas of the most past concentrated livestock use were flooded by the reservoir and are now inundated.

Transportation System and OHV Routes

In 1916, the California-Oregon trail was modernized by the Division of Highways and renamed the Pacific Highway; it was later renamed Highway 99. Some portions of Interstate 5 still follow this route. This was also the route followed by the Central Pacific Railroad (later Southern Pacific Railroad), which was extended northward from Redding beginning in 1883. The Lower Pit River Bridge was also constructed in 1916.

Visual Resources and Scenery

Although poorly documented, visual resources and scenery were almost certainly impacted with increased human activities in the watershed and as a result of periodic forest fires between 1900 and 1945.

Fire and Fuels as Related to Human Uses

As road construction began to open the watershed to increased use by forest visitors, the incidence of human-caused fire starts likely increased. In addition, the burgeoning practice of fire suppression on National Forest System lands following the 1910 fires began to change the role of fire in ecosystems within the watershed. See the Fire and Fuels, Reference Condition section for a more detailed discussion.

1945 – Present

Recreation Uses

After the Shasta Dam was built in 1945, recreation use of the watershed changed considerably. The sudden accessibility of the watershed by watercraft contributed most fundamentally to changes in recreational use. High-use periods for recreation in the watershed increased after the creation of the lake. Holiday weekends and summer season has the highest usage, increasing the number of watercraft and people in the area. As a result, human influence through water-based recreation since 1945 has had a major impact to the ecology of the watershed.

The outdoor recreation industry and profession has become much more complex and sophisticated (USDA Forest Service 2006b). New technology and equipment, more facilities, and diverse public tastes and preferences have spawned a variety of camping, fishing and boating activities.

Other changes occurred after construction of the dam. Loss of the anadromous fishery in the Pit Arm (see the Aquatic and Riparian-Dependent Species and Habitats discussion) led to changes in fishing as a recreational pursuit. Partially submerged trees killed by the inundation of the Pit Arm pose a hazard to boaters; consequently, water skiing has been prohibited above Arbuckle Flat (Luzietti 2010 personal communication).

National Recreation Area

The Shasta-Trinity NRA was established November 8, 1965 by Congress to provide for public outdoor recreation use and conservation of scenic, scientific, historic and other values. Management direction for the Shasta and Trinity units of the NRA was last revised and approved in 1998.

Motorized Recreation

With the expansion of forest roads in the watershed following World War II and the increasing emphasis on motorized transportation after the war, motorized use of the area grew. Following construction of Shasta Dam and the subsequent creation of Shasta Lake in 1945, the use of motorized watercraft quickly became the major recreational activity in the watershed.

Recreation Residences

As mentioned above in Step 3 – Current Conditions, Silverthorn Recreation Residential Tract is one of several recreational facilities developed after 1945.

Trails and Campgrounds

The majority of the developed campgrounds in the watershed were constructed between 1950 and 1965 (USDA Forest Service 1998b). Automobile access camping along the shoreline below high-water line has increased over time. Increased traffic to these low-water camping areas has increased the potential for effects to other resources, particularly the vulnerability of heritage resources that have yet to be surveyed and documented. Sanitation and litter problems have also become a management issue.

Forestwide data for visitor usage are limited. Collection of visitor numbers was taken in the early 1990s through the RIM Database program, and again in 2002 and 2008 with the National Visitor Use Monitoring surveys. There is no information available regarding data collected in the 1990s; however, the 2002 NVUM survey results for Lower Jones Valley show 1,226 annual site visits to the campground; Upper Jones Valley Campground had 86 annual site visits. These surveys were conducted via direct count of fee envelopes; they represent an estimation of number of visitors to the campgrounds in one annual collection.

Other Special Use Permits

In 1984, the Forest Service issued a special use permit to Cal Fire for the construction, operation and maintenance of a 120-person inmate conservation camp – known as Sugar Pine Conservation Camp - on 40 acres of National Forest System lands for a term of 20 years. In 1986, the permit was amended after a survey was completed and the actual acreage was calculated at 75.046 acres. In 1991, Amendment II added an additional 2.527 acres. In 1997, an additional 5.00 acres were added to the permit for construction of additional sewage ponds; this is known as Amendment III. Currently, the existing Sugar Pine Conservation Camp facilities total approximately 83 acres entirely on National Forest System lands.

Caves

As noted above, the extent of historic use of caves in the watershed is unknown. Many of the caves are overgrown with vegetation and have had little recreational activity in the past, most likely due to inaccessibility.

Mining Activities

Mining activities in the watershed dwindled after the 1950s. See Step 3 – Current Conditions for the status of mining activity in the watershed.

Timber Resources

After 1945, sporadic commercial thinning and stand clearcuts occurred in the watershed. The most recent timber harvest occurred under the Bear Fire Heli Salvage project that covered approximately 274 acres (completed in 2005) and as part of a commercial thinning project on 45 acres (completed in 2006). See Table 22 for a list of the most recent timber harvest activities in the watershed.

Table 22. Recent timber harvest activity in the Pit Arm Shasta Lake Watershed Analysis area

Project Name	Harvest Type	Year Completed	Acres
Bear Fire Hazard	Fire salvage	2005	129
Bear Fire Heli	Fire salvage	2005	145
Reynolds Basin	Commercial thin	2006	45
N/A	Stand clearcut	1991	16

Transportation/OHV Routes

The present-day Interstate 5 and Southern Pacific Railroad generally follow the historic Siskiyou Trail. Crossings are facilitated by the Pit River Bridge, perched high above Bridge Bay Resort and the lake; the Pit River Bridge is the highest double-decker bridge in the United States. This bridge replaced the Lower Pit River Bridge, which was inundated after the creation of Shasta Lake in 1945.

In the past, road construction on National Forest System lands was supported by timber harvest. The existing forest transportation system was developed, in part, through the need to provide timber to the public after World War II. This trend continued until the late 1970s or early 1980s.

Creation of OHV routes began around the same time as the logging roads were constructed. Some unauthorized routes became established on remnant logging roads or other formerly managed roads that are no longer part of the National Forest Transportation System but were never obliterated and remain on the landscape. Unauthorized motorized road and trail networks have proliferated over time, resulting in fewer places for quiet recreational pursuits especially for areas outside of designated wilderness (USDA Forest Service 2009).

The creation of unauthorized OHV routes in the Jones Valley increased after the Bear fire of 2004. The fire burned off large stands of manzanita and opened the landscape to increased use and subsequent resource damage (Grigsby 2010 personal communication).

In 2002, the National Visitor Use Monitoring survey assessed the existing recreation demand on the forest by asking visitors what they did during their visits. Based on the reported 3,055,557 visits to National Forest System land on the Shasta-Trinity during fiscal year 2002, 336,111 visitors spent some time driving for pleasure, and 152,778 used OHVs during their visit; the main activity for 9,167 visitors was OHV use. Based on the 2002 year visits, when primary motorized uses are combined (including OHV use, driving for pleasure, and other motorized activities) approximate visitor numbers were 91,667 versus 953,334 for primary nonmotorized uses combined (including backpacking, fishing, horseback riding, hiking/walking, bicycling and other nonmotorized activities).

Visual Resources and Scenery

The past creation of unauthorized routes, particularly in sparsely covered landscapes, has adversely affected visual resources in the Jones Valley area. The 2004 Bear Fire burned the once-thick vegetation, which created large openings and rendered the area vulnerable to additional visual impacts from unauthorized OHV routes (see above).

Of major significance for visual and scenic quality within the watershed ecosystem is the presence of fire and the impact to visual resources as a result of past forest fires. Fire risk and fire hazard from past management activities have led to concerns over future fire behavior within and adjacent to the wildland-urban interface and over fire effects to visual and other resources, with the result that fire suppression in these areas has continued.

The most recent fires have changed the landscape by leaving debris, charred vegetation and downed logs; they have also had a significant impact on recreation resources. In particular, the recreational public has experienced the effects to the scenic value of the watershed in the aftermath of the most recent fires. The upper end of the watershed remains rugged and somewhat inaccessible other than by watercraft, and the vegetation fuel load there remains high.

Over time, the landscape has undergone significant change. The lower section near the marinas and along highway corridors has an historic trend toward more change and a less natural appearing landscape. This trend has been accelerating during the past 35 years (USDA Forest Service 1995).

Accordingly, to estimate the level of visual quality that would be acceptable to most people, recommended standards for managing the visual resource were established in the 1995 LRMP. These inventoried visual quality objectives (VQOs) were based on estimates of public concern, the quality of the landscape, and the distance of the landscape from the viewing area. VQOs identify how much a management activity can contrast visually with the character of the landscape. Management activities are monitored to determine the trend of visual quality throughout the Forest.

Fire and Fuels as Related to Human Uses

Past forest management practices and disturbance history changed the composition and structure of vegetation in the analysis area from what existed before European settlement. Fire prevention and suppression replaced the historic role of fire.

Over the last 20 years, 160 fire starts have been recorded. As noted above in the Fire and Fuels characterization, approximately 82 percent of the fire starts from 1987 to 2008 were human-caused, while the remaining 18 percent were lightning-caused. Within the last 20 years, three major high-severity fires took place in the watershed: the Fountain Fire in 1992; Jones Fire in 1999; and the Bear Fire in 2004. All were human-caused and were started on private property within the surrounding interface areas.

Step 5. Synthesis and Interpretation

The purpose of this step is to compare existing and reference conditions of specific ecosystem elements and to explain significant differences, similarities and/or trends and their causes. The interaction of physical, biological and social processes is discussed. The capability of the system to achieve key management plan objectives is also evaluated.

Applicable key questions from Step 2 and core questions from the Federal Guide for Watershed Analysis (USDA Forest Service 1995, as amended) are restated at the beginning of each section and guide the analysis.

Physical Features

Erosional Processes

Core Questions (from WA Guide)

1. What are the natural and human causes of changes between historical and current erosion processes in the watershed?
2. What are the influences and relationships between erosion processes and other ecosystem processes (e.g., vegetation, woody debris recruitment)?

Present Condition

- Increased surface erosion is occurring in heavily roaded areas and densely populated areas.
- Increased surface erosion has occurred in areas where wildfire has occurred. Areas that burned with high intensity experienced more concentrated and long lasting soil loss.
- Increased surface erosion may be occurring on private land from ground-disturbing activities such as logging.
- OHV use in the Jones Valley area where recent wildfires occurred continues to accelerate surface erosion.
- Erosion is occurring around the lakeshore.
- Dormant and active mass wasting features are present in the watershed.

Causal Mechanisms

- Past road construction
- Logging on public and private lands
- Past and recent wildland fires
- Authorized and unauthorized OHV use
- Construction of Shasta Dam and formation of Shasta Lake
- Topography characterized by steep, fractured rocky slopes

Trends

- Lakeshore erosion is expected to maintain the same trend.
- Increased erosion in concentrated use areas is expected to continue.
- Risk of large, high-severity fires in the area is increasing. Such a fire would dramatically increase erosion.

Influences and Relationships

- Erosion and mass wasting are naturally occurring within the analysis area. The steep, fractured terrain of the Eastern Klamath Mountains is actively eroding. Human influence has hastened the erosional processes in many ways. Disturbance from activities such as road building and logging that occur are mitigated by the implementation of best management practices.
- Wildland fire is a natural component within this system. Suppression of fires may have reduced erosion for intervals where fire would naturally have occurred. The data available indicate the majority of these fires were of low to moderate intensity. Fire suppression in many areas has resulted in conditions that increase the risk of larger fires, with a greater percentage of high-severity fire. Effects on erosional processes are likely to be more severe and persistent.

Conclusions

- Soil resources in the analysis area are at risk from high-severity wildland fires.

Hydrology

Core Questions (from WA Guide)

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

Present Condition

- Thirty miles of the Pit River were inundated by Shasta Lake.
- Peak and base flows of the Pit River are intensively regulated.
- Roads increase water delivery and, therefore, have the effect of increasing peak flows in subwatersheds with high road densities.

Causal Mechanisms

- Formation of Shasta Lake
- Construction of Shasta Dam
- Construction of PG&E McCloud-Pit Hydroelectric Project
- Road systems (both public and private)

Trends

- Flow management of the Pit River into Shasta Lake will continue and likely remain similar in trend.
- Management of Shasta Lake levels will likely remain similar to the last 50 years for at least the next decade.
- Likelihood exists of Shasta Dam modification in next quarter century.

Influences and Relationships

- Riparian vegetation along the Pit Arm is reduced because of the reservoir.
- Increased development (i.e., roads, subdivisions) may increase runoff rates and volume.
- Wildfires and prescribed fires are likely to influence runoff rates and volume.

Conclusions

- The hydrology within the analysis area has been significantly modified by water management facilities constructed for flood control, hydroelectric power generation, and water consumption.

Stream Channel

Core Questions (from WA Guide)

1. What are the natural and human causes of change between historical and current channel conditions?
2. What are the influences and relationships between channel conditions and other ecosystem processes in the watershed (e.g., in-channel habitat for fish and other aquatic species, water quality)?

Present Condition

- Riparian vegetation along the Pit Arm is nonexistent because of the fluctuating reservoir levels.
- Approximately 30 miles of the Pit River is inundated by the high water mark of Shasta Lake.
- Aggradation is occurring in the inlets of Shasta Lake.
- Channels in subwatersheds with higher road densities (Bear Canyon, Clikapudi, Bridge Bay, and Potem) are generally more altered by human use. Impact is typically decreased stream stability, increased scour, change in substrate, and increased channel density.
- Many stream channels reflect changes related to fire and fuels and changes in vegetation structure and composition.

- Mass wasting naturally occurs within the analysis area. Land use activities have the potential to increase both frequency and magnitude of mass wasting.
- Many upland channels remain unsurveyed because of remote and inaccessible terrain.

Causal Mechanisms

- Construction of Shasta Dam and subsequent formation of Shasta Lake
- Road construction and other features such as subdivisions that create impermeable surfaces and alter hydrologic response
- Wildfire and fuels management
- Channels are unsurveyed because of remote and inaccessible terrain.

Trends

- Effects associated with Shasta Lake are expected to remain static.
- Road construction on public land is not expected to change.
- Road density as well as other developments on private land is likely to increase in a trend consistent with the last quarter century.
- Effects from wildfire are likely to increase unless changes in fuels management are implemented.

Influences and Relationships

- Formation of deltas in stream channel confluence locations with Shasta Lake may impede fish passage.
- Riparian reserves protect water quality and provide biologically diverse areas.
- Stream channels can funnel airflow thereby increasing fire intensity.

Conclusions

- Stream channels may be more severely impacted by wildfire if riparian reserves are not treated.

Water Quality

Core Questions (from WA Guide)

1. What are the natural and human causes of change between historical and current water quality conditions?
2. What are the influences and relationships between water quality and other ecosystem processes in the watershed (e.g., mass wasting, fish habitat, stream reach vulnerability)?

Present Condition

- No impaired waters exist in the Pit Arm within the analysis area. Sections of the Upper Pit River are on the Clean Water Act Sec. 303(d) impaired waterbody list; however, those conditions do not extend into the Pit Arm watershed analysis area.
- Several streams within Cow Creek are also listed as impaired. A small part of public land within the analysis area falls within the headwaters of North Cow Creek. Because

these areas are small and located within the headwaters, there is no measurable effect to water quality in Cow Creek (California Regional Water Quality Control Board 2003).

- Little to no water quality data are available for tributaries to the Pit Arm and Cow Creek that fall within the analysis area boundary. Water quality is assumed to be good.
- Discharge of gray water into Shasta Lake is prohibited. Compliance monitoring is conducted by the California Regional Water Quality Control Board (California Regional Water Quality Control Board 2004 and 2008).
- Fuel storage tanks have been upgraded and most tanks are now double-walled floating gas tanks. These facilities are monitored by the California Regional Water Quality Control Board.
- Wave action around the shore of the lake from wind and boats is a source of turbidity.
- Areas with dense road networks impact turbidity in the lake and streams.
- Increased erosion on burned areas has increased the sediment load delivered to streams.

Causal Mechanisms

- Land use activities (e.g., road construction)
- Wildland fire
- Wave action
- High recreation use on Shasta Lake

Trends

- Turbidity levels from wave action are expected to stay the same.
- Overall water quality is expected to remain high.
- Effects from wildfire are likely to increase unless changes in fuels management are implemented.

Influences and Relationships

- Turbidity is likely to increase during flood events and wind events.
- Land use activities that create disturbance increase turbidity.
- Risk of large, high-severity fires in the area is increasing. Large fires with high proportions of high-severity fire such as the Jones Valley Fire would impact water quality by increasing suspended sediment and turbidity.

Conclusions

- Water quality is expected to remain high in the absence of widespread disturbance such as high-severity fire.
- Current water quality monitoring should be continued.
- Opportunities to protect current water quality exist.

Biological Features

Fire and Fuels

Key Questions

1. What is the current fire hazard and risk in the analysis area, including the threat to the wildland-urban interface?
2. How does the current fire regime impact vegetation within the analysis area?
3. What are current fire suppression concerns within the analysis area?
4. How might future high-severity fires affect other resources (i.e., air quality, erosion processes, soil fertility, water quality, fisheries habitat, and human uses)?

Present Condition

- Fire has largely been reduced from historical fire return intervals, as demonstrated by the following analysis:

  Historical fire return intervals (pre-suppression) were compared to contemporary fire return intervals (suppression era) over the analysis area. This analysis is known as "condition class based on departure of fire return interval". The mean historic fire return interval ranged from approximately three years to 40 years depending on biophysical setting. A biophysical setting is defined as a combination of vegetation and topographic, soils, and climate variables that influence vegetation development.

  The following equation is used to determine departure of fire return intervals:

  {1 – (reference FRI/Current FRI)} * 100

  The value obtained is a percent difference, and condition class is determined using the Landfire national scale (i.e., 0-33 percent departure = condition class 1, 33-67 percent departure = condition class 2, and greater than 67 percent departure = condition class 3). Other assumptions come from Safford and Schmidt (2006). Figure 2 depicts condition class by approximate acres of fire return interval departure. The analysis shows that much of the analysis area is in condition class 3 (i.e., much of the landscape has missed four or more fire return intervals compared to historical periods).

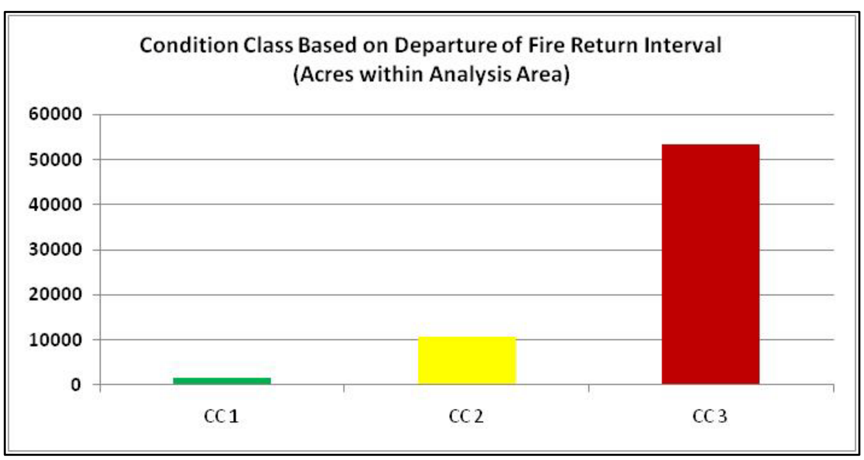

Figure 2. Condition class departure based on fire return interval displayed in approximate acres by condition class

- There are large areas of high vegetation density and high fuel loading.
- There is a high fire start occurrence (fire risk) in the analysis area, and the primary source of ignition (approximately 82 percent) is human caused.
- Approximately 43 percent of the area is subject to crown fire and 47 percent subject to moderate-to-high flame lengths.
- There is a threat to the wildland-urban interface. Approximately 19,945 acres or 41 percent of the urban interface area has moderate-to-high fire behavior potential.
- The wildland-urban interface and associated fire behavior potential create concerns over public and firefighter safety.
- Air quality is at risk in proportion to fire risk and high fire behavior potential.

Causal Mechanism(s)

- Fire exclusion and other past land use management (i.e., mining, timber management, etc.)
- Site quality and productivity

Trends

- Through time, vegetation density and fuel loading has increased. This has, in part, led to an increased likelihood of high fire behavior potential.
- There has been and continues to be a high fire start occurrence in the analysis area.
- Forest vegetation has changed from a heterogeneous pattern to a more homogeneous pattern of smaller openings in a matrix of denser vegetation.
- Air quality is expected to be similar to that in recent years. Activities on NFS lands are guided by provisions of the Federal Clean Air Act, the Shasta-Trinity LRMP, and the California Air Resources Board to minimize adverse effects to air quality. Periods of poor air quality are likely to occur during high-severity fires; however, smoke particulates are expected to be lower than before 1900.

Influences and Relationships

- Numerous fire starts coupled with steep terrain, poor access, dense fuel conditions, and weather patterns conducive to large fire growth have caused difficulties in past and recent fire suppression efforts. These conditions are a concern for future wildfires.
- Vegetation type, disturbance history, soil type, fuels, topography, and weather play a vital role in fire severity patterns on the landscape.
- Fire severity patterns on the landscape influence physical and biological resources (e.g., human uses, water quality, botanical resources, and terrestrial and aquatic wildlife).

Conclusions

- Management of accumulated fuels is needed to reduce the risk that future fires will be of uncharacteristically high severity and to allow fire to resume, as much as possible, its natural role in the watershed.

Vegetation

Forest and Non-forest Vegetation

Key Questions

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

Present Condition

- Fire and fuels analysis indicates much of the watershed has significantly departed from a natural fire return interval. Much of the landscape has not seen fire for four or more fire return intervals (expected occurrences of fire based on historical fire frequency). The lack of natural disturbance and lack of vegetation management (timber harvest) over the last several decades has led to increasing densification of vegetation types.
- Without disturbance, there has been a noticeable decline in early and mid-seral stands and open-canopied stands. Currently, roughly 88 percent of the forested vegetation has dense canopy cover of 60 percent or more. Most (83 percent) of those dense-canopied stands were open-canopied in 1945 (described as poorly stocked or unstocked). About 44 percent of forested vegetation is currently late seral. Most (73 percent) of those late seral-stands were likely early to mid-seral (described as poorly stocked or unstocked) in 1945. For this analysis, late seral is defined as stands that are WHR size class 5, which corresponds to an average tree diameter at breast height (d.b.h.) of 24 inches or more. Large old trees (40 inches d.b.h. and greater) are scattered and make up only a minor component of late-seral stands; many late-seral stands do not include a component of large old trees.

Causal Mechanism(s)

- Fire exclusion
- Localized timber harvest of large trees during the mining and settlement era (late 1800s)
- Fire history
- Site quality and soil productivity

Trends

- Vegetation densities have increased over time. Vegetation will continue to grow until some form of disturbance mechanism occurs (wildfire, density-induced mortality, insects and disease, etc.) or vegetation management activities are conducted. Dense vegetation and increased fuel loadings lead to an increased likelihood of high fire behavior potential.
- In the absence of large-scale disturbance, late-seral stands will slowly continue to develop larger overstory trees and structural complexity. However, current vegetation densities and fuels accumulation, coupled with increasing inter-tree competition over time, leads to an increasing likelihood of disturbance, which would alter the current development trajectory of late-seral stands.
- Early seral habitats will remain at low levels (currently 2 percent) until disturbance events or management activities occur to cause an increase in early seral habitat.

- Chaparral stands will grow towards senescence or remain senescent in the absence of fire. Senescence in chaparral commonly begins developing after roughly 35 years of age (England in Mayer and Laudenslayer 1988). Roughly two thirds (67 percent) of existing chaparral is over 60 years old, the remaining chaparral stands are 6 to 12 years old. Older over-mature brush provides lower quality browse material for wildlife than younger more succulent brush.

Influences and Relationships

- Fire exclusion has encouraged the development of late-successional forests and a corresponding decrease in early seral vegetation. Habitat for species dependent on early seral vegetation has decreased.
- High vegetation densities and fuel loadings create a potential for high-severity fire that could cause large-scale loss of late-seral habitat and reversion to early seral conditions. These dense vegetation and fuel loadings occur in riparian as well as upland areas and increase the risk that high-severity fire will negatively affect the integrity of riparian reserves.
- High-severity fire can create subsequently extremely high levels of dead fuel accumulation. If left untreated, these heavy fuel accumulations pose a risk of later reburning at high intensities within the next few following decades. A secondary fire of this nature can cause early seral stages to persist for much longer and can create hydrophobic soils and reduce soil productivity because of high burn temperatures and fire residence time (the amount of time fire actively burns at a location due to fuel supply).
- The condition and distribution of vegetation types within the watershed affects wildlife habitat and species distribution.
- High severity fire can remove riparian vegetation, which would affect stream temperatures, water quality and streambank and channel stability.
- Large-scale high-severity fire can cause increased soil erosion due to loss of vegetation cover.

Conclusions

- Long-term departure from historic fire return intervals has had the most widespread influence on current vegetation conditions within the watershed.
- Current levels and conditions of late-seral habitats are a result of active fire suppression and do not reflect late-seral conditions expected under a natural fire regime.
- The amount and distribution of early and mid-seral habitats has greatly declined over recent decades with the advent of active fire suppression.
- Historic logging associated with mining operations and settlement removed most if not all large timber in localized areas. Much of that ground is now underneath the Shasta Lake reservoir.
- Recent vegetation management (timber harvest, etc.) has been very limited in scope and has little effect on overall vegetation conditions within the watershed.
- There is an increased risk of large-scale high-severity fire due to the amount and distribution of dense canopied stands with ladder and surface fuels.

Threatened, Endangered and Sensitive (TES) Plants and Other Species of Concern

Key Questions

1. What is the current status and distribution of documented rare plant occurrences and/or suitable rare plant habitat in the watershed?
2. How have past activities and events impacted rare plant populations and/or suitable rare plant habitat?
3. How can future management practices help maintain or restore rare plant habitat in the watershed?

Present Condition

- Populations of sensitive plants are known to occur throughout the watershed. Rare plant habitat is declining and existing habitat is threatened by potential high-severity wildfires. Although some surveys for rare species have occurred in the watershed, a comprehensive inventory for rare plant, fungi, lichens, and bryophytes, is lacking.

Causal Mechanisms

- Rare plant habitat is imperiled by fuels accumulation from fire suppression. Many rare species rely on forest openings and may be limited in reproductive capabilities due to a dense overstory condition. Recent high-severity wildfires may have reduced habitat for some rare plant species (e.g., *Clarkia borealis* ssp. *borealis*) while apparently not affecting others (e.g., *Viburnum ellipticum*). These species' responses to various fire frequencies or intensities are not well documented. One study, however, showed *Fritillaria eastwoodiae* as having "no apparent change in population'' after a spring underburn was implemented (USDA Forest Service 2006c), while another study documented a *Thermopsis* species (*macrophylla* var. *angina*) resprouting after fire and establishing large numbers of seedlings one year after fire via heat-stimulated germination (Borchert 1989).
- Human-caused disturbances such as mining, logging, road and trail construction, and OHV use may also have contributed to a lack of rare plant habitat.
- Competition from noxious weeds may be displacing rare plant species. A lack of comprehensive information regarding rare plant microsite associations can also diminish the quality of survey results.

Trends

- Habitat for several rare plant species has been declining in the watershed, and the decline is expected to continue if no protection measures are implemented to reduce the risk from recreation and other human uses and as described above.
- The risk of high-severity fire – and thus its negative impacts to rare plant populations and suitable rare plant habitat – has increased with fire exclusion and in the absence of treatment of accumulated fuels.

Influences and Relationships

- High-severity wildfire can extirpate rare plant populations and result in temporary loss of rare plant habitat. Continued accumulation of untreated fuels in the watershed will increase the risk of high-severity fire.
- Reduced sunlight in the absence of disturbance results in habitat loss for some rare plant species.
- Human activities such as OHV use, hiking, driving, and camping may threaten rare plant populations and habitat through direct trampling, soil compaction and/or introduction and spread of noxious weeds.
- Competition from noxious weeds may displace rare plants.
- Protection measures that maintain the viability of rare plant populations during Forest activities increase the likelihood of their survival.

Conclusions

- Unmanaged human and natural influences that imperil rare plant population viability and habitat within the watershed (e.g., illegal OHV use, illegal camping, and high-severity wildfires due to fuels accumulation) will continue to impact rare plant species. Properly managed activities will continue to have moderate to little negative impacts.
- Appropriate management of fuels to maintain or enhance habitat conditions for known rare plant occurrences will likely promote stable or increased population numbers of these plant occurrences within the watershed.
- Surveys for sensitive plant, lichen, fungus, and bryophyte species are needed in the majority of the watershed.

Noxious Weeds

Key Questions

1. How have past activities or events influenced noxious weed populations in the watershed?
2. What are the potential effects of current or future potential noxious weed infestations on rare plants and on general ecosystem function and integrity in general?
3. How can future management practices reduce the potential for noxious weed introduction and spread?

Present Condition

- Several noxious weed species have established in the watershed and are continuing to spread. Documented populations of yellow star thistle, tree of heaven, Himalayan blackberry and invasive broom species are competing with – and in some cases have displaced – native species.

Causal Mechanisms

- Causal agents for the introduction of individual noxious weed populations in the watershed are unknown. Several species, however, may have been spread through prolonged periods of grazing. Wildfires, prescribed burning, logging, transmission-line creation, and road creation have all created openings in the forest canopy where invasive species have proliferated. Additionally, numerous recreation facilities (campgrounds, trails, OHV parks) have been created in the watershed over the past 50 years, likely increasing the presence and spread of invasive species.

Trends

- Non-native species are continuing to spread throughout the watershed. These species' populations will continue to increase if no or insufficient weed-removal plans are implemented.
- Species such as invasive brooms, if untreated, will continue to impact rare plant habitat and populations. There is a proposal to remove invasive broom species from the Packers Bay area of the watershed as well as the Bailey Cove recreation area adjacent to the watershed boundary. Past efforts (2004-2005) to remove invasive broom via solely mechanical methods were ineffective.
- Insufficient funding does not permit a systematic program to effectively deal with invasive species removal presently. PG&E is currently required to perform invasive species management on their rights-of-way within National Forest boundaries (including the Pit Arm watershed); however, their right-of-way has numerous noxious weed species, primarily Himalayan blackberry and bull thistle, which are encroaching into the nearby forest. If more aggressive measures are not taken to control these species, they will continue to dominate the area.

Influences and Relationships

- Species such as Himalayan or cut-leaf blackberry may outcompete and thus diminish available browse for wildlife. French broom and Scotch broom are also toxic to ungulates and therefore may negatively affect wildlife.
- High-severity wildfires increase the risk of introduction and spread of noxious weeds.
- Ecosystem function in the watershed may be negatively affected by noxious weed invasion via changes in the fire regime. For example, broom species form dense stands which burn readily and may carry fire into the canopy, increasing the intensity and frequency of fires in the watershed. Additionally, cheatgrass (*Bromus tectorum*) has been shown to increase the frequency of wildfires leading to a loss of native shrubs and a continued dominance by this species (Bossard et al. 2000).
- Human activities such as OHV use, hiking, driving, and camping act as vectors for the spread of noxious weeds.
- The proposed removal of broom species in the Packer's Bay recreation area would improve habitat suitability for native plants and protect a nearby rare plant population.

Conclusions

- Yellow star thistle, non-native blackberry, cheatgrass, and thistles are likely to spread in the watershed and continue to compete with native species without active weed management.
- Black locust may continue to spread in road and riparian areas but will not encroach into conifer stands in the absence of severe fire events.
- Broom species may decrease in the watershed with treatments that are currently proposed.

Terrestrial Wildlife Species and Habitats

Bald Eagle Viability and Habitat Integrity

Key Questions

1. How are current conditions influencing the potential for high-severity wildfire to destroy stands with large, overstory trees?
2. Is there currently enough recruitment of younger ponderosa pine stands for future eagle habitat?
3. How have past management actions influenced current and future eagle habitat?
4. What is the current distribution of bald eagle nests, territories and winter roosts?
5. What management actions and protection measures can be undertaken to provide the most benefit for eagles in the watershed?

Present Condition

- Due to the abundance of bald eagle nesting, roosting and foraging habitat, the watershed supports multiple eagle territories. The Pit Arm of Shasta Lake has the highest density of known nests on the lake, thereby increasing the importance of maintaining and protecting this high-value habitat. The habitat throughout the watershed plays a major role in the viability of eagles that use the area for wintering as well as for nesting.

Causal Mechanism(s)

- The construction of Shasta Dam created a large body of water that currently serves as bald eagle foraging habitat for both resident nesting eagles and migratory over-wintering eagles.
- The Pit Arm watershed did not receive the same amount of logging prior to construction of the dam, so large ponderosa pine trees were retained throughout the area. These large, overstory trees in close proximity to the water created ideal conditions for bald eagle nesting habitat.
- After construction of the dam, many of the stands along the lake and river were logged using the seed-tree or shelterwood harvest method, which left several large overstory trees per acre while the remaining stand was harvested. This left the understory to be either replanted with pine or to grow back with brush. These conditions are now heavy with fuels that put the overstory trees (i.e., potential or current eagle nest trees) at risk of a high-severity fire event.
- Disturbance to nesting eagles occurs during periods of high recreational use on the lake such as during spring break, Memorial Day, Fourth of July, and Labor Day holidays.

Trends

- Though the bald eagle was delisted as an endangered species in 2007, several mechanisms continue to govern the protection of bald eagles and eagle nests on Shasta Lake: the standards and guides in the Shasta-Trinity Forest Plan, the Bald and Golden Eagle Protection Act, the Migratory Bird Treaty Act, and the guidance provided by the USFWS following delisting in the National Bald Eagle Management Guidelines.

- Current management practices, such as buoying off eagle nests that are known to be actively nesting to reduce the amount of houseboat disturbance directly beneath nest and roost trees along the shoreline, provide protection to nesting eagles during particularly sensitive reproductive periods. However, such recreational activities are likely to increase, which could necessitate additional protection measures.
- A few of the eagle nest trees and associated territories have had fuels treatments beneath the nest tree and surrounding area in an effort to protect the territory from severe fire.
- Current accumulation of heavy fuels in the form of brush or young pine regeneration and the subsequent risk of high-severity fire threaten the existing large overstory trees that provide critical nesting structure for bald eagles. Without these large trees, the habitat surrounding the lake would no longer be suitable for eagle nesting. An example of this can be seen on other sections of the lake (west of Interstate 5); where pre-dam logging was much heavier, few overstory trees exist and very few eagles use the area.

Influences and Relationships

- Shasta Lake and the Pit Arm watershed in particular, provide excellent bald eagle habitat due to the close proximity of large overstory trees to a large body of water that contains abundant prey species (e.g., fish, waterfowl, etc.).
- Heavy accumulation of fuel in the understory of nest stands puts the nest trees, roost trees and future nest trees at risk from a high-severity wildfire.
- High-severity wildfire may result in bald eagle habitat loss and destroy important habitat components.
- High levels of recreational activity near eagle nests during sensitive periods may negatively impact the eagles’ nesting success.
- Monitoring of and surveys for eagle nests within the watershed are necessary to inform managers of areas that need increased protection during sensitive reproductive periods. In addition, long-term population data acquired during surveys and annual monitoring are a valuable tool for managers to use to inform management decisions.

Management of Late-successional Habitat

Key Questions

1. What is the current distribution and location of the late-successional habitat in the area?
2. What is the current risk to these areas and how can these risks be alleviated?
3. How are current conditions influencing the potential for high-severity wildfire to consume late-successional habitat?

Present Condition

- While the vegetation analysis refers to 44 percent of the watershed as late seral (greater than 24 inches d.b.h. and greater than 60 percent canopy cover), certain forest vegetation types do not meet the criteria described in Step 3 – Current Condition for late-successional habitat, as displayed in Tables 14 and 15 in Step 3 above. The 15,212 acres of Douglas-fir and Sierran mixed-conifer forest vegetation types in WHR size class 5 are considered to be potential late-successional wildlife habitat.

- Management of late-successional habitat can be challenging with high fuel levels and drier growing sites because of the conflict between retaining large woody debris, large snags, understory structure and high canopy closure while reducing fire severity risk.

Causal Mechanism(s)

- Much of the late-successional habitat was fragmented with the increase in timber harvest in the 1960s, mainly in the eastern section of the watershed, on both National Forest and private lands.
- Clearcut areas caused fragmentation of the late-successional habitat and impacted the species normally associated with this habitat type, though to what extent is not known, as no surveys were conducted before harvest activities at that time.
- Fire suppression and exclusion have caused accumulation of a dense, shade-tolerant understory.

Trends

- Trees and other surrounding vegetation will continue to grow until some form of disturbance occurs (e.g., wildfire, density-induced mortality, insects and disease, etc.) or vegetation management activities are conducted.
- In the absence of large-scale disturbance, late-seral stands will slowly continue to develop larger overstory trees and structural complexity. However, current vegetation densities and fuels accumulation, coupled with increasing inter-tree competition over time, lead to an increasing likelihood of disturbance that would alter the current development trajectory of late-seral stands. See the Vegetation section of this watershed analysis for more detail.

Influences and Relationships

- Dense vegetation and increased fuel loadings lead to an increased likelihood of high fire behavior potential; high-severity fire affects the current and future availability of late-successional habitat for wildlife species.
- Species associated with late-successional habitat will be displaced in the event of a large-scale disturbance such as high-severity fire.
- In the absence of low-level disturbance, stand densities increase over time, which can reduce wildlife habitat suitability.
- With low-level disturbance such as low-intensity fire, late-seral stands develop larger overstory trees and structural complexity.

Management of Early Seral Brush and Browse Habitat

Key Questions

1. What is the current distribution of early seral browse habitat in the area?
2. What is the current condition of the browse?
3. How have past management actions impacted the current conditions?
4. What management actions can be undertaken to improve conditions where they are not in the desired condition?

Present Condition

- The shrub lands, hardwood stands, and hardwood/conifer mixed stands in the watershed currently provide a moderate to high level of forage and cover for game species. In areas with previous fuels management (i.e., mastication and/or prescribed fire), browse condition is of higher quality than in untreated areas, where brush has become unpalatable due to decadence (Johnson 2009 personal communication).
- Approximately two-thirds (67 percent) of existing chaparral is over 60 years old; the remaining chaparral stands are 6 to 12 years old. Older over-mature brush provides lower quality browse material for wildlife than younger more succulent brush.

Causal Mechanism(s)

- The mixed-severity wildfires that occurred in the watershed prior to aggressive fire suppression provide a diversity of wildlife habitat, including high-quality browse/forage and cover.
- Fire exclusion has resulted in reduced palatability of browse for wildlife, while increasing the occurrence and future likelihood of large-scale high-severity fires. While such fires may increase the availability of browse habitat, they reduce the occurrence of effective cover for wildlife.
- Site quality and soil productivity, which directly affect the quality of browse habitat, are at risk from future high-severity fires.

Trends

- Chaparral stands (see Present Condition above) will grow toward senescence or remain senescent in the absence of fire. Senescence in chaparral commonly begins developing after roughly 35 years of age (England in Mayer and Laudenslayer 1988).
- Within the oak woodlands, fire suppression has reduced the amount of browse available in the understory in the form of mast, herbaceous growth or early seral shrubs/browse. Herbaceous growth may have been hindered since understory growth of shrubs and oak seedlings, usually tempered by frequent fire, outcompete the herbaceous plants. Shrub species in the understory then mature and become unpalatable as browse (USDA Forest Service 1998a).

Influences and Relationships

- Increased canopy closure may have led to a decline of oaks and other shade-intolerant species in the understory and to a decrease in structural diversity and as forage (such as mast and herbaceous vegetation), which are important to many different wildlife species.
- Forage and browse species composition and condition influence the distribution of herbivorous wildlife species and the species for which they are prey.

Conclusions

- Increases in recreational activity within the watershed may require additional measures to protect nesting eagles.
- Current and future eagle nest trees, pilot trees and roosting areas are at risk from high-severity fire due to heavy accumulation of fuels in the understory. Additional fuels treatments to reduce the risk of a stand-replacing wildfire – particularly in eagle territories within the watershed - may provide long-term benefits.

- Limestone extraction operations on National Forest lands may adversely impact limestone-associated vertebrate and invertebrate species.
- Management activities that enhance early seral and oak woodland habitat would increase quality and availability of browse in the watershed. Protection of existing large oaks in the watershed from fire would increase the likelihood that current mast production and oak habitat would persist while encouraging and providing for future habitat.

Aquatic and Riparian-dependent Species

Key Questions

1. What is the status and distribution of aquatic and riparian-dependent species of concern in the watershed?
2. What areas are critical for maintenance, protection, and recovery for aquatic and riparian dependent species of concern?
3. How do the current riparian habitats compare to optimum habitats, and how can riparian areas be protected and/or restored?
4. Are riparian reserve widths adequate for riparian habitat and travel corridors?

Present Condition

- As noted above in Step 1 – Characterization and Step 3 – Current Conditions, the construction of Shasta Dam and filling of Shasta Lake ended the anadromous fisheries resource in the Pit, McCloud and upper Sacramento Rivers and altered upland stream and riparian habitats. Federally listed anadromous salmon and steelhead were blocked from their historic range in the Pit River, and the remnant populations of these species upstream of the dam were not self-perpetuating. Some aquatic Forest Service sensitive or survey-and-manage species remain abundant in the analysis area, while others have either suffered serious declines in population numbers or have apparently been extirpated from the watershed.
- Today, Shasta Lake, the Pit Arm, and the perennial fish-bearing Pit River tributaries within the analysis area generally provide good fish habitat for a variety of coldwater fishes. Perennial stream drainages that flow into Shasta Lake are critical in providing high-quality, cool water for many aquatic species, especially in summer months. These streams are generally small, well shaded with consistent base flows, and provide refugia for all life stages of invertebrate, fish, and amphibian species.
- Recent habitat enhancement projects have improved conditions for warmwater fishes in some areas of the Pit Arm. However, riparian reserves in the watershed with heavy fuel accumulations remain at risk of high-severity, stand-replacing fires, which could degrade riparian habitat through loss of cover and shade and through accelerated erosion processes.

Causal Mechanisms

- Construction of Shasta Dam and the subsequent creation of Shasta Lake – as well as construction of the Pit No. 6 and Pit No. 7 Dams - fundamentally altered aquatic habitats in the Pit Arm watershed

- Current and historic natural and human-caused disturbances that have most influenced habitat conditions within riparian reserves include fires, floods, mining, road construction, and timber harvest.
- With little current timber harvest or mining activity, and with relatively low road densities, the greatest threat to the function of riparian reserves in the analysis area is high-severity fire.
- Fire suppression has led to increased upland stand densities, which has resulted in less frequent but higher-severity fires across the landscape. These high-severity upland fires have burned through riparian reserves with similar intensity.

Trends

- The lake environment is expected to continue to provide a good fishery regardless of watershed condition. Cover for juvenile warm water fish species will continue to be a limiting factor in the lake drawdown zone.
- Fish populations within streams are expected to remain stable. Aquatic and riparian-dependent species habitat will fluctuate in response to the occurrence and magnitude of future disturbances (e.g., fires, floods).
- Populations of aquatic mollusk species of concern are expected to remain stable in the absence of disturbance to their perennial spring habitats. Adverse effects to these species could occur in the event of major habitat disturbance such as from high-severity fire.

Influences and Relationships

- Upland ephemeral and intermittent stream drainage riparian reserves are at the greatest risk of loss from high and moderate burn intensities. Fires in upland areas generally burn swales, ephemeral and intermittent stream channels at the same intensities as the adjacent hillslopes because of dry summer conditions that deplete moisture and create favorable conditions for fire (Skinner 1997). Burn intensities in riparian reserves are also influenced by microclimate conditions, drainage slope and aspect. Swales and stream channels can enhance fire activity by concentrating heat and funneling the fire upward through the incised drainage. This can also occur on lower slopes within smaller drainages that are tributaries to larger perennial streams (i.e., Potem Creek) or to Shasta Lake.
- Fire impacts to vegetation in riparian reserves can be highly variable and are dependent on a wide variety of factors including fire intensity and behavior, fire weather, vegetation type, vegetation density and age, topographic factors such as slope, aspect, and elevation, and local soil moisture conditions. Generally, large perennial channels burn at low intensity and have little hardwood and conifer mortality. Moderate to high-severity burns are more common in upland riparian reserve areas dominated by live oak and chaparral vegetation communities. However, hardwood dominated stands and chaparral can recover rapidly from fire impacts with resprouting of oaks and ground cover beginning immediately following a fire.

Conclusions

- Within the Pit Arm watershed, future fires in riparian reserves with high fuel loading will likely be high severity.

- Vegetation treatments within riparian reserves - including prescribed fire - may be appropriate, especially in previously burned riparian areas, to protect them from future high-severity wildfire. Reduction of fuel loading would help attain Aquatic Conservation Strategy objectives by improving riparian habitat and by providing for better long-term growth and persistence of vegetation communities in riparian reserves.
- Species of concern dependent on late-seral habitats in riparian reserves may benefit from prescribed fire or other fuels treatments that improve or enhance these areas.

Human Uses

Key Questions

1. How has the use of the lake by boaters affected wildlife? How might an increase in other human uses impact other resources (e.g., water quality, fire and fuels, and botanical resources)?
2. How does OHV traffic affect the integrity of watershed resources and impact other recreation experiences?
3. What management practices might alleviate some of the problems associated with peak season usage (i.e., trash, litter, debris and wildlife protection)?
4. How does human usage within the watershed increase the potential for high-severity fire and the resulting effects on other resources (i.e., caves, scenery, recreation and public utilities)?
5. How have past management practices (e.g., mining, road construction, logging and prescribed fire) and events (e.g., wildfire) affected recreation and other human uses in the watershed?
6. What future management practices and events might adversely affect the recreation experience?
7. How might future management practices reduce the potential for adverse effects to the recreation experience?

Present Condition

- Recreation activities and other human uses in the watershed pose risks to other resources and increase the risk of human-caused fire starts.
- As accumulating untreated fuels increase fire risk and fire behavior potential in the watershed, the risk of adverse effects to recreation resources (e.g., scenery and access) also increases.

Causal Mechanisms

- Construction of Shasta Dam and subsequent creation of Shasta Lake as a recreational attraction dramatically increased human use of the watershed after 1945.
- Past road construction opened the watershed to increased recreational use.
- The most recent wildfires have affected the watershed’s visual resources.
- Increase motorized and pedestrian traffic along the lake during periods of low water exposes heritage and visual resources at the shoreline to direct and indirect impacts.

- Unauthorized OHV routes expose upland areas to direct and indirect resource impacts. Current closure orders have not eliminated this concern.
- Small watercraft have access to the upper reaches of the watershed, which are generally inaccessible by larger boats.
- Restrictions for protection of bald eagle nests during hatching periods coincide with the highest recreation use periods on the lake.

Trends

- The Forest Service buoys off known bald eagle nest sites periodically between January and June, conducts mid-winter eagle surveys for counts on mating pairs, and periodically monitors new nest sites for breeding young. Since the delisting of the bald eagle in 2007, fewer sites are affected by seasonal restrictions on recreational use for bald eagle protection, as only active nests are protected.
- OHV, watercraft and pedestrian traffic are expected to increase.
- Recreation use in the watershed is expected to increase the potential for human-caused fire starts.

Influences and Relationships

- Of concern within the watershed is the intrusion of houseboats mooring near the known bald eagle nests that are situated on or visible from the water. Increase in houseboats in the watershed would increase the amount of visitors to the area, and possible impacts to other resources such as the integrity of the shoreline area and soil composition.
- High use periods for recreation in the watershed have increased since the creation of Shasta Lake. Holiday weekends and summer season have the highest usage, increasing the amount of houseboats, smaller watercraft and recreationists in the area.
- Although current gray water concerns are being managed, gray water concerns have the potential to intensify with an increase in recreation usage, and continued monitoring may indicate the need for additional regulation.
- Wave action from motorcraft may cause soil disturbance along the shoreline.
- Debris from recreationists and logs and litter from seasonal runoff are often deposited along the shoreline as the lake level fluctuates.
- Increased OHV traffic has the potential to impact the integrity of the watershed by creating new routes on the landscape, creating ruts that channel water downslope, impacting soil, and spreading noxious weeds. In addition, the proliferation of unauthorized routes, particularly in sparsely covered landscapes, can adversely affect the forest’s visual resources and rare plant populations and habitat.
- High recreation use increases the likelihood of human-ignited fires. Runaway campfires, fireworks, and ignition from OHVs have the potential to create conditions for high-severity fire. Accessibility of the upper stretch of the watershed by watercraft has created a vector for human fire starts in areas that are rugged and inaccessible by any other means. Major wildfires, in turn, have the potential to affect access to and the quality of recreational activities.

- Widespread high intensity wildfires burn large areas of vegetation, which may expose caves to increased exploration and resource damage; major wildfires also impact visual resources.
- Impacts to air quality from major wildfires are of concern for their effect on human uses. Prescribed fires may also impact air quality; however, these impacts are managed to reduce adverse effects.

Conclusions

- Current bald eagle monitoring and lake access restrictions occur annually to protect the species during critical nesting periods. Fewer sites are subject to the restrictions since the bald eagle was delisted in 2007; however, the restrictions coincide with the highest recreation use periods on the lake. The impacts of the restrictions to recreation will likely increase as recreational use increases.
- Increased recreational use of the watershed by both land and watercraft may increase soil erosion, human-caused fire starts, and noxious weeds infestations, thereby adversely affecting water quality, heritage, visual resources, rare plant populations and habitat, and special features such as caves.
- The continued use and proliferation of unauthorized OHV trails may increase damage to heritage and other resources, particularly along the lake during periods of low water levels. Current OHV restrictions have not eliminated this concern.
- Major wildfires have the potential for adverse impacts to recreation, visual resources and other human uses in the watershed. As the risk of major wildfires increases with continued fuels accumulation, the risk of impacts to human uses from fires also increases.
- Limestone extraction operations (such as that on private land noted above) on National Forest lands may adversely impact limestone-associated vertebrate, invertebrate and plant species.

Step 6. Recommendations

The purpose of this step is to focus on management recommendations that respond to needs and opportunities identified in the "Conclusions" sections at the end of each resource section in Step 5. Monitoring activities are identified as needed. Data gaps and limitations of the analysis are also documented.

Physical Features

Riparian Reserves

Present Condition

- The riparian reserve along the shoreline of Shasta Lake cannot support riparian vegetation and is not critical in providing coarse woody debris to aquatic and riparian ecosystems.
- Stream channel corridors are at risk to intense fire if the fuel loading is not treated. The drainages are typified by steeply incised slopes, which can funnel air during fire events, causing higher severity burns.

Recommendations

- Use the existing riparian reserve widths as delineated in the Shasta-Trinity corporate geodatabase unless wider widths are specified by a hydrologist or geologist on a site-specific basis.
- Do not manage the riparian reserve along the shoreline of Shasta Lake with the objective of providing coarse woody debris for aquatic and riparian habitat. However, this area may be managed to provide snags and dead/down woody material for terrestrial habitats.
- The following resource activities are considered acceptable within riparian reserves when designed to meet the objectives of the Aquatic Conservation Strategy:
  - Timber harvest to reduce fuel loads
  - Slashing and piling of natural and activity fuels
  - Prescribed burning
  - Planting of conifers and other native species
- Use low-intensity prescribed fires within riparian reserves.
- Apply prescribed fire with an objective of retaining 60 percent duff and ground cover.
- Consider consolidating unstable areas and leaving larger areas unburned if management objectives for prescribed fire can still be met.
- Include a hydrologist or geologist in the design process for all prescribed burning projects in this watershed.

Rationale/Objective

- There is no benefit to aquatic and riparian-dependent species from large woody debris introduced from the riparian reserve along the shoreline of Shasta Lake. Such material is also considered a hazard to recreation use on Shasta Lake.
- Prescribed fire is preferable to wildfire because fire impacts can be managed and are typically significantly less than a wildfire.
- Burn plans that incorporate unstable area concerns will greatly reduce the risk of impact to soil and water resources.

Watershed Restoration Opportunities

Present Condition

- Several subwatersheds within the analysis area have moderately high to high road densities.
- Potem Creek subwatershed is a 2nd priority candidate for restoration (USDA Forest Service 2006a).
- Roads within the analysis area are closed and have since overgrown. These roads were not actively decommissioned. Site-specific opportunities exist to remove drainage structures and restore unstable areas.

Recommendations

- Focus road maintenance efforts on areas that yield high sediment delivery.
- Consider road surfacing on high use or overly steep sections of road.
- Perform a comprehensive assessment on Potem Creek for a restoration plan.

- Implement restoration projects in the watershed as opportunities arise.

Rationale/Objective

- Regular road maintenance will reduce the risk of impacts associated with plugged culverts and poor drainage.
- Surfacing high-use roads will reduce stream turbidity during winter storms.
- Reducing the existing road network through active decommissioning will reduce impacts to water quality, habitat fragmentation, and channel morphology.

Biological Features

Fire and Fuels

Present Conditions

- There is a need to reduce fire risk and fire hazard in the analysis area.
- There is a need to protect communities at risk and the wildland-urban interface.
- There is a need to provide continued fire suppression to maintain or protect existing improvements and natural resource values in the watershed; however, long-term widespread fire exclusion may have detrimental impacts to some resources.

Recommendations

- Continue fuels management as needed to reduce fire effects and fire behavior in the analysis area, to meet land management objectives and to restore fire processes as compatible with other resource needs. Focus fuels treatments on areas with high resource values that are subject to high hazard and high risk.
- Employ a collaborative landscape approach with adjacent landowners and agencies to reduce fire hazard and fire risk to values identified in the analysis area. The majority of this approach would be prescribed burning; however, managing fire for resource benefit, thinning, mechanical treatment, and other fuels and vegetation treatments may be considered. Focus fuels treatments to alter the fuels profiles consistent with policy and land management direction.
- Use natural and human-caused fuelbreaks in future wildfire suppression and fuels treatment activities in the analysis area. These fuelbreaks can be maintained and used with little additional investment and increase the safety and effectiveness of fire management activities.
- Continue fire prevention and education programs to help prevent unwanted wildfires.
- Encourage all residents in the analysis area to use defensible space precautions around their homes.
- Manage fuels to reduce the potential for adverse impacts to air quality from future wildfires. Maintain air quality to meet or exceed applicable standards and regulations during fuels treatment activities.
- Incorporate lessons learned into future fire management planning.

Rationale/Objective

The above recommendations were made to achieve the following objectives:

- Protect existing watershed resources from high-severity wildfire events through enhanced suppression and treatment opportunities.
- Create and maintain acceptable fuel profiles within the watershed that are characteristic of its natural fire regime.
- Reduce high-severity fire behavior by reducing surface fuels and stand densities to acceptable levels.

Forest and Non-Forest Vegetation

Present Condition

- Over 80 percent of the current forest vegetation is mid- and late seral and nearly all stands (88 percent) have 60 percent or more canopy cover.
- Highly dense mixed conifer, pine and Douglas-fir stands generally have little to no live understory.
- Mixed chaparral stands have become senescent, with increasing amounts of dead leaf litter and standing dead material.

Recommendations

- Treat current fuels conditions in dense late-seral stands – including riparian areas - to improve stand resilience to survive wildfire. Treatments could include hand or mechanical thinning, mastication, hand or mechanical piling of fuels, and prescribed burning of fuel concentrations or broadcast burning.
- Consider treatments, including prescribed fire, that create patches of early seral habitat and develop high-quality browse for wildlife species.
- Create fuelbreaks or areas of potential fire control adjacent to vegetation types that provide high wildlife habitat value.
- Utilize a landscape approach to review the extent and conditions of vegetation communities and seral stages for the reintroduction of natural (frequent low to moderate severity) fire processes. At the landscape level, review current levels of early, mid- and late-seral habitats and introduce treatments to reflect management direction regarding their distribution.
- Monitor stand densities in key late-seral habitat. Consider treatments including thinning to both remove fuel accumulations and reduce competition for resources to promote the survival and growth of large tree and other desirable late-seral attributes.

Rationale/Objectives

Current vegetation conditions over much of the watershed are at risk of high-severity fire due to fuels and vegetation accumulation. These conditions have developed largely due to fire suppression efforts over recent decades. Much of the current vegetation within the watershed reflects the departure from a natural more frequent fire return interval, and as such do not reflect sustainable vegetation conditions.

General Forest objectives that apply to the watershed include:

- Implement practices designed to maintain or improve the health and vigor of timber stands, consistent with the ecosystem needs of other resources (USDA Shasta-Trinity LRMP, p. 4-4).
- Restore fire to its natural role in the ecosystem when establishing the desired future condition of the landscape (USDA Shasta-Trinity LRMP, p. 4-4).
- Plan and implement fuel treatments emphasizing those treatments that will replicate fires natural role in the ecosystems (USDA Shasta-Trinity LRMP, p. 4-18).

Nearly half of the analysis area falls within the Shasta Management Unit as described in the Shasta-Trinity LRMP. This same area is also designated as a National Recreation Area (NRA). The desired future conditions for this area include:

- Vegetation is managed to a level that results in healthy forest stands, maintenance of wildlife habitat, good scenic quality, public health and safety, and reduction of fire hazards (Shasta-Trinity LRMP, p. 4-112).
- Forest stand densities are managed to protect forest health and vigor recognizing the natural role of fire, insect and disease and other components that have a key role in the ecosystem. Stand understories appear more open with less ingrowth particularly in stands on sites where wildfire plays a key role in stand development (USDA Forest Service 1998b).

The remainder of the analysis area falls within the Front, Nosoni and Pit Management Units as described in the LRMP. Desired vegetation conditions for these areas include:

- Forest stand densities are managed at levels to maintain and enhance growth and yield to improve and protect forest health and vigor recognizing the natural role of fire, insects and disease and other components that have a key role in the ecosystem. Stand understories appear more open with less ingrowth particularly in stands on sites where wild fire plays a key role in stand development (LRMP, pp. 4-126, 4-130, 4-133).

As forest stands grow increasingly dense in the absence of disturbance, overall stand health typically declines because of increased competition for resources. Under these conditions, stands are at increasing risk of insect and disease outbreak, and drought-related mortality (Oliver and Larson 1996, Kolbe et al. 2007). Management of current fuels and vegetation densities can help promote healthy forest stands and reduce fire hazards.

Threatened, Endangered and Sensitive (TES) Plants and Other Species of Concern

Present Condition

- Rare plants (e.g., *Neviusia cliftonii*) are threatened by invasive weed displacement.
- The accumulation of untreated fuels has increased the potential for high-severity wildfires in the watershed that could negatively affect rare plant populations and habitat.
- Several areas of the watershed have not been recently assessed for rare plant populations and habitat.
- Available information on rare plant habitat associations, management guides, and GIS information within the watershed is not current.

Recommendations

- Augment habitat association data on rare plants and refine existing GIS layers to provide opportunities for targeted assessments of potential habitat within the watershed.
- Continue rare plant surveys in the watershed and assess whether or not the habitats surveyed represent suitable rare plant habitat.
- Update this watershed analysis with new information on rare plant locations and surveys as those surveys are accomplished.
- Manage documented rare plant populations in the watershed to maintain or enhance viability.
- Manage currently suitable rare plant habitat within the watershed to maintain or enhance suitability.
- Evaluate riparian habitats impacted by past activities or events for possible restoration of habitat suitable for riparian-associated rare plant species.
- Continue to develop species management guides for rare plants of interest.
- Explore opportunities for conducting monitoring of rare plants in the watershed, particularly in response to fire and fuels treatments.

Rationale/Objective

- Rare plant populations and habitat within the watershed are imperiled by both noxious weed infestations and the risk of widespread high-severity fire.
- Comprehensive surveys for rare plants and habitat in the watershed are lacking.
- Current information on rare plant habitat associations, management guides, and GIS information within the watershed is needed for proper management of these species.

Noxious and Undesirable Weed Species

Present Condition

- Identification and prioritization of key areas for noxious weed removal within the watershed is lacking.
- Rare plant populations and habitat in the watershed are at risk of being displaced by noxious weeds.
- Noxious weeds within the watershed have the potential to alter future fire behavior and severity.
- Current noxious weed populations have the potential to spread into areas disturbed by recreation and other human uses, wildfire or vegetation management activities.

Recommendations

- Develop a weed management plan for the watershed (including an implementation schedule).
- Identify possible treatment areas and methods for noxious weed species control or eradication.
- Prioritize the removal of yellow star thistle and invasive brooms, especially in areas with heavy recreation use such as the Packer’s Bay boat launch area and the Clikapudi trail.

- Survey for noxious weeds in the watershed and develop more information on documented occurrences.

Rationale/Objective

- There is no current weed management plan at the watershed level.
- Noxious weed treatment is underway in certain portions of the watershed; a comprehensive plan would increase the overall effectiveness of such treatments.
- Yellow star thistle and invasive brooms are displacing or are threatening to displace native species and their habitats.

Terrestrial Wildlife Species and Habitats

Present Condition

- Terrestrial wildlife species and habitat in the watershed are vulnerable to disturbance from high levels of recreational and other human uses, particularly adjacent to Shasta Lake. Wildlife habitat is vulnerable to degradation from excessive fuels accumulation and/or an increasing risk of high-severity, stand-replacing fires.

Recommendations

- Continue monitoring and survey efforts for bald eagles.
- Continue protective measures during periods of high sensitivity for bald eagles and high human use on the lake.
- Consider additional fuels treatments within stands containing active eagle territories.
- Consider fuels treatments that benefit and/or protect current late-successional stands; consider these also for older forested stands so that development into late-successional habitat is enhanced and encouraged.
- Continue and/or increase survey efforts for limestone-associated vertebrate and invertebrate species so that effective protective measures can be implemented during management activities. Consider the potential for effects to limestone-associated flora and fauna when managing areas of limestone (i.e., mining or removal under special use permits) in the watershed.
- Implement fuels reduction projects such as prescribed burning to enhance early seral and oak woodland habitat. To the extent practicable, protect existing large oaks from mortality during prescribed fires.
- Retain and protect existing snag habitat along the shorelines within the watershed. The harvest or other removal of these features, with the exception of identified hazard trees, is not recommended.

Rationale/Objective

The above recommendations were made to achieve the following objectives:

- Protect existing species and specialized and unique habitats from stand-replacing wildfire or other causes of habitat loss.
- Protect irreplaceable, unique and specialized habitats from loss, destruction or disturbance.

- Protect FS sensitive and/or federally listed species and their habitats and promote their overall productivity and viability.
- Improve the quality and quantity of browse and oak woodland habitats for the persistence of game species.
- Gather information on the locations of the species discussed in this analysis and their habitats to facilitate management activities that maintain or enhance habitat suitability.

Aquatic and Riparian-dependent Species

Present Condition

- Fire suppression has decreased sediment inputs and increased channel stability in some areas where fire has been excluded. However, there is a need to manage the accumulation of fuels in areas where fire has been excluded. There is also a need to monitor the effects of fuels management (especially prescribed fires) on riparian reserves.
- Aquatic habitats for fish species, aquatic mollusks of concern and amphibians are generally considered in good condition. However, the condition of specific habitat parameters and accurate species range and location information are largely unknown.

Recommendations

- Continue warmwater fish habitat improvement work within the drawdown zone of Shasta Lake. Habitat improvement should focus on the development of cover for young-of-the-year fish. Improvement activities such as constructing brush structures and planting willows are recommended.
- Complete location surveys and habitat surveys for aquatic species of concern.
- Implement vegetation and fuels management treatments to riparian reserves to trend them toward desired conditions, reduce fuel loading, and improve habitat conditions, especially in intermittent and perennial stream drainages. Prescribed fire intensity within riparian reserves should be low with an objective of reducing ground fuels and removing fuel ladders while still retaining large wood, large trees and snags that will provide a continuous supply of large woody debris in the future.

Rationale/Objectives

- Cover for the warmwater fishery is lacking within Shasta Lake, particularly for young-of-the-year. Since most fish are highly susceptible to predation during early life stages, the availability of cover can contribute significantly to increased survival and improve productivity.
- Survey information for aquatic species of concern will allow natural resource professionals to accurately plan for future projects proposed in the analysis area.
- Much of the riparian reserve areas in the analysis area have treatment needs similar to those of adjacent upland areas. Carefully planned vegetation management activities will trend riparian reserves toward desired conditions and benefit a diversity of species.
- Successful recovery efforts for species of concern will conserve and restore the long-term dynamics of watersheds, rather than just habitat attributes.

Human Uses

Present Condition

- Recreation activities and other human uses in the watershed pose risks to other resources and increase the risk of human-caused fire starts.
- As accumulating untreated fuels increase fire risk and fire behavior potential in the watershed, the risk of adverse effects to recreation resources (e.g., scenery and access) also increases.

Recommendations

- Manage recreational access and mooring in the vicinity of bald eagle nests to provide continued protection from disturbance to nesting pairs of eagles during critical hatching periods, while minimizing the effect of closures on recreationists.
- Manage access to the lakeshore and other vulnerable areas, particularly during periods of low water levels, to reduce the risk of erosion and other environmental impacts.
- Manage fire and fuels in the watershed to reduce the risk of lightning- and human-ignited fires becoming major stand-replacing wildfires.
- Implement the standards and guidelines in the new Travel Management Plan (USDA Forest Service 2009) once that plan is finalized. In the interim, consider ways of increasing the effectiveness of current OHV restrictions in the watershed to reduce impacts to other resources.
- Implement monitoring and inventory of facilities in the watershed as recommended in the Master Development Plan and Facility Analysis (USDA Forest Service 2008).
- Consider the potential for effects to limestone-associated flora and fauna when managing mining resources in the watershed.

Rationale/Objective

- The objective of the above recommendations is to maintain and enhance recreational and other human uses in the watershed while providing for other resource needs.

References

Agee, James K. 2007. Steward's Fork: A Sustainable Future for the Klamath Mountains. University of California Press.

Alexander, John D., Nathaniel E. Seavey, C. John Ralph, and Bill Hogoboom. 2006. Vegetation and topographical correlates of fire severity from two fires in the Klamath-Siskiyou region of Oregon and California. International Journal of Wildland Fire 15:237-245.

Anderson, Hal E. 1982. Aids to determining fuel models for estimating fire behavior. General Technical Report INT-122. USDA Forest Service Intermountain Forest and Range Experiment Station. Ogden, UT.

Aubury, Lewis E. 1905. The copper resources of California. Bulletin No. 23, second edition. California State Mining Bureau. San Francisco, CA. pp. 1-96.

Bachmann, Steve. 2010. Email correspondence regarding copper mining and hydropower operations in the Pit Arm Watershed.

Banci, V. 1994. Chapter 5 - Wolverine. *In* Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, L.J. Lyon, and W.J. Zielinski, technical editors. 1994. The Scientific Basis for Conserving Forest Carnivores: American marten, fisher, lynx, and wolverine in the United States. USDA Forest Service General Technical Report RM-254. 183 pp.

Barrett, L.A. 1935. A Record of Forest and Field Fires in California From the Days of the Early Explorers to the Creation of the Forest Reserves. San Francisco, CA.

Beres, Virginia. 2009. Personal communications with Shasta-Trinity NRA Special Uses Staff Officer regarding the Silverthorne Recreation Residence Report (Fryman 2009) and the Silverthorne Marina and Jones Valley Marina special use permits. December 17, 2009. Records of telephone communications and email discussions are included in the project file.

Bettinger, R.L. and M.A. Baumhoff. 1982. The Numic Spread: Great Basin Cultures in Competition. American Antiquity 47:485-503.

Bolster, B. C. 2005. Western Red Bat. Western Bat Working Group Species Accounts. http://wbwg.org/species_accounts/vespertilonidae

Borchert M. 1989. Postfire demography of *Thermopsis macrophyll*a var. *agnina* J. T. Howell (Fabaceae), a rare perennial herb in chaparral. American Midland Naturalist 122: 120–132.

Bossard, C. C., J. M. Randall, and M. C. Hoshovsky, editors. 2000. Invasive plants of California's wildlands. University of California Press. Berkeley, California, USA.

Brooks, M.L.; C.M. D'Antonio; D.M. Richardson; J.B. Grace; J.E. Keeley; J.M. DiTomaso; R.J. Hobbs; M. Pellant and D. Pyke. 2004. Effects of invasive alien plants on fire regimes. Bioscience 54:677–688.

Brown, G. Chester. 1915. Mines and Mineral Resources of Shasta County, Siskiyou County, Trinity County. California State Mining Bureau. California State Printing Office. San Francisco, CA.

Buskirk, S.W. and R.A. Powell. 1994. Habitat ecology of fishers and American martens. *In*: Buskirk SW, Harestad AS, Raphael MG, Powell RA, editors. Martens, sables and fishers: biology and conservation. Cornell University Press. Ithaca, NY. pp 283-296.

California Department of Fish and Game (CDFG) Natural Diversity Database. 2003. Full report for Pacific fisher. Sacramento (CA): California Department of Fish and Game. Available at http://www.bios.dfg.ca.gov

CNDDB. 2010. California Department of Fish and Game Natural Diversity Database: accessed January 2010. Available at http://www.bios.dfg.ca.gov and http://imaps.dfg.ca.gov/.

California Department of Food and Agriculture. 2009. Noxious weed ratings. http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/winfo_weedratings.htm. Accessed on December 18, 2009.

California Department of Forestry and Fire Protection (CDF). 2008. 2008 Shasta Trinity Unit Fire Plan. California Department of Forestry and Fire Protection, Shasta-Trinity Unit.

Cal-IPC (California Invasive Plant Council). 2010. The California invasive plant inventory web page. Available at: http://www.cal-ipc.org. Accessed on 12 February, 2010. California Invasive Plant Council.

California Native Plant Society (CNPS). 2010. Inventory of Rare and Endangered Plants (online edition, v7-08a). http://www.cnps.org/inventory. Accessed on 12 February, 2010. CNPS. Sacramento, California.

California Office of Mine Reclamation. 2000. California's abandoned mines: A report on the magnitude and scope of the issue in the state. Vol. 2. Department of Conservation Office of Mine Reclamation. Abandoned Mine Lands Unit. Accessed online.

California Regional Water Quality Control Board, Central Valley Region. 2003. Cow Creek Water Quality Study.

California Regional Water Quality Control Board, Central Valley Region. 2004. Gray water Annual Report for 2003.

California Regional Water Quality Control Board, Central Valley Region. 2008. Gray water Annual Report for 2007.

California Regional Water Quality Control Board, Central Valley Region. 2007. Pit River Watershed Alliance water quality study: 2003-2005.

Clewett, S.E. and Elaine Sundahl. 1979. Clikapudi Archaeological District: Research design. Prepared by the Shasta College Archaeological Laboratory. Report on file at the Shasta Lake Ranger District, Shasta-Trinity National Forest. Redding, California.

Countryman, C. 1972. Fuel moisture and fire danger—some elementary concepts. USDA Forest Service Region 5 Aviation and Fire Management. 4 pp.

Cranfield, C. 1984. A Land-Use History of the McCloud River Region, California. Humboldt State University. 55 pp. *In*: USDA Forest Service. 1998. McCloud Arm Watershed Analysis. Shasta-Trinity National Forest.

Crowley, T.J. and T.S. Lowery. 2000. How Warm was the Medieval Warm Period? Ambio 29(1):51-54.

Cruz, M.G.; Alexander, M.E. and Wakimoto, R.H. 2003. Assessing canopy fuel stratum characteristics in crown fire prone fuel types of western North America. International Journal of Wildland Fire 12:39–50.

Delacorte, M.G. 2002. Late Prehistoric Resource Intensification in the Northwestern Great Basin. *In*: Boundary Lands: Archaeological Investigations Along the California-Great Basin Interface, edited by K. R. McGuire. Nevada State Museum Anthropological Papers no. 24, Carson City, NV.

Dubois, C.A. 1935. Wintu Ethnography. University of California publications in American archaeology and ethnography, vol. 36. University of California. Berkeley, CA.

Erlandson, Jon M.; Torben C.; Rick; Terry L. Jones and Judith F. Porcasi. 2007. One if by Land, Two if by Sea: Who Were the First Californians? *In*: California Prehistory: Colonization, Culture, and Complexity. Edited by Terry L. Jones and Kathryn A. Klar. AltaMira Press. Lanham, MD.

Finney, M.A. 1998. FARSITE: Fire Area Simulator – model development and evaluation. Research Paper RMRS-RP-4. USDA Forest Service Rocky Mountain Research Station. 47 pp.

Foltz, R.B. 2006. Erosion from all terrain vehicle (ATV) trails on National Forest lands. American Society of Agricultural and Biological Engineers. Paper number 068012.

Frest and Johannes. 1995. Freshwater mollusks of the Upper Sacramento System, California, with particular reference to Cantara spill. 1994 yearly report to California Department of Fish and Game. Deixis Consultants, Seattle, WA. Contract #FG2106R1. *In:* Furnish, J.L. 2005. Guide to Sensitive Aquatic Mollusks of the U.S, Forest Service Pacific Southwest Region. USDA Forest Service Pacific Southwest Region.

Fry, D.L. and Stephens, S.L. 2006. Influence of humans and climate on the fire history of a ponderosa pine-mixed conifer forest in the southeastern Klamath Mountains, California. Forest Ecology and Management 223:428-438.

Fryman, L. 2009. National Register of Historic Places Evaluation of the Silverthorn Recreation Residence Tract, Whiskeytown-Shasta-Trinity National Recreation Area. Shasta-Trinity National Forest. Redding, CA.

Fulé, Peter Z.; Charles McHugh; Thomas A. Heinlein and W. Wallace Covington. 2001. Potential fire behavior is reduced following forest restoration treatments. Proceedings No. RMRS-P-22. USDA Forest Service Rocky Mountain Research Station. Ogden, UT.

Furnish, J.L. 2005. Guide to Sensitive Aquatic Mollusks of the U.S, Forest Service Pacific Southwest Region. USDA Forest Service Pacific Southwest Region.

Furnish, J.L. and R.W. Monthey. 1998. Management Recommendations for Aquatic Mollusks version 2.0. Prepared for USDA Forest Service and USDI Bureau of Land Management. Available at: http://www.blm.gov/or/plans/surveyandmanage/MR/AQMollusks/toc.htm

Grigsby, Mary Ellen. 2010. Personal communication with Shasta Unit Recreation specialist regarding recreation use in the Pit Arm Watershed analysis area.

Gruver, J.C. and D.A. Keinath. 2006. Townsend's Big-eared Bat (Corynorhinus townsendii): a technical conservation assessment. USDA Forest Service Rocky Mountain Region. http://www.fs.fed.us/r2/projects/scp/assessments/townsendsbigearedbat.pdf

Henery, R. 2008. The Upper McCloud River Watershed: a Basin Roadmap. Produced by The River Exchange and the Bella Vista Foundation. 66 pp.

Henn, Winfield and Elaine Sundahl. 1986. Shasta Lake Archaeological Sites Project: Study of the Effects of Reservoir Drawdown. Report on file at the Shasta Lake Ranger District, Shasta-Trinity National Forest. Redding California.

Hickman, J. C., editor. 1993. The Jepson manual, higher plants of California. University of California Press. Berkeley, California.

Irelan, Wm. Jr. 1893. Eleventh report of the state mineralogist, two years ending September 15, 1892. California State Mining Bureau. Sacramento, CA. pp. 1-53.

Jensen, Peter M. and Paul R. Reed. 1979. An anthropological overview of the Sacramento valley and southern Cascade range. Contract No. CA-030-CT8-004. Prepared for the Bureau of Land Management, Redding District Office CA-030.

Jimerson, T.W. and D. W. Jones. 2003. Megram: blowdown, wildfire and the effects of fuel treatment. Tall Timbers Research Station. Miscellaneous Report No. 13:55-59.

Keeley, J. E. 2006. Fire management impacts on invasive plants in the western United States. Conservation Biology 20:375-384.

Kolb, T.E; J.K. Agee; P.Z. Fule; N.G. McDowell; K. Pearson; A. Sala and R.H. Waring. 2007. Perpetuating old ponderosa pine. Forest Ecology and Management 249: 141-157.

Lamb, S.M. 1958. Linguistic Prehistory in the Great Basin. International Journal of American Linguistics 24:95-100.

Landenberger, R.E., N.L. Kota, and J.B. McGraw. 2007. Seed dispersal of the non-native invasive tree Ailanthus altissima into contrasting environments. Plant Ecology 192:55-70.

Lanspa, K.E. 1993. Soil Survey of Shasta-Trinity Forest Area, California. USDA Forest Service Shasta-Trinity National Forest. Redding, CA, USA. 521 pp.

Leitritz, Earl. 1970. A History of California's Fish Hatcheries 1870 – 1960. Fish Bulletin 150. State of California Department of Fish and Game.

Lewis, H. T. 1973. Patterns of Indian Burning in California: Ecology and Ethnohistory, Ballena Press Anthropological Papers, No. 1. Ramona, CA: Ballena Press.

Lindstrand, L., and J.K. Nelson. 2006. Habitat, geologic, and soil characteristics of Shasta snow-wreath (*Neviusia cliftoni*) populations. Madroño 53:65-68.

Luzietti, Cindy. 2010. Shasta-Trinity NF Recreation Planner. Personal communication regarding the Shasta Lake Recreational Area Development Plan (USDA Forest Service 1953), the completion of the Clikapudi trail in 1976 and development of the Land Management Plan in 1947- Historic Documents. Record of telephone communication and email discussion is in the project file.

Mackie, Richard S. 1997. Trading beyond the mountains: The British fur trade on the Pacific 1793-1843. University of British Columbia Press, Vancouver, B.C.

Madsen, D.B. and D. Rhodes (editors). 1994. Across the West: Human Population Movement and the Expansion of the Numa. University of Utah Press, Salt Lake City, UT.

Mann, M.E. and S. Rutherford. 2002. Climate Reconstruction using "Pseudoproxies." Geophysics Research Letters 29 Art. No. 1501.

Mayer, K.E., Laudenslayer, W.F. Jr., Eds. 1988. A Guide to Wildlife Habitats of California. State of California, Resources Agency, Department of Fish and Game, Sacramento, CA. 166 pp. http://www.dfg.ca.gov/biogeodata/cwhr/wildlife_habitats.asp

McGuire, Kelly R. 2002. Introduction. Late prehistoric resource intensification in the northwestern Great Basin. In Boundary Lands: Archaeological investigations along the California-Great Basin interface, ed. by K.R. McGuire. Anthropological Papers, No. 24. Nevada State Museum. Carson City, NV.

McGuire, Kelly R. 2007. A Prehistory of Northeast California. In California Prehistory: Colonization, Culture, and Complexity. Edited by Terry L. Jones and Kathryn A. Klar. AltaMira Press. Lanham, MD.

Miller, Jay D.; Knapp, Eric E.; Key, Carl H.; Skinner, Carl N.; Isbell, Clint J.; Creasy, Max R. and Sherlock, Joseph W. 2009. Calibration and validation of the relative differenced Normalized Burn Ratio (RdNBR) to three measures of fire severity in the Sierra Nevada and Klamath Mountains, California, USA. Remote Sensing of Environment 113: 645-656.

Moberg, A.; D.M. Sonechkin; K. Homgren; N.M. Datsenko and W. Karlen. 2005. Highly Variable Northern Hemisphere Temperatures Reconstructed from Low- and High-Resolution Proxy Data. Nature 433:613-617.

Moratto, M. 1984. California archaeology. Academic Press. Orlando, CA.

Moyle, Peter B. 2002. Inland Fishes of California. University of California Press. Berkeley, CA. 502 pp.

Munthe, J. and Hirschfield, S.E. circa 1978. Paleontological significance of the Shasta Lake area, Northern California. *In:* USDA Forest Service. 1998c. McCloud Arm Watershed Analysis.

Newburn, Ben. 2009. Personal communication with Shasta Unit fuels officer regarding past and current mining operations in the Pit Arm Watershed analysis area.

Newburn, Ben. 2010. Personal communication with Shasta Unit fuels officer regarding past and current timber harvest in the Pit Arm Watershed analysis area.

O'Connell, James F. 1975. The Prehistory of Surprise Valley, edited by L. J. Bean, Anthropological Papers 4. Ballena Press, Romona, CA.

Oliver, C.D., and B.C. Larson. 1996. Forest stand dynamics. New York: Wiley. 540 p.

Pacific Gas and Electric Company (PG&E). 2008. Technical memorandum: special status aquatic mollusks and invasive crayfish (TM-69). McCloud Pit Project, FERC Project No. 2106.

Pacific Gas and Electric Company (PG&E). 2009. Technical Memorandum: Fish Populations in Project Reservoirs (TM-15). McCloud Pit Project, FERC Project No. 2106, updated January, 2009.

Parendes, L. A., and J. A. Jones. 2000. Role of light availability and dispersal in exotic plant invasion along roads and streams in the H.J. Andrews Experimental Forest, Oregon. Conservation Biology 14:64–75.

Pierson E.D. and W.E. Rainey. 2007. Bat distribution in the forested region of northwestern California. Report prepared for the California Department of Fish and Game. Contract Number FG-5123-WM. Sacramento, California, USA.

Regional Interagency Executive Committee and the Intergovernmental Advisory Committee. 1995. Ecosystem analysis at the watershed scale, version 2.2. Portland, OR: Regional Ecosystem Office. 1995-689-120/21215. 26 pp.

Rothermel, Richard C. 1972. A mathematical model for predicting fire spread in wildland fuels. Research Paper INT-115. USDA Forest Service Intermountain Forest and Range Experiment Station. Ogden, UT.

Scott, J.H. and Burgan, R.E. 2005. Standard fire behavior fuel models: A comprehensive set for use with Rothermel's surface fire spread model. General Technical Report RMRS-GTR-153. USDA Forest Service Rocky Mountain Research Station. Ft. Collins, CO.

Scott, J.H. and Reinhardt, E.D. 2001. Assessing crown fire potential by linking models of surface and crown fire behavior. Research Paper RMRS-RP-29. USDA Forest Service Rocky Mountain Research Station. Ogden, UT. 59 pp.

Sedgwick, James A. 2000. Willow flycatcher (*Empidonax traillii*). Birds of North America Online (A. Poole, Ed.). Cornell Laboratory of Ornithology. Ithaca, NY. Retrieved from the Birds of North America Online. http://bna.birds.cornell.edu/bna/species/533.

Sherwin, E.R., D. Stricklan and D.S. Rogers. 2000. Roosting affinities of Townsend's big-eared bat (Corynorhinus townsendii) in northern Utah. Journal of Mammalogy 81(4):939–947.

Skinner, C.N. 1997. Fire history in Riparian Reserves in the Klamath Mountains. Presented at the Symposium on Fire in California Ecosystems: Integrating Ecology, Prevention, and Management. San Diego, CA. 12 pp.

Skinner, C.N. 2006. Unpublished data on file at the Pacific Southwest laboratory in Redding, CA.

Skinner, Carl N.; Taylor, Alan H. and Agee, James K. 2006. Klamath Mountains bioregion. In: Sugihara, Neil G.; Van Wagtendonk, Jan W.; Shaffer, Kevin E.; Fites-Kaufman, Joann and Thode, Andrea E. (eds.). Fire in California's ecosystems. pp. 170-194.

Squires, J.R. and R.T. Reynolds. 1997. Northern Goshawk. *In* The Birds of North America, No. 298 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and the American Ornithologists' Union, Washington.

Stratton, J.D. 2004. Assessing the effectiveness of landscape fuel treatments on fire growth and behavior. Journal of Forestry, October/November, vol. 102, no. 7. pp. 32-40

Sundahl, Elaine. 1986. Archaeological investigations in the Jones valley area of Shasta Lake, Shasta County, California. Report on file at the Shasta Lake Ranger District, Shasta-Trinity National Forest. Redding, CA.

Sundahl, Elaine. 1992. Cultural Patterns and Chronology in the Northern Sacramento River Drainage. *In*: Proceedings of the Society for California Archaeology 5, edited by M.D. Rosen, L.E. Christenson, and D. Laylander. Society for California Archaeology, San Diego, CA.

Taylor, A.H. and Skinner, C.N. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. Forest Ecology and Management 111:285-301.

Taylor, A.H. and Skinner, C.N. 2003. Spatial patterns and controls on historical fire regimes and forest structure in the Klamath Mountains. Ecological Applications 13:704-719.

Theodoratus, Dorothy J. 1981. Native American Overview. Contract No. 53-9A28-9-2957. Prepared by Theodoratus Cultural Research for the Shasta-Trinity National Forest. Report on file at the Shasta Lake Ranger District, Shasta-Trinity National Forest. Redding, California.

USDA and USDI (U.S. Department of Agriculture and U.S. Department of the Interior). 1994. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl; Standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. Portland, OR.

USDA Forest Service and USDI Bureau of Land Management (BLM). 2001. Record of decision and standards and guidelines for amendments to the survey and manage, protection buffer, and other mitigation measures standards and guidelines. USDA Forest Service, Portland, Oregon and BLM - Moscow, Idaho.

USDA Forest Service Region 5 Remote Sensing Lab. GIS coverage of historical vegetation data from 1934 and 1945 map source.

USDA Forest Service. 1938. Land Use Plan of the Kennett Area. Shasta National Forest.

USDA Forest Service. 1945. Grazing Management Plan. Shasta-Trinity National Forest, Redding District. Redding, CA.

USDA Forest Service. 1953. Shasta Lake Recreation Area Development Plan. Pacific Southwest Region, Shasta National Forest, Shasta Ranger District. Mount Shasta, CA.

USDA Forest Service. 1995. Shasta-Trinity National Forests Land and Resources Management Plan (LRMP). Shasta-Trinity National Forest. Redding, CA.

USDA Forest Service. 1997. Land and Resource Management Plan Amendment for NRA. Shasta-Trinity National Forests

USDA Forest Service. 1998a. Lower McCloud River Watershed Analysis. Shasta-Trinity National Forest. Shasta-McCloud Management Unit. Redding, CA.

USDA Forest Service. 1998b. Whiskeytown Shasta-Trinity National Recreation Guide.

USDA Forest Service. 1999. Squaw Creek Watershed Analysis. Shasta-Trinity National Forest.

USDA Forest Service. 2000. Shasta Lake West Watershed Analysis. Shasta-McCloud Management Unit of the Shasta-Trinity National Forest.

USDA Forest Service. 2000a. Clikapudi Watershed Analysis. Shasta-Trinity National Forest, Shasta-McCloud Management Unit. Redding, CA.

USDA Forest Service. 2006a. Priority watershed process paper for Shasta-Trinity National Forest. ACT2 Enterprise Unit. Unpublished paper.

USDA Forest Service. 2006b. Application of the Water Recreation Opportunity Spectrum (WROS) to Shasta Lake and Keswick Lake. Whiskeytown- Shasta-Trinity National Recreation Area. Redding, CA.

USDA Forest Service. 2006c. Herger-Feinstein Quincy Library Group Botany Monitoring Report. Vegetation Management Solutions Enterprise Unit. Oroville, CA.

USDA Forest Service. 2008. Master Development Plan and Facility Analysis. Shasta-Trinity National Forest. Redding, CA. Schedule of Proposed Actions, Shasta-Trinity National Forest. Redding, CA.

USDA Forest Service. 2009. Motorized Travel Management Draft Environmental Impact Statement. Shasta-Trinity National Forest. Redding, CA.

USDA Forest Service. Draft in progress. Draft Revision of the Whiskeytown Shasta-Trinity National Recreation Guide. Unpublished document.

USDA Forest Service. 2010a. Northern spotted owl habitat GIS layer from STNF district files, compiled by Kelly Wolcott – Forest Wildlife Biologist.

USDA Forest Service. 2010b. 2010 Shasta-Trinity Unit Fire Management Plan. Section II – Fuels Management. Shasta-Trinity National Forest. Redding, CA.

USDA Natural Resources Conservation Service. 2010. The PLANTS Database (http://plants.usda.gov, 16 February 2010). National Plant Data Center. Baton Rouge, LA 70874-4490 USA.

USDI Bureau of Reclamation. 1947. A Report on the Development of a Land Management Plan for the Shasta Reservoir Lands under Bureau Jurisdiction. Bureau of Reclamation Branch of Operation and Maintenance. Sacramento, CA.

USDI Bureau of Reclamation. 2003. Ecosystem Restoration Opportunities in the Upper Sacramento River Region. Shasta Lake Water Resources Investigation, Office Report. November 2003.

USDI Bureau of Reclamation. 2004. Shasta Lake Water Resources Investigation - an Overview of Initial Alternatives.

USDI Fish and Wildlife Service. 1986. Recovery plan for the Pacific bald eagle. Portland, OR. 160 pp.

USDI Fish and Wildlife Service. 2007. National Bald Eagle Management Guidelines. USDI Fish and Wildlife Service.

USDI Fish and Wildlife Service. 2008. Final Recovery Plan for the Northern Spotted Owl, Strix occidentalis caurina. USDI Fish and Wildlife Service. Portland, Oregon. pp. xii + 142.

Valenzuela, Kathy. 2009. Personal communication regarding mining and caves within Pit Arm Shasta Lake Watershed, Shasta-Trinity National Forest Supervisor's Office. Record of telephone communication is in the project file.

Wales, J.H. 1939. General report of investigations on the McCloud River drainage in 1938. California Fish and Game 25(4):272-309.

Weatherspoon, C. and Skinner, C. N. 1995. An assessment of factors associated with damage to tree crowns from the 1987 wildfires in northern California. Forest Science 41(3):430-451.

West, G. James, Wallace Woolfenden, James, A. Wanket, and R. Scott Anderson. 2007. Late Pleistocene and Holocene Environments. *In*: California Prehistory: Colonization, Culture, and Complexity. Edited by Terry L. Jones and Kathryn A. Klar. AltaMira Press. Lanham, MD.

Yeager, Scott. 2005. Habitat at fisher resting sites in the northern Klamath province. MS thesis at Humboldt State University. Arcata, California. 198pp.

Zeiner, D.C; W.F. Laudenslayer, Jr.; K.E. Mayer and M. White. 1990. California Statewide Wildlife Habitat Relationships System. California's Wildlife; 1-3 vol. California Dept. of Fish and Game. Sacramento, CA.

Zouhar, K.; Smith, J.K.; Sutherland, S.; and Brooks, M.L. 2008. Wildland fire in ecosystems: fire and nonnative invasive plants. Gen. Tech. Rep. RMRS-GTR-42-vol. 6. U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. Ogden, UT: 355 pp.