Upper Sacramento River Watershed Assessment and Management Strategy

Prepared for

The River Exchange
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List of Acronyms and Abbreviations

˚F	degrees Fahrenheit
af	acre feet
APCD	Air Pollution Control District
AQMD	Air Quality Management District
B.P.	before present
BLM	Bureau of Land Management
BMP	Best Management Practice
Cal-IPC	California Invasive Plant Council
CalFire	California Department of Forestry and Fire Protection
CAA	Clean Air Act
CAAQS	California Ambient Air Quality Standards
CARB	California Air Resources Control Board
CCAA	California Clean Air Act
CCC	Civilian Conservation Corps
CDFA	California Department of Food and Agriculture
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFPA	California Forest Practice Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGS	California Geological Survey
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
CPRR	Central Pacific Railroad
CTC	Cantara Trustee Council
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
CWHR	California Wildlife Habitat Relationship
CWPP	Community Wildfire Protection Plan
dbh	diameter at breast height
DPA	Direct Protection Area
DPS	Distinct Population Segment
DWR	Department of Water Resources
e.g.	for example
ECW	Emergency Conservation Work
EIR	environmental impact report
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FESA	Federal Endangered Species Act
FPA	Z'berg–Nejedly Forestry Practice Act

GEP	generic erosion potential
GIS	Geographic Information Systems
HFI	Healthy Forests Initiative
HFRA	Healthy Forests Restoration Act
HUC	Hydrologic Unit Code
i.e.	that is
IAI	impervious area index
LRMP	Land and Resource Management Plan
LSR	Late Successional Reserve
MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MLSA	Managed Late Successional Area
MRZ	Mineral Resource Zone
MUSYA	Multiple-Use Sustained-Yield Act
NAAQS	National Ambient Air Quality Standards
NAWQA	National Water Quality Assessment Program
NEPA	National Environmental Policy Act
NFMA	National Forest Management Act
NFTS	National Forest Transportation System
NRA	National Recreation Area
NSVAB	Northern Sacramento Valley Air Basin
NTU	nephelometric turbidity unit
NWFP	Northwest Forest Plan
OHV	off-highway vehicle
RNA	Research Natural Area
ROD	Record of Decision
RSL	Remote Sensing Lab
SCDA	Siskiyou County Department of Agriculture
SDWA	Safe Drinking Water Act
SMARA	Surface Mining and Reclamation Act
SPI	Sierra Pacific Industries
SPRR	Southern Pacific Railroad
STNF	Shasta-Trinity National Forest
Subbasin	Sacramento Headwaters HUC-4 Subbasin
SWAMP	Surface Water Ambient Monitoring Program
SWCMP	Sacramento Watershed Coordinated Monitoring Program
THP	timber harvest plan
TPI	Topographic Position Index
TPZ	Timber Production Zone
U.S.C.	United States Code

UPRR	Union Pacific Railroad
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
watershed	Upper Sacramento River Watershed
WEPP	Water Erosion Prediction Project
WUI	wildland-urban interface

CHAPTER 1

Introduction

Chapter 1 Introduction

1.1 Overview of the Watershed Assessment Process

One of California's most valuable natural assets is its water and waterways. Watersheds, also known as catchments or drainage basins, provide a useful, natural unit for better understanding and protecting our lakes, rivers, and streams. When speaking about a watershed, we are referring not only to a river basin, but also to all of the life, land, development, and water within it. Assessing a watershed to understand its current condition, and how it got there, is usually the first step taken in developing a strategy toward improving and protecting the watershed (Shilling 2005).

This watershed assessment for the upper Sacramento River watershed is intended to (1) provide a high-level overview and summary of available watershed information and key data gaps for funding agencies, resource managers, scientists, and other interested parties; (2) provide the informational and conceptual foundation for the development of a watershed management strategy; and (3) identify actions that can be taken to address or inform a particular need or opportunity in the watershed.

A useful watershed assessment addresses the sources of watershed impacts rather than just their symptoms, which is key to achieving effective watershed protection and restoration. Thus, understanding historic watershed uses and conditions is important for providing the context for current conditions. Conditions evaluated in this watershed assessment include human components and processes, physical components and processes, and biological components and processes.

Assessing a watershed is an ongoing resource-management task that includes data collection and analysis to inform decision-making. Watershed assessments benefit from a cooperative approach that includes a framework for evaluating the effects of management decisions on natural resources. This watershed assessment provides baseline information to identify watershed priorities, policies, and projects. It may be used as a resource management tool to anticipate and measure the effects of specific policies and projects on watershed health.

In 2008, an inclusive public process was established to assess the upper Sacramento River watershed (Figure 1.1-1). The River Exchange began the watershed assessment by inviting resource agencies, counties, cities, tribes, conservation organizations, industry, and landowners to a meeting to discuss a coordinated watershed assessment effort. A project steering committee was formed to direct the assessment process and content. The steering committee met on several occasions to determine the goals and objectives of the watershed assessment. The committee formulated the project goals and objectives by asking several basic questions:

Why assess the upper Sacramento River watershed?

- This was the first question that brought the steering committee participants to the table for discussion.

- The steering committee identified several short-term and long-term needs for a coordinated watershed assessment of the upper Sacramento River watershed.

Where should the watershed assessment be focused?

- The steering committee identified the geographic scope of the watershed assessment.

Who could provide and gather information for the watershed assessment?

- The steering committee identified many individuals, agencies, and organizations that have information relevant to the watershed assessment.

- The steering committee chose several consultants and individuals to draft a watershed assessment under their guidance and review.

What topics should be researched and discussed in the watershed assessment?

- The steering committee identified the major components within the watershed (physical, biological, and human) and approved topics to be addressed by the watershed assessment.

- The steering committee determined the depth of research and information for the watershed assessment based on project goals and the available budget.

When can the assessment occur?

- The steering committee approved a project schedule that included time for research, analysis, and final document preparation.

- The committee modified the project schedule according to the grant funding schedule.

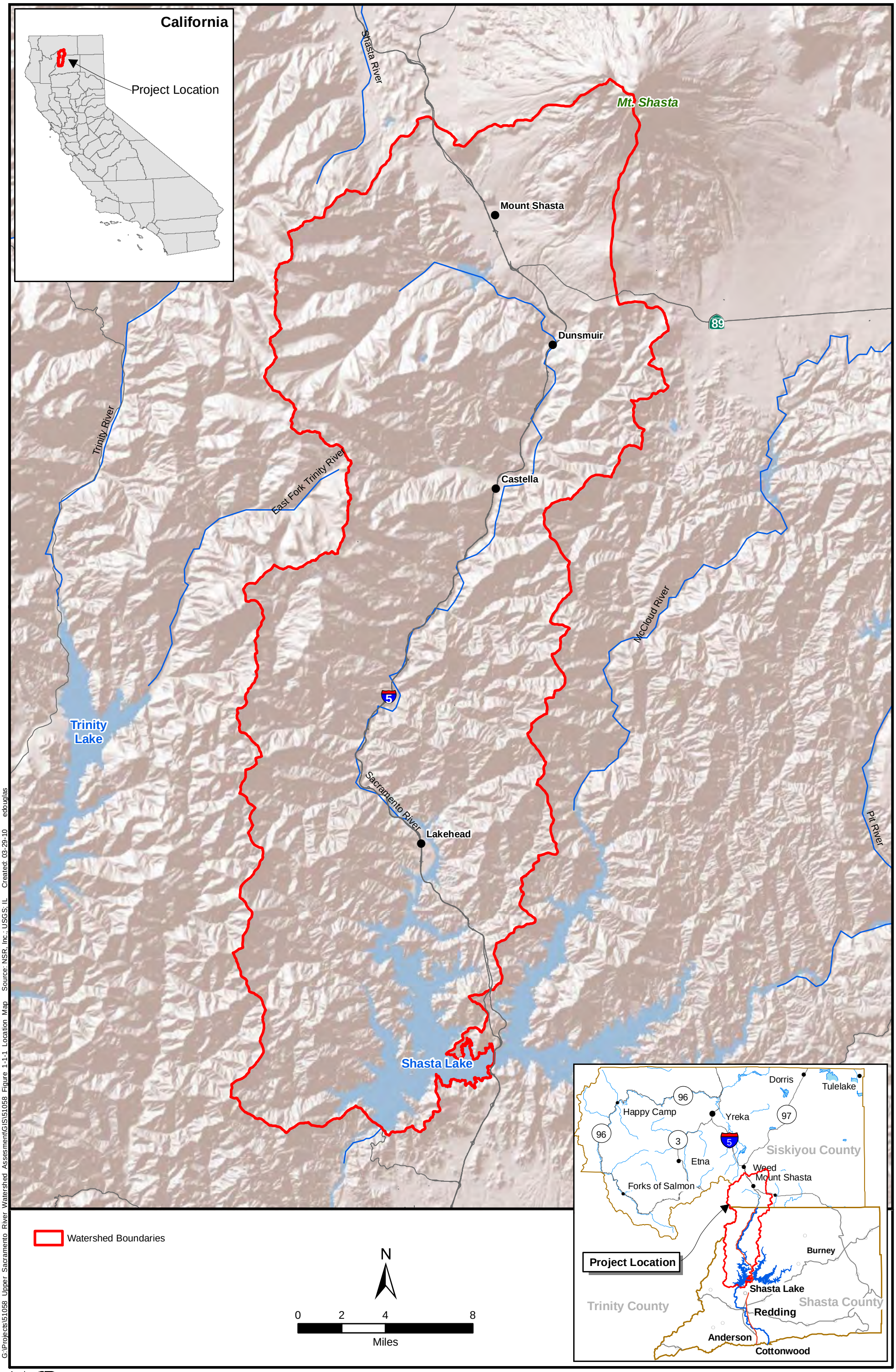
How should information be presented and evaluated to provide an accurate story?

- The steering committee developed and approved a document outline to present historic and current watershed conditions based on three major topics: the physical, biological, and human components of the watershed.

1.2 Project Goals and Objectives

The primary goals of the Upper Sacramento River Watershed Assessment are to provide a better understanding of the past and current physical, biological, and human-influenced conditions in the watershed and to lay the groundwork for the development of a management strategy for the watershed. The following goals developed by the steering committee provided a roadmap for the development of measurable project objectives.

- Understand the ecological processes at work in the upper Sacramento River watershed.
- Link past and current human activities and land uses to current landscape conditions.
- Emphasize the aquatic resources assessment.



G:\Projects\51058 Upper Sacramento River Watershed Assesment\GIS\51058 Figure 1-1-1 Location Map Source: NSR, Inc.; USGS; IL Created: 03-29-10 edouglas

North State Resources, Inc.

Upper Sacramento River Project

Figure 1.1-1
Project Location and Vicinity Map

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Objectives for the Upper Sacramento River Watershed Assessment, as identified by the steering committee, are summarized as follows:

- Identify topics and watershed features in the upper Sacramento River watershed to be included in the watershed assessment.
- Research and collect information on historic and current watershed conditions for each assessment topic.
- Use mapping tools, such as geographic information systems (GIS), to illustrate and assess watershed conditions.
- Characterize the dominant physical, biological, and human processes and features in the upper Sacramento River watershed , including:
  - vegetation
  - fire and fuels management
  - biotic communities
  - water supply and water quality
  - fluvial geomorphology
  - watershed heritage
  - land use patterns and infrastructure
  - communities and economic activities
  - regulatory context
- Characterize the range, distribution, and condition of ecosystem elements in the watershed (historic and current).
- Describe how ecosystems and human land use patterns in the watershed have changed through time.
- Synthesize and interpret the information about current and historical ecosystem components to establish cause and effect relationships between these components.
- Determine which watershed conditions limit beneficial water uses and how those uses are affected.
- Identify data gaps and watershed assessment topics that require additional information.
- Facilitate development of conclusions and recommendations by the public agencies and non-governmental stakeholders that will respond to the cause and effect relationships between ecosystem components.
- Identify components of the watershed (human, physical, or biological) where watershed functions could be improved.
- Measure the success of watershed maintenance and enhancement efforts.

- Produce a document for land owners and managers in the watershed that summarizes historic and current watershed conditions.

- Produce a document that can be incorporated into future watershed planning and management decisions.

1.3 Project Participants and Funding Sources

The Upper Sacramento River Watershed Assessment project was guided by a diverse 16-member steering committee of watershed stakeholders:

- U.S. Fish and Wildlife Service
- U.S. Forest Service, Shasta-Trinity National Forest
- Winnemem Wintu Tribe
- California Department of Fish and Game
- California Regional Water Quality Control Board – Central Valley Region
- California Department of Water Resources
- Siskiyou County
- Shasta Valley Resource Conservation District
- Western Shasta Resource Conservation District
- CalTrout
- The River Exchange
- Sierra Pacific Industries
- Union Pacific Railroad
- Roseburg Forest Products

The Steering Committee operated under a consensus-seeking process as it led the development of the Watershed Assessment. While committee members supported the concept of producing the assessment, each individual organization did not necessarily support all of the conclusions or management directions that the assessment contains. See Appendix J for specific comments from one Steering Committee member. The data and factual assertions contained in the assessment were compiled from existing public and private sources. Reasonable attempts were made to ensure the accuracy of the information included in the assessment, but scheduling and budgetary constraints precluded any detailed data review by outside reviewers.

In addition to steering committee input, the process also included several public outreach meetings in both the upper and lower parts of the watershed. The scope and process for developing the assessment was presented, and the public was given the opportunity to provide input, ask questions, and express concerns.

The Upper Sacramento River Watershed Assessment project was funded by the State of California through a Proposition 50 grant, via the CALFED Watershed Program. The California Department of Water Resources was the state agency responsible for administering the Watershed Program grants funds. The River Exchange, a non-profit organization headquartered in Dunsmuir, was responsible for administering the grant funds, which were obtained in partnership with CalTrout, U.S. Forest

Service, Shasta Valley Resource Conservation District, Western Shasta Resource Conservation District, and U.S. Fish and Wildlife Service.

1.4 Watershed Location

The upper Sacramento River watershed is located in northern California, where the inland Cascade Range meets the Klamath Mountains (Figure 1.1-1). The watershed boundaries are formed partly by the steep Klamath Mountains, which direct precipitation and streams down mountain faces into the Sacramento River for several miles before the river empties into Shasta Lake above Shasta Dam. Mount Shasta, a 14,000+ foot dormant volcano, forms the northeastern watershed boundary, and Shasta Dam marks the southern boundary for the assessment. The watershed drains approximately 383,000 acres (600 square miles) of land. Prominent features in the basin include Mount Shasta, Interstate 5, Union Pacific railroad, Shasta Dam, Shasta Lake, and Castle Crags State Park.

The McCloud and Pit rivers, which flow into the Sacramento River at Shasta Lake and are part of the larger Sacramento River Watershed, were not included in the upper Sacramento River watershed boundary for the purposes of this assessment.

1.5 Dominant Social and Ecological Components and Processes

The study area is home to a variety of valued ecological components and ecosystem processes. Identifying components and processes that are especially influential—or dominant—focuses the watershed assessment on factors that currently control the uses and condition of the aquatic environment and will control them in the future. Management decisions that affect dominant components and processes have greater potential to affect the aquatic environment than decisions affecting less influential ecosystem elements.

Dominant ecological components and ecosystem processes in the upper Sacramento River watershed are those that:

- control the established and future uses and condition of aquatic resources;
- are important to the diversity, vigor and sustainability of biological resources; and
- are important to the community.

The three dominant components of the watershed identified by the steering committee are the physical, biological, and human components. These components are defined and described in their historic and present context (Chapters 2 and 3). Generally speaking, the human component refers to human development, infrastructure, and land uses; the physical component refers to the shape of the natural environment; and the biological component refers to the flora, fauna, and their specific habitats in the watershed.

It is important to recognize that these components are both dependent on one another and independent of one another. While each major component of a watershed can function independently of another, they are all connected to one another in some way because they all share the space that is the upper Sacramento River watershed.

1.6 References

Shilling, F., S. Sommarstrom, R. Kattlemann, B. Washburn, J. Florsheim, and R. Henly. 2005. California watershed assessment guide. Prepared for the California Resources Agency. July 2005.

CHAPTER 2

Watershed Heritage and Human Influences

Chapter 2 Watershed Heritage and Human Influences

Chapter 2 establishes a historical context for understanding how we got to the current conditions in the watershed, as described in Chapter 3. This chapter discusses how past and present human activities and communities are tied to and have influenced or altered the resources in the watershed.

2.1 Native American Heritage and Influences

This section of Chapter 2 discusses the historic Native American territories and tribes that occupied the Upper Sacramento River watershed, and how Native American activities have influenced the natural resources and landscape in the watershed.

2.1.1 Prehistory

The upper Sacramento River watershed lies at the convergence of the Klamath Mountains, Cascade Range, and Great Valley physiographic provinces and is composed of several vegetation and zoological life zones (U.S. Geological Survey 2007). Prehistorically, several climate shifts created a varied landscape in the watershed. West (1989) describes a warmer and drier climate before 3,500 years before present (B.P.) creating a "richer, more productive resource base" in the higher elevations above the Sacramento River Canyon (West 1989). This climate would have allowed an oak woodland forest within the canyon in a much larger area than found today (West 1989). The many rivers and creeks provided a substantial amount of water as well as many of the freshwater resources such as fish and mussels that were used by local people prehistorically. Among the major plant resources recorded in prehistoric contexts as well as in ethnographic contexts are acorns, pine nuts, bulbs and corms, a variety of seeds, and manzanita (Basgall and Hildebrandt 1989). Animal remains collected and analyzed from four prehistoric sites in the Sacramento River canyon contained predominately large game, specifically artiodactyls (even-toed, hoofed animals such as deer and pigs), indicating a consistent use throughout prehistory (Basgall and Hildebrandt 1989).

The *Paleo-Indian Period* (12,500 to 10,000 B.P.) is characterized by the warming period associated with the Pleistocene/Holocene transition seen throughout North America. The tool technology of California during the Paleo-Indian period is delineated by fluted projectile points similar to Clovis, Cody, and Hellgap projectile point types that are found in the Great Basin (Statistical Research, Inc. 2004). These projectile point types are part of the larger Big-Game Hunting Tradition evidenced across North America during this period (Moratto 1984). The *Early Holocene Period* (10,000 to 8,000 B.P.) is a period of global deglaciation in the northern hemisphere, creating warmer and drier climates. Projectile point sequences are dominated by large stemmed projectile points subsumed under the Great Basin Stemmed series, in the area spanning the southern Cascade Range and the northern Sierra Nevada (Hildebrandt and King 2002). In addition to projectile points, bifaces, scrapers, large cores, and crescent forms are often found in deposits from this period, with very few manos, milling stones, and other food processing tools in association (McGuire 2002). Obsidian

sources for these tools and projectile points are found over 100 miles away, suggesting a highly mobile population (McGuire and Nelson 2002).

The *Early Archaic Period* (8,000 to 5,000 B.P.) marks a period of change in climate that is wetter, as well as a shift in use of the land and subsistence by prehistoric populations. Occupation sites begin to shift from lakeshores and marshes to perennial waterways and springs, and there is a marked increase in milling equipment located in the site assemblages (McGuire and Nelson 2002). Often discussed as the *Borax Lake Pattern,* the Early Archaic Period is typified by large lanceolate, corner-notched, and wide-stemmed projectile points. Unifacial flaked stone tools are typically manufactured from obsidian, local cherts, and basalts. It is likely that these points were hafted onto large darts or spears used in conjunction with an atlatl (a spear thrower designed to create a greater velocity on a thrown spear using leverage). Manos (handstones) and metates (milling slabs) are the most common form of milling equipment. The noted increase in milling equipment in site assemblages first seen in the Post Mazama Period is still observed during the Early Archaic (McGuire and Nelson 2002). There is evidence of increased use of vegetal materials and specialized processing techniques, and cultural elaboration from the wider Modoc Plateau area (McGuire and Nelson 2002).

The *Middle Archaic Period* (5,000 to 3,000 B.P.), often discussed as the *Squaw Creek Pattern* for the Redding/Upper Sacramento Valley area, saw continued use of manos and metates, and the introduction of the mortar and pestle. Stone tool forms include contracting stem projectile points (Squaw Creek Series), unifacial flake tools (McKee Uniface), awls, and wedges from a wider variety of obsidian sources. Atlatl weights imply use of the atlatl as the primary hunting weapon, and net weights and fishhooks imply an increased reliance on fishing (Basgall and Hildebrandt 1989). During this time, California began to experience more rainfall and a reestablishment of glaciers at the upper elevations in the Sierra Nevada (Minnich 2007). Recent research in eastern Shasta County indicates current vegetation regimes began to develop 2,200 years ago (Anderson et al. 2008).

The *Late Archaic Period* (3,000 to 150 B.P.) includes two distinct patterns: the *Whiskeytown Pattern* and the *Augustine Pattern*.

The *Whiskeytown Pattern* (3,000 to 1,700 B.P.) sees the continuation of atlatl use as a hunting weapon. Small to large side-notched and corner-notched darts are the most common form of projectile point. Manos and metates remain in use, and there is an increase in mortar and pestle use, indicating an increased focus on acorns.

The *Augustine Pattern* (1,700 to 150 B.P.), at times referred to as the *Shasta Aspect* for the Redding/Upper Sacramento Valley area, is marked by the introduction of the bow and arrow and the adoption of the hopper mortar and pestle (Johnson and Theodoratus 1984, Moratto 1984). Small projectile points (Gunther series, Desert Side-Notch series) suitable for arrow tips are found with increasing frequency in archaeological contexts. Hopper mortars, indicative of intensive use of acorns, become the dominant milling equipment. Manos and milling stones are used infrequently. The reliance on acorns and river resources such as salmon leads to the development of food preservation and storage (e.g., granaries). Well-established trade networks are in use as evidenced by obsidian from distant sources as well as coastal shell beads. Clamshell disc beads, spire lopped *Olivella* beads, and *Haliotis* ornaments and pendants are common forms of ornamentation. This pattern is associated with the ethnographically known Wintu.

2.1.2 Ethnography

The Wintu

The *Nomtipom* (Upper Sacramento Wintu) and *Winnemem Wintu* (McCloud Wintu) territories lie in the upper Sacramento River watershed area. At the time of contact with Euro-Americans, they were a semi-sedentary, foraging people living in permanent villages near rivers and streams (DuBois 1935). The *Nomtipom* occupied the area from Kennett (present-day Shasta Dam) north to Lamoine, particularly in the narrow canyon areas along the Sacramento River (DuBois 1935). The *Winnemem Wintu* occupied the McCloud River and Squaw Creek drainages as well as the area around the confluence of the Pit, Sacramento, and McCloud Rivers; a large majority of this area now lies under the waters of Shasta Lake (DuBois 1935). The pre-contact population of the Wintu is estimated at around 14,250 (LaPena 1978). Figure 2.1-1 shows the proposed historic extent of the territories occupied by these groups.

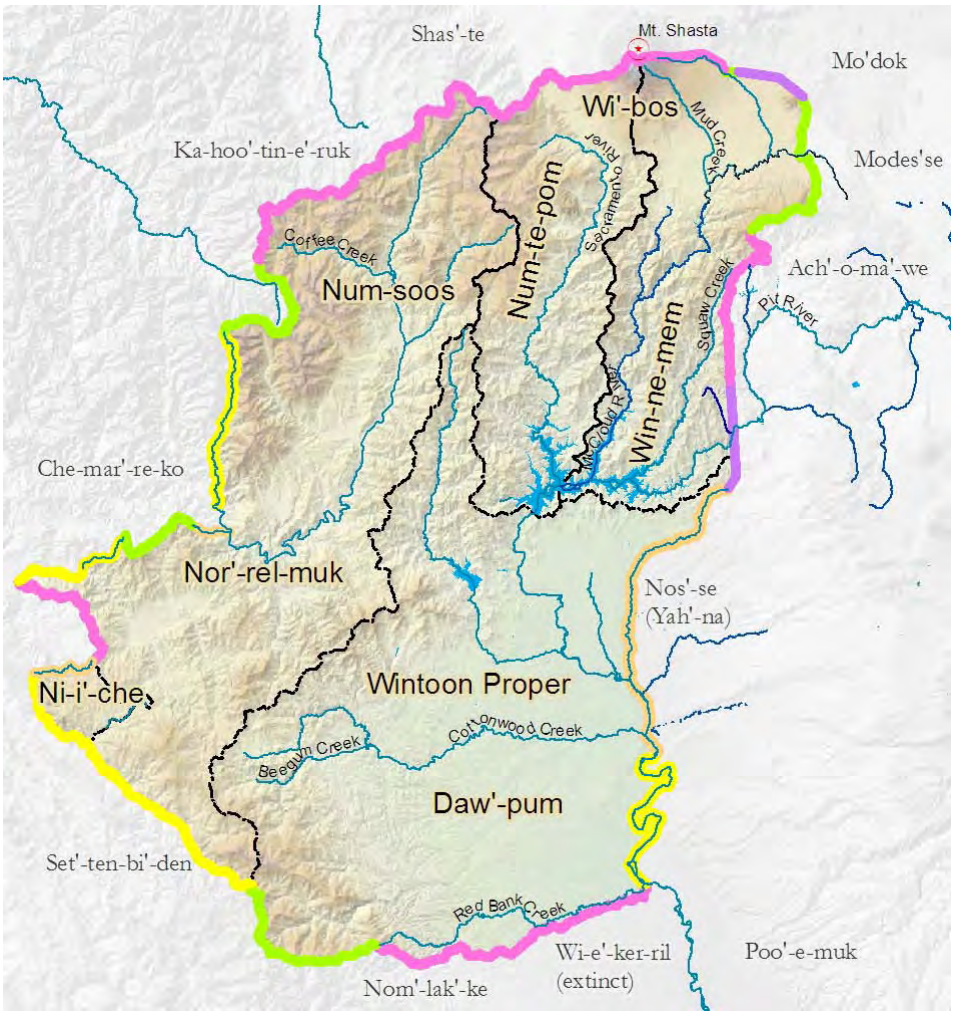

Figure 2.1-1. Wintu boundaries as described in *Studies of California Indians* (Merriam 1955), and depicted by McTavish (2010).

The primary diet of the Wintu consisted of deer, rabbits, and other small mammals; fish, including salmon, steelhead, Sacramento sucker, freshwater shellfish, and lamprey; grasshoppers, salmon flies, and other insects; acorns, pine nuts, and buckeyes; manzanita berries and other berries; *Brodiaea* sp. and other bulbs; clovers, miner's lettuce, and other greens; and grass seeds. In general, sturgeon, dog, bird eggs, and angleworms were not eaten (DuBois 1935). In addition to eating fresh fish, the Wintu preserved salmon by drying it for use throughout the year. Dried salmon was processed into salmon flour and used in a variety of ways.

Mortars and pestles were used to grind seeds, acorns, and pigment and to soften meat. Manos and metates were also used. Bone was used as awls for basketry, harpoons, and hooks, and wedges for wood cutting. Digging sticks for root retrieval, house excavation, and grave digging were made from sharpened hardwood. Soaproot fibers were used for acorn meal brushes, paintbrushes, and hairbrushes. Rope and cordage were usually made from iris fibers (DuBois 1935). Materials such as hazel, skunkbrush, willow, grapevine, redbud, pine root, poison-oak, maidenhair fern, porcupine quills, and some grasses were used to create baskets and traps, including sifters, seedbeaters, trays, bowls, hats, dippers, hoppers, cooking baskets, burden baskets, storage, and fish traps (DuBois 1935). Bows were made from yew and arrow shafts made from reed or lightwood with a hardwood tip. Arrow points were made from obsidian or basalt. Logs were used as bridges; rafts of lashed together logs were poled across streams; and at several locations along major tributaries "complicated bridges lashed together by grapevines" could be found (La Pena 1978). *Olivella*, abalone, and clamshell were used for adornment such as earrings and beads. Blankets and clothing were made from deer hide and rabbit skins. A moccasin-like shoe of deer hide was worn in the winter or for long treks. Snowshoes were used in the winter (DuBois 1935).

Ethnographically, Wintu mortuary customs involved primary burial rather than cremation (Du Bois 1935). The Wintu interred the dead in graveyards located near the village (approximately 100 yards away) in graves of a depth of about 4 feet (DuBois 1935). Some plots were inclusive of an entire village; some were reserved for a family. If during the course of excavation other human remains were encountered, they would be wrapped in a hide and re-interred with the new burial. The body would be bound by sinew or rope in a tightly flexed position, placed in the grave along with a basket of acorn-meal water and other items such as projectile points or beads. The grave was lined with and the body covered by pine bark, with stones placed on the bark, and then filled in with the excavated dirt (DuBois 1935). At times the graves were then topped with white sand; with the introduction of Euro-American burial practices, flowers were substituted (DuBois 1935).

Wintu religion and mythology were intimately connected with the environment, made concrete by all features of nature possessing historic, mythological, and religious importance. Places of unusual configuration such as distinctive outcrops of rock, caves, mountains, and whirlpools might be considered "holy," of special importance, or the dwelling places of spirits (Ritter and Burcell 1995; Burns personal communication) Many modern Wintu peoples believe very strongly in the sacredness of certain environmental features, although many locations have been lost to time, have been forgotten, or, for a variety of reasons, have not been revealed to ethnographers, archaeologists, or land managers (Ritter and Burcell 1995, Burns personal communication, Hayward personal communication, Sinclair personal communication, Root personal communication). A prime example of this sacredness is the importance of Mount Shasta. Mount Shasta dominates the horizon, provides a landmark, supplies a geographical reference for the delineation of territories, and is important in the

cosmological and mythological realms of the people living around the mountain (Henn 1994). Much of the information regarding sacred locations, Traditional Cultural Properties, and important use areas for the Wintu and other Native American groups in the watershed has not been recorded or is known to only a few people. This gap in information may be addressed through ethnographic and oral history work.

The first reported contact that the Wintu had with Euro-Americans occurred in 1826 and 1827 when expeditions of Hudson's Bay Company trappers and traders led by Peter Skene Ogden and Jedediah Smith made forays into the region (Quint 1960). The discovery of gold by Pierson B. Reading on Clear Creek and at the mouth of Reading's Creek on the Trinity River in 1848, and the creation and settling of Shasta County in 1850 and Siskiyou County in 1852 created a hotbed of culture clashes.

The massive influx of miners during the Gold Rush resulted in significant changes in the lifestyles and interaction patterns of the Indians in northern California. Miners drove Indians off their land; polluted the waters, destroying fishing grounds; and brought in livestock (Theodoratus Cultural Research 1981). After the initial wave of miners passed through, settlers moved in and set up homesteads. According to McTavish (2010), as settlers claimed the flat areas first, the Wintu found refuge in the mountainous areas of their territory for a time and were among the last tribes in the region to remain culturally viable. For a detailed discussion of Winnemem Wintu land claims within the watershed, see *The Role of Critical Cartography in Environmental Justice: Land-Use Conflict at Shasta Dam, California* (McTavish 2010).

2.1.3 Native Americans and Fire

In general, Native Americans in California used fire for hunting and insect collection (see Barrett and Gifford 1933, Faye 1923, Curtis 1924, Goldschmidt 1951); for management of pests and disease, especially in oak trees; for health of and underbrush clearing in forests and riparian areas to create a biotic mosaic and for ease of travel (Keeley 2002); for plant management for better yields of acorns, grasses, basketry materials, and so on (Anderson 1999); to create firebreaks and open areas around villages and clear cover vegetation from trails (Williams 2005); to aid in the felling of trees (Williams 2005); and as an element of warfare (Williams 2005, Dixon 1905).

Native Americans in the watershed actively managed the land to ensure that plants would reproduce and provide abundant food supplies. The historic record includes numerous accounts of the use of fire in the region as a means of propagating acorns and native grasses. Based on recorded uses of fire in the region and the abundance of berries, it is reasonable to suggest that Native Americans in the watershed also used fire to assist with the propagation of berries. In addition, while not referred to as "ranching" because the Native Americans were not raising domesticated animals, they did actively shape the land with fire in a way that assisted the wildlife populations that were essential to their diet. While fire management for the purpose of maintaining food supply may not be considered "agriculture" or "ranching," it does illustrate that Native Americans in the watershed actively managed resources with a purpose and end product similar to those of agriculture and ranching (Basgall and Hildebrandt 1989). Section 3.1.8, *Fire and Fuels*, provides more information on the effects of Native American fire use in the watershed.

2.1.4 Native American Fisheries

The Native Americans in the upper Sacramento River watershed used the vast variety of resources in the streams, rivers, forests, and meadows of the area. Fish, including salmon, steelhead, Sacramento sucker, freshwater shellfish, and lamprey, were an important part of their diet. Communal fish drives of salmon or steelhead were conducted at night in the McCloud and Sacramento rivers and entailed the use of large nets stretched across the river with people, bearing torches, wading and swimming downstream to corral the fish (Dubois 1935). The fish were then easily scooped up and hung on grapevines. The fish drives brought together many communities and provided opportunities for trade and social networking, including the parsing out of the catch among the people and villages involved (DuBois 1935). Individuals would fish for salmon with a harpoon usually tipped with bone from a small brush-covered platform extending over a stream (DuBois 1935). The brush disguised the presence of the fisherman and provided shade for better visibility. Smaller fish, such as trout, were captured by individuals with a hook and line or, in summer, pools were poisoned using soaproot (*Chlorogalum pomeridianum*) and the fish picked up by hand and net (DuBois 1935). Spring-run salmon were baked, allowed to dry, and then pounded into flour, whereas fall-run salmon were immediately dried and stored or pounded into flour (DuBois 1935). Small fish were roasted and eaten immediately or preserved by cooking, salting, and drying and stored in baskets. Fish preserved in this manner were boiled before eating (DuBois 1935). Mussels and freshwater shellfish were not as plentiful in the watershed as elsewhere in the state; however, there were several productive areas that were exploited by small groups of people (DuBois 1935). The shellfish were acquired by diving to the bottom of the pools, and then boiled or roasted to open the shells, and sometimes dried on flat trays for later use (DuBois 1935).

2.1.5 Native American Place Names

All people categorize, identify, mystify, and name their surroundings, be it the place where they reside or a geographic feature on the distant horizon. When people migrate, they bring with them their manner of naming. Places will be named for the owners or tenants (e.g., Mears Creek), figures or events in stories, physical descriptions (e.g., Castle Crags), persons of importance (e.g., Dunsmuir), home towns and regions (e.g., Lamoine), and so on. In the Spanish- dominated areas of California, many words of Native American origin have been Hispanicized and applied to land grants, towns, streams, etc. Unlike the colonization and settlement of the Sacramento Valley and Lower California by the Spanish, the large, rapid migration and settlement of Euro-Americans in the watershed after 1848 was not conducive to Native Californian place names continuing to present day. Several Native Californian terms and names have been applied to features in the upper Sacramento River watershed, and several terms of possible Native American origin, but not necessarily Californian terms have been applied to well-known features in the area.

Bohemotash Mountain is derived from the Wintun word for "large," *bohem:* the second half of the name has been discussed as of unknown meaning or perhaps deriving from the Wintun word *thoos* or "camp" (Kroeber 1916, Gudde 2004).

Bally or Bully is used in several place names in Tehama and Shasta counties and is derived from the Wintu word *boli* or "spirit" (Kroeber 1916). Bully Hill is the closest example to the watershed of use of this term, being located between the Pit and McCloud rivers near Shasta Lake.

Tauhindauli Park is named in honor of Grant Towendolly (whose Wintu name was Laktcharas Tauhindauli) a well-known Wintun who was born in 1873 at Upper Soda Springs (Masson 1966). The Towendolly family was originally from the Trinity River watershed near present-day Hay Gulch, and moved to the upper Sacramento River watershed after the discovery of gold and subsequent influx of miners to the Trinity area. Upper Soda Spring was a traveler's stop on the Siskiyou Trail and later a stage stop and resort on the Oregon-California Road. After 1855, it was owned and run by Ross and Mary McCloud, two early Euro-American pioneers in the watershed (Masson 1966). Grant lived at Upper Soda Springs working at the resort as a gardener until the resort closed in 1920 (Masson1966). He was chosen by his father to follow as the headman or chief of the Trinity Wintu, and so was taught the knowledge and the important stories of the group. He told many of the stories to Marcelle Masson, who later wrote them down and published them in *A Bag of Bones* (1966).

Although its origin has been lost in time, there are several proposed origins for the word *Siskiyou*. It has been proposed that *siskiyou* is a Cree or Chinook word for "bob-tailed horse" (Mackie 1997). While traveling through modern-day southern Oregon in 1829, a horse belonging to Alexander McLeod's trapping party died, and so the word *siskiyou* was applied to the pass (Mackie 1997). As to how a Cree or Chinook word came to be applied to a California county, one need only look to the Hudson's Bay Company fur trappers who employed many Native Americans from a wide region, several of whom were involved in trapping expeditions into California. The trapping companies were a mixture of French, Canadians, and Native Americans, with French as their common spoken language. However, in close contact, groups will adopt foreign terms creating a mutually understandable jargon. The other possible origin of *siskiyou* is credited to Michel Laframboise's 1832 trapping party applying the French term *six cailloux* or "six stones" to a ford on the Umpqua River in present-day Oregon (Gudde 2004).

The word *Shasta* did not appear in its modern form until 1850 when the State of California applied it to the northernmost county (Gudde 2004). Before the official naming of the county, the word was applied in various forms and spellings to Indian groups in present-day southern Oregon and northern California, and to landmarks and geological features, most notably Mount Shasta (Gudde 2004). Two of the earliest references to a word spelled in a similar manner are found in journals of early trappers and explorers. Alexander Henry and David Thompson mention a group of Indians who stated "they were of the *Wallawalla*, *Shatasla*, and *Halthwypum* nations" (Gudde 2004). Peter Skene Ogden, on a trapping expedition in 1826–1827, makes reference in his journal to a group of Indians as the *Sastice*, a name he then applies to a river (Rogue River), and a mountain (Mount McLoughlin), although in later entries he spell the word *Sasty* (Gudde 2004). Later expeditions to the northern California area would mistakenly apply Ogden's *Sasty* to modern-day Mount Shasta.

Lacking a complete place name study covering both the built and natural environment (creeks, mountains, towns, parks etc.), it is unknown how many words of Native American origin are applied to features in the watershed.

2.1.6 The Wintu and Land Ownership and Title in California

Section 2.1.6 was submitted by the Winnemem Wintu Tribe and was mainly derived from Anne Kathryn McTavish's 2010 Master of Arts thesis in Geography titled, "The Role Of Critical Cartography In Environmental Justice: Land-Use Conflict At Shasta Dam, California."

The Wintu and other tribes are sovereign nations as they were pre-contact. Historically, within their traditional aboriginal boundaries, the Wintu protected, tended, manipulated, utilized, revered, and named the land and those things that are now called resources. Natural systems continue to be respectfully cared for by the Winnemem Wintu with the recognition of mutual interdependence, equal in both the physical and the spiritual world. The belief is still held by the Winnemem Wintu that if life is carried on in this way, the continuance of both the people and those good things the Creator gave them to live and enjoy life will be guaranteed.

Europeans swept into the traditional cultural land of the Wintu in the 1800's and brought with them a social system based on the economic imperatives of land ownership and resource extraction. The physical manifestation of these opposing worldviews has been described by some historians, anthropologists, and aboriginal peoples of California as genocide, with the control of the land passing to the European Americans.

The history of legal land ownership and title in California begins with the conquest and removal of Native peoples from their aboriginal lands. The neutralization of California Indian tribes was a prerequisite for the aggressive utilization of the vast mineral, timber, agricultural and recreational wealth of the state. The new laws, legal precedents, and bureaucratic culture that were established because of this conflict favored the state and the federal governments and European Americans in general. These legal/bureaucratic constructs became the template for natural resource extraction and management, which, largely, are followed to this day.

California before Statehood

Spain claimed all of California, but the country was so vast that many areas, including the upper Sacramento River, were basically untouched by European influence. After the United States acquired the Spanish claims to the Pacific Northwest in the Adams-Onis Treaty of 1819, Hudson's Bay Company built Fort Vancouver on the Columbia River in Oregon. From there fur trappers began regular expeditions into California, following the Indian footpath that came to be known as the Siskiyou Trail. As the number of expeditions into California by fur trappers and military survey parties increased, hostilities and epidemics resulted in Indian deaths. However, Indian societies remained largely intact through this period because their culture, food sources, and trade networks were still in place (chase-Dunn et al. 1998, Cook 1943, Ellison 1974, Knudtson 1977, Sanchez 2003, Theodoratus Cultural Research 1981). [McTavish 2010. pg 48]

Spain tried to maintain full possession of California but did not have enough people in the area to defend against incursions by Russian, English, and American fur trappers. After the War of Independence from Spain in 1821, the Mexican government became increasingly concerned by the growing numbers of foreigners, especially Americans arriving from Oregon, who began to settle in the interior valleys of California. Many Americans settled as squatters, but some applied for land grants, which were given in exchange for becoming a Mexican citizen and pledging allegiance. Over 800 Spanish and Mexican grants were made in California. [McTavish 2010. pg 49]

With the Treaty of Guadalupe Hidalgo of May 30, 1848, the United States government assumed control of all of present day California, Nevada, Utah, most of Arizona, the western portions of New Mexico and Colorado, and part of Wyoming. The Treaty also called for the United States to recognize existing land titles and accept all people living in the ceded territory as citizens. William

Carey Jones was appointed Confidential Agent of the United States government and was to examine the land titles, and determine what rights the Indians held during the Spanish and Mexican regimes (Robinson 1948, Starr 2005). Jones's report was clear and direct. He confirmed that the Indians did indeed have secure title and right to their lands under the Treaty. [McTavish 2010. pg 53]

Squatters and Homesteaders

Though the Treaty of Guadalupe Hidalgo had promised continuous ownership of existing land grants, it conflicted with the view held by land-hungry settlers that California should be open to Americans (Robinson 1948). American squatters, impatient with the slow government process and contemptuous of the rights of the inhabitants already in California—be they Mexican, Indian, or American—organized into armed bands in an attempt to take over lands. Riots resulted; some of the worst were in Sacramento (Robinson 1948). Gwin sponsored "An Act to Ascertain and Settle the Private Land Claims in the State of California," which passed on March 3, 1851, Stat 631. The Act required that existing land titles had to be registered and affirmed by the Land Commission within a five-year period. If a claim was not filed with the Land Commission, the land was considered abandoned. Land from abandoned and rejected claims went back into the public domain to be surveyed and made open to settlement (Robinson 1948, Sanchez 2003). Very few claims were presented on behalf of the Indians. Many Spanish and Mexican land grants were also not presented. [McTavish 2010. pg 53]

Squatter troubles were not uncommon in California from the 1850s through the 1870s because so few titles had been confirmed by the Land Commission (Robinson 1948). Before any of this was settled, the Homestead Act was enacted in 1862, allowing any citizen or naturalized alien the right to claim 160 acres, provided they worked the land continuously for five years (Parsons 2003). [McTavish 2010. pg 54]

Un-ratified Treaties

In 1851, President Fillmore appointed three commissioners to conduct treaties with the California Indian Tribes. O.M. Wozencraft, Redick McKee, and George Barbour arrived in San Francisco in January 1851, with instructions to quickly conclude as many treaties as possible. Between March 19, 1851 and January 7, 1852 at various central meeting places throughout California, they met with 402 tribal heads – representing 139 tribes or bands of Indians, and entered into eighteen treaties (Ellison 1974, Heizer 1972, Robinson 1948). The designated reservations would have added up to 7,488,000 square acres of land, or 7.5 percent of the total area of the state. Wozencraft negotiated the treaty that included the Wintu. This treaty of peace and friendship was signed at Reading's ranch in Cottonwood on August 16, 1851 (Heizer 1972, Hoveman 2002).

The eighteen treaties were sent to the United States Senate on June 1, 1852. Most Californians were opposed to having the government sign treaties with the Indians. The Americans in California believed the reservations included valuable land that should be reserved for mining and farming instead of for Indians. Despite President Fillmore's recommendation that the treaties be confirmed, Congress not only rejected every one of the treaties, they also ordered them sealed in a secret file, where they remained for fifty-three years. The injunction of secrecy was not removed until January 18th, 1905 (Goodrich 1925, Heizer 1972, Hoveman 2002, Sanchez 2003).

Eventually some temporary reservations were set up, some of which were later given permanent status by executive order (Ellison 1974, Theodoratus Cultural Research 1981). Writing about the treaties, Heizer said,

> "Taken all together, one cannot imagine a more poorly conceived, more inaccurate, less informed: and less democratic process than the making of the eighteen treaties in 1851-52 with the California Indians. It was a farce from beginning to end" (Heizer 1972). [McTavish 2010. pg 58].

Railroad Expansion

The Railroad Act of July 25, 1866, authorized construction of a railroad and telegraph line through the Sacramento and Shasta valleys to Portland. With a right-of- way 400 feet wide, plus patents for twenty alternate sections per mile, the railroad was granted up to 12,800 acres per mile of completed line (Robinson 1948). The United States extinguished the Indian titles that conflicted with railroad titles, but did not extinguish homestead or mineral claims (Robinson 1948). The railroad patents created the checkerboard pattern of land ownership still seen in Shasta County, California. [McTavish 2010. pg 61]

The arrival of the railroad affected the Wintu as well, destroying Wintu transportation corridors, sacred sites, and historical villages. Colton's 1876 map shows Dog Creek, where as many as 1,500 Wintu assembled each year in July to gather salmon for the winter. Building the railroad destroyed this site (Hoveman 2002). Copper mining and smelting industries also grew, resulting in considerable damage to the landscape (Radcliff 1913).

In the United States as a whole, 9.5 percent of the public domain was patented to railroads (Robinson 1948). In California alone, between 1850 and 1880 over 16 million acres were patented to different railroad companies. Figure 2.1-2 shows that by 1880, railroads possessed sixteen percent of the land in California (Sanchez 2003, Short 2001, White 1983). [McTavish 2010. pg 63-64]

Extending the railroad north from Redding toward Oregon along the Sacramento River in 1883 fouled the water badly, reducing salmon egg production. [McTavish. 2010. pg 70]

Indian Allotments

Indians were prohibited from owning or leasing land, selling timber, mining, or pursuing other income-generating activities. By 1853, Indians were starving and begging for food. Congress appointed Edward Beale as the first Indian superintendent for California (Hurtado 1988). The administrations of Beale and his successor, Col. Thomas J. Henley, lasted over a decade and were rife with corruption and incompetency (Hoveman 2002, Sanchez 2003). Cattle for starving Indians wound up with subagents; reservation boundaries were changed, land was lost to squatters; vouchers were irregular; and the books were incomplete (Hoveman 2002, Sanchez 2003). It was not until the 1870s and 1880s that the efforts of humanitarians advocating reform of the living conditions and treatment of Indians began to make a difference. [McTavish. 2010. pg 65]

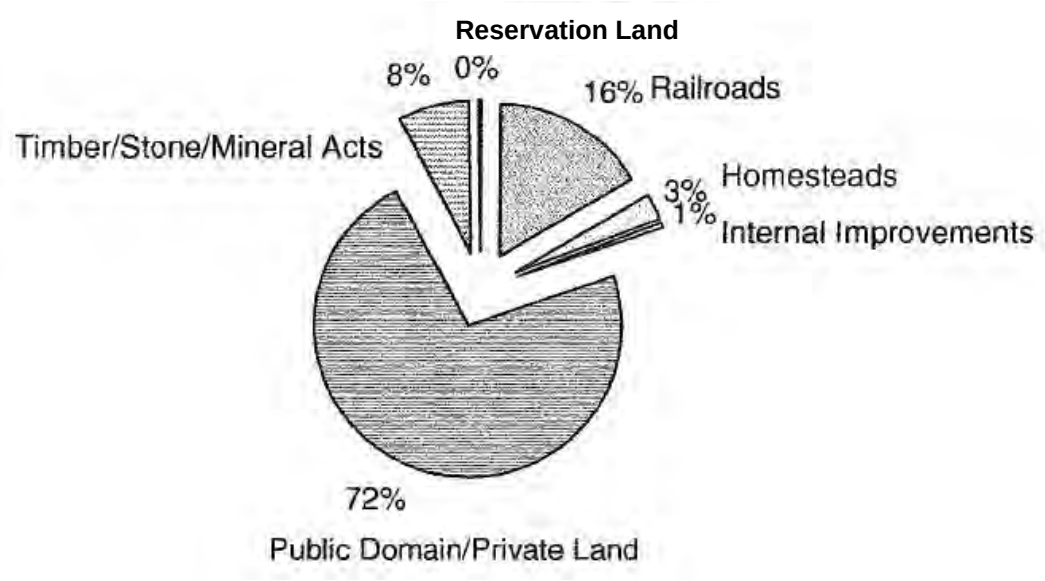

Figure 2.1-2. Ownership of California Land from the Public Domain in 1880 (Sanchez 2003).

From 1846 to 1884, Indians could not acquire land because they were not citizens. Jeremiah Curtin reported in 1889 that the conditions for the Wintu were such that "There was not a spot of land where they could build a hut without danger of being ordered away from it" (Theodoratus Cultural Research 1981). Moved by their plight, Curtin transcribed the Wintu and Yana petition and delivered it personally to President Harrison in May 1890 (Hoveman 2002). [McTavish 2010. pg 77]

Under pressure from influential social reformers, Congress struggled for two decades to develop a new Indian policy. Congress wanted to identify more land for white settlement, to reduce the cost of treaty obligations to tribes, and to satisfy the reformers. The reformers wanted more education, less abuse, and less poverty for the Indians. Both Congress and the reformers believed the best approach was to assimilate Indians into mainstream American society. The General Allotment Act of February 8, 1887, 24 Stat. 388, generally known as the Dawes Act, also referred to as the Indian General Allotment Act, the Committee on Indian Affairs Act, and the Severalty Act (*Dawes Act* 1887), provided for reservations to be divided and allotments be given to individual Indians. Less known is that Clauses Four and Five of the Dawes Act provided a means for providing allotments to landless Indians (Goodrich 1925, Sutton, 2003, Thomas 1971). [McTavish 2010. pg 79]

In 1891, the Bureau of Indian Affairs (BIA) appointed Special Agent Michael Piggott and the first allotments were made for the Wintu. The early letters between Piggott and the Commissioner (of the BIA) in Washington reflected efforts to efficiently carry out the goal of getting land for the homeless Indians. The bureaucracy balanced the will of the President, the laws of Congress (Dawes Act and PLSS), and the rules of the agency (appointment, budget, paperwork). Piggott appears to have made every effort to secure allotments. But, given the poor condition of the land, shortage of water, and lack of start-up farm equipment, animals, or seed, most Indians could not make a subsistence living from agriculture on the allotments. Because so much land had already been patented to the railroads, the allotments were discontinuous, which fragmented the Winnemem Wintu and made it difficult to maintain a tribal relationship with the BIA agents. Agent efforts to secure replacement land were

often half-hearted, underfunded, or blocked by private owners. Agents frequently supported the efforts of interested buyers to purchase allotment land because they believed the land was useless to the Indians. [McTavish 2010. pg 99]

If the Agents had bought land for a village, the act of purchasing land for the Wintu and the spatial nature of a village would have established the beginning of a tribal relationship with the BIA. While the agents wrote to people who inquired about land, no letters were found in the National Archive files to suggest the allottee was simultaneously consulted regarding the potential sale. Available land was rapidly disappearing from Shasta County. The effects of this failure to secure land and create a village for the Winnemem Wintu were compounded over time. [McTavish 2010. pg 94]

In 1906 C. E. Kelsey, a special agent for Indian Affairs, reported that 2,058 allotments had been made in California with 261 canceled, leaving 1,797 outstanding. The majority of these allotments were in Lassen, Modoc, Plumas, Shasta, and Siskiyou counties (Robinson 1948, Theodoratus Cultural Research 1981). [McTavish 2010. pg 79]

Shasta Dam

The site of Shasta Dam may have been a logical engineering solution but was selected without regard to Indian traditions or values. When Shasta Dam was completed, it created the largest man-made lake in North America, covering traditional Winnemem Wintu ancestral villages, homesteads, cemeteries, and sacred sites. It submerged most of the habitable terrain, including the Baird Fish Hatchery, Kennett, Copper City, and the Pit River Railroad and it blocked the salmon run that used to fill the rivers (Clark 2005, Franco 2007). [McTavish 2010. pg 105]

Among the many tasks required in order to build Shasta Dam, the USBR had to acquire the Redding Allotments and move the graveyards that were below the impoundment level of Shasta Lake. Of the 196 Wintu Redding Allotments (located for the McTavish study), 157 were in the Shasta Reservoir area. How much time and resources the USBR dedicated to acquiring title for the Indian Allotments from 1938 through 1941 isn't known. Each allotment case was unique. Determining the ownership and probate status, finding all the heirs, and completing the document search must have been time-consuming. Acquiring all the allotment titles was far from completed in 1941. Faced with the realization that lack of titles to the allotments might actually hold up progress on the project, the USBR turned to Congress for assistance. The Central Valley Project Indian Lands Acquisition Act of July 30, 1941, 55 Stat 612, gave the USBR "all the right, title, and interest of the Indians in and to the tribal and allotted lands within the area embraced by the Central Valley Project." The funds were to be deposited with "the superintendent of the appropriate Indian Agency." [McTavish 2010. pg 115] Given the issues with probate and the difficulty of finding all the heirs it seems unlikely all the money was distributed [McTavish 2010. pg 123]. The Winnemem Wintu Tribe considers this a justice issue and continues to press the federal government to fulfill all the CVPILAA provisions and to provide payment and/or like lands for the allotments now under the lake.

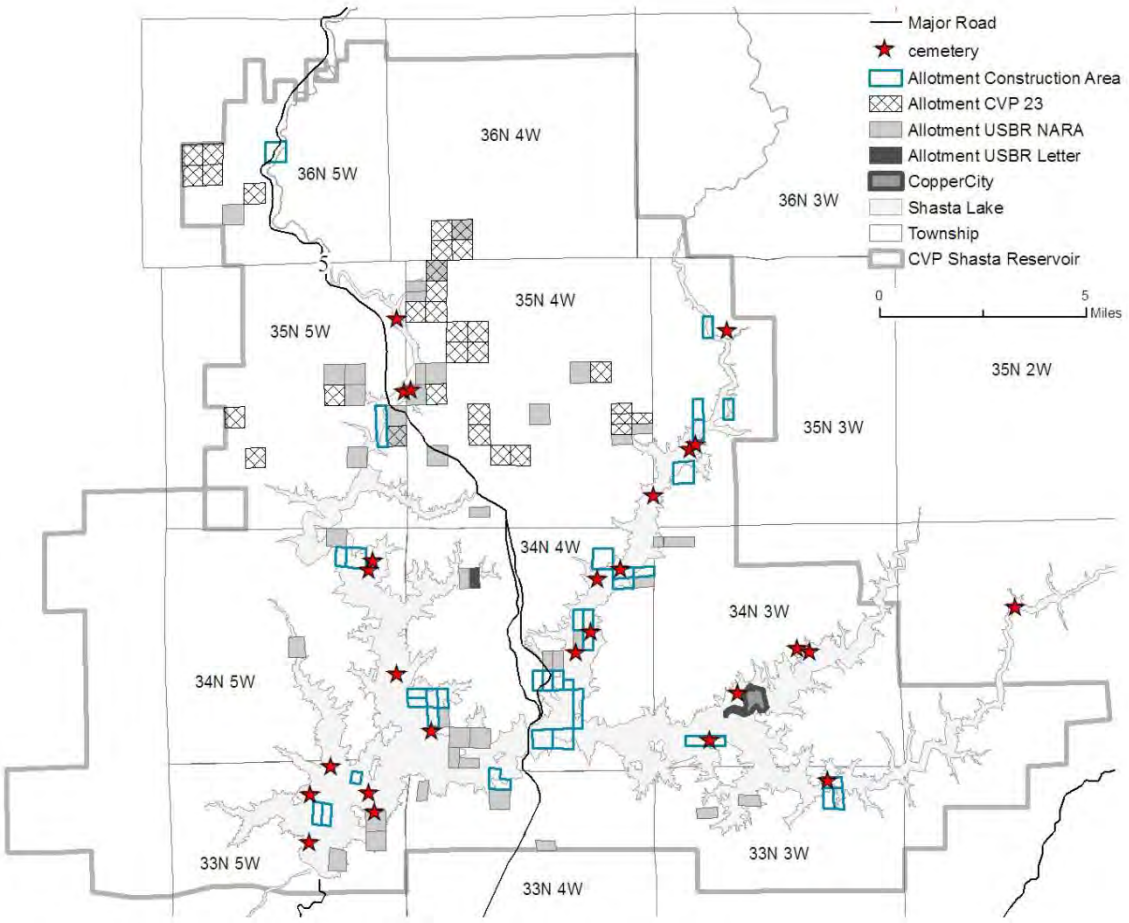

Figure 2.1-3. Shasta Reservoir area showing the 72 allotments the USBR needed to acquire for CVP Shasta Dam in relationship to the graveyards that had to be relocated. None of the allotments outlined in blue were identified in any of the available USBR documents, yet Calland wrote, "A considerable area of the lands involved have actually been taken for construction purposes." In order to confirm that the allotments were acquired by USBR, "appraisal report for Unit No. 6-S, Shasta Reservoir, appraised June 22, 1939" would need to be located (CVP Shasta Dam 2006a, 2006b; Bureau of Reclamation 1947). (Source: compiled from *CVP Problem 23* map, Letter from Young to Nash, Redding Allotments, USBR National Archive files, USBR Graveyard map, BLM PLSS, ESRI Data Disk, Cal-Atlas). [McTavish 2010. pg 118]

Continued Involvement of the Winnemem Tribe in Affairs of Their Aboriginal Lands

In 1924, in gratitude for their service during World War I, the federal government granted Indians citizenship and the right to vote. Equally as important, in 1926 they were granted the right to sue. This would give the Winnemem Wintu, along with other California Indians, a chance to get back on the map. Their struggle moved into the legislature and courtroom. [McTavish 2010. pg 95]

Generally, Indians learned to be guarded about the location of sacred sites because of the appeal they have to a variety of non-Indian groups. The Winnemem Wintu are no exception, but Panther Meadows on Mount Shasta became very public when they participated in a successful cooperative effort to stop plans to build a ski resort there. This $21 million project was to accommodate 5,000 skiers a day with seven lifts and three lodges (Beggs et al. 2003). The U.S. Forest Service completed

the EIS in 1990, found it to be in compliance with the multiple-use classification of the mountain, and approved the project. Opposition to the ski resort united diverse groups such as *Save Mount Shasta*, the *Native Coalition for Cultural Restoration of Mount Shasta*, two nonprofit Indian tribes and various other organizations. Using the 1966 National Historic Preservation Act, they succeeded in getting the U.S. Forest Service to reverse the decision in 1998 (Huntsinger and Fernandez-Gimenez 2000). The U.S. Forest Service found "Contemporary Indian uses of Mount Shasta are clearly rooted deeply in traditional values and beliefs. The spiritual and secular activities being practiced today on Mount Shasta are consistent with historic Native American activities" (Theodoratus et al. 1991 in Huntsinger et al. 2000).

Cultural conflict continued in various forms after the U.S. Forest Service withdrew the permit for the ski resort. Panther Meadows is an alpine wildflower meadow that attracts environmentalists, hikers, rock climbers, and New Age spiritual pilgrims. To provide visual and physical separation from the path and to protect the spring, U.S. Forest Service built a U-shaped rock wall that now surrounds it on three sides. [McTavish 2010. pg 132]

2.2 Euro-American Exploration and Settlement

In the early part of the 1840s, word of the apparent fertility and wealth of land and resources in California, accompanied by the weakening control of the territory by the Mexican government, prompted many people to emigrate (Cleland 1922). The watershed remained unsettled and relatively unexplored by Euro-Americans until after 1848, when the discovery of gold at John Sutter's sawmill in Coloma on the American River opened the floodgates of immigration. Nearly 100,000 people had moved to California by 1849 and nearly 250,000 people by 1852 (California State Parks 2007).

This section of Chapter 2 discusses Euro-American exploration, settlement, and development in the upper Sacramento River watershed and how, historically, Euro-Americans have interacted with and influenced natural resources and the landscape.

2.2.1 The Fur Trade and Early Exploration

The earliest known use of the watershed by Euro-Americans occurred in the early 19th century. The Hudson's Bay Company's Southern Brigade trappers and traders, led by Alexander Roderick McLeod, John Work, Michael Laframboise, Thomas Mckay, Peter Skene Ogden and others, worked their way through much of northern California between 1826 and 1845 (Mackie 1997). Headquartered in Fort Vancouver in modern-day Washington, the Southern Brigade was organized to focus the fur trapping endeavors of the Hudson's Bay Company on modern-day southern Oregon and California (Mackie 1997). Each expedition of the Southern Brigade was headed by one individual and included around 20 trappers and 60 auxiliary party members, including the usually Native American wives of the trappers, their children, and Native American men hired or enslaved as laborers (Mackie 1997, Hafen 1983). John Sutter, an early settler who received a Mexican land grant in 1840 at present-day Sacramento, recounted a visit of the Southern Brigade in the lower Sacramento Valley as being of sufficient size that "when they pitched their tents it was like a village" (Dana 1934, Mackie 1997).

Alexander Roderick McLeod led the initial expedition in 1828 into and through the Sacramento Valley, eventually reaching the San Joaquin River near present-day Stockton in 1829 (Galbraith 1955). He was followed by Peter Skene Ogden in 1829 and Michael Laframboise in 1834, both of whom trapped along the Sacramento River to the San Francisco Bay. Two trapping expeditions led by John Work from 1832–1833 and Thomas Mckay in 1836 also entered the area and concentrated on trapping along the Pit River, making occasional forays into the Sacramento Valley (Mackie 1997). The goal of the trapping parties was primarily beaver pelts, although they would take otters and other fur bearing mammals of economic value when encountered. The reason for this narrow focus on specific furs was in large part due to a fashion trend for felt hats that began in Europe during the 17th century (Ray 1999). As demand for felt hats increased, more and more regions and people became enmeshed in the fur trading economic system, and as animal supplies were depleted in a given area, more and more regions were exploited, thus drawing "diverse regions into a single economic network, which, in turn, was linked to the expanding world economic system centered in Western Europe" (Ray 1999: vi).

This "world economic system" became focused on the upper Sacramento River watershed by the early 19th century and brought with it extreme changes to traditional Native American ways of life, as well as habitat changes brought about by the wholesale removal of animals important in the functioning of the environment. In particular, beavers influence water and sediment movement along channels because of their dams. The dams create ponds that act as sediment traps creating swamps and meadows where different vegetation regimes can take hold (Wohl 2005). These areas also act as flood control, flattening out flows and slowing down the water velocity (Wohl 2005). When beavers are removed from stream systems, rapid incising of channels follows, leading to increased erosion and a less diverse habitat (Wohl 2005). The removal of beaver from the watershed had a profound effect of unknown extent on the environment, creating changes in plant and animal regimes.

2.2.2 Fisheries

The State of California was formed in 1850, and laws regulating the hunting and capture of various game and fish were immediately implemented (see Section 2.3, *Evolution of Laws and Regulations Affecting the Watershed*). However, early laws regarding game and fish were rarely, if ever, enforced, and unrestrained fishing, coupled with the environmental destruction caused by hydraulic mining and the construction of railroads led to a severe decrease in fish in the streams and rivers of California (Lufkin 1990). As a means of improving fisheries, especially commercial and game fish, and enforcing laws, the Board of Fish Commissioners was created in 1870 (Leitritz 1970). The Board was tasked with creating "fish breederies" for stocking streams and lakes and general habitat improvement (Leitritz 1970).

One of the earliest fish hatcheries in California was the Baird Hatchery built on the McCloud River near the confluence of the McCloud, Pit, and Sacramento rivers. Established in 1872, this was the first public salmon breeding station not only in California but also on the West Coast (Leitritz 1970). Egg collection for propagation was one of the many tasks performed at the Baird Hatchery, and the number of eggs available was found to fluctuate annually while exhibiting an overall decline. In 1893, the lowest number of eggs was taken since the founding of the hatchery. The low number was attributed to the construction activities of the Oregon-California railroad line (Leitritz 1970). The blasting and construction of the railroad disturbed the salmon and other fish and deposited debris in

the waterways. In addition, salmon were collected to feed the railroad workers, and still more fish were destroyed for amusement by the railroad workers (Leitritz 1970). In 1884, the hatchery was closed due to diminishing returns; however, it was reopened in 1888 to supply the new hatchery that had been established near the present-day City of Mt. Shasta, and remained in operation until 1935, when construction of Shasta Dam began (Leitritz 1970). In 1898, two smaller egg-collecting stations were placed near Sims in the Sacramento River canyon (Leitritz 1970). The stations were placed in Hazel and Mears creeks in an attempt to gather rainbow trout eggs, but, due to low water years and lack of fish runs, were removed in 1899 (Leitritz 1970).

The Sisson Hatchery (now the Mount Shasta Hatchery) was established near the present-day City of Mt. Shasta in 1888 on a tributary stream to the Sacramento River. It is reported that J. H. Sisson, the original owner of the land upon which the hatchery is located, had installed a trout pond on his property in an effort to provide fishing opportunities for the guests at the Sisson Tavern, a stage stop along the Oregon-California Road (Leitritz 1970). The location of the hatchery was chosen for its water supply and proximity to the railroad line, which facilitated shipping the fish throughout the state (Leitritz 1970). In 1950, the hatchery was modernized, the old ponds and several old buildings were removed, and at least 24 new ponds were created (Leitritz 1970). The hatchery has continuously propagated salmon and trout varieties and is still in use today

The building of Shasta Dam created a major change in the fisheries in the Upper Sacramento watershed. The salmon runs that accessed the many tributaries of the upper Sacramento River were now prevented from migrating upstream, and the flow of cool water downstream was curtailed (Bureau of Reclamation 1984).

2.2.3 Mining

Historically, mineral exploration and subsequent mining operations were conducted throughout the upper Sacramento River watershed. Mining activities began upon the arrival of the Euro-American settlers during the California Gold Rush (circa 1850) and were typically small- to medium-scale operations. Immigrants from China, Mexico, and South America also came to the area to find their fortunes. Historic accounts and news articles from that time speak of animosity between the Euro-American settlers who moved into the area to mine and Native Americans who inhabited the watershed. Tensions were also high between Euro-American settlers who were hungry for gold profits and settlers from other countries, who were viewed as unfair competition and outsiders who were not entitled to the bounty of these lands.

The earliest mining operations tended to be located in portions of the watershed that were accessible by wagon road. Subsequently, numerous transportation corridors were built to access and transport minerals, including trails, roads, and railroads, all of which provided access to the steep mountain terrain characteristic of the area.

Mining activity continued following the Gold Rush, but went through boom and bust periods as the focus shifted to other minerals, including copper, chromite, zinc, silver, limestone, and asbestos, which were mined extensively during the turn of the century era (circa 1890 to 1920). The surges in mining activity in the watershed typically ended as quickly as they started. For example, the rush to find gold was generally over in about 5 years. What started in the watershed in 1850 was nearly over

by 1855, by which time most of the easily accessible gold had been taken from the riverbeds. With the exception of Dog Town (Vollmers and Delta), most towns that had sprung up along the river and its tributaries had emptied, and many of the inhabitants headed on to other locales to seek their fortunes (Vaughn 2004).

The bulk of the mining activity in the watershed subsided by 1920. Although activity picked up during the Great Depression and again during World War II, the mining era that defined the watershed was over. Mineral production during the Great Depression increased primarily because it became cost effective due to cheap labor and the high prices paid for metals. The increased mining activity during World War II was due to the increased demand for mineral resources for the production of steel and other wartime materials. These needs coincided with government subsidies (Rawls and Orsi 1999, Orre 1999).

A discussion of specific early mineral prospecting and mining operations that occurred in the watershed is provided below.

Mining Operations

Gold Mining

In 1843, the Chiles-Walker party entered California, and Pierson B. Reading, a man who would have a significant impact on the history of Shasta and Trinity counties, was a member of this party (Cleland 1922). In 1844, the Mexican government granted Reading the 26,633-acre Rancho Buenaventura land grant located in the area of modern-day Redding, just south of the upper Sacramento River watershed (Bancroft 1890). Most of the early settlement in California was located along the Pacific Coast and in the Sacramento Valley, and Reading's land grant was the most northerly of the Mexican grants. In 1848, after visiting the land near Coloma, Pierson B. Reading realized the geologic similarity between his land along the Sacramento River and the gold bearing regions of the Sierra Nevada foothills (Hittell 1898). Reading began prospecting in the Redding area with a crew of Native Americans, discovering gold 5–6 miles up Clear Creek from its confluence at the Sacramento River (Bancroft 1888). Reading also discovered gold in 1848, at the mouth of Reading's Creek on the Trinity River near present-day Douglas City. Along with a crew of "three white men, one Delaware, one Chinook, and about sixty Indians from the Sacramento Valley," and a good supply of cattle and provisions, Reading worked the placer gravels for about six weeks, recovering 80,000 dollars worth of gold. He abandoned his diggings when confronted by parties of miners moving into the area who disliked his use of Indian labor (Federal Writer's Project 1939). Reading's discovery of gold in the foothills and mountains west of the Sacramento River signaled the opening of the northern mines and created the impetus for a large influx of miners and settlers into the watershed.

The discovery of gold sparked mass migrations to the watershed. As word spread across the world via explorers and merchants, Euro-American and foreign settlers hungry to make a fortune responded quickly. They traveled to the area by horse and wagon, and by sea. Foreign settlers came from as far away as Central and South America and China (Eidness 1997).

While there was some early gold prospecting done by Euro-American settlers in the northern portion of the watershed near Mount Shasta, these prospectors generally turned up empty handed. Most of

the successful early gold prospecting occurred in the southern portion of the watershed, which was more easily accessed via the shipping ports of San Francisco and Sacramento, as well as from wagon roads leading up through the Sacramento Valley. The deep river canyon, which separates the Sacramento Valley in the south from the Shasta Valley in the north, also acted as a physical barrier to the early gold prospecting efforts in the watershed (Vaughan 2004, McDonald 1979).

Historic accounts tell of the migrations of Euro-American settlers from Oregon, which were first led by Linsdsey Applegate in June 1849. He and six wagons traveled the route walked by McLeod's band of trappers; they headed south across the Siskiyou Mountains and down into the Shasta Valley in search of gold, but eventually returned to Oregon. There is no record of their success or failure in prospecting, but we can assume that their retreat to Oregon meant they did not find gold in the Shasta Valley or in the northern portions of the watershed (McDonald 1979).

Other early gold prospecting in the northern reaches of the watershed occurred shortly thereafter. In July of 1850, a posse of 40 prospectors, all men, joined a small group that was on a Klamath River expedition. Together they worked their way up the Klamath River and down the Sacramento River. These men had begun their prospecting expedition a month earlier on the north fork of the Trinity River (Helena), and from there made their way north and east over the mountains and through the riverbeds, until they worked their way up the Shasta River to Mount Shasta. The group then headed south through the upper Sacramento River watershed, where they met with Native Americans in the river canyon. In 1855, after years of bloodshed in the canyon, the Native Americans were outnumbered and outgunned, and they lost their holdout in the Castle Crags area. Gold prospectors immediately established claims and began gold mining operations in the Castle and Soda Creek areas (McDonald 1979).

Around the same time, the southern portion of the watershed was expanding because of gold mining activity. Shasta County was established in 1850 and the City of Redding, which lies several miles to the south of the watershed's southern boundary, served as the central supply center for gold miners in northern California. While the southern portion of the watershed did not produce the amount of gold areas due west and south did, several successful mining operations were established that produced notable amounts of gold. These gold mining settlements, which sprang into existence around 1850, generally fizzled out of existence by 1855. The operations were located in the Delta, Girard, and Tom Neal Creek areas, at Portuguese Flat (Pollard Flat) and other places adjacent to the Sacramento River (Parsons 2003b, Orre 1999).

Gold had been discovered on Dog Creek in 1850 (near Vollmers and Delta), but the area was not settled or mined by Euro-Americans and other nationalities until 1855, when the conflicts between Native Americans and settlers were ended. This area became the largest and richest gold-producing area of the upper Sacramento River canyon. In 1855 there were approximately 400 miners living in the area known as Dog Town or Dog Creek Place, located at the confluence of Dog Creek and the Sacramento River. However, by 1880, the Dog Creek mines were tapped out, and the boomtown became a town of only 25 (Vaughan 2004).

As noted above, gold mining activities in the watershed were sporadic and ended shortly after they began. In general, the easily accessible gold was taken quickly from riverbeds and exposed bedrock. The gold that remained was more difficult and more costly to access and produce. The more destructive methods of mining, namely hydraulic mining, were essentially stopped by legislation

initiated by angry farmers whose land was covered by dredge spoils and whose water was polluted by the sediments flowing downstream from the hydraulic mines. Legislation for clean water did not stop the practice, but the rules it set in place made the practice too costly. It is worth noting that a significant portion of the gold extracted from the watershed was mined primarily from 1880-1920, after the Gold Rush, as a byproduct of copper processing operations.

Copper, Chromite, and Other Mining Activity

The Gold Rush spurred additional mineral prospecting in the watershed. In the late 1890s to 1920s, copper and chromite replaced gold as the primary minerals produced in the area. While the early mining days saw individuals from the United States and foreign countries seek their fortunes in these mountains, the copper and chromite mines brought large-scale investment from national and foreign companies. The copper extraction and processing that occurred in the watershed was located in and around the area that is now the Sacramento arm of Shasta Lake. The principle copper deposits were located in a 30-mile crescent shaped copper-zinc belt extending from Iron Mountain (southwest of the watershed) northeast through Backbone Creek and beyond the watershed to Ingot in the east (Elliott 1991, Smith 1999). Most of the chromite mining took place on the west side of the Sacramento River between Pollard Flat and Castella (Parsons 2003b, Aubrey 1908, California State Mining Bureau 1915, Orre 1999).

Copper was discovered in the area in the 1850s, but was first mined at Copper City (which is now under Shasta Lake) in 1862. At that time, the copper was found in small quantities by miners who were exploring underground for gold and silver. It was shipped to San Francisco and beyond for quality inspection and processing, and was reportedly found to have high quality. However, not much was thought of it by the miners at that time. It was not even recognized by Shasta County as an important mineral resource of the county until 30 years later. Even if it had been, the price of copper dropped for a time and made it uneconomical to mine until the 1890s (Aubrey 1908, California State Mining Bureau 1915).

As soon as copper prices rose and people became aware of the potential money to be made, they again flocked to the area to stake claims for copper mines. Where previously there had been several attempts to mine for gold and silver, albeit not too successfully, a copper industry popped up overnight. Instead of shipping the ore out of town for processing, the mining companies built and operated large copper smelting plants in the mountains. To the prospectors' delight, the copper ore in the watershed also contained valuable gold and silver. Even though the amount of gold and silver was not large compared to the amount of copper, the profit from these metals was significant (Aubrey 1908).

The first copper smelter was built south of the watershed in Keswick. The area in and adjacent to the watershed became home to numerous large smelters (Parsons 2003b). The Iron Mountain District, which covered areas in and around the Sacramento arm of Shasta Lake, eventually became the most important copper district in Shasta County. It included the Balaklala, Keystone, Mammoth, Shasta King, and Sutro mines (Aubrey 1908, Smith 1999, California State Mining Bureau 1915). The town of Kennett served numerous copper mines in this area, but is now under the waters of Shasta Lake (Aubrey 1908).

Local mining of chromite was limited because the costs associated with processing the ore were often more than the profit that could be earned. While there was plenty of ore to be mined, it was done on an as needed basis. Accounts of the chromite industry note that it was only profitable to mine when the U.S. government subsidized the mining operation (Parsons 2003b, Orre 1999).

The decline of the copper and chromite industries in California occurred shortly after World War I, but like other mineral production, copper and chromite were mined sporadically during the Great Depression and World War II (Parsons 2003b, Elliott 1991).

Euro-American and foreign settlers also prospected for several other minerals in the mineral rich watershed. The areas mined and timeframes generally mirror that of copper and chromite (circa 1890 to 1950).

Although not documented as the Silver Rush, much of the early and later gold exploration in the watershed included silver prospecting and mining. Gold, however, overshadowed these efforts, which were ongoing throughout the mining era (1850 to 1950). As mentioned above, the quantities of silver found by the miners was not great, but the profit from the mines was significant (Aubrey 1908, California State Mining Bureau 1915).

Asbestos was another mineral that was discovered in large quantities throughout the watershed. Several asbestos claims were developed during the early 1900s near Castella and Mears Creek (California State Mining Bureau 1915). The Trinity Asbestos Mining Company was responsible for planning the road between Castella and Carville, which is located to the east in the Trinity River watershed. The company's plan was eventually carried out by the U.S. Forest Service (Forest Service). Asbestos from the watershed was used regionally in the manufacture of pipe covering, composition flooring, and plaster for stucco. In the 1950s, asbestos from the area was used by a Redding paint manufacturer in fire-resistant paint marketed under the name "Syl-a-bestos." The paint was used in US Plywood and R .L. Smith Lumber Company sawmills (Orre 1999).

Another mineral sometimes mined in conjunction with chromite was olivine**.** The Lucky Strike Mine near Castella produced both minerals. Olivine became an important material for steel manufacturing because it can withstand higher temperatures, is easier to clean off the castings, and does not crack or shatter. Its use also prevented steel foundry workers from contracting silicosis (Aubrey 1908, Orre 1999).

Although not a mineral, sand and gravel have been extracted along the Sacramento River and its tributaries for many uses throughout the years. For example, the river rock from Sims was mined by the state for several years and was used to build Highway 99. The river rock from this source was sufficient to meet strict engineering properties required for freeway construction. The material for the highway was processed locally in a temporary hot mix plant and crushing and screening plant (Vaughan 2004, Orre 1999).

Methods Used to Mine

Several different processes were used by settlers and later generations of residents of the area to separate the choice minerals from other materials. The processes ranged from the very simple, small scale, crude methods (panning and digging) to very technically advanced, large scale operations

(placer and hydraulic). Often times, techniques for extracting minerals were imported from other countries and adapted to local circumstances (e.g., arrastas[1] from Mexico and Central and South America), while other techniques used in the watershed were developed in California (e.g., hydraulic mining) (Vaughan 2004, McDonald 1979). The more complex placer mining operations would often involve groups of prospectors who would combine efforts to divert large amounts of water from creeks or rivers into a sluice alongside the river. They would then dig for gold in the newly-exposed river bottom (Praetzellis and Praetzellis 1993, Rawls and Orsi 1999). Hydraulic mining operations, which would hose off entire hillsides to get to ancient gold bearing veins and which was typically done by companies and individuals with large amounts of money, was not widespread in the watershed.

Miners also engaged in "hard-rock" mining, which entails extracting the gold directly from the rock that contains it. This was usually done by digging and blasting the land and then removing the exposed veins of the gold-bearing quartz (Praetzellis and Praetzellis 1993, California State Mining Bureau 1915). Once the gold-bearing rocks were brought to the surface, the rocks were crushed and the gold was separated out (using moving water) or leached out, typically by using arsenic or mercury (sources of environmental contamination). This method was used to a significant degree throughout the watershed (Aubrey 1908, Praetzellis and Praetzellis 1993, Rawls and Orsi 1999). Regardless of the method used, miners left an indelible mark on the shape and character of the watershed, remnants of which are still visible today.

The mining industry required large amounts of lumber to build and maintain its infrastructure. Milled lumber was used for housing, water flumes, support structures, and other constructs, and fuel wood was necessary to keep steam-powered equipment running. This spurred the development of the timber industry in the 19th century, which remained an integral part of the watershed area well into the 20th century.

2.2.4 Timber

Timber Use in the Early Years (1850-1945)

The amount of early logging in the watershed was quite modest, confined primarily to the selective "high grading" of mature ponderosa pine (*Pinus ponderosa*) and sugar pine (*Pinus lambertiana*) from the most accessible areas for localized use by early Euro-American settlers. Rugged, steep terrain with few access routes and only patchy stands of mature conifers throughout much of the watershed deterred many lumber companies from moving into the area. Rather, they favored the more easily accessible and somewhat gentler topography that supported contiguous stands of merchantable timber located in the upper watershed to the west and south of the community of Sisson (present day Mt. Shasta).

As discussed above, by the 1890s, mines and communities of various sizes dotted the watershed, primarily in its southern and northern ends. It was around this time that a number of lumber mills began operating in the watershed near the present day communities of Castella and Lamoine. This coincides with the advent of railway access between Redding and the Mount Shasta area via the

[1] *Arrasta is a method of crushing and recovering gold. The ore is placed in a hole and mercury added. The ore is ground and the mercury absorbs the gold into itself. At the end of the process, the amalgam is recovered and the gold extracted.*

Sacramento River canyon in 1887 (see Section 2.2.8, *Transportation History*). The presence of the railroad allowed for easier transport of logs and wood products out of the canyon, thus encouraging some lumber companies to expand their timber harvest operations further into the watershed. Flumes, steam donkeys (steam-powered logging engine), and narrow gauge railroads were used to move logs out of the surrounding mountains to mills or railheads. By 1896, the railroad had opened up the entire watershed to timber harvest, cattle grazing, and recreation (USDA Forest Service 2001). Virgin stands of ponderosa pine in the lower elevation drainages of the watershed accessible by narrow gauge railroads were nearly clearcut, leaving significant accumulations of logging slash (USDA Forest Service 2001). Often, these areas reverted to seral (intermediate stage) shrublands and knobcone pine (*Pinus attenuata*) following the occurrence of fire. Large stands of old growth timber in the Deer Creek, Castle Creek, Ney Spring, and North Fork Sacramento River drainages were harvested and burned. Old-growth dependent wildlife species populations declined as habitat became fragmented or was eliminated on the lower slopes of the Sacramento River headwaters. During this period, the logging practices of the day, which were generally conducted with little or no regard for its effect on riparian or aquatic resources, had a significant impact on streams (USDA Forest Service 2001) by contributing to erosion, sedimentation, and loss of biological habitat.

As logging in the watershed increased, the structure and composition of the forest began to change (USDA Forest Service 2000). However, such changes during this period were relatively minor in comparison to the years following World War II (which is discussed in the following section). Most logging during these pre-war years occurred in the low- to mid-elevation mixed-conifer zone (USDA Forest Service 2001) and consisted of selective harvest. Although prior to 1930, lands reserved under the National Forest System (established in 1905) made up only a very small portion of the watershed, one of the earliest records of active forest management in the watershed by the Shasta National Forest dates back to 1908. At that time, the Shasta National Forest conducted a timber sale on its lands in the Castle Crags area (USDA Forest Service 2001). Hundreds of thousands of trees (cedar, fir, and pine) were harvested and the brush was burned (USDA Forest Service 2001). Throughout the watershed, reforestation was slow and dependent on natural processes. Thus, seral shrubs often overtook lands that were once forested.

Increasing settlement of the watershed and increasingly active forest management by federal agencies and local landowners led to a rise in fire suppression efforts beginning around 1920. With the end of World War I in 1918, there was now the work force available to actively suppress wildfires throughout the western United States. After 1920, suppression of all fires on the Shasta National Forest and the adjoining Trinity National Forest lands was attempted as suppression forces grew and the ability to enforce aggressive fire prevention policies improved (USDA Forest Service 1999). However, fire-fighting efforts were primarily directed at the most accessible and heavily settled areas to protect human life and private property (Frost and Sweeney 2000). Some studies suggest that fire suppression efforts prior to the 1940s likely had little effect on the character of vegetation across large portions of the Klamath Mountains (Frost and Sweeney 2000, Taylor and Skinner 1998). Nevertheless, the effect of active fire suppression on forests adapted to frequent fires, such as the mixed-conifer forests of the upper Sacramento River watershed where the fire return-interval ranged between 3 and 7 years on average (USDA Forest Service 1999) and where selective logging was standard practice, was not necessarily conducive to sustainable forest health. Where frequent fire (or logging) did not reduce stand density and competition levels, changes in the composition and structure of the forest resulted in crowded, closed canopy stands over time. Old growth and less

shade tolerant species such as ponderosa pine and Douglas-fir (*Pseudotsuga menziesii*) were eventually replaced by the more shade tolerant white fir *(Abies concolor)*. In addition, significant accumulations of surface and standing fuels increased the risk of large stand-replacing fires within the watershed. Three significant fires (>600 acres) were recorded in the watershed between 1922 and 1939 (USDA Forest Service 2001). A discussion of the role that fire suppression has played in the watershed is provided in Section 3.1.8, *Fire and Fuels*.

In 1930, a major part of the cutover lands in the headwaters of the watershed, located at the base of Mount Shasta, came under federal ownership as a result of land exchanged with private timber companies (USDA Forest Service 2001). The Depression years of the early 1930s not only affected the private sector, but the Forest Service as well. As more and more lumber companies were forced to cease operations in the national forests, federal budgets for land management activities declined (Cermak 2005). During this era, conservation goals that had once seemed obtainable now appeared to be impossible. Claims by timber industry insiders and federal regulators alike insinuated that overproduction of lumbering had contributed not only to destructive lumbering, waste, and premature cutting, but had also resulted in the loss of land from tax rolls and unemployment (Steen and Guth 2004). Such claims led to the Presidential appointment of a Timber Conservation Board in 1930, which was charged with developing "sound and workable programs of private and public effort, with a view to securing and maintaining an economic balance between production and consumption of forest products" (Steen and Guth 2004). The resulting recommendations made by the Timber Resources Board resulted in the concept of "sustained yield." By definition, sustained yield was market oriented, whereby supplies would be kept level with demand by holding public timber unavailable as long as private supplies were adequate (Steen and Guth 2004). When private lands were diminished, public forests would provide needed timber while private lands regrew (Steen and Guth 2004). Thus, yield would be sustained in coordination with demand (Steen and Guth 2004).

Although in theory, the application of sustained yield to achieve a stable forest industry and, therefore, a stable local community was a desired goal of both federal and private timber interests, unsustainable logging practices continued on some private lands. Thus, federal regulation of private logging practices again became a major focus of forest policy (Steen and Guth 2004).

A discussion of the settlement of the watershed including sawmills and communities that arose during this period use is provided in Section 2.2.9, *Communities in the Upper Sacramento River Watershed*.

Timber Use in the Post-World War II Years (1950 to 1974)

The years following World War II mark a turning point in the federal government's management of forestlands in northwestern California. Increased demand for lumber and dwindling timber supplies on private lands made logging on federal lands more economically attractive (Frost and Sweeney 2000). Technological advances such as lighter weight chainsaws and yarding systems and construction of an extensive network of forest roads made logging possible in areas, including the watershed, once considered unprofitable or inaccessible (Frost and Sweeney 2000). The historical practice of selective cutting in which only commercially valuable trees were harvested was replaced by clearcutting as consumer demand for wood products led to an expansion of the acceptable size and species of merchantable trees. Throughout the 1950s and 1960s, the practice of clearcutting, followed by broadcast burning and replanting to desirable tree species, became standard practice. By the late-1960s, federal lands in the watershed and throughout the region were managed to promote even-aged

stands of merchantable timber. Thousands of acres of late-successional forests in and around the watershed had been converted to tree plantations (Frost and Sweeney 2000). Clearcutting of low- to mid-elevation forests allowed hardwoods to sprout and become established, dominating the vegetative community of the cut-over site for many years. Logging slash, flammable hardwood vegetation, and the uniformly dense canopies combined with high tree stocking densities put tree plantations at considerable risk of damage from wildfires.

Although the Shasta and the Trinity National Forests had been established as forest reserves in 1905, the Shasta-Trinity National Forest, as a unit, was not established until 1954 (USDA Forest Service 1999). The expanded network of roads and trails throughout the watershed not only made logging access easier, but attracted recreationists as well. Forest managers of the era no longer were simply custodians of the timber resource in the watershed, but now found themselves in the role of multiple-use natural resource managers. By the mid-1950s, a growing population of young, middle-class families flooded the forest. Development of outdoor recreation opportunities (discussed in Section 2.2.7, *Recreation and Tourism Management*) had to be integrated into forest management actions concurrent with the demand for increased timber yields.

Portions of the watershed, particularly in the south and along the Sacramento River corridor, were gradually inundated by water held back by Shasta Dam, which was completed in 1945. The effect of the newly created reservoir was two-fold: (1) increased recreational use of the watershed and (2) loss of some timberlands along affected drainages. The economic loss of these timberlands was offset by the increased economic opportunities afforded by the newly created recreational possibilities. The existing conditions of forest resources in the watershed are discussed in detail in Chapter 3.

2.2.5 Agriculture and Ranching

Historically, ranching and agricultural activities in the watershed have been limited by the steep mountainous terrain. However, wherever there were relatively flat lands or hills, there was often some sort of agricultural or ranching development to serve the small communities and travelers that passed through or stopped by the area on vacation. This section describes the development of agricultural establishments in the watershed.

Agriculture and Ranching Prior to 1850

Although the onset of agriculture and ranching activities in the watershed would not occur until the Gold Rush era (1850s), the area had contact with ranchers in the 1830s. Euro-Americans drove herds of horses and cattle from Mexican-controlled California to Oregon. Expeditions up the canyon were led by John Work in 1832–1833 and Ewing Young, who reportedly drove 700 head of cattle from Monterey to Oregon in 1837. This same route was used annually by the Hudson's Bay Company parties through the 1830s and 1840s. This cattle drive reportedly came up through the Sacramento River canyon and stopped at Upper Soda Springs (Vaughan 2007).

Agriculture and Ranching (1850–1950)

A comprehensive record of historic agricultural and grazing practices in the watershed is lacking. This is likely because much of the watershed is mountainous, so agricultural and grazing activities were scattered. It is generally thought that agriculture and ranching practices were brought into the

watershed by the early settlers around 1850. Agricultural activities began as small backyard vegetable gardens and often included a few dairy cows or chickens (Scanlon 1981). Later developments included small- and large-scale farming and ranching operations. The general trend was for agricultural activities to follow mining and mineral prospecting activities. While the earliest mining camps in the watershed were dependent upon food packed in from other areas, land in the Sacramento and Shasta valleys was soon used to raise dairy cows and cattle and to grow food crops and hay (around 1852–1855). Shortly thereafter, wheat, barley, and oats were being grown in the most northerly and southerly reaches of the watershed. Mills were built in the following years to grind the grain. Gradually, as settlements increased in size and expanded to serve the miners and their families, agriculture was incorporated into many areas and became another mainstay of the local economy (Parsons 2003b, McDonald 1979).

Up until the early 1900's, federal lands generally were open for public divestment and use, including grazing (Musgrave 1998). However, when the U.S. Forest Service acquired Shasta National Forest, it established regulations to limit grazing on the forest, which resulted in bitter disputes with the stockmen. Grazing also occurred on land allotted to Indians, and although Indians throughout California, including the Wintu, complained, it was to little avail (McTavish 2010).

Upon arrival to the Mount Shasta area, the early settlers noted the abundance of many wild berries, in particular, strawberries. Historic accounts tell how the local Native Americans would pick the strawberry flowers as they traveled through the area so that the berries would be larger upon their return (Brunmeier personal communication 2008). The area was so abundant with berries that it became known as Berryvale, and the area by Wagon Creek was referred to locally as Strawberry Valley. The town name was changed years later to Sisson, but not for lack of berries. Strawberries were cultivated around Mount Shasta for decades. Other berries were also cultivated and included raspberries, blackberries, elderberries, and logan berries. In the early 1900s, growing berries was a profitable business. Strawberries sold for $1.25 a crate and brought growers $375.00 per acre.

Large-scale development for agriculture came about in conjunction with the federal Homesteading Act (1862), abandoned mine claims, and the extension of the railroad line, which eventually made its way north through the steep river canyon to Mount Shasta. After gold fever subsided, Shasta and Siskiyou counties continued to grow because of homesteading or purchasing of fertile farmlands (Parsons 2003b, Siskiyou County Sesquicentennial Committee 2008), and many of the town names in the watershed come from ranch family names.

In 1881, in the area now known as Delta and Vollmers, the remains of the boom and bust gold mining town called Dog Town were purchased by Louis Autenrieth. At the time, it consisted of 160 acres, which Louis converted to agricultural land. The area was farmed by Louis, his wife Bertha, and their eight children. Louis died shortly thereafter at the age of 53, leaving the Autenrieth Ranch to be run by his surviving family. Accounts of the ranch note that cattle raising was likely its primary focus. Other ranch operations that were typical of the time were conducted by the family and included a cider mill, keeping a milk cow, and growing several types of crops (Vaughan 2004).

The Autenrieth Ranch changed ownership several times in the early 1900s. It was eventually acquired by William Vollmers in 1909. The ranch was also enlarged several times, growing from 160 acres to 660 acres. The additional acreage was located in the adjacent hills and was used for grazing up to 100 head of cattle. Horses were used for plowing the fields and a variety of crops, including

alfalfa, tomatoes, corn, peas, watermelons, and strawberries were grown. Commercial strawberry production on the ranch was big for a while in the 1920s, and provided local employment for as many as 25 laborers. The Vollmers also maintained an extensive orchard and kept a milk cow (Vaughan 2004).

Vehicular traffic in the area changed the face of the Vollmers Ranch and probably other ranches in the watershed as well. As car travel increased, resulting in the construction of Highway 99, the ranch's operations evolved to accommodate the latest trend. The Vollmers began operating a small summer resort and a combination store, gas station, garage, and restaurant. The commercial operation serving travelers was relocated and rebuilt several times on account of the construction, relocation, and widening of Highway 99. The ranch bought and operated the first Model A Ford tow truck, and worked in association with the American Automobile Association (AAA) (Vaughan 2004).

Around 1930, a small airport was constructed at the Vollmers Ranch that was used by the U.S. Army and for mail deliveries. The ranch also operated a weather station, which reported the local weather regionally. The historic records note that commercial airplanes would occasionally land at the Vollmers Ranch airport when the Redding airport was closed by fog. After World War II, the resort, airport, and restaurant closed. The Vollmers continued to raise cattle and grow strawberries until about 1960. The ranch sold in 1967, and records indicate that the remaining buildings were torn down shortly thereafter (Vaughan 2004).

A ranch operation was also recorded near Pollard Flat. Historic records note how the Baker Ranch, located west of Pollard Flat, used a ditch originally constructed for hydraulic mining to serve as irrigation for cattle (Orre 1999). The conversion of mining ditches to agricultural ditches exemplifies a common theme throughout the watershed and throughout the West.

Further north was the DeMarco homestead, located on Flume Creek. The family settled the property in 1863 and made a living raising goats and making goat cheese for local residents. This area is fairly steep, and while it was not suitable for crop production, it was well suited to raising goats. The ranch held between 700 and 1,000 of the animals, which ranged throughout the mountains in the vicinity. Although not in the record, the goat cheese was likely sold and traded to people living throughout the river canyon, and based on the size of the operation, the goat ranch probably employed several people to assist with milking chores. During those years, the landscape would have had far less brush than currently exists due to grazing by the goats. For a time, cabins on the ranch property were used to house sawmill residents and served as an office for a local sawmill operation. The property also had a bathhouse used by sawmill workers (Orre 1999).

In the 1880s, farming was taking place near Sims at a location known as Southern's Station or Sim's Resort. Like many commercial operations in the watershed at this time, the farming operation was run in conjunction with other business activities. The place was a popular hotel and stage stop along the Sacramento River, about 5 miles south of Sweetbriar (Vaughn 2007). Records show the area was farmed by C. C. Huffacre, who later moved north to Castella, another river canyon settlement to the north near Mount Shasta. While living in Castella and serving as the Leland postmaster, Huffacre reportedly grazed his dairy herd on land he owned along the south side of Castle Creek (near Castle Crags State Park). The self-proclaimed farmer also held numerous mining claims in the area (Vaughan 2007).

By the early 1900s, the area around Mount Shasta was full of farms and orchards. Much of the land was leased for the purposes of farming. Apple, cherry, plum, and pear trees were planted throughout the Mount Shasta area as early as 1887. Cattle grazing was also prevalent at this time on the lush grasslands west of the present day City of Mount Shasta. Historic records note that the young orchards and vegetable patches would thrive without much rain. This was because the area had plentiful water, including several wet and dry meadows. As a result, there was moisture enough in some areas to grow fruits and vegetables without resorting to irrigation (Brooks et al. 1987, Cutting 1997). Areas with wet meadows were partially drained to irrigate dry meadow gardens and orchards.

Farming and dairy cows played a great part in the economy of the Mount Shasta area in the early 1900s. The area had dairymen who would deliver milk to people's homes (Brooks et al. 1987). In the City of Mt. Shasta, the Sisson family owned a significant amount of land and raised much of the food in the area. It was served at the Sisson tavern, and the milk from their farm was sold locally (Brooks et al. 1987). There was also a large produce farm in town. It was known as George Ferraro's celery field and was located on Lake Street, about where Mt. Shasta Shopping Center is currently located. Historic accounts note that Ferraro also grew cabbage and became known as "The Cabbage King" because he won a gold medal for his cabbage at the Panama-Pacific International Exposition in San Francisco. Ferraro later bought an 80-acre ranch, which he farmed in North Sisson, off Ivy Street. The former ranch is now a housing development (Brooks et al. 1987). Produce, orchards, and animals were also raised south and west of the city in areas that were known as Azalea, Mott, and Shasta Springs.

While agricultural and ranching practices of the early settlers contributed to the current shape of the watershed, much of the land that was used for such purposes was later abandoned or developed for other purposes. Agricultural and ranching practices along the old Highway 99 soon gave way to forestlands or housing developments once Interstate 5 was constructed. Farms and ranches around Castella, Dunsmuir, and Mt. Shasta began to disappear in conjunction with the construction of Highway 99 and later I-5. In the industrial era, vehicular traffic grew, refrigeration and packaged foods became the norm, and small family farms and garden plots gave way to residential, industrial, and commercial developments.

In summary, portions of the watershed were used by inhabitants throughout history to cultivate and raise food supplies. Agricultural and ranching practices brought by the Euro-Americans and other settlers altered the shape and function of the watershed. Rather than relying upon fire and natural water and wildlife cycles for food supplies, the watershed's new inhabitants relied upon water diversions, hybrid seeds, and domesticated animals. The effects of abandoning fire as a means of land management and of diverting water from its natural course are still being studied. In general, agriculture and ranching practices introduced by settlers were more intensive than the previous land management practices used by the Native American inhabitants.

2.2.6 Water Resources and Infrastructure

The Sacramento River is the largest river system in California and accounts for an average annual discharge of 21.6 million acre-feet of water into the Sacramento/San Joaquin River Delta (Bureau of Reclamation 2003). The entire Sacramento River watershed encompasses 27,210 square miles, with

the upper Sacramento River portion of the watershed accounting for approximately 6,500 square miles of this total (Bureau of Reclamation 2003).

While other types of water infrastructure (e.g., wells, diversions, etc.) have surely been constructed throughout the history of settlement in the watershed, none have had the impact that Shasta Dam and Box Canyon Dam have had on not only the landscape of the local areas, but on the water supply, water quality, power supply, agricultural economy, and recreation opportunities for the state. Therefore, these two water infrastructure features are the focus of this section.

Shasta Dam

On March 25, 1936, the United States and the California Water Project Authority executed a cooperative agreement to coordinate the Central Valley Project (CVP) and the California State Water Project (Bureau of Reclamation 1984). The CVP is an ongoing federal water project implemented by the Bureau of Reclamation in 1935 as a long-term plan for the use of water in California's Central Valley. The purpose of the CVP is to redistribute water in the Central Valley from the more abundant supplies available in its northern portion to its drier southern portion. Such transference of water across the Central Valley allows for the production of hydroelectric power, flood control, and improved navigability of the lower reaches of the Sacramento River. The CVP also allows for the development of water supplies for cities and towns in the Central Valley.

At the time it was conceived, Shasta Dam was viewed by both the federal and state governments as the key to the CVP (Bureau of Reclamation History Program 1994). The location of Shasta Dam and the reservoir created by it would accomplish several goals, including water storage for irrigation and salinity control in the Delta; flood control to protect communities along the Sacramento River; and power generation. The resultant structure, completed in 1945, is the second-largest dam in the United States, behind the Grand Coulee Dam in Washington (Bureau of Reclamation 1984). It measures 602 feet in height and is 3,460 feet across. Feeding the Shasta power plant, the dam's spillway is the largest man-made waterfall in the world (Bureau of Reclamation 1984).

The construction of Shasta Dam had a tremendous influence on the watershed (USDA Forest Service 2000). With the onset of construction in 1937, thousands of workers poured into the area, settling primarily south of the project area; however, numerous work camps sprang up in the area ultimately inundated by the reservoir, as the CCC and various contractors cleared the area of timber and brush (Bureau of Reclamation History Program 1994). Although the watershed had been populated to some degree prior to construction of the dam, communities in the region (including those within the watershed) experienced staggering growth rates after the beginning of construction of the dam. Smaller increases have persisted over the subsequent years.

As discussed in Section 2.1.4, *Native American Fisheries*, fish resources in the upper Sacramento River and its tributaries were historically a vital part of the local Native American culture. Salmon, steelhead, Sacramento sucker, freshwater shellfish, and lamprey were gathered in communal fish drives, which brought Native American communities together, providing opportunities for trade and social networking. The building of Shasta Dam curtailed the movement of anadromous fish throughout the watershed and disrupted the traditions and utilitarian uses associated with fisheries resources that had been a part of Native American culture.

Construction of the dam also triggered the development of additional roads and transportation infrastructure throughout the lower portion of the watershed (USDA Forest Service 2000), including the double-duty Pit River Bridge. Completed in 1941, the bridge allowed for the continued passage of train and vehicle traffic along the upper Sacramento River corridor.

Shasta Dam first began spilling on May 18, 1952 (Bureau of Reclamation History Program 1994). In 1955, the Bureau of Reclamation temporarily stopped the flow of water from Shasta Dam. Subsequently, the state claimed the lowered water levels of the Sacramento River downstream of the dam allowed levee banks to slip (Bureau of Reclamation History Program 1994), setting a precedent for the continuous release of water from the dam. However, perhaps the greatest environmental effect that resulted from the construction of Shasta Dam is its impact on anadromous fish. Completion of the dam effectively blocked access to approximately 110 miles of spawning habitat historically used by salmon and steelhead and an unknown amount of habitat for white sturgeon (USDA Forest Service 2001). The rising environmental movement, which came into its own in the early 1970s, including the federal Endangered Species Act of 1973 (see Section 2.3, *Evolution of Laws and Regulations Affecting the Watershed*), created more controversy around the CVP, particularly with regard to salmon and trout (Bureau of Reclamation History Program 1994). Fish traps and hatcheries combined to move the migrating fish upstream or artificially breed them, but they could not keep pace with the decreasing population of migratory aquatic wildlife (Bureau of Reclamation History Program 1994). Shasta Dam not only blocked migration upstream, but it blocked the flow of cool water downstream, keeping water temperature above the maximum 56 degrees Fahrenheit (˚F) necessary for the spawning salmon (Bureau of Reclamation History Program 1994). A comprehensive discussion of the effects of Shasta Dam on fish resources of the Upper Sacramento River watershed is provided in Chapter 3.

The building of Shasta Dam and creation of Shasta Lake had social effects as well, both positive and negative. The creation of Shasta Lake led to a surge in recreational use of the lower portion of the watershed. Boating, fishing, swimming, and other water-based activities, as well as more passive uses such as picnicking, camping, and site-seeing continue to contribute to the regional economy. Although much of the land surrounding the lake is federally owned, many homesites have been developed on available private lands around the shoreline and throughout the extent of the upper Sacramento River Arm.

The construction of dams throughout the western United States has been a major cause of cultural disconnection from the landscape for many people. The Winnemem Wintu have experienced a serious disconnect from their traditional lands since the building of Shasta Dam and subsequent creation of Lake Shasta. Their traditional ceremonial grounds, family burial plots, resource procurement areas, villages and general connection to the Winnemem sense of place as it relates to the local natural environment have been and continue to be impacted by the existence of the dam, lake, and associated recreation.

Box Canyon Dam

In 1969, Box Canyon Dam was completed, creating Lake Siskiyou. The dam significantly affected processes controlling channel morphology and water quality (USDA Forest Service 2001). While the Sacramento River above Lake Siskiyou remains unregulated and subject to seasonal fluctuations, the reservoir and dam completely cut off the supply of sediments and bedload (i.e., the sand, gravel,

boulders, or other debris transported by rolling or sliding along the bottom of a stream) to the Sacramento River immediately below the dam (USDA Forest Service 2001, SHN Consulting Engineers & Geologists 2004). Lake Siskiyou serves as a kind of detention basin, blocking the traditional movement of bedload and suspended sediments downstream. Changes in flow and sediment transport affect the temperature and flow regime of the Sacramento River beyond the local watershed (SHN Consulting Engineers & Geologists 2004).

Siskiyou County is a significant landholder around Lake Siskiyou. These lands were acquired to facilitate construction and operation of the Box Canyon Dam and provide recreational opportunities, including water-based recreation and camping. Of the 2,240 acres owned by Siskiyou County, approximately 550 acres are below the ordinary high water mark of the reservoir, 1,390 upland acres are adjacent to the lake, and approximately 300 acres have been set aside as deer winter range (SHN Consulting Engineers & Geologists 2004). Flood control and water conservation in Siskiyou County is managed by the Flood Control and Water Conservation District.

2.2.7 Recreation and Tourism Management

The upper Sacramento River watershed area has a rich history of recreation and tourism. The rivers, lakes, and mountainous terrain create different venues for outdoor recreation enthusiasts, including hiking, camping, fishing, hunting, and boating. The beauty, mineral springs, and recreational opportunities in this area have been promoted by both private and public organizations since the late 19th century. In addition to the many publicly owned recreational facilities, there are many privately owned facilities, including boat ramps, boat rentals, RV parks, and campgrounds.

Resorts

The establishment of resorts in the Upper Sacramento River watershed was largely driven by the Southern Pacific Railroad (SPRR) and the belief that the mineral springs throughout the watershed offered healing powers for the sick and infirmed. The earliest facilities got their start as crude inns that opened along what was known as the Sacramento Trail. Soda Springs became a prime stopping point because it was the last time travelers would cross the Sacramento River if heading north and the first time if they were heading south. The Upper Soda Springs area included a large meadow and a mineral spring, making it an advantageous location to stop. The Lockhart Brothers, Harry and Samuel, recognized an opportunity and constructed a cabin for these early travelers in 1852. They operated their inn until 1855, when they sold it to Ross and Mary McCloud, who continued to operate the inn. In 1859, the widening of the Sacramento Trail created a road large enough to accommodate stagecoach and wagon traffic. As a result, settlers established numerous small inns along the road to accommodate the increased road activity (Masson and Masson 1985).

In the 1880s, the SPRR reached the Shasta Cascade area and it quickly created a tourism industry by making the area more accessible. More and more residents from the San Francisco Bay Area and Sacramento would take the train to enjoy the wonders of the Sacramento River canyon. To accommodate these travelers, innkeepers constructed larger and more elaborate resorts to replace the smaller, more rudimentary facilities. Perhaps the most successful of these large resorts was the Upper Soda Springs Resort. The Upper Soda Springs Resort was built by Isaac Fry, a former Mississippi riverboat operator who married Mary McCloud after her husband's death. Fry built the hotel with verandas that stretched the entire length of the building and resembled a riverboat. Enhancements to

the property continued into the 1880s. Because the resort was constructed on the main line of the SPRR and was located 15 miles from Mount Shasta, it served as a popular destination among railroad travelers. It was the place to visit for distinguished guests and functioned as a popular resort for thirty years (Masson and Masson 1985).

Shasta Springs Resort was another successful resort that catered to the railroad traveler. It was located on the upper Sacramento River, just north of Dunsmuir and Upper Soda Springs. It was billed as having many of the "finest springs" on its property and was promoted for its potential for improved health. Its "altitude, combined with the tonic effects of the balsamic air and the health-giving properties of the mineral waters" were ideal for a guest's health (Southern Pacific no date). Other amenities offered were scenic views, swimming, and croquet and tennis courts. The resort featured all the modern amenities available at the time, while still maintaining its quiet, natural surroundings. Historic photographs depict guests relaxing on the hotel's deck, drinking the mineral water, and strolling the hotel's grounds. The resort remained popular through the 1940s, eventually closing in the 1950s (Shasta Resorts 2008).

The SPRR played an important role in promoting the resorts and the Shasta Cascade's beauty. The company published brochures and offered excursion rates throughout the area. Its Pacific Improvement Company purchased the existing hotels and resorts scattered along the SPRR line and made improvements. The Castle Crag Tavern is one such example. The original hotel was destroyed by fire in 1890 and a second hotel was constructed in its place two years later. In addition to the hotel, there was a clubhouse and private dining room for children and their caregivers. The hotel could accommodate 300 guests and offered bridle paths and hiking trails. In 1900, the hotel was again destroyed by fire and was never rebuilt, but the Pacific Improvement Company continued to the lease the grounds and a hotel was operated, albeit unsuccessfully, for many years out of the former summer home of Charles Crocker, who had constructed his house across from the original hotel (Masson and Masson 1985, Schönewald no date).

Auto Camps

The automobile greatly changed the tourist industry in Shasta and Siskiyou counties. The resort hotels were located along the railroad, making it easy for visitors to reach their destination, but as automobiles became more popular, fewer tourists preferred to travel by rail. Because of varying road conditions, automobiles could not easily travel into the canyon, requiring travelers to seek out accommodations closer to the main roads. Auto travelers would often camp at tent sites or cabins, with water, wood, and cots or beds supplied by the campsite owners. Some of the older, established resorts closed rather than try to accommodate the new tourists, while others adapted and remained profitable (Masson and Masson 1985).

Brown's Auto Camp, built and operated by Clint and Ida May Brown, successfully adapted to accommodate the automobile tourist. In 1916, the Browns assumed management of Castle Crags Resort. However, as Clint aged, the responsibilities of maintaining the facility became too strenuous. In 1922, he and Ida May purchased land that was already being operated as a campsite for automobile travelers. The Browns moved there permanently in 1925. They added showers and toilets and set about making additional improvements to the facilities. Through their efforts, six cabins and tent platforms were added along the river, in addition to the construction of their own residence and a store closer to the highway. The following year, they replaced the tent platforms with double cabins

and constructed some small cabins at the top of the hill with a community bathroom and laundry facility nearby. By 1929, they had expanded their facility, and it was known as Brown's Auto Camp. The auto camp struggled through the Great Depression of the 1930s, and in 1946 Ida May sold the auto camp after her husband's death. In 1950, the facility became known as Brown's Modern Motor Lodge and featured modernized shower and laundry facilities. The name eventually changed to Cave Springs. By the late 1950s, the automobile and tourism industry continued to evolve. Increasingly, automobile travelers were drawn to vehicles providing comfort on the road, including large sleeping trailers. Cave Springs evolved, and by 1967 it was remodeled with a swimming pool and room for RV parking (Masson and Masson 1985).

Water Sports

Water sports became increasingly popular in this area with the creation of Shasta Lake, which continues to be one of the most visited recreation destinations in the area. Today people enjoy houseboating, boating, and waterskiing, in addition to fishing and camping at Shasta Lake. In 1968, Lake Siskiyou was created by the construction of Box Canyon Dam. This man-made reservoir is unique in that the primary purpose for which it was created was for recreation and fisheries enhancement. Its primary focus was fishing, and it is the only lake that offers anglers the opportunity to fish for both cold and warm water species of fish. Like Shasta Lake, Lake Siskiyou continues to be a popular recreation destination for tourists. Boat launches, campsites, RV parks, hiking trails, and a golf course were all constructed in the immediate vicinity of Lake Siskiyou (SHN Consulting Engineers & Geologists 2004).

Other Recreational Activities

Recreational activities in the watershed encompass a variety of winter and summer sports; mountaineering, skiing, hiking, camping, fishing, hunting, boating, and pleasure driving are but a few. The early resorts offered tourists opportunities to enjoy the great outdoors. The area was promoted as having an amiable climate with warm days and cool nights. All areas offered access to fresh water and plenty of fish and game. One publication promoted camping in the area as: "Exercise moderately; have games and music for the evenings around the camp fire; go to bed early; get up early; make life as wholesomely enjoyable as you can" (Schönewald no date). Fishing and hunting were particularly promoted in the early tourist years. The resorts, the SPRR, the counties, and the California Fish and Game Commission (Commission) created brochures describing the best places to hunt and fish. Since its inception in 1870, the Commission's goal was the preservation and protection of California's fishing population. This was the first wildlife conservation program in the United States, and it was responsible for setting sport hunting and fishing seasons in Shasta and Siskiyou counties.

Interest in preserving the natural beauty and the areas where outdoor recreation could be enjoyed has always been important in the region. In 1928, Californians approved bond money to begin buying lands for the creation of state parks. The newly established State Parks Commission completed a statewide survey, headed by Frederick Law Olmstead, for potential state park lands. Castle Crags was considered for acquisition and the Castle Crags Wilderness Association, created in 1930, raised half the money required to purchase Castle Crags and assist the state in establishing the park. In 1933, the State Park Commission authorized the purchase of 925 acres to establish Castle Crags Wilderness State Park. What has been described as a "…most picturesque glacier-carved mass of

pinkish-white granite" (Stahl 1989) that was historically enjoyed by many, today features 76 campsites, 28 miles of hiking trails, fishing, and swimming areas.

2.2.8 Transportation History

Transportation infrastructure in the Upper Sacramento River watershed was minimal prior to the 1850s. The area originally included incomplete makeshift mule and wagon trails used by Native Americans long before the California Gold Rush of 1848. During those years, Native Americans likely navigated the trails along the river for hunting and trade with other local Native American groups. By the mid-19th century, Euro-Americans began streaming into the state, often by way of the Sacramento River canyon. This influx initiated the development of roads and other transportation routes. Over time, wagon and trapper trails were reconstructed to create state highways, which were eventually renamed or reconstructed to form the interstate highway system. Additional transportation development in the area during the 20th century included tramways and the railroad. Because of the steep slopes and narrow canyon walls of the upper Sacramento River canyon, most of the transportation infrastructure had to be funneled through the canyon along the river. As a result, relatively few east-west routes intersect this north-south corridor (Giles 1949, Smith 1995).

Early Roads/Trails and Highways

One of the first major trails in the area was the Siskiyou Trail. During the 1810s, the trail consisted of a system of narrow pathways created by Native Americans that connected California's Central Valley to the Pacific Northwest, traversing through Shasta County along present day Interstate 5. In the 1820s, the trail was further defined by use from the Hudson's Bay Company fur trappers. In 1834, trapper Ewing Young of the Willamette Cattle Company led a herd of horses and mules from California to Oregon via this trail. Three years later, Ewing Young and his group traveled the trail with a group of 700 cattle. The 3-month journey resulted in the further widening of the Siskiyou Trail (Dillon 1975).

Early roads in the area included the Lockhart Road, the Walla-Walla Trail, and Ross McCloud's stage road. Native Americans established the Walla-Walla Trail by 1846, and Sam Lockhart opened the Lockhart Road in 1855 when he led a group of 35 wagons from Yreka in a southerly direction to the Pit River. Also during that year, Ross McCloud surveyed the McCloud road, which ran from Shasta to Soda Springs and was eventually widened and extended further north to Yreka (Giles 1949, Masson 1949).

Following the Gold Rush, incoming miners from out of state journeyed to Trinity, Siskiyou, and Shasta counties along the Siskiyou Trail at an increasing rate. The trail eventually served as a major transportation artery known as the California-Oregon Road. By 1856, the Central Pacific Railroad (CPRR) completed tracks from Roseville through Shasta County following the California Oregon Road alignment. Historic records indicate the California-Oregon Road was improved by 1901. Also by that time, an unimproved road extended along the Sacramento River, beginning at what was known as Gregory Bard (near present-day Dunsmuir) and ending at the Morley Wintun Lodge (near present-day Sims (Dillon 1975, Giles 47-4).

Creation of the Shasta and Trinity National Forests in 1905 began a period of significant road development throughout the watershed because development of the region's natural resources

required increased access. Road construction, particularly in the upper watershed, became a priority of federal land managers, with the most significant period of construction occurring between 1920 and 1945 (SHN Consulting Engineers & Geologists 2004).

U.S. Highway 99 and Interstate 5

The California-Oregon Road, also known as the Redding-Yreka Stage Road, and the Soda Springs and Pit River Turnpike, evolved over time with increased use. The advent of the automobile by the 1920s induced newly formed motor clubs to organize auto trails and various sightseeing routes. The Pacific Highway, which followed the Siskiyou trail closely, particularly from Stockton, California to Vancouver, Washington, was one such organized road. In 1915, the California State Highways Act resulted in the designation of the California-Oregon Road as the Pacific Highway/State Highway 3. Ten years later, the American Association of State Highway Officials created the U.S. Highway numbering system, and the Pacific Highway/State Highway 3 was renamed U.S. Highway 99. In 1956, Congress passed the Federal Aid Highway Act, thereby creating the Interstate Highway System. The state renamed existing highways interstates and began new construction to replace previous main roads. Construction of Interstate 5 over Highway 99 north of Red Bluff was primarily completed between 1960 and 1965, following a portion of Highway 99. Each time the route was upgraded, the alignment stayed roughly the same, following along the Sacramento River through the upper Sacramento River watershed. This route remains the primary north-south route in use to the present day (California Department of Transportation 2008).

Tramways

Tramways have also played a role in the transportation history of the Sacramento River canyon area through Shasta and Siskiyou counties. Tramways were triggered by local miners' need for hauling equipment. Tramways involved a cable and pulley system used to carry ore from local mines to nearby railroad lines, where it was then transported to nearby smelters. Constructed of heavy cables, tramways also included iron buckets and apparatuses affixed to a series of elevated towers the length of the tramway route. Frequently associated with ore bunkers, main line railway sidings, warehouses, and dwellings, tramways were difficult to build and expensive, often involving the erection of many high towers at inaccessible locations (Colby 1982, Finlay 1920, Smith 1995).

Specific tramways in the watershed included the Balaklala Mine Tramway, (closed in 1911), the Iron Mountain Mine Tramway, the Hornet Mine Tramway, and the Mammoth Mine Tramway. The Hornet Mine Tramway began operation in 1921, constructed by the Iron Mountain Copper Company to replace the deteriorated Iron Mountain Railway. The tramway was located close to the Hornet Mine south of Redding. It began operation in late 1921, was extended 1 mile in 1953, and operated intermittently into the 1970s. Balaklala Mine owners constructed the Balaklala Mine Tramway, which ran from Coram and traveled straight up the Sacramento River canyon. The Balaklala Mine Tramway operated from 1906 to 1911 (Colby 1982, Finlay 1920, Smith 1995).

Railroads

During the 1850s, California expanded its transportation infrastructure to include both major and minor rail lines. Railroad transportation in the Sacramento River canyon area began during the

1870s, when major transcontinental lines increased to include several small, local lines that were primarily used to haul lumber (Colby 1982, Parsons 2003b).

Early railroads in the watershed included the Iron Mine Railroad, constructed by the Iron Mountain Railway Company in 1895. The 11-mile railway ran from a local mine to a smelter via Spring Creek, connecting with the Southern Pacific mainline at the mouth of Spring Creek. A rail line known by the names "Old Diggings Railroad," "Quartz Hill Railroad," "Central Mine Railroad," and "Mammoth Mine Railroad" was established by the early 1900s. This rail line was used to haul copper ore out of the surrounding mountains for processing at smelters in the Redding area. The railroad once extended a narrow gauge line approximately 5 miles from the mine at Quartz Hill to the Central Mine Spur located between Keswick Station and Motion, just west of the Sacramento River canyon area (Colby 1982, Smith 1995).

By 1920, the Iron Mountain Railway Company was faced with the line's extreme deterioration. Additionally, new regulation by the Interstate Commerce Commission and the Railway Commission of the State of California resulted in the need to upgrade the line. However, rather than refurbish the line, the Company built an aerial tramway system, a form of transportation not subject to restrictions, taxes, and controls imposed on common carriers. In 1921, after railway operations were ceased, the Iron Mountain Railway machine shop was moved from Keswick to a location more convenient to both iron Mountain and the Hornet mines (Smith 1995).

The first railroad in the Shasta area traveled from Sacramento valley to Portland, Oregon. The line was provided for by the U.S. Congressional Act, which passed on July 25, 1866. By the 1870s, the California and Oregon Railroad Company incorporated and consolidated with the CPRR, led by Sacramento merchants Leland Stanford, Charles Crocker, Mark Hopkins, and Collis Huntington, also known as the "Big Four." The company's chief engineer was Theodore Judah, formerly with the Sacramento Valley Railroad. In 1872, due to financial difficulties, construction of the line stopped just south of the Sacramento River canyon at present day Redding. Work resumed in 1883 and approximately 2,000 manual laborers, many of them Chinese, constructed roadbeds, drilled and blasted rock, and laid ballast ties and rails. By 1887, laborers completed construction on the Sacramento River canyon route and express cars began running on the tracks (Parsons 2003b, Smith 1995).

The first passenger rail was constructed by 1888 and included express trains running between Portland, Oregon, and Oakland, California, passing through the Sacramento River Canyon Route, also known as the Shasta Route. The rail carried Pullmans, coaches, dining cars, and immigrant sleeper cars. In 1942, in order to avoid conflict with the construction of Shasta Dam, a section of the main line was relocated to its new location between Redding and Delta. Five years later, because the newly constructed Keswick Dam resulted in rising waters, SPRR laid tracks adjacent to Iron Mountain Road as a spur line to haul ore. In 1962, when Iron Mountain mine ceased operation, this line was closed. Tracks remained in place until the late 1980s, when they were dismantled and sold (Smith 1995).

In 1885, when SPRR assumed operation of the CPRR, it added tracks connecting the Sacramento Valley to California's northern border. That northern boundary eventually connected with an Oregon line, extending south from Portland. On December 17, 1887, the project was completed and the event was recognized with a local celebration at Ashland, Oregon. During the 1890s, the Union Pacific Railroad (UPRR) acquired SPRR. Today, the UPRR traverses the entire length of Shasta and

Siskiyou counties, paralleling both Interstate 5 and the Sacramento River (Parsons 2003b, Smith 1995).

2.2.9 Communities in the Upper Sacramento River Watershed

The upper Sacramento River watershed historically contained many small communities and towns built in support of lumber mills, mining ventures, recreational locales, or transportation hubs. These communities often contained nothing more than a few cabins for housing located near the main economic focus of the area, be it a sawmill, mine, railroad yard, stage stop, or gas station (Figure 2.2-1).

One of the earliest communities in the watershed, alternately called Dog Creek or Dogtown and later Delta, was located at the confluence of Dog Creek and the Sacramento River. Gold was discovered along Dog Creek in 1850, and by 1858, approximately 1,000 miners were living in the area (Vaughn 2007). By 1880, the gold mines had played out, and the community was reduced to 25 persons. With the northward construction of the railroad, many stops and stations were created. Some of these stops were for loading and unloading cargo, including agricultural products, lumber, or mining products. Therefore, they were rather insubstantial in infrastructure. However, many stations were more substantial because they were the end of the line at the time, or, like Dunsmuir, they contained yards and plants related to the railroad infrastructure. Delta, located at the confluence of Dog Creek and the Sacramento River, was the end of the line for the railroad until 1886, when construction on the California and Oregon Railroad in the Sacramento River canyon continued (Vaughn 2007). In 1875, a post office was established at Delta, which was renamed Bayles in 1884 for the first postmaster (Gudde 2004).

Delta was also a stage stop on the California-Oregon Road, also known as the Soda Springs and Pitt River Turnpike toll road and the Redding and Yreka Stage Road, and the beginning point of the Shasta and North Trinity River toll road leading to the mining regions of the upper Trinity River watershed (Vaughn 2007, Klein and Yin 1994). At its height, Delta contained hotels and saloons as well as two stores, but began to decline after the completion of the railroad through the canyon (Vaughn 2007). In the 20th century, after the construction of Highway 99 in 1914, the area had a small camp resort with facilities for six guests and a combined gas station/garage/store/restaurant near the highway. The remaining area was used for agricultural purposes, such as grazing and strawberry cultivation (Vaughn 2007). After 1945, the store and resort closed, and by 1967 the buildings were removed (Vaughn 2007).

Delta exemplifies the use of the watershed, especially in the steep walled canyon area. Communities arose around an industry, be it mining, lumber, or transportation, and declined when the industry moved, closed, or became unimportant. Declines were followed by a brief respite as a result of an interest in recreation fueled by the creation of the early 20th century highway system. However, this brief respite was followed by a steady decline in the latter half of the 20th century.

Kennett (Figure 2.2-2), named after a CPRR stockholder, was established in 1883 as a station on the California and Oregon Railroad line (Elliott 1991), and was a shipping center for the gold mines in the hills west of the Sacramento River. A post office was established there in 1886, and service continued until 1942 (Durham 1998). In 1886, copper mining began in earnest in the Hills

Mott

Shasta Springs

Dunsmuir

Soda Creek (Castle Crag)

Castella

Sims

Watershed Boundaries

Communities

N

0 1.25 2.5 5

Miles

Source:NSR Inc, USGS L Created:01-14-10 Revised: cdshoemaker edouglas

G:\Projects\51058 Upper Sacramento River Watershed Assesment\GIS\51058 Figure 2-2-1.mxd

North State Resources, Inc.

Upper Sacramento River Project

Figure 2.2-1
Communities

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surrounding Kennett (Hayes and Lindgren 1910). One of the largest copper mines in Shasta County, the Mammoth mine, and several smaller but important mines were located west and northwest of Kennett. The infrastructure of these operations, however, was located in Kennett itself. The Mammoth mine operation included a sawmill, machine shops, railways to move ore, a smelter, worker housing, and other buildings all located at Kennett (California State Mining Bureau 1916). Partly in response to litigation over the loss of forests and environmental impacts caused by the toxic smelting process, a "bag house" (towers containing woolen bags to capture the fumes from the smelting process) was built at the smelter in 1910 (Department of Conservation 2000, California State Mining Bureau 1916).

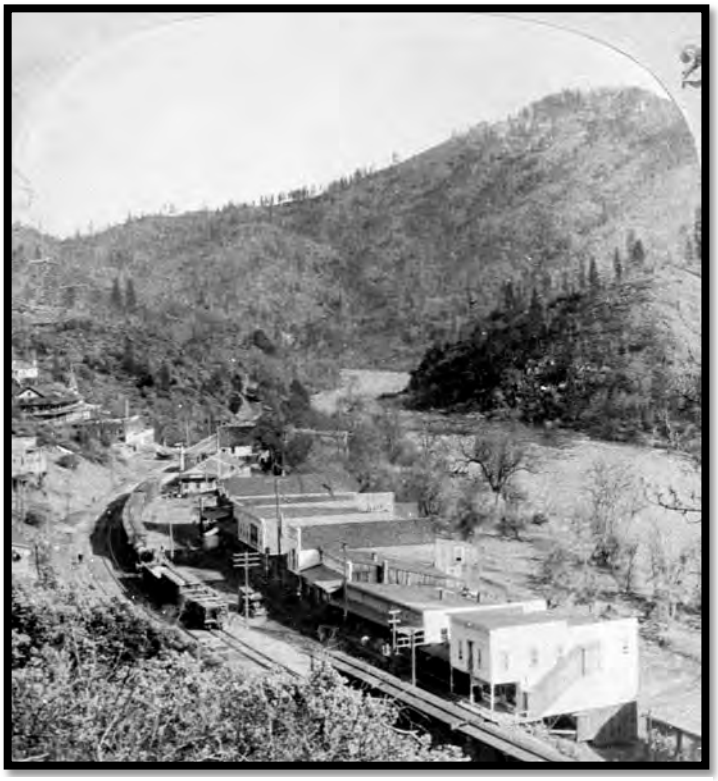

Figure 2.2-2. Photograph shows general view of Kennett, California, ca. 1907. Photograph by Earl A. McGarry. Photo Credit: California State University, Chico, Miriam Library, Special Collections. Donor: Harold Lapham.

The Holt and Gregg Limestone Quarry was also located near Kennett. The operation quarried limestone, which was then sent on an electric railroad to a kiln at Kennett for processing (California State Mining Bureau 1916). This quarry and several others like it in Shasta County provided an important ingredient, lime, needed for the copper smelting process. Kennett's copper production hit a high in the second decade of the 20th century, and the copper industry experienced a boom time during WWI, when copper was required for munitions and other materials associated with the war effort. After WWI, the decreased demand for copper, coupled with the litigation over environmental damage caused by smelting and the high cost of shipping the ore to other locations for refining, caused many of the copper mines to close. The smelter at the Mammoth mine was the last one in operation in the area, closing in 1924, and by the mid-1920s, copper mining as an industry in Shasta County had effectively ceased (Department of Conservation 2000). Kennett as a town continued until the Depression, but the town dis-incorporated in 1933 (Schuldberg 2005). In 1935, the Bureau of Reclamation began surveying the Kennett area to find a suitable location for a large dam, and in 1937, construction work on the infrastructure, including work camps and exploratory drilling, of Shasta Dam began (Bureau of Reclamation 1994). By 1950, construction on the dam and all related infrastructure was completed, and Kennett was buried under the waters of Shasta Lake (Bureau of Reclamation 1994).

Although it never achieved the status of community, the location of Sims, alternately called Sims Station, Southern's Stage Station, or Southern's Hotel and Stage Station, has a unique and important place in the history of California and the upper Sacramento River watershed. Originally the location

was the site of a log cabin built in 1859 by Simeon (Sims) Fisher Southern, who had settled in the area of Hazel and Mears Creeks, that was used as a trading post along the Siskiyou Trail (Smith 1999). He expanded his operation to include a hotel and corrals for fresh horses for the new stage line when the trail was improved to a road. The hotel became widely known as an early sportsman's resort perfectly located for hunting and fishing, and was visited by many persons prominent in California and United States history (State of California Office of Historic Preservation 2008). The United States Postal Service opened an office, the Hazel Creek post office, in the hotel in 1877, and Southern acted as postmaster until his death (Delay 1924). In 1887, Southern deeded over a right of way to the Oregon-California Railroad, and the railroad placed a station near the hotel. The location is now California Historical Landmark No. 33, Southern's Stage Station, and the monument marker is located on old Highway 99, near the Sims exit off Interstate 5.

Although copper and gold mines were located well to the south of Sims, other materials were found in the area. The Anaconda Mine, an asbestos mine owned by the Pacific Coast Asbestos Company, was in operation in the late 19th century and was still noted on an historical map of the Shasta National Forest in 1934 (USDA Forest Service 1934). With the interest in fisheries for sport and commercial use high in the 19th century, the Board of Fish Commissioners for California decided to place two egg-collecting stations in the Sims area, one on Mears Creek and one on Hazel Creek. Unfortunately, the water was too low during the years of operation for a good take of fish so the stations were abandoned and moved elsewhere. A sawmill was also located at Sims shortly after the turn of the 20th century, and the surrounding hills were heavily logged during that time (Smith 2007). Finally, a Civilian Conservation Corps (CCC) camp was placed at Sims in 1933 (Smith 2007).

One of the best-known projects of the New Deal of the 1930s was the CCC. The CCC was created in 1933 by Franklin Roosevelt as one of many programs designed to combat the unemployment and economic downturn created by the Great Depression. The focus of the work conducted by the CCC was restoration of forests, conservation and reclamation projects, and infrastructure construction, such as roads and communication lines (Oregon Coast Magazine Online no date). Approximately 150 camps were created in California, including three in Shasta County, with Company 978 stationed at Sims (Oregon Coast Magazine Online no date, California Genealogy and History Archives 1938). Company 978 constructed trails, campgrounds, and other infrastructure in the newly created Castle Crags State Park, and also built a cable suspension bridge spanning the Sacramento River at Sims (California Genealogy and History Archives 1938). With the start of World War II, attention and funds moved away from domestic conservation to support the war effort, and by 1943 the CCC had been disbanded (Oregon Coast Magazine Online no date). The camp at Sims was closed by 1939, and today only the suspension bridge and rock lined paths and stairs remain (Smith 2007).

Resorts

As discussed in Section 2.2.7, *Recreation and Tourism Management,* the upper Sacramento River watershed contains many mineral springs, some of which have been exploited in the past as healthful waters with resorts and spas built around them. Others have been used for commercial enterprises. One of the best-known mineral springs is Shasta Springs, located several miles north of Dunsmuir. In 1887, railroad construction had progressed to the area and the springs became a station and water stop for trains (California State Mining Bureau 1916). In 1889, the Mt. Shasta Mineral Springs Company was founded, and bottling of the mineral waters began. A resort soon followed (Figure 2.2-3). A

railroad station and gift shop, incline tram station, and bottling plant were all located along the Southern Pacific Railroad tracks, while the rest of the resort, including the main hotel, dining room, clubhouse, cabins and cottages, was located above the river canyon on the plateau (Drury and Drury 1913). The resort was open until the 1950s, when it was sold. The bottling plant remained in operation at least through the 1920s, shipping water in glass-lined redwood railroad cars to bottling plants in the western states (Shasta Soda Museum no date). With the introduction of ginger ale in 1931, the Mt. Shasta Mineral Spring Company became Shasta soda (Shasta Soda Museum no date).

Figure 2.2-3. Photograph shows the scenic railway, Shasta Springs, California, ca. 1907. Photo Credit: California State University, Chico, Miriam Library, Special Collections. Donor: Pioneer Museum, Oroville, California.

Other resorts that were popular during the late 19th and early 20th centuries and were centered on springs include Castle Crags Soda Springs and Upper Soda Springs. Castle Crags Soda Springs, owned by Pacific Improvement Company, consisted of log cabins, a dining room, clubhouse, social hall, and casino located near Castella (James 1914, California State Mining Bureau 1916). Waters from the mineral springs located at Castle Crags, alternately called Castle Rock, were sold on the market around the turn of the 20th Century (California State Mining Bureau 1916). Upper Soda Springs was originally a traveler's stop on the Siskiyou Trail. A toll bridge and inn were established in 1855 by Ross and Mary McCloud, and with the arrival of the railroad, the resort was established (California State Mining Bureau 1916). A larger inn and an improved spring were built, and the resort was open until the 1920s.

With the introduction of the automobile and the creation of Highway 99, the resorts and recreation in the watershed became more focused on camps and campgrounds rather than train access resorts. Auto and trailer camps along with gas stations and stores sprang up along the highway at such places as Shiloah Springs and Pollock (Federal Writer's Project 1939). In 1933, Castle Crags State Park was established. The CCC stationed at Sims worked on the infrastructure of the park, including roads and trails, campsites, and public restrooms, creating a popular camping destination (Dietzel 2008).

Stage Stops, Railroad Stations, Post Offices, and Homestead Ranches

The Southern Pacific Railroad was the main transportation corridor through the upper Sacramento River watershed from the 1880s until the construction of Highway 99 in the 1920s (the rail line is still used for cargo). Many of the earlier stage stops along the California-Oregon Road lay near the rail line and were selected as stations for cargo loading, water and fuel loading for the engines, and as

passenger stops. Other stops were placed near economically important areas such as mills or mines. These stations became important hubs in the commerce and social life of the watershed, often becoming small communities or resorts. Stations, water stops, and other stops from south to north include Kennett, Pitt, Elmore, Antler, Delta, Lamoine, Gibson, Sims, Conant, Castella, Castle Rock, Castle Crags, Dunsmuir, Upper Soda Springs, Shasta Retreat, Shasta Springs, Cantara, Mott, Sisson (modern-day City of Mt. Shasta), and Upton (Drury and Drury 1913) (see Figure 2.2-1).

Many of these railroad stops had started out as stage stops, travelers' rests, or homesteads that doubled as stops on the Oregon-California Road/ Redding-Yreka Stage Road. Many of them were named for the original owners of the property such as Sims and Smithson, and others were named for local pioneers like Gibson, or for investors in the railroad or stage road ventures like Dunsmuir. Several also hosted post offices for a period. Kennett was the southern-most post office in the watershed. The next post office location changed names and specific locations but remained within a small radius and was known alternately as Antler, Gregory, Halcyon, and Smithson. The post office at Delta was also known as Bayles (Dunham 1998). The Lamoine area was known as Pollock, Portuguese Flat, Slate Creek, and Slatonis, while Sims was known as the Hazel Creek Post office (Dunham 1998). Castella's post office is still in operation, although the next post office to the north at Eubanks no longer exists. Dunsmuir still operates a post office, while the Shasta Retreat office and the Mott office have shut down (Dunham 1998). The Berryvale post office has undergone several name and location changes and is now the City of Mt. Shasta office (Dunham 1998). At times, these offices have offered services to as few as 50 people; however, they usually marked a center of community for their areas.

Mill Towns and Mining Towns

The upper Sacramento River watershed has been exploited for mineral and timber resources since the earliest days of the State of California. Many small communities have risen and fallen with the mining and timber industries. The better known mining towns include Dogtown, a gold era town near present-day Delta; Kennett, a copper town now under the waters of Shasta Lake; Portuguese Flat, a gold era community; and Castella, with chromite deposits located in the nearby Castle Crags (California State Mining Bureau 1916, Vaughn 2007). The communities all experienced boom and bust cycles, with some towns disappearing altogether after the depletion of the ores and others changing industries and persisting to the present.

The mining industry spawned the timber industry in the watershed. Several sawmills and towns were advantageously located near large timber stands and along the major shipping corridor of the railroad. Lamoine, Castella, Dunsmuir, Mott, Soda Creek (Castle Rock), and Sims all housed sawmills and logging operations of varying sizes. Lamoine was the headquarters of the Lamoine Lumber and Trading Company created in 1898 by the Coggins Brothers (Gudde 2004). This operation harvested timber in the hills surrounding Lamoine using not only oxen and horses, but also using a railroad system (Orre 1999). Extensive tracks were laid through the forest to aid in bringing the timber to the mill. In 1917, a large fire destroyed much of the town and sawmill, and, in 1922, the logging equipment was sold to the Solinsky mill in Castella (Orre 1999). Mott experienced a similar bust and boom cycle. The Red Cross Lumber Company operated a sawmill at Mott until 1891, when a large fire "destroyed the mill and surrounding timber" (Orre 1999). The lumber company then transferred operations to Soda Creek near Castella (Orre 1999). Castella became the largest of the lumber towns

at the turn of the 20th century, supporting at least 10 different operations between 1800 and 1960 (Dietzel 2008).

A timeline of some of the major events in the recent history of the watershed is presented as Figure 2.2-4.

2.3 Evolution of Laws and Regulations Affecting the Watershed

2.3.1 Mining

Mining Claims

In 1848, gold deposits were discovered in California. This stimulated tremendous controversies as to how the minerals should be disposed of. Most of the controversy was between the federal government and the State of California.

The earliest governments and laws established by the Euro-American settlers in the watershed created mining districts and laid the ground rules for establishing a mining claim. Equally important to the miners were the rules of abandoning a mining claim. These rules were a means to settle disputes arising from gold fever and an attempt to curb the increasing chaos. Regardless of the fact that the land and the minerals taken by the early settlers was not legally theirs to take, they were being taken nonetheless. The land and its minerals were theoretically owned by the United States government, although even that ownership status was questionable in 1849.

Rather than establishing dominance over the settlers and all others in what became California, the federal government allowed the miners to develop the rules. As Davis put it, "the gold seekers were so firmly established on the land that it would not have been practicable to evict them, had the government so desired" (Davis 1937). The hands off approach of the federal government meant that much of the west's future was sculpted by the minds and hands of miners, a legacy that persists today.

Typically, the local governments would pass regulations or statutes that applied to several mining districts. While the various mining districts often had different regulations, the basic concepts were the same or very similar. The regulations typically made the right to hold a claim dependent on the discovery of the mineral (gold) followed by appropriation, and upon continuing to work or develop the ground. In practice, miners worked at a claim only long enough to determine its potential. If a claim was deemed to be of low value, and most were, miners would abandon the site in search for legendary "bonanza" sites. Where a claim was abandoned or not worked, other miners would "claim-jump" the land. "Claim-jumping" simply meant that a new miner began work on a previously claimed site (Rohrbough 1998).

Rules or no rules, disputes over gold claims and profits were often handled personally and violently. These disputes were sometimes handled by groups of prospectors acting as arbitrators (Rawls and Orsi 1999). However, this often led to heightened ethnic tensions. Numerous accounts tell of racial tensions between the Euro-American settlers and their foreign counterparts, and it was not uncommon for racial tensions over gold to end in bloodshed or lynching (Gonzales-Day 2006, McDonald 1979).

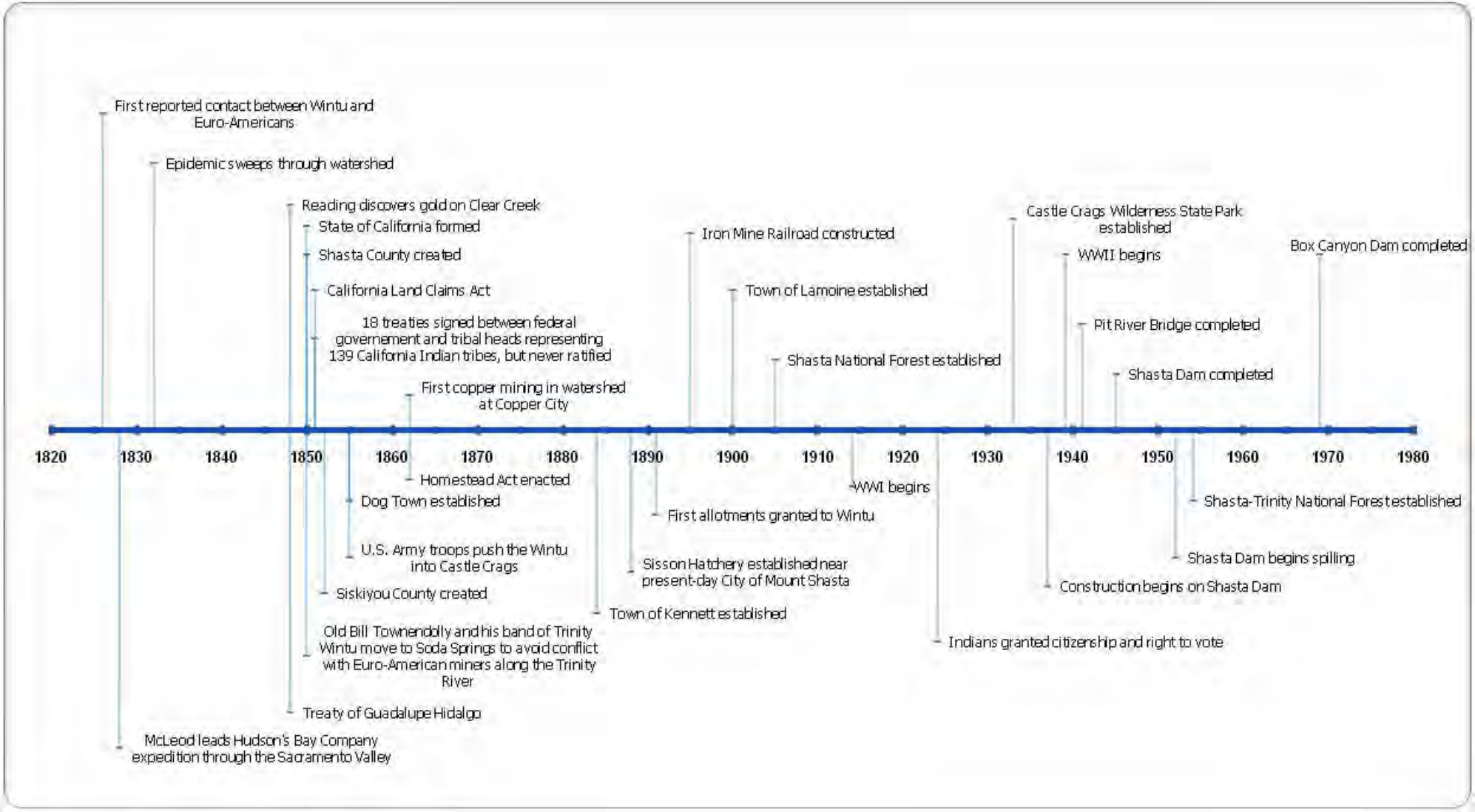

Figure 2.2-4. Timeline of Recent Major Events in the Upper Sacramento River Watershed

Almost 20 years later, in 1866, the U.S. Congress finally passed the "Chaffee laws." Congress tried to make the best of the situation by opening the lands of the United States to mineral exploration and occupation. The act recognized the validity of the local customs or rules of the miners so long as they were not in conflict with the laws of the federal government. The federal act both forgave and legalized the 18-year trespass. The law was later repealed and replaced with the 1872 Mining Act, which has governed mineral exploration and exploitation ever since (Davis 1937).

Mineral Rights

In addition to the mining claims that were akin to leasing land from the government for production, the federal government now recognized mining rights that were a kind of property, which could be owned by an individual or company. These newly granted mineral rights provided a legal right for settlers to explore for, and produce, resources on and below the surface. Ownership of mineral rights gave settlers the right to extract valuable commodities such as gold, silver, copper, and iron (Davis 1937).

Laws Governing Mining/Regulatory Context

Federal

The federal **Mining Act of 1872** still applies to mineral exploration in the watershed today.

The **United States Mining Laws** (30 U.S.C. 21-54) confer statutory right to enter upon public lands in search of minerals. Regulations found in 36 CFR 228, Subpart A, set forth rules and procedures to minimize adverse environmental impacts on National Forest resources. Access for mineral exploration and development is generally unrestricted, subject to the mitigation of adverse impacts to surface resources.

Access for mineral exploration on Shasta-Trinity National Forest (STNF) land is restricted in wildernesses, the "wild" portions of Wild and Scenic Rivers, botanical areas, Research Natural Areas (RNAs), National Recreation Areas (NRAs), and areas that have been withdrawn from mineral entry. Minerals in the NRA are not locatable but they are leasable (USDA Forest Service and USDI Bureau of Land Management 1994).

State

The primary state law regarding mining operations is the **California Surface Mining and Reclamation Act (SMARA) of 1975**. The intended purpose of SMARA is to reclaim mined lands to a condition that is readily adaptable for an alternative use. The law is a response to the previous era of mineral exploitation and the ensuing environmental degradation. SMARA provides a tool for the state to analyze potential impacts of mining operations, and a means to ensure that mined areas will be cleaned up and the surface of the land restored or reclaimed for another use. The law does not apply to mining operations that were abandoned or ceased prior to 1975; it apples to mining activities (operations and reclamation) that were in existence in 1975 or that started after that time. SMARA is enforced by the California Department of Conservation, Office of Mine Reclamation, as well as by county and city governments, which act on the state's behalf as lead agencies.

The scope of the law is unusually broad. It covers mining activities on both state and federal lands. By way of a Memorandum of Understanding with the California Department of Conservation, the BLM and U.S. Forest Service (USFS) have agreed that the statutes and regulations of SMARA are applicable to lands regulated by BLM and Forest Service. A focal point of the state's argument for jurisdiction on federal lands was the amount of abandoned mines on federal lands within the state that contribute environmental health and safety hazards, and the lack of federal requirements and action to remedy these problems. The upper Sacramento River watershed is no stranger to these problems. Several abandoned copper mines located on federal lands around Shasta Lake continue to leach acid mine drainage into surface waters, and countless abandoned mines with open shafts and abandoned equipment dot the watershed's landscape.

Under SMARA, mining operations that produce more than 1,000 cubic yards of material must provide a reclamation plan. These plans must disclose the type, scope, timeframe, and means of mineral extraction proposed, as well as a detailed plan for reclaiming the mined area to an agreed upon condition (e.g., open space, wildlife habitat, industrial site, etc.).

In addition to SMARA, the California Health and Safety Code requires covering, filling, or fencing abandoned shafts, pits, and excavations (California Health and Safety Code Sections 22440-03).

Local

Mining activities are also regulated and monitored by local governments through general plans and zoning ordinances.

2.3.2 Agriculture and Ranching

The **Homestead Act** was passed by the U.S. Congress in 1862. It provided for the transfer of 160 acres of unoccupied public land to each homesteader on payment of a nominal fee and after 5 years of residence. Land could also be acquired after 6 months of residence at $1.25 per acre. Prior to this act, the government had sold land to settlers in the West for revenue purposes, but as the West became politically stronger, pressure on Congress to guarantee free land to settlers was increased. Even so, several bills providing for free distribution of land were defeated before the Homestead Act was passed, including a bill passed by Congress in 1860 that was vetoed by President Buchanan. However, with the ascendancy of the Republican Party (which had committed itself to homestead legislation) and with the secession of the South (which opposed free distribution of land), the Homestead Act, sponsored by Galusha A. Grow, became law. In 1976, the Homestead Act expired in all states but Alaska, where it ended in 1986 (Parsons 2003b, Eidness 1997).

Many people who settled in the watershed took advantage of the Homestead Act and some turned over their land to others for a pre-arranged price. Many of the early large ranches were developed over previous mining claims. As homesteaders took up more and more land, the pressure continued to push the remaining Indians to local reservations (Parsons 2003b).

2.3.3 Timber Management

Federal

Simple laws to protect certain types of trees have been around since colonial times. However, the creation of the Department of Agriculture in 1862 marks the beginnings of a national effort to protect the nation's agricultural health. It wasn't until 1875, though, that Congress allocated $2,000 for the purpose of hiring a forestry agent to investigate the subject of timber management (Thornton 1995). This was unanticipated, since the discipline of forestry was new and there were very few trained foresters in America at this time (Thornton 1995). The Division of Forestry was created in 1881.

The **Weeks Act of 1911** marked the beginning of federal forestry assistance programs. The Act authorized federal purchase of forestlands in the headwaters of navigable streams, established the National Forest Reservation Commission, gave consent for states to enter into compacts for the purpose of conserving forests and water supplies, and authorized federal matching funds for approved state agencies to protect forested watersheds of navigable streams.

The **Clarke-McNary Act of 1924** was one of several pieces of federal legislation that expanded the Weeks Act. It enabled the USFS to enlarge the relatively new National Forest System through the purchase of lands predominantly within predetermined national forest boundaries. It authorized the Secretary of Agriculture to work cooperatively with state officials for better forest protection, chiefly in the areas of fire control and water resources, while providing for continued timber production. In addition, the Clarke-McNary Act encouraged a cooperative reforestation effort between the USFS and private forestland owners through the production and distribution of tree seedlings and forestry assistance. Because of this act, all 50 states have an established a state forestry agency or forestry extension agency. The Clarke-McNary Act is widely held as the first federal legislation that firmly established as its principle effort the promotion of forestry at the state level.

The **Multiple-Use Sustained-Yield Act (MUSYA),** first enacted in 1960, provides little in the way of legal standards, but does set forth policy guidelines for use by the USFS in its management of the nation's forests. According to the MUSYA, the USFS must give due consideration to the relative values of the various natural resources and multiple uses that occur on its lands, including outdoor recreation, range, timber, watershed, and wildlife and fish habitats. This act advocates a policy of "sustained yield and services," whereby the variable renewable resources of national forests will be maintained in perpetuity without impairment of the productivity of the land.

Although the need for cohesive forest management policies and directives for both private and public lands was not a new concept prior to the 1970s, decades of declining forest health and increasing public pressure demanded that previous management practices be reassessed and that significant changes be made to ensure forest sustainability. Since the 1950s, widespread clearcutting had converted tens of thousands of acres of mature and old growth forests in and around the watershed into young, even-aged tree plantations (Lininger 2003). It is estimated that by 1990, approximately 80 percent of the watershed had been logged (USDA Forest Service 2001). Mounting pressure for changes in forest management practices including logging, and an increased demand by the public for public lands to be managed for multiple uses, was felt not only on a national level, but at a local level as well. Numerous policies were enacted during this period by federal and state governments,

intended to encourage a broadscale assessment of the environmental consequences that could result from management actions.

The **National Environmental Policy Act (NEPA),** enacted in 1970, requires federal agencies, including the USFS, that manage public timberlands to integrate environmental values into their decision-making processes by considering the environmental impacts of proposed actions and reasonable alternatives to those actions. The primary purpose of NEPA is to promote informed decision-making by federal agencies by making detailed information concerning significant environmental impacts available to both agency leaders and the public. NEPA requires that federal agencies disclose the findings of their environmental analysis and the effects of project implementation on the human environment, and solicit comments from interested and affected parties.

The **National Forest Management Act (NFMA)** of 1976 was designed to balance the timber industry's interest in providing a steady supply of harvestable timber with those of the public and environmentalists in protecting forests for recreation and conservation purposes. Under NFMA, the USFS must develop specific land use plans (called Land and Resource Management Plans (LRMP)) in cooperation with state, local, and federal agencies and the public to govern the management of forests within its jurisdiction. The plans, which are binding, divide each forest into "management areas" and dictate how the forest will be managed over a 10- to 15-year period. NFMA prohibits harvesting under LRMPs where it may cause extensive or irreparable harm to resources, biological diversity, or watersheds; restricts the use of clear cutting; and limits the volume of trees that can be removed to the number that can be harvested annually in perpetuity on a sustained-yield basis. LRMPs must also be consistent with the MUSYA and be NEPA-compliant. The STNF completed its LRMP in 1995.

The **Northwest Forest Plan (NWFP)**, adopted in 1994, consists of a series of federal policies and guidelines governing land use on federal lands in the Pacific Northwest region of the United States. It covers areas ranging from northern California to western Washington and includes the upper Sacramento River watershed. The NWFP was originally drafted with the intent of protecting critical habitat for the northern spotted owl and the marbled murrelet, though the plan came to include much broader habitat protection goals.

The NWFP takes an ecosystem management approach to forest management, with support from scientific evidence, while adhering to the requirements of existing laws and regulations. The dual intent of management on affected federal lands is (1) to maintain a sustainable supply of timber and other forest products that will help maintain the stability of local and regional economies on a predictable and long-term basis to meet the need for forest habitat and forest products, and (2) to maintain a healthy forest ecosystem with habitat that will support populations of native species (particularly those associated with late-successional and old-growth forests), including protection for riparian areas and waters.

Concurrent with the NWFP, the 1994 Final Supplemental Environmental Impact Statement (FSEIS) on Management of Habitat of Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl and its associated Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl (ROD) established a network of Late Successional Reserves (LSR), to include 100-acre

core areas and Managed Late Successional Areas (MLSA). The network of reserves are intended to provide old-growth forest habitat, provide for populations of species that are associated with late-successional forests, and to help ensure that late-successional species diversity will be conserved (USDA Forest Service 1999). This direction was incorporated into the STNF's LRMP, which provides for a multi-level approach to timber management (intensive, modified, minimal, and uneven-aged) on USFS lands within the watershed that will achieve the desired output for a given area with regard to yield, forest health, and cultural practices (USDA Forest Service 1995).

Adoption of the Northwest Forest Plan and the 1994 FSEIS on management of northern spotted owl habitat created a much more involved process, requiring more in-depth survey protocols and analysis for approving timber-harvesting projects in northern spotted owl habitat on National Forest and Bureau of Land Management (BLM) lands. The result has been a substantial reduction in timber harvesting on national forest lands within the STNF compared to prior levels of harvesting. It also created an additional set of standards that timber harvesting plans and operations have to meet, and new opportunities for projects to be challenged through appeals or litigation; thus, more timber harvest projects have been delayed and the total timber harvest acreage on national forest lands has been reduced. This reduction in timber harvest volumes contributed to economic effects in the local communities within and surrounding the watershed, such as reduced prices for logs, closing of mills, reduced competition for logs, and loss of jobs. In recent years, mills located in Mt. Shasta, McCloud, and Redding, which provided markets for logs from the upper Sacramento River watershed, have closed.

The **Healthy Forests Restoration Act of 2003**, often referred to as the Healthy Forests Initiative (HFI), was enacted to address the overcrowding of forests and excessive accumulations of fuels that have resulted from nearly a century of fire suppression and the effects that these conditions are having on forest health. The intent is to reduce the risk of catastrophic wildfires through the restoration of healthy forest ecosystems and watersheds on federal lands. The HFI also endorses a collaborative approach to watershed forestry management on nonindustrial private forest lands owned by any nonindustrial private individual, group, association, corporation, or other private legal entity (such as tribal lands) by providing federal technical assistance and cost-sharing (H.R. 1904—2, Title 3, Sections 302 and 303).

State

Founded in 1885, the California State Board of Forestry was the first state-appointed forestry board in the nation. The board was authorized to investigate, collect, and disseminate information about forestry. In 1887, the board members were given the power of peace officers to enforce compliance with the few laws that the state had enacted concerning brush and forest lands. However, a hostile political climate led to the abolishment of the board in 1893 (Thornton 1995).

In 1903, California Governor George Pardee stated his desire for a joint federal-state study and survey of the forest situation in California. The survey was conducted from 1903 to 1907. Commencement of the project set the stage for the establishment of a new Board of Forestry and the creation of the position of State Forester in 1905 (Thornton 1995).

In 1945, the original **California Forest Practice Act (CFPA)** was passed by the state legislature as a means to quell fears of an impending timber famine and to prevent any potential federal mandates on

forestry practices (Dicus and Delfino 2003). This act regulated the harvesting of timber on private lands in California by requiring that notification be given to the State Forester by any person who intended to cut merchantable timber. The original CFPA was much narrower in scope than its present-day successor (the Z'berg-Nejedly Forestry Practice Act, described below), focusing almost exclusively on timber resources and fire prevention. The original act was nullified in 1971 when a state appeals court found that it was "pecuniary interested in the timber industry" and subsequently declared void. The Z'berg-Nejedly Forestry Practice Act, which followed, was considerably modernized to reflect the public's growing interest in fish and wildlife conservation, water quality protection, and the general sustainability of the state's forest industry (Klamath Resource Information System No date).

The **Z'berg-Nejedly Forestry Practice Act (FPA)** of 1973 replaced the original California Forest Practices Act nullified in 1971. The FPA parallels the federal NFMA, but goes further in regulating forestry practices on private lands. Whereas the NFMA regulates federal forestlands, the FPA governs the management of non-federal timberlands in California including state and private timberlands. The FPA, in conjunction with the Professional Foresters Law, was established to address the public's growing concern over the environmental effects of timber harvesting.

To accomplish its goals, the FPA includes certain licensing provisions for persons cutting and removing forest trees on private property in order to sell the logs or to develop a building site on forest covered lands. A timber harvest plan (THP), prepared by a Registered Professional Forester, must also be submitted to the Director of California Department of Forestry and Fire Protection (CalFire) for review and approval prior to harvesting timber.

Following harvest, the FPA requires that logged areas be restocked according to proper standards. Under the authority of the FPA, the California State Board of Forestry and Fire Protection is responsible for oversight, maintenance, and revisions as needed in order to sustain forest productivity and protect the forest environment.

Prior to passage of the FPA, timber-harvesting regulations in California had already been on a path of improving forest practices. The FPA formalized the standards for forest practices by creating the THP requirement, which eventually was certified as a CEQA process functional equivalent for planning and harvesting operations on state and private timberlands. It incorporated public and agency review, analysis of environmental impacts, assessment of alternatives, inspections, and monitoring into the standards to protect public trust resources such as waterways and soils. It has also increased the costs of timber harvesting planning and operations. Some effects on resources that passage of the FPA has had in the upper Sacramento River watershed and throughout private timberlands in California have been the substantial reduction in the size of clear cuts, and increased protections for watercourses and riparian zones.

In 1975, a court decision mandated that forestry practices were subject to CEQA, which required that an Environmental Impact Report (EIR) be filed for any activity requiring state approval (e.g., authorization from the State Board of Forestry and Fire Protection) and that may cause a change in the environment. While NEPA primarily covers the federal lands and federal actions in California, CEQA applies to all state and private properties (California State Board of Forestry and Fire Protection 2003). In 1979, the Secretary of the Resources Agency certified the preparation of a THP, as applied under the state FPA is the functional equivalent to the environmental assessment process

required under the CEQA. Therefore, timber harvest activities carried out under the FPA are exempt from the EIR requirement. In order to meet functional equivalent status, THPs are subject to review by not only the State Board of Forestry and Fire Protection, but also by a multidisciplinary review panel that includes the California Department of Fish and Game, the appropriate Regional Water Quality Control Board, the California Geological Survey, and others.

2.3.4 Water Resources

Federal

The **Safe Drinking Water Act (SDWA)** of 1974 is intended to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources (e.g., rivers, lakes, reservoirs, springs, and ground water wells). SDWA does not regulate private wells serving fewer than 25 individuals. SDWA authorizes the Environmental Protection Agency (EPA) to set national health-based standards for drinking water to protect against both naturally-occurring and man-made contaminants that may be found in drinking water. The EPA endorses a collaborative *watershed approach* between federal, state, and local water agencies to make sure that these standards are met.

USFS **Riparian Reserves and Key Watersheds.** Current management objectives within riparian areas are directed toward maintenance and improvement of the riparian ecosystem and protection of water quality and stream courses. Designated Riparian Reserves include streams and riparian systems as well as an upland buffer from the edge of the stream or riparian system. The width of the upland buffer included within a riparian reserve varies, depending on the type of system. The STNF can manage vegetation on its lands within the buffer if the activities maintain and/or enhance the riparian and aquatic habitats and are consistent with the Aquatic Conservation Strategy. The buffer for permanently flowing non-fish bearing streams is 150 feet on each side of the stream. For fish-bearing streams, the buffer is 300 feet on each side (600 feet total). For lakes and natural ponds, reservoirs, and wetlands greater than 1 acre, riparian areas generally comprise 300 feet of the high water mark (USDA Forest Service 1995). The LRMP also includes a directive for the minimum buffer needed for seasonally flowing or intermittent streams, wetlands less than 1 acre, and unstable and potentially unstable areas.

The LRMP strives to maintain the quality of riparian and aquatic habitats through the implementation of the Aquatic Conservation Strategy objectives and by implementing Best Management Practices (BMP) to protect water quality. The nine Aquatic Conservation Strategy objectives require that the maintenance and restoration directives for biological and hydrological systems be met within a Riparian Reserve.

The LRMP provides the following Standards and Guidelines for land management within Riparian Reserves:

- Identify in-stream flows needed to maintain riparian resources, channel conditions and fish passage.

- For activities other than surface water developments, issue leases, permits, rights-of-way, and easements to avoid adverse effects that retard or prevent attainment of Aquatic Conservation Strategy objectives.

Permits under **Section 404 of the Clean Water Act**, as amended, are required for the placement of dredge or fill materials into waters of the United States, including wetlands and "other waters." Projects are permitted under either individual or general (e.g., nationwide) permits. The specific applicability of a permit type is determined by the Corps on a case-by-case basis.

The **federal CWA** contains laws protecting navigable waters, and the California Water Code (CWC) is the state body of law protecting groundwater and fresh and marine surface waters. Section 303 of the CWA requires states to adopt water quality standards (water quality objectives and beneficial uses), and the 1987 provisions also mandated adoption of numerical standards for 126 "priority pollutant" toxic chemicals (33 U.S.C. 2002). CWA Section 303(b) requires states to submit water quality conditions of their navigable waters to the federal government on a reoccurring basis (33 U.S.C. 2002). The federal CWA requires states to provide a list identifying the waters, or water segments, that do not meet applicable water quality standards with technology-based controls alone. The California State Water Resources Control Board (State Water Board) and the Regional Water Quality Control Boards (Regional Water Boards) implement the federal CWA in California under the oversight of the U.S. Environmental Protection Agency (EPA), and as a result, statewide water quality results are submitted to the EPA (California Water Boards 2006).

Executive Order 11990 is an overall wetlands policy for all agencies managing federal lands, sponsoring federal projects, or providing federal funds to state or local projects. The order requires federal agencies to follow "avoidance-mitigation-preservation" procedures, provide the opportunity for public input before proposing new construction in wetlands, and avoid impacts on wetlands where practicable.

State

The **California Safe Drinking Water and Toxic Enforcement Act (CA SDWA) of 1986**, was passed to build on and strengthen the federal SDWA. The CA SDWA authorizes the state's Department of Health Services to protect the public from contaminants in drinking water by establishing maximum contaminants levels (MCLs) that are at least as stringent as those developed by the EPA, as required by the federal SDWA.

Any entity proposing an activity that will substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake designated by the California Department of Fish and Game (CDFG) must receive a discretionary **Lake or Streambed Alteration Agreement permit** from the CDFG pursuant to Section 1602 of the California Fish and Game Code. Typically, this requirement applies to any work undertaken within the 100-year floodplain of a stream or river containing fish or wildlife resources.

The **Porter-Cologne Water Quality Control Act (Porter-Cologne Act)** was established by the State of California, in part, to meet the requirements of the CWA. The Porter-Cologne Act is integrated with the CWA and authorizes the State Water Board to adopt, review and revise state water policy, which may include water quality objectives, principles, and guidelines (State Water Resources

Control Board 2010). In addition, the preparation and adoption of water quality control plans (Basin Plans) is required by the CWC and supported by the federal CWA. Basin Plans designate waters bodies and beneficial uses to be protected under the CWA and CWC. Water quality objectives are established to protect the beneficial uses, and a program of implementation necessary for achieving the objectives is included as part of the Basin Plans. State law also requires that Basin Plans conform to the policies set forth in the CWC and any state policy for water quality control. Since beneficial uses, together with their corresponding water quality objectives, can be defined as water quality standards, the Basin Plans are actually regulations for meeting the state and federal requirements for water quality control. One significant difference between the state and federal programs is that California's Basin Plans establish standards for groundwater in addition to surface waters (Central Valley Regional Water Quality Control Board 2009).

Local

The **Siskiyou County General Plan** (Siskiyou County Planning Department 1973) contains goals and policies designed to guide the future development of the County, based on current conditions. The Conservation Element of the General Plan, as defined in Section 653:Q2(d) of the Government Code, is "for the conservation and development and utilization of natural resources including water and its hydraulic force, forest, soils, rivers and other water areas, including harbors, fisheries and wildlife habitat" (Siskiyou County Planning Department 1973). It also covers minerals and other natural resources.

The objectives of the General Plan pertinent to water resources are as follows:

- To protect and conserve the lakes, streams and reservoirs of the county for potable and agricultural water, for recreation areas but more important as wildlife habitat which will be beneficial to the residents, present and future of Siskiyou County and the state.

- To conserve and maintain habitat for wildlife species and plant life.

The **Shasta County General Plan** (Shasta County 2004) identifies several policies to protect life and property from flooding or dam failure, including the reach of the upper Sacramento River between Box Canyon Dam in Siskiyou County and Shasta Lake, as well as areas that would be at risk in the event of failure of Shasta Dam. Relevant policies include:

- New development in floodplains shall be regulated through zoning regulations addressing land use type, density, and siting of structures.

- The impacts of new development on the floodplain or other downstream areas due to increased runoff from that development shall be mitigated.

- Known flood hazard information shall be reported as part of every General Plan amendment, zone change, use permit, variance, building site approval, or other land development applications subject to environmental assessment.

- Flood Hazard Maps shall be maintained by the County to aid in the project review process.

- Dam Failure Inundation Maps shall be maintained by the County to aid in the project review process.

- The Shasta County Emergency Plan shall provide for early warning and emergency evacuation routes in the event of dam failure.

The upper Sacramento River watershed is critical to the water supply for much of the state. Policies relevant to the maintenance of the quality and quantity of water produced by the watershed include:

- Sedimentation and erosion from proposed developments shall be minimized through grading and hillside development ordinances and other similar safeguards as adopted and implemented by the County.

- Septic systems, waste disposal sites, and other sources of hazardous or polluting materials shall be designed to prevent contamination to streams, creeks, rivers, reservoirs, or groundwater basins in accordance with standards and water resource management plans adopted by the County.

- The potential for cumulative water quality impacts resulting from widespread use of septic systems in poorly suited soil areas shall be periodically evaluated by the County for the need to provide greater monitoring and possible changes to applicable sewage disposal standards.

- The Shasta County Water Agency should encourage and promote interagency water planning efforts within the County, particularly in the Redding Basin.

The County shall encourage and participate in interagency planning efforts, such as the Redding Area Water Council, to protect and enhance the quality of all groundwater and surface water resources.

2.3.5 Fire Management

Federal

In the first two decades of the century, wildfire ran essentially unchecked through America's forests. Before 1930, from 20 to 50 million acres commonly burned each year and few forests were effectively protected (MacCleery 1992). In 1902, a series of catastrophic fires near Yacolt, Washington, burned more than a million acres and took 38 lives. These fires encouraged the forest industry to set up private fire protection associations (MacCleery 1992). In 1910, devastating fires in northern Idaho and northwestern Montana prompted Congress to pass the **Weeks Act**, which authorized federal matching funds for state fire-control agencies (MacCleery 1992). The **Clark-McNary Act** of 1924 augmented cooperative federal and state fire suppression efforts as well as existing funding under the Weeks Act (MacCleery 1992). By the end of the 1930s, these programs began to show results. However, of all the efforts to educate the public about fires, the introduction of Smokey Bear as a symbol of fire prevention was perhaps the most successful and widely recognized (MacCleery 1992).

In recent years, the role of fire in the environment has become increasingly valued as societal concerns for managing natural resources have grown. The focus of fire policy and management has

shifted away from the overall goal of removing fire from the ecosystem toward the much more complex goal of managing fire (Stephens and Sugihara 2006a). The challenge today is to develop fire policies, management actions, and budgets that recognize the need for both fire suppression and the management of fire as an ecosystem process and hazard reduction tool (Stephens and Sugihara 2006a). In response, several important fire management plans and policies have been developed by the federal and state agencies that are responsible for implementing fire suppression and fire management policies.

The **Northwest Forest Plan (NWFP)**, adopted in 1994, was intended to promote forest resource sustainability through an ecosystem approach. Although the NWFP helped stabilize the number of large-diameter forests in the Pacific Northwest, fire has since become the main reason for loss of these forests. The dense forest structure is not supported by the fire disturbance regime, and the greater propensity for large stand-replacing fires results in an increasingly elevated risk of long-term habitat loss (USDA Forest Service 2001a).

In 2000, President Clinton requested the Secretaries of the Departments of Agriculture and Interior to prepare a report recommending how to respond to severe, ongoing fire activity; reduce impacts of fires on rural communities and the environment; and ensure sufficient firefighting resources in the future. The resulting report (U.S. Department of Agriculture and U.S. Department of the Interior 2000) became the cornerstone of what was to become known as the **National Fire Plan**. A collaborative effort between the Departments of Agriculture and Interior, the Western Governors' Association, and other southern governors, counties, and tribes produced the two reports that compose the National Fire Plan: the August 2001 *10-Year Comprehensive Strategy* (U.S. Department of Agriculture and U.S. Department of the Interior 2001) and its subsequent May 2002 *Implementation Plan* (U.S. Department of Agriculture and U.S. Department of the Interior 2002b). The *Implementation Plan* was updated in 2004 to emphasize the importance of the collaborative framework between partners if the plan is to succeed.

The purpose of the National Fire Plan is to improve the resiliency and sustainability of forests and grasslands at risk of wildfire; conserve priority watersheds; protect and promote species biodiversity; reduce wildland fire costs, losses and damages; and ensure firefighter and public safety. Achievement of these goals is being met through increased firefighting preparedness, prevention through public education and collaborative stewardship, rehabilitation of watershed function, hazardous fuel reduction, monitoring, and applied research and technology transfer.

The 2002 **Healthy Forests Initiative** responds to the growing national priority for protecting communities and the environment from the risk of wildfire. President George W. Bush directed the Secretaries of the Departments of Agriculture and Interior and the Chairman of the Council on Environmental Quality to develop a plan that would improve regulatory processes to ensure more timely decisions, greater efficiency, and better results in reducing the risk of catastrophic wildfires by restoring forest health (U.S. Department of Agriculture and U.S. Department of the Interior 2002a). The resulting legislation emphasized administrative and legislative reforms to expedite the delivery of fuels treatments and post-fire actions.

In February 2003, Congress delegated long-term stewardship contracting authority to the USFS and the BLM, which was followed by passage of the Healthy Forests Restoration Act (HFRA) in December 2003. The purposes of this act are as follows:

- to reduce wildfire risk to communities, municipal water supplies, and other at-risk federal land through a collaborative process of planning, prioritizing, and implementing hazardous fuel reduction projects;

- to authorize grant programs to improve the commercial value of forest biomass (that otherwise contributes to the risk of catastrophic fire or insect or disease infestation) for producing electric energy, useful heat, transportation fuel, and petroleum-based product substitutes, and for other commercial purposes;

- to enhance efforts to protect watersheds and address threats to forest and rangeland health, including catastrophic wildfire, across the landscape;

- to promote systematic gathering of information to address the impact of insect and disease infestations and other damaging agents on forest and rangeland health;

- to improve the capacity to detect insect and disease infestations at an early stage, particularly with respect to hardwood forests; and

- to protect, restore, and enhance forest ecosystem components:

  - to promote the recovery of threatened and endangered species;
  - to improve biological diversity; and
  - to enhance productivity and carbon sequestration.

State

On March 18, 1905, the California State Legislature approved the establishment of a new Board of Forestry and the position of State Forester (see above) (Thornton 1995). The act granted to the State Forester the right to appoint local fire wardens. The State Forester could also "maintain a fire patrol at places and times of fire emergency." However, the fire patrol system was to be funded by the county in which the action took place. Although the California Department of Forestry and Fire Protection (CalFire) could be said to have started in 1905 with the creation of the position of State Forester, from 1905 until 1919, the State Forester and the "forestry department" were one-and-the-same.

As described above, in 1911 Congress passed the "Weeks Law," which provided fiscal aid for cooperative fire protection work between the USFS and qualifying states. In 1919, the California Legislature appropriated money for fire prevention and suppression work. The state's first four rangers or "Weeks Law Patrolmen" were hired for a four-month period covering the summer of 1919. They worked wherever needed but were individually headquartered in Redding, Oroville, Placerville, and Auburn (Thornton 1995).

In 1920, the ranger organization was restructured and expanded with 10 rangers overseeing 10 districts. The districts were: 1) Shasta County; 2) Butte and Yuba counties; 3) Placer and Nevada counties; 4) El Dorado and Amador Counties; 5) Tehama County; 6) Colusa County; 7) Lake County; 8) Mendocino County; 9) Napa County; and 10) Santa Cruz, Santa Clara, and San Mateo counties. Over the next decade, the district system and the ranger force slowly grew.

In April 1933, the Emergency Conservation Work (ECW) program was established. It became known almost instantly as the Civilian Conservation Corps (CCC). In California, the USFS's District Forester developed a plan of attack on how to use this new labor pool. The CCC was assigned three basic tasks: firebreak construction, lookout station building, and general improvements. The "Three Cs" cut fuelbreaks around the state, with particular emphasis on establishing the "Ponderosa Way Firebreak." This continuous fuelbreak extended the length of the Sierra Nevada, and into the Cascades, ending north of Redding. The firebreak was intended to be a permanent defensive line between the lower foothill regions and the higher elevation National Forest lands. The second project was the construction of an integrated, statewide fire detection network. The third task, general improvements, included the building of administrative and fire suppression bases, installation of roads, bridges, telephone lines, and many other conservation projects.

The ECW programs lasted from 1933 to 1942. All told, the laborers constructed over 300 lookout towers and houses; some 9,000 miles of telephone lines; and 1,161,921 miles of roads and trails; and numerous fire stations and administrative buildings in California. The CCC also planted over 30 million trees and spent nearly one million "man days" in fire prevention and suppression activity. Because the CCC was expected to fight forest fires, they constituted the single largest wildland suppression force ever assembled in American history. For the California Division of Forestry, a system of fire stations and lookouts now existed throughout many of the fire prone areas of California.

The **California Fire Plan** (California Board of Forestry and Fire Protection and California Department of Forestry and Fire Protection 1996) has been implemented by CalFire as a pre-fire management initiative designed to reduce wildland fires and the associated costs of suppression. Through the systematic application of risk assessment, fire safety, fire prevention, and fire hazard reduction techniques, the initiative is aimed at protecting assets at risk through focused pre-fire management prescriptions and increased initial attack.

Localized components of the California Fire Plan, specific to the watershed, are listed in the Siskiyou Unit Fire Management Plan (California Department of Forestry and Fire Protection 2005a) and the Shasta-Trinity Unit Fire Management Plan (California Department of Forestry and Fire Protection 2005b). These dynamic working plans provide for an ongoing assessment of the fire situation within their respective units. Specific to each region, these plans identify pre-fire management target areas based on the identification of such areas by those who live and work in the community.

Assessments of the units involve the analysis of four components: level of service, assets at risk, hazardous fuels, and severe fire weather. Computer-based modeling and data and Geographic Information Systems (GIS) are used to create maps that identify high-risk/high-value areas where large, damaging fires are most likely to occur. It is assumed that through the implementation of such proactive, pre-fire management actions, costs and losses during periods of severe fire weather (the period when most wildfire costs and losses occur) would be significantly reduced.

Local

Community-based **Fire Safe Councils** have been formed in Mt. Shasta, Dunsmuir, and Lakehead by consortiums of interested citizens, fire protection personnel, industry representatives, and government

agencies who have come together to address fire safety and natural resources issues in their communities.

Typical council duties consist of

- Preparation and administration of a Community Wildfire Protection Plan.
- Providing recommendations, as needed, to the private and public sector on matters pertaining to fire safety.
- Preparation of proposals and administration of grants for fire safe-related projects.
- Development and implementation of fire safe programs.

Council projects and activities are funded primarily through agency grant programs (e.g., USFS, BLM, EPA), although occasionally private foundation funding sources may be used.

In addition to the USFS and BLM, several other large-scale public and private landowners hold property in and around the watershed. These include the California State Lands Commission, the California Department of Parks and Recreation, the U.S. Bureau of Reclamation, Siskiyou County, Sierra Pacific Industries (SPI), and Roseburg Forest Products, in addition to numerous smaller land owners. Fire protection agencies in Siskiyou and Shasta counties work cooperatively through a mutual aid agreement with the USFS, CalFire, and other fire agencies to provide fire suppression resources and to reduce fire threats to communities in the region. Pre- and post-fire management activities on State of California lands are administered by CalFire under the California Fire Plan.

Both SPI and Roseburg Forest Products are relatively large-scale holders of private forestlands near or adjacent to the watershed, particularly in its northern half. Active forest management practices such as thinning and understory brush removal are routinely employed by these companies as a means of reducing potential loss of merchantable timber to wildfire. Other pre-emptive actions taken by these companies might include:

- The creation of shaded fuel breaks, or defensible space, through thinning, typically along ridges, near towns/communities, and along major roads.
- Routine removal of ladder fuels.
- Actively cooperating with nearby communities and agencies to make fire awareness a community issue.

2.3.6 Wildlife Management

By the 1800s, habitat destruction, a lack of wildlife law enforcement, and the assumption by early Americans that natural resources were limitless led to a severe decline in wildlife populations in America (Musgrave 1998). Since this time, the approach to wildlife laws in America have evolved from one reflecting the English tradition of restricting public access to royal forests, to one

acknowledging the importance of protecting wildlife for the benefit of future generations as well as aesthetic and moral reasons (Musgrave 1998).

Federal

At the turn of the century, President Theodore Roosevelt brought the ideals of conservation of nature, into his Administration, and the American public soon began to adopt his ideals (Musgrave 1998). A process that was, at least in part, spurred by the extinction of the passenger pigeon and the near extinction of the buffalo. The **Migratory Bird Treaty Act (MBTA)** of 1918 represented one of the first major federal legislative attempts to protect a particular type of wildlife. It prohibited the taking of migratory birds except under federal guidelines and provided strict civil and criminal penalties.

Franklin D. Roosevelt made land and resource preservation a cornerstone of his national economic restoration plan during his term in the presidency (1933–1945), and legislation during this period attempted to integrate many diverse natural resource concerns into comprehensive laws (Musgrave 1998). The **Fish and Wildlife Coordination Act** (1934) was enacted in the midst of the Great Depression. It authorized "investigations…to determine the effects of domestic sewage, trade, wastes, and other polluting substances on wild life," (ch. 55 § 2, 48 Stat. 401) and encouraged the "development of a program for the maintenance of an adequate supply of wild life" (ch. 55 § 5) on federal lands, and called for state and federal cooperation in "developing a Nation-wide program of wild-life conservation and rehabilitation" (ch. 55 § 1).

The Act was overhauled in 1946 and again in 1958 when Congress concluded that the results of the Act were inadequate (Bean and Rowland 1997). The 1946 revisions deleted the goals of establishing a nationwide program of wildlife conservation and of maintaining an adequate supply of wildlife on federal lands. However, it required consultation with the USFWS and with appropriate state wildlife agencies when authorization was provided for any water body to be impounded or controlled for any purpose by any public or private agency under a federal permit (Bean and Rowland 1997). The revisions in 1958 required that wildlife conservation be given equal consideration with other features of water resource development and introduced the goal of wildlife enhancement (Bean and Rowland 1997).

The **Bald Eagle Protection Act of 1940** was the first federal statute to prohibit the taking, possession of, or commerce in a particular species of wildlife.

In 1934, the **Taylor Grazing Act** was enacted to control overgrazing and overproduction on unappropriated public lands. The Act's establishment of grazing districts marked the final closure of public unappropriated lands to private divestment.

In the 1950s, post-war prosperity led to an unprecedented increase in highway and housing construction, which led to an increased demand for natural resources (Musgrave 1998). The Fish and Wildlife Act of 1956 set forth a comprehensive fish and wildlife policy. It emphasized the commercial fishing industry but also included direction to administer the Act with regard to the inherent right of every citizen and resident to fish for pleasure, enjoyment, and betterment and to maintain and increase public opportunities for recreational use of fish and wildlife resources (U.S. Fish and Wildlife Service 2010).

The 1960s marked the beginning of the transition into the modern era of wildlife regulation. President Lyndon Johnson cooperated with Congress to pass a series of federal public land and wildlife habitat protection laws, including the Wilderness Act, Wild and Scenic Rivers Act, and the National Trails System. The **Wilderness Act** was enacted in 1964 and set aside specific areas for preservation in their natural state. The **Wild and Scenic Rivers Act** and the provided a basis for setting aside additional public land for scenic and recreational uses, and simultaneously protecting wildlife habitat. In addition, the National Wildlife Refuge System was brought together under one administrative roof in 1966.

The **Endangered Species Preservation Act of 1966** represented the first federal attempt to preserve endangered species. It was followed by the **Endangered Species Conservation Act of 1969**, which strengthened protection of endangered species by authorizing development of a worldwide list of species and outlawing commerce in these species. The **Anadromous Fish Conservation Act** directed the Secretary of the Interior to study and make recommendations for the conservation and enhancement of anadromous (salt-to-freshwater migratory) fishery resources.

The **National Environmental Policy Act (NEPA)**, which President Nixon signed on January 1, 1970, was the broadest piece of Congressional legislation yet passed for protection of the environment. It requires federal agency consideration of impacts on the whole environment before major federal action is undertaken. Environmental assessments or environmental impact statements are required as part of that consideration. Its provisions declare as federal policy the use of all practicable means to administer federal programs in the most environmentally sound fashion.

The federal **Endangered Species Act of 1973** (ESA) replaced previous weaker acts. It not only requires federal consultation before major federal action impacting threatened or endangered species is undertaken, but it outlaws the taking of such species and provides for acquisition of habitat to protect threatened and endangered species. Federal support also is provided to states that enter into cooperative agreements for conservation of listed species.

State

In 1849, the California Territorial Legislature adopted the common law of England as the rule in all state courts. In 1851, the State of California enacted its first law specifically dealing with fish and game matters, a law dealing with the right to take and plant oysters. In 1852, the first game law was enacted. It protected elk, antelope, deer, quail, mallards, and wood ducks for 6 months of each year. Also passed in this year was the first law protecting salmon runs.

In 1870, the Board of Fish Commissioners, the forerunner of the Fish and Game Commission, was established "to provide for the restoration and preservation" of fish in California waters (California Department of Fish and Game 1999). This was the first wildlife conservation agency in the country, and in 1878, its authority was expanded to include game as well as fish.

After the turn of the century, the administration of fish and game laws was strengthened and expanded and the first bag limits were set (deer, ducks, doves, and quail.) In 1909, the name was changed from the Board of Fish Commissioners to the Fish and Game Commission to reflect the growing importance of game conservation. In 1927, the administrative functions of the Commission were assumed by the newly established Division of Fish and Game within the Department of Natural

Resources. In 1951, the Division of Fish and Game was elevated to the Department of Fish and Game, which became a component of the new Resources Agency of California in 1961.

In 1965, the **California Fish and Wildlife Plan** was completed. It was the first statewide master plan for fish and wildlife in the United States. California Fish and Game Code Section 2050, known as the **California Endangered Species Act (CESA)**, was enacted in 1970. Under CESA, CDFG is responsible for maintaining a list of endangered and threatened species. CDFG also maintains a list of "candidate species," which are species that CDFG formally notices as being under review for addition to the list of endangered or threatened species, and lists of "species of special concern," which serve as species "watch lists."

Pursuant to the requirements of CESA, an agency reviewing a proposed project within its jurisdiction must determine whether any state-listed endangered or threatened species may be present in the project area and determine whether the proposed project could have a significant impact on such species. In addition, CDFG encourages informal consultation on any proposed project that may affect a species that is a candidate for state listing as threatened or endangered.

2.4 References

2.4.1 Literature Cited

Anderson, R. S., S. J. Smith, R. B. Jass, and W. G. Spalding. 2008. A late Holocene record of vegetation and climate from a small wetland in Shasta County, California. Madrõno 55(1):15-25.

Anderson, M. K. 1999. The fire, pruning, and coppice management of temperate ecosystems for basketry material by California Indian tribes. Human Ecology 27(1):79-113.

Aubrey, L. E. 1908. The copper resources of California, edited by C. S. M. Bureau.

Bancroft, H. H. 1888. The works of Hubert Howe Bancroft, volume XXIII. Vol. XI, History of California. San Francisco, California: The History Company.

———. 1890. History of the Pacific States of North America, Vol. 14. California, Vol. 7, 1860-1890. The History Company, San Francisco.

Barrett, S. A. and E. W. Gifford. 1933. Miwok material culture. Bulletin of Milwaukee Public Museum 2(4).

Basgall, M. E. and W. R. Hildebrandt. 1989. Prehistory of the Sacramento River Canyon, Shasta County, California. Vol. Publication Number 9, Center for Archaeological Research at Davis. Davis, California: University of California, Davis.

Bean, M. J. and Rowland, M. J. 1997. The evolution of national wildlife law. 3rd ed. Praeger Publishers, Westport, Connecticut.

Beggs, M. and C. McLeod. 2003. The sacred land reader. http://www.sacredland.org/PDFs/SLReader.pdf (accessed May 13, 2007).

Brooks, D., D. Park, and L. Apperson. 1987. Sisson Mount Shasta, the early years, centennial edition 1887-1987.

Bureau of Reclamation. 1947. Central Valley Project studies: Payments for beneficiaries, problems 10-13. U.S. Department of the Interior Bureau of Reclamation.

———. 1984. The Central Valley Project (General Overview).

———. 2003. Shasta Dam and reservoir enlargement project: Lower McCloud River technical report. Prepared for the U.S. Department of the Interior, Bureau of Reclamation by North State Resources, Inc. September 2003.

Bureau of Reclamation History Program. 1994. Central Valley Project-Shasta Division.

California Department of Fish and Game. 1999. Department of Fish and Game celebrates 130 years of serving California. *Outdoor California* Nov-Dec.

California Board of Forestry and Fire Protection, and California Department of Forestry and Fire Protection. 1996. California fire plan. California Department of Forestry and Fire Protection. March 1996.

California Department of Forestry and Fire Protection. 2005a. Siskiyou unit-fire management plan. Siskiyou Unit Fire Prevention Bureau.

California Department of Forestry and Fire Protection. 2005b. Shasta-Trinity Unit fire plan.

California Department of Transportation. 2008. Interstate 5 transportation concept report. California Department of Transportation - District 2. June 2008.

California Genealogy and history Archives. 1938. Miscellaneous California records: Civilian Conservation Corps yearbook 1938. http://www.calarchives4u.com/misc/ccc1938/ccc2.htm (cited October 28, 2008).

California State Mining Bureau. 1915. Mines and mineral resources of Shasta County, Siskiyou County, Trinity County. California State Printing Office.

———. 1916. Gold mining history digital collection - mine list with brief history source http://www.snowcrest.net/siskiyoulibrary/gold/minefram.html (cited September 22, 2008).

California State Parks. 2007. Gold rush overview. http://www.parks.ca.gov/?page_id=1081 (cited May 3, 2007).

California Water Boards. 2006. Water quality assessment of the condition of California coastal waters and wadeable streams. Clean Water Act Section 305b Report.

Central Valley Regional Water Quality Control Board. 2009. *Water quality control plan (basin plan) for the Sacramento and San Joaquin River basin.* California Regional Water Quality Control Board, Central Valley Region. Fourth Edition.

Cermak, R. W. 2005. Fire in the forest-a history of forest fire control on the national forests in California 1898-1956 (R5-FR-003): USDA Forest Service, Pacific Southwest Region.

Clark, H. 2005. Environmental Justice Subcommittee report to Bay-Delta Public Advisory Committee: Winnemem Wintu and Shasta Lake enlargement. http://calwater.ca.gov/CBDA/AgendaItems_6-8-05/BDPAC_Meeting_6-8-2005_Agenda_Item_5D.pdf (accessed May 11, 2008).

Cleland, R. G. 1922. A history of California: The American period. New York, New York: The MacMillan Company.

Colby, W. H. 1982. A century of transportation in Shasta County: 1821-1920. Sacramento, California: Association for Northern California Records and Research.

Cook, S. F. 1976. The conflict between the California Indian and white civilization. Berkeley, California: University of California Press.

Curtis, E. S. 1924. The Achomawi. The North American Indian 13.

Cutting, S. 1997. Weekly stories from the north star, the newspaper of Mott, California.

CVP Shasta Dam. 2006a. Land acquired by the United States that was held in trust for the Indians by the federal government. Winnemem Wintu Library, Redding: Shasta Dam record group 115 land acquisition. Correspondence between Reclamation and BIA file code 2-440 and MP-420. Information pertaining to CVPILAA 55 Stat 612 Act of July 30, 1941. National Archives and Records Administration: Denver, Colorado.

CVP Shasta Dam. 2006b. Land acquired by the United States that was once Indian allotments turned fee patent, or land purchased in fee by individuals of Indian descent. Winnemem Wintu Library, Redding: Shasta Dam record group 115 land acquisition. Correspondence between Reclamation and BIA file code 2-440 and MP-240. Information pertaining to CVPILAA 55 Stat 612 Act of July 30, 1941. National Archives and Records Administration: Denver, Colorado.

Dana, J. 1934. Sutter of California. New York: Halcyon House.

Davis, B. G. 1937. Fifty years of mining law. Harvard Law Review 50:897-908.

Delay, P. J. 1924. History of Yuba and Sutter counties, California: With biographical sketches of the leading men and women of the counties who have been identified with their growth and development from the early days to the present. Los Angeles, California: Historic Record Co.

Department of Conservation. 2000. California's Abandoned Mines: A Report on the Magnitude and Scope of the Issues in the State, Vol II. Electronic document http://www.conservation.ca.gov/omr/abandoned_mine_lands/AML_Report/Pages/volume_2.aspx, accessed 10-20-2008.

Dicus, C. A. and K. Delfino. 2003. A comparison of California forest practice rules and two forest certification systems. California Polytechnic State University. April.

Dietzel, W. 2008. Castle Crags State Park. http://ww.aycsnetwork.com/castellacastlecragspark.htm (cited November 5, 2008).

Dillon, R. 1975. Siskiyou trail: McGraw Hill.

Dixon, R. B. 1905. The northern Maidu. Bulletin of the American Museum of Natural History 17(3):119-346.

Drury, W. and A. Drury. 1913. California: Tourist guide and handbook. Berkeley, California: Western Guidebook Company.

Du Bois, C. A. 1935. Wintu ethnography. Vol. 36, University of California publications in American archaeology and ethnography. Berkeley, California: University of California Press.

Dunham, D. L. 1998. California's geographic names: A gazetteer of historic and modern names of the state. Berkeley, California: University of California Press.

Eidness, J. P. 1997. California's archaeological heritage. Society for California Archaeology.

Elliott, D. R. 1991. A brief history of the Golinsky mine, Shasta County, California, edited by U.S. F. S. U.S. Department of Agriculture, Mount Shasta Ranger District.

Ellison, W. H. 1974. The Federal Indian policy in California, 1846-1860. Reprinted in Saratoga: R and E Research Associates. Original edition, Thesis, 1913, Berkeley: University of California.

Faye, P. 1923. Notes on the southern Maidu. University of California Publications in American Archaeology and Ethnology 20(3):35-51.

Federal Writers' Project. 1939. California: A guide to the golden state. New York, New York: Compiled and written by the Federal Writers' Project of the Works Progress Administration for the State of California. Hastings House.

Finlay, J. R. 1920. The cost of mining: A discussion of the production of minerals with remarks on the geologic, social and economic foundations upon which it rests. 3rd edition ed. New York, New York: McGraw Hill Book Company.

Franco, M. 2007. Winnemem issues and the journey to justice. http://www.winnememwintu.us/Documents/Winnemem%20Issues%20and%20the%20Journey%20to%20Justice.pdf (accessed May 4, 2007).

Frost, E. J. and R. Sweeney. 2000. Fire regimes, fire history and forest conditions in the Klamath-Siskiyou region: An overview and synthesis of knowledge. Prepared for the World Wildlife Fund, Klamath-Siskiyou Ecoregion Program by Wildwood Environmental Consulting. December 2000.

Galbraith, J. S. 1955. A note on the British fur trade in California, 1821-1846. The Pacific Historical Review 24(3):253-260.

Giles, R. A. 1949. *Shasta County, California: A history*. Oakland, California: Biobooks.

Goldschmidt, W. 1951. Nomilaki ethnography. University of California Publications in American Archaeology and Ethnology 42(4):303-437.

Gonzales-Day, K. 2006. Lynching in the west: Duke University Press.

Goodrich, C. S. 1925. Legal status of the California Indian. *California Law Review* 14:157.

Gudde, E. G. 2004. California place names: The origin and etymology of current geographical names. 4th ed. Berkeley, California: University of California Press.

Hafen, L. R. 1983. Trappers of the far west: Sixteen biographical sketches: University of Nebraska Press.

Hayes, C. W. and W. Lindgren. 1910. Contributions to economic geology: Part I. Metals and nonmetals except fuels. Washington, D.C.: Government Printing Office.

Healey, S., W. Cohen, M. Moeur, D. Pflugmacher, M. G. Whitley, and M. Lefsky. 2008. The relative impact of harvest and fire upon landscape-level dynamics of older forests: Lessons from the Northwest Forest Plan. Ecosystems 11(7):1106.

Heizer, R. F. 1972. The eighteen unratified treaties of 1851-1852 between the California Indians and the United States government. University of California, Berkeley, Archaeological Research Facility, Dept. of Anthropology.

Henn, W. 1994. Mt. Shasta now on the National Register of Historic Places. Society of California Archaeology Newsletter 28(5).

Hildebrandt, W. R. and J. H. King. 2002. Part 1. Projectile point variability along the northern California-Great Basin interface: Results from the Tuscarora-Alturas projects. Boundary lands: Archaeological investigation along the California-Great Basin interface, Anthropological Papers Number 24: Nevada State Museum.

Hittell, T. H. 1898. History of California. Vol. 3: N. J. Stone and Company.

Hoveman, A. R. 2002. *Journey to justice: The Wintu people and the salmon*. Vol. 18: Turtle Bay Exploration Park.

Huntsinger, L. and M. Fernandez-Gimenez. 2000. Spiritual pilgrims at Mount Shasta, California. *Geographical Review* 90(4):536-538.

Hurtado, A. L. 1988. Indian survival on the California frontier, Yale Western Americana Series. New Haven: Yale University Press.

James,G. W. 1914. California Romantic and Beautiful. The Page Company: Boston, MA.

Johnson, J. J., and D. J. Theodoratus. 1984. Dutch Gulch Lake intensive cultural resources survey. Report submitted to U.S. Army Corps of Engineers, Sacramento District.

Keeley, J. E. 2002. Native American impacts on fire regimes of the California coastal ranges. Journal of Biogeography 29(3):303-320.

Klamath Resource Information System. No date. The regulation of timber harvest on private lands in California. Available from http://www.krisweb.com/policy/forest.htm (accessed November 7, 2008).

Kroeber, A. L. 1916. California place names of Indian origin. University of California Publications in American Archaeology and Ethnology 12(2):31-69.

———. 1925. Handbook of the Indians of California. New York, New York: Dover Publications. Original edition, 1925.

La Pena, F. R. 1978. Wintu. In Handbook of North American Indians. Vol. 8. California, edited by R. F. Heizer. Washington, D.C.: Smithsonian Institution.

Leitritz, E. 1970. A history of California's fish hatcheries 1870-1960. Fish Bulletin 150.

Lininger, J. C. 2003. Fire history and need for fuel management in mixed Douglas-fir forests of the Klamath-Siskiyou region, northwest California and southwest Oregon, USA. Paper read at 2nd International Wildland Fire Ecology and Fire Management Congress.

Lufkin, A. 1990. California's salmon and steelhead: The struggle to restore an imperiled resource. Berkeley, California: University of California Press.

Mackie, R. S. 1997. Trading beyond the mountains: The British fur trade on the Pacific 1793-1843. Vancouver, British Columbia: UBC Press.

MacCleery, D. W. 1992. *American forests. A history of resiliency and recovery*. Durham, North Carolina: USDA Forest Service in cooperation with Forest History Society.

Malery, T. S. 1985. *Mining law from location to patent*. Boise, Idaho: Mineral Land publications.

Masson, C. and M. Masson. 1985. Early days inns of southern Siskiyou...and some history of the area. Originally published in The Siskiyou Pioneer, Vol. 3, No. 2, 1959. Reprinted in Dunsmuir Centennial: 1886-1986: Edited by Reva Coon. Walker Lithograph, Inc.

Masson, M. 1949. Alexander Roderick McLeod: Compiled by the Hudson's Bay Company. In *The Siskiyou pioneer in folklore, fact and fiction and yearbook*: Siskiyou County Historical Society.

Masson, M. 1966. A bag of bones: Legends of the Wintu Indians of northern California. Happy Camp, California: Naturegraph Press.

McDonald, J. 1979. Klamath National Forest overview part IV, edited by U.S. Department of Agriculture.

McGuire, K. R. 2002. Introduction. Late prehistoric resource intensification in the northwestern Great Basin. Boundary lands: Archaeological investigations along the California-Great Basin interface, Anthropological Papers Number 24: Nevada State Museum.

McGuire, K. R. and W. J. Nelson. 2002. Archaeological Evaluation Report for CA-MOD-3681/H, CA-MOD-3016, CA-MOD-3859/H, CA-MOD-3858, and CA_MOD-3856, along U.S. Highway 395 in Modoc County California, Alturas Road Rehabilitation Project. Report No. 5533.

McTavish, A. K. 2010. The role of critical cartography in environmental justice: Land-use conflict at Shasta Dam, California. Master's thesis, San Francisco State University, San Francisco, California.

Merriam, C. H. 1955. Studies of California Indians. Edited by Staff of the Department of Anthropology of the University of California. Berkeley: University of California Press.

Minnich, R. A. 2007. Climate, paleoclimate, and paleovegetation. http://earthscience.ucr.edu/docs/chapter2.pdf (cited July 15, 2008).

Morratto, M. J. 1984. California archaeology. Orlando, Florida: Academic Press, Inc.

Musgrave, R. 1998. Federal wildlife law of the 20th century. http://www.animallaw.info/articles/arusfedwildhistory.htm (accessed March 8, 2010).

Lufkin, Alan. 1990. California's Salmon and Steelhead: The Struggle to Restore an Imperiled Resource. University of California Press: Berkeley, CA.

Oregon Coast Magazine Online. no date. Civilian Conservation Corps (CCC): 1933-1941. http://www.u-s-history.com/pages/h1586.html (cited November 11, 2008).

Orre, E. R. 1999. Gutshot THP Archaeological Addendum. Report #4093. On file at California Historical Resources Information Service, Northeast Information Center, California State University Chico.

Parsons 2003. Goat Ranch quarry draft EIR; Cultural resources. http://www.co.shasta.ca.us/Departments/Resourcemgmt/drm/Goat%20Ranch%20EIR/Chapter%204/4.09%20Cultural.pdf (accessed January 2009).

Parsons. 2003b. U.P.R.R. concrete tie and bridge maintenance program valley subdivision cultural resources inventory and evaluation.

Praetzellis, A. and M. Praetzellis. 1993. Mining frontiers of the far west. In: There grows a green tree, papers in honor of David Fredrickson.

Quint, C. B. 1960. Jedediah Strong Smith. Covered Wagon 1:14-18.

Radcliff, P. C. 1913. Radcliffe and Randolph (Indian Land Agent) letters regarding smelter smoke damage on Tom Young allotment. Red #50, Redcliff, Paren C. Box 20. Cases 43-50. Land Transaction Case Records, 1950-1958. Record Group 75, Bureau of Indian Affairs, California Sacramento Agency. San Bruno: National Archives and Records Administration - Pacific Region.

Rawls, J. J. and R. Orsi. 1999. A golden state: mining and economic development in gold rush California, California History Sesquicentennial. Berkeley and Los Angeles: University of California Press.

Ray, A. J. 1999. Introductory essay. In The fur trade in Canada: An introduction to Canadian economic history, edited by A. Innis. Toronto, Ontario: University of Toronto.

Ritter, E. W. and J. Burcell. 1995. The 1995 Sheridan-Carr Creek proposed timber sale archaeological and ethnographical report, Trinity County, California. Bureau of Land Management.

Robinson, W. W. 1948. *Land in California*. Berkeley, California: University of California Press.

Rohrbough, M. 1998. Days of gold, California gold rush and the American nation: University of California Press.

Sanchez, S. L. 2003. The selling of California: The Indians Claims Commission and the case of the Indians of California v. the United States. Ph.D. in History, University of California, Riverside.

Scanlon, H. F. 1981. The Siskiyou pioneer, in folklore, fact, and fiction.

Schönewald, G. no date. Shasta and the crags.

Schuldberg, J. B. 2005. Kennett: The short, colorful life of a California copper town and its founding family. Chico, California: Stanbury Publishing.

Shasta County. 2004. Shasta County general plan as amended through September 2004.

Shasta Resorts. 2008. Shasta Springs historic photos. http://www.snowcrest.net/photobob/shspring1.html (cited November 12, 2008).

Shasta Soda Museum. no date. December 6, 1989 - In the beginning. http://www.shastapop.com/museum.html (cited November 3, 2008).

SHN Consulting Engineers & Geologists, I. 2004. Administrative draft, Lake Siskiyou Watershed assessment. Prepared for Siskiyou County Planning Department. January 2004.

Short, J. R. 2001. Representing the republic: Mapping the United States, 1600-1900. London: Reaktion.

Silver, S. 1978. Shastan peoples. In Handbook of North American Indians. Vol. 8. California, edited by R. F. Heizer. Washington, D.C.: Smithsonian Institution.

Siskiyou County Planning Department. 1973. The conservation element of the General Plan Siskiyou County, California. June.

Siskiyou County Sesquicentennial Committee. 2008. SiskiyouHistory.org. http://www.siskiyouhistory.org/ (accessed 2008).

Smith, D. 1995. Historical data inventory of the Shasta County interlakes special recreation management area. Report prepared for Bureau of Land Management.

———. 1999. The dictionary of early Shasta County. Second edition ed.

———. 2007. First historic monument in county found at Sims Camp. October 28, 2008).

Stahl, E. 1989. Mount Shasta Journal 1917-1923. Chico, California: Association for Northern California Records and Research.

Starr, K. 2005. *California: A history*. New York: Modern Library.

State Water Resources Control Board . 2010. Porter-Cologne Water Quality Control Act.

Statistical Research, Inc. 2004. Distant shores: Cultural resources survey at Honey Lake, Lassen County, California. U.S. Army Corps of Engineers.

Steen, H. K. and C. Guth. 2004. The U.S. Forest Service: A history: University of Washington Press.

Stephens, S. L. and N. G. Sugihara. 2006. Chapter 18. Fire management and policy since European settlement. In Fire in California's Ecosystems, edited by N. G. Sugihara, J. W. van Wagtendonk, K. E. Shaffer, J. Fites-Kaufman and A. E. Thode. Berkeley, California: University of California Press.

Sutton, I. 2003. American Indian territoriality: An online research guide. http://thorpe.ou.edu/treatises/AITExtra.pdf (accessed January 21, 2009).

Taylor, A. H. and C. N. Skinner. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. Forest Ecology and Management 111:285-301.

Theodoratus Cultural Research. 1981. Native American cultural overview: Shasta–Trinity National Forest. Theodoratus Cultural Research.

Thomas, C. 1971. Indian land Cessions in the United States, introduction. In *The first American frontier*. New York: Arno Press.

Thornton, M. V. 1995. General history. http://www.fire.ca.gov/about/about_calfire_history.php (accessed March 11, 2010).

U.S. Department of Agriculture. 1994. Final environmental impact statement Shasta–Trinity National Forest Land and Resource Management Plan. 1994.

U.S. Department of Agriculture and U.S. Department of the Interior. 2000. Managing the impacts of wildfire on communities and the environment: A report to the president in response to the wildfires of 2000

———. 2001. A collaborative approach for reducing wildland fire risks to communities and the environment. 10-year strategy implementation plan. August 2001.

———. 2002a. A collaborative approach for reducing wildland fire risks to communities and the environment. 10-year strategy implementation plan. May 2002.

———. 2002b. Healthy forests - an initiative for wildfire prevention and stronger communities. August 22, 2002.

———. 2006. A collaborative approach for reducing wildland fire risks to communities and the environment. 10-Year strategy implementation plan.

———. 2007. Wildland fire management: The national fire plan (2007 budget justification).

U.S. Department of Interior and U.S. Department of Agriculture. 1995. Federal wildland fire policy and management. Final report. December 18.

U.S. Fish and Wildlife Service. 2008. Final recovery plan for the northern spotted owl (Strix occidentalis caurina). U.S. Fish and Wildlife Service.

———. 2010. Digest of federal resource laws of interest to the U.S. Fish and Wildlife Service. http://www.fws.gov/laws/lawsdigest/fwact.html (cited May 11, 2010).

U.S. Geological Survey. 2007. Physiographic provinces of California. http://education.usgs.gov/california/maps/provinces_B&W1.htm (cited November 5, 2008).

USDA Forest Service. 1934. Shasta National Forest, California. http://cricket.csuchico.edu/scripts/PortWeb.dll?query&field1=Filename&op1=starts+with&value1=CA_2235.JPG&template=mapsSIDsearch&catalog=catMaps (cited October 13, 2008).

———. 1995. Shasta-Trinity National Forest land and resource management plan. U.S. Forest Service, Shasta-Trinity National Forest.

———. 1999. Shasta-Trinity National Forest forest wide LSR assessment.

———. 2000. Shasta Lake West watershed analysis. Prepared for USDA Forest Service, Shasta-McCloud Management Unit. October 11, 2000.

———. 2001. Headwaters Sacramento River ecosystem analysis. USDA Forest Service, Mount Shasta Ranger District. January 01, 2001.

USDA Forest Service and USDI Bureau of Land Management. 1994. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl and standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. USDA Forest Service and USDI Bureau of Land Management.

Vaughn, T. 2004. Archaeological reconnaissance for the proposed Friedli parcel split (APN 19-220-008) on Dog Creek Road, Shasta County, California. Coyote & Fox Enterprises.

———. 2007. Archaeological reconnaissance for upgrades to the Castella water district treatment plant (Shasta County service area #3) Castella, California. Coyote & Fox Enterprises.

West, G. J. 1989. Late Pleistocene/Holocene vegetation and climate. In Prehistory of the Sacramento River Canyon, Shasta County, California. Davis, California: University of California, Davis.

White, C. A. 1983. *A history of the rectangular survey system*. Washington, D.C.: U.S. Dept. of the Interior Bureau of Land Management.

Williams, Gerald W. 2005. References on the American Indian use of fire in ecosystems. USDA Forest Service: Washington D.C. http://www.fs.fed.us/fire/fmt/Bibliography/Introduction.doc, accessed 11-17-2008.

Wohl, E. 2005. Compromised Rivers: Understanding Historical Human Impacts on Rivers in the Context of Restoration. Ecology and Society 10(2). Electronic document http://www.ecologyandsociety.org/vol10/iss2/, accessed 10-8-2008.

2.4.2 Personal Communications

Brunmeier, P., Staff archeologist North State Resources. November 2008 - conversation with K. Hitt, North State Resources.

Burns, R., Wintu Educational Council. 2008 - conversation with P. Brunmeier, North State Resources.

Hayward, J., Sr., Redding Rancheria Cultural Resources. 2008 - conversation with P. Brunmeier, North State Resources.

Root, M., Wintu Native American Heritage Contact. 2008 - conversation with P. Brunmeier, North State Resources.

Sinclair, C., Wintu Native American Heritage Contact. 2008 - conversation with P. Brunmeier, North State Resources.

CHAPTER 3

Current Conditions of Major Components and Processes

Chapter 3 Current Conditions of Major Components and Processes

This chapter expands on the descriptions of the watershed history in Chapter 2 by examining the current human, physical, and biological conditions of the watershed. Human components include demographics; land uses, including mining and timber harvest; water use; and fire management. Physical components and processes include geology, hydrology, and climate. Biological components and processes include biological communities, unique biological resources, and game animals.

3.1 Human Components and Processes

For the purposes of this assessment, human components and processes are discussed in terms of the physical modifications that humans have made to the natural environment. Modifications to the landscape include construction of the transportation network; residential development, including urban and rural communities; mining; agriculture and ranching; forest management; and water resource management. These land uses shape and are shaped by the natural world in which they occur. Land ownership guided historic land use patterns and continues to guide development today.

Resource assessment and land management in the watershed are currently based on several local, state, and federal management plans. As discussed in the Section 2.3, *Evolution of Laws and Regulations Affecting the Watershed*, resource assessment and planning on federally owned lands in the watershed are a matter of jurisdiction. The STNF LRMP directs land management for USFS land; the BLM Redding Land Management Plan directs land management for BLM land; and the U.S. Army Corps of Engineers Flood Control Manual dictates how the Bureau of Reclamation manages Shasta Dam. California State Park legislation and regulations provide guidance for land management of most state lands in the watershed, and other state land is managed in accordance with CDFG's Lands Program. County and city general plans direct development and land use on private lands in the watershed. These local plans are prepared in accordance with state regulations.

3.1.1 Human Communities, Demographics, and Transportation

Chapter 2 provided the context for the ways land use, topography, and biological resources affected the rise and fall of communities in the watershed. Several of these communities are still thriving and have grown together to form larger communities, particularly around Mount Shasta. In contrast, many of the historic mining communities and settlements in the river canyon have disappeared as changes occurred in land use and transportation networks, leaving behind only remnants of past inhabitance. Pieces of old mining equipment, building foundation remnants, and fruit trees provide visible evidence of past communities in the watershed.

Communities

Communities in the watershed tend to be clustered at the base of Mount Shasta and along the major transportation corridors. Communities in the watershed include the City of Mt. Shasta and outlying residential development, the city of Dunsmuir and outlying residential development, Castella, Lakehead, and Lakeshore. In addition to these communities, several privately owned residential parcels are located in isolated parts of the watershed. These residences are typically located in secluded mountain settings and along the Sacramento River.

Demographics

The population of the watershed has increased over the years, but remains relatively low and sparse compared to populations in the rest of the state. The total population for the watershed is approximately 11,000, with the majority of the people living within a 25-square-mile radius at the base of Mount Shasta (Shasta County 1998, U.S. Census 2000, PMC 2007).

Approximately 7,300 people live in the community of Mt. Shasta, 3,621 within the city limit and 3,670 in the adjacent unincorporated area (PMC 2007). The community of Mt. Shasta is perched above the Sacramento River canyon between the base of Mount Shasta and the Eddy Mountains. Dunsmuir, the next largest community in the watershed with approximately 2,000 people, is the northernmost community in the river canyon (U.S. Census 2000).

The Shasta-Siskiyou county line is located immediately south of Dunsmuir. The population estimate for the Shasta County portion of the Sacramento River canyon is a little over 1,700 (Shasta County 1998). Castella and Sweetbriar are two small mountain communities 6 and 9 miles south of Dunsmuir and adjacent to Castle Crags State Park. The communities of Lakehead and Lakeshore are located at the north end of the Sacramento River Arm of Shasta Lake, 20 miles south of the other river canyon communities. The population of these neighboring reservoir communities is approximately 550 (U.S. Census 2000).

Populations fluctuate seasonally in all of these communities. This is evidenced by the number of second homes and the amount of outdoor recreational use in the watershed, including hiking, boating, fishing, and skiing.

Land Use

Land ownership has guided historic and current land use patterns in the watershed. A large portion of land in the watershed is federally owned forest land managed by the STNF (Figure 3.1-1). The STNF manages land for multiple uses, including timber harvest, recreation, and wildlife values. Five broad categories of land use apply to the STNF lands in the watershed: Congressionally Reserved Areas, Late Successional Reserves (LSR), Administratively Withdrawn Areas, Riparian Reserves, and Matrix (Figure 3.1-2) (U.S. Forest Service 1995). Standards and guidelines are imposed for each of these land uses. Lands designated as Riparian Reserve, for example, have specific management standards and guidelines for air quality, biological diversity, fire and fuels, etc.

Watershed Boundaries

Ownership

- California Dept. of Parks and Recreation
- Shasta-Trinity National Forest
- State Lands--State Lands Commission
- US Bureau of Land Management
- US Bureau of Reclamation
- Unclassified (Includes private lands)

N

0 2 4 8

Miles

G:\Projects\51058 Upper Sacramento River Watershed Assesment\GIS\51058 Figure 3-1-1 Ownership.mxd Source: NSR Inc, USGS IL Created: 01-14-10 Revised: 03-12-10 cdshoemaker edouglas

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Figure 3.1-1
Land Ownership

City of Dunsmuir Land Use Planning Jurisdiction

City of Mount Shasta Land Use Planning Jurisdiction

Watershed Boundaries

Shasta County Land Use Planning Jurisdiction

Siskiyou County Land Use Planning Jurisdiction

California State Park

Land Use Designations Applicable on National Forest Land

Administratively Wi hdrawn

Congressionally Reserved

Late Successional Reserves

Matrix

N

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G:\Projects\51058 Upper Sacramento River Watershed Assesment\GIS\51058 Figure 3-1-2 Landuse.mxd Source:NSR Inc, USGS IL Created: 03-30-2010 Revised: cdshoemaker edouglas

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Figure 3.1-2
Land Use Planning Jurisdictions

Table 3.1-1 describes each STNF land use in the watershed. Most of these lands (approximately 225,500 acres) are designated as Matrix. These lands are managed primarily for timber harvest, wildlife, and recreation values. Portions of STNF managed as Wilderness and National Recreation Area include the Castle Crags Wilderness (approximately 14,700 acres) and the Whiskeytown-Shasta-Trinity National Recreation Area (NRA) (approximately 32,300 acres). Specific planning guidance for the NRA is provided in the *Shasta and Trinity Units, Whiskeytown-Shasta-Trinity National Recreation Area Management Guide*.

Table 3.1-1. STNF Land Use Designations in the Watershed

LAND USE DESIGNATION	DESCRIPTION OF LAND USE
National Forest Lands	
Matrix	Mixed use. Most timber harvest would occur on these lands. Standards and guidelines are in place to ensure appropriate conservation of ecosystems as well as provide habitat for rare and lesser-known species.
Late-Successional Reserves	Established to protect and enhance conditions of late-successional and old-growth forest ecosystems and to ensure the support of related species, including the northern spotted owl.
Administratively Withdrawn Areas	Recreation and visual areas, backcountry, and other areas where management emphasis precludes scheduled timber harvesting.
Riparian Reserves	Provide an area along streams, wetlands, ponds, lakes, and unstable and potentially unstable areas where riparian-dependent resources receive primary emphasis.
Congressionally Withdrawn	Wilderness areas where management emphasis is on enhancing the natural conditions for wildlife habitat and non-motorized recreation. Timber harvest is precluded.
Bureau of Land Management Lands	
Interlakes Special Recreation Management Area	Multiple land uses permitted that are compatible with motorized and non-motorized outdoor recreation.
Private Lands in Siskiyou County and Shasta County	
Residential	Low-density to high-density residential areas generally encompass lands with access to community water, sewer, and utility services. Rural Residential areas encompass lands that receive minimal community services, and are usually within or near a rural community center.
Agricultural	Land identified as suitable for cropland and ranchland.
Commercial	Land identified for development with commercial business operations.
Resource	Land identified as containing valuable natural resources, including timber, minerals, and conservation values (e.g., wildlife habitat, water resources, or scenic value).

Table 3.1-1. STNF Land Use Designations in the Watershed

LAND USE DESIGNATION	DESCRIPTION OF LAND USE
Public Facilities	Land publicly owned by county or city, including parks, nature preserves, community centers, educational facilities, and infrastructure maintenance facilities.
Industrial	Land identified for light to heavy industrial uses, such as manufacturing operations.

BLM manages a small portion of the watershed near Shasta Lake west of Backbone Ridge. These lands consist of several sections (i.e., 620-acre tracts) located in a patchwork of private, STNF, and BLM ownership. This area is managed in accordance with the *Interlakes Special Recreation Management Area* (Bureau of Land Management 1993). Land in this area is managed for multiple uses, including motorized recreation, timber harvest, wildlife habitat, scenic viewshed, and mineral development.

The California State Parks agency manages Castle Crags State Park, which covers about 4,000 acres of the watershed. This land is protected from development and is managed for resource preservation and non-motorized outdoor recreation.

Private land uses in the watershed include timber harvest, residential, agricultural, industrial, and commercial development. Land uses on private lands are guided by the city and county general plans. Each county and city in the watershed is required by state law to adopt a General Plan to guide the physical development of private lands in the area. Each General Plan has a Land Use Element section that defines the types of land uses allowed in the area.

Transportation

Development and maintenance of transportation infrastructure continues to affect the watershed from both an ecological and a land-use perspective. I-5 and the Union Pacific Railway remain the major north-south transportation corridors. These transportation corridors generally run parallel to one another, with the railroad tracks immediately adjacent to the Sacramento River through much of the canyon.

As Chapter 2 describes, as the mode of mass transportation changed along with the nature of the road that became I-5 and the vehicles travelling along it, community development patterns followed. The raised construction of the interstate highway visually disconnects drivers and passengers from the river below and connects them to the surrounding mountains instead. At the same time, increased fuel efficiency and decreased travel time decreased the need for the private guesthouses that had developed throughout the river canyon to accommodate travelers.

3.1.2 Mining

Mineral Resources

As described in Section 2.2.3, *Mining*, mineral resources played a significant role in the history of the watershed, and mining activity continues to occur in several locations. The Siskiyou County and Shasta County general plans describe the region as rich in mineral resources. However, the quality of minerals, the total area being mined, and the number of operations are greatly reduced from historic levels both regionally and within the watershed.

The STNF Minerals Specialist describes current mineral resources in the watershed as "spotty" (Van Susteren 2010), and depletion of the easily accessible mineral resources in the watershed is well documented (e.g., copper, silver, and gold) (Chapter 2).

The California Geological Survey (CGS) has not identified the presence and significance of mineral deposits in Shasta or Siskiyou counties (Kohler 2002). The CGS designates Mineral Resource Zones (MRZ) throughout the state in accordance with the California Surface Mining and Reclamation Act of 1975 (SMARA) (see Section 2.3, *Evolution of Laws and Regulations Affecting the Watershed*). The lack of MRZ designations in the region is likely attributable to the rural demographic rather than a complete lack of important minerals.

Mining Activity in the Watershed

Several factors have contributed to the decline of mining in the watershed, including the accessibility of minerals, the cost of developing the mineral resources, and court orders. Existing mining activity in the watershed is limited to two permitted commercial operations and small-scale recreational gold mining. The Spring Hill Mine, owned by Sousa Ready Mix, is located in the City of Mt. Shasta. This aggregate operation is located on private land in the Spring Hill area adjacent to I-5 (PMC 2007). Stone and cinder are excavated and used for aggregate and concrete production. An underground gold mine is permitted to operate in the STNF at Pollard Flat, adjacent to the Sacramento River (Van Susteren 2008). This tunnel claim is worked intermittently (Van Susteren 2010). STNF is currently reviewing a proposal to operate a placer gold mine at Pollard Flat. The proposed operation would disturb approximately 1 acre of surface lands. Another gold mine may open in 2010 on the STNF across the river from the existing underground gold mine. A permit application is currently under review by the STNF (Van Susteren 2010).

Despite the spotty nature of the mineral resources remaining in the watershed, mining claims cover the majority of the Sacramento River and its tributaries, including several claims above Siskiyou Lake. In recent years, speculators claimed much of the river and sold the claims to hobby miners via the internet. These claims were intermittently worked by suction dredges in the summer months until a court order required CDFG to suspended all suction dredge mining permits in 2009 (California Department of Fish and Game 2010, Van Susteren 2010). The moratorium on instream dredge mining is in effect until CDFG completes environmental review of the permitting program and updates applicable regulations accordingly (estimated to occur in late summer 2011).

No permitted mines operate in the NRA (Office of Mine Reclamation 2000, Van Susteren 2008). Federal lands in the NRA, except those with valid existing rights, were withdrawn from mineral entry

by the legislation that created the NRA. BLM and the USFS conducted validity determinations on most of the existing claims and contested the majority of them based on the absence of a valid discovery. There are five claims in the NRA that predate the withdrawal. The lands covered by these claims remain open to mineral leasing, but there are no approved operating plans for these claims. Hard rock minerals in the NRA are available for prospecting, exploration, and development under solid mineral leasing regulations (36 CFR Subpart 3583). Authorization for this land use requires permits and leases subject to USFS terms and conditions to protect the values of the NRA.

The historic Balakala, Keystone, and Mammoth Complex mines of the West Shasta Copper-Zinc Mining District and the Bully Hill Mine of the East Shasta Copper-Zinc Mining District are undergoing active remediation (Office of Mine Reclamation 2000).

It is possible that other small mining activities occur in the watershed. The State of California does not regulate mining operations that produce less than 1,000 cubic yards of material. Additionally, gold panning for recreation is also not regulated by the state or federal governments.

3.1.3 Agriculture and Ranching

Agriculture and ranching occupy much of the valley and foothill areas of Siskiyou and Shasta counties; however, these activities are limited in the watershed because of the steep mountainous terrain, federal land designations, and historic development patterns. Currently, there are no grazing allotments on federal lands in the watershed. The last grazing allotment in the watershed, the Bear Creek allotment, was recently eliminated. A portion of the allotment remains, but is located within the Shasta watershed. There are no grazing permits authorized for the Shasta Unit of the NRA, primarily because of a lack of suitable range. No grazing occurs on state lands in the watershed.

Several small- and medium-sized farms and cattle ranches operate on the outskirts of the City of Mt. Shasta and the NRA. Farms and ranches in the watershed are primarily family owned and operated (Shasta County 1998). In Shasta County, the number of farms has been slowly increasing since 1969, while the average farm size decreases (Shasta County 1998). A similar trend is reported in Siskiyou County, where historic ranches have been subdivided into smaller "ranchettes." Cattle from private lands occasionally wander into the NRA around Shasta Lake, where much of the private land is designated as Open Range (Van Susteren 2010).

3.1.4 Timber Resources Use

Timber Management

Timber management, otherwise known as forestry, is a specialized form of agriculture in which the crops take decades to mature for harvest. Over the last 40 years, public policy has had a direct bearing on forest management at both the national level and local level. As described in Chapter 2, a number of federal and state forest management policies have been enacted over the last century, the goal of which was to encourage forest management practices that would yield sustainable, healthy forest ecosystems. Two recent federal statutes in particular have arguably had the greatest impact on the management of federal forests: the Northwest Forest Plan (NWFP) (1994) and the Healthy Forests Restoration Act (HFRA) (2003). These policies are described in detail in Section 2.3, *Evolution of Laws and Regulations Affecting the Watershed*.

Forest Vegetation

Throughout the western United States, a century of fire suppression and logging has left forestlands fire prone and has put forest health at jeopardy. Such is the case in much of the upper Sacramento River watershed as well.

The watershed forests exhibit a variable response to disturbance from fire or logging. Some stands regenerate quickly through natural processes, while others are prevented from naturally regenerating to original densities due to competition from pioneer early seral species. Many decadent shrublands that formed following historic wildland fires have not naturally regenerated to conifer tree types (USDA Forest Service 2001b). Some of these shrublands are now mature and over mature and are vulnerable to stand-replacing fire (USDA Forest Service 2001b). Additionally, within the upper Sacramento River headwaters watershed, there has been a general species composition shift in many mixed-conifer stands to more shade-tolerant white fir (USDA Forest Service 2001b). There has been a significant reduction in the old-growth forest age class, and the amount of moderate and dense canopy closure stands have been reduced (USDA Forest Service 2001b). The density of some of the white fir stands near the watershed's headwaters has now reached levels that exceed the capability of the site to support, and mortality has begun a natural thinning process (USDA Forest Service 2001b). As vegetation growth and mortality in these dense stands continues to increase, the risk of a stand-replacing wildfire also increases. However, management practices derived from policies such as those set forth by the NWFP and HFRA are being used to improve forest sustainability.

Insects and disease pathogens are common in the watershed. Overcrowded, decadent stands, particularly those experiencing drought stress, are at greatest risk of attack. Most of the organisms are host-specific, causing mortality, top-kill, dieback, defoliation, or structural weakening. These processes can create snags, downed logs, defects, and small openings within a stand. In general, the native insects and pathogens present in the watershed cause small-scale disturbances, not catastrophic effects (USDA Forest Service 2001b).

One non-native pathogen, *Cronartium ribicola*, has spread throughout the entire United States; this pathogen is widespread throughout the watershed area. This introduced pathogen targets white pine (*Pinus monticola*) and sugar pine, among others. Sugar pine has exhibited some resistance to infection in areas outside the watershed, but, currently, no resistant trees have been identified in the watershed itself or in the range in which white pine blister rust is capable of breeding in the watershed (USDA Forest Service 2001b).

The watershed contains several populations of Port-Orford-cedar (Figure 3.1-3), a species known for its versatile wood. Active restrictions to prevent the spread of the root disease *Phytophthora lateralis* (USDA Forest Service 2001b) have been applied to areas in the watershed where Port-Orford-cedar stands are located. The disease is easily spread by waterborne spores and the movement of moist soils that contain the spores (USDA Forest Service 2001b). Active restrictions are designed to limit the movement and activities of vectors, principally humans, and include closing roads to travel, requiring dry season harvesting, and cleaning of all vehicles before they leave infested areas or enter clean areas. In addition, specific measures to contain infestations have occurred on land managed by the USFS.

Port-Orford-cedar root disease was discovered within the Shasta-Trinity National Forest at Scott Camp Creek in 2001. This is the only known Port-Orford-cedar root disease infestation on the Shasta-Trinity National Forest. Girdling of the infected Port-Orford-cedar took place in 2003. USFS personnel came back twice in 2005 and re-girdled with much deeper cuts to make sure the job was completely effective. Since 2006, monitoring has continued and no new infections have been found. Additionally, baiting with Port-Orford-cedar seedlings has tracked the decline of *P. lateralis* on the site (1 PL positive in 24 baits in 2008; 0 PL positive in 25 baits in 2009).

In the mainstem of the Sacramento River, outside the boundary of the Shasta-Trinity National Forest, the Port-Orford-cedar root disease was first discovered by Greg DeNitto and Dave Schultz near the I-5 Conant Road exit in 1995. In a survey of Port-Orford-cedar and root disease on the Sacramento River from 2000-2002, researchers found that the furthest downstream Port-Orford-cedar was a single tree north of Pollard Flat on a gravel bar on the east shore of the Sacramento River. Groups of Port-Orford-cedar became more common upstream (north) from there. The survey identified 10 separate infestations of Port-Orford-cedar root disease along the main stem of the Sacramento River. The furthest south infestation was near the mouth of Shotgun Creek, and the furthest north was at Shasta Retreat, north of Dunsmuir. The number of Port-Orford-cedar affected at each site varies.

For more information on Port-Orford-cedar, see Section 3.3.3 *Biotic Communities in the Watershed*.

Table 3.1-2 summarizes the most common current vegetative conditions occurring on the watershed's federal forestlands, including the causal mechanism and anticipated future trends.

Table 3.1-2. Forest Health Conditions

EXISTING CONDITION	CAUSAL MECHANISM	FUTURE TRENDS
Less than 5 percent old-growth within the watershed.	Historic logging and stand-replacing fire removed much of the old-growth component.	Allocation of Late Successional and Riparian reserves should create old-growth stands on approximately 20 percent of the watershed within the next century.
Overstocked stands that are susceptible to stand-replacing fire and insect and disease attack.	Exclusion of wildland fire since aggressive suppression actions started in early to mid 1900's.	Continued aggressive suppression actions and development of overstocked conditions. Increasing potential for stand-replacing fires.
Plantations dominated by ponderosa pine and not representative of adjoining mixed conifer type.	Reforestation following logging and shrubland conversions that used ponderosa pine as the preferred species.	Continued use of ponderosa pine as the dominant species in reforestation of shrublands.
Shrublands that have not advanced to early seral stage conifer forests.	Historic logging and stand-replacing fires during both historic and prehistoric times.	Older shrublands continue to occupy sites that could support forested communities. Some development of conifer tree cover, mostly shade-tolerant white fir. Increasing potential for stand-replacing fires.
Build-up of natural fuel, both live and dead, that exceeds desired future conditions.	Exclusion of wildland fire since aggressive suppression actions started in early to mid 1900s.	Continued aggressive suppression actions and build-up of live and dead fuels. Increasing potential for stand-replacing fires.

Source: USDA Forest Service (2001b)

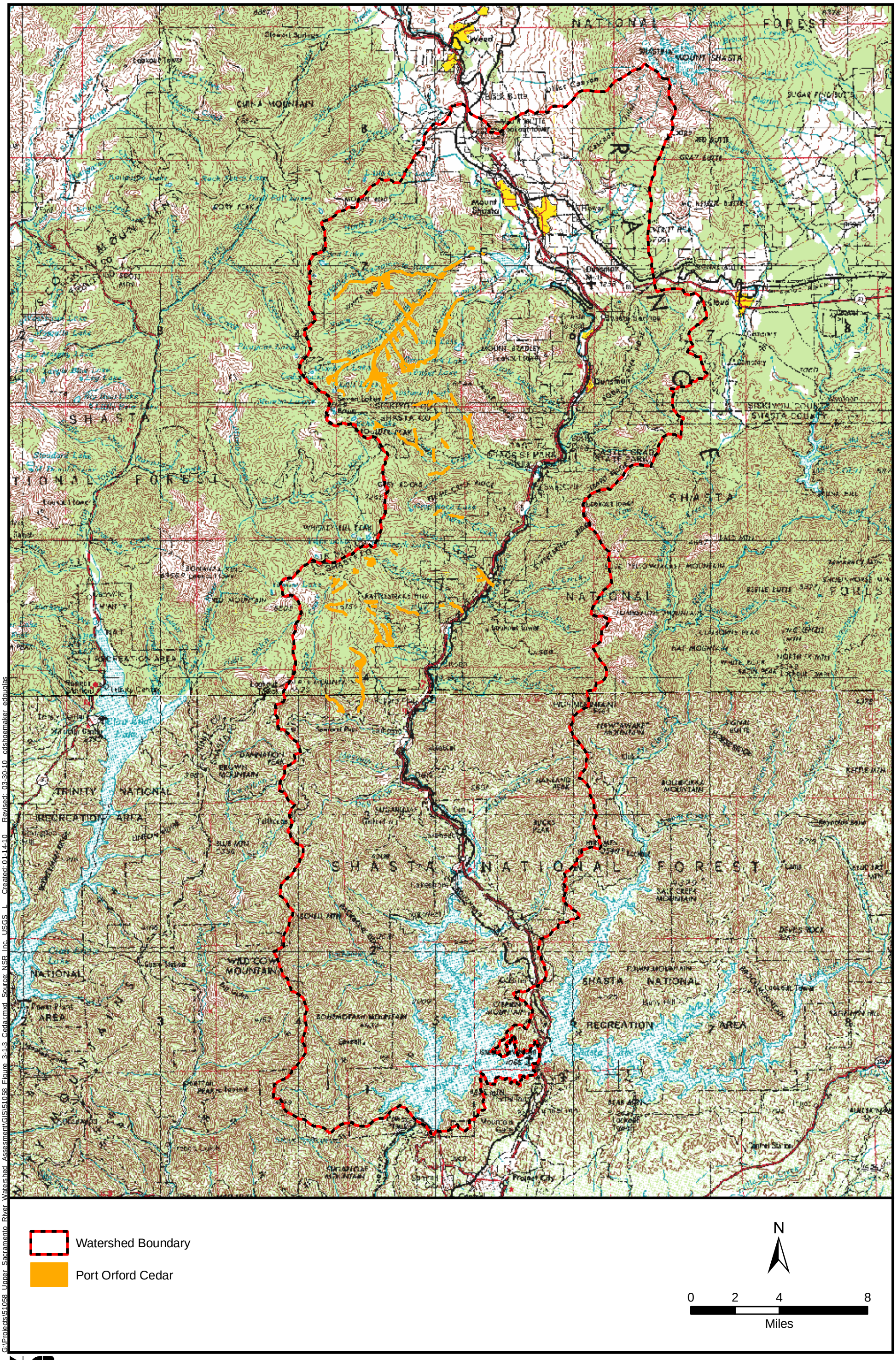

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Figure 3.1-3
Port-Orford-Cedar Locations

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Timber Harvest

The upper Sacramento River watershed contains approximately 261,100 acres of forested lands (USDA Forest Service 2008a). Timber is commercially harvested at varying scales, often in conjunction with fuels management activities, throughout the watershed. Commercial timber species in the watershed include ponderosa pine, Jeffrey pine (*Pinus jeffreyi*), Douglas-fir, white fir, sugar pine, western white pine, red fir (*Abies magnifica*), lodgepole pine (*Pinus contorta*), and incense cedar (*Libocedrus decurrens*). Port-Orford-cedar is also found at the fringes of some perennial streams and wet meadow areas (USDA Forest Service 2001b). The mix of species varies with elevation, aspect, and soil type (USDA Forest Service 2001b). Noncommercial forestlands in the watershed typically support stands of chaparral, knobcone pine, gray pine (*Pinus sabineana*), and hardwoods, including black oak (*Quercus kelloggii*) and live oak (*Quercus* spp.). Such lands are almost entirely non-federal, falling under state, county, or private ownership (USDA Forest Service 2001b).

Private Lands

On private lands in the watershed, parcels that have been zoned to restrict their use to the growing and harvesting of timber and compatible uses are designated as Timber Production Zones (TPZ) (Shasta County 2004). Such lands may be used for growing of forest products and compatible uses only, and property taxes for these lands are based on these limited uses (Shasta County 2004). Siskiyou County also designates private lands used for timber production as TPZs. In both counties, the purpose of the TP zoning district is to preserve lands devoted to and used for growing and harvesting timber and to provide for uses compatible with the growing and harvesting of timber. In both counties the TP district is equivalent to the timberland production zone (TPZ) referred to in the California Timberland Productivity Act of 1982; land within a TP district is subject to all conditions and restrictions applicable to a TPZ under the act.

Large-scale private landholders in the watershed, such as Roseburg Resources Company and Sierra Pacific Industries, manage their holdings as commercial forestland. Management objectives for such lands are based on sustainable forestry and landscape practices. Private commercial timberland management decisions are tied to regional trends in population growth, diversifying economies, and to some degree by public expectations of how these lands ought to be managed.

Active forest management practices, such as thinning and understory brush removal, are routinely employed by these companies as a means of reducing potential loss of merchantable timber to wildfire. Other pre-emptive actions taken by these companies might include:

- The creation of shaded fuel breaks, or defensible space, through thinning, typically along ridges, near towns/communities, and along major roads.
- Routine removal of ladder fuels.
- Actively cooperating with nearby communities and agencies to make fire awareness a community issue.

Public Lands

Most timber management activities on public lands in the watershed occur within the STNF's Matrix land allocation, Late Successional Reserves (LSR), and Managed Late Successional Areas (MLSA) (USDA Forest Service 2001b). As a result of passage of the NWFP, the Record of Decision on Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl (USDA Forest Service and USDI Bureau of Land Management 1994) established a network of LSRs and MLSAs in order to (1) provide old-growth forest habitat, (2) provide for populations of species that are associated with late-successional forests, and (3) help ensure that late-successional species diversity will be conserved on federal lands (USDA Forest Service 1999a). All, or part, of three designated LSRs (Eddy, Deer, and Wagon) and one MLSA (Castle Lake) are located in the portion of the STNF within the watershed. The management objective within the LSRs is to protect and enhance conditions of late-successional forest ecosystems, which serve as habitat for late-successional and old-growth related species, including the northern spotted owl (USDA Forest Service 1995, 1999). Similarly, MLSAs are intended to maintain and enhance late-successional forest ecosystems that are not only areas of potential habitat, but are areas that have been identified as owl activity centers (USDA Forest Service 1995). Figure 3.1-4 shows the locations of LSRs and MLSAs in the watershed. These areas account for approximately 38,780 acres of the timbered watershed.

Matrix lands consists of lands on which most timber harvest will occur and where standards and guidelines are in place to ensure appropriate conservation of ecosystems as well as provide habitat for rare and lesser known species. Vegetation is managed on Matrix lands to maintain forest health and provide a sustained supply of forest products, whereas the objective of management actions taken on LSR and MLSA lands is to protect and enhance the conditions of late successional and old-growth forests.

In mixed conifer stands, the stand composition objective is to increase the percentage of pine and Douglas-fir to be more representative of historic conditions (USDA Forest Service 2001b). The age stand class diversity objective is to increase the percentage of late successional and old-growth forests to represent more historic levels (USDA Forest Service 2001b). This objective is mandated by the allocation of LSRs, Riparian Reserves (e.g., the Sacramento River), and Congressionally Withdrawn Areas (i.e., the Castle Crags Wilderness) in the watershed (USDA Forest Service 2001b).

Priority silvicultural objectives and treatments for forested Matrix lands are:

- Ensure that existing plantations become established at required stocking levels and have a mix of species that represent natural stand composition. Treatments will include release, thinning, and interplanting.

- Ensure that stocking levels maintain forest health. In overstocked stands, the treatment would be thinning and uneven-age management. In understocked stands, the treatment would be site clearing and interplanting.

- Restore previously forested lands that have converted to shrublands as a result of wildland fire or other natural disturbance. Treatment would be site clearing and planting.

Source: NSR Inc, USGS IL Created: 01-14-10 Revised: 03-30-10 cdshoemaker edouglas
G:\Projects\51058 Upper Sacramento River Watershed Assessment\GIS\51058 Figure 3-1-4 LSRs.mxd

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Upper Sacramento River Project

Figure 3.1-4
Locations of Late Successional Reserves and Managed Late Successional Areas

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- Obtain a representative mix of conifer tree species in the mixed conifer zone. Treatments will be group selection and regeneration harvest and site clearing for natural and artificial reforestation.

Silvicultural treatments in LSRs and the MLSA include thinning and prescribed fire, but any such actions are subject to comprehensive environmental review and will be guided by the objective of maintaining adequate amounts of suitable old-growth habitat. The age and structure of timber stands protected under an LSR or MLSA designation reduces the amount of suitable harvestable timberland in the watershed.

Following the guidance of the NWFP and HFRA, among other federal and state statutes related to timber management, the USFS developed and has begun implementing an annual program of fuels reduction projects, giving priority to at-risk communities that have developed wildfire protection plans. The fuels management actions that have recently been completed or are currently proposed in the watershed, as of the date of this document (USDA Forest Service 2007c, 2007b, 2007a, 2008c), include:

- **Deer Creek Timber Stand Improvement—**a pre-commercial thinning, pruning, and brush mastication project proposed on approximately 700 acres of conifer tree plantations located approximately 5 miles west of the City of Mt. Shasta. The objective is to create an approximately 1.0-mile-long shaded fuel break along Rainbow Ridge.

- **Elmore Mountain Hazardous Fuels Project**—a hazardous fuels reduction and wildlife habitat improvement project proposed for the Elmore Mountain area in the Whiskeytown–Shasta-Trinity NRA, approximately 2 miles south of the community of Lakeshore.

- **Mt. Shasta Plantation Maintenance Project**— a pre-commercial thinning, pruning, and brush mastication project conducted on approximately 5,000 acres of conifer tree plantations. Completed 2007.

- **Lakehead Fuel Hazard—**a fuels treatment project in the Wildland-Urban Interface (WUI) adjacent to the community of Lakehead. Completed 2007.

- **North Shore/Rainbow Ridge Shaded Fuel Break—**creation of a shaded fuelbreak approximately 150 feet on either side of the North Shore Road and Rainbow Ridge. Included removal of brush and some trees less than 10 inches in diameter, and the burning of piles of brush and cut trees. Area is approximately 60 acres total. Completed 2007.

Reforestation

Natural and human-caused disturbances in California's forests make reforestation an essential element of forestry management. The dry summer climate and abundance of volatile vegetation—conditions that are common to the watershed—ensure that wildfire will occur at some time in the forest. Other natural events that can significantly change the forest structure and that have been known to occur in the watershed include windstorms, insect and disease attacks, floods, and mudflows in the headwaters region around Mt. Shasta. In the wake of such events, reforestation is commonly used to restore the forested values desired by the public. Planting new trees that are suited

to the environmental conditions found in the watershed (e.g., soils, precipitation amounts), and that are able to survive exposure to full sunlight, may be necessary to ensure reestablishment of the forest. As many as 500 trees per acre may be planted in a disturbed area in a manner similar to agricultural row crops. It is important to note that not all plantations have been created following disturbance; instead, some plantations, such as some of those adjacent to the Everitt Memorial Highway, were established in an effort to convert brush fields to forests (Bachman personal communication). Over time, these "plantation" stands require thinning to allow adequate growing space for trees, reduce crowding, and minimize the chance of loss to wildfire. Larger trees can eventually be thinned to produce commercial products. No publicly available data that accurately characterizes the extent of private plantations in the watershed could be located for incorporation into this assessment.

Economic Implications

Since the early 1990s, the contribution of National Forests to regional timber supplies across the state of California has declined sharply (U.S. Department of Agriculture 1994). Passage of the NWFP was intended to restart the commercial logging industry, which was slowed in the 1980s and early 1990s by federal court injunctions. These injunctions held that the USFS and the BLM had failed to consider adequately the effects of timber sales on species associated with old-growth forests in the Pacific Northwest, of which the upper Sacramento River watershed is a part. In the watershed, commercial timber harvest on public lands has been minimal, primarily limited to fuels management actions. Timber sales that have occurred in the watershed since 1990 are shown on Figure 3.1-5. The Shasta Lake West Watershed Assessment (USDA Forest Service 2000), which covers lands primarily within the upper Sacramento River watershed, states that no commercial logging had occurred on public lands in the 10 years prior to its issuance. Timber harvesting and its associated byproducts continue to maintain an important role in the region. However, changes in utilization levels (i.e., harvested volumes) and the type of wood products now available (often smaller diameter logs suitable for biomass or small saw logs) have led to a shift in the economic base of some communities in the watershed and a refocusing of goods and services marketed to both residents and visitors to the area. In the watershed, recreational opportunities (described in Section 3.1.6, *Recreation and Tourism*) have surpassed timber production to become a primary driver of the local economy.

Conclusions

The establishment of LSRs, the MLSA, and the focus on fuels management and forest health means that a higher percentage of merchantable timber harvested from the watershed will be as biomass and small-diameter saw logs. The USFS and others manage their lands for multiple uses and for the protection of communities against catastrophic wildfire. Local economies, once heavily associated with timber production, will continue to find new markets based on the many uses of lands in the watershed, such as recreation. Future trends in forest management within the watershed are discussed in Chapter 5

3.1.5 Water Resources Utilization and Infrastructure

As discussed in Section 2.2.6, *Water Resources and Infrastructure*, Shasta Dam and Box Canyon Dam and the reservoirs created by them are the most prominent water supply/flood control

G:\Projects\51058_Upper_Sacramento_River_Watershed_Assessment\GIS\51058_Figure_3-1-5.mxd Source: NSR, Inc., USGS, IL Created: 01-14-10 Revised: 03-30-10 cdshoemaker_edouglas

North State Resources, Inc.

Upper Sacramento River Project

Figure 3.1-5
Timber Sales Since 1990

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infrastructure features present in the watershed and have directly and indirectly induced significant changes in the landscape.

Shasta Lake and Shasta Dam

The Sacramento River is the largest river system in California and accounts for an average annual discharge of 21.6 million acre-feet (af) into the Sacramento/San Joaquin River Delta. The Sacramento River watershed upstream from Shasta Lake has an area of about 6,420 square miles. Water from the river provides water supplies for agricultural, municipal, and environmental needs as well as flood control throughout the Central Valley of California. The Bureau of Reclamation's Central Valley Project (CVP) controls the hydrology of the Sacramento River in the Shasta County area. Shasta Dam is the CVP's dominant feature, with a current storage capacity in Shasta Lake of 4.5 million af. In addition to altering flood flows in the Sacramento River, Shasta Dam has changed the seasonal hydrology of the river by storing water during the wet season and releasing water later in the year. Flow releases are scheduled on an annual basis to meet flood control requirements and scheduled agricultural deliveries as well as to help meet the needs of aquatic species listed under the federal and state endangered species acts.

Although its primary function is water storage, Shasta Lake has evolved into a significant recreation destination and is managed as such by the USFS and other landowners having property adjacent to the lake. The USFS's Shasta Unit of the Whiskeytown-Shasta-Trinity NRA oversees management of most federal lands around the lake, including the reach of the Sacramento River Arm that extends upstream to the community of Lakehead. Shasta Lake is a significant economic base for many businesses in the watershed.

Currently, a proposal to enlarge the storage capacity of Shasta Lake is being considered. The primary objectives for the proposed increased storage capacity are to: (1) enhance the restoration of anadromous fish populations in the Sacramento River, primarily upstream from the Red Bluff Diversion Dam and (2) increase water supplies and water supply reliability for agricultural, municipal and industrial, and environmental purposes to help meet future water demands. Secondary objectives associated with the proposed dam raising are to: (1) preserve and restore ecosystem resources in the Shasta Lake area and along the upper Sacramento River, (2) reduce flood damage along the Sacramento River; (3) develop additional hydropower capabilities at Shasta Dam, and (4) preserve outdoor recreation opportunities at Shasta Lake (Bureau of Reclamation 2006).

Lake Siskiyou and Box Canyon Dam

Before it reaches Shasta Lake, flow in the upper Sacramento River is supplied by numerous streams and rivers. Eight significant drainages—the south, middle, and north forks of the Sacramento River; Scott Camp Creek; Castle Lake Creek; Wagon Creek; Big Springs Creek/Cold Creek; and Cascade Gulch—convey runoff from Mount Shasta into Lake Siskiyou, a 430-acre reservoir created in 1968 with the building of Box Canyon Dam (SHN Consulting Engineers & Geologists 2004). Upstream of the dam, flows are unregulated and are affected only by direct precipitation and runoff from rainfall and snowmelt (SHN Consulting Engineers & Geologists 2004). The reservoir is fed by the high-elevation snowpack that often persists into the early summer months and by subsurface flows of water from Mount Shasta, which maintain perennial flows in the watershed's significant drainages. The outfall from numerous high-elevation lakes in the mountains surrounding Lake Siskiyou also

contributes to the reservoir's level and ability to produce continuous flow in the upper Sacramento River. The largest of these lakes are Toad, Castle, Gumboot, Cedar, Cliff, Gray Rock, and Timber lakes.

Use of water in the upper Sacramento River for the production of hydroelectric power was first explored in 1952 by the California-Oregon Power Company, which subsequently determined that such a project would not meet its requirements (SHN Consulting Engineers & Geologists 2004). In 1957, the California Department of Water Resources identified the Sacramento River headwaters area west of Mount Shasta as a possible reservoir site. Further feasibility studies and site investigations ultimately led to the construction of Box Canyon Dam and the creation of Lake Siskiyou. At a height of 209 feet, Box Canyon Dam provided an excellent opportunity for Siskiyou County to generate limited hydroelectric power under a Federal Energy Regulatory Commission (FERC) exemption, through Pacific Power and Light (SHN Consulting Engineers & Geologists 2004). The power generation facility is operated by Synergistics Corporation and is licensed to supply a maximum of 5 megawatts of power (SHN Consulting Engineers & Geologists 2004). Siskiyou County receives an annual revenue of $500,000 from Synergistics, regardless of the amount of power generated (SHN Consulting Engineers & Geologists 2004).

Because recreation is a primary use of Lake Siskiyou and outflows are critical to the maintenance of lake levels and continuous flow in the upper Sacramento River below the dam, lake levels are maintained at or near full pool year-around. Both the lake and the dam are located on county-owned lands. The Siskiyou County Flood Control and Water Conservation District (part of the county's Public Works Department) administers lands around the lake to provide opportunities for public and private development (through leases) for recreational purposes.

Community Water Systems

In addition to the many domestic water systems that are scattered throughout the watershed, a number of local community and city water systems are also either partially or fully dependent on water derived from the watershed. These include the following:

- Lakeshore Heights Mutual Water Utility
- City of Redding
- City of Shasta Lake
- Bella Vista Water District
- Centerville Community Services District
- Mountain Gate Community Services District
- Dunsmuir City Water Department
- Lake Siskiyou Mutual Water Company
- Crag View Community Service District
- City of Mt. Shasta
- Bridge Bay Resort
- Shasta Dam Public Utilities District

There is no formal agreement with these users regarding watershed management; however, water quality for these domestic uses must meet state objectives (USDA Forest Service 1995).

Commercial Water Development

Long recognized for its purity and quality, bottled drinking water from the Mount Shasta area has become a profitable and somewhat controversial use of the water resource. The short- and long-term effects of bottling plant intake on the groundwater supply are unknown. Currently two commercial plants, Mt. Shasta Spring Water and Aquapenn Spring Water, operate in the upper Sacramento River watershed.

Economic Implications

Recreation and tourism are two of the primary drivers of the watershed's local economy. Many businesses and communities have shifted their economic base away from that of logging and forest products to take advantage of the economic opportunities afforded by the region's abundant recreational and scenic qualities. The creation of Shasta Lake and Lake Siskiyou, for example, attracts large numbers of visitors annually who contribute significantly to local economies. As described previously, the maintenance and potential growth of a number of local community and city water systems are dependent on water available in the watershed.

Shasta Dam is the cornerstone of the CVP. Agricultural production in the Central Valley relies in large part on water supplied by the Sacramento River watershed system. Similarly, numerous communities throughout the Central Valley also draw their municipal water supplies from water stored in Shasta Lake. The system of water storage that has been created in the watershed (i.e., Lake Siskiyou/Box Canyon Dam, Shasta Lake/Shasta Dam) is also critical to fish and wildlife. Although the construction of Shasta Dam significantly altered the historic range of anadromous fish in the upper Sacramento River, outflows are used to maintain anadromous fisheries and wildlife habitat downstream, subsequently contributing to local economies throughout the Sacramento River system. In addition, flood control associated with the dams and lakes within the watershed serve to protect downstream communities and properties from catastrophic flooding.

The proposed raising of Shasta Dam would have both long- and short-term economic implications. It is anticipated these implications would be fully assessed during the planning phase of the project.

The commercial development of groundwater resources in the watershed is a use of water that has created jobs and contributes to the local economies of the City of Mt. Shasta and Dunsmuir. However, the long-term effects of such use on the aquifer(s) are unknown.

Conclusions

The water resource infrastructure that has been created in the watershed is not only locally significant, but is also critical to the state's economy. Shasta Dam is the cornerstone of the CVP. Its interrelationship with Box Canyon Dam, which provides flood control in the upstream portion of the watershed, and Shasta Lake, which allows for the storage of a large portion of the water needed to meet the demands of the Central Valley's agricultural producers and communities, is critical to the state and local economies. The importance of the water infrastructure in the watershed itself is reflected in the region's increased commercial and residential development over recent years, which is tied to community and city water developments and the abundant recreational and tourism

opportunities that it affords. Factors that influence the biological integrity of the watershed are discussed in Chapter 4.

3.1.6 Recreation and Tourism

The Shasta Cascade area is described and promoted as an "outdoor recreation wonderland" (California Travel and Tourism Commission; and California Business Transportation and Housing Agency, Division of Tourism 2006). In the upper Sacramento River watershed, there are abundant opportunities for tourists and local residents to enjoy such activities as fishing, hunting, camping, boating, cycling, skiing, and mountaineering. These recreational activities promote a healthy lifestyle and are important industries that feed the local economies.

Recreational Activities

Across California, the tourism industry is an important economic driver for many local economies, and recreational activities in the watershed play an important role in the economies of both Shasta and Siskiyou counties. In 2005, California was the destination for more than 335 million leisure and business travelers and almost 14 million international travelers (California Travel and Tourism Commission and California Business Transportation and Housing Agency Division of Tourism 2006), and in 2007, travel spending generated $2.2 billion dollars in local tax dollars (Dean Runyon Associates 2008).

One of the audiences often targeted for their recreation and tourism dollars is the "baby boomer" population. This generation is coming of age and seeking what is described as "softer vacations" (Urness 2007), with RV camping being one of the most popular passive recreation activities for people between the ages of 55 and 64 (KOA 2007). In the upper Sacramento River region, facilities began accommodating motor homes as early as the 1960s. Today, facilities such as the Lake Siskiyou Camp Resort continue to thrive and offer full RV hookups and hundreds of campsites (SHN Consulting Engineers & Geologists 2004, California State Parks 2005).

Another outdoor recreation activity that is rising in popularity is off-highway vehicle (OHV) parks and trails. Between 1995 and 2003, annual sales of OHVs tripled, and more than 1.1 million vehicles were sold in 2003 (Cordell et al. 2005). California accounts for about 11 percent of the U.S. total (Cordell et al. 2005). California State Parks estimates that OHV recreation contributes $9 billion annually to California's economy (California State Parks 2007). Most of this recreation occurs on publicly owned land, and it is the responsibility of the federal or state agency to implement policies and regulate OHV recreation.

In 2009, the California State Parks Off-Highway Motor Vehicle Recreation Division released its strategic plan, which responds to the increasing pressures on existing OHV areas and promotes development of additional areas while maintaining the highest standards of sustainability and environmental protection. In June 2009, the STNF issued a Draft Environmental Impact Statement disclosing the impacts of prohibiting OHV cross-country travel off designated roads/trails and adding additional roads/trails for OHV use based on vehicle class and season (USDA Forest Service 2008b). The proposed action would add approximately 44.2 miles of existing unauthorized routes to the National Forest Transportation Systems (NFTS) for public motor use. Approximately 36.51 miles of unauthorized routes would be added as roads classified open to all vehicle classes and approximately

7.69 miles would be added as motorized trails. Designating specific routes for OHV use would help lessen the impacts that unauthorized routes have on the forest system and would bring the Forest Plan into conformity with the Travel Management Rule (CFR Part 212, Subpart B).

While the national trends for recreational vehicle camping and OHV use are expected to rise, there is debate about the popularity of nature-based recreation in the United States. After reviewing national and state park visitation numbers, hunting and fishing licenses sales, and camping reservations, a 2008 report by University of Illinois scholars determined that since the 1980s, there has been a decline in nature-based recreation in the United States (Pergams and Zaradic 2008). That same year, H. Ken Cordell of the USFS argued that a rise in nature-based recreation and an increased demand for recreational activities existed between 1994 and 2008 (Cordell 2008), with the exception of hunting. This was attributed to a decline in popularity of game hunting, a more urban population, and an increase in private residences encroaching on natural lands (Cordell et al. 2008, Rogers 2008). In the watershed, however, hunting is still a popular activity, and many businesses (e.g., restaurants, supply stores, guides, motels) benefit economically from hunters' continued use of the region.

Fishing also remains a popular recreational activity that contributes notably to the local economy, particularly in the upper Sacramento River watershed region. The local chambers of commerce and visitors bureaus actively promote the excellent fishing in the watershed region, and several fishing events and tournaments occur year-round in the region (Siskiyou County Economic Development 2006, City of Dunsmuir 2008). Between November 2004 and April 2005, CDFG observed 191 anglers who fished for a total estimated 7,316 hours during the winter fishing season. During the same period, CDFG issued 304 non-resident sport fishing licenses in Shasta County and another 209 in Siskiyou County. The CDFG's study determined that 60 percent of the anglers interviewed traveled more than 75 miles from home, with most coming from Sacramento and the San Francisco Bay Area. Those traveling long distances for short fishing trips spent on average one night in a local hotel (Dean 2005). The anglers were also likely to eat in local restaurants, purchase their supplies from local businesses, and employ local fishing guides. According to the Mt. Shasta Chamber of Commerce, recreation, lodging and food services, entertainment, and art comprise 8 percent of the city's employment industries (City of Mt. Shasta 2008).

The watershed is fortunate to have recreational opportunities for every season. Mountain climbing is one sport enjoyed year round at Mount Shasta. Professional guides from such companies as Alpine Skills, Shasta Mountain Guides, and Sierra Wilderness, are highly trained professionals employed to guide climbers up the mountain safely. Winter sports, particularly downhill and cross-country skiing, are other popular draws and attract hundreds of visitors to the region each year. Downhill skiers frequent the Mt. Shasta Board & Ski Park, which opened in 1985. The Ski Park contributes to the local economy and employs people in such areas as food service, maintenance, and sales as well as professional guides and instructors (Mt. Shasta Ski Park 2008). The Nordic Center is another venue for cross-country skiing at Mount Shasta. It opened during the winter of 1991-1992 and offers beginner and intermediate lessons. This is a community-based facility and contributes to the local economy by employing local residents in a variety of positions and attracting outside visitors who spend money at other local businesses.

Recreation Facilities

As previously stated, camping (including RV/trailer camping) and boating are popular activities in the watershed. Within the area, there are both publicly and privately operated campgrounds. Along the river, there are campsites around three primary destination spots: Castle Crags State Park, Lake Siskiyou, and Shasta Lake.

Castle Crags State Park

At Castle Crags State Park, there are 76 developed campsites and six environmental campsites. The developed campsites can accommodate family camping and RV/trailers. Amenities include fire rings, picnic tables, restrooms, and showers. The environmental campsites at Castle Crags State Park offer campers a more natural setting (i.e., table, clearing for tents, and a primitive toilet nearby) (California State Parks 2008). Privately operated facilities for buying gas and supplies are conveniently located adjacent to the park (California State Parks 2002).

Lake Siskiyou

Lake Siskiyou was developed in 1969 for recreational use under the Davis-Grunsky Act and is situated on lands owned by Siskiyou County. As part of the development of the reservoir, Siskiyou County is obligated to promote commercial recreational development around the lake, which has led to the development of commercial improvements around the lake, such as Lake Siskiyou Camp-Resort and the Mt. Shasta Resort. Lake Siskiyou Camp-Resort has more than 300 campsites, with amenities including toilets, showers, picnic tables, fire rings, recreation halls, arcade, grocery store, outdoor movie theatre, laundry facilities, bait and tackle shop, fishing dock, boat launching, marina, and mooring. The Mount Shasta Resort includes a golf course, tennis courts, restaurant, and chalets for lodging. Non-commercial opportunities for use of the lake exist in the form of beaches and boat launch areas, and a hiking trail has been constructed around a major portion of the lake.

Shasta Lake

Within the upper Sacramento River watershed region of Shasta Lake, there are several campgrounds that together offer more than 100 campsites. Antlers Resort is the furthest north on the lake and has 41 single and 18 double sites. It operates year round and offers potable water, toilets, picnic tables, bear boxes, fire rings, and paved parking. Antlers Resort can also accommodate RVs/trailers up to 30 feet in length. Southeast of Antlers is Gregory Creek campground. It is open between late spring and late summer. The 18 single sites have picnic tables and fire rings. Gregory Creek can accommodate smaller RVs/trailers (16 feet maximum). Lakeshore East is located southwest of Gregory Creek. It offers amenities similar to those offered by Antlers, but has fewer sites, with only 17 single sites, six double sites, and three yurts. Lakeshore East also operates year round. Nelson Point is on Salt Creek Inlet and is one of the smaller campground facilities, with only eight single sites available. It is open during the summer and offers campers picnic tables, fire rings, stoves/grills, and an unpaved parking spot. Like Gregory Creek, it can only accommodate RVs/trailers up to 16 feet long. Just west of Nelson Point on the Sacramento River is Beehive Cove, which is open year round for shoreline camping. The facilities are limited, with only portable restrooms and trash receptacles. Gooseneck Cove is southwest of Beehive and is on the Sacramento River Arm of Shasta Lake. It is a small campground with eight sites and is accessible only by boat.

Many campers who frequent Shasta Lake come with their boats and take advantage of the public boat ramps. Each ramp is paved and features a lighted parking area, public restrooms, and garbage and recycling containers. Antlers and Sugarloaf (Sacramento River Arm, furthest north from the dam) each have eight launching lanes, Centimudi (located on Shasta Lake, northeast of the dam) has 19 launching lanes, and Packers Bay has 10 launching lanes.

In addition to the public facilities, Shasta Lake has privately owned facilities in the region that cater to boaters. Sugarloaf Resort, located on the Sacramento River Arm of Shasta Lake, features 16 cabins and offers moorage. Houseboats, patio, ski, and fishing boats are all available for rental at the Sugarloaf Resort. Packers Bay Marina, south of Sugarloaf and northwest of the Pit River Bridge, caters to visitors interested in vacationing on houseboats. The company has a fleet of boats available for rental and is in close proximity to Packers Bay. Bridge Bay Marina is a full-service marina located at the southern end of Shasta Lake in the watershed region. The marina has mooring facilities, fueling docks, slips, houseboat accommodations, and a lodge. There is also a restaurant, small grocery store, and bait shop. Houseboats, patio, ski, and fishing boats are available for rental. Digger Bay Marina is located the farthest south in the region and closest to Shasta Dam. Amenities include a floating grocery store and tackle shop, boat rentals, boat repair shop, and a gas dock.

3.1.7 Historical and Cultural Resources

The following discussion is a brief overview of the general characteristics and locations of known archaeological sites in the watershed. This information was synthesized from a general overview of archaeological site records housed at the Northeast Information Center of the California Historic Resources Information System. Specific locations of sites and archaeological materials are protected information and are therefore omitted from the discussion.

Native Americans

Prehistoric and historical archaeological resources of Native Americans occur throughout the watershed, and may include temporary campsites with lithic scatters or food-processing artifacts; bedrock mortar locales; villages and areas of long-term occupation; petroglyph or rock art sites; historic homesteads or occupations; and prehistoric, historic, and modern-day Traditional Cultural Properties. In the watershed, temporary campsites are most often found in high-elevation areas where occupation during winter would be difficult; however, they are also found in lower elevations throughout the region. These sites usually consist of scatters of lithic debitage or the waste materials from the creation of stone tools and other food processing artifacts, such as milling stones or mortars. Although temporary campsites may seem to be less important than a large village site, they supply important information regarding the use of resources and movement of people in the watershed, and sometimes the small sites with less visible material may actually be an older occupation. Large villages and long-term occupation areas are usually located near perennial water sources such as springs and major streams.

Many of the largest and most recently occupied village sites in the watershed were built over during the historic era by Euro-American communities, destroyed by mining activities, or inundated by the creation of Shasta Lake; however, many smaller or older village sites still exist. Several known historic-era homesteads or occupations by Native Americans in the watershed are on flat areas along main waterways, oftentimes alongside Euro-America sites (Basgall and Hildebrandt 1989). An

example of this co-occupation occurred at Upper Soda Springs where Ross and Mary McCloud lived alongside and employed Trinity Wintu, including Grant Towendolly (Masson 1966).

As discussed in Section 2.1.2, *Ethnography*, Native American peoples were, like all people, intimately involved with the environment, and this involvement manifested itself in their cosmological and mythological beliefs concerning the landscape and world around them. Prehistoric, historic, and modern Traditional Cultural Properties, sacred locations, and important use areas are located throughout the watershed and include but are not restricted to mountains, unique landforms, caves, distinctive rock outcrops, waterfalls, pools, springs, and resource gathering areas. These locations may be considered negative, positive, or neutral in their energies or influence. Many locations have been recorded by ethnographers and writers (Masson 1966, Basgall and Hildebrandt 1989) and many are known but are not in the public record (Native American Heritage Commission personal communication).

Euro-Americans

Historically, resource use in the watershed has included exploitation of animal and fish resources, particularly the fur trade of the early 19th century and recreational hunting of the late 19th and the 20th centuries; the timber and mining industries; roads, trails, railroads, and other routes of travel; homesteading, agriculture and ranching; and recreation, including resorts and campsites. Although much of the known occupation is concentrated in the small valleys and flats along the Sacramento River and its major tributaries, other uses cover the entirety of the watershed. As described in Section 2.2.1, *The Fur Trade and Early Exploration,* the fur traders of the early 19th century trapped along the streams and rivers in the region, and, although no known archaeological resources from this era exist, it is conceivable that some evidence may yet remain.

Roads, trails, and railroads create an interconnected web of routes of travel throughout the region. Many of the trails and roads remain only as blazed trees, barely identifiable wagon ruts, or abandoned segments of asphalt; however, many travel routes persist today on or near the original routes. Along these routes lay many small historic and modern communities as well as numerous campgrounds and resorts.

Historic communities were usually centered on stage stops and railroad stations, particularly along the Sacramento River itself, and served as community and mercantile centers for larger populations spread throughout the surrounding region. Some of the communities have faded from the landscape, leaving behind an interstate exit name like Lamoine, while others are robust and growing towns like Dunsmuir. Similar to the communities, most of the resorts and camping areas in the watershed were located near mineral and other springs easily accessible from the railroad and later from asphalted roads. Some, like Shasta Springs, have been repurposed but survive to the present day, and some, such as the CCC camp at Sims, have been reclaimed by nature and only traces survive. Recreational campsites, resorts, and communities create a robust archaeological record, including landscaping, foundations, and trash deposits, which may still be found and interpreted by researchers.

After the construction of the railroad through the Sacramento River canyon, railroad logging became a major industry in the watershed. Extensive networks of railroad grades and evidence of logging from this era can be found throughout the watershed, in particular west of the Sacramento River extending out from the present day communities of Mt. Shasta, Dunsmuir, Castella, and Lamoine

towards the Shasta and Trinity counties border. Archaeological evidence of the logging activities include sawmill locations, work camps, railroad grades, donkey platforms, skid trails and log chutes, high-cut tree stumps, and trash scatters.

The upper Sacramento River watershed contains many valuable mineral resources that have been mined in the historic era, including gold, copper, lime, and asbestos. The largest and most productive mining occurred in the southwestern portion of the watershed and involved the extraction and refinement of copper ore. The creation of Shasta Lake inundated the town of Kennett, the center of a large mining and copper smelter industry; however, archaeological traces of the mines remain above the water line to the west of the lake. Archaeological evidence of gold mining may be found along creeks, particularly in the area of Delta, where an early gold mining town existed in the 1850s. Other minerals, such as lime and asbestos, would exhibit an archaeological footprint similar to other mining concerns. Trash scatters, machinery, foundations, landscape alterations, water ditches and dams, mining tailings or adits, and work camps may be found in the archaeological record of mining ventures.

3.1.8 Fire and Fuels

The following discussion of fire and fuels describes the regions' fire regime (i.e., return intervals, severity, fire rotation1); the influence that humans have had on the fire regime and vegetation structure of the watershed; and the effects and spatial extent of documented fires that have occurred in the watershed. A detailed discussion of the methodology used to ascertain the region's fire regime is presented in Appendix A.

History of Fire and Fire Management

The record of fire in the Klamath Mountains, including the watershed, extends back to about 13,000 to 15,000 years before present (Skinner et al. 2006). Forest structure, species composition, soil properties, wildlife habitat, landscape patterns, watershed hydrology, nutrient cycling, and other ecosystem processes have evolved in large part in response to fire (Frost and Sweeney 2000). Most native species and communities in the region have co-evolved with fire, adapting to its periodic occurrence. Some researchers have suggested that the region's globally outstanding biodiversity is due at least in part to the natural disturbance regime in general and fire in particular (Frost and Sweeney 2000). Present-day vegetation assemblages found in the watershed coalesced approximately 3,000 to 4,000 years ago when the climate cooled and became moister than the preceding millennia (Skinner et al. 2006).

Fossilized charcoal deposits preserved in lake sediments indicate that the frequency of fire extending back over the previous 15,000 years is a function of variation in precipitation and temperature, while trends in the spatiality and severity of burns reflect the amount of available biomass at the time of the burn rather than fire frequency (Skinner et al. 2006). Paleoecological evidence suggests there is only a loose coupling between fire regimes and any particular vegetation assemblage (Whitlock et al. 2003, Skinner et al. 2006).

[1] *The length of time necessary to burn an area of specific size (e.g., the watershed).*

Prior to the introduction of fire suppression, fires in the mid-elevation Douglas-fir–dominated forests of the Klamath Mountains region were fairly frequent, generally less severe, and had shorter fire rotations than in similar forests in other regions. The development and dynamics of stand conditions were strongly influenced by this fire regime (Taylor and Skinner 1998). 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). These mixed-severity fires perpetuated multi-aged stands.

As discussed in Section 2.1.3, *Native Americans and Fire*, the Native American populations that inhabited the region prior to the arrival of Euro-Americans likely had well-developed traditions of intentional burning that undoubtedly had a significant influence on vegetation patterns (Frost and Sweeney 2000). Although fires ignited by Native Americans were more commonly applied in the lower elevation oak woodlands, such as those that occur in the southern portion of the watershed, oral history suggests that anthropogenic fires regularly burned up to 6,000 feet in elevation (Lininger 2003). Historical accounts of Native American subsistence patterns suggest that fire was ignited in oak woodlands at intervals typically less than 5 years, with the more heavily used sites burning almost every year (Frost and Sweeney 2000). Low-intensity, frequent fires sustained the character of many oak woodlands by retarding conifer encroachment, while making acorn gathering easier. However, it is difficult to confirm the historical frequency of fire in oak woodlands since oaks are capable of regenerating from both seedlings and basal sprouts, and their thick, corky bark protects them from low-intensity fire. Though Native American ignitions appear to have been widespread, the broad scale extent of their influence on the fire regime and vegetation is unknown (Skinner et al. 2006).

Prior to the mid-nineteenth century (which coincides with the influx of Euro-American settlers), it is believed that fires in mid-elevation forests—such as those in the watershed dominated by Douglas-fir, ponderosa pine, and hardwoods—were relatively common as anthropogenic fires spread out of the lowlands (Lininger 2003). Although historically, as now, mid-elevation forests in the region experienced a high number of lightning ignitions, it is probable that Native Americans also ignited fires in these forests to clear travel corridors and/or maintain populations of plants used for food and basketry (Frost and Sweeney 2000). Regardless of the ignition source, studies in mid-elevation forest types similar to those occupying a majority of the watershed determined that fires would have burned at low to moderate intensity, with frequencies ranging from about 3 to 90 years and median return intervals of about 10 to 13 years (Wills and Stuart 1994, Frost and Sweeney 2000).

Euro-American settlers in the early to mid 1800s are reported to have set fires to make travel easier, to clear ground for prospecting, to drive game, and to encourage forage production for sheep and cattle (Whittaker 1960, Skinner et al. 2006). Though settlement is thought to have increased fire frequency and perhaps fire intensity, no increases in fire occurrence during the settlement period are evident in fire scar studies conducted in the region (Agee 1991; Wills and Stuart 1994; Taylor and Skinner 1998, 2003; Skinner et al. 2006).

Following the end of World War I, the demand for national forest resources increased considerably, especially for water and timber. However, this demand was not only for tangible forest products. Increased outdoor recreation and the expansion of homesites into forested lands increased the potential for fire ignitions in the watershed. The fire suppression policy, which was aggressively applied throughout most of the 20th century, was intended to protect public and private lands and properties. The policy of excluding fire, or at the very least, significantly limiting its extent, has

resulted in an unnatural build-up of fuels and the encroachment of a less fire-tolerant understory in most western United States forests. Ironically, studies indicate that the effects of fire suppression have been far less in the Klamath/Siskiyou region, which includes the watershed, than in many other forested regions of the west (Frost and Sweeney 2000). The primary reasons for this difference are that: (1) fire suppression was effective over a considerably longer period in other regions—sometime between 1850–1900 rather than during the mid-twentieth century (Skinner and Chang 1996); and (2) fire return intervals are on average longer and more variable in the Klamath Mountains (Frost and Sweeney 2000). Further, difficult terrain has caused most fire suppression efforts in the Klamath/Siskiyou region to be most successful in areas closer to human settlements—because protecting private property has always been given priority—and less so at higher elevations and in remote areas with steep terrain (Frost and Sweeney 2000).

As described in Section 2.3, *Evolution of Laws and Regulations Affecting the Watershed*, the 1994 NWFP significantly altered timber management practices across the Pacific Northwest. Fewer and smaller timber sales have contributed to increased fuel loads as many forests are managed to perpetuate old-growth or late-successional characteristics. Concurrently, in recent years, societal concerns for managing natural resources have shifted to include the role of fire as a dynamic and predictable part of wildland ecosystems (Stephens and Sugihara 2006). Fire is now recognized for its role in the functioning of the healthy, natural ecosystem. The focus of fire policy and management has shifted away from the overall goal of removing fire toward the much more complex goal of managing fire (Stephens and Sugihara 2006). The *Collaborative Approach for Reducing Wildfire Risks to Communities and the Environment: Ten-Year Comprehensive Strategy* (U.S. Department of Agriculture and U.S. Department of the Interior 2006) established by the National Fire Plan recognizes the importance of fuel management and that key decisions in setting priorities for restoration, fire, and fuel management should be made collaboratively at local levels (Stephens and Sugihara 2006).

The STNF has a comprehensive fire program with engine companies, hand crews, helitack, lookout, fire managers, dispatchers, and an air tanker base, any of which may be deployed in the event of fire in the watershed. In addition, CalFire is a significant presence in the wildfire suppression community of the region. A cooperative fire protection agreement has been adopted by federal and state fire protection agencies, providing for wildfire protection for lands that are “intermingled” or adjacent to public lands regardless of ownership (USDI Bureau of Land Management et al. 2001). The federal agencies and the state have agreed upon and have prepared maps of Direct Protection Areas (DPAs), filed in the offices of each fire agency, in which each assumes the responsibility of maintaining a wildland fire protection system. These maps show the established DPAs and are kept current on an annual basis.

Although limited in their extent, some fire history studies that have been conducted on the STNF and in the larger Klamath Mountains region have included portions of the watershed (USDA Forest Service 2000, Skinner 2001, Fry and Stephens 2006). Prior to about 1922, when fires in the watershed began being recorded and mapped, studies have shown that fires were a common ecosystem process (Fry and Stephens 2006); however, their extent and year of occurrence are unavailable. Table 3.1-3 summarizes the year and approximate size and location of fires documented in the watershed since the 1920s. This table corresponds to Figure 3.1-6.

Table 3.1-3. Documented Fires in the Watershed (1922–2008)

FIRE ID #	FIRE NAME	FIRE YEAR	ACRES BURNED
0	—	1922	159
1	—	1922	339
2	—	1922	607
3	—	1923	148
4	—	1924	186
5	—	1924	634
6	—	1924	3,332
7	—	1924	398
8	—	1924	114
9	—	1924	1,000
10	—	1924	152
11	—	1930	293
12	—	1930	273
13	—	1931	155
14	—	1931	424
15	—	1931	847
16	—	1931	125
17	—	1931	1218
18	—	1931	142
19	—	1931	101
20	—	1931	240
21	—	1931	247
22	—	1931	102
23	—	1932	110
24	—	1933	401
25	—	1934	775
26	—	1934	674
27	—	1934	183
28	—	1934	156
29	—	1934	157
30	—	1936	1,375
31	—	1939	313
32	—	1939	203
33	—	1939	7,936
34	—	1944	223
35	—	1944	120
36	—	1945	97
37	—	1946	82
38	—	1949	125
39	—	1950	154
40	Tunnel 16	1950	154
41	Lester Flat	1950	111
42	—	1951	189
43	—	1952	830
44	—	1952	8
45	Leach Ranch	1954	213
46	East Fork	1962	217
47	—	1985	1,782
48	Bow	1990	550
49	Pocket	1996	47
50	Sugar	1999	3,154

Table 3.1-3. Documented Fires in the Watershed (1922–2008)

FIRE ID #	FIRE NAME	FIRE YEAR	ACRES BURNED
51	Sugar	1999	3
52	Sugar	1999	1
53	Sugar	1999	3
54	Sheep	1999	2,047
55	Sheep	1999	19
56	Sheep	1999	80
57	Reptile	1999	6
58	Reptile	1999	1,617
59	Jackass	1999	3,498
60	Jackass	1999	75
61	Jackass	1999	25
62	Lunch	1999	1,426
63	Lunch	1999	2
64	Lunch	1999	5
65	Lunch	1999	4
66	Bohemotash	1999	4,158
67	High	1999	3,064
68	Pollard	2003	41
69	Green	2003	13
70	Tollhouse	2005	13
71	Bass	2006	9
72	Motion	2008	7,813
73	Elmore	2008	243

Source: USDA Forest Service 2008e

Regional Fire Environment

California is composed of a diverse landscape that is mirrored in its wide range of climates, geomorphology, and vegetation. In fact, the biological diversity (both plant and animal) of the state has been driven over space and time by the occurrence of fire and the ecological processes it perpetuates. Climatic variations, geomorphology, and vegetation throughout the state are often described using an ecosystem classification system of bioregions (Miles and Goudey 1997) based on consistent patterns in vegetation and fire regimes over a specific landform (e.g., mountain ranges, coastal steppes, deserts, the Central Valley) (Sugihara and Barbour 2006). In this context, the watershed falls primarily within the Klamath Mountains bioregion, with some incursion into the Southern Cascades bioregion on the western and southern slopes of Mount Shasta.

Climate and Weather

California's unique Mediterranean climate, which is typified by long, dry summers and cool, wet winters, is conducive to the occurrence of fire (Sugihara and Barbour 2006). In California, the eastern Klamath Mountains are the first major mountain range encountered by southwesterly flowing winds moving northeast across the Sacramento Valley (Skinner et al. 2006). Orographic uplift (the upward lift of an air mass over mountainous terrain) of moist air masses over the eastern Klamath Mountains produces high levels of precipitation, falling mostly as snow in the higher elevations. Steep elevation gradients have a further effect on temperature and the spatial pattern of precipitation, with most precipitation falling between October and April.

In the watershed, there are no readily discernible differences in the precipitation pattern and climate of the Southern Cascades bioregion from that occurring in the Klamath bioregion. A west-to-east precipitation and temperature gradient creates wetter and warmer conditions on the west side of the southern Cascades Range south of Mount Shasta. Conifer forests, intermixed with woodlands and shrublands, dominate the mid-montane zone.

Lightning is common in the Klamath Mountains and the southern Cascades, increasing in occurrence with distance inland from the Pacific Ocean and with increasing elevation. Although it seems counterintuitive, the number of lightning strikes does not necessarily correspond to the number of lightning-caused fires (Skinner et al. 2006). Lightning-caused fires result from storms that produce drier air and more unstable weather patterns than storms that produce a greater number of lightning strikes. Conditions in the Klamath Mountains and the southern Cascades favor lightning-caused ignitions, which when coupled with the steep topography, extensive strong canyon inversions, and the difficult access for fire-suppression forces, can create situations where fires burn for weeks to months and cover very large areas (Skinner and Taylor 2006, Skinner et al. 2006).

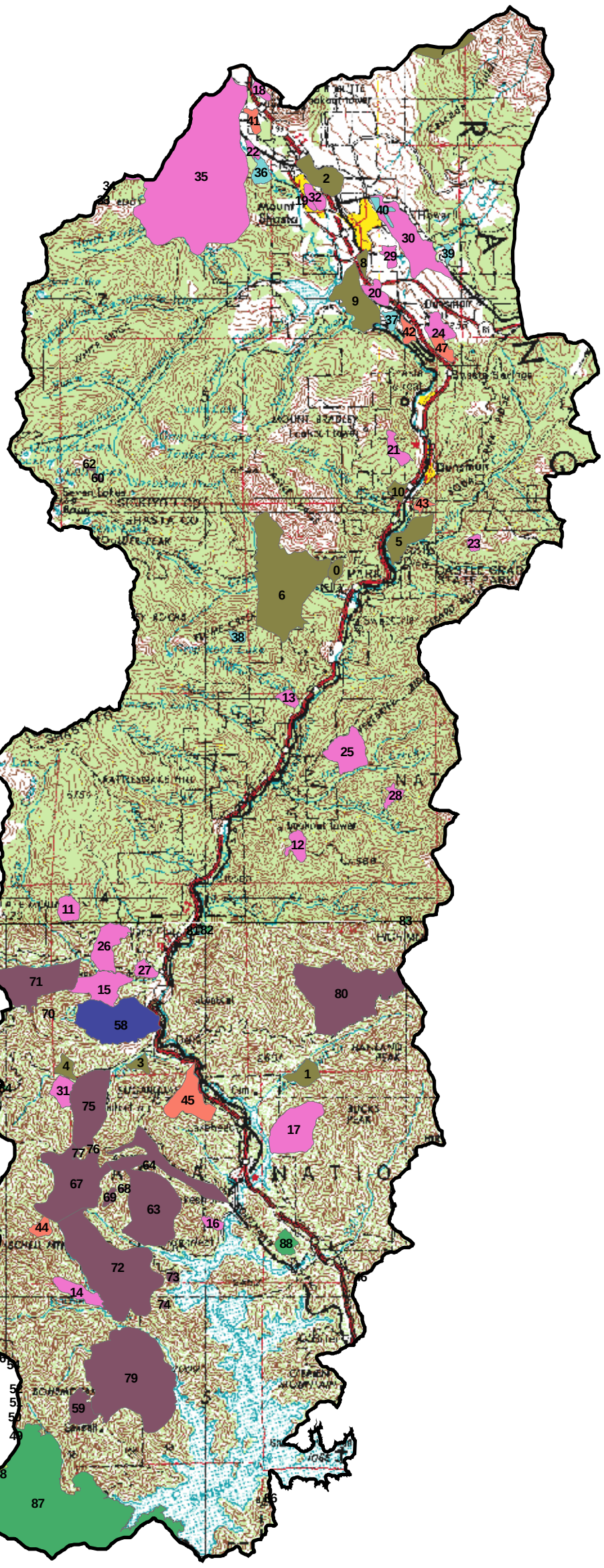
Ecological Zones

In California, vegetation is the meeting place of fire and ecosystems. The plants are the fuel and fire is the driver of vegetation change. Fire and vegetation are often so interactive that they can scarcely be considered separately from each other (Barbour et al. 1993).

The Klamath Mountains bioregion is an area of exceptional floristic diversity and complexity in vegetative patterns (Whittaker 1960, Stebbins and Major 1965, Skinner et al. 2006). The Klamath Mountains are recognized as a transition zone where the floras from the Cascade/Sierra Nevada axis and the Oregon/California coastal mountains intersect. The rugged terrain, diverse lithology (rock-forming processes), and diverse fire regimes combine to create the heterogeneity of plant life that has evolved over time in the Klamath Mountains bioregion. Conifer forests and woodlands are found in all elevational zones throughout the bioregion (Skinner et al. 2006). Despite the complex intermixing of vegetation, which is further complicated by rugged topography, three general ecological zones based on elevation are used to characterize the Klamath Mountains heterogenic vegetative assemblage: lower montane, mid to upper montane, and subalpine (see Section 3. 3, *Biological Components and Processes*, for additional details on the vegetation communities present in the watershed).

In the watershed, shrublands are the dominant vegetative form in the lower montane zone. Warm, dry, rocky sites typify the areas of the watershed where shrublands occur, as do areas in which site quality has been permanently reduced by past disturbance such as mining, or that are in the early successional stages of recovery from a disturbance such as fire or clearing. However, the lower montane zone is not purely shrublands. Douglas-fir–dominated and mixed evergreen forests also occur with relative frequency in this zone. Although not so common in the watershed, small areas of grasslands also occur.

The mid- to upper-montane zone of the watershed is differentiated from the lower montane zone by the increased importance of the conifer component and a decrease in hardwoods. The extreme northern end of the watershed is the only area in the watershed where the subalpine zone occurs. There is no upper elevation limit of the subalpine zone, which occurs on the higher elevation slopes



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Upper Sacramento River Project

Figure 3.1-6
Fire History

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of Mount Shasta on the east side of the watershed, and Mount Eddy and the Trinity Mountain Range (a part of the Klamath Mountains) on the west side. Vegetation types found in this zone of the Klamath Mountains (and the southern Cascades for the Mount Shasta portion of the watershed) are a function of the soil depth or parent material rather than low temperatures (Sawyer and Thornburgh 1977, Skinner et al. 2006). Forests in the subalpine zone are generally open patchy woodlands of widely spaced trees, with a discontinuous understory of shrubs and herbs and large areas of bare ground (Skinner et al. 2006).

Fire Regimes

Fire regimes[2] in the Klamath Mountains have varied over millennia, primarily due to variations in climate. In terms of fire regimes, historical conditions and processes are most often described by ignition source, frequency, severity, seasonality, and spatial extent over a landscape (Frost and Sweeney 2000). The steep and complex topography of the Klamath Mountains provides for conditions that make it difficult to separate fire regimes by ecological zones (Skinner et al. 2006). The most common fire regime in the Klamath Mountains typically extends from the lower montane through the mid-montane into the upper montane ecological zones, from canyon bottoms to over 6,000 feet in elevation. Because the Klamath Mountains are generally very rugged, several ecological zones can occur over the elevational gradient of a single slope. These steep, continuous slopes that run from low to high elevation, coupled with varying slope aspects and summer drought conditions, create conditions for frequent, mostly low- and moderate-intensity fires in most ecological zones of the Klamath Mountains (Skinner et al. 2006).

Vegetative species composition within the watershed and tree age and stand structure demonstrate the influence that topography has had on the region's fire regimes. A discussion of the fire history of the watershed is presented in the following section.

Fuel Loads and Distributions

Following a disturbance such as fire or logging, vegetation typically returns in a series of successional stages (e.g., grasses give way to shrubs, which eventually give way to trees), each of which will influence fire behavior in unique ways. Vegetative properties, including type, density, size, and structure of vegetation in a given area, are considered when assessing fuel loads. A quantitative basis for rating fire danger and predicting fire behavior became possible with the development of mathematical fire behavior models (Anderson 1982). Mathematical modeling of potential fire behavior and/or fire danger indices requires inputs that describe fuel properties, specifically fuel loads and distribution of fuels among fuel size classes. The collections of fuel properties are referred to as "fuel models" and are organized into four groups: grass, shrub, timber, and slash. These four groups are indicative of the stratum of available surface fuels most likely to carry the spreading fire. Within these groups, further distinctions are made based on the fuel load and depth and its orientation (vertical or horizontal). Fire behavior predictive fuel models (Albini 1976) representing the fuel load

[2] *Description of the patterns of fire occurrences, frequency, size, severity, and sometimes vegetation and fire effects as well, in a given area or ecosystem. A fire regime is a generalization based on fire histories at individual sites. Fire regimes can often be described as cycles because some parts of the histories usually are repeated, and the repetitions can be counted and measured, such as fire return interval (National Wildfire Coordinating Group Incident Operations Standards Working Team 2007).*

and the ratio of surface area to volume for each fuel size class, the depth of the fuel bed involved in the flaming fire front, and fuel moisture, including that at which fire will not spread—referred to as the "moisture of extinction"—are used to model potential fire behavior during the severe period of the fire season when wildfires pose greater control problems and impacts on land resources. Accordingly, standard fire behavior fuel models (Scott and Burgan 2005) were input into the FlamMap fire modeling computer program to determine potential fire intensity (predicted flame length) should a fire ignite.

In the watershed, forest vegetation management actions and past wildfires account for much of the current vegetation condition, including the amount of late-successional habitat in the watershed (USDA Forest Service 1999a). Although the LSR Assessment (USDA Forest Service 1999b) is specific to late-successional forest habitat and thus does not directly address the potential fire risk associated with the various seral[3] and other climax[4] habitats occurring throughout the watershed, vegetative conditions in the LSRs are the result of the dynamic, diverse biological and physical conditions that occur throughout the watershed. The structure and compositions of the nearly continuous coniferous forests of the middle and upper watershed (see Section 3.3, *Biological Components and Processes*) vary by forest type, site quality, and fire regime. Changes brought about by fire suppression efforts have not only changed the forest structure, stand density, and species composition of the watershed, but have also had a direct effect on forest health.

Fuel models in the watershed were identified by the USFS using aerial photograph imagery, forest stand assessment information, and field verification. Eight standard fuel models (1, 2, 4–6, and 8–10) and three "custom" fuel models were used to identify urban areas (Fuel Model 28), open water (Fuel Model 98), and bare ground (Fuel Model 99) in the watershed (Figure 3.1-7).

In those parts of the LSRs/MLSA that are roaded and where recreational use occurs, the incidence of human-caused fire starts is generally analogous to an increased level of risk. While lightning has and continues to be a significant source of fire starts, the influence of humans, not only as a source of ignition, but whose management actions (e.g., suppression) have dramatically altered the type and structure of vegetation in the watershed, is often a determinant of risk.

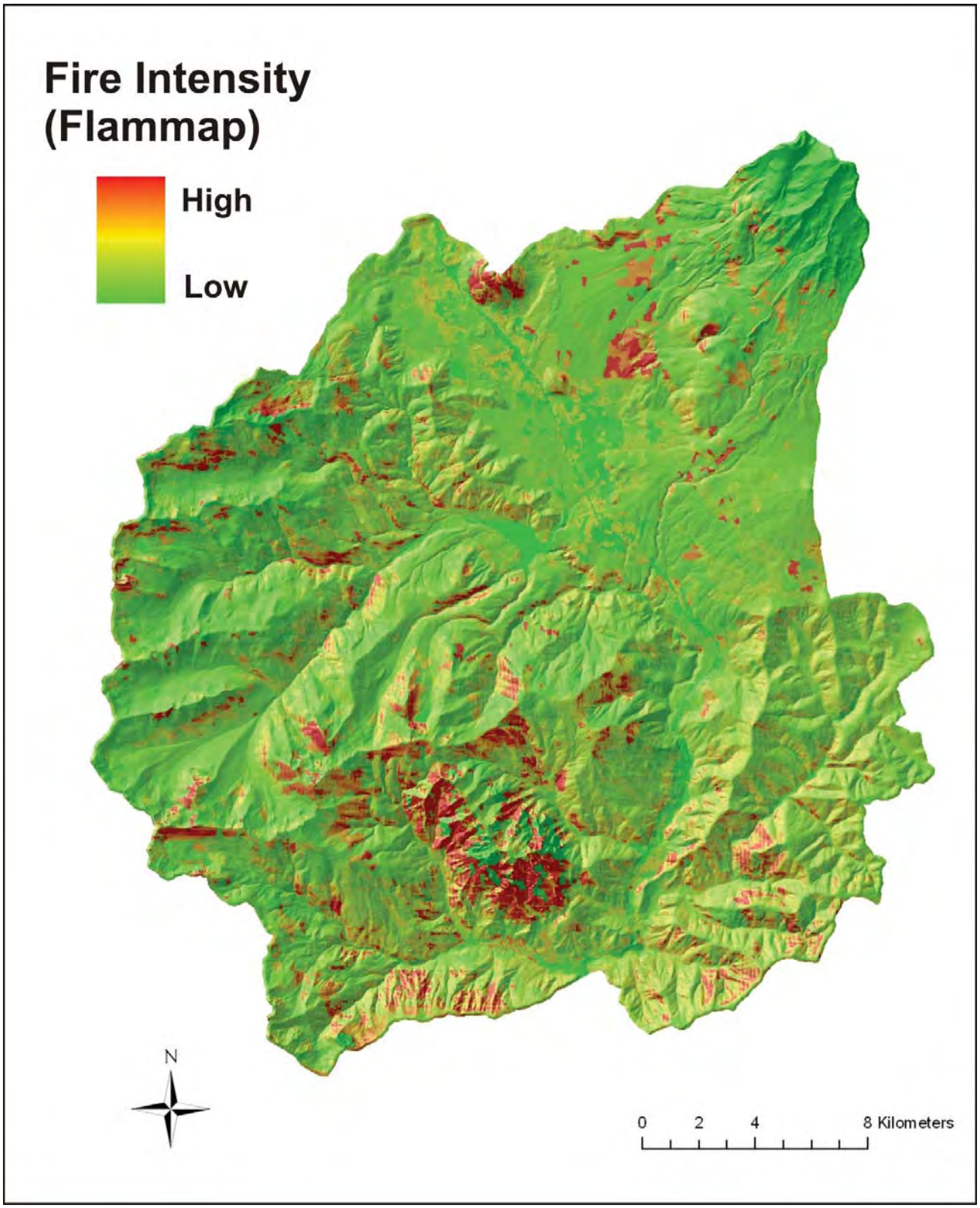
Fire Behavior

Fire behavior is a function of weather, topography, and fuels, with weather being the most variable factor. These characteristics determine not only how a fire will burn at its leading edge but also the immediate and long-term effects of a fire on the vegetative community, post-fire erosion potential, and effects on biological resources and the human environment.

Methodology

For the purpose of predicting potential fire behavior in the watershed, environmental variables, including weather conditions common to the region, fuel loads (provided by the USFS), and watershed topography, were input into the FlamMap computer model (Fire Sciences Lab and Systems

[3] *"Seral" refers to a plant species or community that will be replaced by another species or community in the absence of disturbance.*
[4] *"Climax" refers to species or communities representing the final (or indefinitely prolonged) stage of succession.*



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Potential fire intensity in units of flame length was predicted for the upper watershed of the project area using the fuels data provided by the U.S. Forest Service. The fire behavior model, Flammap, was used in the analysis (http://firemodels.fire.org/). Sid Beckman of the U.S. Forest Service conducted the fire analysis. In Flammap, the fire behavior fuel model #10 was used in the analysis.

Figure 3.1-7
Modeled Fire Intensity
(Modeled results not field verified.)

for Environmental Management 2006). It was used by the USFS to generate the predictions presented in the following discussion.

FlamMap

FlamMap was designed to help plan fuel treatments (Finney 2006, Husari et al. 2006). It calculates fire behavior independently for each pixel across the landscape and holds the key fire weather variables (i.e., wind speed, wind direction, fuel moisture) constant (Vaillant 2008). Outputs capture the spatial variability in fire behavior due to differences in fuel conditions (Finney 2006).

In order to model potential fire behavior, eight data layers are used, consisting of topographic information (elevation, slope, and aspect), canopy characteristics (canopy cover, canopy base height, canopy bulk density, and canopy height), and surface fuels information (fuel model). In addition, simulation of fire behavior requires the input of non-temporal and non-spatial weather and fuel moisture information. Six fuel models were used in FlamMap: #1 (grass), #2 (grass/shrub), #3 (shrub), #4 (timber and understory), #5 (timber and litter), and #6 (slash).

Influence of Weather Systems on Fire Behavior

Critical fire weather in the Klamath Mountains bioregion is generated by conditions of both the California and Pacific Northwest weather types (Hull et al. 1966, Skinner et al. 2006). Sustained periods of high-velocity winds and low humidity will have a direct effect on fire behavior. In the Klamath Mountains, critical fire weather conditions are created by three different weather patterns: (1) Pacific High–Post-Frontal (Post Frontal), (2) Pacific High–Pre-Frontal (Pre-Frontal), and (3) Subtropical High Aloft (Subtropical High) (Hull et al. 1966, Skinner et al. 2006). Post-Frontal conditions occur when high pressure following the passage of a cold front causes strong winds from the north and northeast. Relative humidity levels drop and temperatures increase with these winds. Pre-Frontal conditions occur when strong southwesterly or westerly winds are generated by the dry, southern tail of a rapidly moving cold front. Although relative humidity levels increase and temperatures decrease, the strong winds that characterize this weather condition are often associated with the rapid spread of fire through heavy fuels. Subtropical High conditions result when descending air from high pressure causes temperatures to rise and humidity levels to drop. An inversion layer is often created by such conditions, which traps smoke in canyons and valleys, and reduces fire intensity. Under Subtropical High conditions, fires create mainly low- to moderate-severity effects. However, fires burning above the inversion layer often burn at much higher intensity; thus, the steep topography of the Klamath Mountains will often determine the severity and intensity of fires occurring in the region.

Fire Intensity and Severity

The magnitude of fire effects is described in terms of fire intensity and fire severity, two distinctly different terms. Fire intensity is defined as the amount of energy released from a fire and may or may not be used to describe the effects of fire on the biota (Frost and Sweeney 2000). Rate of spread, the amount of fuel consumed, and the position of the fire's active front within the forest profile (i.e., surface, subcanopy, and overstory) are descriptors of fire intensity.

Fire severity refers to the qualitative degree to which vegetation and site conditions have been altered by a fire (Frost and Sweeney 2000). Temporal and spatial factors such as forest structure, fuel availability and moisture, topography, weather, and fire behavior in adjacent areas combine to dictate the severity of a fire. Post-fire, the mortality rate of a dominant tree species present in a given area can be an indicator of fire severity. Three levels of fire severity are commonly used to further characterize fire effects:

- **High severity**—Most trees, including overstory trees, are killed
- **Moderate severity**—Partial stand-replacing fires that include areas of both low and high severity; some overstory trees are killed or heavily damaged in patches
- **Low severity**—Light surface fires that have minimal impacts on forest overstories, but may kill small trees and shrubs

Historic fire severity usually cannot be directly measured. Inferences are generally drawn based on patterns of fire return intervals, stand age class structures, and species composition (Frost and Sweeney 2000).

Fire frequency and severity are, in general, inversely related. Longer intervals between fires allow for a greater accumulation of fuels that lead to hotter, more severe fires when ignited (Agee 1993, Frost and Sweeney 2000). The continuity of surface fuels in the watershed is fragmented by rivers, ridges, rock outcrops, and serpentine barrens, all of which influence the extent and pattern of most fires. Shallow, rocky, and dry soils on lower elevation steep canyon slopes prevent establishment of most shrubs and trees. Thus, fuels accumulate rather slowly and are often discontinuous. Local-scale variations in topography can affect the moisture content of fuel by influencing microclimate and can further affect fire regimes by influencing fuel continuity (Frost and Sweeney 2000). In the watershed, the upper Sacramento River acts as an effective barrier to the spread of many low-intensity and some moderate-intensity fires.

In the steep, narrow canyons of the watershed, differentials in temperature, humidity, and fuel moisture between the canyon bottoms and the ridgetops are amplified by the common occurrence of strong thermal inversions (Schroeder and Buck 1970, Skinner et al. 2006). Diurnal patterns of local sun exposure and wind flow combine with slope steepness to affect fire behavior (Schroeder and Buck 1970, Rothermel 1983, Skinner et al. 2006). The exposure to wind and solar insulation combines with position on steep slopes to create conditions where upper slopes experience higher intensity fires more often than do lower slopes (Skinner et al. 2006). The greater drying and heating of fuels on steep slopes, especially those with westerly or southern aspects, contribute to greater fire and burn intensity (as depicted in Figure 3.1-7). As shown on Figure 3.1-7, fire severity generally occurs in a somewhat predictable pattern, where the upper third of slopes and ridgetops, particularly on south- and west-facing aspects, experience the highest proportion of high-severity burns, while the lower third of slopes and north- and east-facing aspects experience mainly low-severity fires. Middle slope positions typically act as an intermediary of severity between the upper and lower slopes.

When wildfire occurs in the watershed, the severity of the fire combined with the slope conditions (e.g., steepness, aspect) will determine the susceptibility of the burn area to soil erosion. In the upper part of the watershed, steep and convergent landforms may pose less of an erosion hazard due to

gradual spring snowmelt runoff, although post-fire gullying may be significant in these areas. In the mid and southern parts of the watershed, where most precipitation falls as rain, the erosion potential following wildfire can be significant. In all parts of the watershed, burned-over convergent areas will concentrate overland flow, making these areas particularly susceptible to gully development. The volume and types of sediment eroded from the watershed's hillslopes strongly influence the types of aquatic habitats that form in the Sacramento River and its tributaries.

The severity with which wildfire has and will burn in the watershed has a significant effect on the types of vegetative communities that occupy a previously burned area. 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). In some areas of the watershed that have been subject to particularly severe fire, forests have been replaced by a persistent shrub-dominated community that inhibits the reestablishment of tree species. Mature or over-mature shrub-dominated vegetative communities are vulnerable to atypical fire behavior (i.e., increased fire severity). The effects of fire severity on vegetative communities, and, consequently, its effect on wildlife species is discussed in Section 3.3.4, *Plants, Wildlife, and Fish of Ecological/Cultural Concern*.

Fire Behavior in Dominant Vegetation Types in the Watershed

The following is a discussion of the dominant types of vegetative communities occurring in the watershed and their relationship to fire behavior and fire effects.

Oak Woodlands

Many low-elevation sites, river canyons, and areas of droughty, shallow, rocky soils below about 3,000 feet elevation are occupied by oak-dominated woodlands. Although these woodland types may differ in terms of species composition and structure, they all occur in areas that are physiologically marginal for tree growth because of water limitations caused by low rainfall and/or thin, droughty soils (Frost and Sweeney 2000).

Canyon live oak is a common, dominant species in the lower montane zone of the watershed, particularly near Shasta Lake and in the southern portion of the watershed. This species, like most oaks, is sensitive to fire and is easily top-killed by fire. Dense canopies and thin bark make canyon live oak susceptible to crown scorch and cambium damage, but like most oaks, if the top is killed, it will sprout vigorously from the root crown.

The accumulation of fuel in oak woodlands, such as canyon live oak stands, growing on unproductive sites found in the lower to middle portions of the watershed occurs rather slowly and is often discontinuous. The hardwood and brush species in these areas have evolved under a fire regime of low- to moderate-intensity surface fires; however, exclusion of natural wildfires over the past century has increased the intensity with which fires now burn (USDA Forest Service 2000).

Douglas-Fir

Moderate to dense Douglas-fir communities occur in the lower to mid elevations of the watershed. Typically, Douglas-fir prefers the cooler northern or eastern exposures at lower elevations, but at higher elevations becomes much more variable. Species composition in Douglas-fir dominated

communities consists of other conifer species such as ponderosa pine, sugar pine, and incense cedar; hardwoods, including canyon live oak, California black oak, and big-leaf maple; and a shrub understory.

Douglas-fir forests tend to occur in relatively dry areas where fire return intervals are fairly frequent. Known for its superior ability to adapt to fire, mature Douglas-fir stands are resistant to low- and moderate-severity fires and are likely to maintain dominance (Agee 1993). However, when low- to moderate-severity fire occurs in immature Douglas-fir stands, the species is not as fire tolerant and may be out-competed by shrubs and hardwoods for decades before regaining dominance.

Ponderosa Pine

Ponderosa pine is a fire-adapted species that evolved under frequent low-severity fires. The frequency of these historic, pre-suppression era fires (often occurring at a mean fire interval of 10 years or less) have reduced potential competition from shrubs and grasses that would compete with young ponderosa pine trees for limited resources, such as sun and moisture, and would also periodically thin the stand. Pine needles, small twigs, and branches accumulated on the forest floor would be quickly consumed, allowing for the establishment of the shade-intolerant pine seedlings. Fire suppression activities in the watershed have significantly altered the composition of ponderosa pine stands by interrupting the natural fire return interval and creating unnatural accumulations of understory vegetation or dense, even-aged stands of plantation-grown ponderosa pine capable of carrying an active crown fire.

Mixed Conifer

Fire intensities appear to have been mostly low to moderate in the mixed conifer forest of the eastern Klamath Mountains (which includes the watershed), generally thinning the forest according to species' susceptibility to fire, tree size, and density (Frost and Sweeney 2000). Pre-historic and historic land use patterns had a particular influence on the fire histories of mixed conifer forests (Agee 1993). In the western United States, this forest type experienced a significant component of Native American burning. In the watershed, it may be speculated that periodic burning by Native Americans was done not only to make the collection of acorns easier, but to kill diseases and pests, create openings for hazel and beargrass—both of which were used for basketry—and maintain travel corridors along ridgetops. Fire return intervals were relatively frequent in mixed conifer forests of the region, averaging a mean fire-return interval of 37 years between 1650 and 1930 in the nearby Siskiyou Mountains (Agee 1993).

Douglas-fir is a major component of mixed conifer forests in the watershed, although ponderosa pine is a common co-dominant. Its ability to adapt to relatively frequent fire enables mature Douglas-fir to maintain dominance so long as fires are not too intense. Low- to moderate-intensity fires typically top-kill the understory hardwoods, leaving them to resprout from the ground. However, if mixed conifer forests burn at higher frequencies (i.e., every one or two decades), young Douglas-fir trees will not be fire-tolerant and will be killed, leaving the hardwoods to resprout again and become dominant for many decades as Douglas-fir trees must compete not only with hardwoods but shrub species as well. Eventually, a mixed conifer forest will re-emerge with multiple-age species. The patterns of stand development in mixed conifer forests represent variable fire severities and the ability of the different species to take advantage of post-fire conditions (Agee 1993).

Shasta Red Fir

Shasta red fir is a high-elevation species found in parts of the watershed where substantial winter snows tend to accumulate. Natural fire frequencies in Shasta red fir forests are relatively long (often 65 to 125+ years); thus, when fire occurs, it burns at a moderate level of severity (Agee 1993). Red fir communities are composed of moderate to dense conifer stands dominated by red fir. Associated species include white fir and, occasionally, mountain hemlock (*Tsuga mertensiana*) and western white pine. Shrubs that may be present include huckleberry oak (*Quercus vacciniifolia*) and mountain spirea (*Spiraea densiflora*).

Red fir-dominated forests represent a classic mosaic of patches associated with historical variation in disturbance intensity, primarily from fire (Agee 1993). However, fire suppression has resulted in minor landscape-level shifts in the forest mosaic of red fir forests, although the variable fire intensities and regimes under which these forests have evolved suggest that under most weather conditions, fires in this forest type will remain within controllable intensities (Agee 1993).

Riparian Areas

Riparian areas are found in all vegetative habitat types. In the Klamath Mountains, these areas are often dominated by species such as deciduous hardwoods that are relatively uncommon in upland settings. Lower ambient temperatures, moister air and soils, and less flammable vegetation combine to reduce fire intensities in riparian areas (Frost and Sweeney 2000). While stand-replacing fires can occur in riparian areas, particularly in steep canyons, which can act as a wind tunnel, it is much more common for fire to burn as a low-intensity ground fire. In less steep montane riparian areas, disturbance from high winds may be lower than in surrounding uplands and along ridgelines, and, consequently, the quantity of downed large wood fuels could potentially decrease (Dwire and Kauffman 2003). During fire events, if wind speeds are lower in riparian areas than surrounding uplands, fire behavior may be less severe, with decreased rates of spread, decreased flame lengths, and lower fireline intensities (Dwire and Kauffman 2003). Shrubs and some deciduous trees may be subject to topkill, but most of these species readily resprout and soil stability is not impaired (Frost and Sweeney 2000). Most conifers survive such fires, and fire-sensitive species like Pacific yew (*Taxus brevifolia*) often do so because they grow in wetter microsites (Frost and Sweeney 2000).

However, the higher fuel loads that result from the higher vegetation densities and low fire return intervals generally associated with riparian areas can increase the vulnerability of these areas in drought conditions to increased fire severity, intensity, and return intervals. Under drought conditions, with the simultaneous occurrence of high temperatures, high wind speeds, and low relative humidity, fire weather could likely override local physical variables as the primary determinant of fire behavior (Dwire and Kauffman 2003). Such conditions may cause fire to behave similarly in riparian areas and in uplands.

The landscape position and size of the riparian areas appear to be an important determinant of the fire regime for a particular location. Small, narrow riparian areas, particularly those associated with intermittent and ephemeral streams, are likely to experience more frequent and higher intensity fires than large, broad riparian areas, and those in drier areas will probably burn more frequently than those in wetter areas (Frost and Sweeney 2000, Skinner et al. 2006). Riparian areas along perennial watercourses, such as the upper Sacramento River, serve as an effective barrier to the spread of low-

intensity and some moderate intensity fires and have a strong influence on the patterns of fire occurrence beyond their immediate vicinity (Skinner et al. 2006). Consequently, by affecting fire spread, riparian areas are a key topographic feature that also contribute to the structure and dynamics of upland forest landscapes (Taylor and Skinner 2003, Skinner et al. 2006).

Wildfire Relationships with Urban and Wildland Settings

It has been said that the wildland–urban interface (WUI) is a defining fire management issue of the 21st century (Husari et al. 2006). However, interface issues have been a part of the fire dynamic for as long as fires have burned from wildlands into communities. Expanding communities are at risk, not so much because of fuel accumulations within the community itself, but because of the vegetation types in which homes and towns are being built. In California, vegetation types that naturally burn with high intensity and rapid spread are increasingly punctuated by new homes and communities, greatly increasing the number of people and amount of property at risk.

Continued development in the interface area is causing fire resources and funding for fuel management programs to be reoriented, with the emphasis now on home and community protection rather than fire suppression. Increasing loss of homes in the interface has spurred Congress to allocate more fuel management funds to treat more acres at risk (Husari et al. 2006). The use of prescribed fire as a fuel management tool can be an efficient means by which the federal policy of emphasizing the restoration of fire to the ecosystem can be achieved, but it is not without some risk. The potential for escape, particularly into the WUI, and the health impacts associated with smoke generated by prescribed fire are a liability. Although the Klamath Mountains generally have a far lower human population compared to California as a whole, the Klamath and the Southern Cascades (in the vicinity of the upper Sacramento River watershed) bioregions are classified by CalFire as mixed interface because of the dispersed nature of dwellings in small, scattered communities in flammable wildland vegetation (Skinner and Taylor 2006, Skinner et al. 2006).

Within the Mt. Shasta community WUI, there is a high risk of human-caused fires due to the presence of residences, railroad tracks, and Interstate 5. Human-caused fires are often the result of negligence, but there have been some cases of arson reported in the Mt. Shasta community. Lightning-caused fires (as a percentage of all fires) are not as common in the WUI, but episodes of multiple lightening strikes can stretch suppression resources beyond their ability to deal with the numerous fires that could be ignited by a single storm. In these situations, fires located in or near the most valuable resource at risk, such as the City of Mt. Shasta, receive the highest priority.

Other communities in the watershed, including Dunsmuir and Lakehead, provide additional examples of the inexorable WUI development radiating outward from the Interstate 5 corridor into the forested areas of the watershed. Fire hazard severity zones have been delineated by CalFire for both Siskiyou and Shasta counties and for some specific communities (California Department of Forestry and Fire Protection 2008). In addition, some communities in the watershed (Lakehead, City of Mt. Shasta, and Dunsmuir) have or are currently preparing Community Wildfire Protection Plans (CWPP), which are prepared by a consortium of community volunteers organized into a Fire Safe Council. The intent of these community-based fire protection plans is to identify measures that will reduce the risk of wildfire spread into or out of the community; identify key properties, infrastructure, and other valuable assets at risk, including streams, timber, and wildlife; prioritize areas of hazardous fuels and identify fuel treatment needs (e.g., fuel breaks, defensible space); and assess community fire

emergency preparedness. The advent of the CWPP program stems from the HFRA. This landmark legislation included the first meaningful statutory incentives for the USFS and BLM to give consideration to the priorities of local communities as they develop and implement forest management and hazardous fuel reduction projects (Society of American Foresters 2004).

The State of California has adopted a number of building code regulations and requirements specific to homes and other buildings located in the WUI (California Department of Forestry and Fire Protection 2007). Primary among these is Public Resources Code 4291 (effective January 1, 2009), which requires landowners having property in or adjacent to mountainous, forested, brush-covered, or grass-covered areas to maintain a defensible space no greater than 100 feet from each side of structures. A greater distance may be required by state law, local ordinance, or regulation. The intent of such codes is to provide minimum standards to increase the ability of a building to resist vegetation fires.

3.2 Physical Components and Processes

3.2.1 Climate and Air Quality

Within the watershed, topography and elevation are highly variable, with elevations ranging from 1,075 feet near Delta to 14,162 feet at the summit of Mount Shasta. Approximately 50 percent of the watershed is located above 3,000 feet, and approximately 16 percent is above 6,000 feet. As a result of this vast vertical range, air temperature, rainfall, and snowfall amounts can vary greatly across the watershed, and regional weather patterns, local storm patterns, topography, and elevation ultimately determine the climate of any specific location.

The global position of the watershed (approximately 41^{o} north latitude and 122^{o} west longitude) and its proximity to the ocean greatly influence its climate, which can be characterized as Mediterranean, having a distinctive hot and dry summer season and a cool and wet winter season. The main controlling factor of a Mediterranean-type climate in California is the relationship between the subtropical high and the westerlies, which are the prevailing winds in the mid-latitudes ($35–65^{o}$) of the globe. During the summer, the center of a subtropical high resides in the southwestern portion of the United States and expands pole ward, exerting its influence on the west coast between approximately 30^{o} and 40^{o} north latitude. Subsiding air from the high creates stable atmospheric conditions when coupled with cold ocean currents along the coast. The stable subtropical high-pressure air mass diverts the westerlies away from California. During the winter, the subtropical high shifts to the south, which allows the westerlies to transport moisture-laden storms that formed in the Pacific Ocean into California and the interior United States. Although this is an overgeneralization of the regional weather patterns, the movement of the sub-tropical high largely influences the general weather pattern of the watershed.

There is little meteorological data regarding storm movement in the watershed. Observational and anecdotal evidence suggests that most storms generally track from west to east with some slight variation to the north or south. However, the topographic disposition of the watershed can often greatly influence precipitation amounts and types regardless of the storm track. Often, easterly moving low-pressure systems track to the north of the watershed, but precipitation amounts can be the greatest to the south along the Sacramento River canyon and on the southern flanks of Mount Shasta.

It appears that higher pressure air from the Sacramento Valley to the south flows north up the Sacramento River canyon towards the low-pressure center of the storm. The topographic confines of the canyon combined with adiabatic[5] cooling of the air mass causes large amounts of precipitation to fall. This phenomenon is observed in the climate record of weather stations in the subbasin[6] and will be discussed in conjunction with regional weather patterns and topography to characterize the climate of the upper Sacramento River watershed. The spatial and temporal distribution of precipitation is used to classify landforms and runoff/erosion potential.

Data Sources

In the watershed, 24 weather-monitoring stations are actively collecting weather observations or have collected weather observations in the past (Table 3.2-1; note that some stations are listed twice due to an interruption in data collection or change of the data steward). The historical weather records of all of the stations contain enough data to characterize the rainfall, snowfall, and air temperature of the watershed. Rainfall data are the most abundant type of data in the historic record and air temperature the rarest. The weather station at the town of Mt. Shasta (#45983) has the most complete and extensive record (1948–2009) of air temperature, rainfall, and snowfall observations of the stations in the watershed.

In order to characterize the climate of the watershed across a range of elevations, three zones were chosen based on site elevation and the length and quality of climate records from nearby weather stations (Figure 3.2-1). The weather station near the City of Mt. Shasta is considered representative of the upper elevations of the subbasin. The weather stations near Dunsmuir (#42574 and 42572) are considered representative of the middle elevations, and the weather stations near Shasta Lake (i.e., Lakehead, Lakeshore, Vollmers, and Gibson) are considered representative of the lower elevations of the subbasin. Annual snowpack trends were characterized using snow course data from the highest elevation stations.

Precipitation

General Trends

In the subbasin, precipitation occurs as both rainfall and snowfall. All of the three precipitation zones summarized herein receive abundant precipitation during the winter and limited amounts of precipitation from thunderstorms during the summer months (Figure 3.2-2). The lower elevation Lakehead/Lakeshore area receives the most precipitation of the three areas analyzed, followed by Dunsmuir and the City of Mt. Shasta, respectively. Generally, the amount of precipitation in an area increases with elevation, but this is not true along the Sacramento River canyon. Located at an elevation of 1,100 feet, the Lakehead/Lakeshore area receives approximately 69 inches of combined precipitation. The data suggest that this area receives 10 more inches of precipitation than the Dunsmuir area at 2,400 feet in elevation receives in the form of rain and 17 more inches of precipitation than the City of Mt. Shasta at 3,500 feet in elevation.

[5] *Changes in temperature caused by the expansion (cooling) or compression (warming) of a body of air as it rises or descends in the atmosphere.*

[6] *See Section 3.2.7,* Hydrology, *for a definition of subbasin as used herein.*

Table 3.2-1. Current and Historic Weather Monitoring Stations in the Upper Sacramento River Watershed

STATION ID	STATION NAME	OPERATOR[A]	DATA STEWARD	LATITUDE (OW)	LONGI-TUDE (ON)	ELEVA-TION (FT)	AIR TEMP	RAINFALL DATA	SNOW DATA	WIND DATA	OTHER
DLT	Sacramento River at Delta	USGS/BOR	CDEC	40.94	122.416	1,075	X				
LKS	Lakeshore	BOR	CDEC	40.867	122.383	1,100	X	X		X	
44709	Lakeshore 1&2	NWS	WRCC	40.52	122.23	1,080	X	X			
44683	Lakehead	NWS	WRCC					X	X		
49386	Vollmers	NWS	WRCC	40.57	122.26	1,340		X	X		
SUG	Sugarloaf	USFS	CDEC	40.917	122.438	4,200	X	X		X	X
GIB	Gibson	DWR	CDEC	41.0225	122.3992	1,633	X	X			
GBS	Gibson Maintenance Station	NWS	CDEC	41.025	122.41	1,650		X			
43405	Gibson Maintenance Station	NWS	WRCC	41.01	122.24	1,650		X	X		
SLT	Slate Creek	BOR	CDEC	41.045	122.478	5,700	X	X	X		
GRD	Girrard	BOR	CDEC	41.133	122.283	4,800	X	X			
DNM	Dunsmuir Treatment Plant	NWS	CDEC					X			

Table 3.2-1. Current and Historic Weather Monitoring Stations in the Upper Sacramento River Watershed

STATION ID	STATION NAME	OPERATOR[A]	DATA STEWARD	LATITUDE (OW)	LONGI-TUDE (ON)	ELEVA-TION (FT)	AIR TEMP	RAINFALL DATA	SNOW DATA	WIND DATA	OTHER
42574	Dunsmuir Treatment Plant	NWS	WRCC	41.12	122.16	2,170	X	X	X		
42572	Dunsmuir RS	NWS	WRCC	41.13	122.16	2,420		X	X		
GYR	Grey Rocks Lake	USFS-MTS	CDEC	41.217	122.417	6,200			X		
NFS	North Fork Sacramento River	USFS-MTS	CDEC	41.305	122.493	6,900			X		
MSH	Mount Shasta	USFS-MTS	CDEC	41.372	122.23	7,900			X		
SDF	Sand Flat	BOR	CDEC	41.3504	122.2464	6,750	X	X	X		
SFT	Sand Flat Snow Course	USFS-MTS	CDEC	41.353	122.247	6,800			X		
MTS	Mount Shasta	DWR	CDEC	41.313	122.316	3,545	X	X			
MTA	Mount Shasta	USFS	CDEC	41.315	122.317	3,550	X	X	X	X	X
MSC	Mount Shasta	NWS	CDEC					X			
45983	Mount Shasta	NWS	WRCC	41.19	122.19	3,590	X	X	X		
MSH	Mount Shasta	USFS-MTS	CDEC	41.372	122.23	7,900			X		

[a]Operator Codes:

BOR- U.S. Bureau of Reclamation
CDEC - California Data Exchange Center
DWR- California Department of Water Resources
NWS- National Weather Service
USFS- U.S. Forest Service
USFS-MTS- USFS Mt. Shasta Ranger District
USGS- U.S. Geologic Survey
WRCC- Western Regional Climate Center

A majority of the subbasin's annual precipitation falls between December and March (Figure 3.2-2). January is the wettest month of the year, with all three areas receiving an average of at least 10 inches of precipitation and the Dunsmuir area averaging nearly 15 inches of combined precipitation. However, the Lakehead/Lakeshore area has the greatest average monthly precipitation amounts in 10 out of 12 months of the year. This discrepancy is most obvious in April, November, and December. These months occur on the fringes of the region's wet season, and it is possible that storms generated during these months lack sufficient energy to distribute precipitation evenly upslope along the Sacramento River canyon.

The aforementioned relationships between monthly and annual precipitation trends suggest that the topography of the Sacramento River canyon and the abrupt topographic rise of nearly 14,000 vertical feet between the Sacramento Valley and the summit of Mount Shasta greatly influence local precipitation patterns in the subbasin.

Rainfall

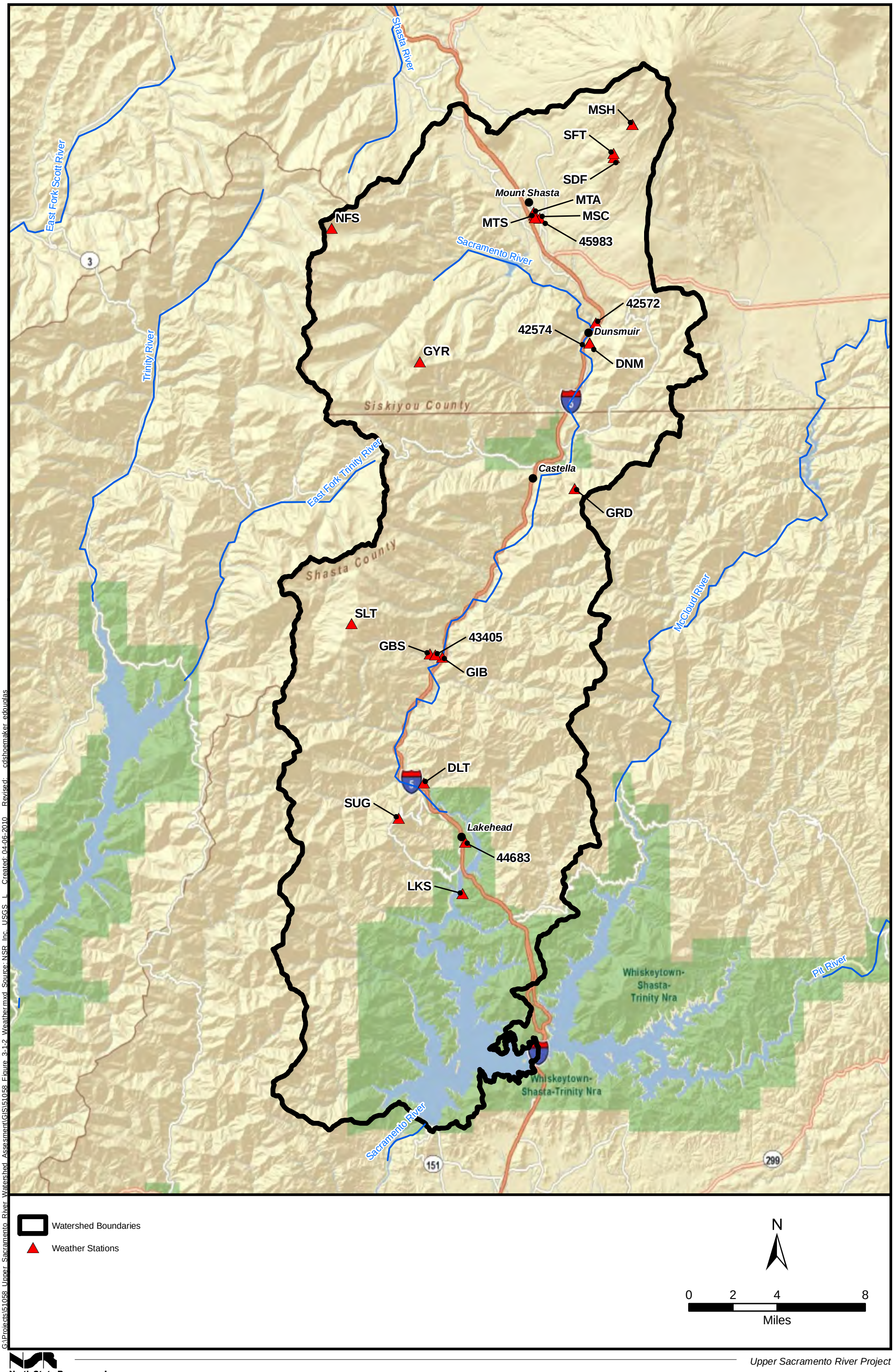
Annual Trends

The annual rainfall records of the City of Mt. Shasta, Dunsmuir, and Vollmers were analyzed to determine the mean annual rainfall for each area. In order to track temporal changes in precipitation trends, the total rainfall for each calendar year was compared to mean (normal) annual rainfall at eachsite to determine if the rainfall in a particular year was above or below the mean rainfall of the area (Figure 3.2-3). Long-term precipitation trends were analyzed by plotting the cumulative departure from the annual mean against an annual timeline for each site.

Figure 3.2-3 shows the wetting and drying trends over the last 60 years. Abrupt changes in cumulative departure from the mean between 1973 and the present are the most notable. These changes can be explained by the high amount of annual rainfall variability during the period. At Dunsmuir, the five largest and lowest rainfall years on record occurred between 1973 and the present (37 years), and four of the five largest and lowest rainfall years on record occurred between 1983 and 2010 (27 years). These trends suggest that there has been increased annual rainfall variability since 1973, but statistical analysis of these data shows that any increases in annual precipitation variability are not statistically significant. Another trend worth noting is that between 1994 and 2009, rainfall amounts were above normal 10 years during the period. These data suggest that the area may be currently experiencing above-average precipitation amounts despite the three below-average years between 2007 and 2009.

24-Hour Rainfall Trends

The watershed receives large amounts of rainfall due, in part, to its close proximity to the Pacific Ocean. Fast-moving or very low pressure systems can distribute large amounts of rainfall in a short time. High-intensity rainfall can initiate hillslope erosion, flash flooding, and slope failure. Figure 3.2-4 illustrates the occurrence and intensity of 24-hour rainfall events. On average, Gibson and the lower elevations of the watershed can expect to receive one annual event that produces 3.3 inches of rain in 24 hours, which is equivalent to constantly receiving 0.13 inch of rain every hour for an entire day. The City of Mt. Shasta can expect to receive one annual event that produces 2.2 inches of rain in 24 hours. This difference suggests that the topography between the two sites—the Sacramento River



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North State Resources, Inc.

Upper Sacramento River Project

Figure 3.2-1
Location of Weather Stations

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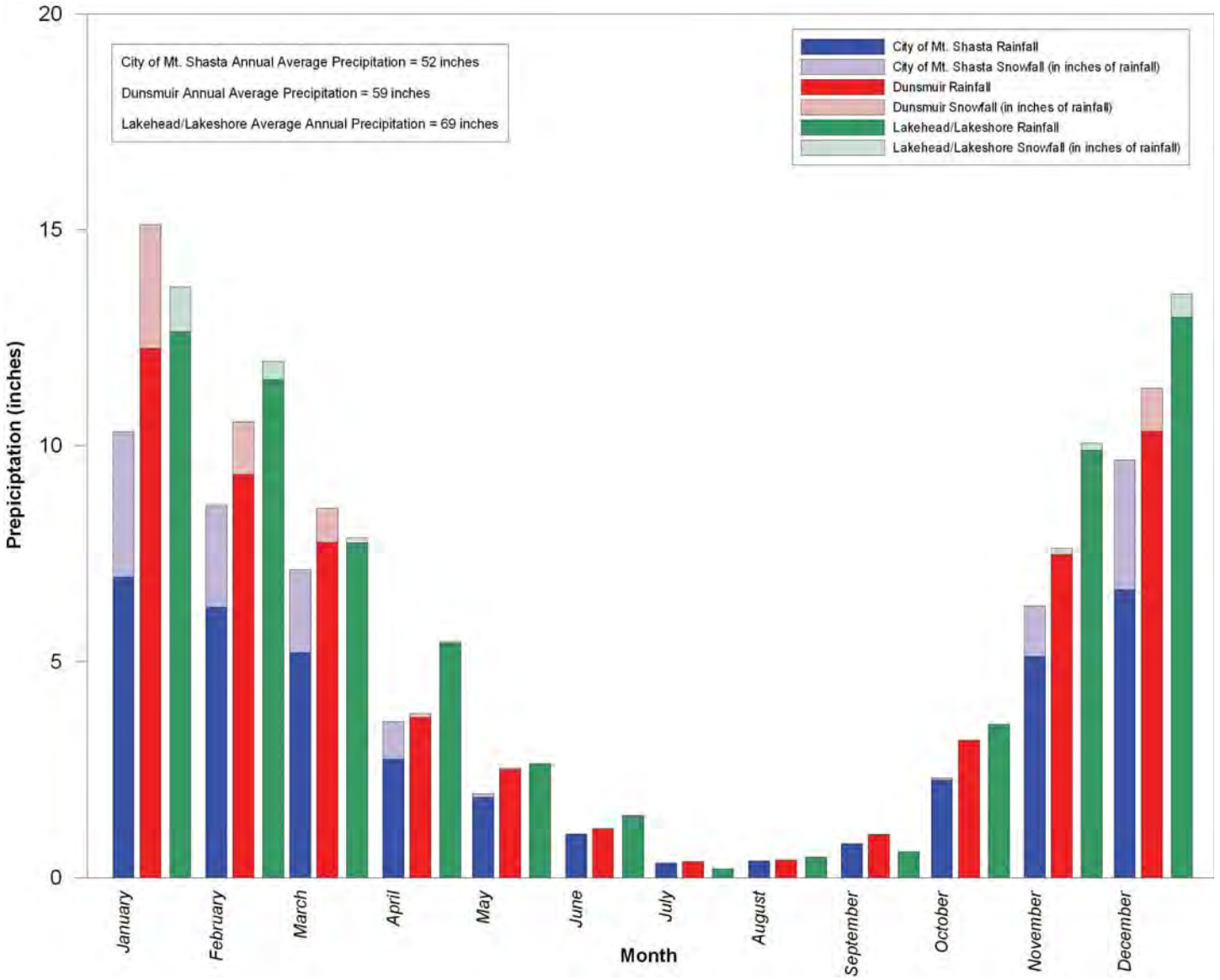

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Figure 3.2-2
Average Monthly and Annual Precipitation
City of Mt. Shasta, Dunsmuir, and Lakehead/Lakeshore Area

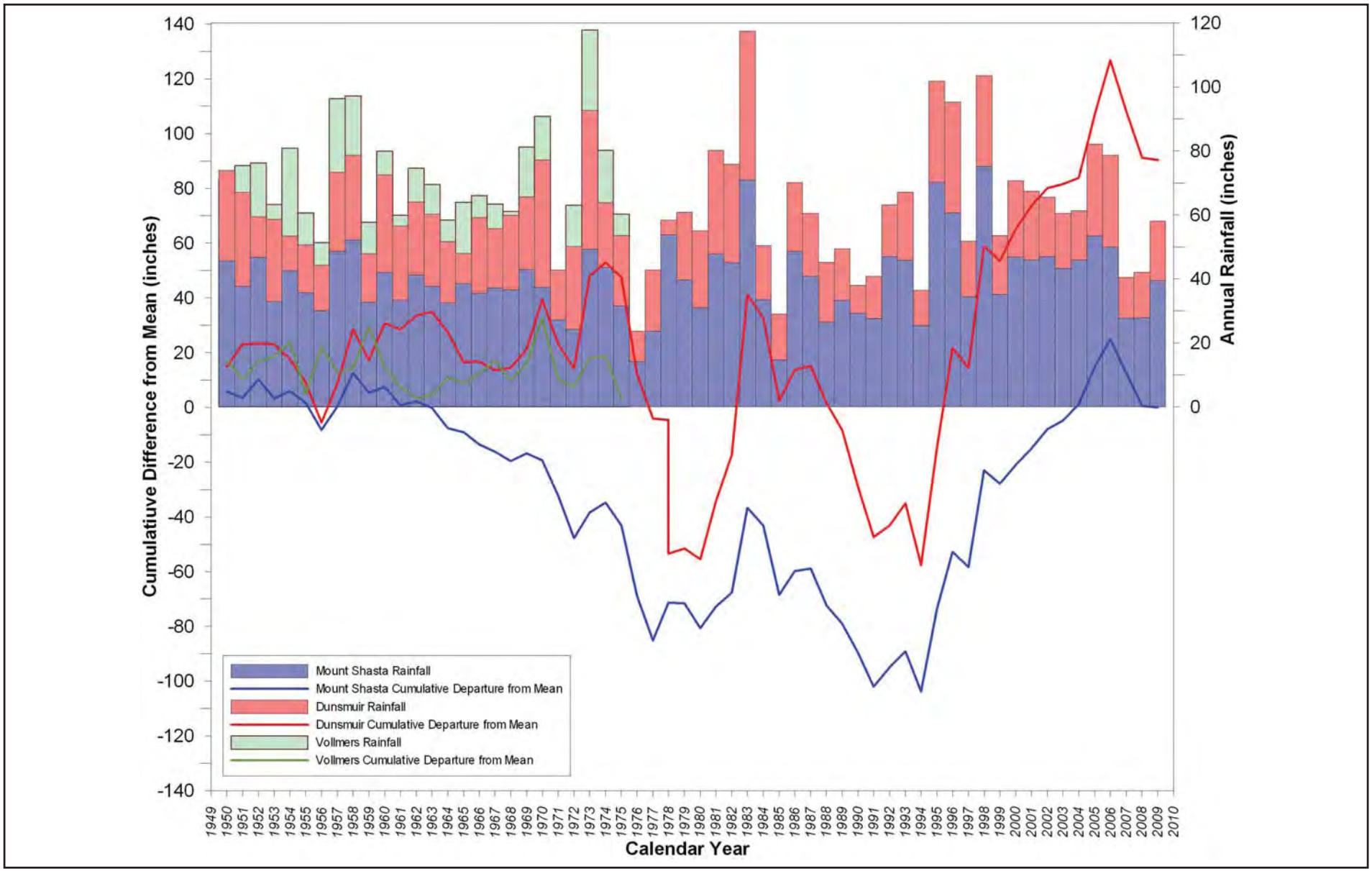

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Figure 3.2-3
Annual Trends in Rainfall

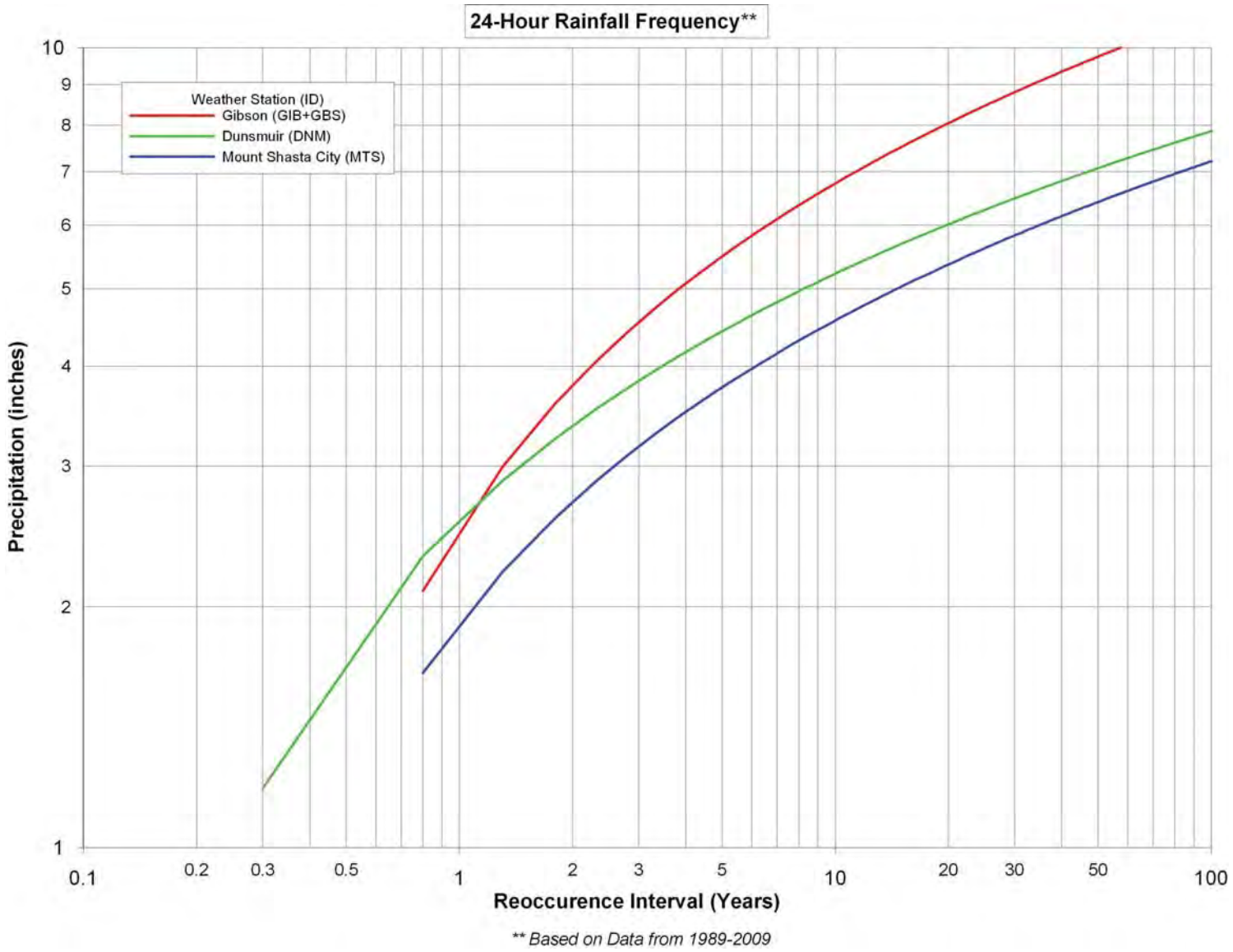

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Figure 3.2-4
24-Hour Rainfall Frequency

canyon—plays a role in precipitation distribution within the subbasin. The narrow north-south oriented canyon forces extremely intense rainfall events mid-slope, as shown in Figure 3.2-4. For example, a 10-year, 24-hour rainstorm at Gibson is between 7 and 8 inches compared between 4 and 5 inches in the City of Mt. Shasta. This volume of rainfall in such a short period will frequently cause upslope convergent hillslopes to fail, especially those cleared of vegetation and/or compacted.

Snowfall and Snowpack

Snowfall occurs at all elevations of the subbasin, but areas above 5,000 feet can receive a majority of their annual precipitation in the form of snow. Approximately 50 percent of the watershed is located above 3,000 feet and, as a result, snowfall and snowpack are major influences on the hydrologic cycle of the area.

The annual snow depth records for the Mount Shasta snow course (7,900 feet), Sand Flat snow course (6,800 feet), and Slate Creek snow course (5,700 feet) were analyzed to characterize the mean annual (January–April) snow depths at varying elevations. In order to track temporal changes in the snowpack in the subbasin, the mean snow depth of each calendar year was compared to the mean snow depth for the period of record at each site (Figure 3.2-5). This comparison helps to determine if the mean snow depth in a particular year was above or below the mean annual snow depth for each snow course. Long-term trends were also analyzed by plotting the cumulative departure from the annual mean against an annual timeline for each site.

Several climate trends are apparent in Figure 3.2-5. All three sites follow the same general snow depth pattern, as demonstrated by the cumulative departure from the mean at all three sites. The general trend is an above-average snowpack between 1950 and 1973, followed by a series of years with a highly variable snowpack between 1974 and 1994, and above-average snowpack between 1995 and 2006. The snowpack variability between 1975 and 1994 can be explained by the occurrence of historic events. For example, four of the five lowest snowpack years occurred at the Mt. Shasta and Sand Flat snow courses during this period as well as three of the five greatest snow depth years on record. In addition, the greatest measured snow depth occurred at all sites in 1983 and the lowest occurred in 1977. Between 1997 and 2009, the trend has been one of above-average snow depths for all sites, with a below-normal trend between 2006 and 2009.

Rainfall and snowpack are closely related within the subbasin. Between 1974 and the present, the trend in annual precipitation closely follows the trend in snow depth at all snow courses. In short, if there is an above-normal precipitation year, there is an above-normal snowpack the same year. However, this relationship is not consistent through the record. Between 1955 and 1977, a majority of the years had an above-average snowpack but below average rainfall. During this period, it is likely that this trend resulted from cooler winter air temperatures causing increased snowfall amounts from the available precipitation. The air temperature data for this period provide further support to this hypothesis.

Air Temperature

Air temperature trends in the watershed are consistent with a Mediterranean-type climate of hot summers and mild winters (Figure 3.2-6). The highest average maximum temperatures occur in July and the coldest average minimum temperatures occur in January.

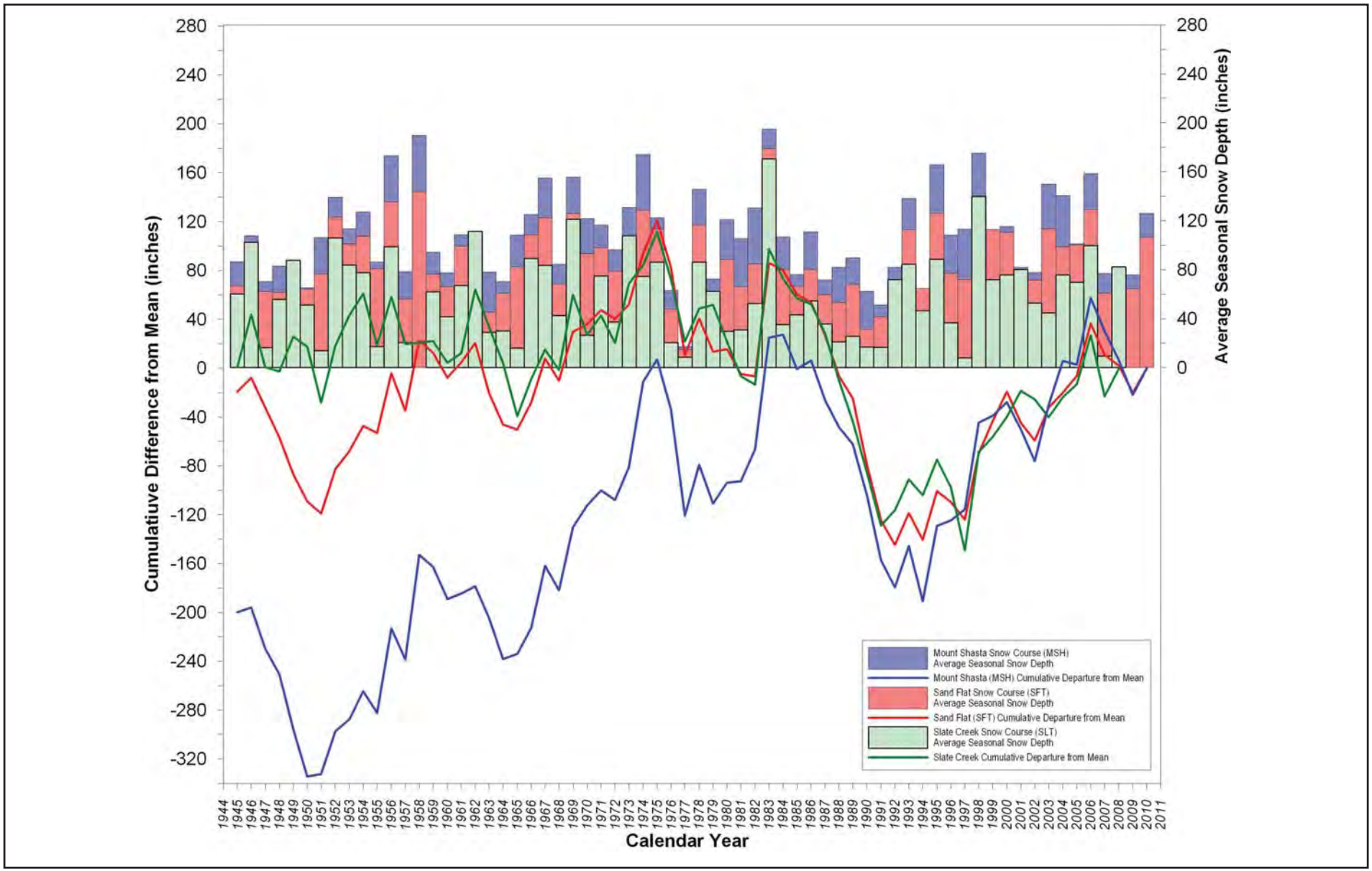

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Figure 3.2-5
Annual Seasonal Snow Depth Trends

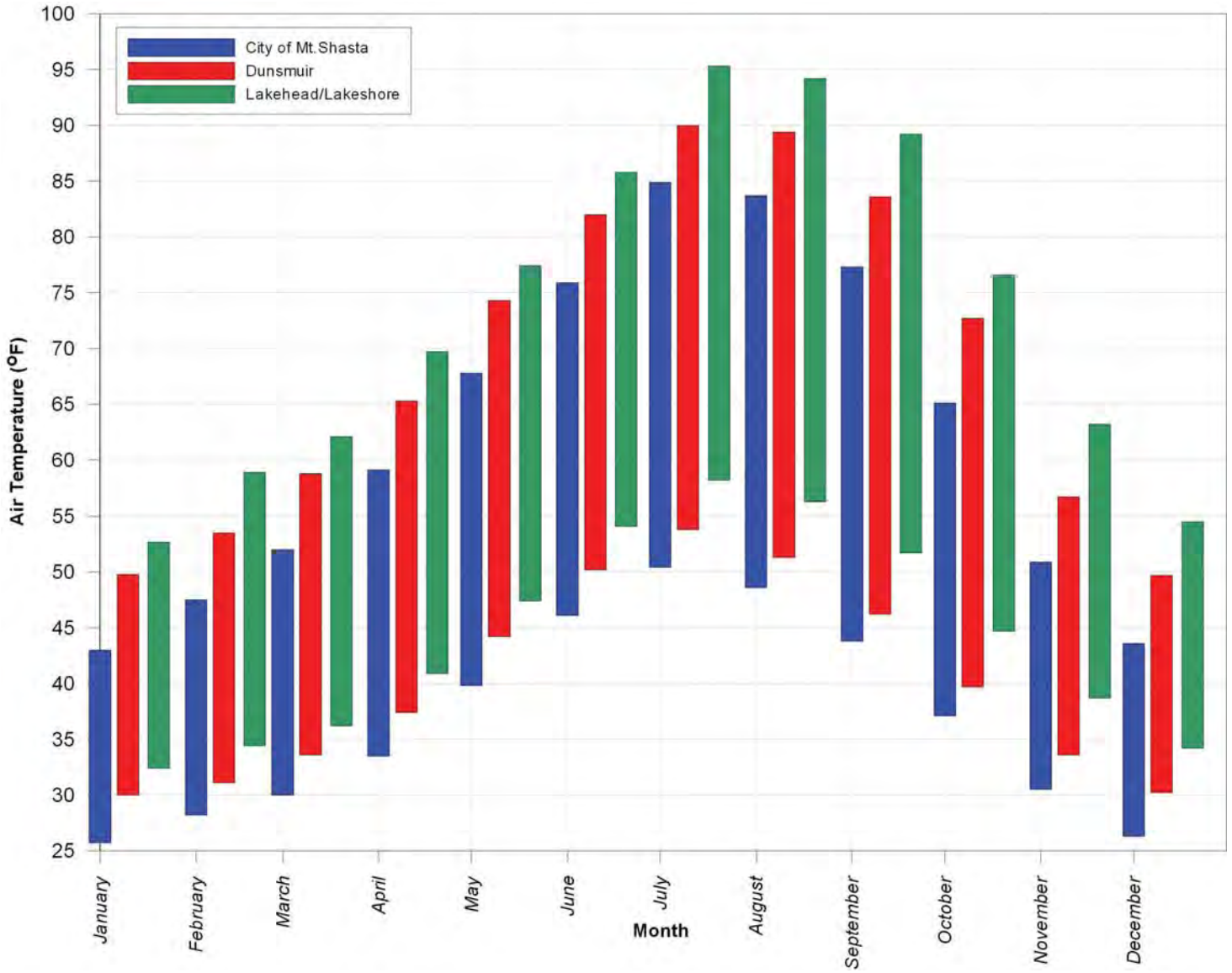

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Figure 3.2-6
Average Monthly Air Temperature Range
City of Mt. Shasta, Dunsmuir, and Lakehead/Lakeshore Area

The warmest area in the watershed, the Lakehead/Lakeshore area, is also located at the lowest elevation (1,100 feet). In July, maximum temperatures in this area occasionally exceed 95 °F or drop below 60 °F (Figure 3.2-6). In January, temperatures rarely reach 52 °F or drop below 32 °F (freezing). The temperature data for the Lakeshore/Lakehead area suggest that the portions of the watershed around 1,000 feet in elevation generally have a mild climate. These low-elevation areas remain frost-free for a majority of the year, average maximum temperatures are above 50 °F all year, and summer temperatures are less than 95 °F a majority of the time.

The coldest area analyzed in the watershed is the City of Mt. Shasta. The City of Mt. Shasta weather station is located at an elevation of approximately 3,550 feet. In July, temperatures in the area occasionally exceed 85 °F or drop below 50 °F (Figure 3.2-6). In January, maximum temperatures can reach 43 °F or drop below 26 °F. These temperature data suggest that the portions of the upper watershed around 3,500 feet in elevation generally have a cool climate. Average minimum temperatures are greater than 40 °F for only four months of the year, and average maximum temperatures exceed 80 °F for only two months of the year.

In order to track temporal changes and temperature trends in the watershed, the average air temperature for each calendar year was compared to mean annual temperature at each of three sites, City of Mt. Shasta, Dunsmuir, and Gibson, to determine if the air temperature of a particular year was above or below the mean at the site (Figure 3.2-7). The City of Mt. Shasta has a complete record, but Dunsmuir and Gibson have limited historic data available. Long-term air temperature trends were analyzed by plotting the cumulative departure from the annual mean against an annual timeline for each site.

The most noteworthy trend visible on Figure 3.2-7 is the negatively sloping trend of the cumulative departure lines of the Mt. Shasta weather station between 1963 and 1985. The incomplete temperature records of the Dunsmuir and Gibson stations also suggest the period had a cooling trend. It appears that the air temperature of the City of Mt. Shasta was generally below normal in this 32-year span. There also appears to be a slight warming trend that has been occurring between 2000 and the present. During this period, the average annual air temperature of the City of Mt. Shasta was nearly 5 percent above normal for the entire period.

The cooling trend between 1963 and 1985 also corresponds with an increased snowpack trend that occurs between 1955 and 1977 at all of the snow courses (Figure 3.2-5). Cooler temperatures generally produced an above-normal snowpack during this period, which means that as the annual temperature decreased, the annual snowpack increased. However, between 1985 and the present, cooler temperatures generally had less influence on snow depth and the snow depth more closely correlated with precipitation. To determine the significance of this discrepancy, the relationship between annual air temperature and snowpack was compared between two periods: 1963 to 1985 and 1985 to present. Analysis indicates that variability between the two periods is not statistically significant, which suggests that all fluctuations within the record are within the natural variation. This suggests that annual average air temperature has little effect on snowpack depth at higher elevations.

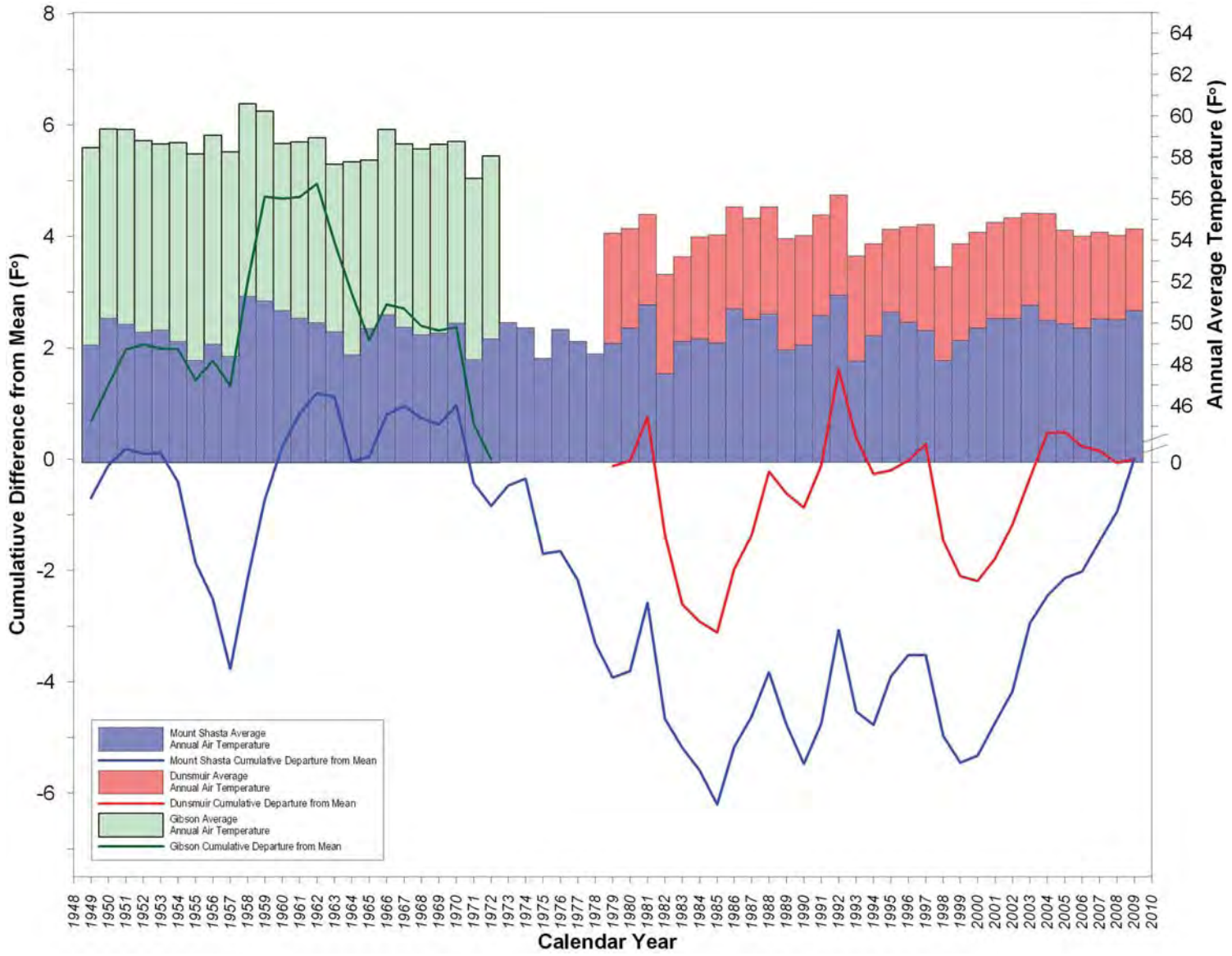

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Figure 3.2-7
Annual Air Temperature Trends

Air Quality

The watershed spans two air basins. The northern portion of the watershed is located in the Northeast Plateau Air Basin, which is characterized by the Klamath Basin and Modoc Plateau and is bounded by the Cascade Range in the east and the Klamath Range in the west. The southern portion of the watershed is located in the Northern Sacramento Valley Air Basin, which is characterized by the expansive Sacramento Valley and is bounded by the Klamath and Coast ranges to the west and the southern limits of the Cascade Range and northern limits of the Sierra Nevada to the east.

The watershed falls under two local air quality management jurisdictions, the Siskiyou County Air Pollution Control District and the Shasta County Air Quality Management District. Both local districts are tasked with implementing federal and state emissions standards and other air quality regulations within their respective jurisdictions. The districts are responsible for regulating stationary source emissions by issuing air quality permits that require implementation of Best Available Control Technology (BACT) if specified trigger levels are exceeded.

Air quality in this remote part of the state is generally good. Tables 3.2-2 through 3.2-4 summarize the air quality in the watershed. Pursuant to the 1990 federal Clean Air Act (CAA) Amendments, the EPA has classified air basins (or portions thereof) as either "attainment" or "non-attainment" for each criteria air pollutant, based on whether or not the National Ambient Air Quality Standards (NAAQS) have been achieved. The California Air Resources Board (CARB) also classifies air basins and air quality districts as being in attainment or non-attainment for state air quality standards. Under the federal CAA Amendments, Shasta and Siskiyou counties are designated attainment or unclassified for all federal ambient standards (California Air Resources Board 2010). Shasta County is in attainment for most California air quality standards, but is not in attainment for the California particulate matter and ozone standards (California Air Resources Board 2010). With the exception of ozone, Siskiyou County is designated as in attainment for state air quality standards. Siskiyou County's attainment status for ozone is "non-attainment-transitional," which means that the air district came into non-attainment as an operation of law when the ozone standards were changed (California Air Resources Board 2010). As required by the California Clean Air Act (CCAA), the Shasta County air quality district has prepared an air quality attainment plan, the Northern Sacramento Valley Planning Area 2006 Air Quality Attainment Plan (Shasta County et al. 2006). The plans address the CCAA requirement to bring the district into compliance with state ambient air quality standards, specifically requirements for ozone. The plan contains control programs for stationary sources and mobile sources. Because of the relative intractability of the PM10 and PM2.5 problem, the CCAA excludes this pollutant from the planning requirements to which other pollutants, such as ozone, are subject. Because Siskiyou County's "non-attainment" status is transitional and accounts for minor air quality exceedances that are associated with wildfire events, the County does not have an ozone attainment plan (Olson 2010). The County continues to work with CARB staff to ensure compliance with state air quality requirements (Olson 2010).

California has adopted ambient standards that are more stringent than the federal standards for the criteria air pollutants. These standards are referred to as the California Ambient Air Quality Standards (CAAQS). Under the CCAA, patterned after the federal CAA, areas have been designated as attainment or non-attainment with respect to the state ambient air quality standards.

Table 3.2-2. Air Pollutant Trends by Air Basin (2000 to 2010)

	POLLUTANT (TONS/DAY, ANNUAL AVERAGE)																	
	ROG (INCLUDING O3 PRECURSORS)			CO			PM10			PM2.5			NOX			SOX		
AIR BASIN	2000	2005	2010	2000	2005	2010	2000	2005	2010	2000	2005	2010	2000	2005	2010	2000	2005	2010
Sacramento Valley	243	207	183	1520	1223	1032	222	227	232	74	73	74	318	290	250	6	5	4
Northeast Plateau	33	31	30	341	319	307	74	73	72	26	25	25	32	30	25	—	—	—

Source: California Resources Board (2009)

Table 3.2-3. Ambient Air Quality Monitoring Data in the Multi-Region Habitat Conservation Plan Area, 2005

	POLLUTANT													
	O_3 (PPM)					CO (PPM)					PM10 (PPM)			
	Max. 1 hr *0.09 ppm*	Max. 8 hr *0.07 ppm/ 0.008 ppm*	Days > State 1 hr max. conc.	Days > State 8 hr max. conc.	Days > Fed 8 hr max. conc.	Max. 1 hr	Max. 8 hr *9.0 ppm*	Days > State 1 hr max. conc	Days > State 8 hr max. conc.	Days > Fed 8 hr max. conc.	Max. 24 hr. State *50 µg/m^3*	Max. 24 hr. Fed *20 µg/m^3*	Days > State 24 hr conc.	Days > Nat. 24 hr std
Sacramento Valley Air Basin	0.134	0.128	33	62	25	8.0	4.2	—	0	0	109	110	42	0
Northeast Plateau Air Basin	0.070	0.062	0	0	0	—	—	—	—	—	28	29	0	0

	POLLUTANT						
	$PM_{2.5}$		NO_2		SO_2		
	Max. 24 hr. State	Max. 24 hr Fed *35 µg/m*	Max. 1 hr *0.18 ppm*	Max. An. Avg.	Max. 24 hr. *0.04 ppm*	Exp. > 1 hr. ppm-hrs/pers	Max. Ann. Avg
Sacramento Valley Air Basin	82.7	80.0	0.079	0.016	0	0.99	0.00
Northeast Plateau Air Basin	26.0	26.0	—	—	—	—	0.00

Source: California Air Resources Board (2009)

Table 3.2-4. Summary of the Federal and State Ambient Air Quality Standards for Criteria Air Pollutants

POLLUTANT	AVERAGING TIME	FEDERAL STANDARD	STATE STANDARD
Ozone (O_3)	1-Hour 8-Hour	0.12 ppm 0.08 ppm	0.09 ppm --
Carbon monoxide (CO)	1-Hour 8-Hour	35 ppm 9 ppm	20 ppm 9 ppm
Nitrogen dioxide (NO_2)	1-Hour	--	0.25 ppm
	Annual	0.053 ppm	--
Sulfur dioxide (SO_2)	1-Hour	--	0.25 ppm
	24-Hour	0.14 ppm	0.04 ppm
	Annual	0.03 ppm	--
Fine particulate matter ($PM_{2.5}$)	24-Hour	65 µg/m^3	--
	Annual Arithmetic Mean	15 µg/m^3	--
Respirable particulate matter (PM_{10})	24-Hour	150 µg/m^3	50 µg/m^3
	Annual Arithmetic Mean	50 µg/m^3	--
	Annual Geometric Mean	--	30 µg/m^3
Lead (Pb)	30-day Average	--	1.5 µg/m^3
	Calendar Quarter	1.5 µg/m^3	--

Notes:
ppm = parts per million
µg/m^3 = micrograms per cubic meter
Source: California Air Resources Board (2009)

Federal and State Air Quality Requirements

The 1977 federal CAA required the EPA to identify National Ambient Air Quality Standards (NAAQS) to protect public health and welfare. NAAQS have been established for the following "criteria"[7] air pollutants: ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), suspended particulate matter (PM_{10} and $PM_{2.5}$), and lead (Pb).

CARB, California's state air quality management agency, regulates mobile source emissions and oversees the activities of county Air Pollution Control Districts (APCDs) and regional Air Quality Management Districts (AQMDs). CARB regulates local air quality indirectly by establishing state ambient air quality standards and vehicle emission standards, by conducting research activities, and through its planning and coordinating activities.

[7] *Termed "criteria" pollutants because EPA publishes criteria documents to justify the choice of standards.*

3.2.2 Climate Change

It is generally agreed by the scientific community that the ambient temperatures of the earth's air and oceans are increasing and will continue to increase into the foreseeable future. In the Pacific Northwest, a warming trend was documented during the 20th century and a continued rise in temperatures is predicted (National Assessment Synthesis Team 2000; Mote et al. 2003; Furniss et al. 2009). Although it is still uncertain how increased air and water temperatures will affect the climates in different parts of the world, especially at a local level, wetter winters are expected in the Pacific Northwest (Mote et al. 2003).

It has been suggested that overall warming will bring large changes in the snowline (Mote et al. 2003), with substantial reductions in the snowpack at lower elevations, causing the timing of the snowmelt to shift earlier into spring (Furniss et al. 2009). It has also been suggested that in higher elevation watersheds, mainly in the Sierra Nevada, the air temperature increases are resulting in rising snow lines, opening up larger areas of a given catchment to rainfall versus snowfall. Long term, this change could shift the flood regime and increase the frequency of flooding (California Climate Change Center 2009).

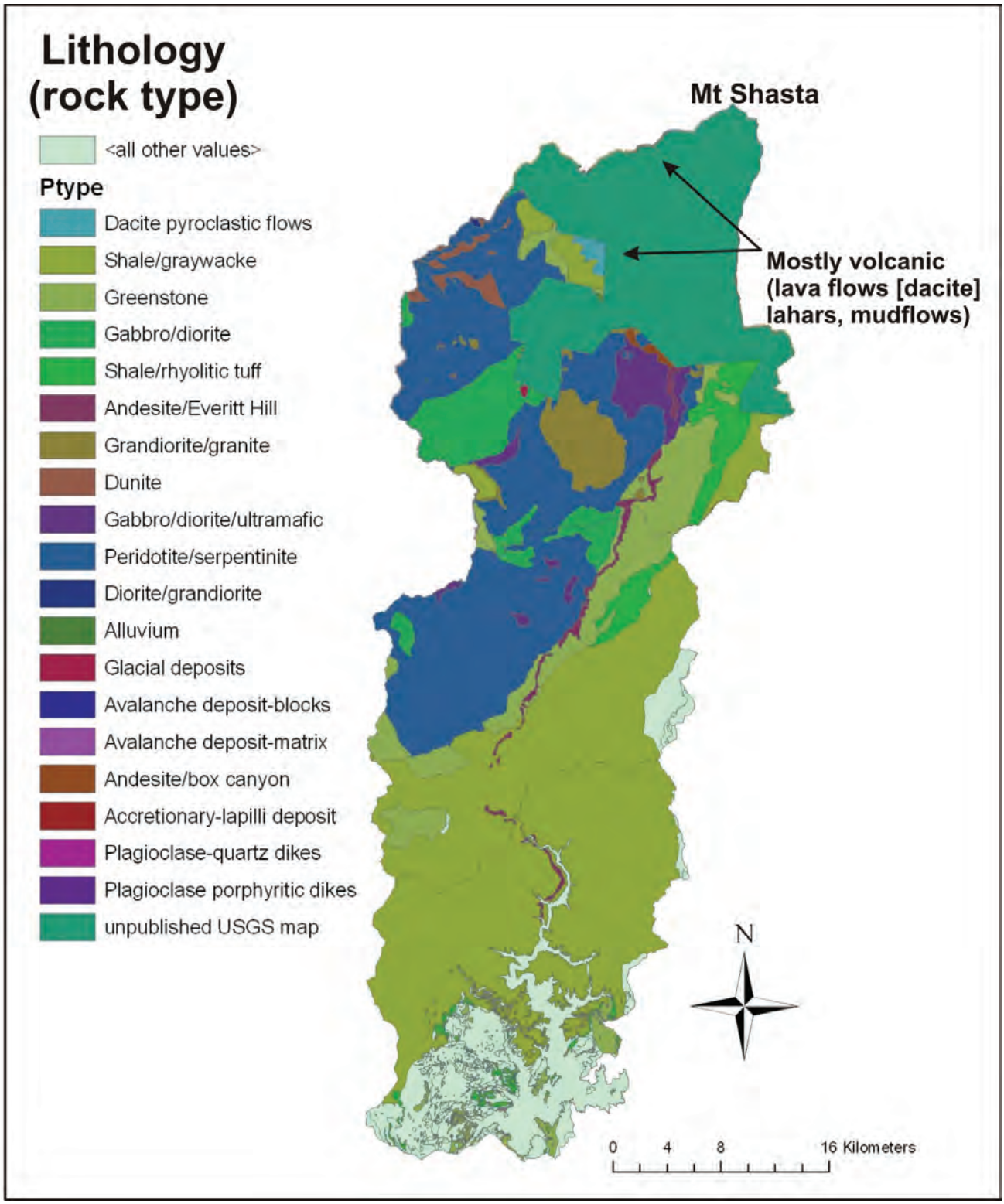
The upper Sacramento River watershed sits on the boundary between the climate of the Pacific Northwest and the Mediterranean climate of central California and is equally influenced by both climate zones. As a result, the effects of climate change may not fit regional predictions. Existing climate data at Mt. Shasta do not show any significant changes for at least the last 50 years. For this period, the average annual air temperature has not measurably increased.

3.2.3 Geology and Soils

The upper Sacramento River watershed is located principally within the Klamath Mountains and Cascade Geomorphic Provinces. The streams draining the assessment area cover a broad expanse of land with a widely diverse and complicated geology. A large portion of the area is underlain by rock units of the Klamath Mountains Province (Figure 3.2-8). This province has been divided into four belts separated by northwest trending faults caused by subduction along the margin between the Pacific and North American Plates. The assessment area covers portions of the eastern, central, and western belts (USDA Forest Service 1995).

Klamath Mountains rocks range in age from the Ordovician Period through the Jurassic Period, or 500 million years to 135 million years before present. The diverse assemblage of rock types in this province were formed as part of an island arc system and include a mix of marine sedimentary and volcanic rock types. Figure 3.2-8 illustrates this diversity in rock types upstream of Shasta Lake.

Metasedimentary rock units dominate the assessment area, including limestone units generally known as McCloud Limestone. The weathering characteristics of limestone have resulted in large areas in the southern portion of the assessment area where the rock has become exposed. Locally, small intrusions of igneous rocks can be found throughout the area, typically iron-rich ultramafics and silica-rich granitics (USDA Forest Service 1995). Within the metamorphic terrain, Castle Crags is a large granitic pluton that was intruded during the Jurassic Period around 65 million years ago. The higher elevations of all of these terrains were glaciated approximately 13,000 years ago, contributing



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Source: Shasta-Trinity National Forest

Figure 3.2-8
Distribution of Different Rock Types

to the formation of many cirque lakes such as Castle Lake, Gray Rock Lake, Timber Lake, and Little Castle Lake.

The northeastern portion of the assessment area is underlain by volcanic rocks of the Cascade Range and the Modoc Plateau. These volcanic rocks are generally younger than 4 million years old. The exposed rock units of the Cascades were deposited over millions of years by volcanic activity. Within this area, the rock units were produced by extrusive igneous activity of Mount Shasta and features associated with the underlying magma chamber. Volcanic debris was extruded above the surface of the earth and deposited on top of the rocks of the Klamath Mountains Geomorphic Province to the north and east. The volcanic deposits that blanket the northeastern portion of the watershed contribute to the rich topographic diversity of the area.

Within the watershed, the units of the Klamath Mountains Geomorphic Province and Cascade Range have been reworked by fluvial and glacial action over the past 1 million years. Alluvial, glacial, and mass wasting deposits are all exposed in the area. Glacial deposits are localized and concentrated in the areas surrounding Mount Shasta and the higher elevation areas along the western portion of the basin.

Large earthquakes are rare in the upper Sacramento River watershed because of the distance to the major fault zones associated with the San Andreas Fault and the Cascadia Subduction Zone of northern California. Only four earthquakes with a magnitude of five or greater have had an epicenter within 100 miles of the assessment area in the last 100 years (Northern California Earthquake Data Center 2008). However, the region has regularly experienced smaller earthquakes (between magnitude three and five). Additionally, there are many pre-Quaternary (inactive) faults located throughout the Klamath Mountains and within the watershed.

Mount Shasta (14,179 feet), the largest stratovolcano of the Cascade chain (217.5 cubic miles), is the dominant mountain landform located in the upper portion of the watershed. It consists of four overlapping volcanic cones that have built a complex shape, including the main summit and the prominent satellite cones of Shastina (12,330 feet). If Shastina were a separate mountain, it would rank as the third-highest peak of the Cascade Range. There are seven named glaciers on Mount Shasta; however, none of them drains into the upper Sacramento River.

About 600,000 years ago, andesitic lavas erupted on what is now Mount Shasta's western flank near McBride Spring in the watershed. Over time, an ancestral Shasta stratovolcano was built to a large but unknown height, and sometime between 300,000 to 360,000 years ago the entire north side of the volcano collapsed, creating an enormous landslide of 6.5 cubic miles in volume outside of the watershed.

Mount Shasta has erupted, on average, at least once per 800 years during the last 10,000 years and about once per 600 years during the last 4,500 years. The last known eruption occurred about 200 years ago. Eruptions during the last 10,000 years produced lava flows and domes on and around the flanks of Mount Shasta, and pyroclastic flows from summit and flank vents extended far from the summit. Most of these eruptions also produced large mudflows, many of which reached more than tens of kilometers (dozens of miles) from Mount Shasta. Future eruptions like those of the past could endanger the communities of Weed, Mt. Shasta, McCloud, and Dunsmuir, located at or near the base of Mount Shasta. Such eruptions will most likely produce deposits of lithic ash, lava flows, and

pyroclastic flows. Lava flows and pyroclastic flows may affect low- and flat-lying ground almost anywhere within approximately 12.4 miles of the summit of Mount Shasta, and mudflows may cover valley floors and other low areas as much as several tens of kilometers from the volcano. Based on its past behavior, Mount Shasta is not likely to erupt large volumes of pumiceous ash in the future. Areas subject to the greatest risk from air-fall tephra are located mainly east and within about 30 miles of the summit of the volcano. The degree of risk from air-fall tephra decreases progressively as the distance from the volcano increases.

Two of the main eruptive centers at Mount Shasta, the Shastina and Hotlum cones, were constructed during the Holocene (approximately the last 10,000 years). Holocene eruptions also occurred at Black Butte, a group of overlapping dacite domes about 8 miles west of Mount Shasta. Evidence of geologically recent eruptions at these two main vents and at flank vents forms the chief basis for assessing the most likely kinds of future eruptive activity and associated potential hazards.

In the last 8,000 years, the Hotlum Cone has erupted at least eight or nine times. About 200 years ago, the last significant Shasta eruption came from this cone and created a pyroclastic flow, a hot lahar (mudflow), and three cold lahars, which streamed 7.5 miles down Shasta's east flank via Ash Creek. A separate hot lahar went 12 miles down Mud Creek. This eruption was observed by the explorer La Perouse from his ship off the California coast in 1786.

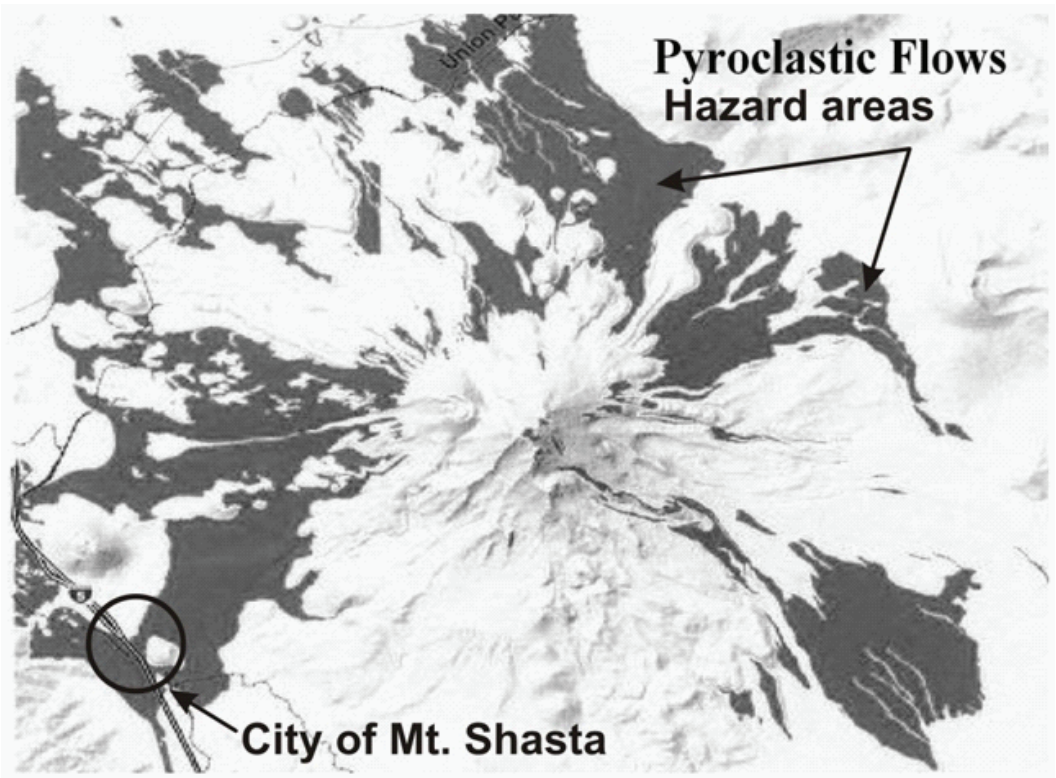
The U.S. Geological Survey (USGS) has analyzed the risk of future eruptions on the local population centers around the mountain, including the City of Mt. Shasta as well as Weed, Dunsmuir, and McCloud (Miller 1980). The main hazards are pyroclastic flows and mud flows (Figure 3.2-9). The majority of the City of Mt. Shasta is located within the predicted zone of pyroclastic flows.

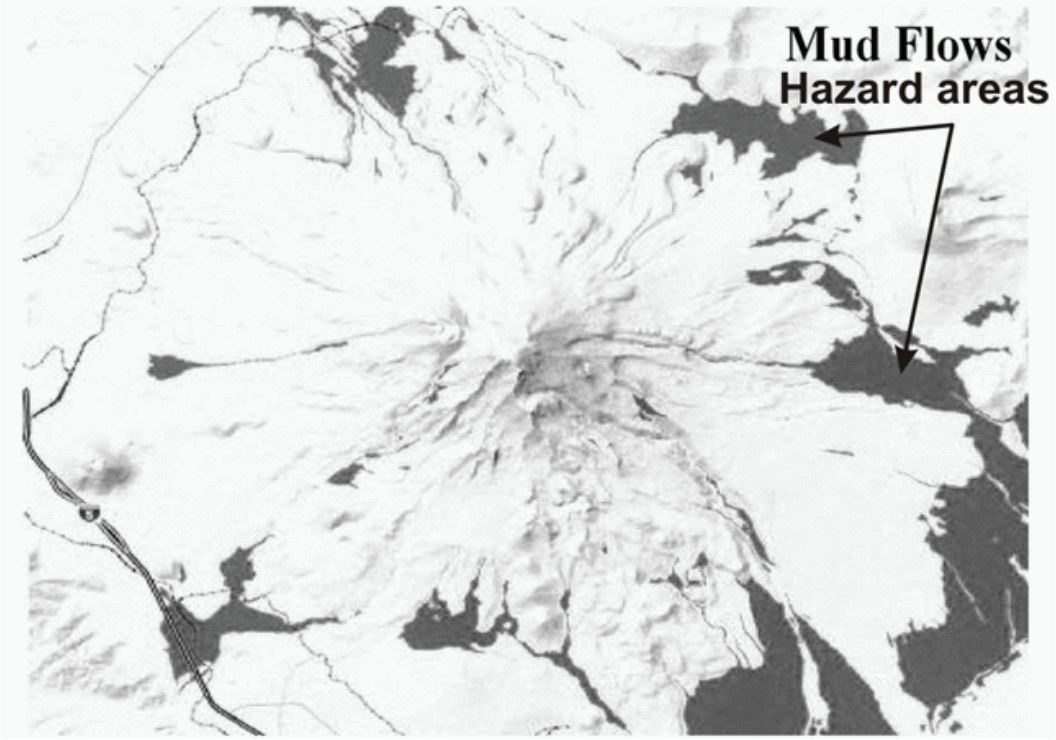
3.2.4 Mineral Resources

Within the assessment area, mineralized rock formations have been mined for several valuable minerals, including copper, gold, silver, and tungsten. Mining is permitted on all public lands not withdrawn from mineral entry, and the United States Mining Laws (30 U.S.C. 21-54) confer statutory right to enter upon public lands in search of minerals. Regulations found in 36 CFR 228, Subpart A, set forth rules and procedures to minimize adverse environmental impacts on National Forest resources. Access for mineral exploration and development is generally unrestricted, subject to the mitigation of adverse impacts to surface resources.

Access for mineral exploration on public lands is restricted in wildernesses, the "wild" portions of Wild and Scenic Rivers, botanical areas, Research Natural Areas (RNAs), National Recreation Areas (NRAs), and areas that have been withdrawn from mineral entry. Minerals in the NRA are not locatable (minerals that may be acquired under the Mining Law of 1872, as amended) but they are leasable (USDA Forest Service 1995).

Mineralized rock formations are relatively sparse in the upper watershed, whereas downstream areas are highly mineralized and are where major mining operations historically occurred. In the lower portion of the subbasin near Shasta Lake, the mining activities were focused on development of massive sulfide deposits. Similar to other areas in the Klamath Mountains Geomorphic Province, copper was the most commonly found metal. Zinc, sulfur, iron, limestone, gold, and silver were produced as by-products of copper production. Once disturbed by mining activities, these types of





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Source: United States Geological Survey

Figure 3.2-9
Mud and Pyroclastic Flow Hazard Areas
Mt. Shasta Area

mineral deposits are a known source of toxic mine waste and acidic fluids to the Sacramento River (United States Department of Agriculture 2000). Other sources found within the upper Sacramento River consist of alluvial sand and gravel, crushed stone, volcanic cinders, limestone, and diatomite.

Most mining within the assessment area ceased prior to 1945. The Golinsky Mine is located in the assessment area about 7 miles west of Shasta Dam in the headwaters of Little Backbone Creek. This abandoned mine complex is very large and has been extensively remediated. The Mammoth and Sutro Mines are of notable size and are located within the assessment area.

3.2.5 Soils

Climate, geology, topography, and other factors determine soil characteristics. Soil productivity is defined as the capacity of the soil to produce a plant community or sequence of plant communities under a specified system of management. The factors that influence the productivity of soil are soil depth, percent of rock fragments, texture, available water-holding capacity, nutrient status, maintenance of the duff layer, mineral toxicity, and pH. Other environmental factors that influence soil productivity are precipitation, aspect, slope gradient, and elevation. The productivity of the soil types in the STNF ranges from very low to high (USDA Forest Service 1995 (Figure 3.2-10). Within the assessment area, the most productive soils occur in flat valley bottoms.

Soils in most of the assessment area have been mapped; however, approximately 21 square miles of the area, mainly near the City of Mt. Shasta, has not been mapped. Soils of low productivity comprise about half of the assessment area, soils of moderate productivity comprise about 30 percent of the area, and soils of high productivity comprise about 20 percent of the area.

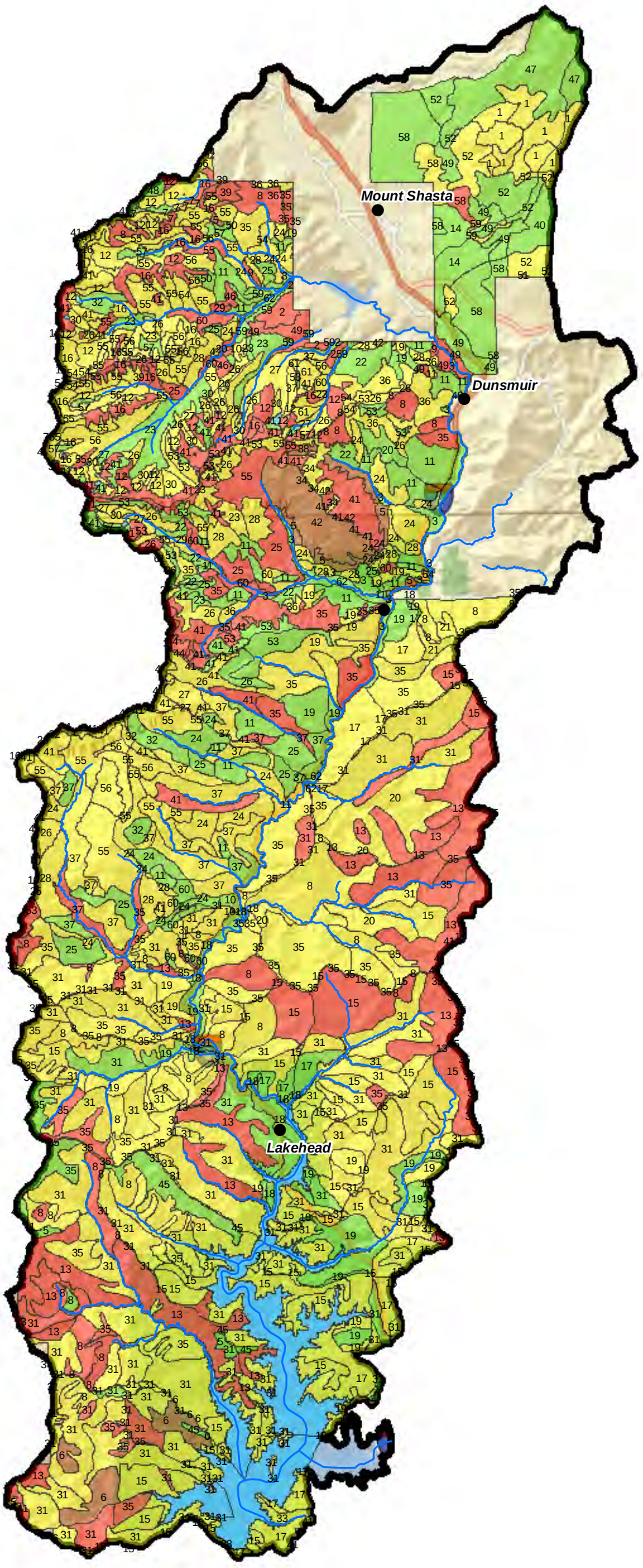
Approximately 25 percent of the soils in the assessment area are classified as highly to very highly erodible. The greatest threats to the maintenance of soil productivity are sheet and gully erosion. Nearly all bare soil is subject to erosion if a sufficient amount of surface water flow is present. Some soils have a higher propensity to erode than others do. Examples of highly erodible soils in the study area are Estel Family, Neuns Family, Goulding Family, and Deadwood Family (Table 3.2-5).

The Soil Survey of the Shasta-Trinity National Forest, California (U.S. Department of Agriculture 1983) identifies 62 soil map units in the assessment area (Figure 3.2-10). The most common soil families are Marpa, Nuens, Goulding, and Estel. These four families are well drained and are of fine loamy-loamy/skeletal mixed composition. The taxonomy characterizing these soils is Ultic Haploxeralfs. Except for Nuens, they also have medium to high erosion severity as defined by the erosion hazard rating (EHR).

Geomorphology

The geomorphic expression of the upper Sacramento River subbasin is controlled by the bedrock geology as expressed in topographic features, including the type, rate, and magnitude of erosional processes. The soils developed from the underlying parent material have distinct and characteristic properties that can affect vegetation patterns and disturbance mechanisms at multiple spatial and temporal scales.

Label	Soil Type
1	Andic Cryumbrepts
2	Asta Family
3	Atter Family
4	Beaughton Family
5	Chaix Family
6	Chawanakee Family
7	Deadfall Family
8	Deadwood Family
9	Dubakella
10	Dubakella Family
11	Dunsmuir Family
12	Endlich Family
13	Etsel Family
14	Germany Family
15	Goulding Family
16	Gozem Family
17	Holland Family
18	Holland Family, ashy
19	Holland Family, deep
20	Hugo Family
21	Hugo Family, moderately deep
22	Huntmount Family
23	Inville Family
24	Ishi Pishi Family
25	Ishi Pishi Family, deep
26	Jayar Family
27	Jayar Family, deep
28	Konocti Family
29	Lithic Haploxeralfs
30	Lithic Xerumbrepts
31	Marpa Family
32	Merkel Family
33	Millsholm Family
34	Nanny Family
35	Neuns Family
36	Neuns Family, deep
37	Olete Family
38	Ovall Family
39	Parks Family
40	Revit Family
41	Rock Outcrop
42	Rock Outcrop, granitic
43	Rock Outcrop, limestone
44	Rock Outcrop, metamorphic
45	Rock Outcrop, sedimentary
46	Rock Outcrop, ultramafic
47	Rock Outcrop, volcanic
48	Rubble Land
49	Sadie Family, deep
50	Shadeleaf Family
51	Shasta Family
52	Sheld Family
53	Skymor Family
54	Tamflat Family
55	Toadlake Family
56	Toadlake Family, till substratum
57	Typic Cryaquolls
58	Washougal Family
59	Washougal Family, deep
60	Weitchpec Family
61	Wintoner Family
62	Xerofluvents



Watershed Boundary
Perennial Stream
Soil Type

Maximum Erosion Hazard Rating

- Very High
- High
- Medium
- Low
- Waterbody

N

0 2 4 8

Miles

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North State Resources, Inc.

Upper Sacramento River Project

Figure 3.2-10
Soil Type and Erodeability Map

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Table 3.2-5. Soil Types by Erosion Severity in the Upper Sacramento River Subbasin Ranked in Descending Order by Percent of Total Assessment Area

SOIL NAME	LOW EHR	MED EHR	HIGH EHR	VERY HIGH EHR	NOT MAPPED
Etsel Family	0%	0%	30%	0%	0%
Neuns Family	2%	10%	11%	0%	0%
Rock Outcrop	2%	1%	11%	0%	0%
Goulding Family	0%	8%	10%	0%	0%
Deadwood Family	0%	6%	9%	0%	0%
Marpa Family	5%	29%	5%	0%	0%
Gozem Family	0%	1%	4%	0%	0%
Toadlake Family	0%	7%	3%	0%	0%
Ishi Pishi Family, deep	5%	0%	3%	0%	0%
Endlich Family	0%	2%	2%	0%	0%
Sadie Family, deep	3%	0%	2%	0%	0%
Weitchpec Family	1%	0%	2%	0%	0%
Olete Family	2%	4%	2%	0%	0%
Asta Family	0%	0%	1%	0%	0%
Skymor Family	4%	0%	1%	0%	0%
Parks Family	0%	0%	1%	0%	0%
Washougal Family	8%	0%	1%	0%	0%
Rock Outcrop, metamorphic	0%	0%	1%	0%	0%
Rock Outcrop, ultramafic	0%	0%	1%	0%	0%
Hugo Family	1%	3%	0%	0%	0%
Lithic Haploxeralfs	0%	0%	0%	0%	0%
Dubakella	0%	0%	0%	0%	0%
Jayar Family	1%	3%	0%	0%	0%
Deadfall Family	0%	0%	0%	0%	0%
Rock Outcrop, limestone	0%	0%	0%	0%	0%
Andic Cryumbrepts	0%	2%	0%	0%	0%
Atter Family	3%	0%	0%	0%	0%
Beaughton Family	0%	0%	0%	0%	0%
Chaix Family	0%	0%	0%	18%	0%
Chawanakee Family	0%	0%	0%	32%	0%
Dubakella Family	0%	0%	0%	0%	0%
Dunsmuir Family	11%	0%	0%	0%	0%
Germany Family	3%	0%	0%	0%	0%
Holland Family	2%	4%	0%	0%	0%
Holland Family, ashy	3%	0%	0%	0%	0%
Holland Family, deep	10%	3%	0%	0%	0%
Hugo Family, moderately deep	0%	0%	0%	0%	0%
Huntmount Family	3%	0%	0%	0%	0%
Inville Family	5%	0%	0%	0%	0%
Ishi Pishi Family	3%	3%	0%	0%	0%
Jayar Family, deep	0%	1%	0%	0%	0%
Konocti Family	0%	2%	0%	0%	0%
Lithic Xerumbrepts	0%	1%	0%	0%	0%
Merkel Family	2%	0%	0%	0%	0%
Millsholm Family	0%	0%	0%	0%	0%
Nanny Family	0%	0%	0%	0%	0%
Neuns Family, deep	0%	2%	0%	0%	0%
Ovall Family	0%	0%	0%	2%	0%
Revit Family	2%	0%	0%	0%	0%

Table 3.2-5. Soil Types by Erosion Severity in the Upper Sacramento River Subbasin Ranked in Descending Order by Percent of Total Assessment Area

SOIL NAME	LOW EHR	MED EHR	HIGH EHR	VERY HIGH EHR	NOT MAPPED
Rock Outcrop, granitic	0%	0%	0%	47%	0%
Rock Outcrop, sedimentary	3%	0%	0%	0%	0%
Rock Outcrop, volcanic	8%	0%	0%	0%	0%
Rubble Land	1%	0%	0%	0%	0%
Shadeleaf Family	0%	0%	0%	0%	0%
Shasta Family	0%	0%	0%	0%	0%
Sheld Family	3%	1%	0%	0%	0%
Tamflat Family	0%	0%	0%	0%	0%
Toadlake Family, till substratum	0%	2%	0%	0%	0%
Typic Cryaquolls	1%	0%	0%	0%	0%
Washougal Family, deep	1%	0%	0%	0%	0%
Wintoner Family	0%	0%	0%	0%	0%
Xerofluvents	1%	0%	0%	0%	0%

HER = Erosion hazard rating

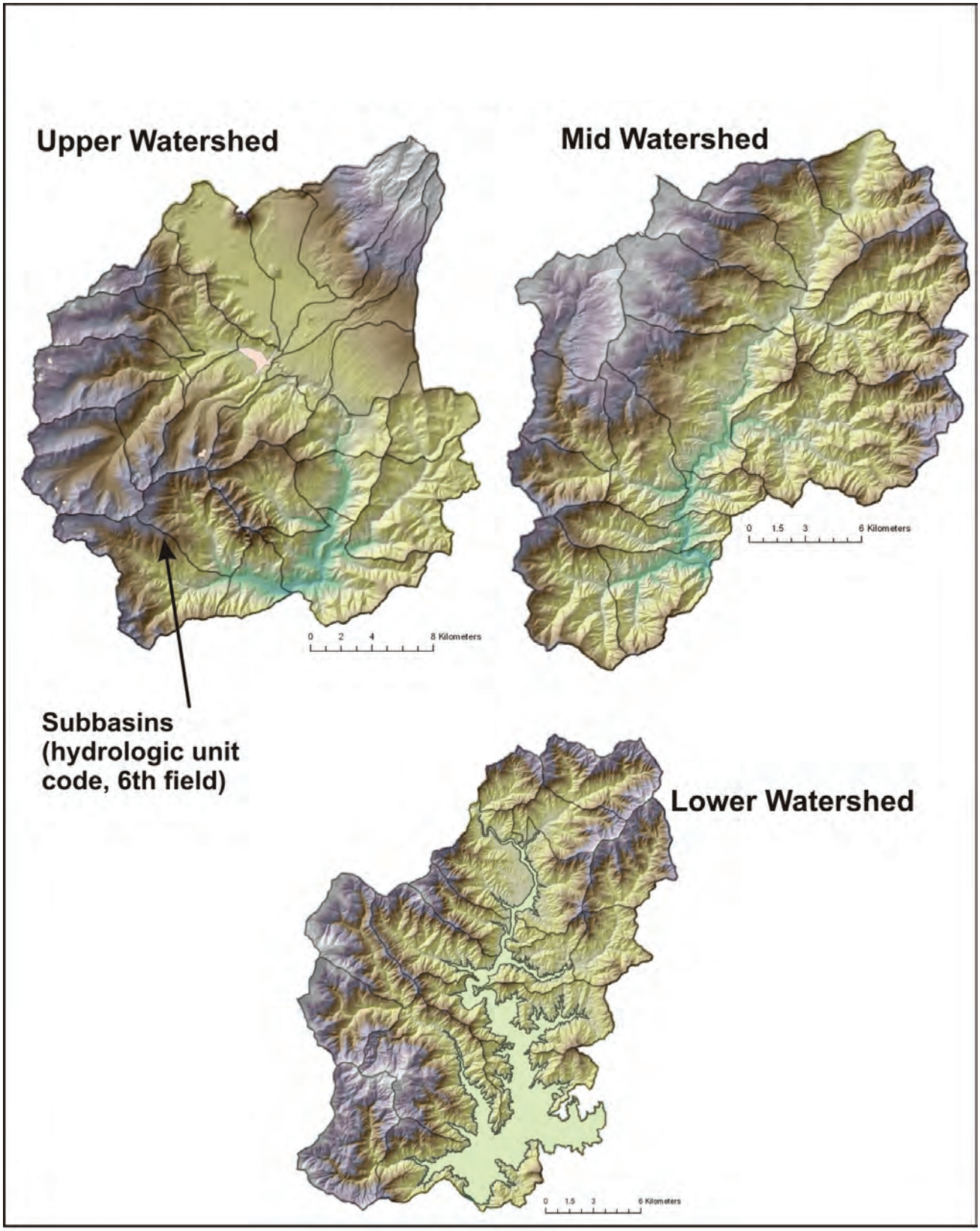
The geomorphic expression of the area was characterized using NetMap, an automated watershed analysis tool. The NetMap system used for the upper Sacramento River subbasin provides a unique capability for this assessment. The analytical tool kit that is part of NetMap allows detailed investigations into the physical attributes of the watershed that can inform pre- and post-wildfire management (see Chapter 4), forestry, road maintenance, habitat restoration, and monitoring. Such watershed analysis assessments pertinent to natural resource management can continue to be conducted by interested stakeholders following the original assessment described herein.

To characterize the geomorphic types (i.e., landforms) within the assessment area, the subbasin was divided into three watersheds for NetMap analyses (Figure 3.2-11). Each of the three watersheds is further divided into Hydrologic Unit Code (HUC) 6th field subwatersheds (5,000–10,000 acres); these three watersheds are used as part of the analysis to classify various watershed attributes. The subwatersheds are included to show the distribution of attributes with each of the three watersheds..

Hillslope Conditions and Processes

Hillslope conditions and processes, or the hillslope geomorphology of the watershed, strongly influence the environmental conditions that occur there, including the susceptibility of the land to erosion, including following wildfires; the supply of sediment to streams and rivers; and the types of aquatic habitats that form in tributaries and in the Sacramento River.

The focus of this section is on the topographic conditions important for surface and fluvial erosion, landslides, and instream sediment supply and storage attributes. Within this framework, the effects of the Box Canyon Dam and Lake Siskiyou on the downstream sediment supply of the Sacramento River will also be assessed.



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Source: NetMap (GIS) Databases (www.netmaptools.org)

Figure 3.2-11
Upper Sacramento River Watersheds

Hillslope Gradient and Form: Generic Erosion Potential

Hillslope gradient fundamentally controls erosion type and magnitude (Dunne and Leopold 1978). For instance, in mountain environments, the highest density of shallow failures due to heavy precipitation occurs on slopes in excess of approximately 35 degrees (> 72 percent) (Dragovich et al. 1993). Hillslope gradient is also a factor in controlling the location of surface and gully erosion that often occurs following fire in semi-arid landscapes; erosion is generally more intense on steeper slopes that are convergent (Istanbulluoglu et al. 2003). Surface erosion can also occur on more gentle terrain, although its magnitude is directly proportional to slope gradient (Elliot et al. 2000).

The morphological form of hillslopes that is related to erosion is often classified into several types, including convergent, divergent, and planar. Divergent and planar slopes typically do not concentrate overland flow. Convergent areas, also referred to as swales, focus the transport of sediment and water. Over time (centuries), soil creep causes soils to thicken in convergent areas, making them more susceptible to landsliding (Dietrich and Dunne 1978). During storms, convergent areas focus shallow subsurface flow, thereby increasing saturation and making them more susceptible to failures. Convergent areas also concentrate overland flow, making them focal areas for gully development, particularly on bare or denuded hillslopes. Steep convergent areas are commonly an initiation point for debris flows in headwater streams (Dietrich and Dunne 1978).

To estimate the intrinsic hillslope erosion potential in the watershed, NetMap generates maps of hillslope gradient combined with curvature, expressed as:

$$(A_L * S)/b$$

where:

b is a measure of local topographic convergence (the length of an elevation contour crossed by flow out of the pixel, values less than one pixel length indicate convergent topography)

$\boldsymbol{A_L}$ is a measure of local contributing area (within one pixel length)

S is slope gradient (Miller and Burnett 2007a).

This gradient-slope convergent parameter is defined as generic erosion potential (GEP) in NetMap.

The GEP equation can be applied to any landscape with steep and convergent topography since such landscapes are preferential locations for erosion. In the assessment area, steep and convergent landforms above 5,500 feet have less erosion potential due to gradual spring snowmelt runoff rather than intense rainfall. The GEP equation does not address other important erosion processes, such as deep-seated rotational failures and earthflows.

The scale of this assessment dictates that the GEP be used as a coarse-level screening for erosion potential. The modeled potential for concentrated surface or gully erosion, as indicated by the GEP, is highly variable across the watershed (Figure 3.2-12). Very high values of GEP, indicating a high potential for bare surface erosion or gullies (in convergent areas), are relatively uncommon.

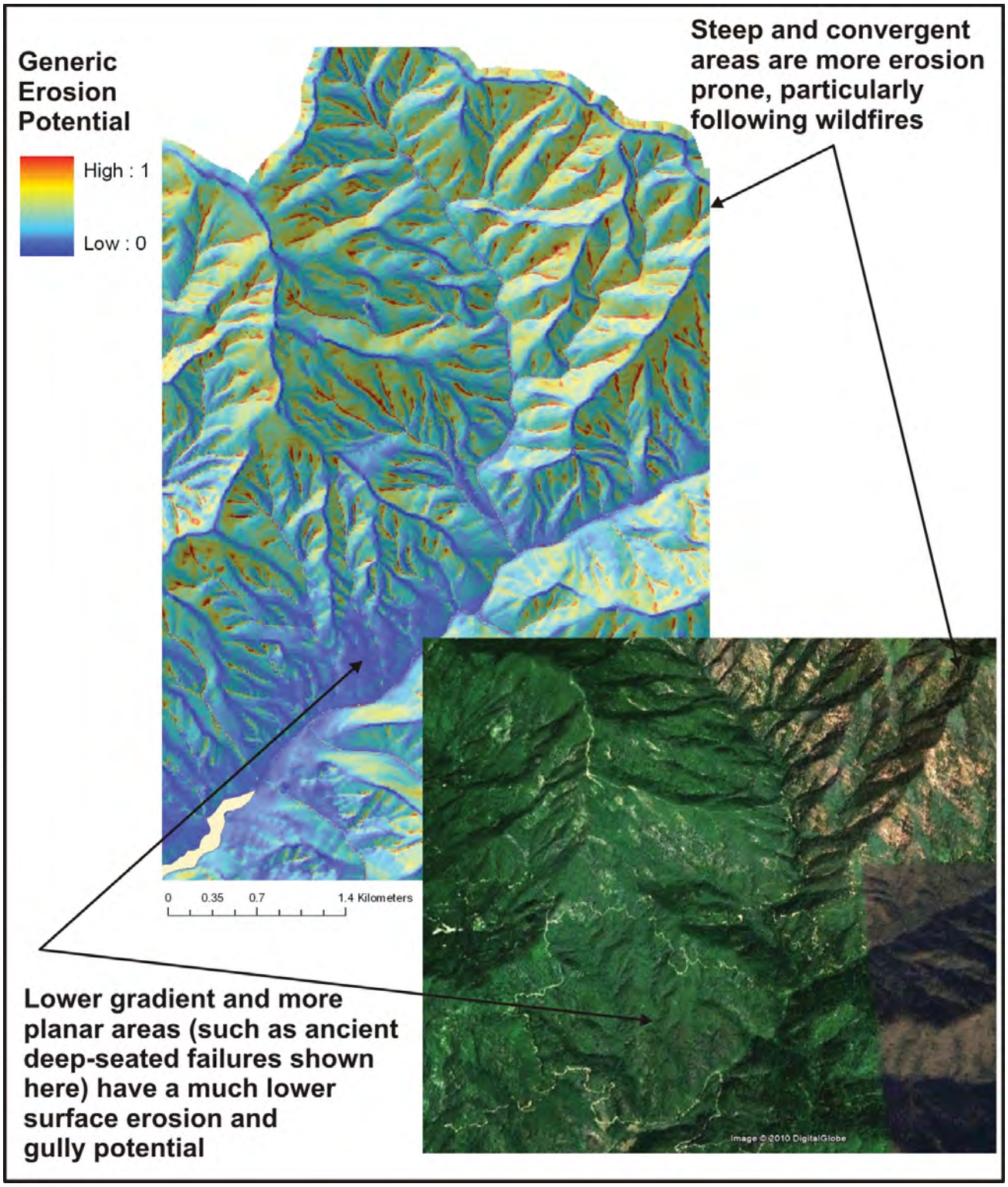

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Figure 3.2-12
Modeled Generic Erosion Potential
(Modeled results not field verified.)

The three watersheds of the upper Sacramento River watershed show marked differences in the spatial distribution of GEP (Figure 3.2-13). The lowest modeled GEP values (per HUC 6th field subbasin) occur in the northern portion of the watershed and the highest values occur south of Castle Crags. The spatial pattern of hillslope gradient and convergence, represented by GEP, appears to be driven largely by rock type. The mechanically strong igneous and plutonic rocks located in the mid to northern portion of the watershed (exclusive of the Mount Shasta, Shastina, and Black Butte volcanic area) are composed of peridotite, greenstone, and granite/granodiorite. Hard rocks of this lithology are more erosion resistant and could promote less headwater channel incision, and, thus, overall lower gradient hillslopes (Figure 3.2-14). Lower gradient hillslopes cause less mass wasting and gullying and, thus, less topographic convergence (in unchanneled, hillslope areas). The reverse is true in the landscape south of Castle Crags, where hillslope gradients become steeper and where greater channel dissection has led to greater topographic convergence and higher modeled GEP ratings (Figure 3.2-14). Additionally, the occurrence of alpine glaciation in the upper elevation areas along the western portion of the study watershed would also presumably lead to smoother, less convergent topography (and lower GEP ratings).

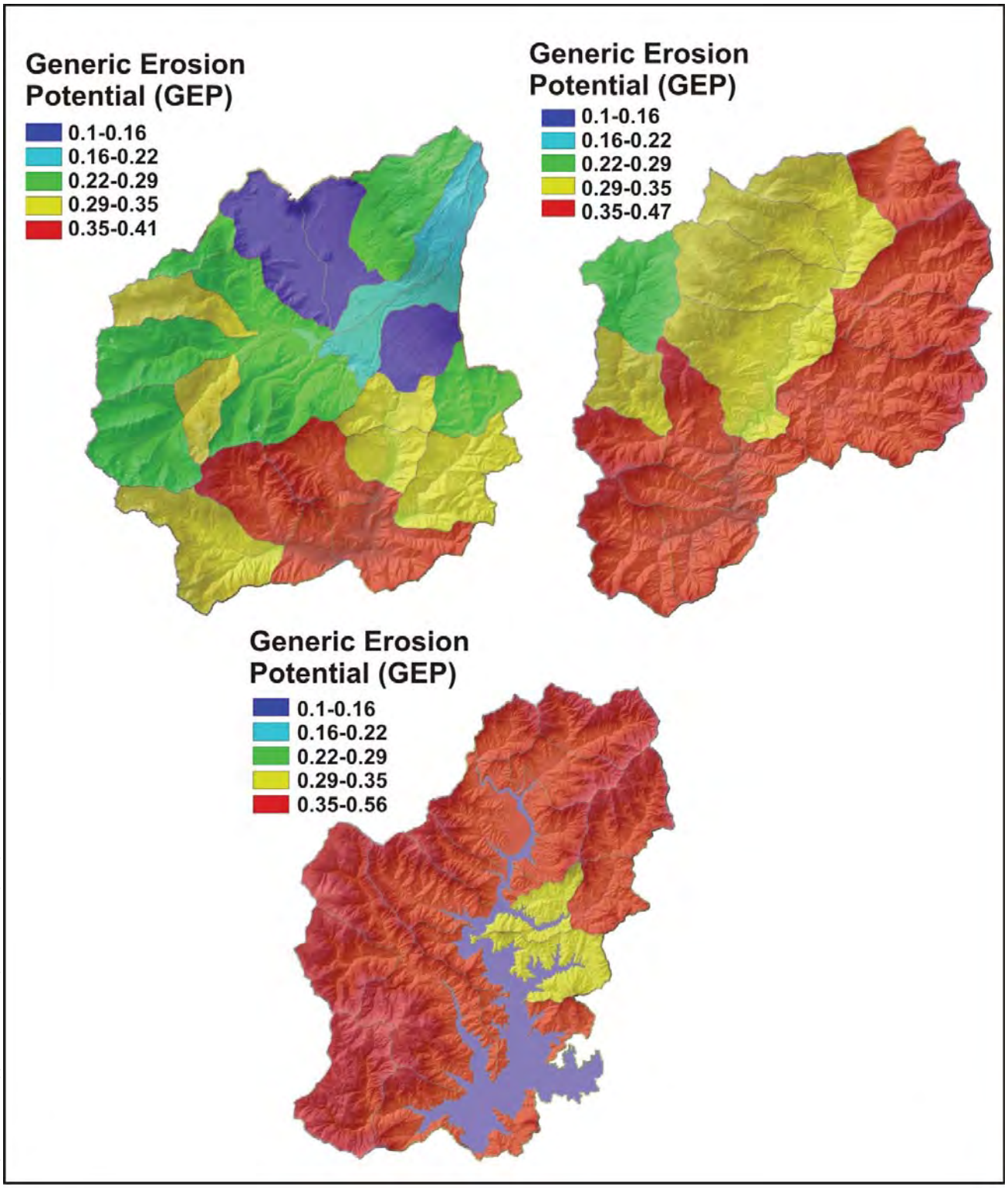
Hillslope Gradient and Form: Shallow Landslide Potential

GEP provides a universal index for predicting the likelihood of surface erosion, gullying, and shallow landsliding. A more focused prediction for shallow landsliding (specifically) is applied to the watershed.

There are a variety of models available to predict shallow landslides (Sidle 1987, Montgomery and Dietrich 1994, Pack et al. 1998). Most models require information on hillslope topography, including gradients and some measure of topographic convergence. In NetMap, the GEP described in the previous section was calibrated using digitized landslide inventories from the Oregon Coast Range (Robison et al. 1999), from which landslide density (e.g., number of landslides per unit area, or area of landslides per unit area) was determined as a function of topographic and vegetation attributes (Miller and Burnett 2007a). Shallow landslide susceptibility in the watershed is predicted in the context of mature forest cover (e.g., not in devegetated conditions following fire). Calculations are made at the resolution of the 10-meter DEM, which for available USGS-provided data, reflects 40-foot contours mapped at 1:24,000 scale. In areas outside of the calibration landscape, the shallow landslide potential parameter is best used as a relative index (high–low).

Topographic information provided by 1:24,000 scale mapping does not resolve all topographic features pertinent to landslide locations (Benda and Dunne 1997). For instance, the landslide model does not account for small streamside failures (often referred to as inner gorge landslides) because of the inability of 10-meter DEMs to resolve low-relief landforms. Mapped landslide potential may not resolve all small convergent areas, which is important to site-specific assessments. However, mapped landslide potential resolves topographic controls over larger areas, such as the relative risk between different first-order basins or between larger watersheds.

The modeled shallow landslide potential for the subbasin reveals that there is large spatial variability across the three watersheds (Figure 3.2-15 and Figure 3.2-16). The areas predicted to have frequent shallow landslides tend to be in steep and convergent topography with frequent rainfall runoff rather than snowfall (Figure 3.2-15). This type of landform is relatively common in the lower and middle watersheds and along the I-5 corridor (Figure 3.2-16. The shallow landslide predictions were not



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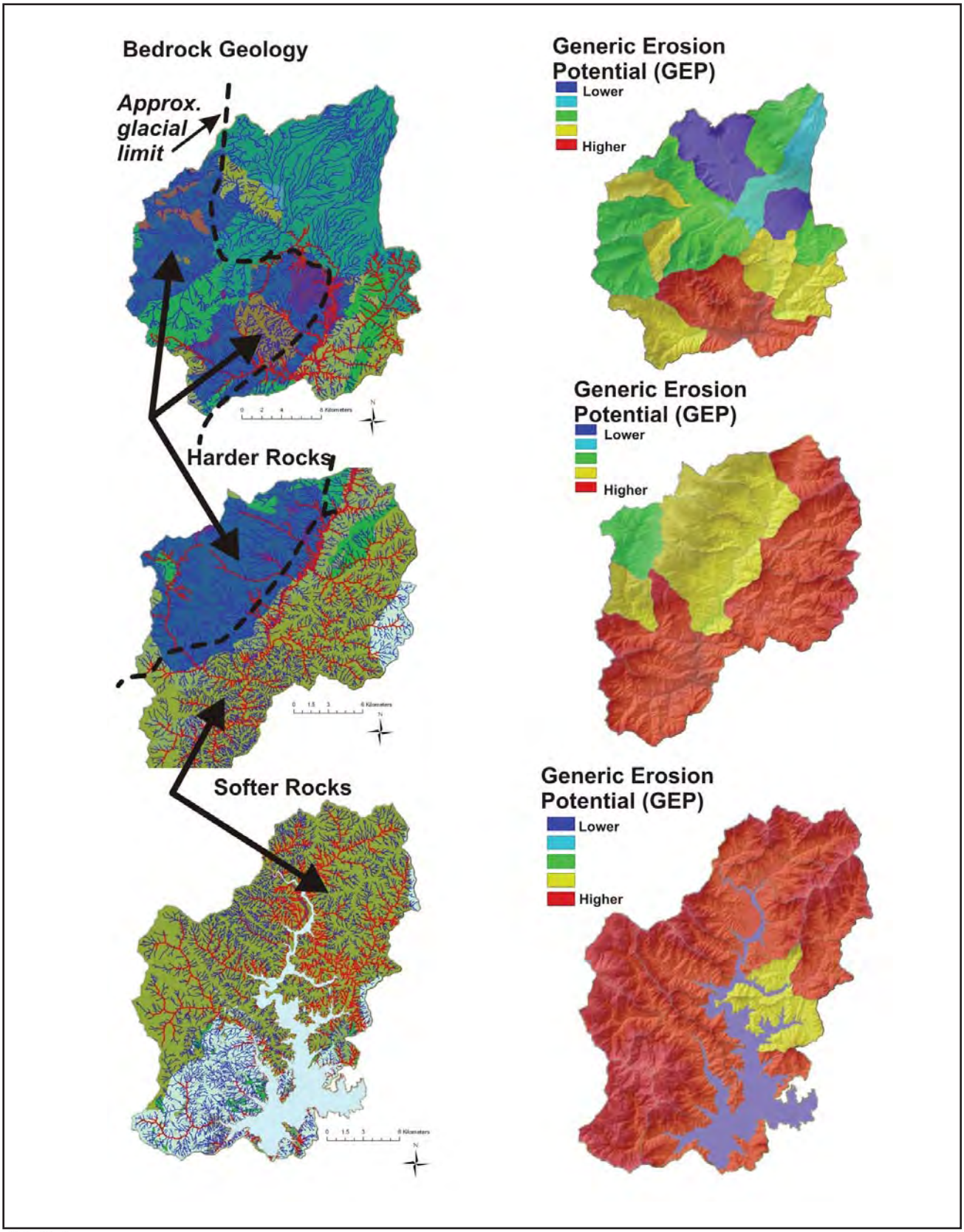
Source: NetMap (GIS) Databases (www.netmaptools.org)

Figure 3.2-13
Modeled Generic Erosion Potential
Upper Sacramento River Watersheds
(Modeled results not field verified.)



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Source: NetMap (GIS) Databases (www.netmaptools.org)
The subbasin classification of average GEP (right hand panel) is compared to the corresponding lithology (left panel). The lowest GEP values correspond to the harder igneous rocks and the zone impacted by alpine glaciation during the Pleistocene Epoch. The highest erosion potential corresponds to the mechanically weaker sedimentary rocks in the mid to southern subwatersheds.

Figure 3.2-14
Modeled Generic Erosion Potential Compared to Bedrock Geology
(Modeled results not field verified.)

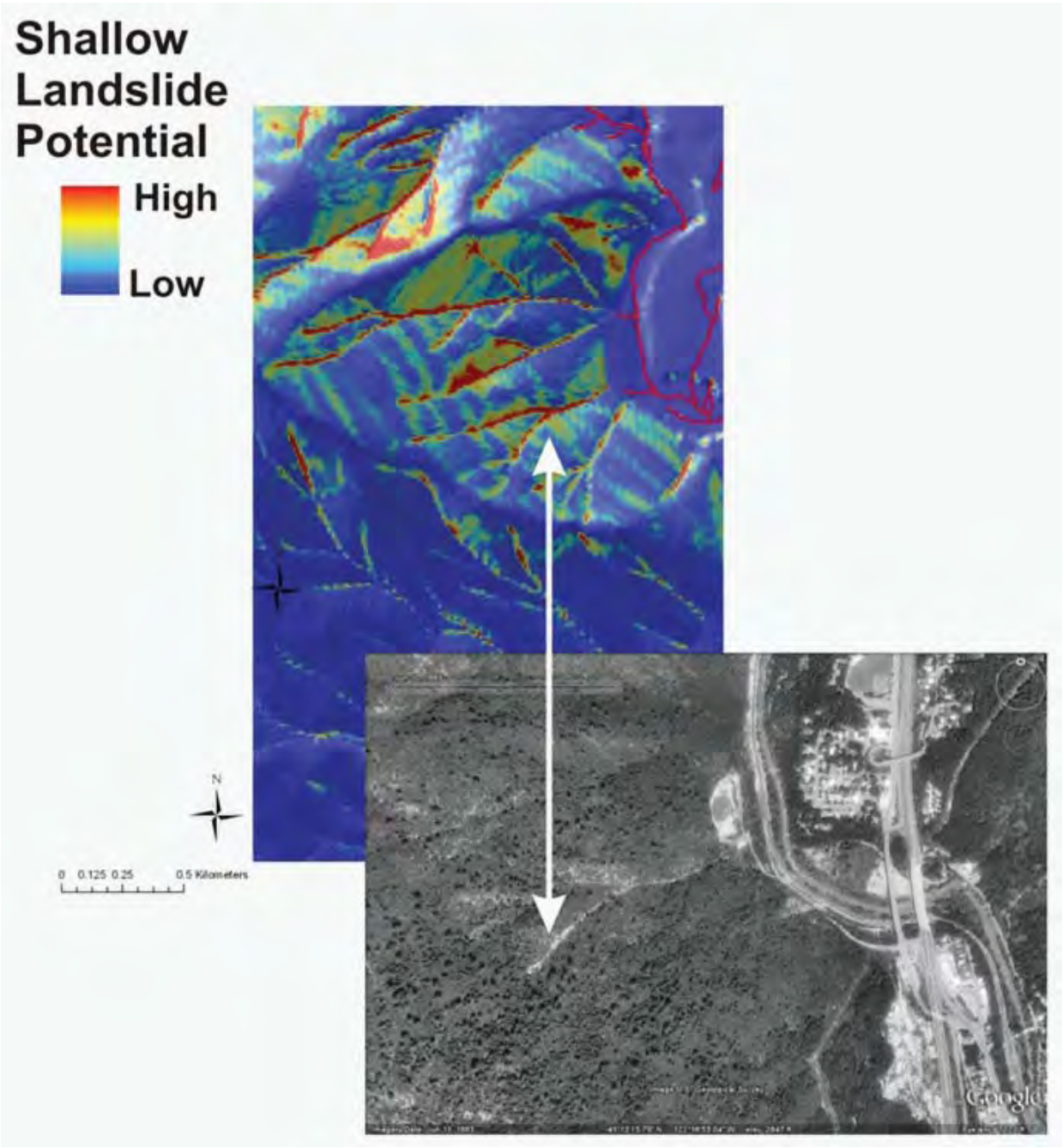

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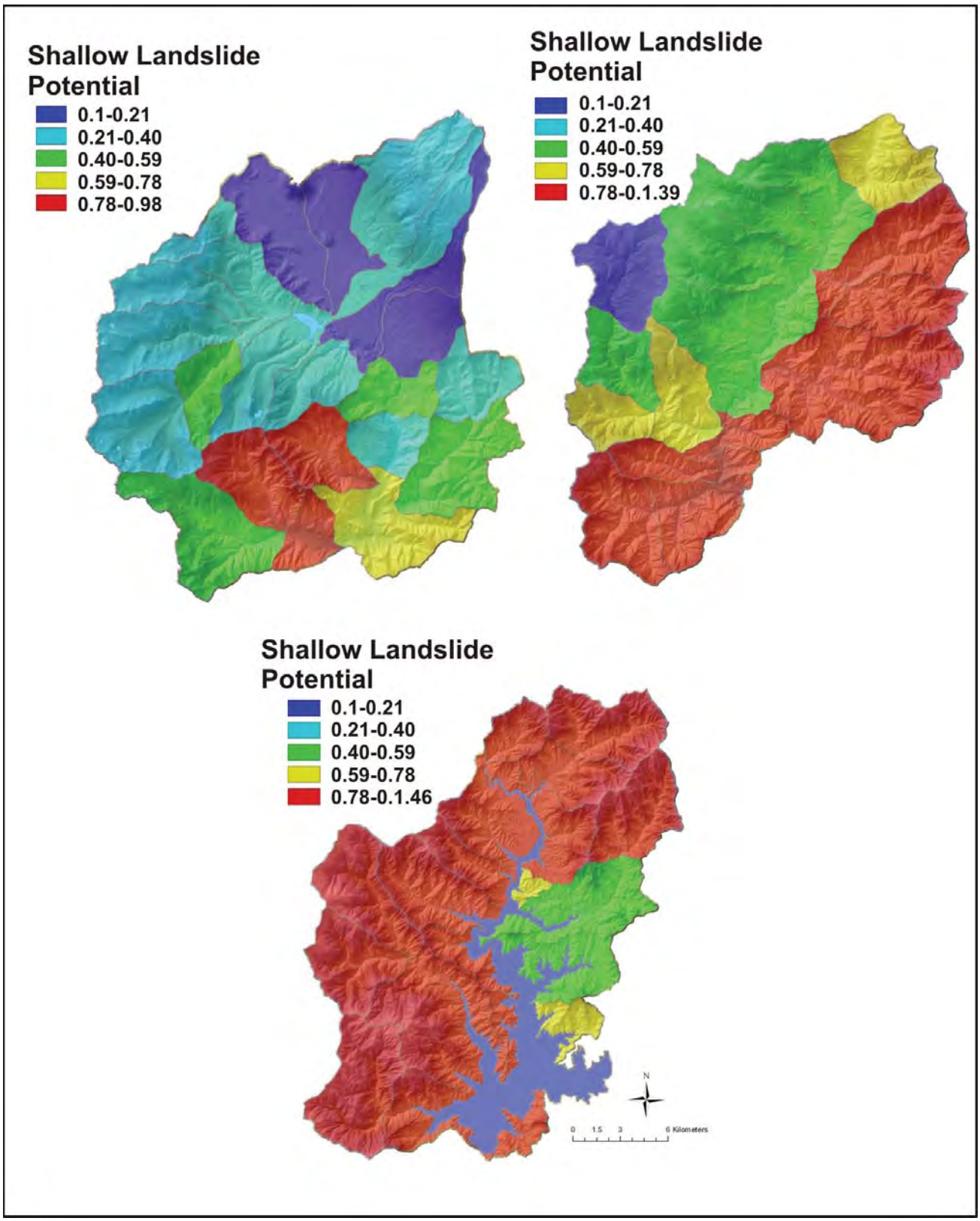
Figure 3.2-15
Modeled Shallow Landslide Potential in Steep and Convergent Areas
(Modeled results not field verified.)



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Source: NetMap (GIS) Databases (www.netmaptools.org)

Figure 3.2-16
Modeled Shallow Landslide Potential
Upper Sacramento River Watersheds
(Modeled results not field verified.)

verified in the field. However, a small amount of aerial photograph verification occurred as part of the assessment. Figure 3.2-15 compares the modeled shallow landslide potential and an active shallow landslide (from 2009 Google Earth image) for the same area. The location of this shallow failure corresponds to the area predicted to have high failure potential. The maps of predicted landslide susceptibility reveal an overall low density of unstable zones (particularly in the northern portion of the subbasin (Figure 3.2-16). The lowest potential for shallow landslides occurs in the northernmost section of the assessment area, and landslide potential increases down valley (Figure 3.2-16). This pattern appears to be driven, in part, by the precipitation patterns and harder rock types (igneous) in the northern areas and mechanically weaker (sedimentary) rocks in the mid to lower watersheds. A contributing factor in smoothing the landscape (lowering hillslope gradients and reducing hillslope roughness [swales or convergent areas]) is likely alpine glaciation during the Pleistocene (e.g., Figure 3.2-14, left panel).

In addition to topographic drivers, climate is a major driving factor in shallow landslide initiation. For example, extended periods of antecedent rainfall (weeks) followed by short periods (hours to days) of high precipitation intensity (often in the absence of snowfall) favors shallow landsliding in more humid, temperate climate zones along coastal regions (Sidle et al. 1985). This type of climate is not found in the upper portion of the subbasin, where snow is common in the uplands and long periods of low to moderate rainfall are rare (see Section 3.2.2, *Climate Change*). However, the middle and lower portions of the subbasin experience frequent and very intense rainfall, where the 2-year, 24-hour rainfall is over 4 inches, making these areas more landslide prone.

Landslide predictions at the scale of the entire watershed can be used as a coarse level screen to focus subsequent field investigations in the contexts of pre-fire and post-fire management planning and forestry activities (see Chapter 5).

Hillslope-Channel Connectivity: Sediment Delivery Potential

Hillslope-channel connectivity refers to the hydrologic (surface flow) connection between hillsides and stream channels. Hillslopes that are steeper and hence more erosion prone and that are in close proximity to stream channels, such as in headwater environments, should have a high "connectivity" (Figure 3.2-17). In contrast, rivers surrounded by large floodplains, channels in wide valleys, or streams coupled to hillsides of low erosion potential should have a lower connectivity.

NetMap contains a tool for calculating hillslope-channel connectivity or the potential for sediment delivery. An index of hillslope-channel connectivity is calculated by dividing the cumulative hillslope GEP (along the hillslope that drains directly into discreet channel segments [channel segment scale in NetMap is between 109 and 219 yards) by a channel confinement parameter (defined by valley width divided by channel width, Figure 3.2-17).

The coupling of channels to hillslopes, or the potential for sediment delivery (given an erosion event, particularly one that occurs independently of a stream channel [e.g., bank erosion or debris flows]), is predicted to be highly variable across the watershed. In general, modeled hillslope-channel connectivity is lower in the northern portion of the watershed and increases in the eastern and southern areas in conjunction with the steeper and more highly dissected landscapes found in those locations (Figure 3.2-18).

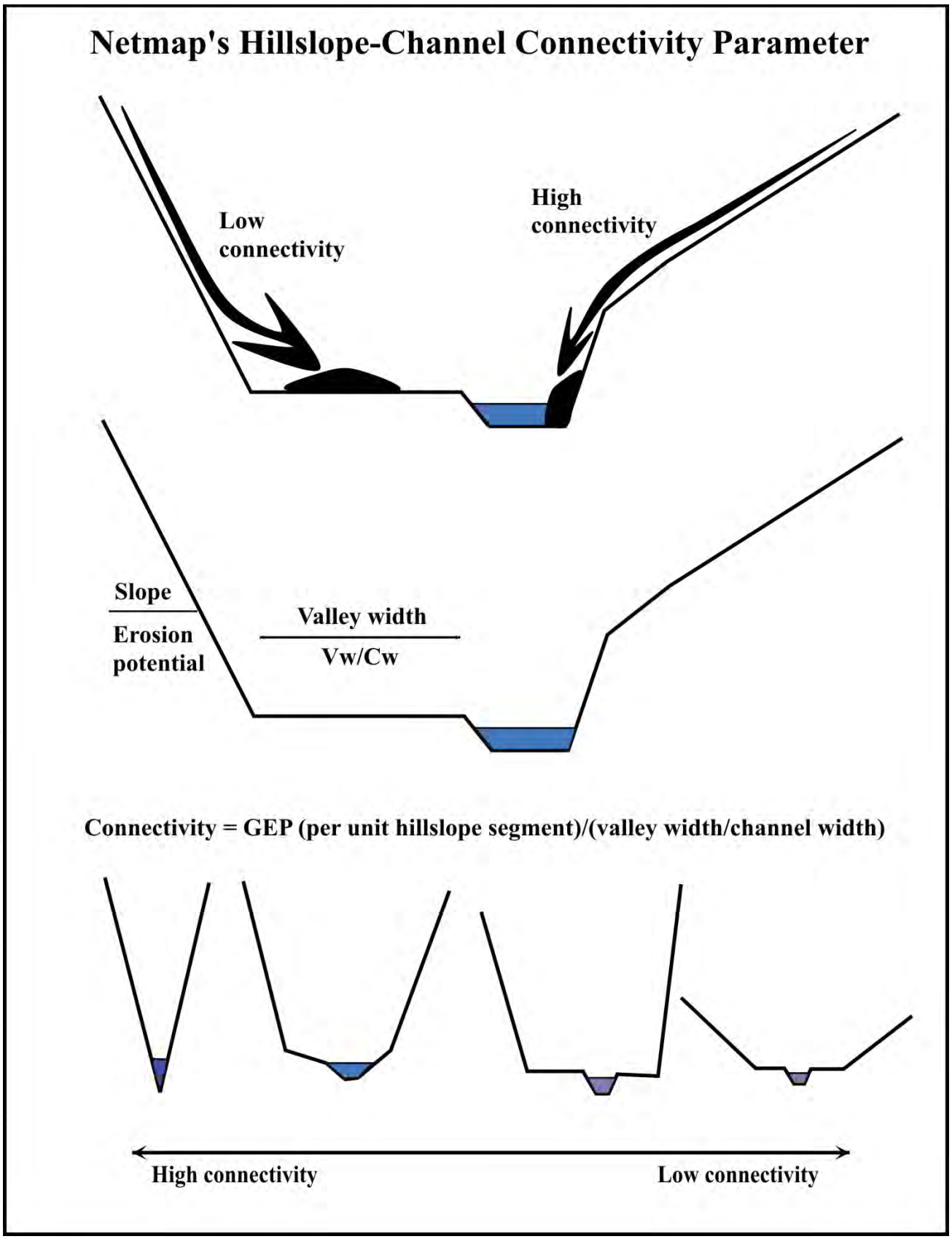

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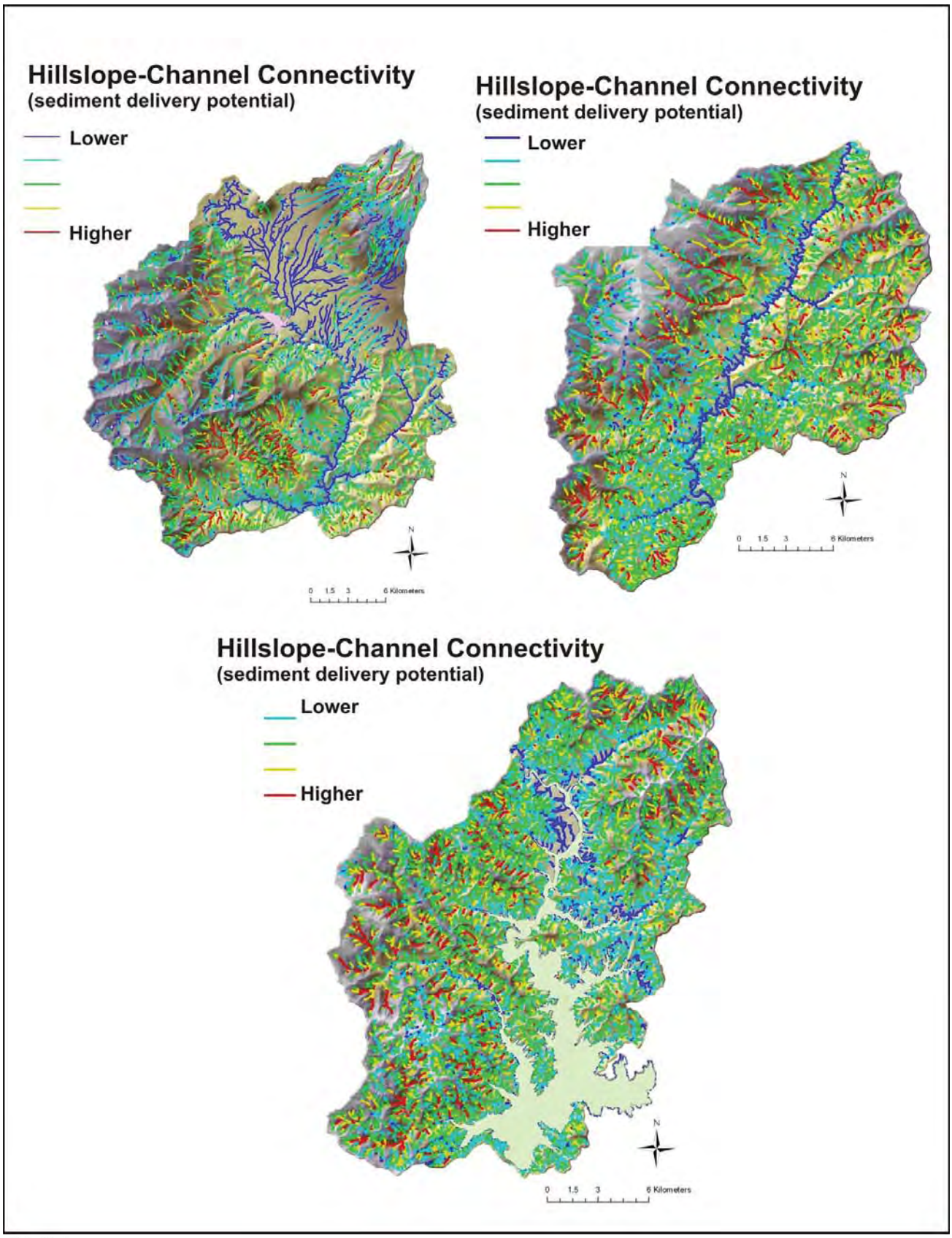
Figure 3.2-17
Modeling of Hillslope-Channel Connectivity
(Modeled results not field verified.)



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Source: NetMap (GIS) Databases (www.netmaptools.org)

Figure 3.2-18
Modeled Hillslope-Channel Connectivity
Upper Sacramento River Watersheds
(Modeled results not field verified.)

Debris Flow Potential

A debris flow is defined as a highly mobile slurry of soil, rock, vegetation, and water that can travel many hundreds of yards from its point of initiation through steep and confined mountain channels. Debris flows are initiated by liquefaction of landslide material concurrently with failure or immediately thereafter as the soil mass and reinforcing roots break up. Debris flows contain 70 to 80 percent solids and only 20 to 30 percent water by volume. Entrainment of additional sediment and organic debris in first- and second-order channels can increase the volume of the original landslide by 1,000 percent or more, enabling debris flows to become more destructive as their volume increases with distance traveled. Debris flows often deposit in low-gradient valley floors.

There are a variety of models developed to predict debris flows and their movement and deposition in headwater streams, primarily in mountain landscapes (Benda and Cundy 1990, Fannin and Rollerson 1993, Lancaster et al. 2001). Most of these models require information on network characteristics of headwater systems such as channel gradients and tributary junction angles. NetMap uses a model that utilizes digital elevation data to predict the susceptibility of headwater streams to debris flows (Miller and Burnett 2007b).

Predictions of debris flows in NetMap are based on four topographic attributes: (1) channel gradient, (2) valley width or channel confinement, (3) angles of tributary junctions, and (4) cumulative length of scour and deposition (i.e., rate of volume increase or decrease) (Miller and Burnett 2007b). In the model, debris flow runout is separated into zones of scour, transitional flow, and deposition. The functional relationships between debris flow scour and deposition and the four topographic factors are based on field research that has illustrated the physical constraints on debris flow travel. For example, debris flow movement declines with decreasing channel slope (Swanson and Lienkaemper 1978, Benda and Cundy 1990, Fannin and Rollerson 1993), declines at sharp-angled tributary junctions (Benda and Cundy 1990), is less in large forests and longer in clearcuts (Ketcheson and Froelich 1978), and increases with larger volumes (Benda and Cundy 1990).

Debris flow susceptibility values indicate the relative potential for debris flow movement through a reach. The susceptibility value is based, in part, on the shallow landslide potential (e.g., Figure 3.2-15) and the probability for delivery from each hillslope pixel. The implications of a given debris flow susceptibility value vary with position within a channel network and with the gradient, size, and valley morphology of the receiving channel. For steep headwater channels, a high debris flow susceptibility value implies a potential for debris flow scour. For lower gradient headwater channels and at tributary junctions, a high susceptibility value implies a potential for debris flow deposition. For mainstem channels, the consequences of debris flow delivery vary with the potential for fluvial transport of the deposited material. The deposits may be long-lived in small, low-gradient channels, resulting in formation of debris fans. As channel size and/or gradient increase, the potential for erosion of debris flow deposits increases. Boulder lags, truncated fans, and downstream fluvial deposition of debris flow–supplied material may be the only evidence of past debris flows. NetMap includes a function for predicting the fate (i.e., erosion) of debris flow deposits and a classification of potential debris flow effects in channels (see below), but it was not applied in this watershed assessment. Debris flows can be viewed as both a hazard to aquatic environments or as a source of habitat heterogeneity (Benda et al. 2003).

The debris flow susceptibility model applied to the watershed indicates that most of the assessment area has a relatively low likelihood of debris flows. However, as shown in Figure 3.2-19, an example of a shallow failure that transformed downstream due to a debris flow is shown in an area just south of the Castle Crags (Figure 3.2-19). These features are also present in the South Fork of Castle Creek, where natural hillslope failure has triggered large inner gorge debris flows. Also shown in Figure 3.2-19 is the corresponding debris flow predicted based on the landform type. Although this Figure shows an example of a debris flow in a steep headwater stream in the upper watershed, most headwater streams in this area are predicted to have a low susceptibility to debris flows due to the lack of frequent rainfall runoff–driven flood events.

The predicted debris flow potential is higher in the middle to lower watersheds of the assessment area due to the steeper hillsides and higher drainage density (see below) in those locations (Figure 3.2-20). The higher debris flow potential in steep headwater streams appears (again) to be driven mainly by landform type. The mechanically weaker sedimentary rocks and the absence of alpine glaciation (during the Pleistocene) (e.g., Figure 3.2-9) have led to a more highly dissected and steeper landscape that can be conducive to debris flows. However, similar to predictions of generic erosion and shallow landslide potential (Figure s 3.2-12 and 3.2-15), the intense rainfall patterns in this portion of the subbasin likely increase the probability of debris flows. Regardless, the predicted probability is low when compared to more humid coastal watersheds in northern California, Oregon, and Washington.

As with all screening tools for slope instability and downstream propagation of impacts (e.g., debris flows), field validation of watershed attributes is critical in the context of pre- and post-wildfire planning and timber harvest and road construction.

Local Sediment Supply and Sediment Storage

To understand how erosion potential in a watershed relates to the supply of sediment to stream channels, a sediment budget is often constructed (e.g., Reid and Dunne 1996). In the watershed, an approximate and partial sediment budget was developed using the generic erosion parameter (Figure 3.2-12). In general, areas that are steeper and more convergent are predicted to have a higher erosion potential (surface erosion, gullying, and shallow landsliding) and thus a higher sediment supply to channels.

The average annual sediment supply in the watershed is estimated using an average basin-wide sediment yield of 100 $t/km^2/yr$ (this value is used as an illustration, since the actual average sediment yield [in the absence of land use] is unknown). The estimated basin sediment yield is distributed across all hillslopes in the watershed using GEP values (GEP per pixel cell) as the index of relative sediment supply. Sediment yield is considered to be linearly proportional to GEP. For instance, higher GEP values will yield higher sediment yield values in the area of 200–300 $t/km^2/yr$ compared to lower GEP values that may have sediment yield values considerably less than the 100 $t/km^2/yr$ on average. Despite hillslope variations in sediment yield (tied linearly proportional to GEP values), the basin average sediment yield must remain at the estimated average of 100 $t/km^2/yr$.

The spatial variation in sediment supply (from hillslopes to channels) is predicted across the watershed. Overall, predicted sediment supply to stream channels is lower in the northernmost watershed and increases in the mid and southern portions of the watershed (Figure 3.2-21).

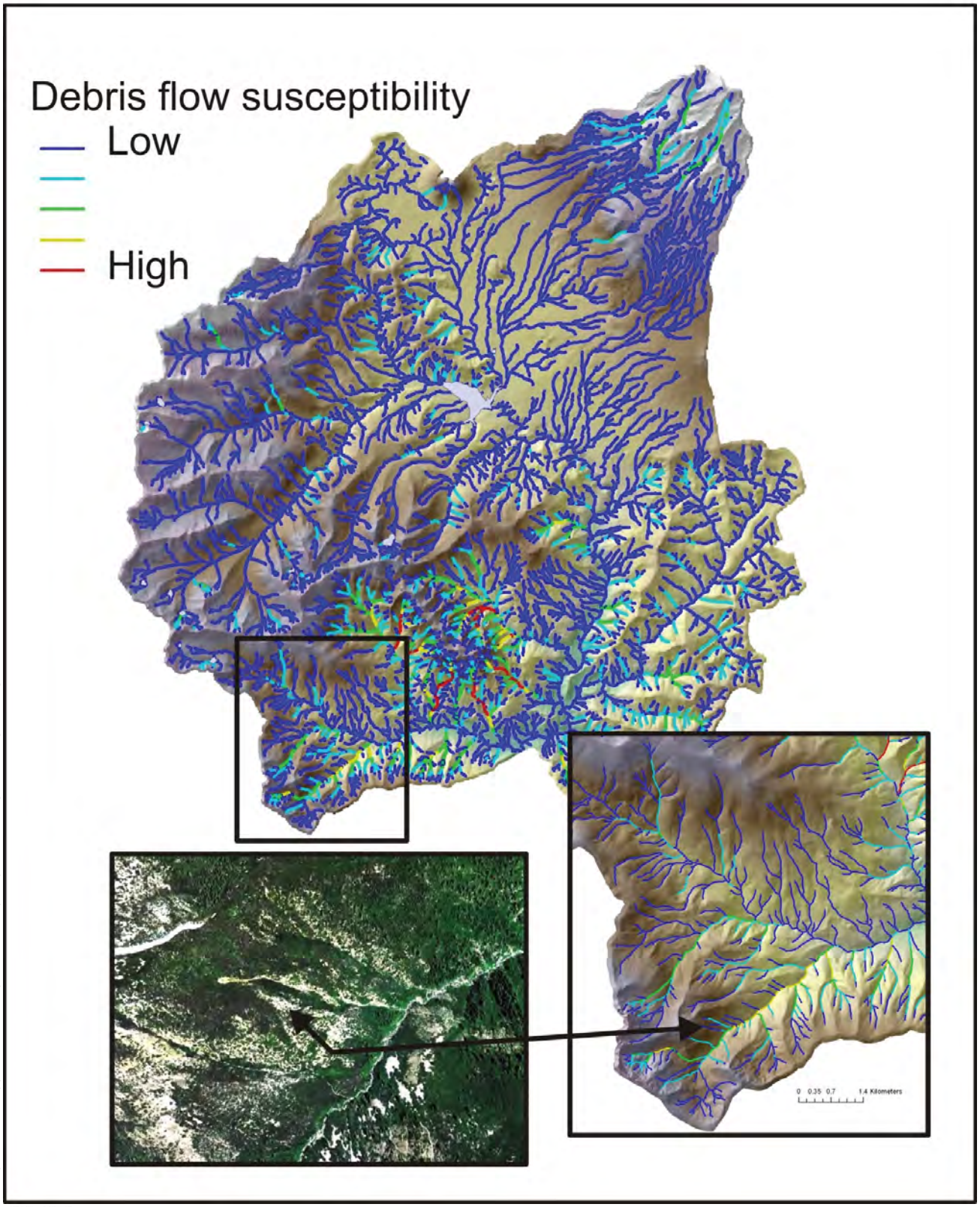

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Figure 3.2-19
Modeled Debris Flow Potential
(Modeled results not field verified.)

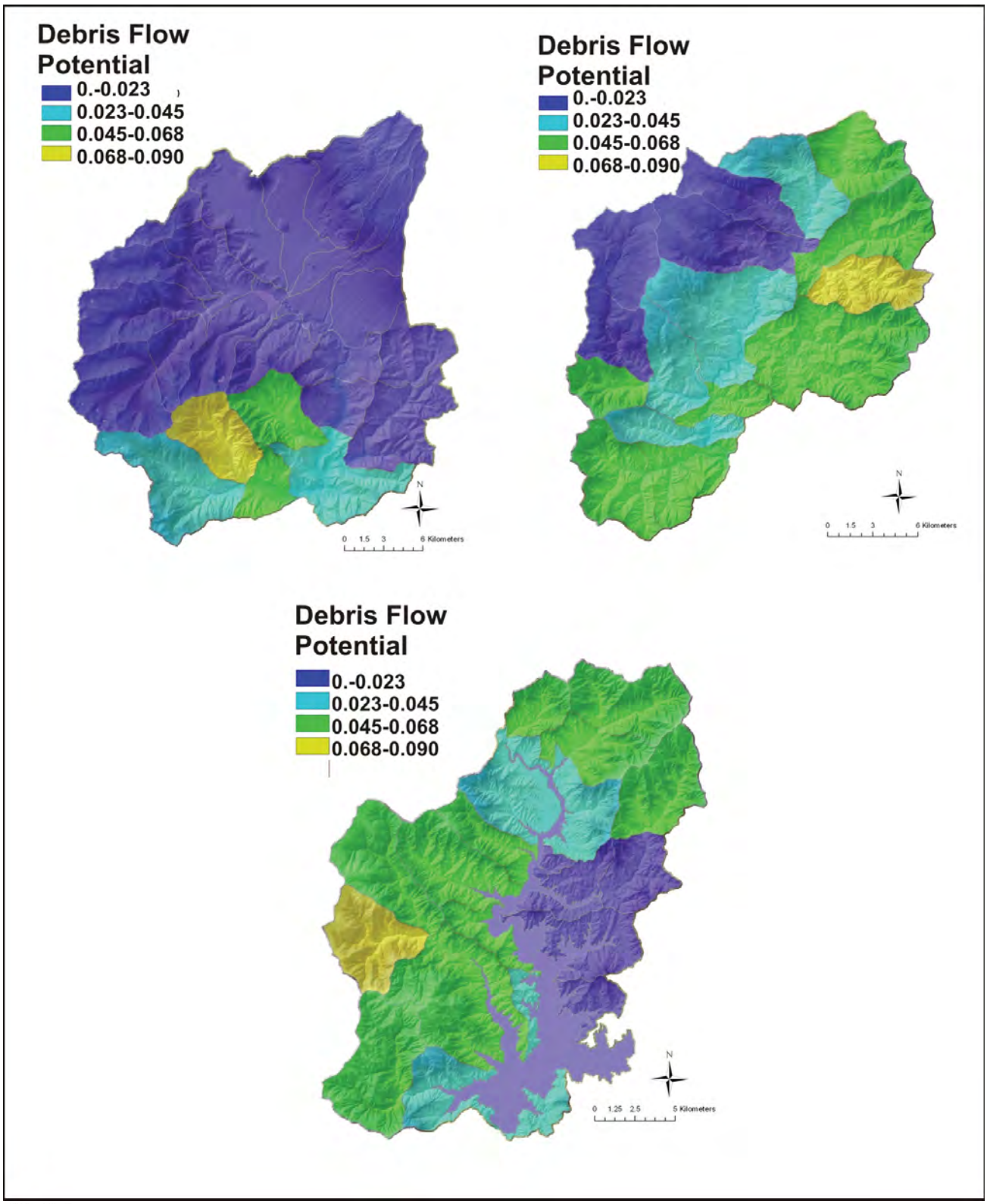

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Figure 3.2-20
Modeled Debris Flow Potential
Upper Sacramento River Watersheds
(Modeled results not field verified.)

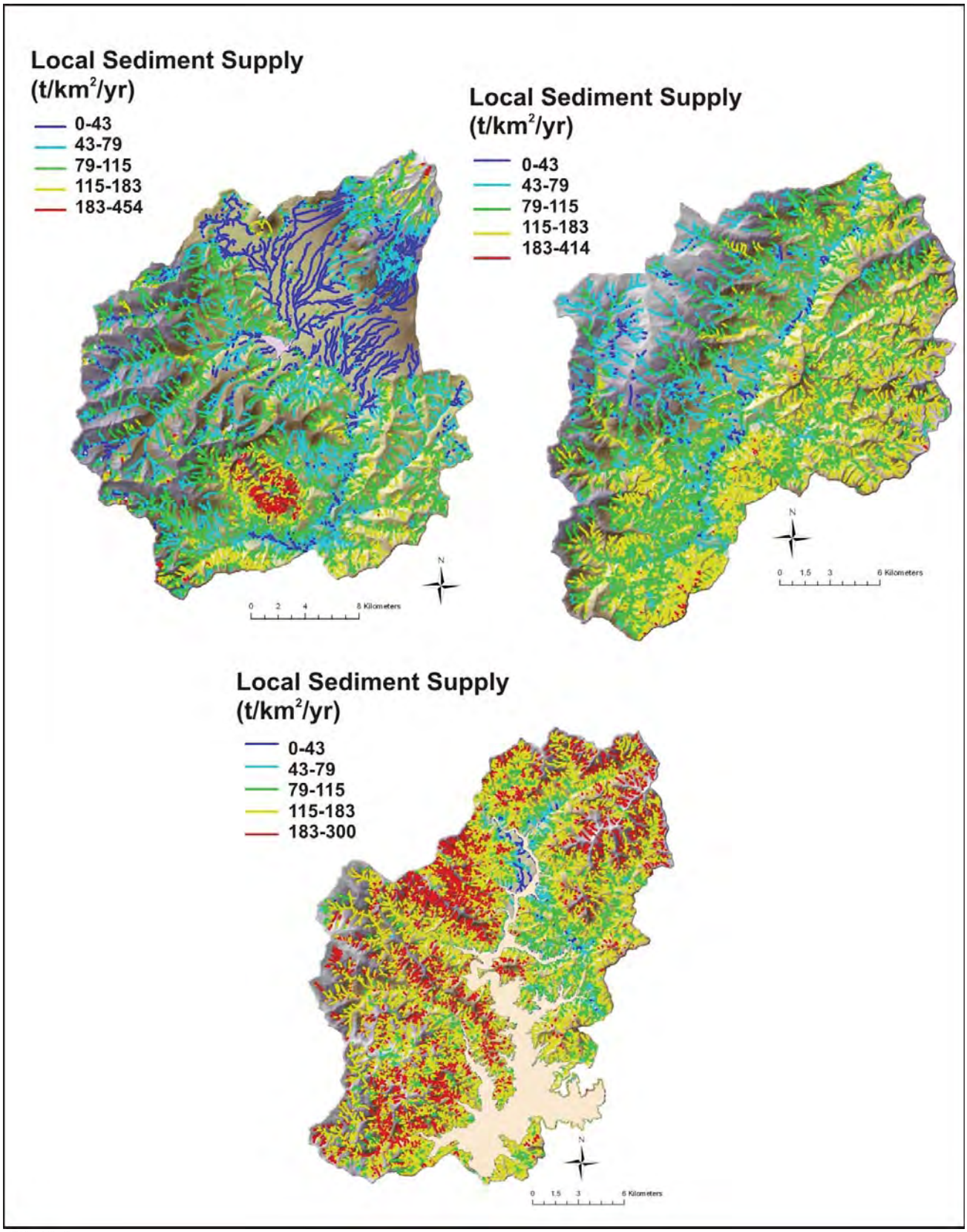

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Figure 3.2-21
Modeled Sediment Supply
Hillslopes to Stream Channels
(Modeled results not field verified.)

This pattern is due to less steep and dissected hillslopes (e.g., less basin dissection), presumably related to the harder rocks and history of alpine glaciation that characterize the northern portion of the watershed. Average sediment yields in the northern and mid portions of the watershed range are often less than the average of 100 t/km^2/yr (and as low as 10–20 t/km^2/yr in the more gentle areas along the foot slopes of Mount Shasta). Much higher values (100–300 t/km^2/yr) are predicted to occur in the mid to southern portions of the watershed due to the steeper hillslopes and higher landscape dissection (more frequent and pronounced convergent areas [unchanneled swales]) (Figure 3.2-21).

Classification of the three break out watersheds according to their average sediment yield shows a non-uniform distribution of predicted sediment yields across the assessment area (Figure 3.2-22). The differences in average sediment yields across the three watersheds are significant. For example, 80 percent of all channel segments in the northern, mid, and southern watersheds have sediment yields less than 100 t/km^2/yr, 125 t/km^2/yr and 180 t/km^2/yr, respectively (Figure 3.2-23).

The approximate sediment budget (Figure 3.2-21) does not account for other erosion processes such as bank erosion (along colluvial toeslopes) and earthflows. It also does not account for erosion related to land use activities, including in urban areas (City of Mt. Shasta, Dunsmuir, etc.), timber harvest areas, and unpaved roads (see Chapter 4 for an analysis of fire-related erosion and road surface erosion potential). Nevertheless, the approximate sediment budget does provide an index of relative sediment supply that can be used to help interpret variation in sediment supply and storage in channels as well as the effects of Box Canyon Dam on sediment routing throughout the lower portions of the Sacramento River (below). The analysis also clearly predicts that the mid and southern watershed areas dominate the sediment supply to stream channels, and it is in those locations where wildfires and land use activities (e.g., timber harvest areas and roads) can have the greatest potential impacts related to erosion and sediment supply to streams.

The predicted sediment supply is related to in-channel sediment storage potential in NetMap by dividing the average annual sediment supply by stream power. Stream power reflects the ability of a channel to transport, and thus store, sediment and is generally calculated as the product of channel gradient and drainage area (per channel segment, as a surrogate for discharge) (Richards 1982). Streams with higher stream power have less opportunity to create large in-channel storage reservoirs in contrast with streams of lower power that can create larger reservoirs of sediment.

Using the relationship described above, sediment storage potential is predicted to vary considerably across the watershed. Certain portions of the mainstem Sacramento River are predicted to have a higher sediment storage compared to other segments. The higher sediment storage found in some of these areas is connected to the high sediment supply and sediment storage in tributaries that originate from the eastern side of the mid basin and across the southern watershed (Figure 3.2-24). Insights into the spatial patterns of sediment supply (Figure 3.2-21) and sediment storage (Figure 3.2-24) are used in the analyses of potential wildfire and land use impacts in Chapter 4.

The average sediment supply represents the central tendency of a given catchment with quasi-static topographic attributes. Erosion and sediment supply vary greatly in time and space in most landforms and are highly stochastic processes driven by interactions among storms, sediment flux potential, and

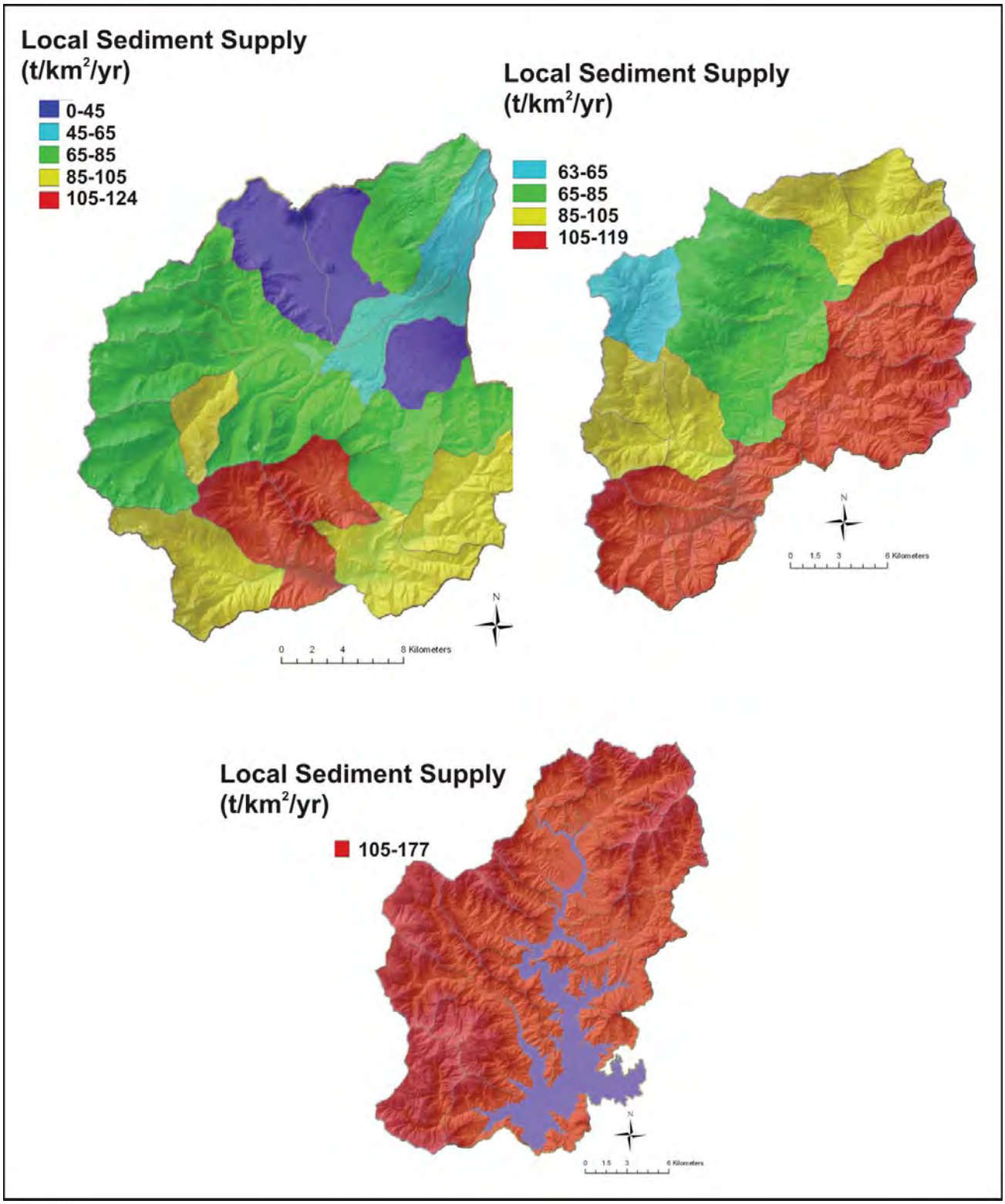

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Figure 3.2-22
Modeled Average Annual Sediment Supply
Upper Sacramento River Watersheds
(Modeled results not field verified.)

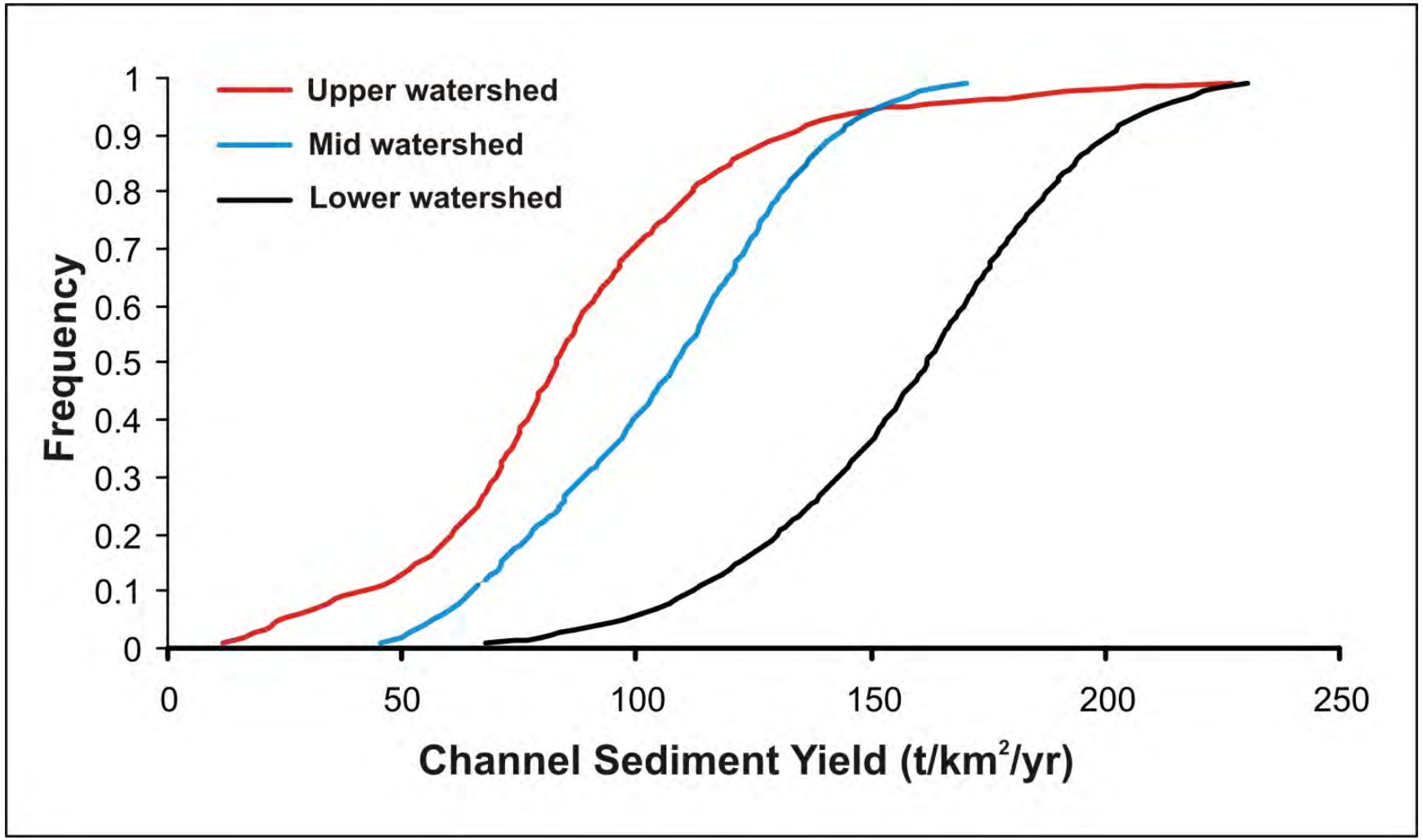

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Figure 3.2-23
Average Annual Sediment Yield
Upper Sacramento River Watersheds
(Modeled results not field verified.)

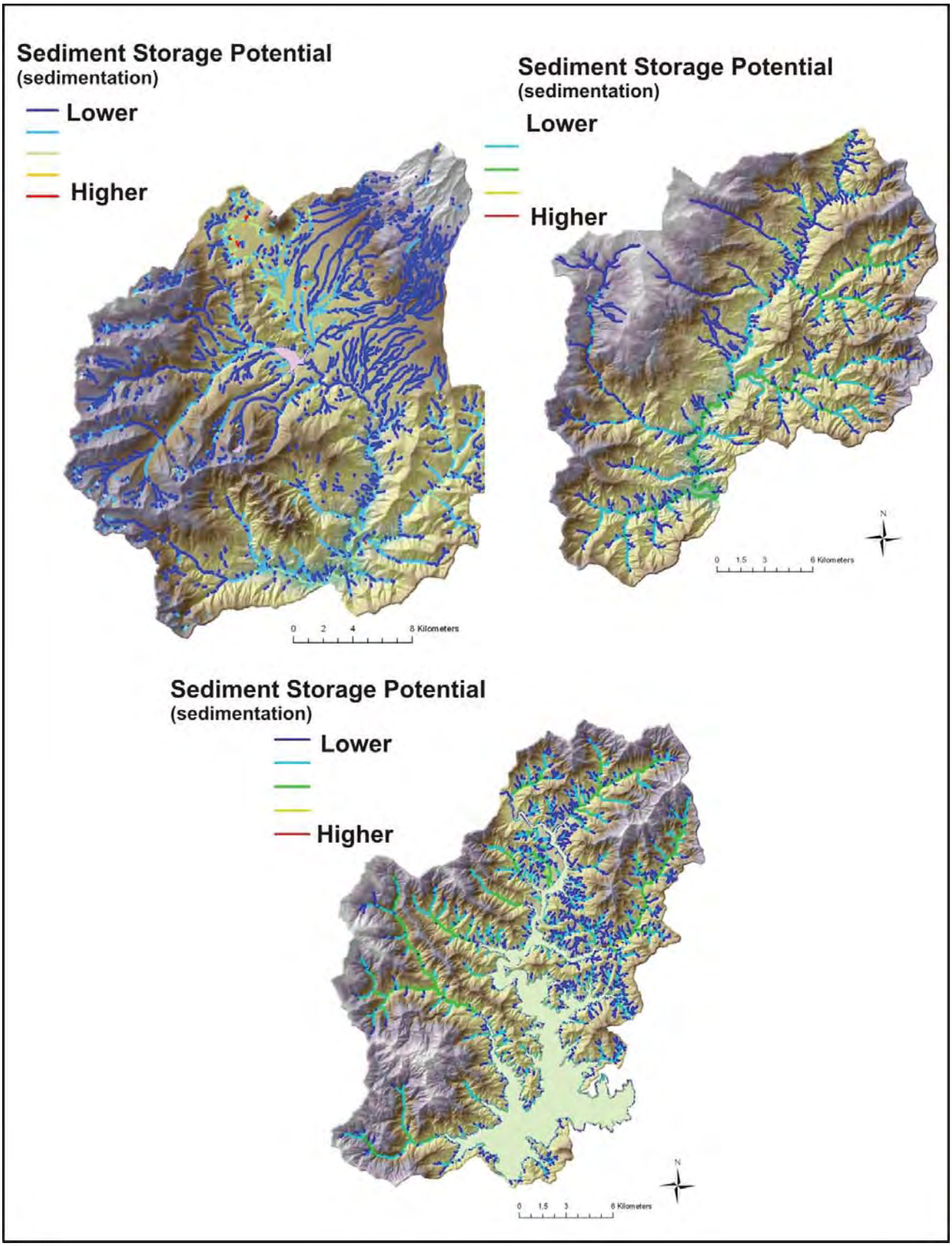

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Figure 3.2-24
Modeled Sediment Storage Potential
(Modeled results not field verified.)

vegetation (Benda and Dunne 1997a). An analysis of the stochastic aspects[8] of the upper Sacramento River basin is outside the scope of this watershed assessment. Nevertheless, a cursory examination of historical photos (in Google Earth) illustrates the temporally variable sediment supply driven by large storms and floods. In the example shown in Figure 3.2-25, the mainstem Sacramento River (near Soda Creek in the mid watershed) has an absence of in-channel sediment storage in photo year 1993. In 1998 (following a major flood in the basin that occurred in December 1997), new extensive gravel bars formed both upstream and downstream of the confluence with Soda Creek (Figure 3.2-25). Presumably, this increase in sediment storage in the form of bars was related to the 1997 storm and associated flood (and heightened hillslope and in-channel erosion). By 2005 (9 years after the large flood), the gravel bars had either reduced in area due to fluvial erosion or they had become vegetated, or both. There are other examples visible on Google Earth not shown here that reflect the stochastic behavior of sediment supply and storage in both the mainstem Sacramento River and its tributaries.

Box Canyon Dam in the Upper Sacramento River: Effects on Sediment Supply and Storage

Box Canyon Dam, a concrete gravity structure impounding 430 acres of water (Lake Siskiyou), was completed in 1969. It is located on the Sacramento River between the communities of Mt. Shasta and Dunsmuir in the upper watershed. The dam effectively traps all of the sediment (bedload and suspended load, perhaps with the exception of silt and clay) that enters Lake Siskiyou from upstream and from several tributaries along the northern and southern boundaries, thereby reducing the sediment supply to the Sacramento River below the lake. The sediment reduction effect of the Box Canyon Dam can be evaluated using the predictions of average sediment supply presented earlier (e.g., Figure 3.2-20).

NetMap was used to model transport (route) of the predicted average sediment supply (or yield) along the Sacramento River and all of its tributaries. This was accomplished by summing the local sediment supply (Figure 3.2-20) downstream and by dividing the steadily increasing amount of sediment by the steadily increasing drainage area along stream and river channels. In this simple approximation of downstream varying average sediment yields, sediment storage and particle breakdown (attrition) are not accounted for directly.

The modeling of sediment supply downstream in pre-dam conditions reveals that upstream of the (future) Box Canyon Dam, sediment yield is between 80 and 90 t/km2/yr (recall that the basin average sediment yield is 100 t/km2/yr) (Figure 3.2-26). Immediately below that location, the average sediment yield drops to 70–75 t/km2/yr because of the area of low erosion potential located along the foot slopes of Mount Shasta on the north side of the river (also see Figure 3.2-13). The sediment yield increases along the mid portion of the Sacramento River below Castle Crags due to the abundance of medium size tributaries of relatively high sediment supply, most originating from the eastern side of the watershed in the mechanically weaker sedimentary rocks that are predicted to have a higher erosion rate (Figure 3.2-26).

A similar analysis was performed but with the Box Canyon Dam and Lake Siskiyou capturing 100 percent of the sediment that originates from the streams that enter the lake (inclusive of the Sacramento River). The predicted sediment yield is reduced to less than 10 t/km2/yr and increases to

[8] *Stochastic aspects are those involving or containing a random variable or variables.*

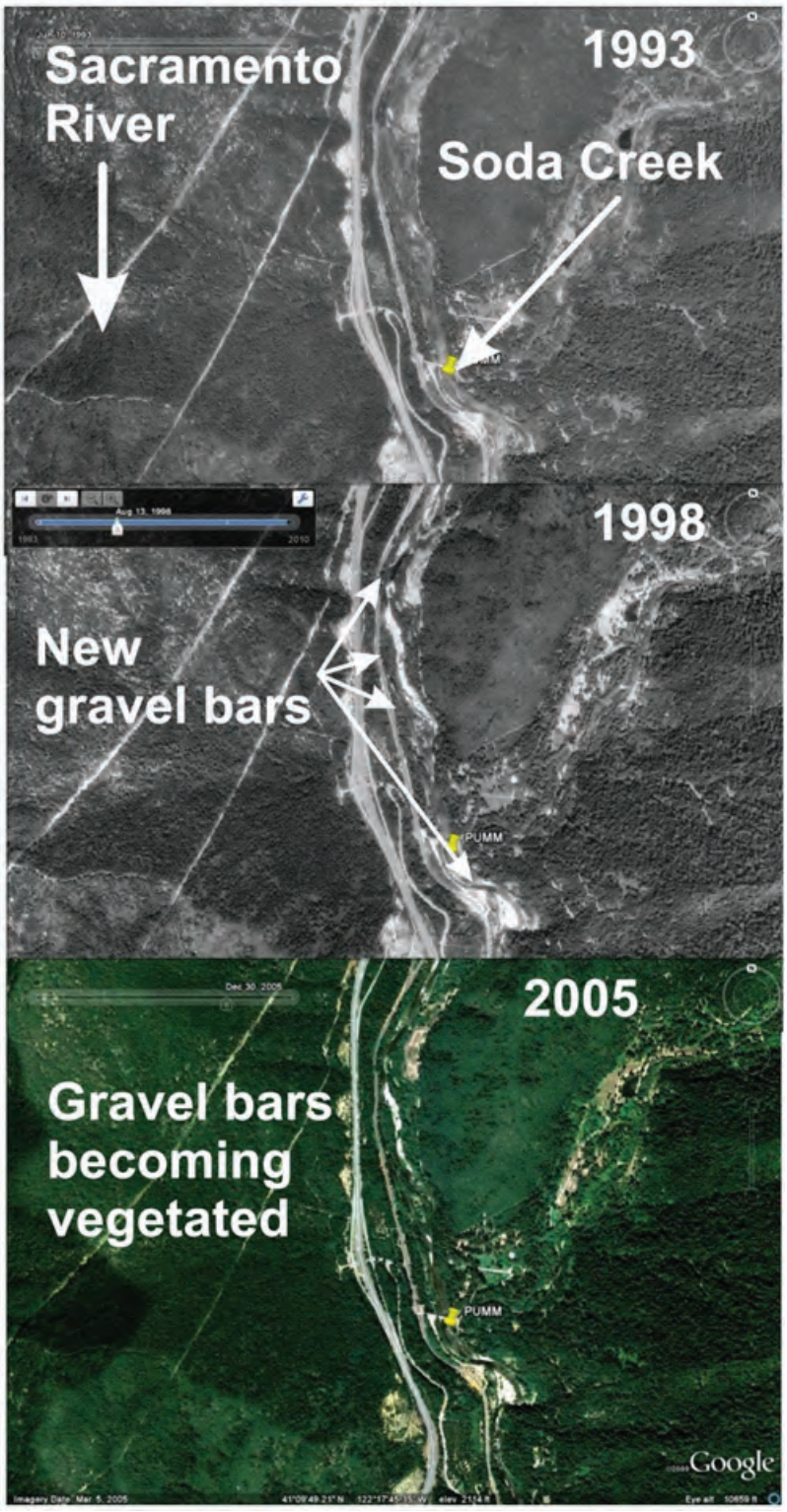

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Figure 3.2-25
Sediment Supply to Streams
Sacramento River, Central Subwatershed

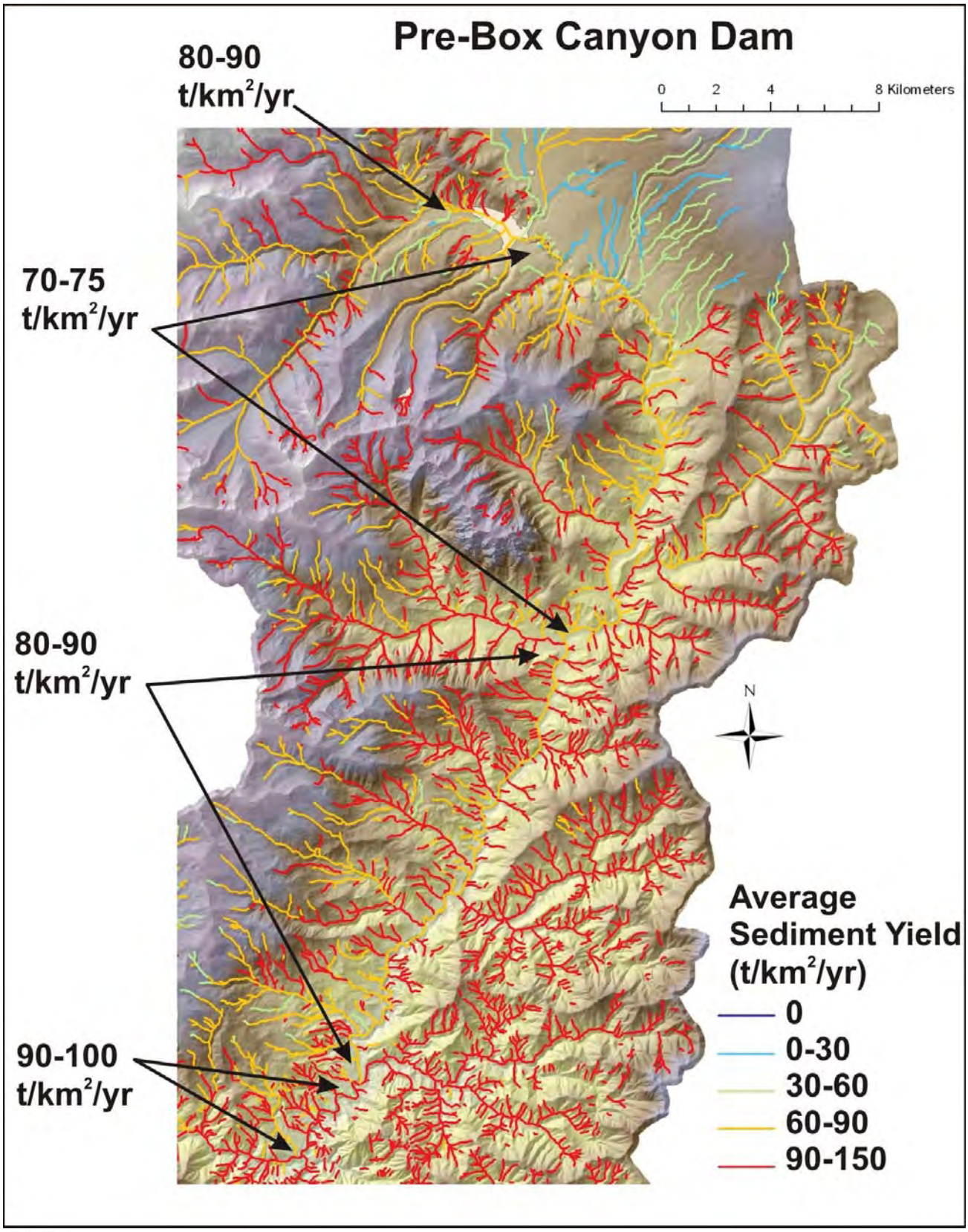

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Figure 3.2-26
Modeled Average Annual Sediment Yield
Pre-Box Canyon Dam
(Modeled results not field verified.)

between 20 and 50 t/km2/yr about 12 to 25 miles below Lake Siskiyou (Figure 3.2-27). The sediment yield steadily increases downstream towards Shasta Lake (reservoir) to around 70 to 75 t/km2/yr.

The NetMap model predicts a 95 percent reduction in coarse sediment yield below the dam. Sediment yield continues to be reduced by 50 percent 18.6 miles downstream of the dam (Figure 3.2-28). The predicted sediment yield 37 miles downstream (near Shasta Lake) is approximately 80 percent of the pre-dam environment. Such dramatic reductions in sediment supply have likely altered the dynamic equilibrium of the upper Sacramento River downstream of the dam. However, as mentioned above, particle breakdown (or attrition) is not accounted for in the calculation described. Bedload size particles (mainly cobbles, gravels, and pebbles in the Sacramento River) break down with distance traveled from the erosion source. Based on tumbling mill studies of particle attrition (Benda and Dunne 1997) and an applied approximate breakdown rate of 10 percent per 0.62 miles (e.g., 10 percent of the rock volume is converted from bedload to suspended load sizes), the reduction in in-channel gravel storage should be significantly less than the values shown in Figure 3.2-28. Considerations of gravel attrition suggest that the reduction in in-stream gravel may approach less than 10 percent 18.6 miles downstream and approach zero 25 to 37 miles below the lake. Even with attrition, however, reduction of in-stream gravels should be significant (>50%) 6.2 miles or more below the dam and Lake Siskiyou.

Landscape Stratification

Landscape stratification can provide information about how the various physical and biological properties of an ecosystem are spatially organized at large scales (Cleland et al. 1997). The watershed is stratified into several zones using the foregoing analysis of geology (lithology), hillslope topography, erosion potential, and sediment supply, routing, and storage.

The various landforms within the subbasin are classified into Lithotopo Units and are used to analyze natural and human-altered hydrologic and geomorphic processes within the subbasin following Shilling et al.'s (2005) guidance and McCammon et al. (1998). These units are presumed to be spatially and temporally a function of climate, bedrock geology, tectonic setting, soil type, ground cover, slope stability, slope steepness and convergence, and stream network geometry. For this assessment, Lithotopo Units are classified by mapping individual polygons with similar climate, topography, and bedrock geology. Data sources used to stratify the subbasin into lithotopo units include (1) bedrock geology, (2) dormant and active landslides, and (3) topography generated from NetMap. A GIS project was used to generate the lithotopo unit polygons, and data gathered as part of this assessment were used to refine each lithotopo unit.

Geology, specifically rock type, is destiny in the context of many of the physical attributes of the watershed. As described above, topography (hillslope gradient and form [convergent-divergent shapes]), erosion potential, hillslope-channel connectivity, and sediment supply appear to be related spatially to differences in lithology, specifically rock mechanical strength and to some extent the occurrence of alpine glaciation. The highest erosion potential, hillslope-channel connectivity, and sediment supply are associated with mechanically weaker sedimentary rocks that occur in the mid and southern portions of the study basin. Conversely, the relatively low relief area within the diverse volcanic deposits associated with Mount Shasta has a predicted low erosion potential.

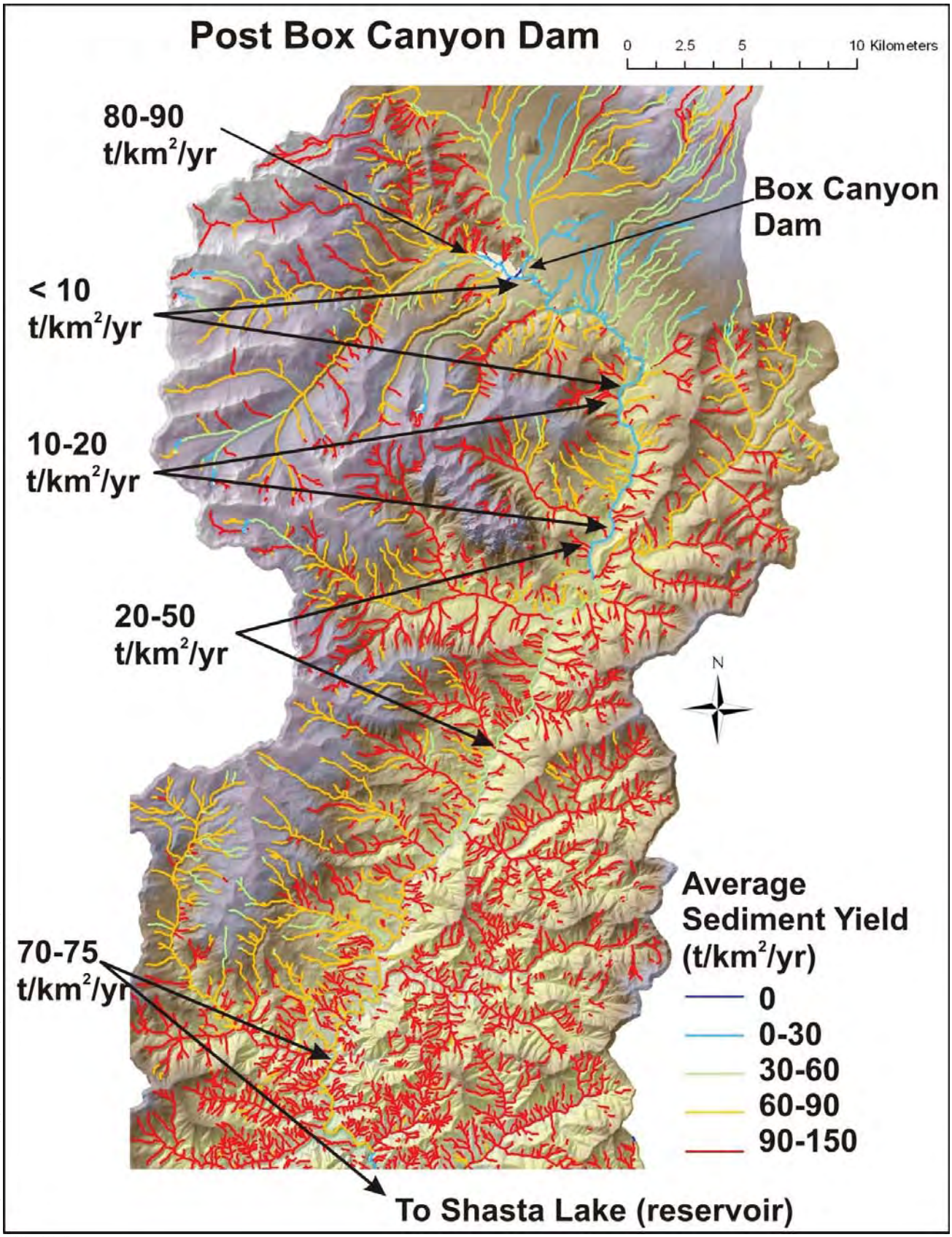

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Figure 3.2-27
Modeled Impact on Downstream Sediment Supply
Post-Box Canyon Dam
(Modeled results not field verified.)

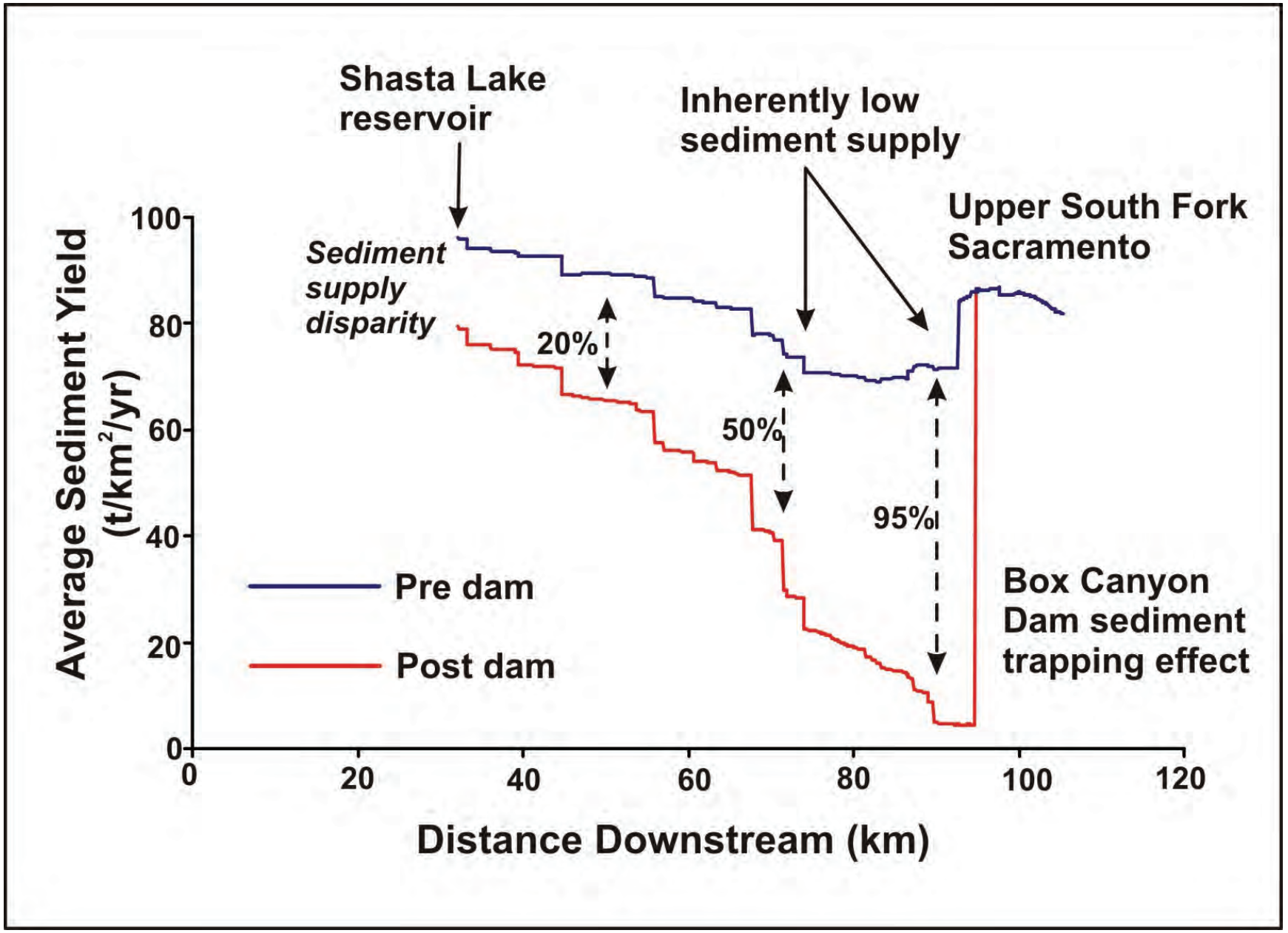

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Figure 3.2-28
Predicted Reduction of Sediment Supply Decreases Downstream Lake Siskiyou

An additional watershed attribute that is influenced by rock strength or erodibility is channel density (number of channels of all sizes per unit area). NetMap's channel density tool is used to classify channel density (km/km^2) across all HUC 6th field subbasins in the assessment area. The lowest channel densities (primarily driven by headwater streams) range from a low of 2 to 3 km/km^2 in the northernmost watershed. The channel densities increase from 3 to 5 km/km^2 in the mid to southern portion of the watershed (Figure 3.2-29). The higher drainage density associated with the sedimentary rocks of the mid to southern watersheds is presumably related to the weaker rocks that promote a greater drainage network dissection (increased channel development and incision).

The drainage density attribute is added to the other discriminating factors (topography, erosion potential, hillside/channel connectivity, sediment supply, channel sediment storage) to stratify the watershed into 4 to 5 prominent zones. The zones include (1) volcanics of the Mount Shasta area, (2) igneous rocks of the northern and northern mid sections of the watershed, (3) plutonic rocks of the Castle Crags areas are subsumed within zone 2 but differentiated based on rock exposure, steepness and lack of vegetation), and (4) sedimentary rocks (Figure 3.2-30). Implications of the landscape stratification on aquatic habitats and on impacts associated with wildfire and land use activities are described later in the report.

Fluvial Conditions and Processes

Channel Network Dynamics

The stream network in the assessment area is defined within NetMap by using a flow routing algorithm that includes parameters of (1) drainage area, (2) drainage area per unit contour length (specific drainage area), and (3) gradient (Miller 2003). NetMap searches for the optimization of specific drainage area to drainage density (km/km^2) by identifying the inflection point in that relationship (Figure 3.2-31). Values of specific drainage area below the inflection can cause drainage density to be under predicted. Values above the inflection can cause drainage density to be over predicted, leading to drainage feathering (too many channels on any given hillslope). The predicted drainage densities (per watershed) are between 3 and 5 (Figure 3.2-29) and are typical of many mountain drainage basins (Benda et al. 2004b). The stream network is divided into individual reaches of between approximately 66 feet and 657 feet (average 327 feet) using an algorithm that searches for similarities in gradient, channel width, valley width, and drainage area (e.g., segments are created where geomorphic conditions change, often at tributary confluences).

The fish-bearing portion of the network is also specified in NetMap. This requires knowledge of the existing fish distribution. If this is not available, then channel gradient and flow thresholds are used to truncate that portion of the total stream network that is likely to contain fish (either resident or anadromous). For resident fish (appropriate for the present day upper Sacramento River watershed [above the Shasta Lake Dam]), a gradient threshold of 20 percent is used to identify fish streams, including even above gradient barriers. In a later analysis of the historical range of anadromous fish in the watershed, a migration-blocking gradient barrier of 10 percent is used. In the analyses of fluvial geomorphology that follow, results will be shown for the predicted resident fish streams only.

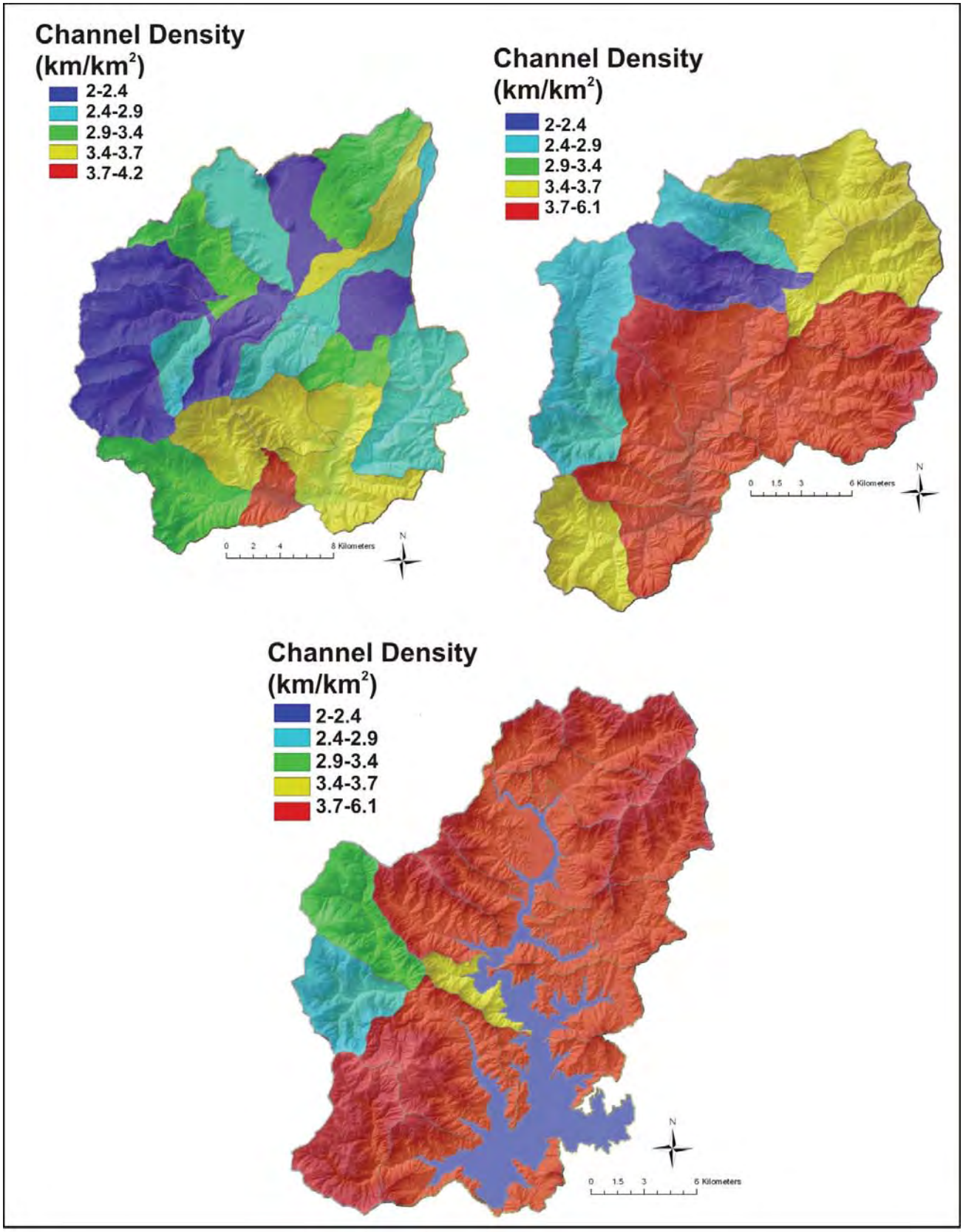

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Figure 3.2-29
Modeled Drainage Density
Upper Sacramento River Watersheds
(Modeled results not field verified.)

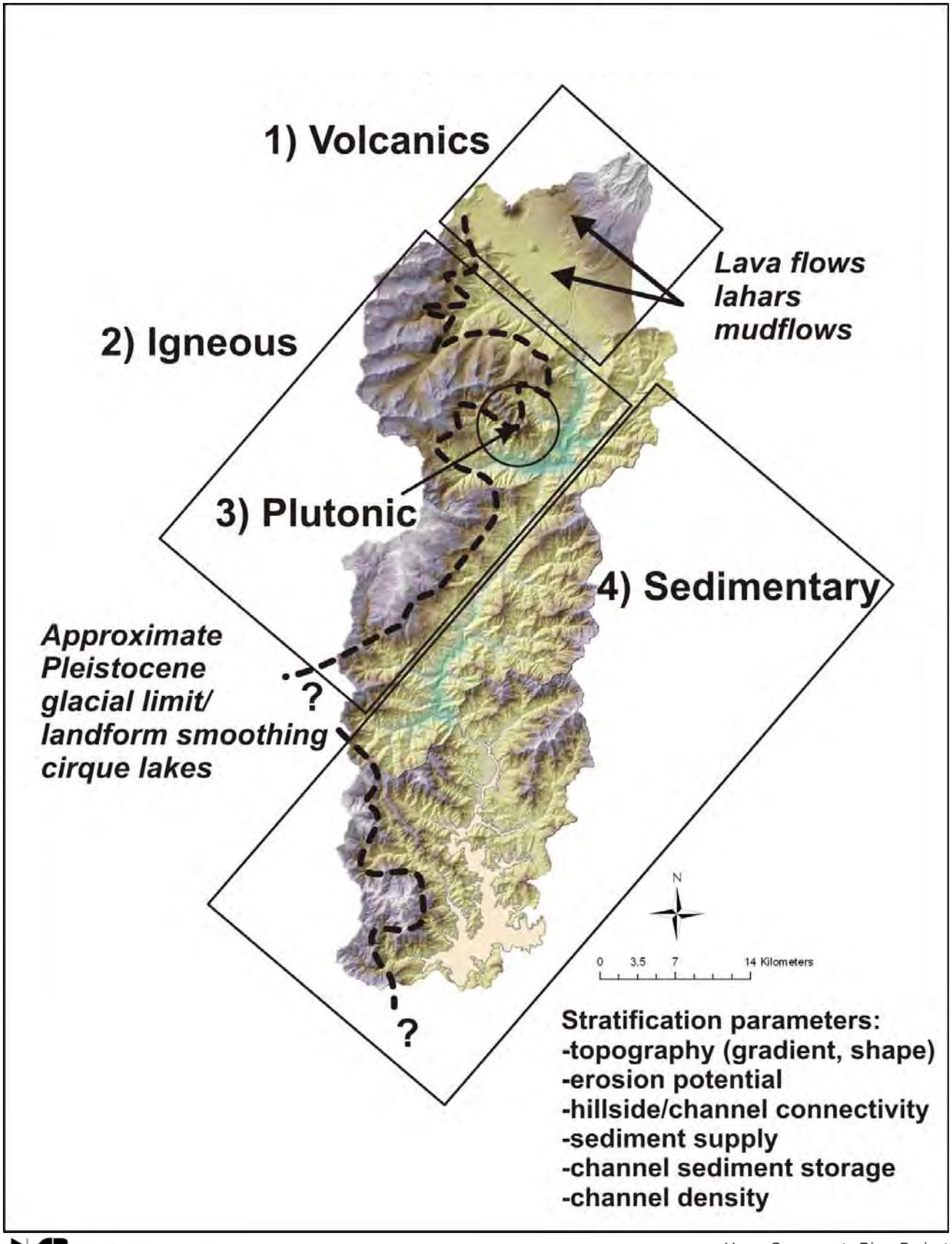

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Figure 3.2-30
Landscape Stratification

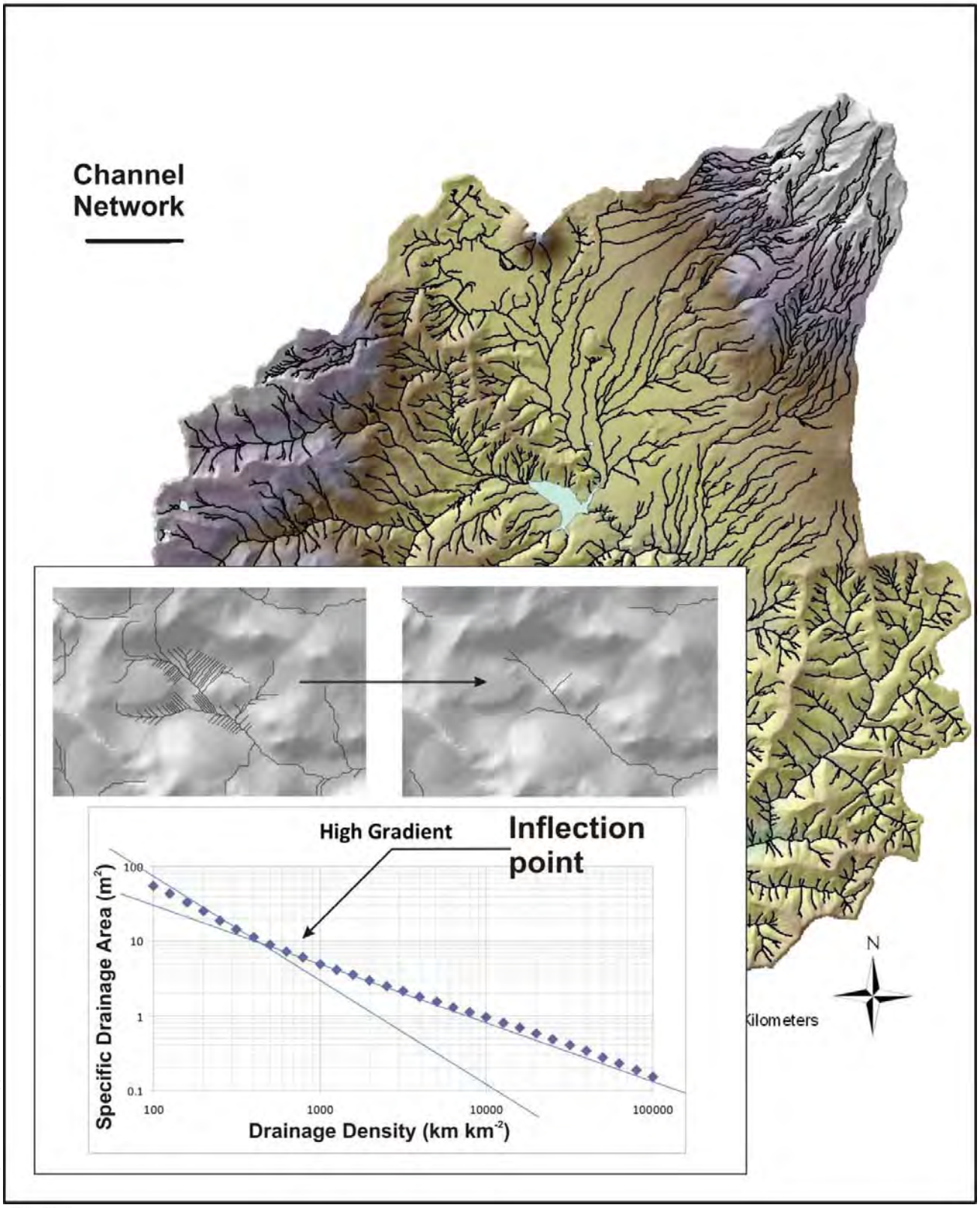

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Figure 3.2-31
Stream Network

Stream Gradient

In the upper Sacramento River, the stream gradients range from over 50 percent in the steepest headwater streams (for example, most of the assessment area) to less than 1 or 2 percent in the low-relief areas located south of Mount Shasta and in the lower river. Channel gradients are shown for all streams and only for the fish-bearing network in the uppermost subbasin (Figure 3.2-32). The subbasin has high topographic roughness formed by ridges that intersect the streams where bedrock outcrops emerge and create falls and rapids. The abundance of bedrock control points is evident in the fact that the average stream gradient of the subbasin is about 25 percent, with over 69 percent of the stream channels steeper than 10 percent. Less than 5 percent of the stream reaches are classified as low gradient, with about 3 percent with a gradient of less than 1.5 percent. As shown in Figure 3.2-32, most of the lower gradient reaches are along the inner gorge of the mainstem and near the headwaters along the contact between Cascade volcanic and Klamath metamorphic rock formations.

Stream gradient is an important parameter for predicting the quality and abundance of fish habitats of different species, channel morphology, and the sensitivity of channels to changes induced by floods, large wood, and sediment transport and storage. Such channel attributes are examined below.

Stream Order

Stream order provides a means to evaluate the relative size and position of channels within a river network. In the Strahler (1952) stream ordering method, the upper tips of a river network are classified as "order 1." The channel becomes a stream of "order 2" where two first order streams converge. Similarly, a 3rd order stream forms where two "order 2" streams intersect. An illustration of Strahler stream ordering is shown in Figure 3.2-32.

The upper Sacramento River is a 7th order river (e.g., the channel of the largest drainage area located immediately above Lake Shasta) (Figure s 3.2-32 and 3.2-33). Channels of orders 1 and 2 are generally considered "headwater" streams. Because of the hierarchical branched pattern of river networks, there are significantly greater numbers of headwater streams compared to 3rd-, 4^{th}-, and higher order channels. Typically, 1st- and 2nd-order streams can comprise about 70 percent of the cumulative length of channels within a drainage network.

Headwater streams typically have many non-fluvial characteristics. In hilly to mountainous terrain, such as in the watershed, headwater streams reflect a mix of hillslope and channel processes because of their close proximity to sediment source areas. Their morphology is an assemblage of residual soils, landslide deposits, wood, boulders, thin patches of poorly sorted alluvium, and stretches of bedrock. Longitudinal profiles of these channels are strongly influenced by steps created by sediment deposits, large wood, and boulders. Due to the combination of small drainage area; stepped, shallow gradient; large roughness elements; and cohesive sediments, headwater streams typically transport little sediment or coarse wood debris by fluvial processes (Benda et al. 2005). Consequently, headwaters act as sediment reservoirs for periods spanning decades to centuries. The accumulated sediment and wood may be episodically evacuated by debris flows, debris floods, or gully erosion and transported to larger channels, particularly following large and severe wildland fires. Such processes may be locally important in the watershed. In mountain environments, these processes deliver significant amounts of materials that form riverine habitats in larger channels. In managed steepland forests, accelerated rates of landslides and debris flows have the potential to seriously affect the morphology of headwater streams and downstream resources.

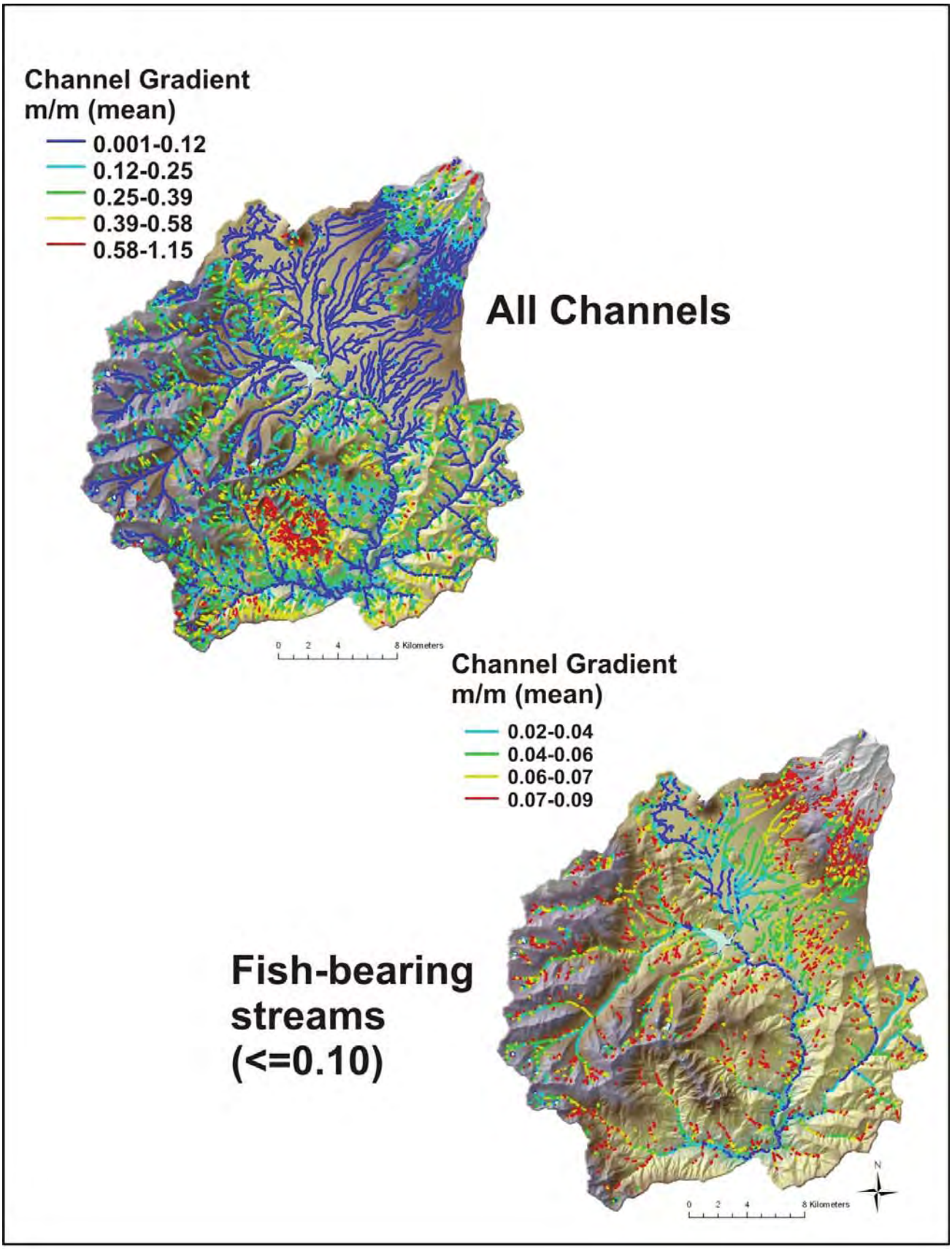

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Figure 3.2-32
Channel Gradients

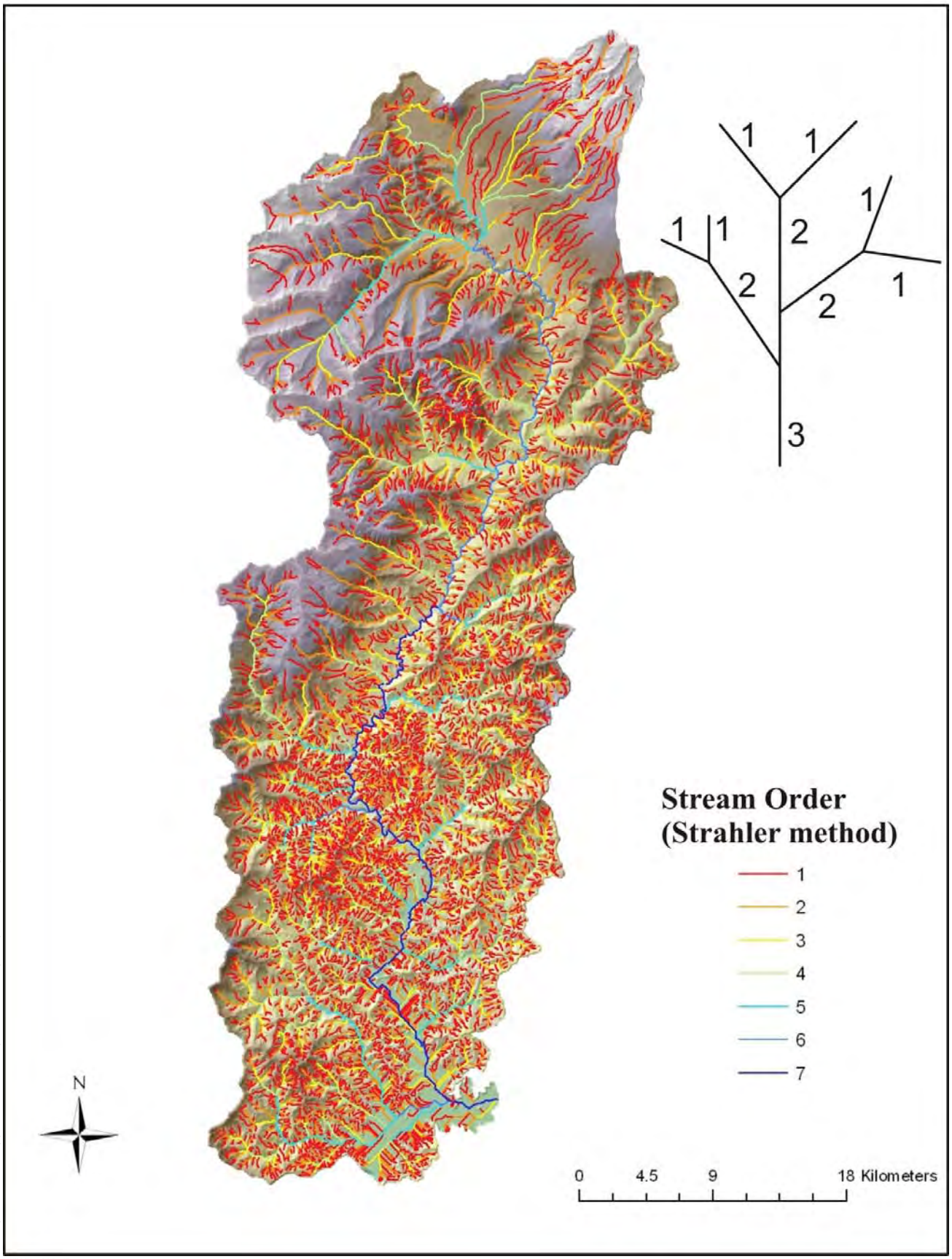

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Figure 3.2-33
Stream Order

Stream Width and Flow Depth

Stream width in NetMap is calculated using a regression function because channel banks are not readily resolvable from a 10-meter DEM (10-meter length scale in the X, Y, and Z coordinates). The widths of channels (bank full) were measured in the field over a range of drainage areas (247–98,842 acres) during the parameter validation stage of this assessment. The regression function is: channel width = 1.949*drainage area^0.4409 (Figure 3.2-34). Predicted channel widths range from approximately 3 feet to 144 feet just above Shasta Lake. Only channel widths for the uppermost basin are shown (Figure 3.2-35).

Predicted channel widths for first-order streams are less than 4.9 feet. Widths of fish-bearing streams (for resident fish with a gradient threshold of 20 percent) are a minimum of about 9.8 feet and increase downstream.

The bankfull flow depth commonly scales with stream size or drainage area. Because an empirical relationship between depth and drainage area is not available for the assessment area, a published relationship for the Oregon Coast Range (Burnett et al. 2003) was used (Figure 3.2-36).

Stream Power and Substrate Size

The size of sediment in channels (cobbles, gravels, pebbles, etc.) is an important determinant of fish habitat quality and availability (Bisson et al. 1987, Everest et al. 1987). Substrate size, particularly the median diameter (D_{50}), can be used to help characterize intrinsic habitat potential for various fish species.

The particle size composition of the streambed can be characterized (and predicted) if the relationship between bed shear stress and particle size is known for a given channel type. This relationship is typically sensitive to specific watershed conditions involving local lithology, stream network geometry, and the nature and timing of disturbances in a landscape. Bed shear stress is calculated in NetMap as the product of channel gradient, flow depth (bankfull or when bedload is in transit), and water density. Then, based on field-measured substrate sizes (within specific watersheds or landscapes), a power law regression between substrate D_{50} and shear stress is created. Particle size values are given for the various substrate name categories (e.g., sand, pebbles, gravel, etc.); in NetMap, the Wentworth (1922) scale is used to define those categories.

The relationship between bed shear stress and particle size in the assessment area is not known. A relationship between shear stress and substrate D_{50} based on a regional regression appropriate for the Pacific Northwest (Buffington et al. 2004) is used for illustrative purposes. However, there may be many departures from this average relationship having to do with specific lithology as well as finer grained substrate due to large-scale mass wasting disturbances (Miller and Benda 2003).

Based on predicted stream power (channel gradient multiplied by drainage area) in the watershed (Figure 3.2-37) and applying the default relationship between stream power and substrate D_{50}, the substrate size is predicted for the watershed (upper subbasin only, Figure 3.2-38). The majority of substrate (defined by the median grain size or D_{50}) is in the gravel to cobble size categories.

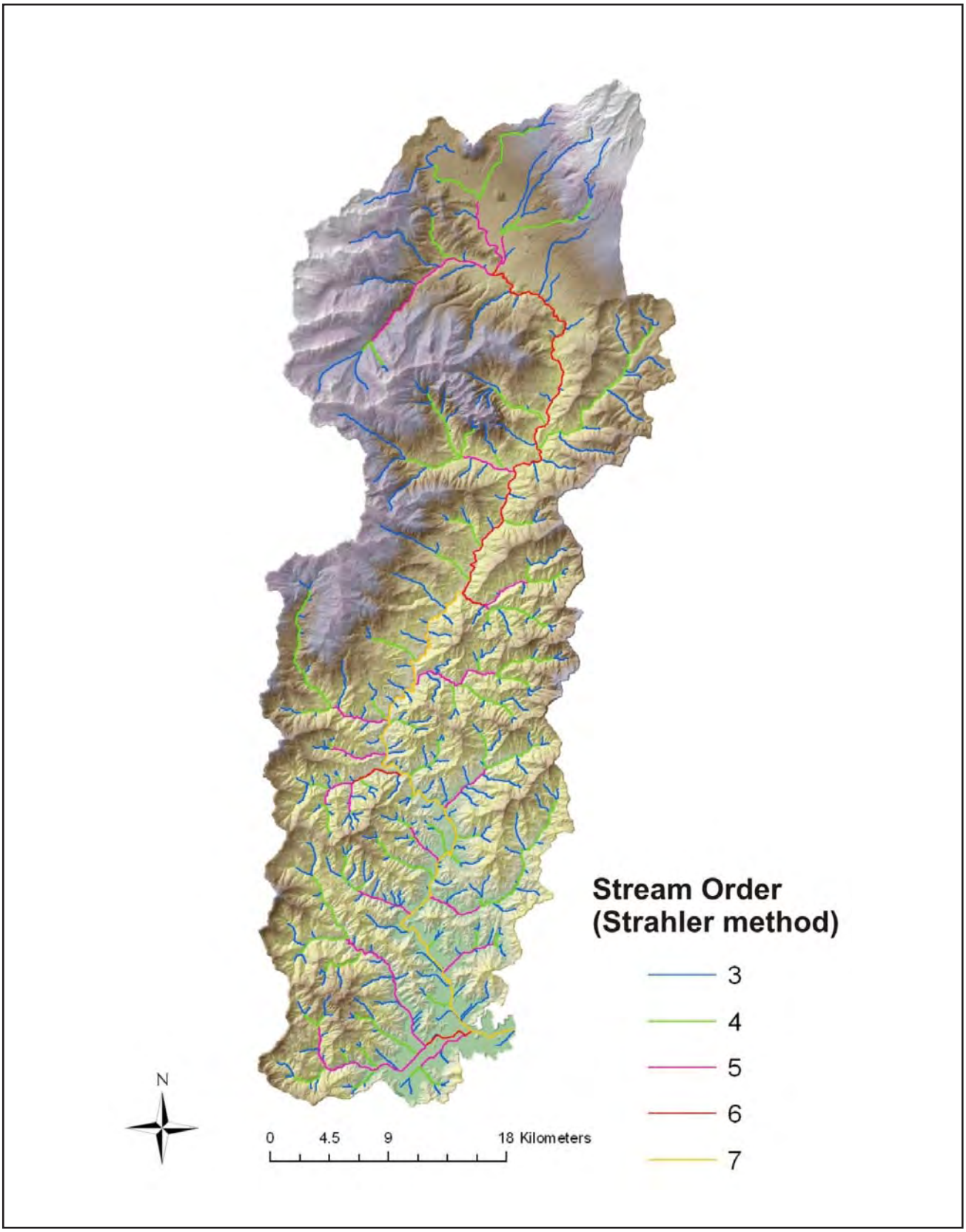

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Figure 3.2-34
Stream Order for the Defined Fish-Bearing Portion of the Assessment Area (Resident Fish <20%)

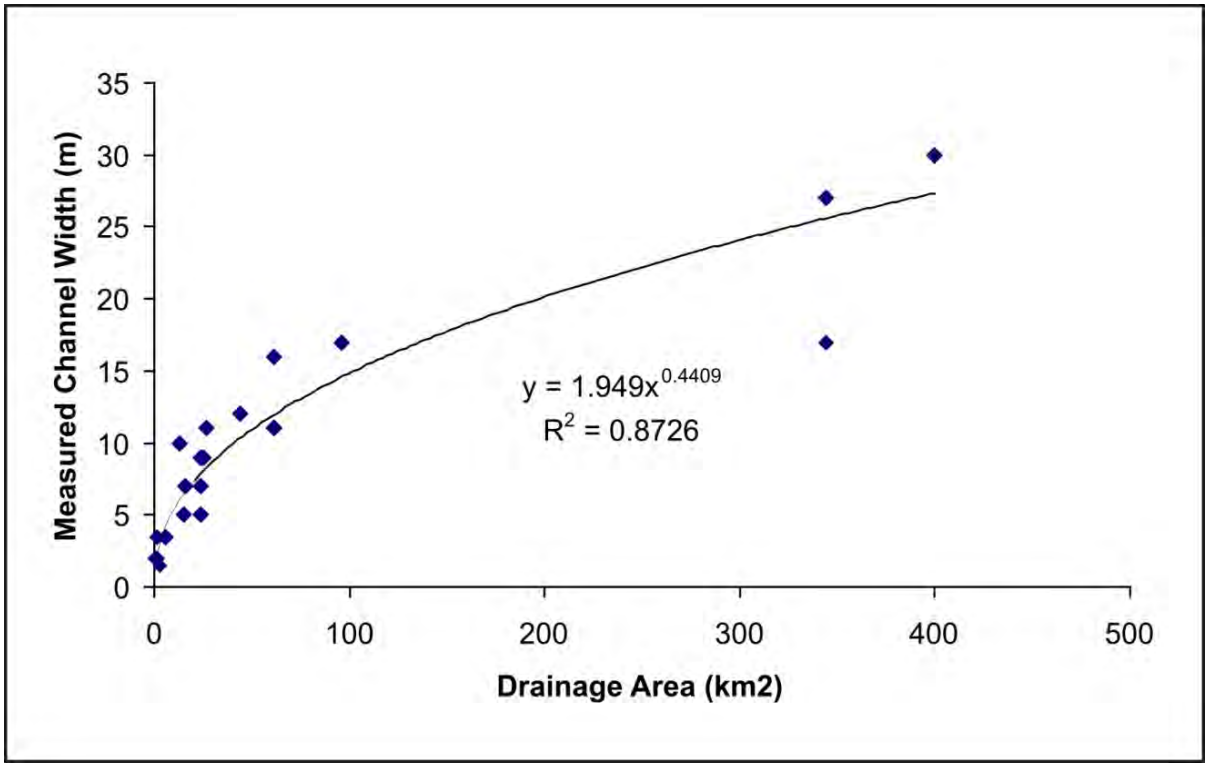

Figure 3.2-35. Relationship of Channel Width to Drainage Area. Channel width (bankfull width) measured in the field plotted against drainage area reveals the typical nonlinear relationship. The regression equation was used within NetMap to assign widths to channel segments based on drainage area. In general, channels cannot be resolved digitally using 10-meter DEMs.

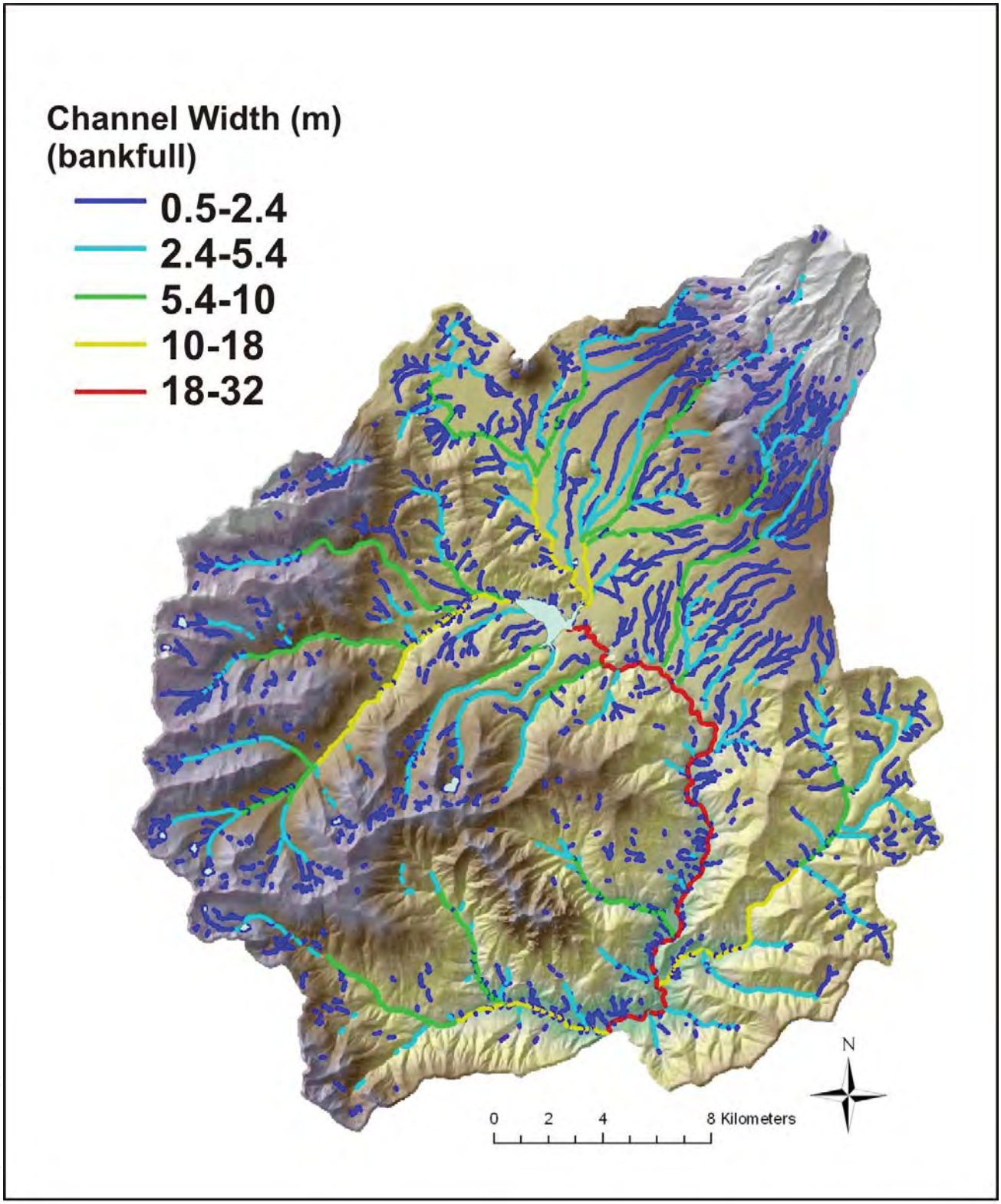

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Figure 3.2-36
Modeled Channel Widths
(Modeled results not field verified.)

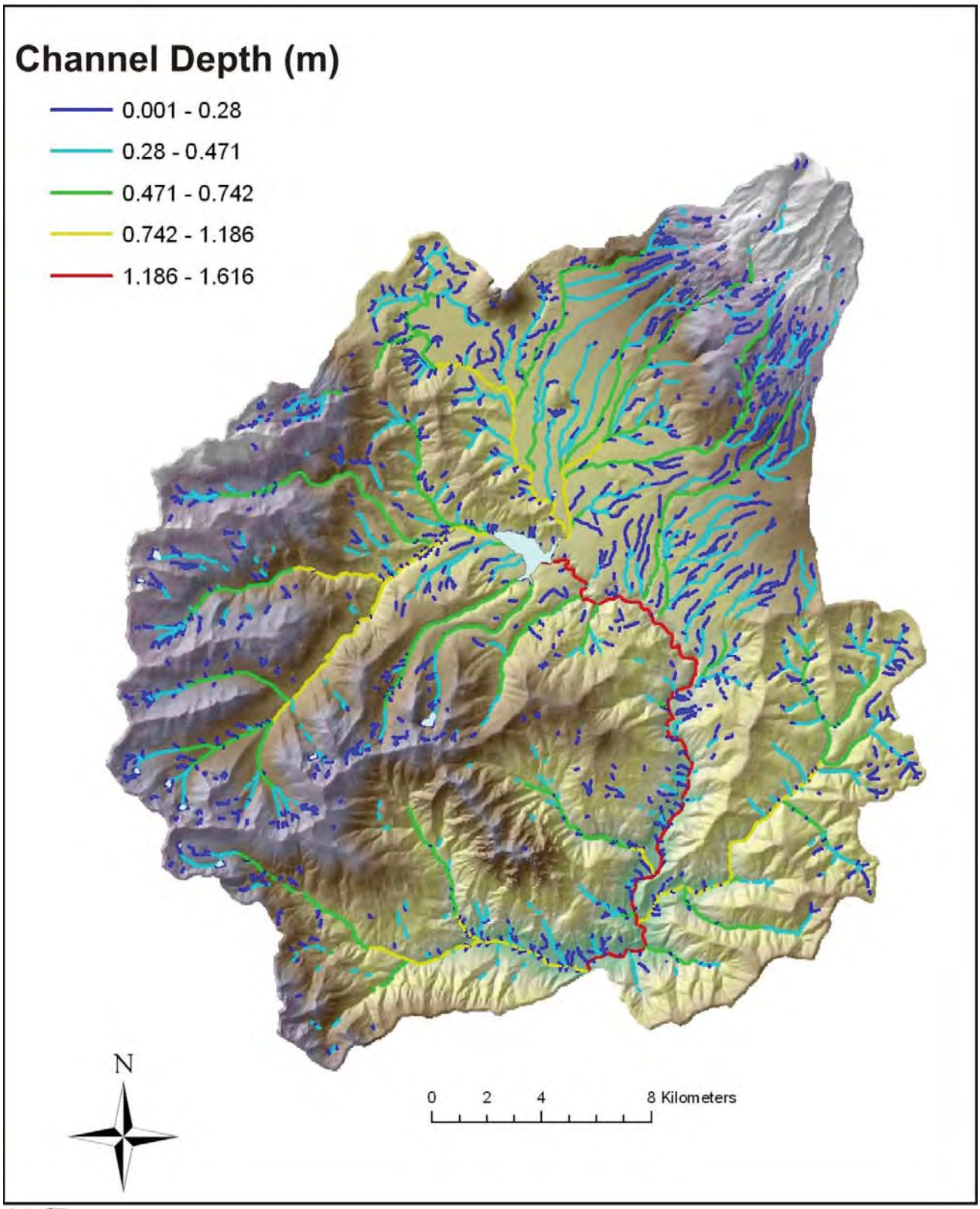

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Figure 3.2-37
Modeled Flow Depth (Bankfull)
(Modeled results not field verified.)

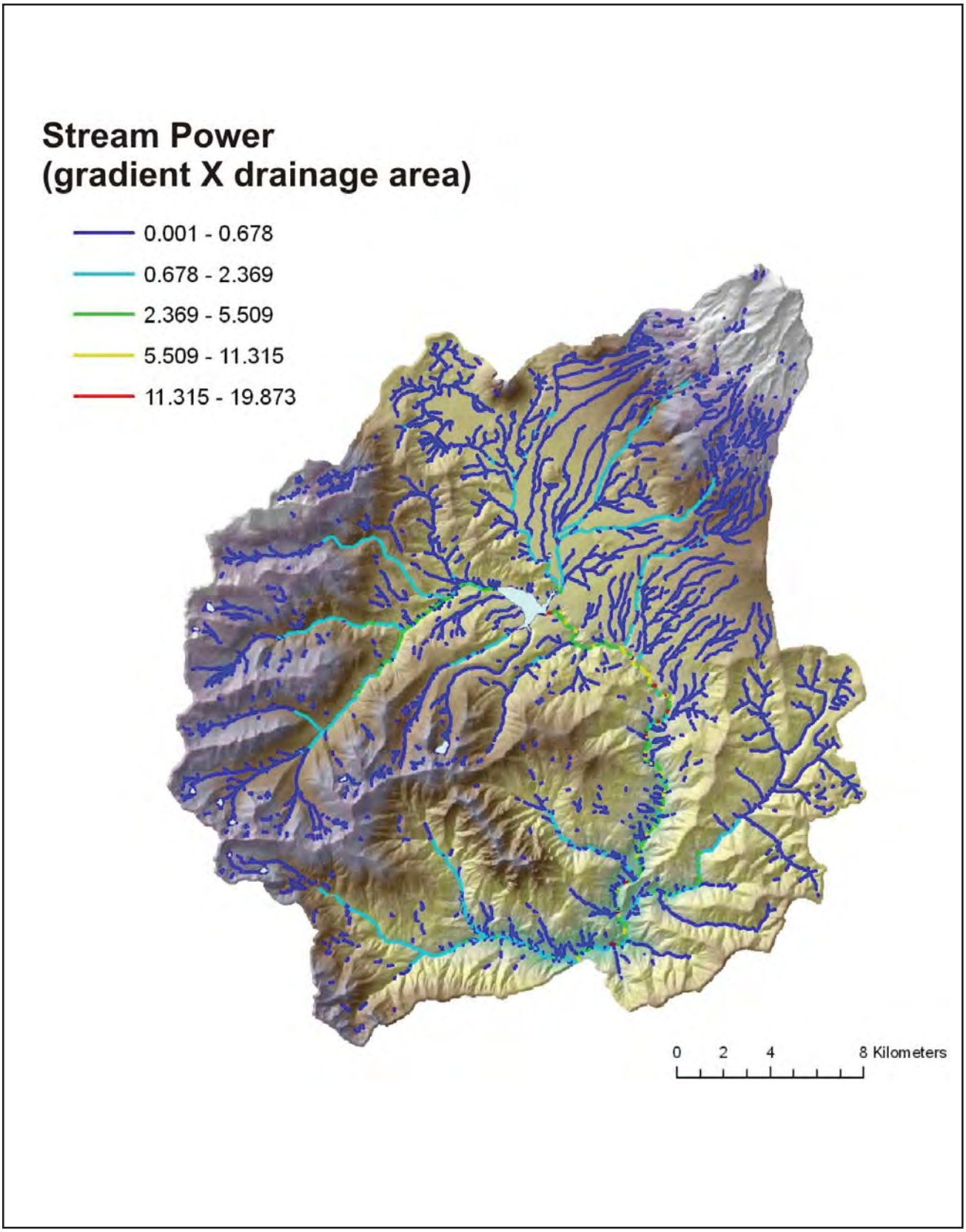

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Figure 3.2-38
Modeled Stream Power
(Modeled results not field verified.)

In-Stream Wood Accumulation Types

Large wood in streams that originates from riparian forests through mortality, bank erosion, and landsliding play an important role in the geomorphology and ecology of streams and rivers (Bisson et al. 1987). Protecting riparian sources of wood to streams is becoming a major component of forestry policy (Bilby and Bisson 2004). Examples include establishing riparian protection zones for wood recruitment (Young 2000), mandating in-stream wood abundance standards or targets (National Marine Fisheries Service 1996), monitoring abundance of wood in streams (Schuett-Hames et al. 1999), and implementing in-stream wood restoration programs (Cedarholm et al. 1997). The processes of forest mortality, bank erosion, streamside landsliding, debris flows, and wildfires govern the supply of wood to streams. An analysis of wood accumulation types in the watershed was not conducted due to a lack of detailed information on riparian forest conditions.

In streams and rivers, large wood in streams can create different types of deposits or accumulations, including (1) individual spanning logs, (2) spanning and partial stream-spanning jams, (3) scattered accumulations on lateral bars, and (4) no wood accumulation (too high energy streams) (Figure 3.2-39). NetMap contains a tool for predicting types of in-stream wood accumulations that can form given the range of drainage areas (surrogate for stream size and stream power) and tree size scaled by channel width. For illustrative purposes, an average tree height of 98 feet is used to predict spatial variation in wood accumulation types in the upper subbasin of the assessment area. For example, the probability of spanning jams in the watershed varies from almost 100 percent to less than zero. The probabilities are used to estimate the most likely type of wood accumulation that would occur across the watershed (Figure 3.2-40).

Floodplains

Floodplain landforms are important for both aquatic and terrestrial wildlife, and thus wider floodplains areas often serve as critical habitats. Wide floodplains also are associated with unconfined channels, and the degree of channel confinement is a parameter in fish habitat potential (see below).

In this analysis, a height above the channel (as detected in a 10-meter DEM) of one channel depth was used to map floodplains (e.g., their approximate locations and dimensions) in the watershed. The results are displayed as both a stream reach attribute (line segments in a GIS) and a polygon showing the variation between left and right sides of the channel (Figure 3.2-41). For example, in the uppermost subbasin, floodplain widths range from less than 17 feet to over 600 feet. In addition, floodplains are non-uniformly distributed across the basin (Figure 3.2-42).

Maps of approximate floodplain locations and dimensions can be used for a variety of purposes in land use management and restoration. For instance, variation in floodplain widths may indicate important geomorphic and ecologic transitions (Figure 3.2-41). The predicted floodplain polygon can be used to identify where roads may intersect floodplains and thus where road surface erosion (and its delivery to streams via floodplains) may be of concern (see Chapter 5).

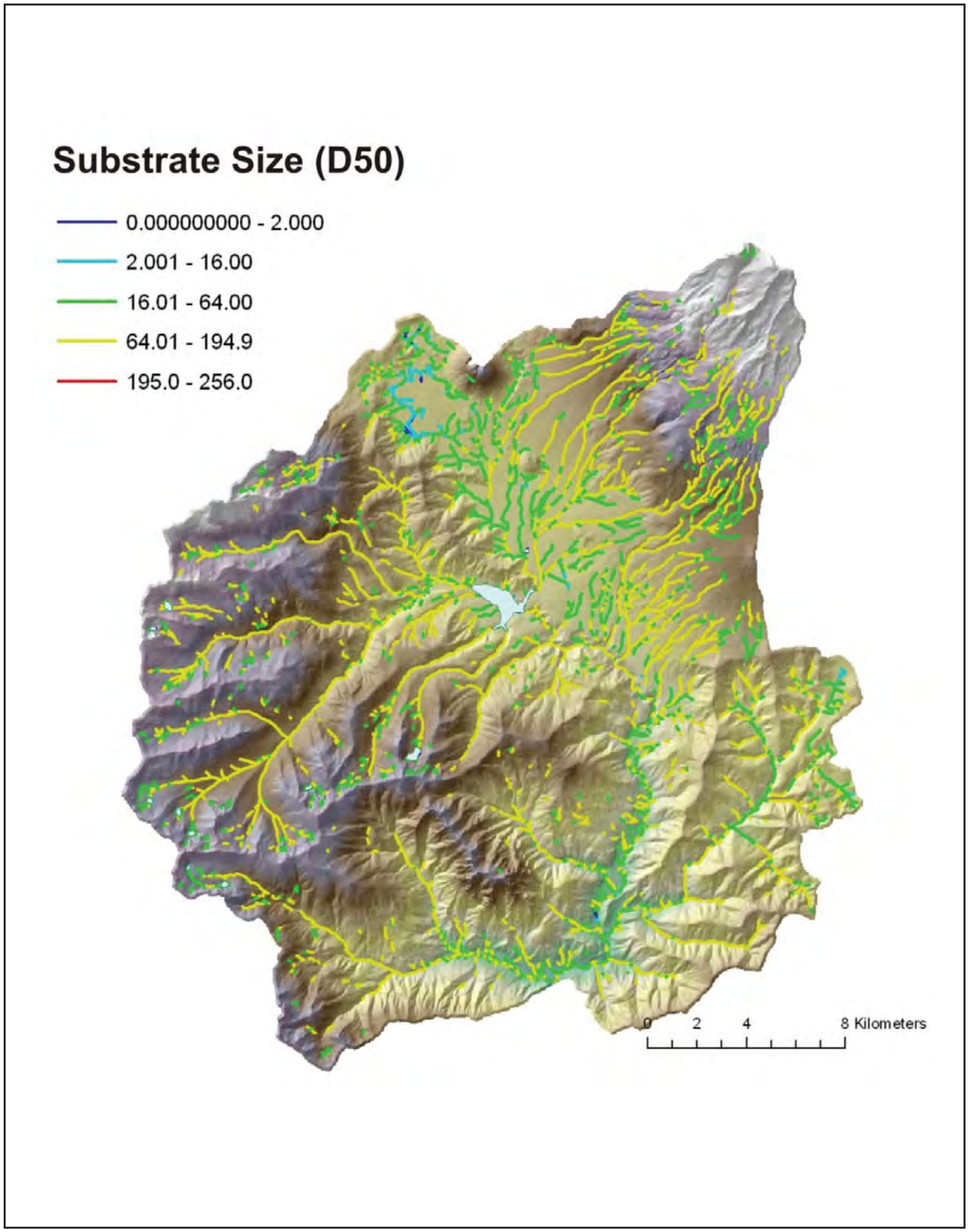

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Figure 3.2-39
Modeled Substrate Size
(Modeled results not field verified.)

NetMap's Woody Debris Accumulation Types

Single Pieces (headwater streams)

Full Spanning Jams

Partial Spanning Jams

Scattered Pieces (on bars)

No Wood Accumulation (high energy)

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Figure 3.2-40
Woody Debris Accumulation Types

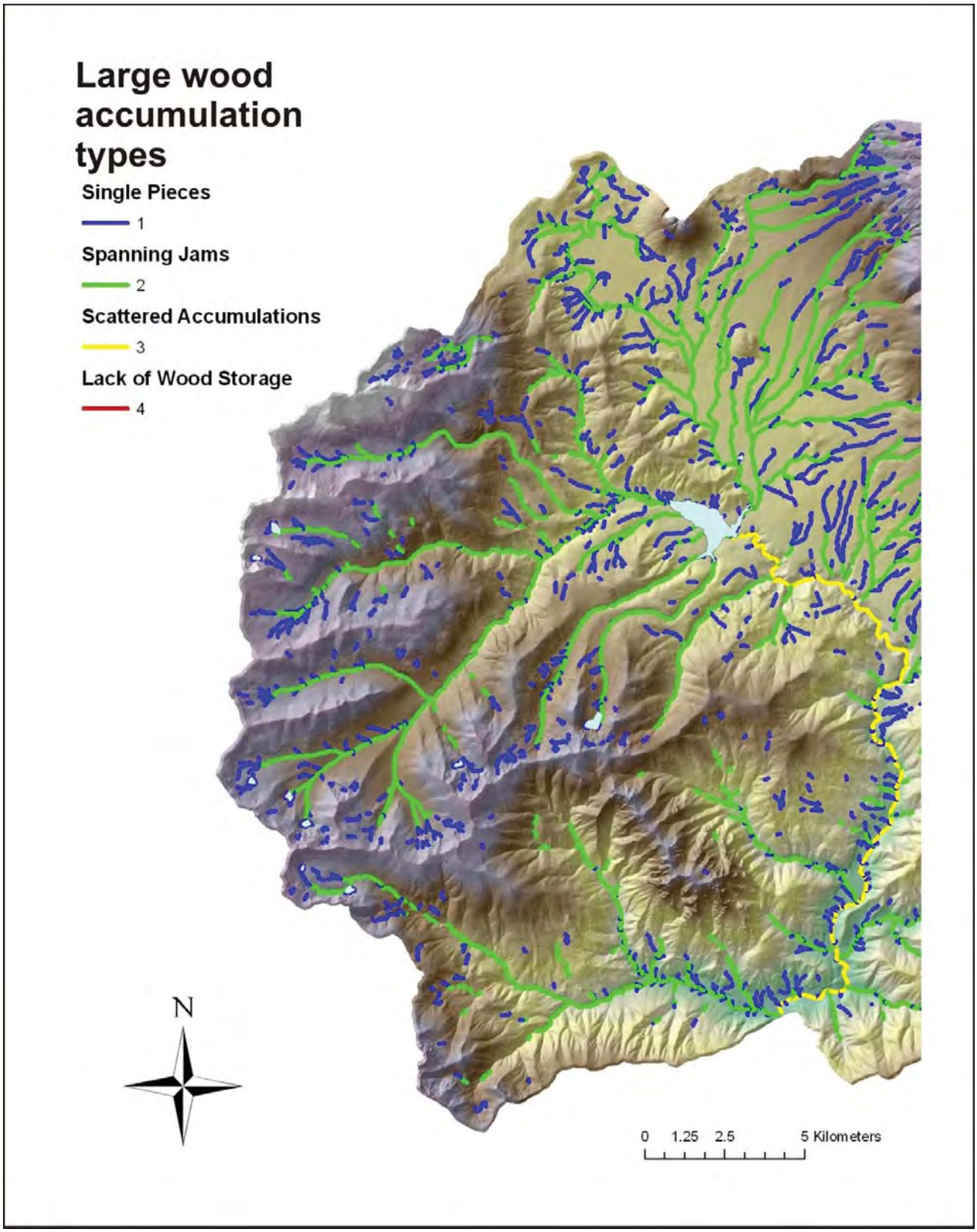

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Figure 3.2-41
Modeled Large Woody Accumulation Types
(Modeled results not field verified.)

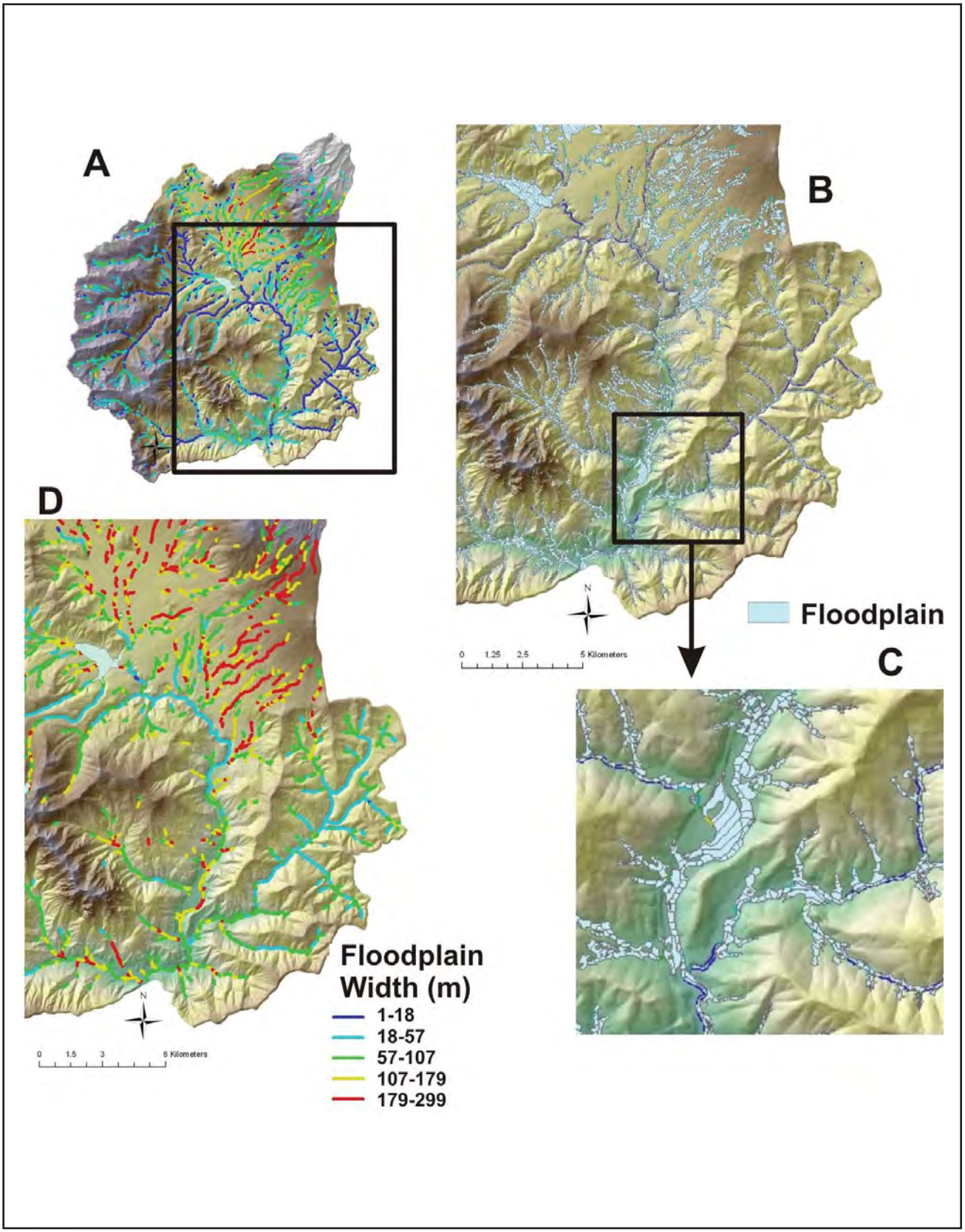

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Figure 3.2-42
Modeled Floodplains
(Modeled results not field verified.)

Tributary Confluence Effects

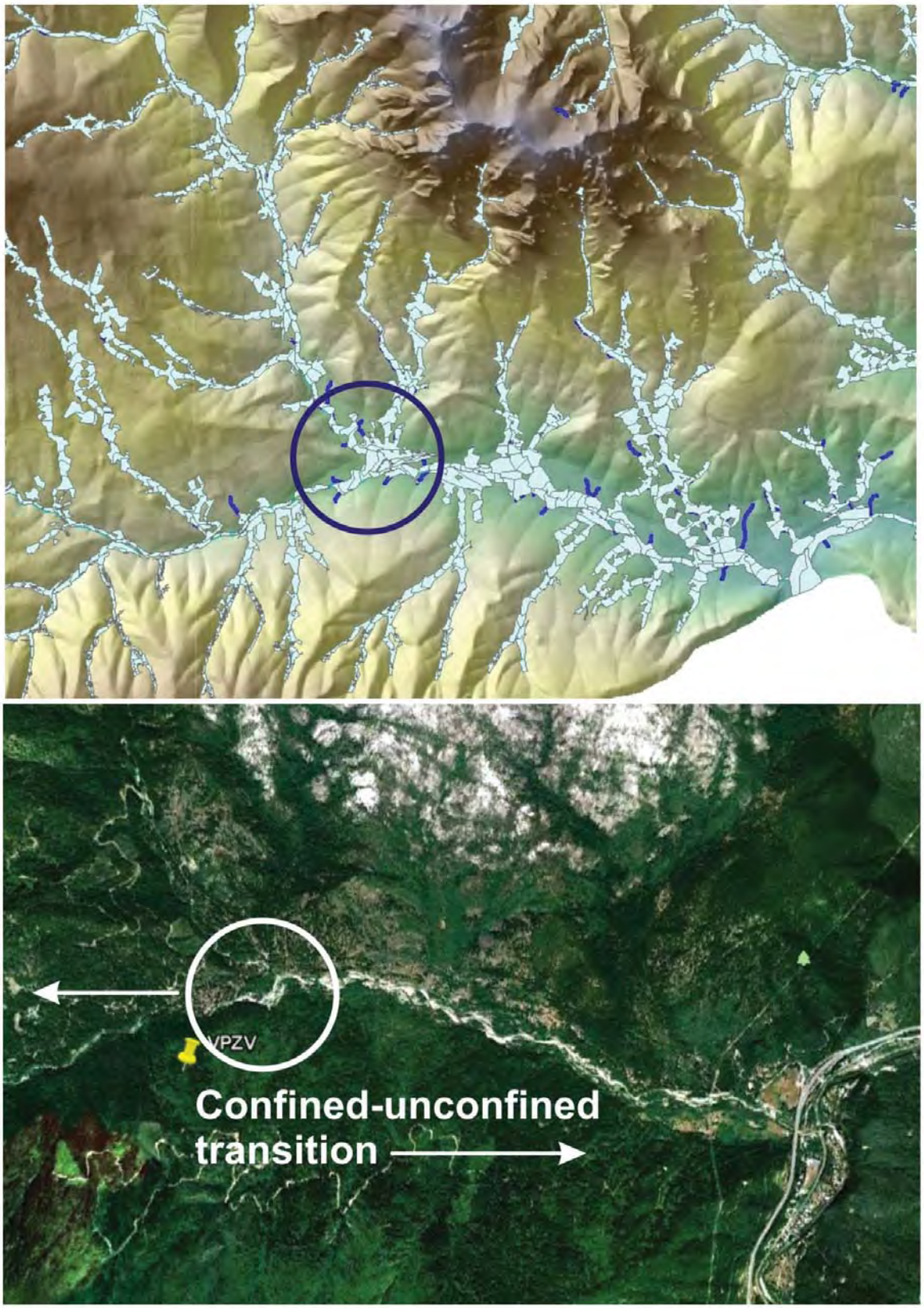
The influence of tributaries on mainstem streams and rivers is well recognized, although not often quantified. Tributaries can deliver higher inputs of nutrients and invertebrates that have been shown to increase primary and secondary productivity in receiving streams at confluences (Kiffney and Richardson 2001). Fish may use tributary mouths as thermal refugia (Scaarnecchia and Roper 2000) or as dispersal corridors that support higher species diversity (Osborne and Wiley 1992). Tributaries also alter the hydraulic geometry of receiving streams, including width, depth, and bar size and occurrence (Best 1988), and they can alter the particle size distribution, either coarsening or fining the channel bed (Rice et al. 2001). Variations in hyporheic exchange also commonly occur at confluences (Baxter and Hauer 2000).

On a somewhat larger morphological scale, topographic knick points in rivers associated with tributary fans and sediment mixing at tributary intersections result in a large variety of morphologic effects at and near confluences, including terraces and wide floodplains, channel meanders and braids, changes in bed substrate including boulder deposits and rapids, deeper and wider channels, mid-channel bars, ponds, and log jams (Church 1983, Grant and Swanson 1995) (Figure 3.2-43).

All nutrient, thermal, and morphological effects can contribute to habitat heterogeneity; hence, tributary confluences can be biological hot spots (Benda et al. 2004a). Consequently, the pattern of the channel network in terms of spacing and size of tributaries in a watershed should influence the non-uniform distribution of certain types of habitats and habitat heterogeneity linked to confluences. For example, geological or topographic constraints on the formation of tributary basins can lead to clumped distributions of intersecting tributaries and associated confluence-derived heterogeneity.

Overall, morphological effects of confluences may tend to be most pronounced in lower-gradient portions of rivers and may decline in steep, narrow valleys where high stream energy quickly erodes fans, or in wide valley floors where fans are isolated from mainstem rivers. In addition, the erosion regime of a watershed, particularly if it is punctuated in time, may influence how tributary confluences affect mainstem channel morphology. NetMap contains a tool for predicting the potential morphological consequences of tributary confluences on channel morphology and aquatic and riparian habitats. In general, the probability of a tributary affecting the morphology of a mainstem river depends on the size of the tributary relative to the size of the mainstem. The empirically based model in NetMap employs logistic regression (based on data from 14 studies in the western United States and Canada) (Benda et al. 2004b). The model was applied to the upper subbasin of the watershed, and it illustrates how channel network geometry leads to spatial variation in confluence effects (Figure 3.2-44).

The extent of confluence-related sedimentary effects in mainstem channels should decrease downstream due to the amount of sediment (and organic) material introduced into the mainstem channel from the tributary. In addition, diffusive sediment transport (e.g., Lisle et al. 2001) should also cause a decay of sediment-related changes downstream of confluences. Tributaries can be viewed in terms of sedimentary links (Rice et al. 2001), with a downstream exponential decay in confluence effects. This concept has been used to describe the decreasing grain size observed downstream of sediment sources (e.g., tributary junctions). To apply this concept in the watershed, the probability of tributary effects (e.g., Figure 3.2-44) is applied to mainstem channel pixels downstream of each tributary junction, with a magnitude that decays exponentially with distance, or



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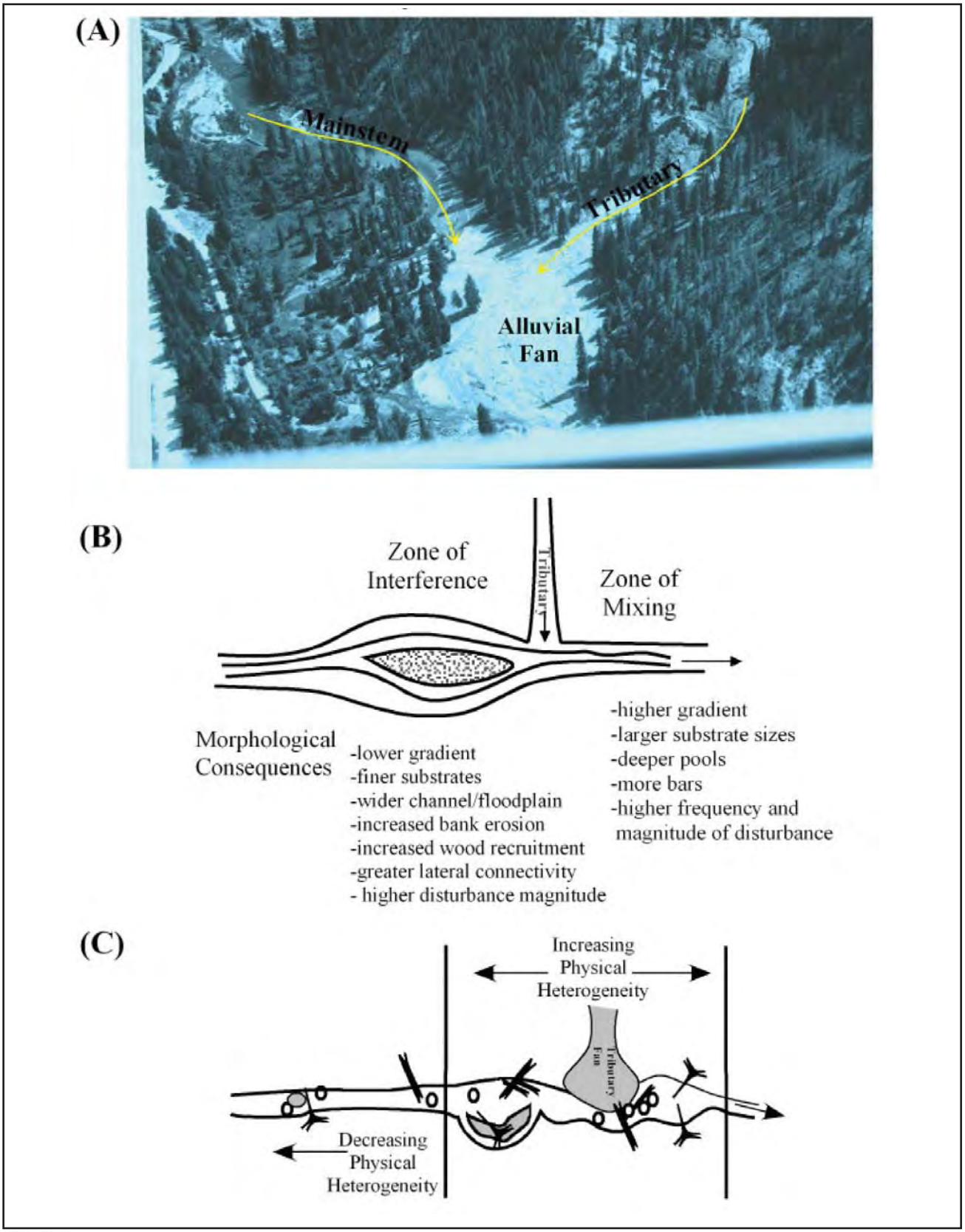
Variations in mapped floodplains (top) can be associated with pronounced changes in channel and valley morphology. The transition of mapped floodplains from narrow to wide corresponds to large changes in channel and valley morphology as seen in Google Earth (bottom).

Figure 3.2-43
Modeled Floodplain Variation
(Modeled results not field verified.)



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Depicted here are sediment-related morphological effects that can occur at confluences both upstream and downstream. Consequently, confluence areas can be zones of higher morphological heterogeneity, although punctuated disturbances cause such effects to wax and wane over time throughout river networks. Post fire erosion and sedimentation creates large fans and confluence effects as shown in the Sawtooth Mountains of Idaho.

Figure 3.2-44
Tributary Confluence Effects

$P_x = P_{x0}e^{-\alpha x}$ P_x is the probability of confluence effect at a distance x downstream from the tributary, P_{x0} is the probability at the tributary (Figure 3.2-44), and α is a decay coefficient. Values reported in the literature span two orders of magnitude, ranging from ~0.05 to 5.0 km^{-1}, and a decay coefficient of 0.5 per square kilometer is used in the illustrative calculation (Figure 3.2-45**)**. The downstream decay of confluence effects is used for predicting channel sensitivity later in this section.

Channel/Habitat Sensitivity

Floods and increased erosion and sediment supply to streams can alter habitats, in some cases degrading them. Channels have different degrees of sensitivity to changes in flow and sediment supply. In general, channels of lower gradient have a greater sensitivity to fluctuations in discharge and sediment supply (Sullivan et al. 1987). Lower gradient channels are more responsive to high flows and higher sediment supply, and they may aggrade and become laterally unstable, resulting in increased bank erosion. Such processes can negatively affect aquatic habitats by filling pools with sediment, by reducing summer low-flow levels (through increased inter-gravel flow), and by increasing fine sediment levels in substrates (Bisson et al. 1987).

An index of channel sensitivity was developed and applied in the uppermost basin of the watershed. The parameters of channel gradient, channel confinement (floodplain width/channel width), and tributary confluence effects (their decay downstream from confluences, e.g., Figure 3.2-45) were used. A commonly applied approach to modeling channel habitat characteristics (Morrison et al. 1998) was used in this exercise. The method involves multiplying the index scores together and then taking the geometric mean of that product. The method assumes that the channel attributes are of approximately equal importance and only minimally compensatory. The index scores, in this case representing channel sensitivity, range from one to zero, with larger values indicating a higher sensitivity. For additional information on the modeling approach, see also Burnett et al. 2007.

The variable weighting applied to each parameter is shown in Figure 3.2-46. For example, the lower channel gradients (0.001–0.02) are weighted the highest (1.0–0.8) while the steepest (and most resistant to change) channel gradients (>0.08) are weighted the least (<0.2). Similarly, unconstrained channels and channels in close proximity to large tributaries are weighted the most. In addition, the parameter of channel gradient was given twice the weight as the other two.

The model reveals significant spatial variability in channel sensitivity across the watershed (Figure 3.2-47). The steeper and more confined streams, particularly those segments located away from large tributary confluences, are predicted to have a low sensitivity. In contrast, lower gradient and unconfined reaches, particularly those located immediately downstream of large tributary confluences, have a higher sensitivity. For instance, the inset box in Figure 3.2-47 illustrates how channel sensitivity abruptly increases in the lower gradient and wider floodplain areas located immediately downstream of a large (high sediment supply) tributary (this area is also characterized by a large floodplain, see Figure 3.2-42).

An index of channel sensitivity could be used to identify which channels (and associated habitats) would be most vulnerable to increases in erosion and sediment supply, conditions that might follow wildfires.

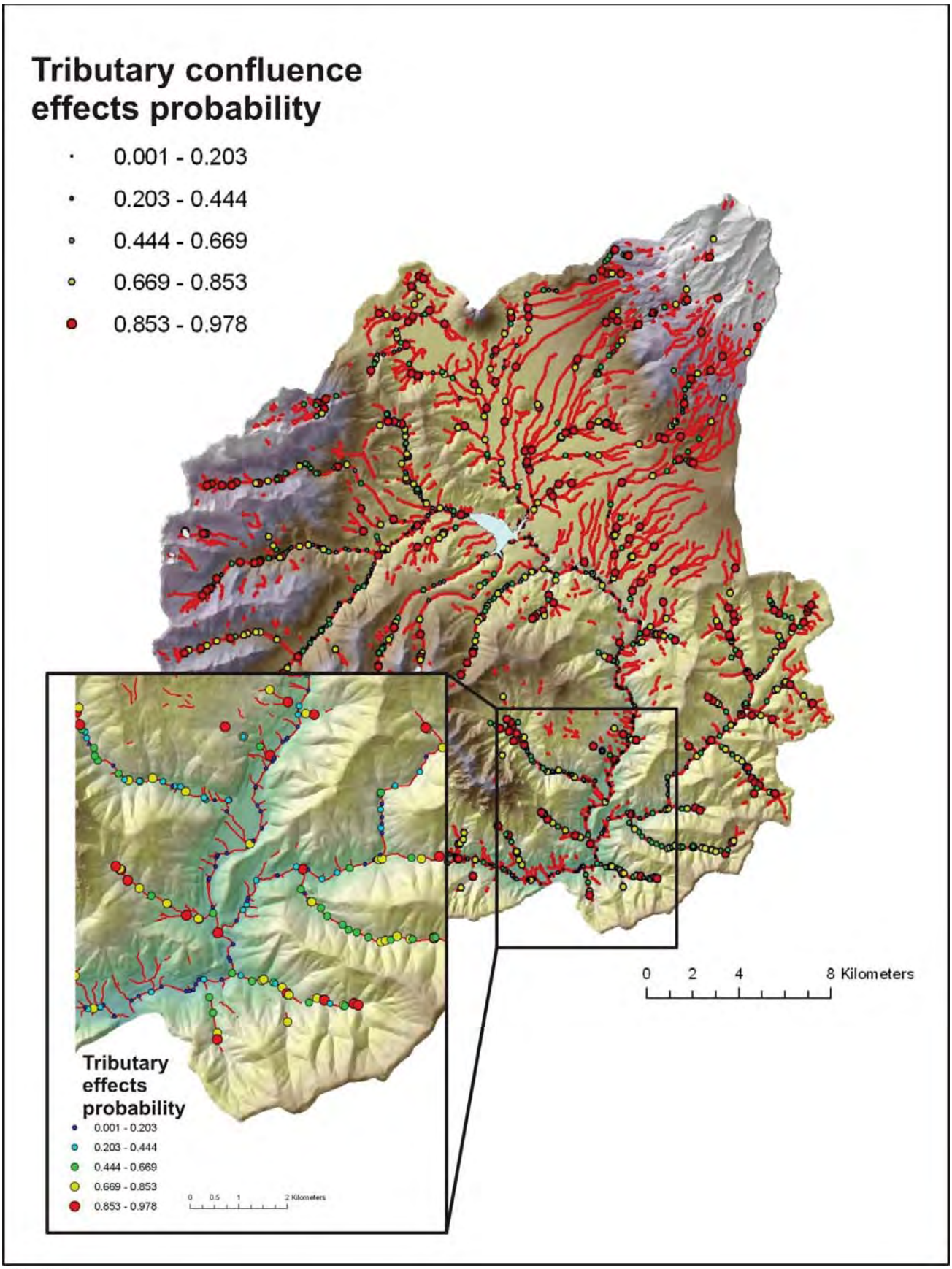

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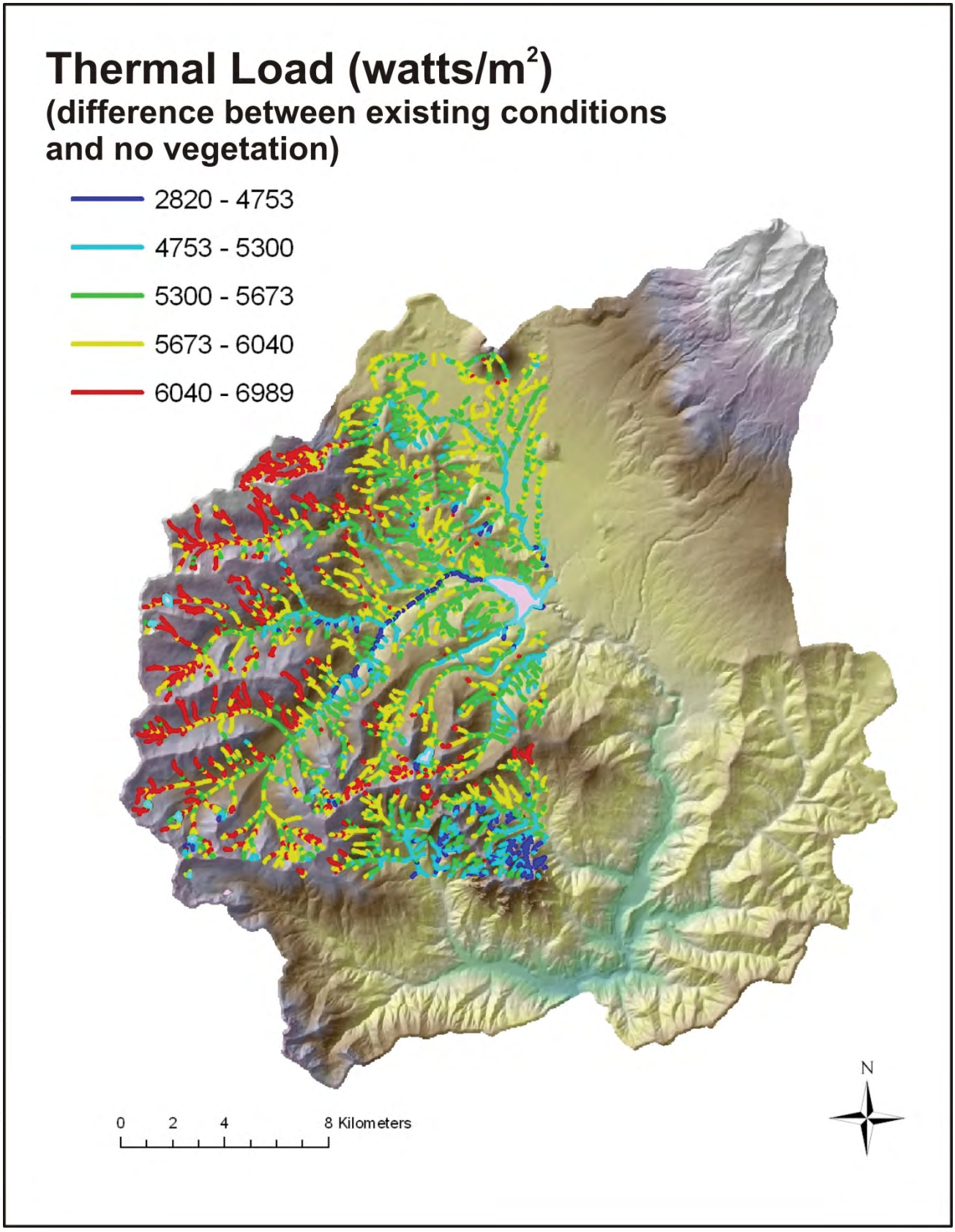
Figure 3.2-45
Modeled Tributary Confluence Effects Probability
(Modeled results not field verified.)



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For this calculation using NetMap's thermal loading tool, an existing condition of 40 m tall trees with a canopy density of 0.75 and a lateral extent on either side of streams of 1000 m (e.g., no timber harvest or fires) is used. The resulting thermal load is contrasted with the thermal load that would occur under no vegetation conditions.

Figure 3.2-46
Modeled Thermal Load
(Modeled results not field verified.)

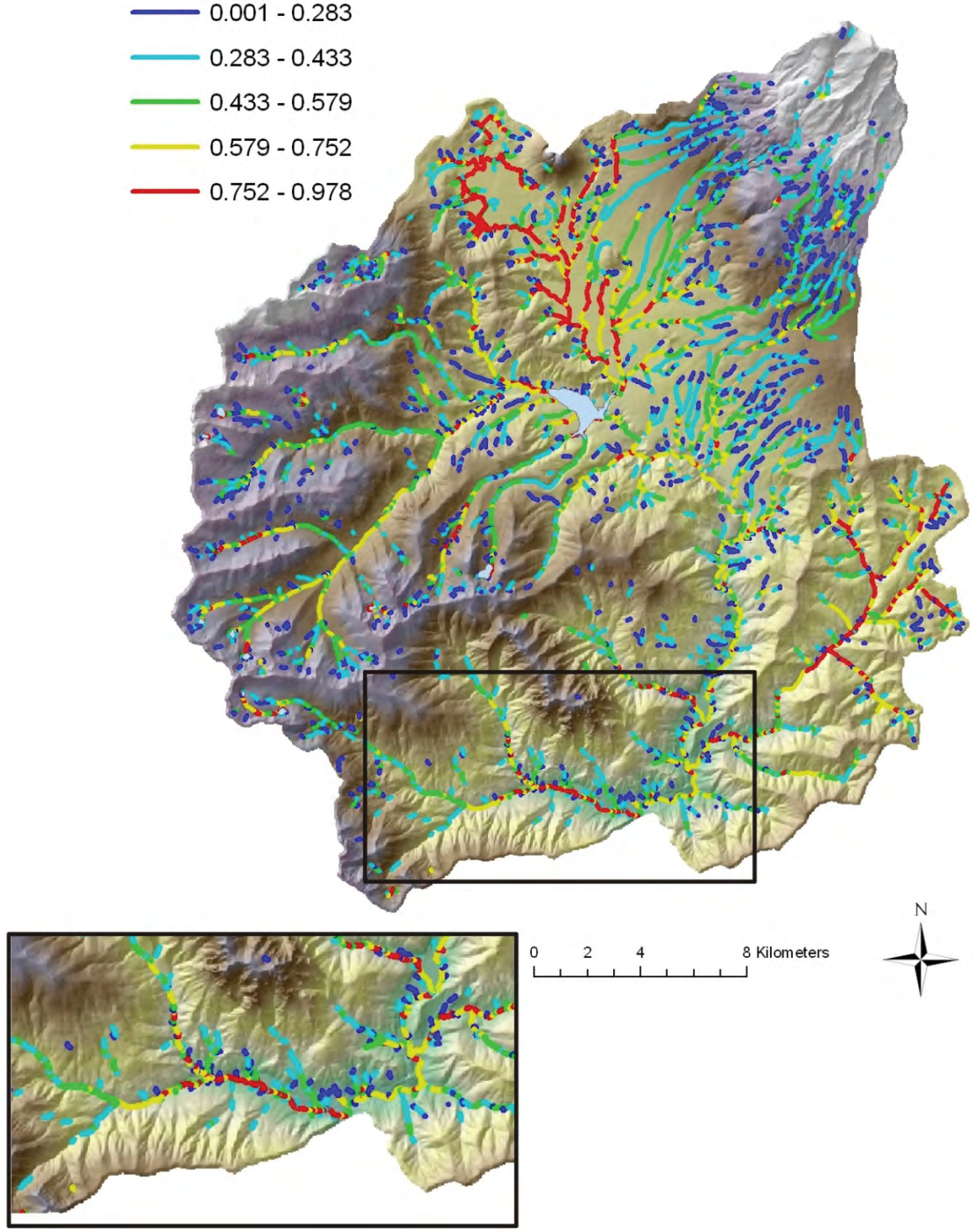

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Figure 3.2-47
ModeledChannel Sensitivity Index
(Modeled results not field verified.)

3.2.6 Hydrology

Surface Water

Hydrologic Setting

The upper Sacramento River watershed drains an area of about 600 square miles and is classified as the Sacramento Headwaters HUC-4 Subbasin 18020005 (Figure 3.2-48). Herein, we refer to the watershed assessment area as the "subbasin" and its component "subwatersheds." The upper Sacramento River has several perennial tributaries, and the mainstem reach of the river is mostly unregulated. Box Canyon Dam is located 29 miles upstream of the upper Sacramento River at Delta stream gauge and is designed to store water for power generation (Figure 3.2-48). The entire subbasin drains to Shasta Lake and is within the upper Sacramento River basin. For this assessment, the subbasin is divided into three watersheds and the available data are summarized accordingly (Figure 3.2-48). Available upland hydrology data are summarized by watershed in Table 3.2-6.

Table 3.2-6. Subbasin Hydrology Subwatershed Attributes

Water-Shed	Subwatershed Name	ID	Drainage Area (Acres)	Drainage Area (Mi^2)	Stream Length (Mi)	Drainage Density (Mi/Mi^2)	Average Elevation (Ft)	Average Stream Gradient (Dec %)
Upper	Cascade Gulch	1001	10946	17	56	0.8	6243	0.16
Upper	Avalanche Gulch	1002	6717	10	34	1	6308	0.13
Upper	Big Canyon Creek	1003	6573	10	62	1.6	4356	0.25
Upper	Lower Wagon Creek	1004	9994	16	32	0.5	4545	0.09
Upper	Spring Hill	1005	6987	11	48	0.9	3786	0.09
Upper	Upper Wagon Creek	1006	2427	4	30	0.1	3978	0.04
Upper	Tom Dow Creek	1007	5773	9	12	0.7	5947	0.14
Upper	North Fork Sacramento River	1008	5676	9	32	1.1	3995	0.14
Upper	Mott	1009	6207	10	57	1.9	2856	0.22
Upper	Scott Camp Creek	1010	7755	12	17	0.4	5556	0.14
Upper	Middle Fork Sacramento River	1011	9006	14	25	0.3	3822	0.08
Upper	Upper Soda Creek	1012	5711	9	30	4.3	3256	0.34
Upper	Lower South Fork Sacramento	1013	4718	7	36	1	4043	0.11
Upper	Ney Springs Creek	1014	5599	9	44	1.8	2614	0.26
Upper	Hedge Creek	1015	4777	7	43	1.5	2852	0.22
Upper	Upper South Fork Sacramento	1016	10079	16	27	0.5	5464	0.15
Upper	Middle Soda Creek	1017	9702	15	24	0.8	3535	0.19
Upper	Little Castle Creek	1018	6592	10	59	1.6	2635	0.24
Upper	Upper Soda Springs	1019	4513	7	37	0.7	3214	0.18
Upper	North Fork Castle Creek	1020	7626	12	30	0.7	4874	0.13
Upper	Upper Castle Creek	1021	11577	18	89	2.4	2334	0.2
Upper	Lower Soda Creek	1022	9580	15	45	2.3	2622	0.26
Upper	Lower Castle Creek	1023	3721	6	22	1.1	3444	0.24
Middle	Sweetbrier Creek	1024	6102	10	27	1.2	3608	0.13

Table 3.2-6. Subbasin Hydrology Subwatershed Attributes

Water-Shed	Subwatershed Name	ID	Drainage Area (Acres)	Drainage Area (Mi^2)	Stream Length (Mi)	Drainage Density (Mi/Mi^2)	Average Elevation (Ft)	Average Stream Gradient (Dec %)
Middle	Flume Creek	1025	6899	11	19	1	4888	0.2
Middle	Mears Creek	1026	5297	8	25	0.9	3840	0.16
Middle	Lower South Fork Sacramento R	1027	8484	13	45	2.6	2428	0.25
Middle	North Fork Shotgun Creek	1028	8952	14	23	0.8	2986	0.17
Middle	Upper Slate Creek	1029	6558	10	28	0.8	5626	0.11
Middle	Boulder Creek	1030	12018	19	44	1	3197	0.14
Middle	Upper South Fork Sacramento R	1031	5526	9	136	2.6	2481	0.27
Middle	Middle Slate Creek	1032	4591	7	38	2.8	3906	0.3
Middle	Lower Slate Creek	1033	5568	9	23	0.8	2825	0.16
Middle	North Salt Creek	1034	15489	24	19	1.1	3148	0.23
Middle	South Fork Slate Creek	1035	3568	6	51	3.6	4116	0.37
Middle	Campbell Creek	1036	2561	4	32	4.7	1934	0.32
Middle	Mosquito Creek	1039	4061	6	55	2.2	2162	0.27
Middle	Upper Dog Creek	1040	7107	11	39	5.1	1870	0.29
Middle	Lower Dog Creek	1042	5644	9	46	4.8	2052	0.3
Lower	Upper Middle Salt Creek	1037	6581	10	54	3.5	2372	0.3
Lower	Campbell Creek	1038	2797	4	37	3.3	1723	0.23
Lower	Lower Middle Salt Creek	1041	4392	7	80	5.5	1963	0.35
Lower	Doney Creek	1043	11033	17	118	4.5	1539	0.25
Lower	Upper Salt Creek	1044	6201	10	54	2.4	2115	0.25
Lower	Charlie Creek	1046	3222	5	38	4.9	2047	0.39
Lower	North Fork Backbone Creek	1047	6764	11	38	1.7	2323	0.29
Lower	Sugarloaf Creek	1048	6575	10	67	3.9	1821	0.31
Lower	Middle Salt Creek	1049	4121	6	35	2.4	1469	0.17
Lower	Lower Salt Creek	1050	3206	5	23	2.9	1315	0.17
Lower	Haycock Peak	1051	716	1	6	3.9	1271	0.18
Lower	South Fork Backbone Creek	1052	5990	9	27	1.1	2211	0.25
Lower	Little Sugarloaf Creek	1053	2303	4	17	2.9	1416	0.32
Lower	Obrien Creek Inlet	1054	5030	8	37	3.1	1269	0.17
Lower	Lower Backbone Creek	1055	11160	17	108	3.7	1959	0.3
Lower	Adler Creek	1056	1257	2	11	5.4	1214	0.28
Lower	Upper Squaw Creek	1058	8438	13	66	2.4	2697	0.28
Lower	Lower Squaw Creek	1059	6169	10	65	4.9	1516	0.29

This table is based on modeled results that have not been field verified.

Generally, there is an overall lack of stream flow data for this subbasin. The surface flow of the upper Sacramento River has been consistently monitored (by the USGS) at only one location (since 1945). The lack of stream flow data at other sites within the subbasin greatly limits our understanding of the water balance. The sole gauge is located just upstream of Shasta Lake at Delta

(DLT) (latitude 40°56′23″ and longitude 122°24′58″) (Figure 3.2-48). Stream flow data from this gauge are used to characterize the annual low flow, high flow, and average flow hydrology of the subbasin.[9] Most of the subbasin, about 425 square miles, is above this gauge, which is located at an elevation of 1,075 feet.

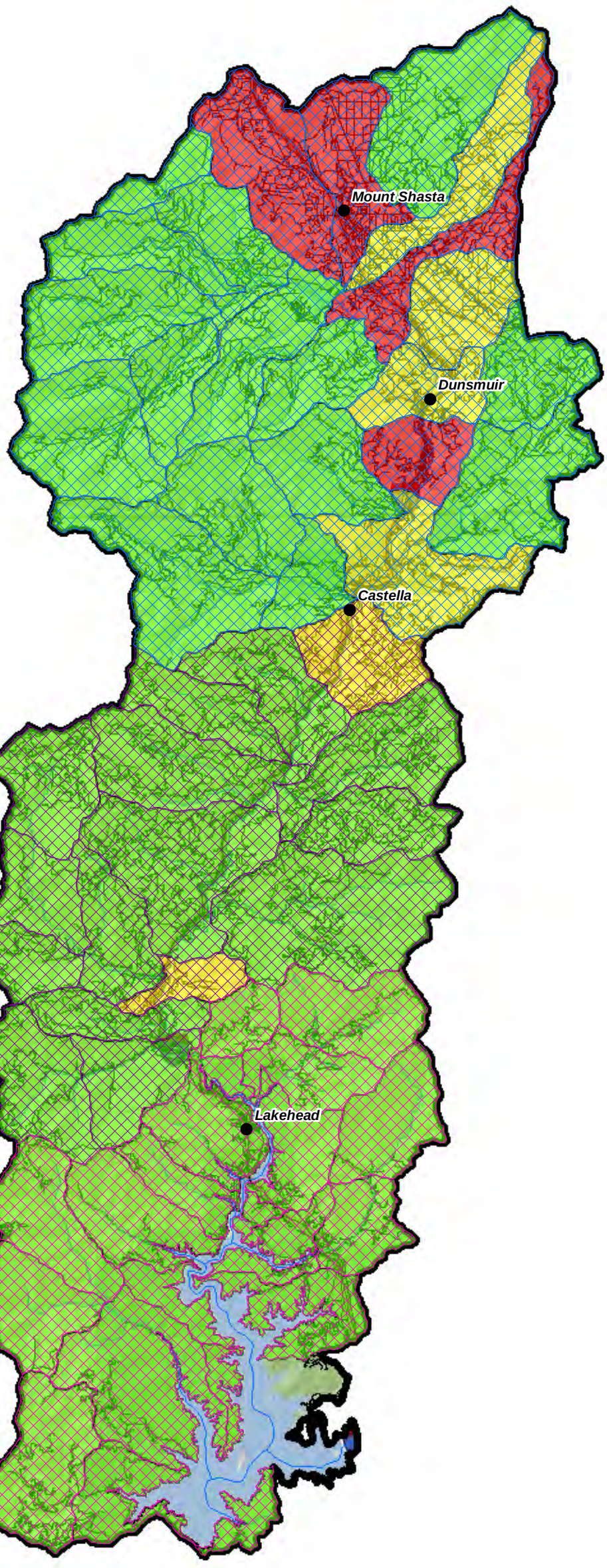
This reach of the upper Sacramento River remained unregulated until 1968, when Box Canyon Dam was put into operation. The mean annual runoff of the upper Sacramento River near Delta for the period of 1945–2009 is 1,191 cubic feet per second (cfs). There is a wide range of annual runoff, with 1977 being the driest year and 1958 the wettest (Figure 3.2-49). There appears to be a statistically significant relationship between years with a deep snowpack and high runoff volume, where 92 percent of time the measured runoff is higher as a function of average snow depth. This relationship is strong for individual years as well as running 7-year running averages. Large flood years do not always correlate as well with wet periods where very large floods have occurred during dryer cycles (e.g., flood of 1996). The highest runoff periods occurred in the late 1950s, mid 1970s, early 1980s, and mid 2000s, coincident with the highest precipitation periods, as described above. There have been several dry spells during the period of record, and overall there are more years below the average annual runoff than above (Figure 3.2-49). The mid 1990s was a particularly dry period, with the lowest consecutive dry years recorded to date. This period's streamflow record correlates well with the precipitation record (Figure 3.2-49).

Compared to other unregulated subbasins in northern California, the watershed has high average annual runoff. For example, Cottonwood Creek near Andersen, California, has a unit runoff of 1.0 cfs per square mile of drainage area, whereas the upper Sacramento River at Delta has a unit runoff of 2.8 cfs per square mile. This is similar to the water yield measured on Mad River near Arcata, California, also with a unit runoff of 2.8 cfs per square mile.

The low flow (i.e., baseflow) of the upper Sacramento River, described herein using the 7-day minimum flow, ranged from 117 cfs in 1977 to 290 cfs in 1958, with an average of 187 cfs for the period of record. Baseflow tends to occur in September and October. The average unit baseflow runoff is 0.4 cfs per square mile of drainage area, with most of this runoff attributable to groundwater discharge. Analysis of the daily stream flow record shows that the operation of Box Canyon Dam has not measurably changed the baseflow discharge of the upper Sacramento River. Since 1968, there has been more annual variability in the 7-day minimum flow.

Flooding in the watershed is most often caused by snowmelt and rainfall runoff. The largest measured flood events have typically occurred in January and February of El Nino weather years. These floods are often caused by rain-on-snow climatic events, where a large cold snow storm is followed by a large warm rain storm and significant snowmelt and runoff occur. The largest measured flood events in the watershed occurred in 1974, 1997, and 2006, with river flows peaking at over 50,000 cfs (Figure 3.2-50). The largest flood occurred in 1974 and peaked at 69,800 cfs. Unlike other subbasins in northern California, the upper Sacramento River watershed did not flood during one of the largest floods in the region, the flood of 1964. The largest flood in the last 15 years,

[9] *The longest record of usable turbidity data is a series of manual turbidity probe measurements taken at DLT about once a month from 1998 to 2010. There are also 20 years of continuous turbidity data available for DLT; however, the continuous data are not presently usable due to technical problems encountered with the probe (Greg Gotham, U.S. Bureau of Reclamation, personal communication).*



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North State Resources, Inc.

Upper Sacramento River Project

Figure 3.2-48
Subwatersheds and ERA
(Modeled results not field verified.)

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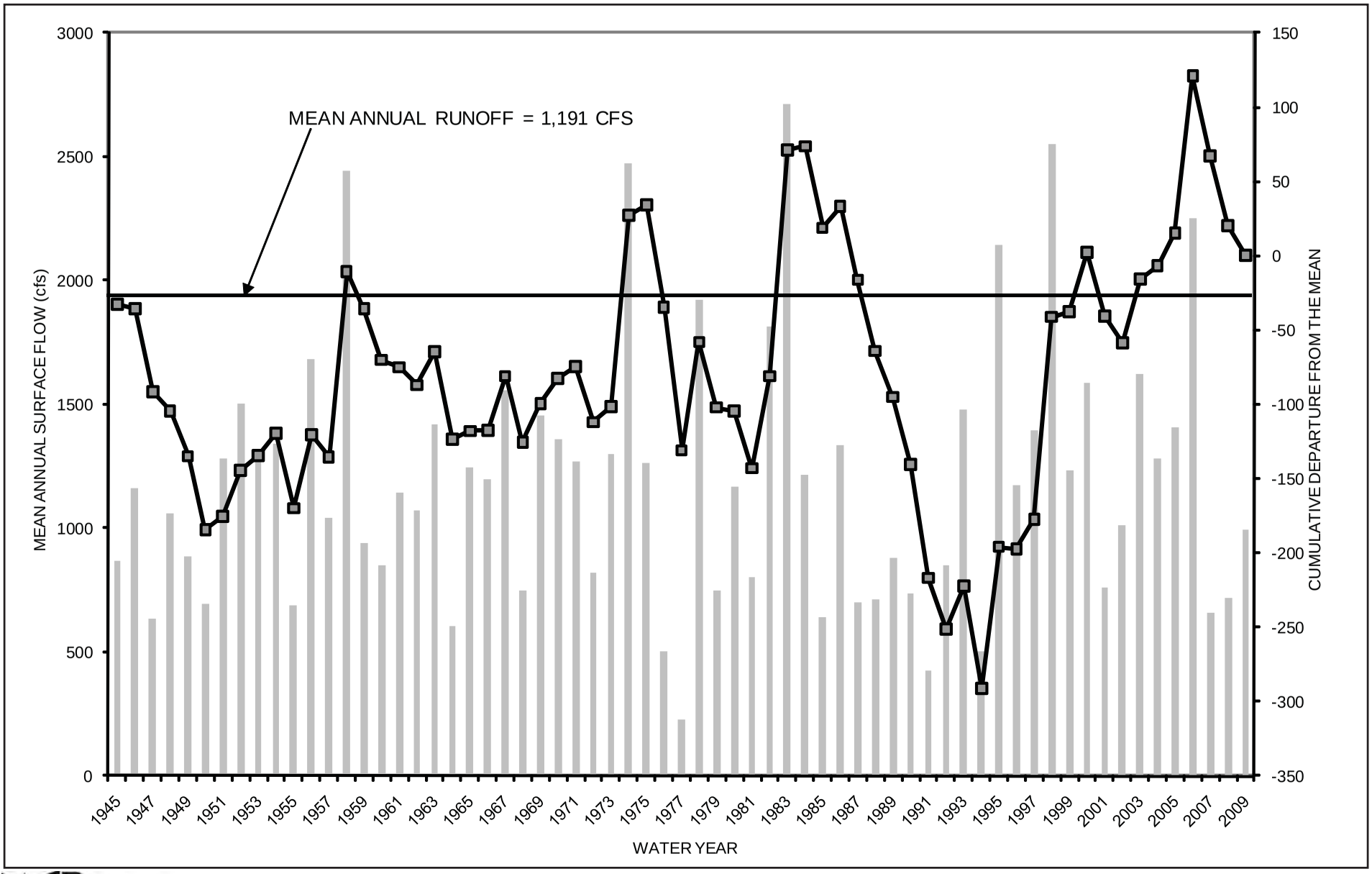

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Figure 3.2-49
Mean Annual Runoff and Cumulative Departure of the Upper Sacramento River near Delta

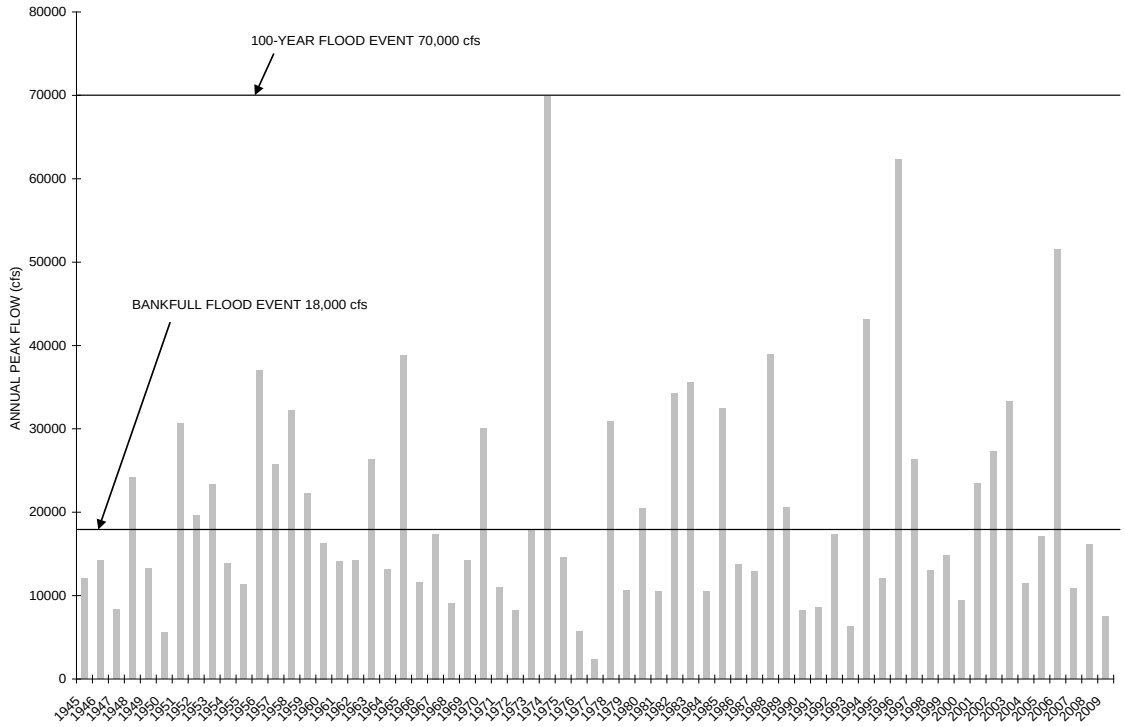

Figure 3.2-50. Peak flood events of the Upper Sacramento River near Delta

known as the flood of 1996, occurred in early 1997, when the entire region flooded. The river peaked at 62,300, cfs which, based on the existing data, equates to a 60-year flood event. The peak bankfull flood event that occurs 50 percent of the time is about 18,000 cfs, and the 100-year flood event that occurs about 1 percent of the time is about 70,000 cfs.

Given the long-term variability in climate and runoff, the significance of the measured flood events of the upper Sacramento River can be evaluated through historical streamflow records. The extensive period of streamflow records for northern California provides an estimate of significant floods prior to 1945. There have been a number of large floods recorded, with the largest occurring in January 1862, which is known to have been a very large—basically a regional—flood similar to the floods of 1964 and 1996. Other significantly large flood events in the region occurred in 1862, 1881, 1890, and 1909. Presumably, most of these floods occurred in this subbasin as well. The available flow data suggest that the flood events measured in water year 1974 and 1997 were the largest floods of record for the upper Sacramento River (DLT gauge period of record). These data suggest that historically, this subbasin has experienced similar floods for at least the last 150 years.

Subbasin Hydrology

For the upper Sacramento River subbasin, there are three watersheds that were used to stratify the assessment area (Figure 3.2-48). Further, watershed attributes were summarized by subwatershed to show the distribution of these attributes within the three watersheds. The subwatersheds are listed in Table 3.2-6. Landform and land use data are summarized for each of the watersheds in Chapter 4.

The shape, texture, drainage pattern, and drainage efficiency of the watersheds are used to qualify and quantify the frequency and magnitude of upland rainfall-runoff relationships. The results of this analysis are used in Chapter 4 to help assess upslope erosion, sediment delivery, and instream sediment transport and storage. Watershed morphometric features are measured using NetMap and 10-meter DEM, including drainage area, maximum and minimum elevation, basin length, stream network length, and channel type. The NetMap model was used to measure the longitudinal profile, distribution of hillslope parameters such as gradient, and drainage efficiency of each watershed and the entire subbasin.

The average subbasin elevation is 3,000 feet, and the average watershed elevation ranges from over 6,000 feet in the upper watershed to about 1,500 feet in the lower watershed (Table 3.2-6). Using the NetMap-generated stream layer, this subbasin has about 2,440 miles of active stream channels. As described above, most of these stream channels are steep, with an average stream gradient of 22 percent. The drainage density is higher in the lower watershed than the upper; near Mount Shasta the average drainage density is less than 1 mile of stream per square mile of drainage area (Table 3.2-6). In the lower watershed, the drainage density is about 5 miles per square mile. Within this subbasin, baseflow does not increase with drainage density and is highest in the northern portion of the drainage where there are fewer stream channels.

The balance between rainfall-runoff and stream channel response are controlled by the types of landforms within the subbasin. Land use activities that create less-permeable ground surfaces, like urban development and road construction, alter the rainfall-runoff balance. Cumulatively, land management activities are known to alter the water balance and can measurably change the magnitude, frequency, duration, and timing of storm runoff (Schumm et al. 1984 and Ziemmer et al. 1991). This assessment created a land use footprint map that combined available land use data into one GIS layer (Figure 3.2-48) to estimate the hydrologic alteration caused by land use activities within the subbasin. This method follows the Equivalent Roaded Area (ERA) method for the Shasta-Trinity National Forest (Shilling et al. 2005). This map includes the following features and is described in more detail in Appendix B:

- major highways
- urban areas and roads
- forest roads
- railroads

Typically, the ERA analysis would include timber harvest. However, within the upper Sacramento River subbasin, the quality of the available harvest data on private lands is too poor to include in this analysis (see data gaps discussion in Chapter 4). The combined land use data for roads and other developed areas were used to create the footprint layer in GIS, and the available data were integrated into NetMap and intersected with the Lithotopo Unit layer (described above) to characterize the relative level of ERA values for the subbasin and three watersheds. Using readily available public data, each type of use feature was classified according to how impervious it makes the ground (see Appendix B). For roads, the impervious area is assumed to be the road prism, and it is also assumed that there is no infiltration within this area (i.e., 100 percent impervious). The same assumption applies to urban areas and the railroad corridor.

The footprint layer was summarized for the subbasin and by watershed. The subbasin average ERA is 4 percent and ranges from 0 to 17 percent. The ERA resulting from roads and urban areas is lower in the upper watershed (Figure 3.2-48) as a result of both the actual land use footprint being smaller and the landforms the uses occur on (the upper watershed has less runoff potential given the climate and drainage patterns). The highest ERA in the watershed occurs in urban areas southwest of Mount Shasta and roaded areas in the middle watershed (Figure 3.2-48). Urban areas, a source of storm runoff, cover about one percent of the subbasin with a maximum of eight percent in the upper watershed. For road related ERA, the Interstate 5 corridor is a large impervious area that measurably increases runoff during rainstorms and accounts for about 10 percent of the ERA from roads. The railroad footprint accounts for about 10 percent as well. Roads on Forest Service and private lands account for 60 percent of the total road ERA, and roads used to access urban areas account for 20 percent of the road ERA.

3.2.7 Water Quality

This section discusses the existing water quality conditions of the upper Sacramento River watershed. The aspects of water quality discussed include the legal basis and authority for water quality monitoring activities, the status of water quality monitoring activities, surface water quality, groundwater quality, and ongoing discharges in the watershed, including point-source and non-point source discharge activity.

Water Quality Monitoring Activities in the Subbasin

Legal Basis and Authority

Most water quality monitoring activities in the watershed are mandated by federal and California law. The primary laws governing water quality in the watershed are the federal Clean Water Act (CWA) and the Porter-Cologne Water Quality Control Act (Porter-Cologne Act) (see Section 2.3, *Evolution of Laws and Regulations Affecting the Watershed*).

Basin Plan

The upper Sacramento River watershed is subject to compliance with the Basin Plan prepared by the Central Valley Regional Water Quality Control Board (Regional Water Board) in 2009. Even though the Basin Plan does not include actual monitoring activity, it is the document that sets the water quality objectives and drives on-going water quality monitoring efforts pertinent to the assessment area. Therefore, the Basin Plan and relevant components are described.

The format for Basin Plans as described in the Porter-Cologne Act follows a logical progression towards water quality protection by

- describing the resources and beneficial uses to be protected;
- stating water quality objectives for the protection of those uses;
- providing implementation plans (which include specific prohibitions, action plans and policies) to achieve the water quality objectives;

- describing the statewide plans and policies which apply to the waters of the region; and
- describing the region's surveillance and monitoring activities (Central Valley Regional Water Quality Control Board 2009).

The 2009 Basin Plan applies to the entire Sacramento and San Joaquin watersheds, covers 27,210 square miles, and includes the entire area drained by the Sacramento River. The Basin Plan divides the upper Sacramento River into three segments: (1) source to Box Canyon Reservoir, (2) Lake Siskiyou, and (3) from Box Canyon Dam to Shasta Lake (Figure 3.2-51). Designated beneficial uses of the upper Sacramento River are listed in Table 3.2-7 and in the Basin Plan (Central Valley Regional Water Quality Control Board 2009). Table 3.2-7 also illustrates whether these beneficial uses currently exist or whether they have the potential to exist.

Table 3.2-7. Upper Sacramento River Beneficial Uses

		AGRI-CULTURE		RECREATION			FRESH-WATER HABITAT		SPAWNING		WILD
		AGR		REC 1		REC 2					
	HYDRO UNIT NO.	IRRIGATION	STOCK WATERING	CONTACT	CANOEING AND RAFTING	OTHER NON-CONTACT	WARM	COLD	WARM	COLD	WILDLIFE HABITAT
Source to Box Canyon Reservoir	525.22	E	E	E	X	E	X	E	X	X	E
Lake Siskiyou	525.22	X	X	E	X	E	E	E	X	P	E
Box Canyon Dam to Shasta Lake	525.2	E	E	E	E	E	X	E	X	E	E

E = Existing beneficial Use
P = Potential beneficial Use
X = Not suitable for use
Source: Adapted from Central Valley Regional Water Quality Control Board (2009)

The beneficial uses of these segments include:

- **Agricultural Supply (AGR).** Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing. This use, specifically irrigation and stock watering, is designated as existing for the following two segments: source to the Box Canyon Reservoir and Box Canyon Dam to Shasta Lake.
- **Water Contact Recreation (REC-1).** Uses of water for recreational activities involving body contract with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Canoeing and rafting is a separate subcategory. This use is designated as existing for all three segments.

- **Non-Contact Water Recreation (REC-2).** Uses of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any likelihood of ingestion of water. These uses include, but are not limited to, picnicking, sunbathing, sightseeing, or aesthetic enjoyment in conjunction with the above activities. This use is designated as existing for all three segments.

- **Warm Freshwater Habitat (WARM).** Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. This use is designated as existing for Lake Siskiyou.

- **Cold Freshwater Habitat (COLD).** Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. This use is designated as existing for all three segments.

- **Spawning, Reproduction, and/or Early Development (SPWN).** Uses of water that support high-quality aquatic habitats suitable for reproduction and early development of fish. Two subcategories, warm and cold, are included to further describe spawning habitat type, but only cold habitat exists within the upper Sacramento River. This use is designated as existing for the Box Canyon Dam to Lake Shasta and is considered a potential use for Lake Siskiyou.

- **Wildlife Habitat (WILD).** Uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources. This use is designated as existing for all three segments.

The Basin Plan identifies both numeric and narrative water quality objectives applicable to the water draining out of the watershed. Table 3.2-8 summarizes the water quality objectives by the categories that have been established by the Regional Water Board to protect the designated beneficial uses. The water quality objectives by specific beneficial uses or individual segments of the upper Sacramento River are individually shown below.

The upper Sacramento River above Shasta Lake is not listed as water quality limited under Section 303(d) of the CWA (Central Valley Regional Water Quality Control Board 2006). For the 36.4-mile reach listed in the Basin Plan, all the beneficial uses are listed as threatened, but supporting (U.C. Davis 2010). The threatened status is related to the suspicion that metals from urban runoff and storm sewers are degrading water quality and threatening beneficial uses. Additionally, significant impacts to water quality have occurred within this reach, namely the Cantara spill of herbicides in 1991 and metals contamination from mine drainage near Shasta Lake.

The Basin Plan identifies water quality objectives for cadmium, copper, zinc, and water temperature that apply to the 36.4-mile reach of the watershed. The Regional Water Board determined that cadmium, copper, and zinc do impair the 25-mile segment of the upper Sacramento River between Keswick Dam and Cottonwood Creek (Regional Water Quality Board 2002). Although this segment of river is not within the watershed, the “impaired” water quality designation is likely a result of metals discharged by acid-mine drainage (AMD) input derived from remnant upstream mining activities (Regional Water Quality Control Board 2002). Water quality objective thresholds for

Mount Shasta
Dunsmuir
Siskiyou County
Castella
Shasta County
Lakehead
Whiskeytown-
Shasta-
Trinity Nra
Whiskeytown-
Shasta-Trinity Nra
3
151
299

Watershed Boundaries
Source to Box Canyon Resevior
Lake Siskiyou
Box Canyon Dam to Shasta Lake

N

0 2 4 8
Miles

G:\Projects\51058 Upper Sacramento River Watershed Assesment\GIS\51058 Figure 3-1-51.mxd Source: NSR, Inc., USGS, IL Created: 04-09-2010 edouglas

North State Resources, Inc.

Upper Sacramento River Project

Figure 3.2-51
Basin Plan Segments of the Upper Sacramento River

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cadmium, copper, and zinc are designated for the segment of the Sacramento River above the Highway 32 Bridge at Hamilton City, which is inclusive of the Sacramento River above Shasta Dam.

Table 3.2-8. Water Quality Objectives for the Upper Sacramento River

CATEGORY	OBJECTIVE THRESHOLD	APPLICABLE PORTION OF WATER BODY
Bacteria	In waters designated for contact recreation (REC-1), the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed a geometric mean of 200/100 ml, nor shall more than 10 percent of the total number of samples taken during any 30-day period exceed 400/100 ml.	Upper Sacramento River
Biostimulatory substances	Water shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.	Upper Sacramento River
Color	Water shall be free of coloration that causes nuisance or adversely affects beneficial uses.	Upper Sacramento River
Chemical constituents	Waters designated for use as domestic or municipal supply shall not contain concentrations of chemical constituents in excess of the limits specified in Title 22 of California Code of Regulations (CCR).	Upper Sacramento River
▪ Cadmium	Waters not to exceed 0.00022 mg/l dissolved concentration.	Sacramento River and tributaries above State Hwy 32 bridge at Hamilton City
▪ Copper	Waters not to exceed 0.0056 mg/l dissolved concentration.	Sacramento River and tributaries above State Hwy 32 bridge at Hamilton City
▪ Zinc	Waters not to exceed 0.016 mg/l dissolved concentration.	
Dissolved oxygen	The monthly median of the mean daily dissolved oxygen (DO) concentration shall not fall below 85 percent of saturation in the main water mass, and the 95th percentile concentration shall not fall below 75 percent of saturation. The dissolved oxygen concentrations shall not be reduced below the following minimum levels at any time:	Upper Sacramento River
	▪ Waters designated WARM 5.0 mg/l	Lake Siskiyou
	▪ Water designated COLD 7.0 mg/l	Upper Sacramento River
	▪ Waters designated SPWN 7.0 mg/l	Box Canyon Dam to Shasta Lake
Floating material	Water shall not contain floating material in any amounts that cause nuisance or adversely affect beneficial uses.	Upper Sacramento River

Table 3.2-8. Water Quality Objectives for the Upper Sacramento River

CATEGORY	OBJECTIVE THRESHOLD	APPLICABLE PORTION OF WATER BODY
Oil and grease	Waters shall not contain oils, greases, waxes, or other materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, or otherwise adversely affect beneficial uses.	Upper Sacramento River
pH	Shall not be depressed below 6.5 nor raised above 8.5. Changes in normal ambient pH levels shall not exceed 0.5 in fresh waters with designated COLD or WARM beneficial uses.	Upper Sacramento River
Pesticides	No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. Discharges shall not result in pesticide concentrations in bottom sediments or aquatic life that adversely affects beneficial uses. Total identifiable persistent chlorinated hydrocarbon pesticides shall not be present in the water column at concentrations detectable within the accuracy of analytical methods approved by the EPA or Executive Officer. Waters designated for use as domestic or municipal supply shall not contain concentrations of pesticides in excess of the limiting concentrations set forth in CCR. Pesticide concentrations shall not exceed those allowable by applicable antidegradation policies (State Water Resources Control Board Resolution No. 68-16 and 40 C.F.R. Section 131.12)	Upper Sacramento River
Sediment	The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.	Upper Sacramento River
Settleable material	Water shall not contain substances in concentrations that result in the disposition of material that causes nuisance or adversely affects beneficial uses.	Upper Sacramento River
Suspended material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.	Upper Sacramento River
Tastes and odors	Water shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, or that cause nuisance, or otherwise adversely affect beneficial uses.	Upper Sacramento River

Table 3.2-8. Water Quality Objectives for the Upper Sacramento River

CATEGORY	OBJECTIVE THRESHOLD	APPLICABLE PORTION OF WATER BODY
Temperature	At no time or place shall the temperature of any WARM or COLD water be increased by more than 5 ˚F above the natural receiving water temperature.	Upper Sacramento River
	From 1 December to 15 March, the maximum temperature shall be 55 ˚F.	Source to Box Canyon Reservoir, Box Canyon Dam to Shasta Lake
	From 16 March to 15 April, the maximum temperature shall be 60 ˚F.	
	From 16 April to 15 May, the maximum temperature shall be 65 ˚F.	
	From 16 May to 15 October, the maximum temperature shall be 70 ˚F.	
	From 16 October to 15 November, the maximum temperature shall be 65 ˚F.	
	From 16 November to 30 November, the maximum temperature shall be 65 ˚F.	
	The temperature in the epilimnion shall be less than or equal to 75 ˚F or mean daily ambient air temperature, whichever is greater.	Lake Siskiyou
Toxicity	All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.	Upper Sacramento River
Turbidity	Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses.	Upper Sacramento River
	Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits:	
	Where natural turbidity is less than 1 Nephelometric Turbidity Unit (NTU), controllable factors shall not cause downstream turbidity to exceed 2 NTU.	
	Where natural turbidity range is 1–5 NTU's, increases shall not exceed 1 NTU.	
	Where natural turbidity range is 5–50 NTU's, increases shall not exceed 20 percent.	
	Where natural turbidity range is 50–100 NTU's, increases shall not exceed 10 NTU's.	
	Where natural turbidity range is greater than 100 NTU's, increases shall not exceed 10 percent.	

Source: Water Quality Control Plan for the Central Valley Region (2009)

Six water temperature objectives are identified (Table 3.2-8) for the entire upper Sacramento River and for the following three segments that comprise the Sacramento River above Shasta Lake: (1) Source to Box Canyon Reservoir, (2) Lake Siskiyou, and (3) Box Canyon Dam to Shasta Lake. The water temperature objectives are numeric and account for temporal fluctuations in ambient water temperature.

The CWA includes provisions for reducing soil erosion relevant to water quality. It makes it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. This pertains to construction sites where soil erosion and storm runoff and other pollutant discharges could affect downstream water quality. The water quality objectives related to sediment are described in Table 3.2-8. For free flowing streams, the turbidity levels are often a function of the suspended sediment, and the water quality objective for turbidity is numeric. Relevant to the assessment area is the relationship between fine sediment and metals. Metals commonly adsorb to clay size particles that are charged, and the fine sediment becomes the transport mechanism delivering metals to the hydrologic system.

Sacramento Watershed Coordinated Monitoring Program

The Sacramento Watershed Coordinated Monitoring Program (SWCMP) is a monitoring effort by the California Department of Water Resources (DWR), Northern District, and the Regional Water Board. The SWCMP is designed to meet the monitoring needs of the Regional Water Board's Surface Water Ambient Monitoring Program (SWAMP) and the DWR Northern District. The purpose of the SWAMP is to implement comprehensive statewide water quality monitoring (Department of Water Resources 2009). The SWCMP program monitors and assesses ambient water quality of the Sacramento River and its larger tributaries at locations from upstream of Lake Shasta downstream to the lower ends of all of the larger tributary streams to the Sacramento River (Department of Water Resources 2009).

SWCMP requires that a minimum of 19 water constituents be measured at each water quality monitoring site either continuously or per sampling event (Table 3.2-9). At a minimum, DWR measures the basic parameters in the field and collects grab samples to be analyzed by DWR's Bryte Laboratory during each sampling event. Additional monitoring of metal and mineral constituents is performed by DWR Northern District but is independent of SWCMP (Department of Water Resources 2009).

Table 3.2-9. SWCMP Water Quality Sampling Parameters

MANDATORY CONSTITUENTS TO BE MONITORED	
Constituent	**Collection**
Water temperature	Continuous measurement every 15 minutes
pH	Measured with pH meter during each sample collection event
Electrical conductivity (EC)	Measured with EC meter during each sample collection event
Dissolved oxygen (DOP	Measured with DO meter during each sample collection event
Turbidity	Measured with turbidity meter during each sample collection event
Total suspended solids	Grab sample; laboratory analysis
Total and dissolved arsenic	Grab sample; laboratory analysis
Total and dissolved copper	Grab sample; laboratory analysis

Table 3.2-9. SWCMP Water Quality Sampling Parameters

MANDATORY CONSTITUENTS TO BE MONITORED	
Alkalinity	Grab sample; laboratory analysis
Total hardness	Grab sample; laboratory analysis
Total ammonia as nitrogen	Grab sample; laboratory analysis
Total Kjeldahl nitrogen	Grab sample; laboratory analysis
Total organic nitrogen	Grab sample; laboratory analysis
Dissolved ammonia	Grab sample; laboratory analysis
Dissolved nitrate + nitrite	Grab sample; laboratory analysis
Dissolved ortho-phosphate	Grab sample; laboratory analysis
Total ohosphorus	Grab sample; laboratory analysis
Total organic carbon	Grab sample; laboratory analysis
OPTIONAL CONSTITUENTS TO BE MONITORED	
Constituent	**Collection**
Water column toxicity	Grab sample; laboratory analysis
Pathogens	Grab sample; laboratory analysis
ADDITIONAL MONITORING BY DWR (NORTHERN DISTRICT) INDEPENDENT OF SWCMP	
Minerals	**Metals**
Total calcium	Total and Dissolved Aluminum
Dissolved calcium	Total and Dissolved Cadmium
Total magnesium	Total and Dissolved Chromium
Dissolved magnesium	Total and Dissolved Iron
Dissolved sodium	Total and Dissolved Lead
Dissolved potassium	Total and Dissolved Manganese
Dissolved sulfate	Total Mercury
Dissolved chloride	Total and Dissolved Nickel
Dissolved boron	Total and Dissolved Selenium
Dissolved hardness	Total and Dissolved Silver
	Total and Dissolved Zinc

Source: California Department of Water Resources (2009)

Upper Sacramento River Water Quality Management Operational Plan (Cantara Trustee Council)

SWCMP has occupied one sampling location, Sacramento River at Delta (DWR station # A2130000), in the watershed above Shasta Lake (Department of Water Resources 2009). Grab samples have been collected at this station on a quarterly basis between 2001 and the present. In addition, DWR station #A2130000 geographically coincides with an existing monitoring station (DLT) that is monitored and maintained by the USGS and the U.S. Bureau of Reclamation. As a result, a continuous record (1-hour sampling interval) exists for dissolved oxygen concentration, water temperature, and turbidity[10]

[10] *The longest record of usable turbidity data is a series of manual turbidity probe measurements taken at DLT about once a month from 1998 to 2010. There are also 20 years of continuous turbidity data available for DLT; however, the continuous data are not presently usable due to technical problems encountered with the probe (Greg Gotham, U.S. Bureau of Reclamation, personal communication).*

of the Sacramento River at Delta. In this discussion, both monitoring sites will be referred to collectively by the acronym DLT.

On July 14, 1991, near the city of Dunsmuir, a Southern Pacific train derailed along a section of track known as the Cantara Loop. A chemical tank car containing the herbicide metam sodium fell into the Sacramento River and released 19,000 gallons of the chemical into the river. As the metam sodium mixed with the water, highly toxic compounds were created. Virtually all aquatic life in the Sacramento River between the Cantara Loop and Shasta Lake was destroyed (2007).

As a result of a lawsuit filed against Southern Pacific, the Cantara Trustee Council (CTC) was established to address the effects of the spill on the upper Sacramento River. In 1996, the CTC granted funding to the Regional Water Board to conduct water quality monitoring and develop an enhanced regulatory program on the upper Sacramento River (Cantara Trustee Council 2007). The CTC's upper Sacramento River Water Quality Management Operational Plan was released in March 1997, and water quality monitoring activities were implemented in 1997 (Cantara Trustee Council 1997). At a minimum, the priority pollutants listed in Table 3.2-10 were monitored.

Table 3.2-10. Minimum Water Quality Monitoring Components of Upper Sacramento River

CONSTITUENT	INITIAL FREQUENCY
Sediment and turbidity	Minimum two per month at selected sites with emphasis during storm events.
Temperature	Continuous recording June through October at 11 sites.
Nutrients and bacteria	Quarterly at 10 locations.
Petroleum products and hazardous materials	Sample urban runoff during the first runoff producing storm event of the season at two locations.
Ambient chronic toxicity	Two screenings will be done in one year.

Under the upper Sacramento River Water Quality Management Operational Plan, water quality monitoring activities continued for five years.

National Water-Quality Assessment Program

The National Water-Quality Assessment Program (NAWQA) is administered by the USGS and is a primary source for long-term, nationwide information on the quality of streams, groundwater, and aquatic ecosystems (U.S. Geological Survey 2001). The NAWQA seeks to improve scientific and public understanding of water quality in the nation's major river basins and groundwater systems.

An assessment of the Sacramento River basin is one of 51 water-quality assessments that have been initiated since 1991 (Domagalski et al. 2000). The results and findings from water quality data collected from 1994 through 1998 were reported in a 2000 USGS report (Domagalski et al. 2000). A second cycle of studies on the Sacramento River basin was scheduled to begin in 2004, but continued water quality monitoring on the upper Sacramento River was not included in the study design.

Although the Sacramento River is studied in detail by NAWQA, there are no NAWQA monitoring sites in the watershed. However, NAWQA is included in this section because the analysis of downstream water quality data has raised some questions about the AMD inputs in the watershed, which will be discussed later.

Surface Water Quality

The water quality of the Sacramento River and its major tributaries supports nearly all beneficial uses most of the time (Domagalski et al. 2000). In general, water quality is exceptional in the watershed. Most of the water in the upper Sacramento River and its tributaries is derived from snowmelt; as a result, the water in the system is relatively pure and low in dissolved minerals (Domagalski et al. 2000). However, storm runoff and AMD from historic mining activities near Little Backbone Creek is a source of cadmium, copper, and zinc to the mainstem river and Shasta Lake (Alpers et al 2000).

Like surface flow data, surface water quality monitoring stations and associated data are severely lacking in the watershed. However, the water quality of the upper Sacramento River can be broadly characterized using existing water quality data from the DLT monitoring site, which has the most complete set of water quality data for the upper Sacramento River. As stated above, the DLT monitoring site is located upstream of the mouth of the upper Sacramento River at Shasta Lake. The site location allows a characterization to be made for the comprehensive water quality of the watershed above Shasta Lake, excluding Little Backbone Creek.

At the DLT site, DWR Northern Division collected grab samples of surface waters on a quarterly basis between 2001 and the present. The surface water samples were tested for 204 different analytes; of these, only 49 analytes were detected (Table 3.2-11). In addition, the USGS collects continuous data (one-hour interval) for dissolved oxygen concentration, water temperature, and turbidity of the Sacramento River at the DLT site. An extensive data set exists for dissolved oxygen concentration and water temperature between 1990 and the present. As stated above, however, the longest record of usable turbidity data is a series of manual turbidity probe measurements taken at DLT about once a month from 1998 to 2010. There are also 20 years of continuous turbidity data available for DLT; however, the continuous data are not presently usable due to technical problems encountered with the probe (Greg Gotham, U.S. Bureau of Reclamation, personal communication). Summaries were created from this data set for dissolved oxygen concentration (Table 3.2-12) and water temperature (Table 3.2-13).

Chemical Constituents

Based on the water data collected by DWR Northern Division (Table 3.2-11), surface water at the DLT monitoring site does not contain any chemical constituents that exceed the objective thresholds set forth in Title 22 of the California Code of Regulations (CCR) during the period of record.

Table 3.2-11. Water Quality Summary of DWR Grab Samples Results from the DLT

CONSTITUENT	UNITS	DATA	TOTAL	CONSTITUENT	UNITS	DATA	TOTAL
Ammonia	mg/L or mg/L as N	Number of samples	10.0	Dissolved zinc	µg/L	Number of samples	21.0
		Average result	0.1			Average result	0.4
		Maximum result	0.1			Maximum result	1.0
Conductance (EC)	µS/cm	Number of samples	18.0	Hardness	mg/L as CaCO3	Number of samples	35.0
		Average result	115.9			Average result	46.7
		Maximum result	159.0			Maximum result	62.0
		Minimum result	66.0			Minimum result	26.0
Dissolved aluminum	µg/L	Number of samples	21.0	pH	pH Units	Number of samples	28.0
		Average result	22.3			Average result	7.4
		Maximum result	191.0			Maximum result	8.6
		Minimum result	1.1			Minimum result	6.0
Dissolved ammonia	mg/L as N	Number of samples	31.0	Total alkalinity	mg/L as CaCO3	Number of samples	28.0
		Average result	0.0			Average result	51.9
		Maximum result	0.0			Maximum result	71.0
		Minimum result	0.0			Minimum result	31.0
Dissolved arsenic	µg/L	Number of samples	21.0	Total aluminum	µg/L	Number of samples	25.0
		Average result	3.1			Average result	80.1
		Maximum result	7.3			Maximum result	598.0
		Minimum result	0.1			Minimum result	4.6
Dissolved boron	mg/L	Number of samples	35.0	Total arsenic	µg/L	Number of samples	25.0
		Average result	0.1			Average result	3.4
		Maximum result	0.2			Maximum result	7.3
		Minimum result	0.0			Minimum result	0.7

Table 3.2-11. Water Quality Summary of DWR Grab Samples Results from the DLT

CONSTITUENT	UNITS	DATA	TOTAL	CONSTITUENT	UNITS	DATA	TOTAL
Dissolved cadmium	µg/L	Number of samples	21.0	Total cadmium	µg/L	Number of samples	25.0
		Average result	0.0			Average result	0.0
		Maximum result	0.0			Maximum result	0.0
		Minimum result	0.0			Minimum result	0.0
Dissolved calcium	mg/L	Number of samples	35.0	Total calcium	mg/L	Number of samples	29.0
		Average result	6.3			Average result	6.5
		Maximum result	9.0			Maximum result	10.0
		Minimum result	4.0			Minimum result	4.0
Dissolved chloride	mg/L	Number of samples	35.0	Total chromium	µg/L	Number of samples	25.0
		Average result	4.0			Average result	1.6
		Maximum result	9.0			Maximum result	6.0
		Minimum result	1.0			Minimum result	0.6
Dissolved chromium	µg/L	Number of samples	21.0	Total copper	µg/L	Number of samples	25.0
		Average result	1.1			Average result	0.6
		Maximum result	2.6			Maximum result	2.4
		Minimum result	0.6			Minimum result	0.3
Dissolved copper	µg/L	Number of samples	21.0	Total dissolved solids	mg/L	Number of samples	34.0
		Average result	0.4			Average result	72.7
		Maximum result	0.9			Maximum result	103.0
		Minimum result	0.2			Minimum result	42.0

Table 3.2-11. Water Quality Summary of DWR Grab Samples Results from the DLT

CONSTITUENT	UNITS	DATA	TOTAL	CONSTITUENT	UNITS	DATA	TOTAL
Dissolved hardness	mg/L as CaCO3	Number of samples	25.0	Total hardness	mg/L as CaCO3	Number of samples	4.0
		Average result	45.9			Average result	45.0
		Maximum result	55.0			Maximum result	53.0
		Minimum result	31.0			Minimum result	39.0
Dissolved iron	µg/L	Number of samples	21.0	Total iron	µg/L	Number of samples	25.0
		Average result	25.9			Average result	100.1
		Maximum result	153.0			Maximum result	716.0
		Minimum result	6.0			Minimum result	9.2
Dissolved lead	µg/L	Number of samples	21.0	Total Kjeldahl nitrogen	mg/L	Number of samples	2.0
		Average result	0.0			Average result	0.4
		Maximum result	0.0			Maximum result	0.4
		Minimum result	0.0			Minimum result	0.4
Dissolved magnesium	mg/L	Number of samples	35.0	Total lead	µg/L	Number of samples	25.0
		Average result	7.2			Average result	0.1
		Maximum result	8.0			Maximum result	0.6
		Minimum result	4.0			Minimum result	0.0
Dissolved manganese	µg/L	Number of samples	21.0	Total magnesium	mg/L	Number of samples	29.0
		Average result	0.9			Average result	7.6
		Maximum result	2.4			Maximum result	9.0
		Minimum result	0.2			Minimum result	6.0

Table 3.2-11. Water Quality Summary of DWR Grab Samples Results from the DLT

CONSTITUENT	UNITS	DATA	TOTAL	CONSTITUENT	UNITS	DATA	TOTAL
Dissolved nickel	µg/L	Number of samples	21.0	Total manganese	µg/L	Number of samples	25.0
		Average result	6.8			Average result	5.6
		Maximum result	12.5			Maximum result	47.7
		Minimum result	3.3			Minimum result	1.3
Dissolved nitrate	mg/L	Number of samples	1.0	Total mercury	ng/L	Number of samples	5.0
		Average result	0.3			Average result	0.6
		Maximum result	0.3			Maximum result	1.0
		Minimum result	0.3			Minimum result	0.4
Dissolved nitrate + nitrite	mg/L as N	Number of samples	35.0	Total nickel	µg/L	Number of samples	25.0
		Average result	0.0			Average result	8.7
		Maximum result	0.1			Maximum result	26.5
		Minimum result	0.0			Minimum result	3.9
Dissolved organic carbon	mg/L as C	Number of samples	3.0	Total organic carbon	mg/L as C	Number of samples	3.0
		Average result	2.0			Average result	3.1
		Maximum result	3.7			Maximum result	6.9
		Minimum result	1.1			Minimum result	1.2
Dissolved ortho-phosphate	mg/L as P	Number of samples	34.0	Total phosphorus	mg/L	Number of samples	35.0
		Average result	0.0			Average result	0.1
		Maximum result	0.0			Maximum result	1.5
		Minimum result	0.0			Minimum result	0.0

Table 3.2-11. Water Quality Summary of DWR Grab Samples Results from the DLT

CONSTITUENT	UNITS	DATA	TOTAL	CONSTITUENT	UNITS	DATA	TOTAL
Dissolved potassium	mg/L	Number of samples	35.0	Total selenium	µg/L	Number of samples	25.0
		Average result	0.8			Average result	0.2
		Maximum result	1.9			Maximum result	0.3
		Minimum result	0.0			Minimum result	0.1
Dissolved selenium	µg/L	Number of samples	21.0	Total suspended solids	mg/L	Number of samples	36.0
		Average result	0.2			Average result	6.8
		Maximum result	0.3			Maximum result	33.0
		Minimum result	0.2			Minimum result	1.0
Dissolved sodium	mg/L	Number of samples	35.0	Total zinc	µg/L	Number of samples	25.0
		Average result	5.7			Average result	1.4
		Maximum result	10.0			Maximum result	6.5
		Minimum result	2.0			Minimum result	0.1
Dissolved sulfate	mg/L	Number of samples	35.0				
		Average result	2.1				
		Maximum result	3.0				
		Minimum result	1.0				

Table 3.2-12. Recorded Maximum Concentrations of Cadmium, Copper, and Zinc at the DLT

CONSTITUENT	MAXIMUM CONCENTRATION THRESHOLD A (MG/L)	MAXIMUM CONCENTRATION AT DLT
Cadmium	0.00022	0
Copper	0.0056	0.0009
Zinc	0.016	0.0065

Table 3.2-13. Recorded Annual Water Temperature Summary at the DLT

YEAR	ANNUAL MEDIAN WATER TEMPERATURE (˚F)	ANNUAL MAXIMUM WATER TEMPERATURE (˚F)	ANNUAL MINIMUM WATER TEMPERATURE (˚F)
1990	56	77	35
1991	50	80	36
1992	53	76	38
1993	48	72	35
1994	52	78	36
1995	52	72	39
1996	50	74	38
1997	54	78	40
1998	49	71	34
1999	51	78	39
2000	50	75	39
2001	51	78	34
2002	52	77	37
2003	51	76	34
2004	52	75	34
2005	50	74	37
2006	48	72	39
2007	51	76	35
2008	50	75	35
2009	51	76	36
Median	50.7	75.5	36.1
Maximum	56.1	80.0	40.1
Minimum	48.1	71.2	33.6

Copper, Cadmium, and Zinc

Surface water at the DLT did not exceed any of the Basin Plan objective thresholds (Table 3.2-11) for dissolved cadmium, copper, or zinc. The Basin Plan specifically identifies objective thresholds for several water quality constituents in the watershed. Cadmium, copper, and zinc are of particular interest because it has been reported that there may be cadmium inputs to the Sacramento River above Shasta Dam and copper and zinc concentrations appear to follow a similar trend (Alpers et al. 2000). In addition, the mainstem reach of the river is listed as threatened by metals input from storm runoff and sewage discharge.

Temperature

The median annual water temperature recorded at the DLT is 50.7 ˚F with a range of between 48.1 ˚F and 56.1˚F. Water temperatures as high as 80 ˚F and as low as 33.6 ˚F have been recorded at the site. In every year of record (Table 3.2-13), the annual maximum recorded water temperature has exceeded all six of the time-specific water temperature thresholds set by the Basin Plan (Table 3.2-9). This fact does not indicate that all of the Basin Plan's maximum time-specific water temperature objectives were exceeded. Rather, it is unknown which time-specific threshold was exceeded each

year and how frequently. However, the maximum water temperature threshold for all objectives is 70 ˚F and the maximum annual water temperature at DLT exceeded 70 ˚F every year during the period of record. As a result, the only conclusion that can be made is that during the period of record the maximum annual temperature of the Sacramento River exceeded one of the Basin Plan's six water quality thresholds.

Dissolved Oxygen

The median annual dissolved oxygen water concentration recorded at the DLT is approximately 10.0 mg/L with a range of between 4.4 mg/L and 11.3 mg/L (Table 3.2-14). Dissolved oxygen concentrations as low as 2 mg/L and as high as 18 mg/L were measured at the site. Using this data, the water of the upper Sacramento River can be characterized as being approximately 95 percent saturated, which suggests it has the capacity to support abundant aquatic life.

Table 3.2-14. Recorded Annual Dissolved Oxygen at the DLT

YEAR	MEDIAN ANNUAL DISSOLVED OXYGEN CONCENTRATION (MG/L)	MAXIMUM ANNUAL DISSOLVED OXYGEN CONCENTRATION (MG/L)	MINIMUM ANNUAL DISSOLVED OXYGEN CONCENTRATION (MG/L)
1990	4.9	15.6	2.0
1991	4.6	10.7	2.0
1992	4.4	15.0	2.2
1993	8.6	12.0	2.0
1994	8.1	18.0	2.0
1995	7.4	12.2	2.1
1996	10.0	15.8	2.3
1997	5.3	10.7	2.0
1998	10.5	17.6	2.0
1999	11.2	16.2	2.0
2000	11.3	14.7	2.0
2001	9.9	15.0	3.0
2002	11.1	17.3	2.0
2003	10.1	15.9	2.1
2004	9.6	15.6	2.0
2005	10.1	13.3	2.6
2006	10.3	14.9	7.1
2007	10.2	15.9	2.7
2008	10.4	15.1	2.0
2009	11.0	16.5	2.9
Median	10.0	15.4	2.0
Maximum	11.3	18.0	7.1
Minimum	4.4	10.7	2.0

For 16 of the 20 years of record (Table 3.2-14), the annual median dissolved oxygen concentration of the Sacramento River at the DLT monitoring station did not fall below Basin Plan thresholds (Table 3.2-9) set for dissolved oxygen. In the years the thresholds were exceeded (1990-1992, 1997),

however, there were large irregularities in the data set, and suspect data points (<2mg/L or > 18 mg/L) were removed from the analysis. Although this did increase the quality of the dataset, the annual median dissolved oxygen concentrations for the aforementioned years were still approximately half of the other 16 annual median values that met Basin Plan criteria. A few explanation for this large variance include: (1) equipment malfunction; (2) equipment placed in area with limited mixing from surface water such as a backwater area; (3) equipment buried by fluvial sediments ; or (4) site was inundated by Shasta Lake due to increased water storage, thus changing the flow regime at the station from flowing water to quiescent water. Even though a definitive explanation for the irregular data is not provided here, all irregularities are likely a result of technical monitoring complications and any characterization of water quality using this data should be done with caution.

Sediment and Turbidity

Sediment and the associated impacts on water quality are a concern in the subbasin and are defined by the State of California as soil, sand, and minerals washed from land into water, usually after rain, that accumulate in reservoirs and streams. Excess sediment commonly degrades fish and wildlife habitat and can cloud water. There are no suspended sediment or bedload data available within the subbasin. There are, however, some turbidity data commonly used as a surrogate for suspended sediment. The turbidity data available for the upper Sacramento River at Delta and Hazel Creek in the middle watershed suggest that since 1998 during low-flow conditions the water clarity is meeting water quality objectives for turbidity, hence sediment (see Appendix B). No other turbidity data are available for other tributaries within subbasin. There are not enough turbidity data available for high-flow conditions to help assess the present sediment load of the subbasin or compare it to water quality objectives. The Basin Plan targets reducing storm water runoff in an attempt to reduce the amount of cadmium, copper, and zinc delivered to the river and lake systems. Trace metals and fine sediment are linked and reducing erosion typically reduces the amount of metals as well. Metals like cadmium commonly adsorb to sediment particles. The Basin Plan sets the stage to identify the occurrence of controllable sediment discharge sources within the subbasin to improve and prevent degrading water quality. Controllable sediment discharge sources are locations or sites that deliver sediment to a stream, are caused by human activity, and may feasibly mitigated.

It was difficult to obtain reliable sediment and turbidity data for the subbasin to help verify the predicted sediment loads and trends. Like for stream flow, there are very limited data available for a subbasin this size (i.e., about 500 square miles). None of the data from the Cantara monitoring listed in Table 3.2-10 were available, and the location of these data is unknown as of the date of this assessment. Turbidity data have been collected over the last 20 years by the BOR at the DLT gauge. However, the turbidity readings taken using a probe are not considered accurate, especially during high-flow conditions. As part of data discovery and analysis review, it was learned that the turbidity data reported on CDEC are not reliable between January and June. SPI provided turbidity records from 2003 to present for Hazel Creek, one of the main tributaries in the middle watershed. These turbidity data are shown in Appendix B.

Groundwater Quality

According to the DWR (Department of Water Resources 2003), groundwater quality in the Sacramento River Hydrologic Region is generally excellent. However, most of the groundwater quality data are collected from areas downstream of the upper Sacramento River watershed and there

are no state-identified groundwater aquifers that fall within the assessment area (Department of Water Resources 2003). There is therefore a lack of groundwater quality data.

In the rural mountains areas of the watershed, domestic supplies come almost entirely from groundwater (Department of Water Resources 2003). A few communities are supplied by surface water, but most communities rely on groundwater supplies for public use (Department of Water Resources 2003). In these regions, groundwater supplies are extracted from highly fractured rocks within the subsurface, but these supplies are highly variable in both quantity and quality (Department of Water Resources 2003).

A majority of the subbasin is underlain by the discontinuous sequences of metamorphic rocks within the Klamath Mountains, and a small area of the northern portion of the watershed is underlain by volcanic deposits of the Cascade Range. The Klamath Mountains, mainly made up of meta-sediment and peridotite rock types, are generally impermeable. Most void spaces capable of storing groundwater are created by fractures and remnant stratigraphic sedimentary features. Overall, the Klamath Mountains bedrock lacks the storage capacity needed to sustain a reliable groundwater aquifer. However, within the northern portion of the subbasin, the volcanic deposits of the Cascade Range are a reliable source of very clean groundwater, as evidenced by the water bottling plants on the flanks of Mount Shasta.

The groundwater quality data that does exist comes from the City of Mt. Shasta Annual Consumer Confidence Report (CCR). A CCR is required when any public water system with more than 10,000 service connections detects contaminants levels above public health goals set by local standards or the State of California (http://www.oehha.ca.gov/water/phg/allphgs.html). The City of Mt. Shasta's public water supply is extracted from one large groundwater spring (Cold Spring) and two groundwater wells within the town limits. Because all the water sources emanate from the subsurface, it is assumed that they can provide some insight into the groundwater quality of the northern portion of the watershed. Brief summaries (Tables 3.2-15, 3.2-16, 3.2-17, and 3.2-18) were created from six years (2003–2008) of CCRs from the City of Mt. Shasta.

Table 3.2-15. Contaminants Detected with a Primary Drinking Water Standard

ANALYTES	SAMPLE YEARS	LEVEL DETECTED RANGE	RANGE OF DETECTIONS	MAXIMUM CONTAMIN-ANT LEVEL (MCL)	PUBLIC HEALTH GOAL (PHG)	TYPICAL SOURCE
Fluoride (ppm)	2002, 2007	0.1–0.12	0–0.12	2	1	Erosion of natural deposits
Chromium (ppb)	2002	1 ppb	1 ppb	50 ppb	N/A	Discharge from steel and pulp mills and chrome plating plants. Also naturally occurring.

Table 3.2-16. Contaminants Detected with a Secondary Drinking Water Standard

ANALYTES	SAMPLE YEARS	LEVEL DETECTED RANGE	RANGE OF DETECTIONS	MAXIMUM CONTAMIN-ANT LEVEL (MCL)	TYPICAL SOURCE
Specific conductance (Umho/cm)	2000, 2004, 2007	62 – 75.8	45–101	1600	Substances that form ions when in water; seawater influence.
Total dissolved solids (ppm)	1993, 2004, 2007	89 – 99	60–101	1000	Erosion of natural deposits.
Chloride (ppm)	2007	0.64	0.19–1.2	500	Erosion of natural deposits.
Zinc (ppb)	2007	71.2	71.2	5000	Runoff or leaching from natural deposits; industrial waste.

Table 3.2-17. Detectable Amounts of Lead and Copper

ANALYTE	SAMPLE YEARS	# OF SAMPLES COLLECTED	REGULA-TORY ACTION LEVEL (AL)	MAXIMUM CONTAMIN-ANT LEVEL (MCL)	90TH PERCENTILE LEVEL DETECTED	# SITES EXCEEDING AL
Lead (ppb)	2006 – 2009	20	15	2	ND	0
Copper (ppm)	2006 – 2009	20	1.3	0.17	0.519	0

Table 3.2-18. Detectable Amounts of Sodium and Hardness

ANALYTE	SAMPLE YEARS	LEVEL DETECTED RANGE (PPM)	RANGE OF DETECTIONS (PPM)	TYPICAL SOURCE
Sodium	2002, 2007	4.28–5.5	2.85–6.0	Generally found in ground and surface water
Hardness	2002, 2006, 2007	23.3–31.0	12.0–31.0	Generally found in ground and surface water

Ongoing Discharges in the Upper Sacramento River Watershed

Regulated Under the National Pollutant Discharge Elimination System

The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. NPDES is authorized by the CWA and is administered by the State of California through EPA

authorization. Point sources are discrete conveyances such as pipes or ditches. Industrial, municipal, and other facilities must obtain NPDES permits if their discharges go directly to surface waters. Facilities may also need to obtain a NPDES permit if they discharge pollutants into a storm sewer system.

Within the watershed, four NPDES permits have been issued for discharge directly into surface waters. Permit information is listed in Table 3.2-19.

Table 3.2-19. NPDES Regulated Point-Source Discharges

NPDES ID	FACILITY NAME	CITY	COUNTY	DESCRIPTION
CA0078441	City of Dunsmuir WWTP	Dunsmuir	Siskiyou	Sewage system
CA0004596	Mt. Shasta Fish Hatchery	Mt. Shasta	Siskiyou	Fish hatcheries and preserves
CA0078051	Mt. Shasta STP	Mt. Shasta	Siskiyou	Sewage system
CAU000133	Southern Pacific Transportation Company	Dunsmuir	Siskiyou	Railroads, line haul operations

Hazardous waste information is contained in the Resource Conservation and Recovery Act Information (RCRAInfo), a national program management and inventory system regarding hazardous waste handlers. Hazardous waste activities are also regulated under the NPDES guidelines. In general, all generators, transporters, treaters, storers, and disposers of hazardous waste are required to provide information about their activities to state environmental agencies. If hazardous waste is not discharged directly into a watercourse, it has the potential to be discharged into groundwater or surface water by seepage or a spill on land.

Within the watershed, 12 hazardous waste handlers have been identified. Hazardous waste handler and facility information is listed in Table 3.2-20.

Table 3.2-20. NPDES Hazardous Waste Handlers

FACILITY NAME	CITY	COUNTY
Caltrans Mt. Shasta	Mt. Shasta	Siskiyou
Caltrans District 2 Bibson Maintenance Station	Dunsmuir	Siskiyou
Caltrans Mt. Shasta Maintenance Station	Mt. Shasta	Siskiyou
CCDA Waters LLC	Mt. Shasta	Siskiyou
Hazmat Cleanup Center	Dunsmuir	Siskiyou
Mt. Shasta Cleaners	Mt. Shasta	Siskiyou
Pacific Bell	Mt. Shasta	Siskiyou
Pacific Bell	Mt. Shasta	Siskiyou
Pacific Bell	Mt. Shasta	Siskiyou
Pacific Bell	Mt. Shasta	Siskiyou
Pacific Bell	Mt. Shasta	Siskiyou
Union Pacific Railroad	Dunsmuir	Siskiyou

Nonpoint Source Discharges

In the watershed, acidic drainage from several copper-zinc mines of the West Shasta mining district flows into Shasta Lake by way of two tributaries, Little Backbone Creek and West Squaw Creek (Alpers et al. 2000). Of the 14 mines identified as potential metal dischargers in the watershed (Regional Water Quality Control Board and California Environmental Protection Agency 2002), 10 mines are upstream of Shasta Dam and five have hydrologic connectivity with Shasta Lake. Data from several studies and from monitoring data from the Regional Water Board suggest that these mines are a significant source of cadmium, copper, and zinc (Alpers et al 2000).

In this document, only the mines on Little Backbone Creek will be discussed. The Mammoth, Golinski, and Sutro mines are estimated to contribute copper loads of 70.55, 1.1, and 0.11 pounds per day, respectively, on an annual basis to Shasta Lake (Alpers et al. 2000). Additionally, it has been reported that a significant portion of the cadmium loads that are present downstream of Shasta Dam may come from Shasta Lake and its tributaries, depending on the flow regime (Alpers et al. 2000).

Nonpoint source regulations cover other types of ground-disturbing activities. Most relevant to the assessment area are construction; timber harvest; and mining regulations and Best Management Practices.

3.3 Biological Components and Processes

3.3.1 Introduction

The upper Sacramento River watershed encompasses a wide diversity of biotic communities (groups of plant, wildlife, and fish populations that interact with one another in the same environment). This diversity results from the large size of the watershed in combination with the variety of landforms, soil types, topography, and microclimates, which have been influenced by natural variation as well as human use and management. The plant species present in a community are generally a response to abiotic (non-living) factors such as climate, topography, and soils, whereas the wildlife species present are largely determined by the plant assemblages. Thus, biological communities are commonly defined in terms of their dominant plant species (e.g., oak woodland, mixed chaparral, annual grassland), and this convention is used in this analysis.

This section describes the biotic communities in the watershed, as well as its sensitive botanical, wildlife, and fisheries resources; invasive and introduced species; and ecologically and culturally important biological resources.

3.3.2 Sources of Data

A variety of literature provided general information on biological resources of interest in the watershed, and the published results of local and regional research applicable to resource issues are discussed. In addition, GIS data layers and spatial analysis of vegetation layers were employed to clarify local patterns.

Vegetation data layers produced by the USFS, Region 5, Remote Sensing Lab (RSL) (USDA Forest Service 2008a) were chosen as the basis for describing communities in the watershed because they

provide comprehensive coverage of the watershed at a consistent scale. In addition, the scale of the imagery is larger (i.e., provides more detail) than that available from other comprehensive sources (e.g., California GAP Analysis). The RSL vegetation mapping team is responsible for producing a comprehensive vegetation database that meets regional and national vegetation mapping standards. A mapping methodology has been developed to capture forest vegetation characteristics using automated, systematic procedures that efficiently and cost-effectively map large areas with minimal bias. However, inaccuracies may occur as vegetation types are assigned based on the use of models and are not 100 percent ground-truthed.[11] The California Wildlife Habitat Relationship (CWHR) and Classification and Assessment with Landsat of Visible Ecological Groupings (CALVEG) classification systems were used to categorize the vegetation data.

To describe the diversity of wildlife species in the watershed, the CWHR database system (California Department of Fish and Game 2008b) was used in combination with information provided by local experts. The CWHR is a predictive system based on scientific information concerning wildlife species and their habitat relationships. Fish and invertebrates are not included in the CWHR system. In addition, the California Natural Diversity Database (CNDDB) was used to identify known occurrences of rare, threatened, and endangered plants and wildlife. Information on known occurrences of invasive plants on portions of the watershed managed by the STNF was provided by the USFS. Information on locally occurring plants, fish, and wildlife was also provided by various experts and persons with local knowledge.

3.3.3 Biotic Communities in the Watershed

As explained in Section 3.1.8, *Fire and Fuels*, vegetation patterns are shaped by the ecological forces at work in a region. Climate, topography, soil, the frequency of natural disturbance, and human management are all driving factors that affect how vegetation is distributed on the landscape.

The watershed straddles two ecological provinces, the Klamath Mountains and the Cascade Range (see Section 3.2.3, *Geology and Soils*, for details on the geology of the watershed) (USDA Forest Service 1997). In the Klamath Province, the complexity of the geology and terrain has a strong influence on the structure, composition, and productivity of vegetation (Whittaker 1960), producing exceptional floristic diversity and complexity in vegetative patterns (Whittaker 1960, Stebbins and Major 1965). The diverse patterns of climate, topography, and parent materials in the Klamath Mountains create a mosaic of vegetation patterns more complex than that found in the Sierra Nevada or Cascade Range (Sawyer and Thornburgh 1977). Indeed, the Klamath-Siskiyou ecoregion, which encompasses a large portion of the watershed, has been designated as "globally outstanding" in terms of biological distinctiveness (Ricketts et al. 1999).

The watershed is characterized by biotic communities typical of the Klamath and California Cascades provinces. The Klamath Province is dominated by Douglas-fir, Douglas-fir/mixed hardwood, mixed conifer, mixed conifer/hardwoods, and ponderosa/Jeffrey pine forests (USDA Forest Service 1999a). The California Cascades Province is dominated by mixed conifer and/or ponderosa pine associations on relatively dry sites (USDA Forest Service 1999a).

[11] *For a complete description of the methods used by RSL, visit http://www.fs.fed.us/r5/rsl/projects/mapping/details.shtml#mud.*

The biotic communities present in the watershed are summarized in Table 3.3-1 and depicted in Figure 3.3-1. Dominant plant species and species composition in these communities vary, with dramatic changes often occurring in relation to aspect, slope, geologic substrate, or juxtaposition with other communities. By far, the dominant community in the watershed is Sierran mixed conifer, covering approximately 46 percent of the total area of the watershed. Mixed hardwood is the next most abundant community, covering approximately 12 percent of the watershed, followed by mixed chaparral, mixed hardwood-conifer, white fir, and lacustrine. The remaining communities each cover less than 3 percent of the watershed.

Table 3.3-1. Biotic Communities Occurring in the Upper Sacramento River Watershed

CWHR HABITAT	ACRES	PERCENT OF TOTAL
Alpine dwarf-shrub (ADS)	182	0.05
Annual grassland (AGS)	3,172	0.83
Barren (BAR)	9,004	2.35
Bitterbrush (BBR)	31	<0.01
Blue oak gray pine (BOP)	2,496	0.65
Closed-cone pine-cypress (CPC)	1,420	0.37
Cropland (CRP)	13	<0.01
Deciduous orchard (DOR)	4	<0.01
Douglas-fir (DFR)	6,666	1.74
Eastside pine (EPN)	3,800	0.99
Fresh emergent wetland (FEW)	3	<0.01
Jeffrey pine (JPN)	386	0.10
Klamath mixed conifer (KMC)	10,464	2.73
Lacustrine (LAC) (Shasta Lake)	15,181	3.96
Low sage (LSG)*	1	<0.01
Mixed chaparral (MCH)	9,316	2.43
Mixed hardwood-conifer (MHC)	27,229	7.11
Montane chaparral (MCP)	28,785	7.51
Montane hardwood (MHW)	47,612	12.43
Montane riparian (MRI)	89	0.02
Pasture (PAS)	52	0.01
Perennial grassland (PGS)*	290	0.08
Ponderosa pine (PPN)	8,517	2.22
Red fir (RFR)	9,114	2.38
Sagebrush (SGB)	2	<0.01
Sierran mixed conifer (SMC)	176,389	46.04
Subalpine conifer (SCN)	2,873	0.75
Urban (URB)	2,777	0.72
Valley foothill riparian (VRI)*	360	0.09
Wet meadow (WTM)	1,117	0.29
White fir (WFR)	15,694	4.10
Total	383,039	

*Although included in the GIS data layer obtained from RSL (USDA Forest Service 2008a), low sage and valley foothill riparian communities are not known to occur in the watershed. The low sage community identified in Figure 3.3-1 is likely mixed chaparral, while the valley foothill riparian community is likely montane riparian. In addition, the perennial grassland community is most likely to be composed of irrigated pastures.

For the purposes of this document, the biotic communities in the watershed have been divided into three general categories: aquatic, riparian, and terrestrial. The function and composition of each type of community is described below. A comprehensive list of wildlife species (not including fish) potentially occurring in the watershed is included as Appendix C. Both common and scientific names of these species are provided in Appendix C. To increase readability, the scientific names of wildlife species other than fish are not included below.

Aquatic Communities

Introduction

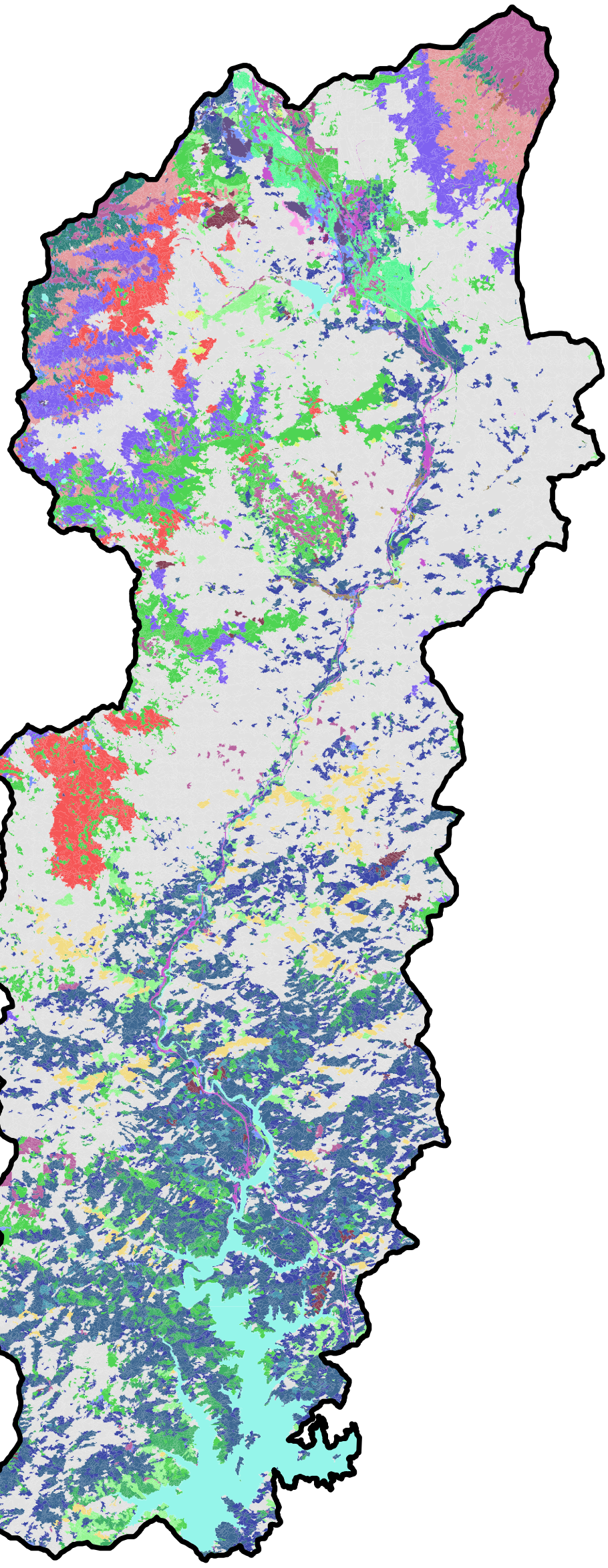
Aquatic ecosystems perform many important environmental functions. For example, they recycle nutrients, purify water, attenuate floods, recharge ground water, and provide habitats for flora and fauna. The aquatic landscape and associated habitat in the upper Sacramento River watershed are diverse and include two reservoirs, 25+ sub-alpine lakes, the south, middle, and north fork of the Sacramento River headwaters (above Box Canyon Dam), the Sacramento River mainstem (below Box Canyon Dam), many perennial tributaries to both the headwaters and river mainstem, and a complex of springs, intermittent steams, seasonal floodplains, wetlands, springs, seeps, fens, and wet meadows. These landforms serve as habitat for many aquatic species and communities. In some cases (e.g., lakes and reservoirs) aquatic communities remain fairly constant throughout the year, though sub-habitat use may vary between seasons (Dr. Sudeep Chandra, personal communication). In other aquatic habitats (e.g., wet meadows, fens, and, wetlands), aquatic communities may be strongly seasonal as well as interannually variable.

Geographic Context

For the purposes of discussing aquatic communities and resources, the watershed can be divided into three geographic subregions: (1) the headwaters (encompassing all portions of the watershed that drain into Lake Siskiyou), (2) the central watershed (generally the drainage areas below Box Canyon Dam and above the Sacramento Arm of Shasta Lake), and (3) Sacramento Arm (the portion of the watershed including and draining into the Sacramento Arm of Shasta Lake). These three regions of the watershed have a number of differences in their physical and biotic characteristics that support distinguishing between them for the purposes of discussion. The utility of this distinction is further reinforced by the existence of a number of differences in land and resource use, management, and research histories.

Headwaters

The headwaters aquatic landscape includes the snowmelt-driven west-side streams and rivers as well as east-side tributaries fed by spring waters from Mount Shasta, all of which drain into Lake Siskiyou. In addition, this portion of the watershed includes 17 sub-alpine lakes. Lake Siskiyou has a surface area of 430 acres and sits at an elevation of 3,200 feet. The alpine lakes range from 50 acres to under an acre in size and from 5,600 to 6,480 feet in elevation. Also contributing to the diversity of the headwaters aquatic landscape are numerous wet meadows, seeps, fens, and other wetlands. In addition to these features, there are a number of constructed ponds (including some for trout propagation), pools, and diversions/ditches. Of the available aquatic habitat in the headwaters, one reservoir, 15 alpine lakes, and approximately 66 miles of streams contain fish (USDA Forest Service



Watershed Boundaries
ADS
AGS
BAR
BBR
BOP
CPC
CRP
DFR
DOR
EPN
FEW
JPN
KMC
LAC
LSG
MCH
MCP
MHC
MHW
MRI
PAS
PGS
PPN
RFR
SCN
SGB
SMC
URB
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North State Resources, Inc.

Upper Sacramento River Project

Figure 3.3-1
Vegetation Communities

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2001b). This habitat as well as the other available aquatic habitat is also home to a variety of other aquatic fauna of interest, including planktonic organisms, invertebrates (native and introduced), and amphibians.

Central Watershed

The central watershed drains into the mainstem Sacramento River between Box Canyon Dam and the Sacramento River Arm of Shasta Lake. It includes many precipitation- and spring-fed tributaries, both perennial and intermittent, joining the Sacramento mainstem from both the west and the east. Also contributing to this portion of the watershed are eight lakes as well as several constructed ponds, ditches, and diversions. Wetland habitats, including seeps, wet meadows, and seasonal floodplains are also present in this portion of the watershed.

Sacramento Arm (Shasta Lake)

At the southern end of the watershed, the Sacramento Arm encompasses a portion of Shasta Lake, the largest human-made reservoir in California. Shasta Lake has a surface area of approximately 30,000 acres, a storage capacity of 4,550,000 af, and a maximum depth of 517 feet (USDA Forest Service 2006).

Aquatic Communities

The discussion of aquatic communities and their key species has been sequenced hierarchically, beginning at the base of the foodweb and progressing up to higher level consumers (i.e., microbes and planktonic organisms, invertebrates, amphibians and aquatic reptiles, and fish and fisheries). Of the special-status species present in the watershed (Table 3.3-3), seven are aquatic. Of these seven, three are fish species (rough sculpin (*Cottus asperrimus*), hardhead (*Mylopharodon conocephalus*), and rainbow trout (*Oncorhynchus mykiss*)), three are amphibians (Cascades frog, foothill yellow-legged frog, and tailed frog), and one is an aquatic reptile (northwestern pond turtle). In addition to these, several other species are considered species of interest for the purposes of this analysis. This inclusion is generally based on the species' unique history in the watershed, importance as game species, or relationship to a specific habitat type of interest. Additional information on special-status species occurring or potentially occurring in aquatic habitats in the watershed is provided in Section 3.3.4, *Plants, Wildlife, and Fish of Ecological/Cultural Concern*.

Invertebrates

Aquatic macroinvertebrate species and communities, which include insects, snails, clams, crayfish, worms, and other invertebrates living in the aquatic environment, are a critical component of aquatic ecosystems and resources. These organisms maintain critical roles in aquatic foodwebs by both breaking down and repackaging carbon from aquatic and terrestrial primary producers, making it available to higher trophic levels. In addition to their roles in the transfer of energy and availability of prey, aquatic macroinvertebrates, and the composition of their communities, are often used as bio-indicators of ecosystem condition. Their environmental sensitivity, sub-habitat scale ecosystem requirements, rapid reproductive rates, and short life spans make them effective benchmarks against which to measure disturbance.

An assortment of different aquatic invertebrates characterizes the three segments of the watershed. The following summary focuses on those species and/or communities with key historic, current, or potential future implications for the ecological condition of the watershed.

Aquatic Insects. Aquatic insects generally feed on algae, terrestrial and aquatic organic debris, and other macroinvertebrates. They provide a critical food source for fish and amphibian species, and certain aquatic insects with a terrestrial life phase have been shown to provide an important food source for riparian and upland reptile, bird, and bat species.

Aquatic insects are often used as indicators of disturbance or degradation within a system, or quality of stream habitat. This is the case as certain taxa and community assemblages (e.g., Tricoptera (caddisflies), Ephemeroptera (mayflies), and Plecoptera (stoneflies)) are often associated with less disturbed conditions and others (e.g., Chironomidae (non-biting midges)) with more. Among the range of disturbance agents that can affect aquatic invertebrate communities are sedimentation, alteration of in-stream vegetation, altered surface and groundwater hydrology, the introduction of predatory species, and climate.

In the headwaters subregion of the watershed, information on the composition and distribution of aquatic insect communities is sparse. CDFG stream surveys, primarily from the late 1970s and early 1980s, identify Odonata (dragonflies and damselflies), caddisflies, mayflies, and Diptera (true flies) as the dominant taxa in most of the streams in this portion of the watershed, but provide little information on relative abundance or diversity of genera represented within each of these larger groupings. Some additional information on upper watershed aquatic insect presence has also been captured as a component of different isolated research projects that have occurred as components of the University of California, Davis, Castle Lake Long-Term Research program. Most recently, the dominant aquatic insect taxa at Castle Lake were determined to include all of those commonly reported in the upper watershed stream surveys (mentioned above). In 2008, the Castle Lake Long Term Research Program began a 3-year in depth study of invertebrate production and flux in Castle Lake basin. The study was designed specifically to characterize the benthic macroinvertebrate communities, as well as spatial and temporal trends in their distribution and abundance. The study is being carried out in collaboration with the USFS and results are expected to be available sometime in mid-2010. Little or no current information is available on the aquatic insect communities of other lakes in the upper watershed, though their communities are likely to resemble those at Castle Lake.

In the central watershed, the bulk of the existing information on aquatic insects was gathered in response to the Cantara spill. All members of the aquatic insect communities were essentially eliminated by the spill (Cantara Trustee Council 2007). Data from 1991 through 1993 and 1996 showed that, at that the end of that period, the composition of the aquatic insect community in the upper Sacramento River mainstem was still unstable, with significant changes continuing to occur (Department of Water Resources 1997). Specifically, opportunistic species initially dominated many of the monitored locations, especially those downstream from the spill site (Department of Water Resources 1997). However, these initial data also indicated development of comparable, though quite variable, numbers of organisms and species, and biomasses between monitoring stations upstream and downstream from the spill (Department of Water Resources 1997). By the second year of the study, the number of species in each order at monitoring stations affected by the spill appeared to be similar (Department of Water Resources 1997). Communities remained unstable, however, with

rapid succession continuing (Department of Water Resources 1997). Researchers hypothesized that the continued succession observed in the communities may have resulted from their continued adjustments to the affects of the spill or reaction to other factors that influenced the composition of the aquatic macroinvertebrate communities (Department of Water Resources 1997). However, that the community composition of riffles affected by the chemical spill differed from that of the upstream control station lead researchers to believe that recolonization was not yet complete (Department of Water Resources 1997).

Subsequent surveys conducted by California Department of Water Resources in 2001 revealed higher densities of a mayfly, stonefly, caddisfly assemblage compared to midges and other flies in two out of six sample stations (Boullion 2006, Cantara Trustee Council 2007). In its final report, the Cantara Trustee Council pointed out that midges and other flies represent species groups that are more successful under conditions of poor water quality or stress while the mayfly, stonefly, caddisfly assemblage represents species groups that indicate high-quality aquatic conditions (Cantara Trustee Council 2007). Despite the Council's including this observation, seemingly as an indication of recovery, the conclusion of the 2001 DWR study could only hypothesize that recovery of these insect assemblages was complete, as continued population fluctuations could not be attributed to any specific driver (Boullion 2006).

Mollusks. Mollusks in the upper Sacramento River serve as primary herbivores and detrivores in benthic stream communities and are major food items for fish and other stream-dwelling or stream-related animals (Frest and Johannes 1997). The freshwater mollusk fauna of the Sacramento River and its tributaries has long been considered exceptionally diverse, but it remains only partially known. In fact, very little information on the fresh water mollusks of the watershed was available prior to the Cantara spill and the research performed to assess its impact and the system's recovery. Additionally, many of the genera present had not been well described or researched anywhere within their broad range, despite being locally abundant and easily collected in springs, streams, and rivers (Hershler et al. 2007).

In the headwaters portion of the watershed, mollusk populations remain largely undescribed. In the central portion of the watershed, initial CDFG surveys following the Cantara spill showed that mollusk densities were low at all upper Sacramento River sample locations affected by the spill compared to the control sites (Cantara Trustee Council 2007). Nevertheless, a diverse mollusk population was found to exist, including generalists snails such as *Physella* as well as cold water–specific genera such as *Fluminicola* (pebble snails) and *Vorticifex* (Frest and Johannes 1993, 1994, 1995, and 1997). Frest and Johannes (1997) provide a detailed summary of both bivalve and gastropod species' presence, distribution, and habitat affinity in the mid segment of the watershed. Of particular note in their report are accounts of 22 new taxa first described as part of the post-Cantara monitoring effort (though a few proved to be previously present in museum collections) (Frest and Johannes 1997). Many of the previously undescribed *Fluminicola* species recorded during the post-spill monitoring, and general diversity and diversification in *Fluminicola* were also more recently described by Hershler and others (2007). Their study reveals that the highly endemic pebble snails of the upper Sacramento River are a polyphyletic assemblage with four separate clades. The upper Sacramento River clade was believed to originate as a result of late Neogene separation of this basin from the neighboring northwestern Great Basin and Klamath River basin, consistent with biogeographical hypotheses based on the distributions of fishes (Hershler et al. 2007). The upper

Sacramento River pebble snails evolved in association with the complex of regional landscape and drainage diversification as well as adaptation to dynamic and often insular spring habitats (Hershler et al. 2007).

While adequate baseline data did not (and do not) exist to thoroughly compare pre- and post-spill communities, the more rapid recolonization of generalists such as *Physella* after the spill (Cantara Trustee Council 2007) suggests the possibility of altered community composition as the result of the event. A reintroduction of several species was proposed following the Cantara spill, based on monitoring of population recovery (Frest and Johannes 1994). This proposed action, however, was never performed.

Crayfish. Non-native signal crayfish are present throughout the upper Sacramento River watershed, although the specific distribution, status, and impact of their populations have been researched only in Castle Lake (Kats and Ferrer 2003) and in tributaries and the mainstem Sacramento River below Box Canyon Dam following the Cantara spill (Clark et al. 1991, Goldman 1992, Brett and Goldman 1993, 1994)

In the headwaters segment of the watershed, what little information is available on crayfish distribution and population status suggests that there has been both expansion and contraction of population size and range in different areas. In Castle Lake, crayfish were first recorded in 1988 (Elser et al. 1994) and were believed to have been introduced shortly before. In 1994, Elser and others estimated the population to be 10,100 individuals. By 2001, however, it appeared from sampling results that the crayfish population of the lake had been wiped out (Dr. Sudeep Chandra, personal communication). Reasons for the disappearance of crayfish from Castle Lake are unclear. However, predation by river otters, possibly in combination with decreased winter temperatures and productivity in their primary habitat, are the leading hypotheses. Ultimately, the disappearance of this non-native species from Castle Lake may have reduced disturbance in the system, as the study by Elser and others (1994) indicated the potential for crayfish to produce sizeable impacts in the lake, particularly on macrophyte populations and littoral habitat productivity and structure.

Conversely, in the south fork of the Sacramento River, crayfish are currently present and appear anecdotally to be expanding because they are widely distributed in locations where they were not in the late 1970s when the streams were last surveyed.

Amphibians and Aquatic Reptiles

The upper Sacramento River has a high diversity of herpetofauna, which include 12 aquatic amphibian species and one aquatic reptile species. Luke and Sterner (1994) attribute this diversity to the overlapping distributions of generalist species that range broadly over the western United States. Amphibians and aquatic reptiles are integral and often abundant members of aquatic ecosystems (Burton and Likens 1975, Bury et al. 1980, Luke and Sterner 1994). Amphibians alone often constitute the highest fraction of vertebrate biomass in an ecosystem (Blaustein and Wake 1990). Additionally, both amphibians and aquatic reptiles provide important links within and across aquatic and terrestrial food webs, consuming large amounts of invertebrate prey from both habitats (Wake 1991) and sustaining numerous predators at multiple trophic levels. Declines in their populations can have widespread, negative consequences for community structure and ecosystem health. Many of these consequences, however, are just beginning to be identified and understood.

Amphibian species and communities can be effective bio-indicators of aquatic ecosystem condition (Luke and Sterner 1995), often reflecting impacts from a broad range of factors such as toxins (as from herbicides) uv-b, species introductions (Halliday and Heyer 1997), timber harvest, (Bury et al. 1991) and grazing (Burton and Likens 1975, Bury et al. 1980, Luke and Sterner 1994). This wide-ranging sensitivity to disturbance agents has also, in the context of California's highly disturbed river systems, factored into the decline of many amphibian populations across the state. Their broad susceptibility has meant almost continual pressure on many of their populations despite changing land use practices over time. In addition, a historic lack of understanding of their role in ecosystem structure and function has contributed to changes in their populations receiving little attention until recently.

While information on amphibian populations in the watershed is limited, what is available suggests a pattern of continual pressure over time, decline in several native populations, and potentially the extirpation of one species. In its *Assessment of the Sacramento River Headwaters*, the USFS concluded that historic grazing in the watershed and fish introductions both likely resulted in a decline in amphibian populations (USDA Forest Service 2001b). The assessment also suggested the possibility that the drastic reduction in grazing within the watershed may have resulted in those populations having stabilized somewhat (USDA Forest Service 2001b). Additional pressure from stocking, accumulation of pollutants in the environment, and predation by other introduced species, however, are likely working against whatever gains have been made since the conclusion of the grazing era. Kats and Ferrer (2003) indicate that species whose introductions are of particular concern for amphibian populations include predatory fish, bullfrogs, and crayfish. All of these species are present in the watershed. In addition, predatory pressure from stocked fish and crayfish may be increasing as crayfish populations expand and increased fishing drives increased stocking. Although a comprehensive study on the impacts of species introductions has not been performed in the upper Sacramento River watershed, research in the neighboring Marble Mountains, Russian, and Trinity Alps wildernesses suggests that the presence and distribution of the Pacific chorus frog and the Cascades frog (species also present in the upper Sacramento River watershed) was negatively affected by the presence of introduced trout in those regions (Welsh et al. 2006).

The most comprehensive research on amphibians in the watershed was conducted following the 1991 Cantara toxic spill. Surveys in the central portion of the watershed were conducted between 1991 and 1994 on the Sacramento River mainstem and 28 of its tributaries. Findings from the study suggest that amphibian populations were significantly affected by the spill. This was the case not only in the mainstem, but also in the tributaries, and was a function of increased predation from river otters and other predators (Luke and Sterner 1995). Additionally, it was hypothesized that impacts on tributaries would slow repopulation of the mainstem (Luke and Sterner 1995). Estimated recovery times for species of interest ranged from 10–14 years for foothill yellow-legged frogs to 27–35 years for Pacific giant salamanders (Luke and Sterner 1995). Neither the ongoing status of these and other amphibian populations nor the degree of their recovery is known.

In 2002, surveys for terrestrial amphibians were conducted at 40 locations in the region north of Shasta Lake (Nauman and Olson 2004). Three species of reptiles and nine species of amphibians were detected, including the federally listed Shasta salamander (see *Special-Status Fish and Wildlife* for a detailed discussion of this species in the watershed).

Fish

Historically, the fish population of what is now considered the upper Sacramento River included a range of native resident fishes, several large seasonal runs of anadromous salmonids (i.e., salmon and steelhead (*Oncorhynchus* spp.)), and migratory populations of sturgeon (*Acipenser* spp.). However, anadromous fishes have not been found in the upper Sacramento River since the 1943 completion of Shasta Dam, and sturgeon are limited to a white sturgeon (*Acipenser transmontanus*) population in Shasta Lake. The current fish assemblage in the watershed is composed primarily of native, introduced, and regularly stocked resident coldwater and warmwater fishes (Appendix D).

The fish assemblage in the watershed varies by subregion. The species in the headwaters portion of the watershed consist primarily of introduced char and possibly a few remnant minnows and suckers in isolated locations. The one exception to this is Lake Siskiyou, which supports a diverse assemblage of primarily introduced warm- and coldwater fishes. The fish assemblage in the central watershed subregion is dominated by rainbow trout. A variety of native species are also present in the mainstem Sacramento River, but are largely absent from the tributaries, with the exception of the riffle sculpin. Several non-native warmwater species are present in the Sacramento River mainstem, with increasing presence in the southern end, close to Lake Shasta. However, these species are also largely absent from the tributaries.

The current composition and distribution of fish species inhabiting Lake Siskiyou and its tributaries reflect the historic fishery, the operational impacts of Shasta Dam as well as dams on several of the upstream tributaries, and the introduction of non-native fish species. The Shasta Lake fish assemblage includes native and non-native species, dominated by mostly introduced warmwater and coldwater species (Weidlein 1971 and CDFG unpublished data). The Shasta Lake tributaries have been managed to favor naturally produced ("wild") and stocked (hatchery-cultured) native and non-native trout species (Rode 1988, Moyle 2002, Rode and Dean 2004).

The distribution and productivity of organisms and aquatic habitats of Shasta Lake are greatly affected by the reservoir's dynamic seasonal fluctuations in surface elevation and thermal stratification. The reservoir's flood control, water storage, and water delivery operations typically result in declining water elevations during the summer through the fall months, rising or stable elevations during the winter months, and rising elevations during the spring months and, sometimes, into the early-summer months, while storing precipitation and snow melt runoff. During summer months, the epilimnion (relatively warm surface layer) is 30 to 50 feet deep and warms up to 80 °F. Water temperatures above 68 °F favor warmwater fishes such as bass (*Micropterus* spp.) and catfish. Deeper water layers are cooler and suitable for coldwater species. Shasta Lake is classified as a cool-water, mesotrophic, monomictic reservoir because it is moderately productive (mesotrophic) and has one period of mixing each year (monomictic), although it never completely turns over (i.e., the warm and cold layers do not mix completely (Bartholow et al. 2001).

Coldwater Species. Shasta Lake and its tributaries provide very productive habitats for coldwater fish species, which typically prefer or require temperatures cooler than 70 °F. During the cooler months, coldwater species such as rainbow trout, brown trout (*Salmo trutta*), and landlocked Chinook (*Oncorhynchus tshawytscha*) may be found rearing throughout the lake; however, these species do not spawn in the lake, preferring to spawn in tributary streams.

Native species such as white sturgeon, hardhead (*Mylopharodon conocephalus*), riffle sculpin, Sacramento sucker (*Catostomus occidentalis*), and Sacramento pikeminnow (*Ptychocheilus grandis*) tend to reside in cooler water strata in the reservoir and in and near tributary inflows (Moyle 2002). Trout may also congregate near the mouths of the reservoir's tributaries, including the upper Sacramento River, at various times of the year for various purposes, including thermal refuge, foraging, and spawning, when conditions are favorable for these species.

Climate conditions and reservoir storage volume are the two most influential factors affecting cold-water habitat and primary productivity in Shasta Lake (Bartholow et al. 2001). Coldwater habitat provided by Shasta Lake is a function of the total storage and associated surface area. This relationship is influenced by variation in the water-surface elevation throughout the year. Variation in water-surface elevation is a function of water demand, water quality requirements, and inflow. Water-surface elevations can change based on the water-year type. Typically, primary production in reservoirs is associated with storage volumes when all other factors are held constant (Stables et al. 1990). Increased storage and the corresponding increase in surface area results in a greater total biomass and a greater abundance of plankton and fish because the available habitat area is increased.

Warmwater Species. The warmwater fish habitats of Shasta Lake occupy two ecological zones: the littoral (shoreline/rocky/vegetated) and the pelagic (open water). The littoral zone lies along the reservoir shoreline down to the maximum depth of light penetration on the reservoir bottom, and supports populations of spotted bass (*Micropterus punctulatus*), smallmouth bass (*Micropterus dolomieui*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), channel catfish (*Ictalurus punctatus*), and other warmwater species.

Warmwater species, such as largemouth bass, smallmouth bass, spotted bass, and other sunfishes, were introduced into Shasta Lake and have become well established with naturally sustaining populations. These warmwater fishes feed primarily on invertebrates while young and become predaceous on other fishes, including engaging in some cannibalism, as they grow. Spawning activity usually begins during late March or April when temperatures rise to around 60 °F.

The primary factors affecting warmwater fish abundance and production in Shasta Lake include seasonal reservoir fluctuations, availability of high-quality littoral habitat, and annual climate variations (Ratcliff 2006). Reservoir level fluctuations, the associated shoreline erosion, and suppression of shoreline and emergent vegetation are generally thought to be the most significant factors affecting warmwater fish production in reservoirs, including Shasta Lake (Moyle 2002, Radcliff 2006). Water-level variations influence physical, chemical, and biological processes, which in turn affect fish populations. Reservoir drawdowns reduce water depths and influence thermal stratification and the resulting temperature, dissolved oxygen, and water chemistry profiles.

Riparian Communities

The term "riparian" pertains to the terrestrial moist soil zone immediately landward of aquatic wetlands, other freshwater bodies, both perennial and intermittent watercourses, and many estuaries. They are the interfaces between terrestrial and aquatic communities. The importance of riparian areas far exceeds their minor proportion of the total acreage in the watershed because of their prominent location within the landscape and the intricate linkages between terrestrial and aquatic communities (Gregory et al. 1991).

Riparian vegetation is important in determining the structure and function of stream ecosystems. Headwater streams are characteristically shaded and kept cool by overhanging riparian vegetation. Shade from this vegetation moderates stream temperatures, often preventing excessive summer temperatures that may be lethal to invertebrates and fish. Shading also affects the rate of chemical reactions and concentrations, metabolic rates of stream invertebrates, cues for life cycle events of aquatic organisms, and the activities of primary producers such as algae and aquatic plants (Knight and Bottorff 1984). Riparian vegetation also often supplies large amounts of organic detritus to the stream, forming a dependable food base for stream invertebrates and fish year after year (Knight and Bottorff 1984).

Fish are not usually considered part of riparian communities, but they interact directly with these communities in many ways, such as feeding on terrestrial insects, using overhanging vegetation as cover, or using flooded vegetation for spawning (Baltz and Moyle 1984). Also important are indirect interactions between riparian systems and fish through nutrient cycling and through the effects of riparian vegetation on flows and temperatures (Baltz and Moyle 1984).

Riparian woodlands form an important link between aquatic and terrestrial wildlife communities. Most aquatic insects are either directly or indirectly dependent on riparian vegetation at some stage in their life cycles (Erman 1984). In California, it is estimated that riparian systems provide habitat for 83 percent of the amphibians and 40 percent of the reptiles known to occur in the state (Brode and Bury 1984). Many species are permanent residents of the riparian zone, while others are transients or temporal visitors.

In addition, riparian woodlands represent some of the most important habitats for terrestrial birds and mammals due to their high floristic and structural diversity, high biomass (and therefore high food abundance), and high water availability. In addition to providing breeding, foraging, and roosting habitat for a diverse array of wildlife, the ribbon-like network of riparian habitats provide movement corridors for some species, connecting a variety of habitats throughout region. Further, trees that fall into aquatic features (e.g., streams, lakes) from riparian forests become habitat for aquatic organisms and are potentially an important link between terrestrial and aquatic ecosystems.

Riparian communities in the watershed are described in more detail below.

Montane Riparian

Montane riparian communities include overstory plant species such as black cottonwood (*Populus trichocarpa*), white alder (*Alnus rhombifolia*), mountain alder (*Alnus incana*), willow (*Salix* spp.), big-leaf maple (*Acer macrophyllum*), Oregon ash (*Fraxinus latifolia*), vine maple (*Acer circinatum*), mock orange (*Philadelphus coronarius*), black-fruited dogwood (*Cornus sessilus*), and mountain dogwood (*Cornus nuttallii*). Understory species include spicebush (*Lindera benzoin*), Douglas' spirea (*Spiraea douglasii*), western azalea (*Rhododendron occidentale*), Indian rhubarb (*Darmera peltata*), sedges (*Carex* spp.), horsetail (*Equisetum* spp.), gooseberry (*Ribes* spp.), California blackberry (*Rubus ursinus*), and Himalayan blackberry (*Rubus discolor*).

Common species nesting and foraging primarily in the riparian tree canopy include the chestnut-backed chickadee, bushtit, and downy woodpeckers. Other resident species, such as the spotted towhee and song sparrow, nest and forage on or very close to the ground, usually in dense vegetation.

A variety of mammals also occur in riparian communities, including the deer mouse, raccoon, ringtail, and Virginia opossum.

Coarse woody debris (snags, fallen logs, windblown trees, and large branches) is an important component of montane riparian communities, as well as many other terrestrial communities. It is an essential habitat component for many birds and mammals, supplying cover, feeding habitat, and/or reproduction habitat. Perhaps the best-recognized use of snags (dead trees that are still standing) is for shelter by cavity-dwelling species. Primary cavity species, such as the northern flicker, acorn woodpecker, and hairy woodpecker, create cavities in snags. Secondary cavity species, such as spotted owls, red breasted nuthatches, oak titmice, tree swallows, and ringtails, use and/or enlarge preexisting cavities. In addition to cavities, protected sites associated with loose bark are important for bat roosting.

Coarse woody debris is also an important substrate for a number of vascular and non-vascular plants, including a variety of algae, mosses, ferns, gymnosperms, and angiosperms (Harmon et al. 1986). Some species are superficially attached to the surface of the woody debris (epiphytes), and some vascular plants may send their roots into rotting wood and bark to extract water and nutrients. Still other vascular plants root in the mat of decaying fine litter that often accumulates on the surface of woody debris.

The leaf litter, fallen tree branches, and logs associated with the riparian communities in the watershed provide cover for amphibians such as the western toad, Pacific chorus frog, Pacific giant salamander, and rough skin newt. A variety of reptiles are also expected to occur here, including the western fence lizard, western skink, and northern alligator lizard.

Terrestrial Communities

Many processes in terrestrial communities, such as erosion, nutrient cycling, input of organic material, evaporative water loss, and movement of wildlife, result in direct interactions with neighboring aquatic and riparian communities. In addition, the conditions of the upslope vegetation and soil can critically affect the capability of a watershed to retain moisture and modulate surface and subsurface runoff into streams (Shilling et al. 2005).

The vegetation and wildlife species typical of the terrestrial communities in the watershed are described in more detail below. Detailed information about the special-status species potentially occurring in these communities is provided in Section 3.3.4, *Plants, Wildlife, and Fish of Ecological/Cultural Concern*.

Sierran Mixed Conifer

Sierran mixed conifer is the most common community in the watershed, occupying 46 percent of the watershed's 383,039 acres. The overstory is composed of moderate to dense stands dominated by a mix of Douglas-fir, ponderosa pine, sugar pine, incense cedar, and white fir, and occasionally knobcone pine. Hardwood trees are also present and may include canyon live oak (*Quercus chrysolepis*), California black oak, mountain dogwood, and big-leaf maple. The understory includes shrubs such as bush tanoak (*Lithocarpus densiflorus*), huckleberry oak, deer brush (*Ceanothus*

integerrimus), snowdrop bush (*Styrax officinalis*), poison oak (*Toxicodendron diversilobum*), gooseberry, greenleaf manzanita, whiteleaf manzanita, and mock orange.

The multi-layered vegetation in the Sierran mixed conifer community supports a variety of wildlife, including several federally and/or state-listed species. A significant feature of the community is the presence of cavity-bearing trees. Mature fire-damaged and wind-damaged forests typically contain snags, which are a valuable resource for birds and mammals such as the flammulated owl, northern pygmy owl, northern spotted owl (federally listed as threatened), and Pacific fisher (federal candidate for listing) that prefer cavities for nest and den sites. Snags also support wood-boring insects that provide food for bark-gleaning insectivorous birds such as the brown creeper. Other birds foraging and/or breeding in this habitat include the American peregrine falcon, bald eagle (state listed as endangered), sharp-shinned hawk, mountain quail, western wood-pewee, and western tanager. Mammals found in this habitat include the long-eared myotis, western red bat, northern flying squirrel, long-tailed weasel, brush rabbit, western red-backed vole, and bobcat. Reptiles and amphibians found in this community include the Pacific chorus frog, Pacific giant salamander, rubber boa, and western skink.

Montane Hardwood

The montane hardwood community is the second-most common community in the watershed, accounting for approximately 12 percent of the total land cover. This community is dominated by hardwoods and typically occurs on hotter, steep, rocky exposures; although black oak may occur on cooler slopes. The montane hardwood community is dominated by canyon live oak and California black oak, with some stands composed almost entirely of only one of these species. Shrubs that may occur include Brewer's oak (*Quercus garryana* var. *breweri*), snowdrop bush, poison oak, whiteleaf manzanita, common manzanita (*Arctostaphylos manzanita*), western redbud (*Cercis occidentalis*), skunkbush (*Rhus trilobata*), deer brush, buckbrush (*Ceanothus cuneatus*), mock orange, and California buckeye (*Aesculus californica*).

Mast crops (i.e., nuts) provided by montane hardwood forests are an important resource for many species, including the acorn woodpecker, Steller's jay, mountain quail, western gray squirrel, and mule deer. In addition, cavities in mature trees provide nesting and denning habitat for species such as the northern flicker, western screech owl, American kestrel, and Virginia opossum. In mesic areas, many amphibians are found in the detrital layer, including ensatina and western skinks.

Alpine Dwarf-Shrub

The alpine dwarf-shrub community occurs above the tree line in the extreme northeastern portion of the watershed. Thus, this community is subject to intense solar radiation and freezing nights year-round. As a result, the perennial herbs and shrubs composing this community are usually less than 18 inches tall. In the watershed, this community is composed of open to moderate stands of shrubs and other species such as buckwheat (*Erigonum* spp.), knotweed (*Polygonum* sp.), arnica (*Arnica* spp.), and lupine (*Lupinus* spp.).

Wildlife that may occur in this habitat include the mountain bluebird, white-crowned sparrow, American pika, bushy-tailed woodrat, montane vole, and common porcupine.

Annual Grassland

Annual grasslands are scattered throughout the watershed, but occur mostly in the area northwest of Mt. Shasta. These communities are composed of various annual grasses and forbs and are productive wildlife habitat. Grassland bird species such as the mourning dove, savannah sparrow, and house finch as well as rodents such as the California ground squirrel, Botta's pocket gopher, and deer mouse may forage on the seed crop this community provides. These species in turn attract predators such as the American kestrel, red-tailed hawk, and coyote. Reptile species expected to occur here include the western fence lizard, western skink, western rattlesnake, gopher snake, and racer.

Barren

Barren land consists primarily of rock and bare soil. Vegetation is usually not present, although sparse opportunistic grasses/forbs or weedy species may occur. This habitat provides few resources for wildlife species; however, some species associated with adjacent habitats likely forage on the bare soil to some extent.

Bitterbrush

Bitterbrush communities occur along the northern boundary of the watershed and are composed of moderate to dense chaparral stands dominated by antelope bitterbrush (*Purshia tridentata*). Associated species include rabbitbrush (*Chrysothamnus* spp.), greenleaf manzanita, big sagebrush (*Artemisia tridentata*), and bitter cherry (*Prunus emarginata*).

Bitterbrush is highly digestible and is an especially important winter food source for black-tailed deer (California Department of Fish and Game 2008c). The seeds are also eaten by many species of birds, rodents, and insects. Wildlife species typically found in this habitat include the western fence lizard, Brewer's blackbird, black-tailed jackrabbit, and American badger.

Blue Oak Gray Pine

Although classified as blue oak foothill pine in Figure 3.2-1, within the watershed, this community does not include any blue oak (*Quercus douglasii*); rather, it is composed of gray pine and canyon live oak. Shrubs that may be present include buckbrush, poison oak, whiteleaf manzanita, and snowdrop bush. Various grasses and forbs are also present.

The blue oak–gray pine plant community provides breeding habitat for a large variety of wildlife species, although no species is completely dependent on it for breeding, feeding, or cover. Acorns and gray pine seeds are an important resource for many of the species using this habitat, such as the acorn woodpecker, western scrub-jay, western gray squirrel, and deer. Snags and trees containing cavities provide nesting habitat for birds such as the western bluebird, tree swallow, and northern flicker as well as potential roost sites for bats. Raptors, including the red-tailed hawk, American kestrel, and great horned owl, may also nest in these woodlands. The newly emerged leaves of oaks in the spring support an abundance of insects that attract migrating and nesting warblers, vireos, flycatchers, and other insectivorous birds. In addition, the shrubs provide habitat for birds such as spotted towhees, California towhees, wrentits, and blue-gray gnatcatchers. Characteristic reptiles and amphibians include western toads, a wide variety of snakes (common garter snakes, California

whipsnakes, gopher snakes, and western rattlesnakes among others), western skinks, northern alligator lizards, and western fence lizards. Coyotes and gray foxes may forage here.

Closed-Cone Pine-Cypress

Closed-cone pine-cypress communities are dominated by dense stands of knobcone pine. Associated overstory species may include ponderosa pine, gray pine, and canyon live oak. Shrub species commonly found in this community include whiteleaf manzanita, poison oak, Brewer's oak, buckbrush, deer brush, western redbud, and snowdrop bush.

Numerous game species and nongame species make use of this type of habitat for feeding and cover. Steller's and western scrub jays and downy woodpeckers as well as western gray squirrels extract seeds from partially opened cones. The great horned owl and red-tailed hawk are among the few species known to use this habitat for breeding.

Cropland

Cropland is extremely rare in the watershed, comprising only 13 acres. It occurs at one location in the northeastern portion of the watershed. Cropland provides wildlife habitat similar in many respects to that found in annual and perennial grasslands.

Deciduous Orchard

Orchards, which are very rare in the watershed, provide limited habitat for wildlife species. The absence of an herbaceous understory deprives many species of food and cover, and on-going maintenance operations may discourage many species. Some species that are tolerant of human encroachment, however, can be quite abundant in such habitats, including northern flickers, western scrub-jays, American crows, and American robins.

Douglas-Fir

Douglas-fir communities typically occur in moderate to dense stands on northern or eastern exposures at lower elevations, but are more variable at higher elevations. The overstory is dominated by Douglas-fir but may also include ponderosa pine, sugar pine, incense cedar, and knobcone pine as well as hardwoods such as canyon live oak, California black oak, mountain dogwood, and big-leaf maple. Shrub species occurring in this community include deer brush, snowdrop bush, poison oak, gooseberry, whiteleaf manzanita, and mock orange.

Mature and old-growth Douglas-fir communities support a high abundance of wildlife species. Wildlife living in the dense canopy are sheltered from enemies and high wind, abundant snags provide ample habitat for cavity nesters, and the lush understory of herbs, shrubs, and small trees that occur where sunlight breaks through the canopy provides protection as well as a food sources for a variety of birds and mammals (Benyus 1989). Wildlife typical of this habitat include the spotted owl, Pacific-slope flycatcher, chestnut-backed chickadee, golden crowned kinglet, Pacific giant salamander, black salamander, western tailed frog, Pacific fisher, western pocket gopher, Douglas' squirrel, and shrew-mole.

Eastside Pine

In California, eastside pine communities occur from about 4,000–6,500 feet in elevation, approximately east of a line drawn from Lake Tahoe to Hilt, a small town on Interstate 5 where it crosses the California-Oregon border (California Department of Fish and Game 2008c). The watershed is situated along the approximate western limits of this community's range. Within the watershed, the eastside pine community occurs only on the lower west slopes of Mt. Shasta, and is composed of ponderosa and Jeffrey pine–dominated stands that may include occasional incense cedar and Douglas-fir trees. The understory includes big sagebrush and rabbitbrush shrubs.

Eastside pine stands often form important migratory and winter range for deer, while higher elevation stands with grassy understories near water may be important fawning areas. Large pine branches also form good nesting substrates for large raptors, such as the red-tailed hawk, northern goshawk, and golden eagle, which prey on the small mammals found in this habitat, including the deer mouse, pinyon mouse, and Douglas' squirrel. Other species likely to occur include the sooty grouse, northern flicker, long-eared owl, northern saw-whet owl, and common porcupine, whose winter diet includes the twigs, bark, and cambium of conifers.

Jeffrey Pine

The Jeffrey pine community is dominated by stands of Jeffrey pine, but may also include ponderosa pine and, occasionally, incense cedar and Douglas-fir trees. This community type is scattered throughout the north-central portion of the watershed. The value of the Jeffrey pine forest as habitat for wildlife is due in large part to the food value of Jeffrey pine seeds, which are included in the diet of numerous wildlife species. The bark and foliage also serve as important food sources for deer, squirrels, and rodents, while the insects that infest the pines provide a food source for woodpeckers and other insect eaters. Other species using this habitat include nuthatches, brown creepers, Sooty grouse, great horned owls, and northern flying squirrels.

Klamath Mixed Conifer

Klamath mixed conifer communities have an overstory dominated by a mix of moderate to dense stands of Douglas-fir, ponderosa pine, sugar pine, incense cedar, white fir, and occasional knobcone pine as well as hardwoods such as canyon live oak, California black oak, and big-leaf maple. The shrub layer may include bush tanoak, huckleberry oak, deer brush, snowdrop bush, poison oak, gooseberry, whiteleaf manzanita, and mock orange.

The Klamath mixed conifer community provides a wide array of nesting and feeding opportunities and thermal cover for wildlife because of its diverse vegetation and soils. Species commonly found in this habitat include the mountain quail, hairy woodpecker, sharp-shinned hawk, western gray squirrel, and gray fox. The leaf litter also provides habitat for reptiles and amphibians, such as the California mountain kingsnake and ensatina.

Mixed Chaparral

Mixed chaparral is found on a variety of slopes and aspects. Many of the plants found in this community are highly adapted to periodic natural fires. Adaptations include the ability to produce

seeds at an early age; the production of seeds that require scarification, or the heat of a fire, in order to germinate; and the ability to sprout from underground woody plant structures after a fire. The mixed chaparral community is composed of open to dense mixed stands of chaparral species such as Brewer's oak, snowdrop bush, poison oak, whiteleaf manzanita, common manzanita, western redbud, silktassel (*Garrya* spp.), skunkbush, deer brush, buckbrush, interior live oak (*Quercus wislizenii*), bush poppy (*Dendromecon rigida*), California buckeye, California ash (*Fraxinus dipetala*), and yerba santa (*Eriodictyon glutinosum*). Lianas (woody vines) that may occur in this community include greenbriar (*Smilax rotundifolia*), chaparral honeysuckle (*Lonicera interrupta*), and virgin's bower (*Clematis virginiana*).

Mixed chaparral provides habitat for a wide variety of wildlife species. It provides seeds, fruit, and protection from predators and harsh weather. In addition, it provides singing, roosting, and nesting sites for many species of birds, including the California quail, wrentit, and Bewick's wren. Other animals common in this habitat include the black-tailed jackrabbit, gray fox, coyote, deer mouse, western fence lizard, and northern alligator lizard.

Montane Chaparral

Montane chaparral communities are composed of open to dense stands of chaparral, and are found on variable slopes and aspects, depending on location. This community is found at a higher elevation and watershed position than the mixed chaparral community. Like mixed chaparral, most plant species occurring in montane chaparral communities are adapted to periodic natural fires. Species found in this community include whiteleaf manzanita, greenleaf manzanita, western redbud, silktassel, deer brush, bush tanoak, huckleberry oak, bitter cherry, western choke-cherry (*Prunus virginiana* var. *demissa*), mountain whitethorn (*Ceanothus cordulatus*), tobacco brush (*Ceanothus velutinus*), bush chinquapin (*Chrysolepis sempervirens*), rabbitbrush, antelope bitterbrush, gooseberry, and big sagebrush.

The wildlife values of montane chaparral are similar to those described above for mixed chaparral.

Mixed Hardwood-Conifer

Mixed hardwood-conifer communities often form transitional areas between dense coniferous forests and montane hardwood, mixed chaparral, or open woodlands. They are composed of open to dense stands dominated by a mix of conifers and hardwoods. Conifers that may be present include Douglas-fir, ponderosa pine, sugar pine, incense cedar, gray pine, and knobcone pine, and hardwoods include canyon live oak, California black oak, and big-leaf maple. Shrubs that may occur include deer brush, buckbrush, brewer oak, snowdrop bush, poison oak, gooseberry, whiteleaf manzanita, mock orange, western redbud, and bush tanoak.

The variability of the canopy cover and understory vegetation make mixed hardwood-conifer communities suitable for numerous species of wildlife. Hollow trees and logs provide denning sites for mammals such as the coyote, black bear, and striped skunk, while cavities in mature trees are used by cavity-dwelling species such as the acorn woodpecker, violet-green swallow, northern flicker, great horned owl, raccoon, and pallid bat. In addition, raptors, such as the red-tailed hawk, construct nests in the upper canopy of mature trees. Moreover, mast crops are an important food source for many birds as well as mammals, including the western scrub and Steller's jay, acorn woodpecker,

California quail, black-tailed deer, and western gray squirrel. In moist areas, many reptiles are found in the detrital layer, including ensatina and western fence lizards. Snakes, including the western rattlesnake and sharp-tail snake, also occur in this community.

Pasture

Pasture is rare in the watershed (52 acres) and consists of lands used for grazing livestock or horses. Many of the same species found in annual grassland habitat are also found in this community.

Ponderosa Pine

The ponderosa pine community is composed of open to dense stands of ponderosa pine. Associates include knobcone pine, Douglas-fir, gray pine, canyon live oak, and California black oak. Shrubs include whiteleaf manzanita, poison oak, Brewer's oak, buckbrush, deer brush, western redbud, and snowdrop bush.

Ponderosa pine needles, cones, buds, pollen, twigs, seeds, and associated fungi and insects provide food for many species of birds and mammals, including the pygmy nuthatch, white-headed woodpecker, western gray squirrel, black-tailed deer, and black bear. Mature trees provide nesting habitat for raptors such as the bald eagle, osprey, sharp-shinned hawk, and red-tailed hawk, while snags and hollow logs provide shelter for species such as the flammulated owl, Virginia opossum, and western spotted skunk.

Red Fir

Red fir communities are composed of moderate to dense conifer stands dominated by red fir. Associated species include white fir and, occasionally, mountain hemlock and western white pine. Shrubs that may be present include huckleberry oak and mountain spirea.

Mature red fir forests provide important habitat for many animals. American martens use large snags, stumps, and logs for den sites, and red fir cones are cut and cached by a variety of squirrels. Other species typically found here include the pileated woodpecker, mountain quail, northern goshawk, black bear, and black-tailed deer.

Sagebrush

Sagebrush communities include moderate to dense chaparral stands dominated by big sagebrush. Other associated species include rabbitbrush, greenleaf manzanita, and antelope bitterbrush. This community is very rare in the watershed, occupying only 2 acres.

Subalpine Conifer

Subalpine conifer communities occur at high elevations and are the last community before the tree line. Conifers present include western white pine, mountain hemlock, foxtail pine (*Pinus balfouriana*), and whitebark pine (*Pinus albicaulis*).

Coniferous forests at high elevations in California typically support fewer species of wildlife than other major forest types in the state (California Department of Fish and Game 2008c). However,

these aged forests often have a profusion of snags and downed logs that provide shelter for cavity dwellers such as the pileated woodpecker, mountain chickadee, and northern flying squirrel. Other wildlife species occurring in subalpine communities include the mountain quail, Clark's nutcracker, golden-mantled ground squirrel, western red-backed vole, American marten, black-tailed deer, and black-tailed jackrabbit.

Urban

Urban habitat includes roadways, residential areas, and commercial areas. Urban areas are largely denuded of native vegetation and what vegetation does exist is predominantly non-native or ornamental. The wildlife species most often associated with urban areas are those that are most tolerant of periodic human disturbances, including several introduced species such as European starlings, rock doves, and house mice. Native species that are able to use these habitats include western fence lizards, American robins, Brewer's blackbirds, northern mockingbirds, mourning doves, house finches, black-tailed jackrabbits, and striped skunks. In addition, bats that forage in nearby habitats may make use of small cavities around the eaves of structures.

White Fir

White fir communities are composed of moderate to dense conifer stands dominated by white fir. Associated species include Douglas-fir, ponderosa pine, Jeffrey pine, incense cedar, sugar pine, and, occasionally, red fir. Shrubs that may be present include huckleberry oak, bush tanoak, deer brush, mountain whitethorn, and gooseberry.

White fir is probably the coolest, moistest non-riparian habitat in the lower to mid-elevation forests in the watershed (California Department of Fish and Game 2008c). White fir trees are used as foraging habitat by a number of insect-gleaning birds, such as yellow-rumped warblers, western tanagers, mountain chickadees, chestnut-backed chickadees, golden-crowned kinglets, and black-headed grosbeaks (Airola and Barrett 1985). In addition, white fir seeds are eaten by squirrels, the bark is eaten by porcupines, and, during the winter, black-tailed deer feed on the buds and leaves.

Wet Meadow

Wet meadow communities occur in scattered locations along the western and northwestern portions of the watershed. Species commonly found in this community include hair grass (*Deschampsia cespitosa*), sedges (*Carex* spp.), sneezeweed (*Helenium autumnale*), western azalea, cluster rose (*Rosa pisocarpa*), and mountain spirea.

Wet meadows are generally too wet to provide suitable habitat for small mammals; however, deer may feed in this community. Waterfowl, such as the mallard, frequent streams flowing through these communities, and yellow-headed blackbirds and red-winged blackbirds nest in wet meadows with tall vegetation. Amphibians and reptiles are common in wet meadows, including the Pacific chorus frog, bullfrog, Cascades frog, striped racer, and western terrestrial garter snake.

Unique Ecological Communities

Serpentine

Serpentine soils can occur in a number of the biotic communities discussed above. They have a high proportion of endemic plants (i.e., plants that are restricted to serpentine). This is because of the harsh nature of serpentine soils, which stems from its strange chemical and physical characteristics. Serpentine soils have high concentrations of heavy metals and magnesium, low calcium concentrations, and low concentrations of essential plant nutrients. In addition, because serpentine soils are dark in color, they absorb tremendous amounts of solar energy, which results in parched soils. Thus, most communities occurring on serpentine soil consist of only a few small populations of dwarfs and xerophytes (plants designed to conserve water). In addition, some species have adapted so well to these harsh conditions that they grow exclusively on serpentine soil (endemic). Over 200 species and varieties of plants are endemic to serpentine soils in California (Schoenherr 1991). Serpentine endemism is not restricted to plants, but no one knows how many insect species are restricted to these areas.

A number of plants that are known to occur, or potentially occur, in the watershed are generally found on serpentine soils, including special-status species (see below for a discussion of special-status species), such as serpentine Beegum onion (*Allium hoffmanii*), goldenbush (*Ericameria ophitidis*), Trinity buckwheat (*Eriogonum alpinum*), peanut sandwort (*Minuartia rosei*), and Red Mountain catchfly (*Silene campanulata* ssp. *campanulata*).

Port-Orford-Cedar

Port-Orford-cedar is the largest member of the cypress family (Cupressaceae), and the fine wood of this tree has long been recognized for its characteristic beauty. Port-Orford-cedar has been an extremely valuable commercial species, both for its use in landscaping and as a finished wood product. Individual mature Port-Orford-cedar trees can bring up to $50,000 on the open market (USDA Forest Service 2008d). The Japanese highly prize the wood for use in their homes, and it is important for traditional uses, such as ceremonial houses and sweat lodges, to Native Americans who inhabit its range.

This valuable tree, however, has a very limited range, occurring naturally (the species has been widely cultivated as an ornamental) only in northwestern California and southwestern Oregon. The species range is primarily along the coast. However, a major inland disjunction includes small populations along the upper Trinity and Sacramento River drainages southwest of Mount Shasta (Zobel 1990) and includes populations in the watershed (Figure 3.1-3). It is often described as a serpentine endemic, but it is also found on other soil types (Schoenherr 1991). With the exception of the northern part of its range, Port-Orford-cedar usually grows primarily along streams and in areas with year-round seepage (Hansen et al. 2000).

As discussed in Section 3.1.4, *Timber Resources Use*, management of Port-Orford-cedar has become difficult in much of its range because of the introduction of *Phytophthora lateralis*, a fatal root rot.

Protected Areas in the Watershed

The federal and state governments have established protections for biological resources within various portions of the watershed. The Cantara/Ney Springs Wildlife Area (operated by the CDFG) was established primarily to provide habitat for wildlife species. This wildlife area is located in Siskiyou County 3 miles south of the City of Mt. Shasta on the Sacramento River. It is composed of 93 acres of mixed conifer, hardwoods, and riparian vegetation occupying two areas along the upper Sacramento River.

The STNF occupies approximately 52 percent of the lands in the watershed, and as discussed in Section 2.3.3, *Timber Management*, the USFS must provide for a diversity of plant and animal communities as part of their multiple use mandate. The USFS must maintain "viable populations of existing native and desired non-native species in the planning area" (36 CFR 219.19). In addition, the STNF LRMP contains goals, standards, and guidelines designed to guide the management of the STNF. Goals pertinent to biological resources include (1) integrate multiple resource management on a landscape level to provide and maintain diversity and quality of habitats that support viable populations of plants, fish, and wildlife; (2) monitor and protect habitat for federally listed threatened and endangered and candidate species; (3) assist in recovery efforts for threatened and endangered species; (4) cooperate with the state to meet objectives for state-listed species; (5) manage habitat for sensitive plants and animals in a manner that will prevent any species from becoming a candidate for threatened or endangered status; (6) meet habitat or population objectives established for management indicators; (7) cooperate with federal, state, and local agencies to maintain or improve wildlife habitat; and (8) maintain natural wildlife species diversity by continuing to provide special habitat elements within forest ecosystems (USDA Forest Service 1995).

As discussed in Section 3.1.4, *Timber Resources Use*, all, or part, of three LSRs (Eddy, Deer, and Wagon) and one MLSA (Castle Lake) are located in the watershed. The management objective within the LSRs is to protect and enhance conditions of late-successional forest ecosystems, which serve as habitat for late-successional and old-growth related species, including the northern spotted owl (USDA Forest Service 1995, 1999). Similarly, MLSAs are intended to maintain and enhance late-successional forest ecosystems; but MLSAs are not only areas of potential habitat, they have also been identified as owl activity centers (USDA Forest Service 1995). The STNF also has a system of Riparian Reserves to protect and enhance riparian dependent resources. The Riparian Reserve System is designed much like the Late Successional Reserve System.

Castle Crags State Park is located 6 miles south of Dunsmuir on I-5. The 4,350-acre park is managed by the California Department of Parks and Recreation. A primary purpose of this department is to preserve the state's extraordinary biological diversity by restoring, maintaining, and protecting native species and natural communities.

The U.S. Fish and Wildlife Service (USFWS) has designated critical habitat for the northern spotted owl (federally listed as threatened) within the watershed boundary (Figure 3.2-2). Critical habitat is a term used in the federal Endangered Species Act (FESA) to refer to specific geographic areas that are essential for the conservation of a threatened or endangered species and that may require special management considerations. The purpose of designating critical habitat is to require federal agencies to consider the effects of actions they carry out, fund, or authorize on habitat that is essential to the conservation of a listed species. The designation of critical habitat on private land has no impact on

private landowner activities that do not require federal funding or permits. The designation of critical habitat is only applicable to federal activities.

3.3.4 Plants, Wildlife, and Fish of Ecological/Cultural Concern

Special-Status Plants

Rare plants are either limited in geographic distribution or they occur in small isolated populations. The reasons for rarity can be natural or anthropogenic; however, only infrequently does a single "cause" by itself truly explain why a species is rare (California Native Plant Society 2001).

California's unique and varied climatic conditions, diverse geological formations, and striking topography contribute to a wealth of variation in present-day local growing conditions. Add to this the state's long geological past, and what has resulted is a high degree of endemism (species that grow only in California and nowhere else) (Nakamura and Nelson 2001). However, many rare and endangered species in California that began as natural rarities have, through one form or another of human-induced detrimental changes in their populations and/or habitat, become anthropogenic rarities (California Native Plant Society 2001).

For the purpose of this analysis, special-status plants are those that are

- listed or proposed for listing as threatened or endangered under FESA;
- listed or proposed for listing by the State of California as threatened or endangered under the California Endangered Species Act (CESA), or listed as rare under the California Native Plant Protection Act; or
- considered by the California Native Plant Society (CNPS) to be "rare, threatened, or endangered in California" (Lists 1B and 2).

The distribution and abundance of rare plants in the watershed is governed by a combination of availability of suitable habitat; connectivity of habitat for dispersal and colonization; and losses of local populations from human impacts, climatic fluctuations, and other environmental events such as floods, fires, and diseases.

Because of the size of the watershed, the following assessment of potentially occurring special-status plants is limited to a search of the CNDDB (California Department of Fish and Game 2008b) within the watershed boundary and information provided by local experts. The CNDDB is a database consisting of historical observations of special-status plant species, wildlife species, and natural communities. It is limited to reported sightings and is not a comprehensive list of special-status species that may occur in a particular area. Therefore, additional special-status plants may occur in the watershed. A list of USFS Sensitive and endemic plants potentially occurring on the STNF is provided as Appendix E.

The CNDDB search yielded 42 special-status plants known to occur in the watershed (Figure 3.2-3). These plants are listed in Table 3.3-2. Information on the habitat requirements of these species was obtained from the CNPS online Inventory of Rare and Endangered Plants (California Native Plant

Society 2008), which features information on the habitats and statewide distribution of special-status plants in California.

Table 3.3-2. Special-Status Plants Known to Occur in the Upper Sacramento River Watershed

SCIENTIFIC NAME COMMON NAME	STATUS*	HABITAT	COMMENTS
Arctostaphylos klamathensis Klamath manzanita	1B.2	Chaparral, lower montane coniferous forest, subalpine coniferous forest, and upper montane coniferous forest/rocky serpentinite or gabbro.	Recorded at several locations in the west-central portion of the watershed
Asarum marmoratum Marbled wild-ginger	2.3	Lower montane coniferous forest.	Recorded at two locations (one historical (1894) and one recent (1993)) along the I-5 corridor in the watershed.
Balsamorhiza lanata Woolly balsamroot	1B.2	Cismontane woodland/rocky, volcanic.	Recorded at one location in the northern-western portion of the watershed.
Botrychium virginianum Rattlesnake fern	2.2	Bogs and fens; lower montane coniferous forest; meadows and seeps; and riparian forest/streams.	Recorded at one location in the north-central portion of the watershed.
Calochortus greenei Greene's mariposa-lily	1B.2	Cismontane woodland; meadows and seeps; pinyon and juniper woodland; and upper montane coniferous forest/volcanic.	Recorded at one location in the north-central portion of the watershed.
Campanula shelteri Castle Crags harebell	1B.3	Lower montane coniferous forest.	Recorded in several locations in the watershed in the vicinity of Castle Crags State Park.
Campanula wilkinsiana Wilkin's harebell	1B.2	Meadows and seeps; subalpine coniferous forest; and upper montane coniferous forest.	Recorded in the northeastern most portion of the watershed near the base of Mt. Shasta.
Carex limosa Mud sedge	2.2	Bogs and fens; lower montane coniferous forest; meadows and seeps; and upper montane coniferous forest.	Recorded at one location along the west-central watershed boundary.
Castilleja miniata spp. *elata* Siskiyou paintbrush	2.2	Bogs and fens and lower montane coniferous forest/often serpentinite.	Recorded at one location in the watershed near the base of Mt. Shasta.
Chaenactis douglasii var. *alpine* Alpine dusty maidens	2.3	Alpine boulder and rock field.	Recorded at one location in the watershed near the base of Mt. Shasta.

Table 3.3-2. Special-Status Plants Known to Occur in the Upper Sacramento River Watershed

SCIENTIFIC NAME COMMON NAME	STATUS*	HABITAT	COMMENTS
Chaenactis suffrutescens Shasta chaenactis	1B.3	Lower montane coniferous forest and upper montane coniferous forest/sandy, serpentinite.	Recorded at three locations in the north-central portion of the watershed. However, all three records are from the early 1900s.
Clarkia borealis ssp. *borealis* Northern clarkia	1B.3	Chaparral; cismontane woodland; and lower montane coniferous forest.	Recorded at several locations in the southern portion of the watershed, around Shasta Lake and along the I-5 corridor.
Cordylanthus tenuis ssp. *pallescens* Pallid bird's-beak	1B.2	Lower montane coniferous forest (gravelly, volcanic alluvium).	Recorded at several locations in the north-central portion of the watershed.
Draba *aureola* Golden alpine draba	1B.3	Alpine boulder and rock field; subalpine.	Recorded at one location along the northwestern watershed boundary.
Draba carnosula Mt. Eddy draba	1B.3	Subalpine coniferous forest and upper montane coniferous forest/serpentinite, rocky.	Recorded at two locations along the northwestern watershed boundary.
Epilobium oreganum Oregon fireweed	1B.2	Bogs and fens/lower montane coniferous forest and upper montane coniferous forest/mesic.	Recorded at two locations along the northern watershed boundary.
Epilobium siskiyouense Siskiyou fireweed	1B.3	Alpine boulder and rock field; subalpine coniferous forest; and upper montane coniferous forest/rocky serpentinite.	Recorded at several locations along the northwestern watershed boundary.
Eriogonum alpinum Trinity buckwheat	1B.2	Alpine boulder and rock field; subalpine coniferous forest; and upper montane coniferous forest/serpentinite, rocky.	Recorded at several locations along the western watershed boundary.
Eriogonum pyrolifolium var. *pyrolifolium* Pyrola-leaved buckwheat	2.3	Alpine boulder and rock field (sandy or gravelly, pumice).	Recorded at three locations in the northeastern-most portion of the watershed.
Erythronium klamathense Klamath fawn lily	2.2	Meadows and seeps; upper montane coniferous forest.	Recorded at one location in the central portion of the watershed.
Eurybia merita Subalpine aster	2.3	Upper montane coniferous forest.	One historical record (1882) along the northern watershed boundary.

Table 3.3-2. Special-Status Plants Known to Occur in the Upper Sacramento River Watershed

SCIENTIFIC NAME COMMON NAME	STATUS*	HABITAT	COMMENTS
Galium serpenticum ssp. *scotticum* Scott Mountain bedstraw	1B.2	Lower montane coniferous forest (serpentinite).	Recorded at two locations along the northwestern watershed boundary.
Aleppo avens Geum aleppicum	2.2	Great Basin scrub; lower montane coniferous forest; and meadows and seeps.	Recorded at two locations in the northern portion of the watershed.
Hierochloe odorata Nodding vanilla-grass	2.3	Meadows and seeps.	Recorded at one location in the north-central portion of the watershed.
Hulsea nana Little hulsea	2.3	Alpine boulder and rock field; subalpine coniferous forest/rocky or gravelly volcanic.	Recorded (1959) in one location along the northwestern watershed boundary.
Ivesia longibracteata Castle Crags ivesia	1B.3	Lower montane coniferous forest (granitic, rocky).	One record in Castle Crags State Park.
Lewisia cantelovii Cantelow's lewisia	1B.2	Broadleafed upland forest; chaparral; cismontane woodland; and lowland montane coniferous forest/mesic, granitic, sometimes serpentinite seeps.	Recorded at five locations in the central watershed.
Meesia uliginosa Broad-leaved hump moss	2.2	Bogs and fens; meadows and seeps; subalpine coniferous forest; and upper montane coniferous forest/damp soil.	One record near the City of Mt. Shasta.
Neviusia cliftonii Shasta snow-wreath	1B.2	Cismontane woodland; lower montane coniferous forest; and riparian woodland/often streamsides; sometimes carbonate, volcanic, or metavolcanic.	One record in the watershed in the Sacramento River Arm of Shasta Lake (Waters Gulch).
Ophioglossum pusillum Northern adder's-tongue	2.2	Marshes and swamps; valley and foothill grassland.	One historical record (1894) near the City of Mt. Shasta.
Parnassia cirrata var. *intermedia* Cascade grass-of-parnassus	2.2	Bogs and fens; meadows and seeps/rocky serpentine soil.	Two records in the central watershed.
Penstemon filiformis Thread-leaved beardtongue	1B.3	Cismontane woodland; lower montane coniferous forest/rocky.	Numerous records in the east-central portion of the watershed.
Phacelia leonis Siskiyou phacelia	1B.3	Meadows and seeps; upper montane coniferous forest (openings)/often serpentinite.	Four records along the western watershed boundary.

Table 3.3-2. Special-Status Plants Known to Occur in the Upper Sacramento River Watershed

SCIENTIFIC NAME COMMON NAME	STATUS*	HABITAT	COMMENTS
Polemonium chartaceum Mason's sky pilot	1B.3	Alpine boulder and rock field; subalpine coniferous forest/rocky, serpentinite, granitic, or volcanic.	Two records along the northwestern watershed boundary.
Potentilla cristae Crested potentilla	1B.3	Alpine boulder and rock field; subalpine coniferous forest/seasonally mesic, often serpentinite seeps, gravelly or rocky.	Two records in the northern portion of the watershed.
Raillardella pringlei Showy raillardella	1B.2	Bogs and fens; meadows and seeps; and upper montane coniferous forest/mesic, serpentinite.	Five records along the western watershed boundary.
Schoenoplectus subterminalis Water bulrush	2.3	Bogs and fens; marshes and swamps (montane lake margins).	One record in the west-central portion of the watershed.
Scutellaria galericulata Marsh skullcap	2.2	Lower montane coniferous forest; meadows and seeps; and marshes and swamps.	One recorded historical occurrence (1894) near the City of Mt. Shasta.
Silene suksdorfii Cascade alpine campion	2.3	Alpine boulder and rock field; subalpine coniferous forest; and upper montane coniferous forest/volcanic, rocky.	One record near the base of Mt. Shasta.
Vaccinium scoparium Little-leaved huckleberry	2.2	Subalpine coniferous forest (rocky).	Two records in the central portion of the watershed.

*CNPS Listing Status
List 1B 'Plants rare, threatened, or endangered in California and elsewhere.'
List 2 'Plants rare, threatened, or endangered in California but more common elsewhere.'
Extensions
.3 Not very endangered in California
.2 Fairly endangered in California
.1 Seriously endangered in California

In addition, several populations of an unusual and undescribed huckleberry (*Vaccinium* sp.) have been found in the last decade at several locations around Shasta Lake, including sites within the watershed boundary. The huckleberry most closely fits the description of red huckleberry (*Vaccinium parvifolium*) except that the berries are purple. This undescribed huckleberry is disjunct from the nearest known extant red huckleberry populations by approximately 40 miles, with the Trinity Alps and other Klamath Ranges lying between them. The undescribed inland plants grow in a distinct, much less moist habitat than does the coastal red huckleberry. Most of the known sites for this odd huckleberry are associated with abandoned or active mines in the watershed (Lindstrand personal communication); in some places, the plants grow on acid mine drainage.

Invasive Plants and Other Noxious Weeds

When plants that evolved in one region of the globe are moved to another region, a few flourish, crowding out native vegetation and the wildlife that feeds on the native species. These invasive plants have a competitive advantage because they are no longer controlled by their natural predators and can quickly spread out of control. The scientific community has come to view invasive species as posing serious threats to biological diversity, second only to the threats resulting from habitat loss and fragmentation (Bossard et al. 2000). Invasive species present complex management issues; even when the species are no longer being actively introduced, they continue to spread and invade new areas. Invasive species affect native species and habitats in several ways, including by altering nutrient cycles, fire frequency and/or intensity, and hydrologic cycles; by creating changes in sediment deposition and erosion; by dominating habitats and displacing native species; by hybridizing with native species; and by promoting non-native animal species (Bossard et al. 2000). In California, approximately 3 percent of the plant species growing in the wild are considered invasive, but they inhabit a much greater proportion of the landscape (California Invasive Plant Council 2007).

Plant pests are defined by law, regulation, and technical organizations, and are regulated by many different sources, including the California Department of Food and Agriculture (CDFA) and the United States Department of Agriculture (USDA). The CDFA uses an action-oriented pest-rating system. The rating assigned to a pest by the CDFA does not necessarily mean that one with a low rating is not a problem; rather the rating system is meant to prioritize response by the CDFA and county agricultural commissioner's. The California Invasive Plant Council (Cal-IPC) has developed a list of plant pests specific to California wildlands. The Cal-IPC list is based on information submitted by land managers, botanists, and researchers throughout the state and on published sources. To determine plant pests potentially occurring in the watershed (Appendix F), this list was reviewed and local experts were contacted to gather knowledge of known weed locations.

A "weed management area" (WMA) is a local organization that brings together all interested landowners, land managers, special districts, and the public in a county or other geographical area for the purpose of coordinating and combining their actions and expertise to deal with their common weed control problems.

Two weed management areas operate in the watershed. The Shasta County WMA functions under the authority of a mutually developed memorandum of understanding and is subject to statutory and regulatory requirements. The Siskiyou County WMA is a cooperative task force focused on the control and eradication of noxious weeds. The Siskiyou County Department of Agriculture (SCDA) has a long history of weed management work and has been the main contact for the WMA.

Special-Status Fish and Wildlife

For the purpose of this analysis, special-status fish and wildlife include:

- Species listed or proposed for listing as threatened or endangered under FESA,
- Species listed or proposed for listing by the State of California as threatened or endangered under CESA,

- Species designated as "species of special concern" by CDFG,
- Species designated as "fully protected" by CDFG,
- Species considered sensitive or endemic by the USFS, or
- Birds designated as "birds of conservation concern" by the USFWS.

Table 3.3-3 (Figure 3.2-4) identifies 36 special-status wildlife species that are known to occur or may occur in the watershed. Their distribution, legal status, general habitat requirements, and known occurrences in the watershed (based on CNDDB (California Department of Fish and Game 2008b) and CWRH (California Department of Fish and Game 2008c)) are also provided. Detailed information concerning threatened and endangered species is provided below in "Species Accounts," and information on other special-status species can be found in Appendix G.

Table 3.3-3. Special-Status Wildlife Species Known to Occur in the Upper Sacramento River Watershed

SCIENTIFIC NAME COMMON NAME	STATUS*	HABITAT	COMMENTS
Federally or State-Listed Species			
Cottus asperrimus Rough sculpin	CT FSS	Prefers sand or gravel substrate in cool streams or reservoirs. Spawns in streams.	Occurs in Shasta Lake.
Hydromantes shastae Shasta salamander	CT FSS	Moist limestone fissures and caves in volcanic and other rock outcroppings, and under woody debris in mixed pine-hardwood stands.	Known only from the southeastern Klamath Mountains region. Twenty-five known occurrences in the watershed near Shasta Lake.
Falco peregrinus anatum American peregrine falcon	BCC CP FD	Forages in many habitats; requires cliffs for nesting.	Species has been recorded nesting in the watershed.
Haliaeetus leucocephalus Bald eagle	CE CP FD	Uncommon to common in riverine and open wetland habitats. Perches high in large, stoutly limbed trees, on snags or broken-topped trees or on rocks near water. Roosts communally in winter in dense, sheltered, remote conifer stands.	Common at Shasta Lake, which has the highest density of breeding bald eagles in the continental United States. Nine nesting territories have been recorded in the watershed.
Strix occidentalis caurina Northern spotted owl	FT	In northern California, resides in large stands of old growth, multi-layered mixed conifer, redwood, and Douglas-fir habitats.	Numerous northern spotted owl territories have been recorded in the watershed.† Critical habitat is present in the watershed.

Table 3.3-3. Special-Status Wildlife Species Known to Occur in the Upper Sacramento River Watershed

SCIENTIFIC NAME COMMON NAME	STATUS*	HABITAT	COMMENTS
Coccyzus americanus occidentalis Western yellow-billed cuckoo	BCC CE FC	Nesting habitat is cottonwood/willow riparian forest. Occurs only along the upper Sacramento Valley portion of the Sacramento River, the Feather River in Sutter Co., the south fork of the Kern River in Kern Co., and along the Santa Ana, Amargosa and lower Colorado rivers.	The species was recorded in the watershed in 1951. However, the western yellow-billed cuckoo has been extirpated from this location (California Department of Fish and Game 2008b).
Empidonax traillii Willow flycatcher	CE FSS	Rare summer resident in wet meadow and montane riparian habitats at elevations of 2,000 to 8,000 feet. No longer known to nest in Sacramento Valley but migrates through the north state region in spring and fall.	Willow flycatchers occur as a migrant in riparian habitat; and may nest in suitable habitat in the upper portion of the watershed.
Gulo gulo luteus California wolverine	CT FP	A variety of habitats within the elevations of 1,600 and 14,200 feet. Most commonly inhabits open terrain above timberline.	Species has been recorded within the watershed; however, it is believed extirpated from this region.
Martes pennanti pacifica Pacific fisher	CSC FC FSS	Intermediate to large dense stages of coniferous forests and deciduous riparian habitats with greater than 50 percent canopy closure.	The Pacific fisher has been recorded in numerous locations throughout the entire watershed.
Vulpes vulpes nector Sierra Nevada red fox	CT	Red fir and lodgepole pine forests in the sub-alpine zone and alpine fell-fields of the Sierra Nevada.	The Sierra Nevada red fox has been recorded historically in the vicinity of Mt. Shasta, but is not expected to occur in the watershed.
Other Special-Status Species			
Mylopharodon conocephalus Hardhead	CSC FSS	Prefers deep, rock- and sand-bottomed pools of small to large rivers and impoundments.	Occurs in Shasta Lake.
California floater Anodonta californiensis	FSS	Aquatic mollusk potentially occurring in shallow areas of clean, clear ponds, lakes, and rivers with a silty substrate.	Suitable habitat is present in the watershed.
Hydromantes shastae Shasta hesperian	FSS	Mixed conifer and conifer/woodland habitats (riparian and/or riverine habitats).	Endemic to Klamath Province. The species has been recorded along the Sacramento River in the watershed.

Table 3.3-3. Special-Status Wildlife Species Known to Occur in the Upper Sacramento River Watershed

SCIENTIFIC NAME COMMON NAME	STATUS*	HABITAT	COMMENTS
Monadenia troglodytes troglodytes Shasta sideband	FSS	Mixed conifer and woodland habitats, especially near limestone.	Endemic to Shasta County. Known occurrences in the McCloud Arm of Shasta Lake, but no records within the watershed.
Monadenia troglodytes wintu Wintu sideband	FSS	Mixed conifer and woodland habitats, especially near limestone.	Endemic to Shasta County. Not known to occur in the watershed.
Trilobopsis roperi Shasta chaparral	FSS	Mixed conifer and conifer/woodland habitats.	Endemic to Shasta County. Known to occur near Shasta Lake within the watershed.
Rana cascadae Cascades frog	CSC	Open coniferous forests along the sunny, rocky banks of ponds, lakes, streams, and meadow potholes. From 2,600 to 9,000 feet in elevation in Cascades and Trinity Mountains.	Species has been recorded in the northwestern portion of the watershed.
Rana boylii Foothill yellow-legged frog	CSC FSS	Rocky streams in a variety of habitats. Found in Coast Ranges.	Species has been recorded in numerous locations throughout the watershed.
Ascaphus truei Tailed frog	CSC	Clear, rocky, swift, cool perennial streams in densely forested habitats.	Species has been recorded in numerous locations in the central portion of the watershed.
Actinemys marmorata Western pond turtle	CSC FSS	Slow water aquatic habitat with available basking sites. Hatchlings require shallow water with dense submergent or short emergent vegetation. Require an upland oviposition site near the aquatic site.	Species has been recorded in the central and southern portions of the watershed.
Asio otus Long-eared owl	CSC	Dense riparian and live oak thickets near meadow edges, and nearby woodland and forest habitats; also found in dense conifer stands at higher elevations.	Suitable habitat is present in the watershed.
Otus flammeolus Flammulated owl	BCC	A variety of coniferous habitats from ponderosa pine to red fir forests. Prefers low to intermediate canopy closure.	Occurs as a summer resident in the watershed.
Aquila chrysaetos Golden eagle	BCC CP CSC	Breeds on cliffs or in large trees or electrical towers and forages in open areas.	Suitable habitat is present in the watershed.

Table 3.3-3. Special-Status Wildlife Species Known to Occur in the Upper Sacramento River Watershed

SCIENTIFIC NAME COMMON NAME	STATUS*	HABITAT	COMMENTS
Accipiter gentiles Northern goshawk	BCC CSC FSS	Breeds in dense, mature conifer and deciduous forests, interspersed with meadows, other openings and riparian areas; nesting habitat includes north-facing slopes near water.	Northern goshawks have been recorded in the watershed.
Buteo regalis Ferruginous hawk	BCC	Requires large, open tracts of grasslands, sparse shrub, or desert habitats with elevated structures for nesting.	May occur as winter resident or migrant in the watershed.
Falco mexicanus Prairie falcon	BCC	Uses open terrain for foraging; nests in open terrain with canyons, cliffs, escarpments, and rock outcrops.	May occur as permanent resident in the watershed.
Melanerpes lewis Lewis's woodpecker	BCC	Open, deciduous, and conifer habitats with brushy understory, and scattered snags and live trees for nesting and perching.	May occur as summer resident in the watershed.
Picoides albolarvatus White-headed woodpecker	BCC	Montane coniferous forests up to lodgepole pine and red fir habitats.	Suitable habitat is present in the watershed.
Cypseloides niger Black swift	BCC CSC	Nests in moist crevice or cave or sea cliffs above the surf or on cliffs behind, or adjacent to, waterfalls in deep canyons; forages widely over many habitats.	Species has been recorded near Mossbrae Falls.
Chaetura vauxi Vaux's swift	CSC	Prefers redwood and Douglas-fir habitats. Nests in hollow trees and snags or, occasionally, in chimneys and forages aerially.	Suitable habitat is present in the watershed.
Contopus cooperi Olive-sided flycatcher	CSC, BCC	Wide variety of forest and woodland habitats below 9,000 feet. Preferred nesting habitat includes mixed conifer, montane hardwood-conifer, Douglas-fir, redwood, red fir, and lodgepole pine.	Suitable habitat is present and the species is known to occur in the watershed.

Table 3.3-3. Special-Status Wildlife Species Known to Occur in the Upper Sacramento River Watershed

SCIENTIFIC NAME COMMON NAME	STATUS*	HABITAT	COMMENTS
Progne subis Purple martin	CSC	Breeding habitat includes old-growth, multi-layered, open forest and woodland with snags; forages over riparian areas, forest, and woodlands.	Shasta Lake is one of the few known breeding sites in interior California. However, the species has not been recorded breeding within the portion of Shasta Lake within the watershed.
Dendroica petechia brewsteri California yellow warbler	CSC	Breeds in riparian woodlands, particularly those dominated by willows and cottonwoods.	Suitable habitat is present and the species is known to occur in the watershed.
Icteria virens Yellow-breasted chat	CSC	Breeds in riparian habitats having dense understory vegetation, such as willow and blackberry.	Suitable habitat is present and the species is known to occur in the watershed.
Lanius ludovicianus Loggerhead shrike	BCC CSC	Forages in open grassland habitats in the lowlands and foothills of California. Nests in shrubs and trees.	Suitable habitat is present in the northern portion of the watershed.
Martes americana American marten	FSS	Mixed evergreen forests with abundant cavities for denning and nesting and open areas for foraging.	Species has been recorded in the northern portion of the watershed.
Lepus americanus klamathensis Oregon snowshoe hare	CSC	Montane riparian habitats with thickets of alders and willows and in stands of young conifers interspersed with chaparral.	Species has been recorded just east of the northern watershed boundary.
Corynorhinus townsendii Townsend's western big-eared bat	CSC FSS	Roosts in colonies in caves, mines, bridges, buildings, and hollow trees in a variety of habitats. Forages along habitat edges. Habitat must include appropriate roosting, maternity, and hibernacula sites free from disturbance by humans.	Species has been recorded in a limestone cave on the Big Backbone Creek Arm of Shasta Lake within the watershed.
Antrozous pallidus Pallid bat	CSC FSS	Forages over many habitats; roosts in buildings, large oaks or redwoods, rocky outcrops and rocky crevices in mines and caves.	Suitable habitat is present in the watershed.
Lasiurus blossevillii Western red bat	FSS	Riparian forests	Suitable habitat is present in the watershed.

Table 3.3-3. Special-Status Wildlife Species Known to Occur in the Upper Sacramento River Watershed

SCIENTIFIC NAME COMMON NAME	STATUS*	HABITAT	COMMENTS
Euderma maculatum *Spotted bat*	CSC	Ponderosa pine region of the western highlands. Prefers cracks/crevices of high cliffs and canyons for roosting.	Species has been recorded in the northern half of the watershed.
Eumops perotis Western mastiff bat	CSC	Many open habitats, including conifer and deciduous woodlands, grassland, and chaparral. Roosts in crevices in cliff faces and high buildings.	Species has been recorded in the northern portion of the watershed.
Taxidea taxus American badger	CSC	Herbaceous, shrub, and open stages of most habitats with dry, friable soils.	Suitable habitat is present in the watershed.
Bassariscus astutus Ring-tailed cat	CP	Riparian habitats and brush stands of most forest and shrub habitats. Nests in rock recesses, hollow trees, logs, snags, abandoned burrows, and woodrat nests.	Suitable habitat is present and he species is known to occur in the watershed.

†Northern spotted owl occurrences are considered sensitive. Thus, they are not depicted in Figure 3.2-4.
*Status Codes:

BCC = Bird of Conservation Concern	FC = Federal candidate for listing
CE = State listed as endangered	FD = Federally delisted
CP = California fully protected	FPD = Proposed for federal delisting
CSC = California species of special concern	FSS = Forest Service Sensitive
CT = California Threatened	FT = Federally listed as threatened

Neotropical Migratory Birds

Of the nearly 800 bird species known to occur in the United States, approximately 500 migrate across our borders, with the large majority wintering in Central and South American (U.S. Fish and Wildlife Service 2001). Hemisphere-wide habitat loss due to deforestation and development threaten the future survival of these neotropical migrants. The USFS is actively integrating neotropical migratory bird management into forest management planning and implementation. It conducts a variety of surveys to identify downward population trends; implements actions to reverse these trends; restores and protects key habitats; conducts inventories and long-term population trend monitoring; addresses fragmentation issues; and implements management practices targeted at habitat features limiting bird populations. The USFS is also involved in national programs such as Monitoring Avian Productivity and Survivorship (MAPS) and Breeding Bird Surveys (BBS). Bird monitoring is one aspect of overall monitoring and inventory of habitat conditions, biodiversity, and forest plan implementation used by the USFS. The USFS is also actively engaged in a broad array of research efforts regarding neotropical migrant birds. Some of these efforts include examining the impacts of cowbird parasitism, logging, grazing, fragmentation, and burning on neotropical migrants. Additional efforts are aimed at investigating ecosystem processes and functions within a complete watershed perspective. A list of neotropical migrants known to occur on the STNF is included as Appendix H.

Species Accounts

Rough Sculpin

Rough sculpins are primarily found in clear, cool, fast water. They live in spring-fed streams where water temperatures rarely exceed 59 °F and occupy areas with aquatic vegetation and a sand or gravel substrate (U.C. Cooperative Extension 2003). However, they are capable of surviving in lakes or reservoirs where surface water temperatures reach 86 °F (U.C. Cooperative Extension 2003). Rough sculpins are known to occur in Shasta Lake.

Shasta Salamander

The Shasta salamander is endemic to a small region of the southeastern Klamath Mountains, generally located north and northeast of Redding, California. Five occurrences of this species have been recorded in the watershed near Shasta Lake (California Department of Fish and Game 2008b). The Shasta salamander has long been known to occur in habitats associated with limestone formations (Stebbins 2003) and was recently found to occur in various non-limestone habitats (Lindstrand 2000, Nauman and Olson 2004). Shasta salamanders have been found at elevations ranging from approximately 800 feet to 3,800 feet (Lindstrand 2008).

Shasta salamander limestone habitat includes large or small limestone outcrops and the immediately adjacent areas. This habitat consists of mainly steep and rocky limestone bluffs, cliffs, and outcrops, and is characterized by abundant limestone rock with fissures, cracks, and occasional small caves. Vegetative cover varies, and includes barren rock with sparse herbaceous growth, open to dense shrub habitat, and open to dense woodland habitat.

Shasta salamander non-limestone habitat has yet to be fully understood and defined. Non-limestone habitat is known to occur in the Shasta Lake area and elsewhere in the southeastern Klamath Mountains region, and includes a variety of montane hardwood-conifer, montane hardwood, and ponderosa pine habitat (Lindstrand 2000, Nauman and Olson 2004). Typically, these habitats are characterized by sparse to dense conifer and/or hardwood canopy closure, open to moderate shrub growth, and a sparse to dense herbaceous layer, and include some type of a ground cover component such as downed woody debris, scattered rock, or leaf/litter layer.

Bald Eagle

The bald eagle first gained federal protection in 1940 when Congress passed the Bald Eagle Protection Act. It was later amended to include golden eagles and renamed the Bald and Golden Eagle Protection Act. The bald eagle was first listed under the federal ESA on February 14, 1978, when it was designated as endangered throughout the lower 48 states, except in Michigan, Minnesota, Wisconsin, and Oregon, where it was designated as threatened (43 FR 6233). The bald eagle was reclassified as threatened in all of the lower 48 states on July 12, 1995 (60 FR 36000). The USFWS proposed to remove the species from the list of endangered and threatened wildlife (delist) on July 6 1999 (64 FR 36454) due to the population's successful rebound. It was delisted on August 8, 2007 (72 FR 37346). The bald eagle continues to be protected under the federal Bald and Golden Eagle Protection Act.

Most of a bald eagle's annual food requirements are derived from or obtained around aquatic habitats. The type of food consumed most often consists of fish, water birds, and small to medium-sized mammals. Because of the dietary association, nesting territories are usually found near water. Perches are used primarily during the day for resting, preening, and hunting, and may include human-made structures such as power poles, although natural perches are used most often. Roosting areas will contain a night communal roosting tree that is tall enough to provide safety from threats from the ground. The number and quality of these roost trees determine the size and importance of the roost. Bald eagle wintering areas and roosts are usually found where human activity is infrequent and/or muted. In California, breeding pairs are found mostly in Butte, Lake, Lassen, Modoc, Plumas, Shasta, Siskiyou, and Trinity counties (California Department of Fish and Game 2008c).

Bald eagles are common at Shasta Lake, occurring at the highest recorded density in the continental United States. Approximately 20 nest sites are currently believed to be active in the watershed. Management of bald eagles on Shasta Lake is directed by knowledge of territory protection needs (Forest Order – December 2004 and updated annually). Each known territory has a strategy that determines management zones and directs which activities are permitted during different times of the year (Forest Order 2004). Activities within these zones may be restricted to ensure that activities permitted within a unit will not have a negative effect on bald eagles.

Northern Spotted Owl

Northern spotted owls are associated with late-successional forest conditions consisting of relatively dense canopies, large-diameter live and dead standing trees, multi-storied crowns, and large diameter downed woody debris (55 FR 26114). In California, the range of the northern spotted owl extends from the Coast Ranges to San Francisco Bay. Spotted owls subsist on a diet of small mammals, birds, amphibians, reptiles and insects.

Locally suitable nesting and roosting habitat is defined as mixed-conifer, Douglas-fir, and true fir stands below 6,000 feet in elevation with an overstory of Douglas-fir, ponderosa pine, sugar pine, incense cedar, white fir, and/or red fir, averaging or above 18 inches dbh; a mid-story composed of the same species with or without hardwoods; a total canopy cover of 50–100 percent; minimum of 1.5 snags per acre greater than 40 inches dbh, and 6–8 down logs per acre greater than 10 inches in diameter (USDA Forest Service 1999a). Foraging habitat includes any stand having a canopy closure of greater than 40 percent (USDA Forest Service 1999a). Nest stand and home range size are dependent on suitability, distribution, and amount of available habitat.

Critical habitat was originally designated on January 15, 1992 (57 FR 1796) and was revised on August 13, 2008 (73 FR 47325). The critical habitat designation includes units within the watershed boundaries.

Western Yellow-Billed Cuckoo

The western yellow-billed cuckoo is generally considered a neotropical migrant that arrives in California to begin breeding in June. It prefers open woodland with clearings and low, dense, scrubby vegetation; often associated with watercourses (Hughes 1999). The yellow-billed cuckoo is an interspecific brood parasite, laying eggs in the nests of at least 11 other bird species (Hughes 1999). Major declines among western populations of yellow-billed cuckoos in the twentieth century

have occurred due to habitat loss and fragmentation, local extinctions, and low colonization rates. The species is now extremely rare in most areas (Laymon and Halterman 1989).

In California, breeding populations of greater than five pairs that persist every year are currently limited to the Sacramento River from Red Bluff to Colusa and the South Fork Kern River from Isabella Reservoir to Canebrake Ecological Reserve (Laymon 1998). Although the species was historically recorded in the watershed (1951), western yellow-billed cuckoos have been extirpated from this location (California Department of Fish and Game 2008b), and the species is not known to occur elsewhere in the watershed.

Willow Flycatcher

Willow flycatchers nest in dense riparian thickets and forage on insects, berries, and seeds. The species has been eliminated as a breeding bird from most of its former range in California, primarily due to the loss and degradation of riparian habitat. In the watershed, willow flycatchers are a rare to locally uncommon spring and fall migrant, occurring in open woodland, chaparral, wet meadow, and riparian habitats.

Pacific Fisher

In California, the Pacific fisher historically occurred in the conifer-dominated forests in the north Coast Ranges, Klamath Mountains, and Cascade Range, and south through the Sierra Nevada to Kern County (Grinnell et al. 1937). Fishers in California have experienced a reduction in geographic range and currently occur as two disjunct populations separated by roughly 248.5 miles (Zielinski et al. 2004). The two remnant populations are located in the southern Sierra Nevada and in the northwest's north Coast Ranges and Klamath Mountains (Zielinski et al. 2004). Fishers occur at elevations between 1,090 to 5,000 feet in the northwest and between 4,000 to 8,000 feet in the southern Sierra Nevada (Freel 1991, U.S. Department of the Interior 2006).

The fisher West Coast Distinct Population Segment (DPS) occurs in Washington, Oregon, and California. The area of the DPS includes the Cascade Range and all areas west to the coast in Oregon and Washington; and in California, the North Coast from Mendocino County north to Oregon, east across the Klamath Mountains and the southern Cascade Mountains, and south through the Sierra Nevada. All historical and current fisher populations in California occur within the DPS. The Pacific fisher has been recorded in numerous locations throughout the watershed (California Department of Fish and Game 2008b).

Sierra Nevada Red Fox

The Sierra Nevada red fox inhabits various habitats in alpine and subalpine zones (California Department of Fish and Game 1991b). They were historically found in the high elevations of the Sierra Nevada and from Mount Shasta and Lassen Peak westward to the Trinity Mountains (Aubry 1997). The Sierra Nevada red fox occurs at elevations from 4,500 to 11,500 feet, but is most commonly found above 7,000 feet (Aubry 1997). The only population known to exist in recent times is found in Lassen National Park and the surrounding Lassen National Forest (Perrine et al. 2007). The Sierra Nevada red fox has been recorded near Mount Shasta (California Department of Fish and Game 2008b).

Extirpated Species

Several wildlife species appear to have been extirpated from the watershed, which means they are no longer known to occur in the area but still occur in other parts of their historic range. Large mammals that have been extirpated include the grizzly bear (*Ursus arctos horribilis*), wolverine, pronghorn antelope (*Antilocapra americana*), and white-tailed deer (*Odocoileus virginianus ochrourus*) (Cronise 1868; Williams 1986, California Department of Forestry and Fire Protection 2003, Laliberte and Ripple 2004).

The grizzly bear once occurred widely throughout California, roaming the Cascades until the 1850s or 1870s (Jameson and Peeters 1988). Because its centers of density coincided with ranching activities, it was persecuted whenever encountered. The last grizzly bear in California was killed in the early 1920s (Jameson and Peeters 1988).

The wolverine, currently state listed as threatened, was likely never numerous in California relative to densities found in other parts of the species' range (California Department of Forestry and Fire Protection 2003). Broadly, they are restricted to boreal forests, tundra, and western mountains.

In 2007, Aubry et al. compiled 820 verifiable and documented records of wolverine occurrences (specimens, DNA detections, photos, and accounts of wolverines being killed or captured) in the continuous United States from 1801 to 2005 (Aubry et al. 2007). Anecdotal accounts (i.e., visual observations made at a distance or reports of tracks or other sign) were not included. (Note that anecdotal sightings have been reported on the Lassen National Forest (1990s) and on the Plumas National Forest. No current records (1995 to 2005) were found for Oregon or California, despite concerted efforts to obtain verifiable evidence of wolverine occurrence using remote cameras, bait stations, and helicopter surveys in many areas of the Pacific states (Zielinski 2004, Aubry et al. 2007). However, in 2008, a photograph of a wolverine was taken on the Tahoe National Forest and verified by a species expert (Zielinski personal communication). To determine the origin of this individual, a genetic analysis was performed on hair and scat samples (Zielinski 2008). This analysis ruled out that this animal persisted from the historical California population. It also eliminated the possibility that the animal came from the current Cascade population. The source location of this animal remains in question.

The pronghorn antelope once inhabited most of the grassland, oak woodland, and sagebrush-steppe plant communities in California (California Department of Forestry and Fire Protection 2003). However, by the early 1870s their numbers were significantly reduced due to market hunting, livestock competition, and changing land use practices. In 1923, it was estimated that less than 1,100 pronghorn were present in seven areas of California (California Department of Forestry and Fire Protection 2003). By 1943, pronghorn were found only in northeastern California (California Department of Forestry and Fire Protection 2003).

Historically, white-tailed deer were reported from localities in Lassen, Modoc, Mono, Shasta, and Siskiyou counties (Grinnell 1933, Hall and Kelson 1959 as cited in Williams 1986) Hall and Kelson, 1959. Little is known of their habitat in California. They were probably extirpated from California sometime between the 1930s and 1950s, mainly because of loss of habitat (Williams 1986).

Although the disappearance of these species is a concern, a greater concern exists for the species that still occur in low numbers in the watershed (see Table 3.3-3).

Locally Important Wildlife and Fish Populations

Hunting is an important cultural value to local residents of the watershed, and many native wildlife species are locally important because of their recreational value. Game species also attract people from outside of the watershed. Information is provided below for a few of these species, including their historic and current distribution, habitat requirements, and population trends.

Game Fish

The sport fishery in the watershed is based primarily around salmonids, and specifically rainbow trout. The fishery of the headwaters portion of the watershed can largely be characterized as created, managed, and maintained through the introductions and continued stocking of regionally native (though often not historically naturally occurring at stocking locations) and non-native fish species. Though warmwater fish populations are self-sustaining, the trout populations in the lakes and many of the streams must be sustained artificially through annual stocking programs provided by CDFG (USDA Forest Service 2001b).

In the central portion of the watershed, a fishery exists in the mainstem for both wild and stocked rainbow trout, brown trout, and spotted bass. Tributary fishing in this portion of the watershed is primarily for rainbow trout.

No stocking of Shasta Dam occurred during the initial impoundment period as it was hoped that the native rainbow trout population would provide enough fish to support the sport fishery (California Department of Fish and Game 1991a). However, by 1946, the excellent rainbow trout fishery that had developed was beginning to decline. Thus, in 1948 and 1949, CDFG conducted large plantings of fingerling rainbow trout. This was followed by the introduction of Kamloops strain rainbow trout and kokanee salmon in the late 1950s, but the desired trophy trout fishery did not develop (California Department of Fish and Game 1991a). In 1949 and 1950, largemouth bass were stocked to increase angler opportunities. This was followed by the introduction of smallmouth bass, threadfin shad (*Dorosoma petense*), black crappie, and channel catfish in the early 1960s (California Department of Fish and Game 1991a). In the period from 1971 through 1974, three species of salmon, three strains of brown trout, and several strains of rainbow trout were stocked experimentally in the lake (California Department of Fish and Game 1991a). Florida strain largemouth bass (*Micropterus salmoides floridanus*) and Alabama spotted bass were introduced in 1981 and 1982 (California Department of Fish and Game 1991a). Subsequently, the spotted bass population exploded and Shasta Lake has become a premier black bass tournament water in California.

Currently, hatchery- and pen-reared trout and salmon are planted at various locations in Shasta Lake several times each year to support the sport fishery (Baumgartner personal communication). About 60,000 pounds of juvenile rainbow trout are planted annually (Baumgartner personal communication).

Salmonids

Throughout the watershed, salmonids, and specifically several species of trout, dominate fish assemblages. While rainbow trout are native to the watershed, non-native trout species including brook trout (*Salvelinus fontinalis*), brown trout, lake trout, and cutthroat trout were also introduced across the watershed and stocked at different times to varying degrees of intensity. In recent years, stocking of non-native trout (all except rainbow trout) has been reduced or eliminated from much of the watershed. Nevertheless, self-sustaining populations of several species (most notably brook and brown trout) continue to persist in a number of locations.

Rainbow trout continue to be heavily stocked throughout the watershed. Stocking spans locations including the mainstem Sacramento River and its larger tributaries where rainbow trout were present historically as well as headwater streams and sub-alpine lakes, many of which were not known to support fish populations prior to introduction and stocking. In many of the larger, more accessible streams, as well as in the Sacramento mainstem, stocking occurs largely as a buffer where natural reproduction cannot meet pressure from anglers (USDA Forest Service 2001b). In some of the smaller streams in the watershed, stocking occurred for several years, but tapered off as natural production was sufficient to meet existing angler demands (USDA Forest Service 2001b). In the lakes, rainbow trout population size and the perceived need for stocking appear to be controlled by a combination of angler pressure, lake productivity, and the presence and availability of an inflow or outflow with spawning habitat. In the Sacramento mainstem, stocking continues. However, genetic research conducted as part of the fish recovery monitoring after the Cantara spill suggests that there is little introgression between the naturally reproducing (i.e., "wild") and hatchery reared rainbow trout populations (Nielsen et al. 2000). Additionally, wild populations appear to constitute the majority of the trout present in the river (Nielsen et al. 2000), suggesting that stocked fish constitute essentially a "put and take" fisheries for anglers.

Other Native Species

In addition to rainbow trout, several other native fish species are still found in the watershed, including white sturgeon, Sacramento blackfish (*Orthodon microlepidotus*), hardhead, rough sculpin, riffle sculpin, Sacramento sucker, and Sacrament pikeminnow. All of these fish species are currently found in the Shasta Lake segment of the watershed. In the Upper Sacramento segment, fewer of the species are present in the mainstem (principally Sacramento sucker, riffle sculpin, speckled dace, and Sacramento pikeminnow), and even fewer in the tributaries. In the headwaters portion, native fish presence appears to be continually decreasing, with persisting populations of riffle sculpin, Sacramento sucker, and Sacramento pikeminnow. It has also been suggested that speckled dace continue to persist in the upper watershed (USDA Forest Service 2001b), but this has not been confirmed. Distribution of these relic populations appears to have been limited primarily to the forks of the Sacramento River and Lake Siskiyou (USDA Forest Service 2001b). However, there has not been a recent assessment of the status of these populations or their distribution. Additionally, there is some anecdotal evidence of a decline in Sacramento sucker presence from the South Fork of the Sacramento, where they were known to occur historically but have not been observed in recent years.

Non-Native Species

In addition to the various non-native salmonid species introduced and in some cases stocked in the watershed over time, a suite of other non-native species have also found their way into the watershed through both planned introductions and illegal or accidental ones. The list of other, primarily warmwater, non-native species present in the watershed is composed of many of the alien species now common to other regions of California, including several species of sunfish and catfish as well as mosquitofish (*Gambusia affinis*), minnows, and carp.

The most diverse assemblages of introduced species in the watershed are found in the two reservoirs, Lake Siskiyou and Shasta Lake. Upon its completion in 1968, Lake Siskiyou was initially stocked with trout species, and in the early 1970s, warmwater fish were introduced by CDFG. Since 1970, Siskiyou Lake has, at different times, been stocked with largemouth bass, smallmouth bass, spotted bass, green sunfish, brown bullhead, carp, and golden shiners (USDA Forest Service 2001b). Brown trout, brook trout, and catchable rainbow trout continue to be planted. Grass carp were also illegally introduced into a local pond, but have not been recorded elsewhere (USDA Forest Service 2001b).

Warmwater non-native species in Shasta Lake include spotted bass, smallmouth bass, black crappie, channel catfish, and bluegill. Any of the non-native fish found in Shasta Lake may also be found in the lower stream reaches of its tributaries as well as in some of the intermittent streams around the lake arms that host fish when lake levels are high (e.g., Dry Fork, Charlie, Doney, Little Sugarloaf, Elmore, Alder, Adler, Shoemaker, and Bull creeks) (USDA Forest Service 2000). Even so, the dominant species in these tributary streams is rainbow trout, and the lower reaches of these streams likely serve as spawning sites for lake-run rainbow trout during the spring (USDA Forest Service 2000).

In general, populations of warmwater non-native species in the watershed have not been closely tracked. In part, this may be a function of their populations being largely self sustaining (USDA Forest Service 2000, 2001a).

Mammals

Deer

Deer are a significant wildlife species in California and an integral component in the food chain. In 2002, CDFG estimated the total population of deer in California as more than 544,000 animals (California Department of Fish and Game 2002). The six subspecies of mule deer found in the state occupy approximately 56 percent of the states lands, although only one subspecies, Columbian black-tailed deer, are found in the watershed (California Department of Fish and Game 2002).

Deer serve as grazers of wildland plants and as prey for carnivores. In addition, deer are the most popular, and accessible, big game animal in the state (California Department of Fish and Game 2002). Deer are among the most studied wildlife species in California, and from this long history of study, researchers have learned that deer often respond predictably to California's changing wildland environment, particularly to changes in forestland habitats that are dominated by a mix of herbaceous and shrub vegetation (California Department of Fish and Game et al. 1998). Thus, deer are often

used by CDFG, USFS, and BLM as an indicator species for a variety of other birds and mammals that use similar habitats (California Department of Fish and Game et al. 1998).

The California deer population peaked during the late 1950s and early 1960s (California Department of Forestry and Fire Protection 2003). In 1976, *A Plan for California Deer* was developed by CDFG to respond to the decline in deer numbers resulting from the loss and degradation of high-quality deer habitat. With the growing human population in California and continuing loss of high-quality deer habitats, biologists have realized that the goal to restore deer herd numbers to those in the 1960s is unlikely and unrealistic. Biologists are currently developing a more realistic approach through a Strategic Plan for California Deer in order to manage deer herds more effectively, given the existing and anticipated changes to California's environment.

In addition, important deer habitats are identified through statewide surveys and investigations conducted throughout the year. The data are used for analysis of local and statewide land-use planning efforts, as well as providing recommendations to the Lands Committee for possible land acquisition through the Wildlife Conservation Board.

CDFG manages deer in California using established deer herds, which are based on approximate natural boundaries of reproductively isolated populations. The state is also divided into 11 Deer Assessment Units (DAU), and the watershed includes portions of two of these units, the North Coast DAU and the Cascade–North Sierra Nevada DAU. The following information concerning these two DAUs is from *An Assessment of Mule and Black-Tailed Deer Habitats and Populations in California* (California Department of Fish and Game et al. 1998).

The North Coast unit comprises about 16,500 square miles south of the Oregon border and west of Interstate 5. Columbian black-tailed deer populations occur at comparatively higher densities in this unit than elsewhere in the state. Deer are migratory in some areas where topographic variation is high, such as the Trinity Alps and Marble Mountains area. Elsewhere they seasonally move within a year-round home range and are considered resident deer. The deer population in the North Coast DAU has been considered fairly stable in recent years, varying from about 170,000–250,000. This DAU is the most productive (based on a per unit area evaluation) in terms of deer/square mile.

The Cascade–North Sierra Nevada unit comprises about 7,000 square miles from the Oregon border south to the Lake Almanor area and Feather River drainage. Deer populations consist of black-tailed and Rocky Mountain mule deer (*Odocoileus hemionus hemionus*); however, as stated above, only Columbian black-tailed deer occur in the watershed. The deer population has changed from 60,000–70,000 animals down to 35,000–45,000 in the past several years. Deer productivity in the winter ranges of Shasta-Tehama counties has been linked to fall rains and the germination of annual vegetation. Recent deer declines may be partially attributable to a hard freeze several years ago that killed desirable browse species in some parts of the summer range.

Bear

Black bears are recognized as an important component of California's ecosystems and as a valuable resource for the people of California. They can be found mostly in mountainous areas above 3,000 feet in elevation (California Department of Fish and Game 1998). As omnivores, black bears will eat whatever seems edible. They commonly consume ants and other insects in summer, but prefer nut

crops, especially acorns, and manzanita berries in the fall. Mostly they are plant eaters, but they have been reported catching and consuming young deer fawns.

Black bears occupy a variety of habitat; however, bear populations are most dense in forested areas with a wide variety of seral stages (California Department of Fish and Game 1998). Mixed conifer forests, montane hardwood conifer, chaparral, and hardwood are important habitat types and support the greatest bear densities in the watershed (California Department of Forestry and Fire Protection 2003). Habitats with both vegetative and structural diversity provide alternate food resources when other foods are in short supply. Vegetation and structure diversity not only allow for greater survival of existing bears, they also provide for increased reproduction (California Department of Fish and Game 1998).

The black bear has been classified as a game mammal since 1948. Since that time, hunting regulations have become more restrictive, prohibiting trapping, killing of cubs or sows with cubs, and reducing the bag limit from two to one bear per license year. Before the early 1980s, regulation changes were infrequent. However, in 1982, CDFG began recommending regulatory and legislative changes to reduce poaching and increase its ability to monitor bear populations.

Black bear numbers in California are now increasing. Important demographic measures such as sex ratio of harvested bears, median age, and number of bears harvested indicate increasing population levels. In addition, the illegal take of bears has been greatly reduced from levels seen prior to 1985. Current population levels are estimated between 17,000 and 23,000. This is up from an estimated population of 10,000 to 15,000 in the early 1980s (California Department of Forestry and Fire Protection 2003).

Mammals Harvested for Furs

CDFG has been gathering information on the number of mammals harvested for furs, their value, and the number of licenses sold in California since 1919. Data for the 2006–2007 trapping season indicate that bobcats were the most economically important animals, providing 80 percent of the total value of California's furs (Garcia 2007). Muskrats were second in value, coyotes ranked third, and gray foxes were fourth for the year. Shasta County reported the harvest of 1 beaver, 17 bobcats, 18 gray foxes, 9 mink, 2 mink, 1,340 muskrats, 5 opossums, 6 raccoons, and 9 striped skunks during the 2006–2007 season (Garcia 2007). For the same period, Siskiyou County reported the harvest of 2 badgers, 7 beavers, 163 bobcats, 66 coyotes, 139 gray foxes, 1 mink, 2,373 muskrats, 11 raccoons, and 6 striped skunks (Garcia 2007).

Upland Game Birds

Wild Turkeys

The wild turkey is a member of the bird order Galliformes, which also includes grouse, pheasants, partridge, and quail. It is the largest game bird in North America. In California, wild turkeys can be found primarily from sea level to about 3,000 feet in elevation, but occasionally as high as 5,000–6,000 feet (California Department of Fish and Game 2005). In the watershed, they are known to occur on the west side of Shasta Lake. Oak habitats with a permanent water source have been described as the major requirement for turkeys in California; however, they also use ponderosa pine

habitats and pinyon juniper in association with ponderosa and Jeffrey pines (California Department of Fish and Game 2005). The average wild turkey harvest in Shasta and Siskiyou counties between 1991 and 2003 was 1,131 and 200–400, respectively (California Department of Fish and Game 2005).

Mountain Quail and California Quail

Two species of quail occur in the watershed, the mountain quail and the California quail. To measure hunter effort and game harvest each year, CDFG conducts an annual "Game Take Hunter Survey." According to the 2000 survey, quail are the third most popular game species in terms of time spent in pursuit, behind only ducks and deer (Mastrup 2002). The California quail comprises most of the annual quail harvest. In 2000, Siskiyou County was ranked first for percent total of mountain quail harvest in the state and tenth for California quail harvest, while Shasta County ranked ninth for mountain quail harvest (Mastrup 2002).

The California quail is associated with a combination of brushy vegetation and more open weedy or grassy habitat with some water supply. They avoid dense forests and dense chaparral (Mastrup 2002). A good distribution and quality of cover is important for efficient and safe access to food and water.

The mountain quail is an animal of mixed evergreen forests and chaparral. This quail is found in habitats associated with pinyon-juniper, oak woodland, chaparral, coastal forest, and mountain forests (Mastrup 2002). Mountain quail like thick brush that covers about half of the area.

Introduced/Invasive Wildlife Species

For over two centuries, people have imported animals into California that are not native to the state. Whether brought here intentionally for food, sport, ornament, as pets, or by accident, many of these species have now been introduced into the wild (California Department of Fish and Game 2003). Although Californians have benefited from the introduction of plant and animal species necessary for food or other human pursuits, many other introduced species can wreak havoc on the state's environment and economy. Those species that cause harm and, once established, spread quickly from their point of introduction are often called "invasive" or "nuisance" species.

Invasive species threaten the diversity and/or abundance of native species through competition for resources, predation, interbreeding with native populations, parasitism, transmitting diseases, or causing physical or chemical changes to the invaded habitat. Through their impacts on natural ecosystems, agricultural and other developed lands, and water delivery and flood protection systems, invasive species may also negatively affect human health and/or the economy. Examples of direct impacts to human activities include the clogging of navigable waterways and water delivery systems, weakening flood control structures, damaging crops, introducing diseases to animals that are raised or harvested commercially, and diminishing sport fish populations (California Department of Fish and Game 2008a). A few of the more common introduced/invasive wildlife and fish species present in the watershed are discussed in additional detail below (see also *Game Fish* above for a discussion of nonnative game fish).

Mosquitofish

Mosquitofish have been introduced throughout the world to control mosquito populations, and these introductions have had negative effects on amphibians. In experimental studies, mosquitofish decreased the survival of larval Pacific treefrogs (Goodsell and Kats 1999) and California newts (Gamradt and Kats 1996) and inflicted tail injury, reduced metamorph size, and altered activity patterns of larval California red-legged frogs (Lawler et al. 1999).

New Zealand Mud Snail

The New Zealand mud snail was recently (December 2007) confirmed to live in Shasta Lake (California Department of Fish and Game 2008d). New Zealand mud snails, which reproduce rapidly and can crowd out native insects that aquatic wildlife depend upon for survival, were first discovered in California in 2000 in the Owens River in Mono County (California Department of Fish and Game 2008d). New Zealand mud snail colonies disrupt the base of the food chain by consuming algae and competing with native bottom-dwelling invertebrates. A population decline of invertebrates can follow the introduction of New Zealand mud snails, which reduces fish forage. With a decrease in food availability, fish populations can decline as well.

New Zealand mud snails can grow as large as one-quarter inch but are often much smaller and are parthenogenic (i.e., able to start a new population with only one snail). They have the potential for extraordinary population densities —up to nearly 1 million snails per square meter and comprising up to 95 percent of the invertebrate biomass of a river. It is believed that populations in New Zealand are kept in check naturally by a native parasite. In North America, however, native stream communities can be altered because the snail has no natural predators or parasites, and its populations have flourished where they have been introduced. It is not believed they can be eradicated once established (California Department of Fish and Game 2008d).

American Bullfrog

The American bullfrog is native to the eastern and midwestern United States and southeast Canada. It has been accidentally and intentionally introduced (e.g., for food in the 1920s by commercial frog farmers due to its large, meaty legs) throughout the world. The American bullfrog is now established throughout most of the western United States and southwestern Canada (California Herps 2008). Their large size, high mobility, generalized eating habits, and huge reproductive capabilities have made bullfrogs extremely successful invaders and a threat to biodiversity (AmphibiaWeb 2008). Bullfrogs prey on native amphibians as well as young western pond turtles, ducklings, and other aquatic and riparian vertebrates (Graber 1996).

Birds

Wild turkeys in California are the result of introductions, which started before the turn of the century, and are managed as resident game birds. For more information on turkeys, see *Locally Important Wildlife and Fish Populations* above.

Barred owls have been expanding their range in the western United States since the 1970s, and were first documented in California in 1981 (Evens and LeValley 1982). They have successfully colonized

a variety of forested and riparian habitats, and have been documented in the watershed near Slate Creek (Lindstrand personal communication). The range expansion of the barred owl may have a negative effect on spotted owls. Barred owls have successfully colonized habitats that are also used by spotted owls and are slightly larger and more aggressive in interactions with the spotted owl (Dark et al. 1998).

Mammals

Domestic cats first arrived in North America with European colonists several hundred years ago. Since that time, cats have thrived as pets, strays, and semi-wild (feral) predators. Free-ranging cats can have a large impact on native wild animals. Nationwide, rural cats probably kill over a billion small mammals and hundreds of millions of birds each year. Some of these kills are house mice, rats, and other species considered pests, but many are native songbirds and mammals whose populations may already be stressed by other factors, such as habitat destruction (Coleman et al. 1997).

Domestic pigs were introduced to California in the 1700s by explorers and settlers who allowed them to forage freely, especially in the fall to take advantage of fallen acorns (Waithman 2001). This resulted in some pigs becoming feral. Since that time, domestic pigs have occasionally escaped and been added to the wild population. In addition, in the 1920s, the European wild boar was introduced into California, which resulted in a wild boar/feral domestic pig hybrid (Waithman 2001). Wild pigs can cause a variety of damage. A common complaint is rooting resulting in the destruction of crops and pastures. Damage to farm ponds and watering holes for livestock is another common problem.

Virginia opossums were first introduced to California in 1910 (Jameson and Peeters 1988). They now occur widely in moist woodlands and brushy habitats at lower elevations.

3.4 References

3.4.1 Literature Cited

Agee, J. K. 1991. Fire history along an elevational gradient in the Siskiyou Mountains, Oregon. *Northwest Science* 65(4):188-190.

Albini, F. A. 1976. Estimating wildfire behavior and effects. General technical report INT-30. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. Ogden, Utah.

Airola, D. A. and R. H. Barrett. 1985. Foraging and habitat relationships of insect-gleaning birds in a Sierra-Nevada mixed-conifer forest. *Condor* 87(2):205-216.

Alpers C. N., R. C. Antweiler, H. E. Taylor, P. C. Dileanis, J. L. Domalgowski. 2000. Metals transport in the Sacramento River, California, 1996-1997 Volume 2: Interpretation of Metal Loads. USGS Water Investigations Report 00-4002.

AmphibiaWeb. 2008. Introduced species. http://amphibiaweb.org/about/index.html (accessed 2008).

Anderson, H. E. 1982. Aids to determining fuel models for estimating fire behavior. General Technical Report INT-122. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. Ogden, Utah. April.

Aubry, K. B. 1997. The Sierra Nevada red fox (*Vulpes vulpes necator*). Paper read at Mesocarnivores of Northern California: Biology, management, and survey techniques, workshop manual, at Humboldt State University, Arcata, California.

Aubry, K. B., K. S. McKelvey, and J. P. Copeland. 2007. Distribution and broadscale habitat relations of the wolverine in the contiguous United States. *Journal of Wildlife Management* 71(7):2147-2158.

Baltz, D. M. and P. B. Moyle. 1984. The influence of riparian vegetation on stream fish communities of California. In *California riparian systems ecology, conservation, and productive management*, edited by R. E. Warner and K. M. Hendrix. Berkeley and Los Angeles, California: University of California Press.

Barbour, M. G., B. Pavlik, F. Drysdale, and S. Lindstrom. 1993. California's changing landscapes: Diversity and conservation of California vegetation. Sacramento, California: California Native Plant Society.

Bartholow, J., R. B. Hanna, L. Saito, and M. J. Horn. 2001. Simulated limnological effects of the Shasta Lake temperature control device. *Environmental Management* 27(4):609-626.

Basgall, M. E. and W. R. Hildebrandt. 1989. *Prehistory of the Sacramento River Canyon, Shasta County, California*. Vol. Publication Number 9, *Center for Archaeological Research at Davis*. Davis, California: University of California, Davis.

Baxter, C. V. and F. R. Hauer. 2000. Geomorphology, hyporheic exchange, and selection of spawning habitat by bull trout (*Salvelinus confluentus*). Can. J. Fish. Aquat. Sci 57:1470-1481.

Benda, L. E. and T. W. Cundy. 1990. Predicting deposition of debris flows in mountain channels. Canadian Geotechnical Journal 27:409-417.

Benda, L. and T. Dunne. 1997a. Stochastic forcing of sediment supply to channel networks from landsliding and debris flow. Water Resources Research 33:2849-2863.

———. 1997b. Stochastic forcing of sediment routing and storage in channel networks. Water Resources Research 33:2865-2880.

Benda, L., C. Veldhuisen, and J. Black. 2003. Debris flows as agents of morphological heterogeneity at low-order confluences, Olympic Mountains, Washington. Geological Society of America Bulletin 115:1110-1121.

Benda, L., D. Miller, T. Dunne, L. Poff, G. Reeves, M. Pollock, and G. Pess. 2004a. Network dynamics hypothesis: spatial and temporal organization of physical heterogeneity in rivers. BioScience 54:413-427.

Benda, L., K. Andras, and D. Miller. 2004b. Tributary effects in river networks: role of basin scale, basin shape, network geometry, and disturbance regimes. Water Resources Research 40:1-15.

Benyus, J. M. 1989. *The field guide to wildlife habitats of the western United States*. New York: FIRESIDE.

Besctha, J. L., B. Bilby, G. W. Brown, L. B. Holtgy, and T. D. Hofstra. 1987. Stream temperature and aquatic habitat. Pages 191-232 *in* E. O. Salo and T. W. Cundy, editor. Streamside Management: Forestry and Fishery Interactions. Institute of Forest Resources, University of Washington, Seattle, Washington.

Best, J. L. 1988. Sediment transport and bed morphology at river channel confluences. Sedimentology 35:481-498.

Bilby, R. E. and P. A. Bisson. 2004. Function and Distribution of Large Woody Debris. Pages 324-346 *in* R. J. Naiman and R. E. Bilby, editors. River Ecology and Management. Springer, New York.

Bisson, P. A., R. E. Bilby, M. D. Bryant, C. A. Dolloff, G. B. Grette, R. A. House, M. L. Murphy, K. V. Koski, and J. R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present, future. Pages 143-190 *in* E. O. Salo and T. W. Cundy, editors. Streamside Management: Forestry and Fisheries Interactions. University of Washington, College of Forest Resources, Contribution 57. University of Washington, Seattle.

Blaustein, A. R. and D. B. Wake. 1990. Declining amphibian populations - a global phenomenon? *Endangered Species Act Bulletin* 71(2):127-128.

Bossard, C. C., J. M. Randall, and M. C. Hoshovsky, eds. 2000. *Invasive plants of California's wildlands*: University of California Press.

Boullion, T. 2006. Cantera project Sacramento River benthic macroinvertebrate sampling program - 2001 results progress report. Unpublished report submitted to the Cantera Program, California Department of Fish and game. California Department of Water Resources.

Brett, M. T. and C. R. Goldman. 1993. Crayfish population size and recolonization potential in the upper Sacramento River following the Cantera Vapam spill. Unpublished report submitted to the California Department of Fish and Game. Ecological Associates.

———. 1994. Crayfish population size and recolonization potential in the upper Sacramento River following the Cantera Vapam spill - 1993 field sampling. Unpublished report to the California Department of Fish and Game. Ecological Research Associates.

Brode, J. M. and R. B. Bury. 1984. The importance of riparian systems to amphibians and reptiles. In *California riparian systems ecology, conservation, and productive management*, edited by R. E. Warner and K. M. Hendrix. Berkeley and Los Angeles, California: University of California Press.

Buffington, J. M., D. R. Montgomery, and H. M. Greenberg. 2004. Basin scale availability of salmonid spawning gravel as influenced by channel type and hydraulic roughness in mountain catchments. Can. Geotech. J. 61:2085-2096.

Burnett, K., G. H. Reeves, D. Miller, S. Clarke, K. Christiansen, and K. Van-Borland. 2003. A first step toward broad scale identification of freshwater protected areas for pacific salmon and trout in Oregon, USA. *in* J. P. Beumer, A. Grant, and D. C. Smith, editors. Aquatic Protected Areas: What Works Best and How Do We Know? Proceedings of the World Congress on Aquatic Protected Areas. Austrian Society of Fish Biology, North Beach, WA, Australia, Cairns, Australia.

Burnett, K. M., G. Reeves, D. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. Ecological Applications 17:66-80.

Bureau of Reclamation. 2006. Environmental scoping report: Shasta Lake resources investigation, California. Department of Interior, Bureau of Reclamation, Mid-Pacific Region February 2006.

Burton, T. M. and G. E. Likens. 1975. Salamander populations and biomass in the Hubbard Brook Experimental Forest, New Hampshire. *Copeia*:541-546.

Bury, R. B., H. W. Campbell, and N. J. Scott. 1980. The role and importance of non-game wildlife. *Proceedings of the North American Wildlife and Natural Resources Conference* 45:197-207.

Bury, R. B., P. S. Corn, K. B. Aubry, F. F. Gilbert, and L. L. C. Jones. 1991. Aquatic amphibian communities in Oregon and Washington. In *Wildlife and vegetation of unmanaged Douglas-fir forests*, edited by L. H. Ruggiero, K. B. Aubry, A. B. Carey and M. H. Huffs: USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-285.

California Air Resources Board. 2009. The 2009 California almanac of emissions and air quality. California Environmental Protection Agency, Air Resources Board. Sacramento, California. http://www.arb.ca.gov/Aqd/almanac/almanac.htm (accessed March 2010).

California Air Resources Board. 2010. 2010 State Area Designations. California Environmental Protection Agency, Air Resources Board, Sacramento, California. http://www.arb.ca.gov/desig/2010statedesig.htm (accessed February 2010).

California Climate Change Center. 2009. Projection of Potential Flood Regime Changes in California. CEC-500-2009-050-F.

California Department of Fish and Game. 1991a. Shasta Lake Management Plan (Draft). California Department of Fish and Game, Inland Fisheries Division.

———. 1991b. Annual report on the status of California state listed threatened and endangered animals and plants.

———. 1998. Black Bear Management Plan. California Department of Fish and Game. July.

———. 2002. *Guide to hunting deer in California*. Second ed.

———. 2003. *Atlas of the biodiversity of California*: California Department of Fish and Game.

———. 2005. *Guide to hunting wild turkeys in California*. Revised April 2005 ed.: California Department of Fish and Game.

———. 2008a. Invasive species program. http://www.dfg.ca.gov/invasives/ (accessed 2008).

———. 2008b. California natural diversity database (CNDDB). http://www.dfg.ca.gov/biogeodata/ (accessed 2008).

———. 2008c. CWHR version 8.2 personal computer program: California Department of Fish and Game, California Interagency Wildlife Task Group.

———. 2008d. DFG seeks assistance in slowing spread of New Zealand mud snails. http://www.dfg.ca.gov/news/news08/08001.html (accessed November 2008).

———. 2010. Recreation and licensing. http://www.dfg.ca.gov/licensing/specialpermits/suctiondredge/ (accessed 2010).

California Department of Fish and Game, USDA Forest Service, and Bureau of Land Management. 1998. Report to the Fish and Game Commission: As assessment of mule and black-tailed deer habitats and populations in California.

California Department of Forestry and Fire Protection. 2003. The changing California forest and range assessment. http://frap.fire.ca.gov/assessment2003/toc.html (accessed 2008).

———. 2007. California's wildland-urban interface building code information. http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_codes.php (accessed January 6, 2009).

California Department of Forestry and Fire Protection. 2008. Fire hazard severity zones RECOMMENDED, 5-2008. Very high zones in LRA. GIS data layer.

———. 2003. California's groundwater. Bulletin 118.

California Department of Water Resources. 2009. Monitoring Plan Sacramento Watershed Coordinate Water Program (SWCMP). California Water Board.

———. 2010. Water Data Library. http://www.water.ca.gov/waterdatalibrary/

———. 2010. California Data Exchange Center. http://cdec.water.ca.gov/cgi-progs

California Water Boards (CWB). 2006. Water quality assessment of the condition of California coastal waters and wadeable streams. Clean Water Act Section 305b Report.

California Herps. 2008. Non-native reptiles and amphibians introduced into California. http://www.californiaherps.com/info/introducedspecies.html (accessed 2008).

California Invasive Plant Council. 2007. Invasive plants. http://www.cal-ipc.org/ (accessed 2008).

California Native Plant Society. 2001. *Inventory of rare and endangered vascular plants of California*. Edited by D. P. Tibor. Sixth ed. Sacramento: California Native Plant Society.

———. 2008. Inventory of rare and endangered plants. http://cnps.web.aplus.net/cgi-bin/inv/inventory.cgi (accessed 2008).

California State Parks. 2002. Castle Crags State Park brochure. http://www.parks.ca.gov/pages/454/files/castle_crags2.pdf. (accessed 2009).

———. 2005. Park and recreation trends in California: An element of the California Outdoor Recreation Planning Program. http://ohv.parks.ca.gov/pages/795/files/recreation_trends_081505.pdf, (accessed 2008).

———. 2007. Gold rush overview. http://www.parks.ca.gov/?page_id=1081 (accessed May 3, 2007).

———. 2008. Assessing trends in nature-based recreation. *The California Park Planner*.

California State Parks. 2009. Strategic Plan 2009. Off-Highway Motor Vehicle Recreation Division.

California Travel and Tourism Commission and California Business Transportation and Housing Agency Division of Tourism. 2006. Statewide and regional tourism facts and Figure s, California fast facts 2006. http://industry.visitcalifornia.com/media/uploads/files/FastFacts-8-06_FINAL2.pdf. (accessed 2009).

Cantera Trustee Council. 2007. Final report on the recovery of the upper Sacramento River - Subsequent to the 1991 Cantera Spill.

Cedarholm, C. J., R. E. Bilby, P. A. Bisson, T. W. Bumstead, B. R. Fransen, W. J. Scarlett and J. W. Ward. 1997. Response of Juvenile Coho Salmon and Steelhead to Placement of Large Woody Debris in a Coastal Washington Stream. North American Journal of Fisheries Management. 17:947-963.

Central Valley Regional Water Quality Control Board. 2009. *Water quality control plan (basin plan) for the Sacramento and San Joaquin River basin.* California Regional Water Quality Control Board, Central Valley Region. Fourth Edition.

Church, M. 1983. Pattern of instability in a wandering gravel bed channel. Pages 169-180 *in* J. D. Collinson and J. Lewin, editors. Modern and ancient fluvial systems. Blackwell, Oxford.

City of Dunsmuir. 2008. Chamber of Commerce. www.ci.dunsmuir.ca.us (accessed 2008).

Clark, J., M. Papenfus, and D. C. Erman. 1991. A survey of the Sacramento River for remnant crayfish populations following the metam sodium spill of July 14, 1991. California Department of Fish and Game Internal Report.

Cleland, D. T., P. E. Avers, W. H. McNab, M. E. Jensen, R. G. Bailey, T. King, and W. E. Russel. 1997. National hierarchical framework of ecological units. Pages 361 p *in* Haney, editor. Ecosystem Management. Yale University, New Haven, Connecticut.

Coleman, J., S. Temple, and S. Craven. 1997. Cats and wildlife. A conservation dilemma.

Cordell, H. K., C. J. Betz, and G. T. Green. 2008. Nature-based outdoor recreation trends and wilderness. *International Journal of Wilderness* 14(2).

Cordell, H. K., C. J. Betz, G. T. Green, and M. Owens. 2005. Off-highway vehicle recreation in the United States, regions and states: A national report from the national survey on recreation and the environment.

Cronise, T. 1868. *The natural wealth of California*. San Francisco, California: H. H. Bancroft & Company.

Dark, S. J., R. J. Gutierrez, and G. I. Gould Jr. 1998. The barred owl (*Strix varia*) invasion in California. *The Auk* 115(1):50-56.

Dean, M. 2005. Upper Sacramento River winter season angler survey 2004-05. California Department of Fish and Game Northern California-North Coast Region Wild Trout Program.

Dean Runyon Associates. 2008. California travel impacts by county, 1992-2006, 2007 preliminary state estimates. http://www.visitcalifornia.com/AM/CM/ContentDisplay.cfm?ContentFileID=2527&MicrositeID=0&FusePreview=Yes. (accessed 2009).

Department of Water Resources. 1997. Aquatic macroinvertebrate recovery assessment in the upper Sacramento River 1991-1996. State of California, The Resources Agency, Department of Water Resources. August.

———. 2003. *California's groundwater. Bulletin 118 - Update 2003*: State of California, The Resources Agency, Department of Water Resources.

———. 2009. Monitoring Plan. Sacramento Watershed Coordinated Monitoring Program (SWCMP). February 19, 2009.

Dietrich, W. E. and T. Dunne. 1978. Sediment budget for a small catchment mountainous terrain. Zietshrift fur Geomorphologie: 191-206.

Domagalski, J. L., D. L. Knifong, P. D. Dileanis, L. R. Brown, J. T. May, V. Connor, and C. N. Alpers. 2000. Water quality in the Sacramento River Basin, California, 1994–98. U.S. Department of the Interior; U.S. Geologic Survey. Report No. U.S. Geological Survey Circular 1215.

Dragovich, J. D., M. J. Brunengo, and W. J. Gerstel. 1993. Landslide inventory and analysis of the Tilton Creek-Mineral River area, Lewis County, Washington: Part 2: Soils, Harvest Age, and Conclusions. Washington Geology 21:1-32.

Dunne, T. and L. B. Leopold. 1978. Water in Environmental Planning. W.H. Freeman and Company, New York.

Dwire, K. A. and J. B. Kauffman. 2003. Fire and riparian ecosystems in landscapes of the western USA. *Forest Ecology and Management* 178:61-74.

Elliot, W. J., D. L. Schelle, and D. E. Hall. 2000. The Forest Service WEPP interfaces. Pages 9p *in* 2000 ASAE Summer Meeting. ASAE, St. Joseph, Michigan.

Elser, J. J., C. Junge, and C. R. Goldman. 1994. Population structure and ecological effects of the crayfish *Pacifastacus leniusculus* in Castle Lake, California. *Great Basin Naturalist* 54:162-169.

Environmental Protection Agency. 2000. Water quality standards; Establishment of numeric criteria for priority toxic pollutants for the State of California; rule. 430 CFR Part 131.

Environmental Protection Agency. 2010. Envirofacts warehouse. http://www.epa.gov/enviro/index.html

Environmental Protection Agency. 2010. Enviromapper. http://www.epa.gov/emefdata/em4ef.html?minx=-124.77173&miny=40.26276&maxx=-120.37720&maxy=42.73087&pText=Siskiyou.

Erman, N. A. 1984. The use of riparian systems by aquatic insects. In *California riparian systems ecology, conservation, and productive management*, edited by R. E. Warner and K. M. Hendrix. Berkeley and Los Angeles, California: University of California Press.

Evens, J. and R. LeValley. 1982. Middle Coast Region. *American Birds* 36:890.

Everest, F. H., R. L. Beschta, J. C. Scrivener, K. V. Koski, J. R. Sedell, and C. J. Cederholm. 1987. Fine Sediment and Salmonid Production: A Paradox. Pages 98-142 *in* E. O. Salo and T. W. Cundy, editors. Streamside Management: Forestry and Fishery Interactions. College of Forest Resources, University of Washington, Seattle, Washington.

Fannin, R. J. and T. P. Rollerson. 1993. Debris flows: some physical characteristics and behavior. Canadian Geotechnical Journal 30:71-81.

Finney, M. A. 2006. An overview of FlamMap fire modeling capabilities. Effectiveness of prescribed fire as a fuel treatment in Californian coniferous forests. In *Fuels Management - How to Measure Success: Conference Proceedings RMRS-P-41*, edited by P. L. Andrews and B. W. Butler. Portland, Oregon: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

FlamMap 3.0.0. Joint Fire Science Program and U.S. Department of the Interior, Bureau of Land Management, Missoula, Montana.

Freel, M. 1991. A literature review for management of the marten and fisher on National Forests in California. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region.

Frest, T. J. and E. J. Johannes. 1993. Freshwater mollusks of the upper Sacramento system, California with particular reference to the Cantera spill. 1992 report prepared for the California Department of Fish and Game. Deixis Consultants. March.

———. 1994. Freshwater mollusks of the upper Sacramento system, California with particular reference to the Cantera spill. 1993 report prepared for the California Department of Fish and Game. Deixis Consultants. February.

———. 1995. Freshwater mollusks of the upper Sacramento system, California with particular reference to the Cantara spill. 1994 report prepared for the California Department of Fish and Game. Deixis Consultants. Prepared for the Cantara Trustee Council. March.

———. 1997. Upper Sacramento system freshwater mollusk monitoring, California with particular reference to the Cantara spill. 1996 yearly report. Deixis Consultants. Prepared for the Cantara Trustee Council. June 10, 1997.

Frost, E. J. and R. Sweeney. 2000. Fire regimes, fire history and forest conditions in the Klamath-Siskiyou region: An overview and synthesis of knowledge. Prepared for the World Wildlife Fund, Klamath-Siskiyou Ecoregion Program by Wildwood Environmental Consulting. December 2000.

Fry, D. L. and S. L. Stephens. 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* 223:228-238.

Furniss, M. J., C. I. Millar, D. L. Peterson, L. A. Joyce, R. P. Neilson, J. E. Halofsky, and B. K. Kerns. 2009. Adapting to climate change: A short course for land managers. USDA Forest Service, Pacific Northwest Research Station. Report No. PNW-GTR-789.

Gamradt, S. C. and L. B. Kats. 1996. Effect of introduced crayfish and mosquitofish on California newts. *Conservation Biology* 10(4):1155-1162.

Garcia, J. R. 2007. Licensed fur trappers' and dealers' report 2006-2007. California Department of Fish and Game. December.

Goldman, C. R. 1992. An investigation of crayfish population size, age structure, and recolonization potential in the upper Sacramento River. Proposal submitted to the California Department of Fish and Game. Ecological Research Associates.

Goodsell, J. A. and L. B. Kats. 1999. Effect of introduced mosquitofish on pacific treefrogs and the role of alternative prey. *Conservation Biology* 13(4):921-924.

Graber, D. M. 1996. Status of terrestrial vertebrates. In *Sierra Nevada Ecosystem Project: Final report to Congress. Chapter 25*. Davis, California: Centers for Water and Wildland Resources.

Grant, G. G. and F. J. Swanson. 1995. Morphology and processes of valley floors in mountain streams, Western Cascades, Oregon. Pages 83-101 *in* J. E. Costa, a. J. Miller, K. W. Potter, and P. R. Wilcock, editors. Natural and Anthropogenic Influences in Fluvial Geomorphology, Geophysical Monograph 89. American Geophysical Union, Washington, D. C.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. An ecosystem perspective of riparian zones. *BioScience* 41(8):540-551.

Grinnell, J. 1933. Review of the recent mammal fauna of California. *University of California Publications in Zoology* 40(2):71-234.

Grinnell, J., J. S. Dixon, and J. M. Linsdale. 1937. *Fur-bearing mammals of California*. Berkeley, California: University of California Press.

Halliday, T. R. and W. R. Heyer. 1997. The case of the vanishing frogs. *Technology Review* 100(4):56-63.

Hansen, E. M., D. J. Goheen, E. S. Jules, and B. Ullian. 2000. Managing Port-Orford-cedar and the introduced pathogen *Phytophthora lateralis*. *The American Phytopathological Society* 84(1):4-14.

Harmon, M. E., J. F. Franklin, F. J. Swanson, P. Sollins, S. V. Gregory, J. D. Lattinn, N. H. Anderson, S. P. Cline, N. G. Aumen, J. R. Sedell, G. W. Lienkaemper, K. Cromack, Jr., and K. W. Cummins. 1986. Ecology of coarse woody debris in temperate ecosystems. *Advances in Ecological Research* 15:133-302.

Hershler, R., H. P. Liu, T. J. Frest, and E. J. Johannes. 2007. Extensive diversification of pebblesnails (Lithoglyphidae: Fluminicola) in the upper Sacramento River Basin. *Zoological Journal of the Linnean Society* 149:371-422.

Hughes, J. M. 1999. Yellow-billed cuckoo (*Coccyzus americanus*). In *Birds of North America*, edited by A. Poole and F. Gill. Washington D.C., Philadelphia: The Academy of Natural Sciences and The American Ornithologists' Union.

Hull, M. K., C. A. O'Dell, and M. J. Schroeder. 1966. Critical fire weather patterns: Their frequency and levels of fire danger. USDA Forest Service, Pacific Southwest Research Station.

Husari, S., H. T. Nichols, N. G. Sugihara, and S. L. Stephens. 2006. Chapter 19. Fire and fuel management. In *Fire in California's Ecosystems*, edited by N. G. Sugihara, J. W. van Wagtendonk, K. E. Shaffer, J. Fites-Kaufman and A. E. Thode. Berkeley, California: University of California Press.

Istanbulluoglu, E., D. G. Tarboton, R. T. Pack, and C. H. Luce. 2003. A sediment transport model for incision of gullies on steep topography. Water Resources Research 39:doi:10.1029/2002WR001467.

Jameson, E. W., Jr. and H. J. Peeters. 1988. *California mammals*. Berkeley, California: University of California Press.

Kats, L. B. and R. P. Ferrer. 2003. Alien predators and amphibian declines: Review of two decades of science and the transition to conservation. *Diversity and Distributions* 9(2):99-110.

Ketcheson, G. and H. A. Froelich. 1978. Hydrologic factors and environmental impacts of mass soil movements in the Oregon Coast Range. Water Resources Research Institute, Oregon State University, Corvallis, Oregon.

Kiffney, P. M. and J. S. Richardson. 2001. Interactions among nutrient, periphyton, and invertebrate and vertebrate grazers in experimental channels. Copeia: 422-429.

Knight, A. W. and R. L. Bottorff. 1984. The importance of riparian vegetation to stream ecosystems. In *California riparian systems ecology, conservation, and productive management*, edited by R. E. Warner and K. M. Hendrix. Berkeley and Los Angeles, California: University of California Press.

KOA. 2007. Kamping trends. http://koapressroom.com. (accessed 2009).

Kohler, S. L. 2002. Aggregate availability in California. California Geological Survey.

Lake Siskiyou Camp-Resort. http://www.lakesis.com/ (accessed 2009).

Laliberte, A. S. and W. J. Ripple. 2004. Range contractions of North American carnivores and ungulates. *BioScience* 54(2):123-138.

Lancaster, S. T., S. K. Hayes, and G. E. Grant. 2001. Modeling Sediment and Wood Storage and Dynamics in Small Mountainous Watersheds. Geomorphic Processes and Riverine Habitat Water Science and Application: Water Science and Application 4:85-102.

Lawler, S. P., D. Dritz, T. Strange, and M. Holyoak. 1999. Effects of introduced mosquitofish and bullfrogs on the threatened California red-legged frog. *Conservation Biology* 13(3):613-622.

Laymon, S. A. 1998. Yellow-billed cuckoo (*Coccyzus americanus*). In *The riparian bird conservation plan: A strategy for reversing the decline of riparian-associated birds in California*: California Partners in Flight.

Laymon, S. A. and M. D. Halterman. 1989. A proposed habitat management plan for yellow-billed cuckoos in California. Gen. Tech. Rep. PSW-110. USDA Forest Service.

Lewis, T. D. 2000. Executive Summary: Regional Assessment of Stream Temperature Across Northern California and Their Relationship to Various Landscape Level and Site Specific Attributes. Humboldt State University Foundation, Arcata, California.

Lindstrand, L. 2000. Discovery of Shasta salamanders in atypical habitat. *California Fish and Game* 86(4):259-261.

———. 2008. A new elevation record for Shasta salamander (*Hydromantes shastae*) in northern California. *California Fish and Game 94(2):119-121*.

Lininger, J. C. 2003. Fire history and need for fuel management in mixed Douglas-fir forests of the Klamath-Siskiyou region, northwest California and southwest Oregon, USA. Paper read at 2nd International Wildland Fire Ecology and Fire Management Congress.

Lisle, T. E., C. Yantao, G. Parker, J. E. Pizzuto, and A. M. Dodd. 2001. The Dominance of Dispersion in the Evolution of Bed Material Waves in Gravel-Bed Rivers. Earth Surface Process and Landforms 26:1409-1420.

Luke, C. and D. Sterner. 1994. Pilot studies to evaluate a Dicamptodon tenebrosus reintroduction program for the main stem of the Sacramento River. Report prepared for the California Department of Fish and Game. Biosystems Analysis, Inc. May.

———. 1995. Cantara bridge chemical spill, 1994 aquatic amphibian survey. Unpublished final report prepared for California Department of Fish and Game. Biosystems Analysis, Inc.

Masson, M. 1966. *A bag of bones: Legends of the Wintu Indians of northern California*. Happy Camp, California: Naturegraph Press.

Mastrup, S. 2002. *Guide to hunting quail in California*. Sacramento, California: California Department of Fish and Game.

May, C. L. 2002. Debris flows through different forest age classes in the Central Oregon Coast Range. Journal of the American Water Resources Association 38:1097-1113.

Miller, D. J. 2003. Programs for DEM Analysis. *in* Landscape Dynamics and Forest Management, General Technical Report RMRS-GTR-101CD. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO, USA.

Miller, D. and L. Benda. 2000. Effects of mass wasting on channel morphology and sediment transport: South Fork Gate Creek, Oregon. Bulletin of the Geological Society of America: 1814-1824.

Miller, D. J., C. H. Luce, and L. E. Benda. 2003. Time, space, and episodicity of physical disturbance in streams. Forest Ecology and Management 178:121-140.

Miller, D. J. and K. M. Burnett. 2007a. Effects of forest cover, topography, and sampling extent on the measured density of shallow, translational landslides. Water Resources Research 43:1-23.

Miller, D. J. and K. M. Burnett. 2007b. A probabilistic model of debris-flow delivery to stream channels, demonstrated for the Oregon Coast Range, USA. Geomorphology 94:184-205.

Miles, S. R. and C. B. Goudey. 1997. Ecological subregions of California: Section and subSection descriptions. Report No. R5-EM-TP-005. USDA Forest Service.

Montgomery, D. R. and W. E. Dietrich. 1994. A physically based model for the topographic control on shallow landsliding. Water Resources Research 30:1153-1171.

Moore, R. D., P. Sutherland, T. Gomi, and A. Dhakal. 2005. Thermal regime of a headwater stream within a clear-cut, Coastal British Columbia, Canada. Hydrological Processes doi: 10.1002/hyp.5733.

Morrison, M., L., B. G. Marcot, and R. W. Mannan. 1998. Wildlife habitat relationships: concepts and applications. The University of Wisconsin Press, Madison, Wisconsin, USA.

Mote, P. W., E. A. Parson, A. F. Hamlet, W. S. Keeton, D. Lettenmaier, N. Mantua, E. W. Miles, D. W. Peterson, D. L. Peterson, R. Slaughter, and A. K. Snover. 2003. Preparing for climatic change: The water, salmon, and forests of the Pacific Northwest. *Climatic Change* 61:45-88.

Mount Shasta City. 2008. Welcome to City of Mt. Shasta California. http://ci.mt-shasta.ca.us/Main/HomePage (accessed 2008).

Moyle, P. B. 2002. *Inland fishes of California*. Davis, California: University of California Press.

Mt. Shasta Ski Park. 2008. Employment. http://www.skipark.com/employment.html, (accessed 2008).

Nakamura, G. and J. K. Nelson, eds. 2001. *Illustrated field guide to selected rare plants of Northern California*: University of California.

National Assessment Synthesis Team. 2000. Climate change impacts on the United States the potential consequences of cliamte variability and change. Overview: Pacific Northwest. http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overviewpnw.htm (accessed 2010).

National Marine Fisheries Service. 1996. Making ESA determinations of effect for individual or grouped actions at the watershed scale. Environmental and Technical Services Division, Habitat Conservation Branch, Portland, Oregon.

National Wildfire Coordinating Group Incident Operations Standards Working Team. 2007. Glossary of wildland fire terminology. http://www.nwcg.gov/pms/pubs/glossary/pms205.pdf (accessed September 26, 2008).

Nauman, R. S. and D. H. Olson. 2004. Surveys for terrestrial amphibians in Shasta County, California, with notes on the distribution of Shasta salamanders (*Hydromantes shastae*). *Northwestern Naturalist* 85(1):35-38.

Nielsen, J., L., E. L. Heine, G. A. Gan, and M. C. Fountain. 2000. Molecular analysis of population genetic structure and recolonization of rainbow trout following the Cantara spill. *California Fish and Game* 86(1):21-40.

Northern California Earthquake Data Center. 2008. http://seismo.berkeley.edu/annual_report/ar08_09/node40.html

Office of Mine Reclamation. 2000. *California's abandoned mine lands.* Vol. 2.

Osborne, L. L. and M. J. Wiley. 1992. Influence of tributary spatial position on the structure of warm water fish assemblages. Canadian Journal of Fisheries and Aquatic Science 49:671-681.

Pack, R. T., D. G. Tarboton, and C. N. Goodwin. 1998. The SINMAP Approach to Terrain Stability Mapping. *in* Eight Congress of the International Association of Engineering Geology, Vancouver, British Columbia.

Pergams, O. R. W. and P. A. Zaradic. 2008. Evidence for a fundamental and pervasive shift away from nature-based recreation. *Proceedings of the National Academy of Sciences* 105(7):2295-2300.

Perrine, J. D., J. P. Pollinger, B. N. Sacks, R. H. Barrett, and R. K. Wayne. 2007. Genetic evidence for the persistence of the critically endangered Sierra Nevada red fox in California. *Conservation Genetics* 8(5):1083-1095.

PMC. 2007. City of Mount Shasta General Plan.

Radcliff, D. R. 2006. Evaluating the impactiveness of grass bed treatments as a habitat for juvenile bass in a drawdown reservoir. Master's thesis, Utah State University, Logan, Utah.

Regional Water Quality Board and California Environmental Protection Agency. 2002. *Upper Sacramento River TMDL for Cadmium, Copper & Zinc.* California Regional Water Quality Control Board, Central Valley Region, Sacramento River TMDL Unit.

Reid, L. M. and T. Dunne. 1996. Rapid Evaluation of Sediment Budgets. Catena Verlag, Reiskirchen, Germany.

Rice, S. P., M. T. Greenwood, and C. B. Joyce. 2001. Macroinvertebrate community changes at coarse sediment recruitment points along two gravel bed rivers. Water Resources Research 37:2793-2803.

Richards, K. 1982. Rivers: Form and Process in Alluvial Channels. Methuen & Co., Ltd., University Press, Cambridge, Great Britain. 361p.

Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks, W. Eichbaum, D. A. Dellasala, K. Kavanagh, P. Hedao, P. T. Hurley, K. M. Carney, R. Abell, and S. Walters, eds. 1999. *Terrestrial ecoregions of North America*. Washington, D.C. and Covelo California: Island Press.

Robison, G. E., K. A. Mills, J. Paul, L. Dent, and A. Skaugset. 1999. Storm Impacts and Landslides of 1996: Final Report. Forest Practices Technical Report 4, Oregon Department of Forestry.

Rode, M. 1988. California wild trout management program: McCloud River wild trout area management plan. California Department of fish and Game, Inland Fisheries. Administrative Report.

Rode, M. and M. Dean. 2004. Lower McCloud River wild trout area fisher management plan 2004 through 2009. California Department of Fish and Game, Northern California - North Coast Region.

Rogers, P. 2008. Hunting fades in California amid sprawl, immigration and video games. *San Jose Mercury News*.

Rothermel, R. C. 1983. How to predict the spread and intensity of forest and range fires. General technical report INT-143. U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

Sawyer, J. O. and D. A. Thornburgh. 1977. Montane and subalpine vegetation of the Klamath Mountains. In *Terrestrial vegetation of California*, edited by M. G. Barbour and J. Major. Davis, California: California Native Plant Society.

Scarnecchia, D. L. and B. B. Roper. 2000. Large scale differential summer habitat use of three anadromous salmonids in a large river basin in Oregon, U.S.A. Fisheries Management and Ecology 7:197-209.

Schroeder, M. J. and C. C. Buck. 1970. Fire weather. US Department of Agriculture, Forest Service.

Schoenherr, A. A. 1991. *A natural history of California*: University of California Press.

Schuett-Hames, D., R. Conrad, A. E. Pleus, and K. Lautz. 1999. Method Manual for the Salmonid Spawning Gravel Scour Survey. TFW Manual TFW-AM9-99-008, NW Indian Fisheries Commission and Timber, Fish and Wildlife.

Schumm, S. A., M. D. Harvey, and C. C. Watson. 1984. *Incised channels: Morphology, dynamics, and control*: Water Resources Publications, Colorado.

Scott, J. H. and R. E. Burgan. 2005. Standard fire behavior fuel models: A comprehensive set for use with Rothermel's surface fire spread model. General technical report RMRS-GTR-153. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, Colorado. June.

Shasta County. 2004. Shasta County general plan as amended through September 2004.

Shilling, F., S. Sommarstrom, R. Kattlemann, B. Washburn, J. Florsheim, and R. Henly. 2005. California watershed assessment guide. Prepared for the California Resources Agency. July.

SHN Consulting Engineers & Geologists. 2004. Administrative draft: Lake Siskiyou watershed assessment. Prepared for Siskiyou County Planning Department. January.

Sidle, R. C. 1987. A dynamic model of slope stability in zero-order basins. IAHS Publ. 165:101-110.

Sidle, R. C., A. J. Pearce, and C. L. O'Loughlin. 1985. Hillslope Stability and Land Use. American Geophysical Union, Washington D. C.

Siskiyou County Economic Development. 2006. Siskiyou County - demographics. www.siskiyoucounty.org. (accessed 2009).

Skinner, C. N. 2001. A tree-ring based fire history of riparian reserves in the Klamath Mountains. Paper read at California riparian systems: Processes and floodplains management, ecology, and restoration. Riparian Habitat and Floodplains Conference, March 12-15, 2001, at Sacramento, California.

———. 2002. Influence of fire on dead woody material in forests of California and southwestern Oregon. In *Proceedings of the Symposium on the Ecology and Management of Dead Wood in Western Forests. PSW-GTR-181*, edited by W. F. Laudenslayer Jr., P. J. Shea, B. E. Valentine, C. P. Weatherspoon and T. E. Lisle. Albany, California: USDA Forest Service, Pacific Southwest Research Station.

Skinner, C. N. and C. Chang. 1996. Fire regimes, past and present. In *Sierra Nevada ecosystem project: Final report to congress. Volume II, assessments and scientific basis for management options*. Davis, California: University of California, Centers for Water and Wildland Resources.

Skinner, C. N. and A. H. Taylor. 2006. Southern Cascades bioregion. In *Fire in California's ecosystems*, edited by N. G. Sugihara, J. W. van Wagtendonk, J. Fites-Kaufman, K. E. Shaffer and A. E. Thode. Berkeley, California: University of California Press.

Skinner, C. N., A. H. Taylor, and J. K. Agee. 2006. Klamath Mountains bioregion. In *Fire in California's ecosystems*, edited by N. G. Sugihara, J. W. van Wagtendonk, J. Fites-Kaufman, K. E. Shaffer and A. E. Thode. Berkeley, California: University of California Press.

Society of American Foresters. 2004. *Preparing a community wildfire protection plan. A handbook for wildland-urban interface communities*. Bethesda, Maryland: Society of American Foresters.

Stables, T. B., G. L. Thomas, S. L. Thiesfeld, and B. G. Pauley. 1990. Effects of reservoir enlargement and other factors on the yield of wild rainbow and cutthroat trout in Spada Lake, Washington. *North American Journal of Fisheries Management* 10:305-314.

State Water Resources Control Board. 2010. Porter-Cologne Water Quality Control Act.

Stebbins, R. C. 2003. *A field guide to western reptiles and amphibians*. 3rd ed. New York, New York: Houghton Mifflin Company.

Stebbins, G. L. and J. Major. 1965. Endemism and speciation in the California flora. *Ecological Monographs* 35(1):2-35.

Stephens, S. L. and N. G. Sugihara. 2006. Fire management and policy since European settlement. In *Fire in California's Ecosystems*, edited by N. G. Sugihara, J. W. van Wagtendonk, J. Fites-Kaufman, K. E. Shaffer and A. E. Thode. Berkeley, California: University of California Press.

Strahler, A. N. 1952. Hypsometric (area-altitude) analysis of erosional topography. Bulletin of the Geological Society of America 63:1117-1142.

Sugihara, N. G. and M. G. Barbour. 2006. Fire and California vegetation. In *Fire in California's ecosystems*, edited by N. G. Sugihara, J. W. Wagtendonk, K. E. Shaffer, J. Fites-Kaufman and A. E. Thode. Berkeley, California: University of California Press.

Sullivan, K., T. E. Lisle, C. A. Dolloff, G. E. Grant, and L. M. Reid. 1987. Stream channels: the link between forests and fishes. Pages 39-97 *in* E. O. Salo and T. W. Cundy, editors. Streamside Management: Forestry and Fishery Interactions, Contribution Number 57. Institute of Forest Resources, University of Washington, Seattle, Washington.

Swanson, F. J. and G. W. Lienkaemper. 1978. Physical consequences of large organic debris in pacific northwest streams. General Technical Report PNW-69, USDA Forest Service, Portland, Oregon.

Taylor, A. H. and C. N. Skinner. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. *Forest Ecology and Management* 111:285-301.

———. 2003. Spatial patterns and controls on historical fire regimes and forest structure in the Klamath Mountains. *Ecological Applications* 13(3):704-719.

Thelander, C. G. and M. Crabtree. 1994. *A guide to California's endangered natural resources: Wildlife*. Santa Cruz, California: BioSystems Books.

Thomas R. Payne and Associates. 2005. Recovery of fish populations in the upper Sacramento River following the 1991 Cantara spill. Unpublished final report to the Cantara Trustee Council, California Department of Fish and Game.

Turek, S. M. 1996. 1994 Upper Sacramento River angler survey, first year of angling following the 1991 Cantara spill.

U.C. Cooperative Extension. 2003. California fish website. Rough sculpin. http://ucce.ucdavis.edu/datastore/datastoreview/showpage.cfm?usernumber=79&surveynumber=241 (accessed January 8, 2009).

U.C. Davis. 2010. Geospatial waterbody system. http://endeavor.des.ucdavis.edu/geowbs/ (assessed March 2010).

U.S. Department of Agriculture. 1983. *Soil survey of Shasta–Trinity National Forest, California*: U.S. Department of Agriculture, Soil Conservation Service, in cooperation with the University of California Agricultural Experiment Station.

———. Final environmental impact statement Shasta–Trinity National Forest Land and Resource Management Plan. 1994.

———. 1999. Shasta-Trinity National Forest forest wide late successional reserve assessment - appendix B fire/fuels modeling. U.S. Department of Agriculture, Forest Service, Shasta-Trinity National Forest. Redding, California. August 26.

U.S. Department of Agriculture and U.S. Department of the Interior. 2006. A collaborative approach for reducing wildland fire risks to communities and the environment. 10-Year strategy implementation plan.

U.S. Fish and Wildlife Service. 2001. Neotropical Migratory Bird Conservation Act. http://library.fws.gov/bird_publications/nmbca_factsheet.pdf (accessed March 24, 2010).

———. 2006. Fisher, West Coast Distinct Population Segment (DPS). U.S. Fish and Wildlife Service.

U.S. Geological Survey. 2001. USGS fact sheet 071-01.

Urness, S. 2007. California tourism outlook. In *Santa Barbara Conference & Visitors Bureau and Film Commission*.

USDA Forest Service. 1995. Shasta-Trinity National Forest land and resource management plan. U.S. Forest Service, Shasta-Trinity National Forest.

———. 1997. Ecological subregions of California: Section and subSection descriptions. USDA Forest Service Pacific Southwest Region. Report No. R5-EM-TP-005. September 1997.

———. 1999a. Shasta-Trinity National Forest forest wide LSR assessment.

———. 1999b. Shasta-Trinity National Forest forest wide late successional reserve assessment - Appendix B fire/fuels modeling. U.S. Department of Agriculture, Forest Service, Shasta-Trinity National Forest. Redding, California. August 26, 1999.

———. 2000. Shasta Lake West watershed analysis. Prepared for USDA Forest Service, Shasta-McCloud Management Unit. October 11, 2000.

———. 2001a. Benefits of hindsight: Reestablishing fire on the landscape. *Pacific Northwest Research Station - Science Findings* (36):6.

———. 2001b. Headwaters Sacramento River ecosystem analysis. USDA Forest Service, Mount Shasta Ranger District. January 01, 2001.

———. 2006. Shasta Unit Whiskeytown-Shasta-Trinity National Recreation Area. gis.fs.fed.us/r5/shastatrinity/documents/st-main/maps/maps/unit/shasta-unit-map-2006.pdf - (accessed December 22, 2008).

———. 2007a. Schedule of proposed action (SOPA): 10/01/07 to 12/31/07. USDA Forest Service, Shasta-Trinity National Forest. October 1.

———. 2007b. Schedule of proposed action (SOPA): 04/01/2007 to 06/31/2007. USDA Forest Service, Shasta-Trinity National Forest. April 1.

———. 2007c. Schedule of proposed action (SOPA): 01/01/2007 to 03/31/2007. USDA Forest Service, Shasta-Trinity National Forest. January 1.

———. 2008a. Existing vegetation data (CALVEG) by tiles in Albers for Shasta-Trinity National Forest. http://www.fs.fed.us/r5/rsl/clearinghouse/aa-ref-shf.shtml (accessed 2008).

———. 2008b. Motorized travel management Draft Environmental Impact Statement. USDA Forest Service, Shasta-Trinity National Forest. June 2009. R5-MB-191a.

———. 2008c. Schedule of proposed action (SOPA): 10/01/2008 to 12/31/2008. USDA Forest Service, Shasta-Trinity National Forest. October 1.

———. 2008d. Port-Orford-cedar. http://www.fs.fed.us/r5/sixrivers/projects/poc/ (accessed November 21, 2008).

———. 2008e. Fire history. GIS data layer.

USDA Forest Service and USDI Bureau of Land Management. 1994. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl and standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. USDA Forest Service and USDI Bureau of Land Management.

USDI Bureau of Land Management, USDI National Park Service, USDA Forest Service, and California Department of Forestry and Fire Protection. 2001. Cooperative fire protection agreement between United States Department of Land Management, California and Nevada; United States Department of the Interior National Park Service, Pacific west region; United States Department of Agriculture Forest Service, regions four, five, and six; and state of California Department of Forestry and Fire Protection. Report No. CDF #7CA01001, NPS #H8000020001, FS #01-FI-11052012-212, BLM #BAI021002. July 25, 2001.

Vaillant, N. M. 2008. Sagehen Experimental Forest past, present, and future: An evaluation of the fireshed assessment process. Doctor of Philosophy - Dissertation, Environmental Science, Policy, and Management, University of California, Berkeley, Berkeley, California.

Waithman, J. 2001. Guide to hunting wild pigs in California. California Department of Fish and Game.

Wake, D. B. 1991. Declining amphibian populations. *Science* 253:860.

Weidlein, W. D. 1971. Summary progress report on the Shasta Lake trout management investigations, 1967 through 1970. California Department of Fish and Game, Inland Fisheries. Inland Fisheries Administrative Report 71-13.

Welsh, H. H., K. L. Pope, and D. Boiano. 2006. Sub-alpine amphibian distributions related to species palatability to non-native salmonids in the Klamath Mountains of northern California. *Diversity and Distributions* 12(3):298-309.

Wentworth, C. K. 1922. A scale of grade and class terms for clastic sediments. Journal of Geology 30:377-392.

Whitlock, C., S. H. Shafer, and J. Marlon. 2003. The role of climate and vegetation change in shaping past and future fire regimes in the northwestern U.S., and the implications for ecosystem management. *Forest Ecology and Management* 178:5-21.

Whittaker, R. H. 1960. Vegetation of the Siskiyou Mountains, Oregon and California. *Ecological Monographs* 30(3):279-338.

Williams, B. D. 1998. Distribution, habitat associations, and conservation of purple martins breeding in California, California State University, Sacramento, California.

Williams, D. F. 1986. Mammalian species of special concern in California. Prepared for the State of California, The Resources Agency, Department of Fish and Game. February.

Wills, R. D. and J. D. Stuart. 1994. Fire history and stand development of a Douglas-fir hardwood forest in northern California. *Northwest Science* 68(3):205-212.

Young, K. A. 2000. Riparian Zone Management in the Pacific Northwest: Who's Cutting What? Environmental Management 26:131-144.

Zielinski, W. J. 2004. The status and conservation of mesocarnivores in the Sierra Nevada. USDA Forest Service, Pacific Southwest Research Station. Report No. PSW-GTR 193.

———. 2008. California wolverine (*Gulo gulo*) non-invasive sample analysis. Redwood Sciences Lab.

Zielinski, W. J., R. L. Truex, G. A. Schmidt, F. V. Schlexer, K. N. Schmidt, and R. H. Barrett. 2004. Home range characteristics of fishers in California. *Journal of Mammalogy* 85(4):649-657.

Ziemmer, R. R., J. Lewis, R. M. Rice, and T. E. Lisle. 1991. Modeling the cumulative watershed effects of forest management strategies. *Journal of Environmental Quality* 20:36-42.

Zobel, D. B. 1990. Port-Orford-cedar. In *Silvics of North America*, edited by R. M. Burns and B. H. Honkala: USDA Forest Service.

3.4.2 Personal Communications

Baumgartner, S., California Department of Fish and Game. 2008. Conversation with K. Marine, North State Resources.

Bachman, S., U.S. Forest Service. Written comments on draft to C. Carpenter, North State Resources, Inc.

Chandra, S., Assistant Professor, Department of Natural Resources and Environmental Science, University of Nevada, Reno. June 2008. Conversation with R. Henery, The River Exchange.

Cloward, V., The River Exchange. November 2008. Email communication with P. Ambacher, ICF Jones & Stokes.

Lindstrand, L., North State Resource, Inc. March 2009. Conversation with G. Bolen, North State Resources, Inc.

Native American Heritage Commission. November 2008. Letter to K. Crawford, North State Resources, Inc.

Olson, E. 2010. April 2010. Phone conversation with K. Hitt, North State Resources, Inc.

Van Susteren, P., Mineral Specialist, Shasta-Trinity National Forest. December 2008. Conversation with K. Hitt, North State Resources, Inc.

Van Susteren, P., Mineral Specialist, Shasta-Trinity National Forest. March 2010. Conversation with K. Hitt, North State Resources, Inc.

CHAPTER 4

Biological Integrity as a Unifying Theme for Watershed Management

Chapter 4 Biological Integrity as a Unifying Theme for Watershed Management

4.1 Biological Integrity

Change is both unavoidable and essential in the watershed, as plant and animal communities continually respond to changes in physiographic and climatic conditions. However, changes that result in significant long-term alterations in, or loss of, primary watershed processes or structural components can adversely affect the overall functioning of the watershed. Changes that raise concerns about watershed health often result from the cumulative effect of natural and human-induced interactions. Even where individual stresses are relatively insignificant, ecological processes and relationships may be significantly influenced by the cumulative impacts of multiple stresses.

To evaluate the condition of the upper Sacramento River watershed, we must first be able to define the attributes of a "healthy" environment so that deviations from this baseline can then be measured. A healthy environment is one that is sustainable, natural, and stable (Andreasen et al. 2001). The concept of sustainability focuses on the ability to maintain ecosystems and their components and processes—biological, physical, and chemical—so that they continue to provide all of the "goods and services" they are capable of providing. Although difficult to define, naturalness signifies something of great aesthetic and even spiritual importance to people. Stability, or resilience, refers to the ability to resist environmental changes and stresses and the ability to recover to pre-stress conditions or trajectories following a disturbance. Collectively, these attributes constitute the "biological integrity" of a watershed.

In this chapter, we examine the relative biological integrity of the watershed's functions and processes by using the historic conditions of the watershed as described in Chapter 2 as a benchmark for comparison to the current conditions described in Chapter 3. The goal is not to determine what is necessary to restore the ecosystem to past conditions but to assess the current biological integrity of the watershed (i.e., its resiliency and sustainability under current conditions) and to use this information to address potential management opportunities, as well as limitations, for maintaining and restoring biological integrity and environmental health in the watershed (Chapter 5).

The topics addressed in this chapter do not constitute a comprehensive treatment of the factors influencing the biological integrity of the watershed; rather, they comprise the processes and structural components identified by the steering committee as being of primary concern: fire, physical processes such as erosion and sedimentation, water quality, interspecific interactions, and human disturbances. Additionally, this chapter describes two primary interrelationships among the factors that are operating within the watershed. Finally, we examine one indicator of the stability of the watershed, its response to the 1991 spill of metam sodium that occurred just north of Dunsmuir at the Cantara Loop.

4.1.1 Factors Influencing Biological Integrity

When examining the biological integrity of a watershed, it is important to consider what is influencing watershed health. Because a watershed is composed of complex and dynamic relationships, many factors affecting biological integrity become relevant when attempting to understand the current condition of the watershed, how this condition developed, and how it may change in the future. Here, we discuss a limited set of physical and biological factors that clearly influence watershed health in the upper Sacramento River watershed.

Fire

Fire operates as a process throughout the landscape. Soils, air, water, plants, and animals are all affected by fire. Degradation of water and air quality and increased plant and animal mortality are some of the more obvious effects. Although less obvious, other effects of fire on the ecosystem are perhaps more important (Sugihara et al. 2006). For example, fire plays important roles in nutrient cycling, fuel reduction, and vegetation succession. Fire complements decomposition by periodically removing debris through combustion; and the fire regime (i.e., return interval, fire size, spatial complexity, intensity, and severity) requires specific responses by vegetation if it is to persist (Sugihara et al. 2006). Additionally, animal communities have evolved in habitats where fire was a common and dynamic perturbation, and the patterns of species in the watershed have been driven by the patterns of fire.

Patterns of fire severity are thus an important determinant of the structural diversity of individual stands as well as the larger landscape. However, as described in Chapter 3, fire suppression has been applied throughout the watershed. Fire suppression has changed the fire regime from frequent low-intensity surface fires to infrequent stand-replacing fires (USDA Forest Service 1999). The result is that the forest has become more closed and multi-storied. Tree species composition has succeeded towards more shade tolerant, fire sensitive species such as white fir and away from more shade intolerant, fire resistant species such as ponderosa pine, and meadow areas are smaller (USDA Forest Service 1999). Pure stands of oak along with the oak component of mixed conifer forests have been encroached upon by conifers, have become more decadent, are less vigorous, and produce fewer acorns (USDA Forest Service 1999). These changes in vegetation composition and successional stages have in turn influenced the wildlife species present in the watershed's forest communities.

The timing, location, and magnitude of a fire all influence wildlife and their habitat (Shaffer and Laudenslayer 2006). Changes in fire return intervals can contribute to conversions of plant community types and alterations in wildlife behavior essential to reproducing, rearing young, defending territory, etc. (Shaffer and Laudenslayer 2006). Differential burning in an area results in a varied, more complex vegetation mosaic consisting of different plant communities and resources in different conditions; the significance of which varies with the size of fire and the particular species in question (Shaffer and Laudenslayer 2006). A fire's complexity and size can also alter the connectivity of one area to another, the size of habitat patches, and the pattern of wildlife habitat on the landscape (Shaffer and Laudenslayer 2006). Fire intensity determines whether animals are injured or killed, whereas severity provides an indication of the degree of habitat alteration. Alterations to the plant and soil communities can affect the shelter, nesting, and foraging components of wildlife habitat (Shaffer and Laudenslayer 2006). For example, prior to effective fire control in the

watershed, species such as the northern spotted owl, goshawk, Pacific fisher, and American marten were probably limited to the denser, layered forests in riparian areas and north-facing slopes of the watershed (USDA Forest Service 1999).

In forest-dominated areas, deer thrive on early successional habitats that are a product of disturbances that open up the forest and shrub canopy to allow grass/forb/shrub growth to occur (see Figure 4.1-1) (California Department of Fish and Game et al. 1998). Historically, fire and logging have been the primary mechanisms that created forest openings. However, management changes over the decades have decreased these disturbances to habitats throughout California, resulting in declining habitat conditions for deer (California Department of Fish and Game et al. 1998). Not as many deer are able to survive per acre as would have survived under a natural fire-based ecosystem because the suppression of fire causes vegetation to grow older than it would have without fire suppression. The older, more decadent vegetation is not as nutritious as young vegetation (USDA Forest Service 2008).

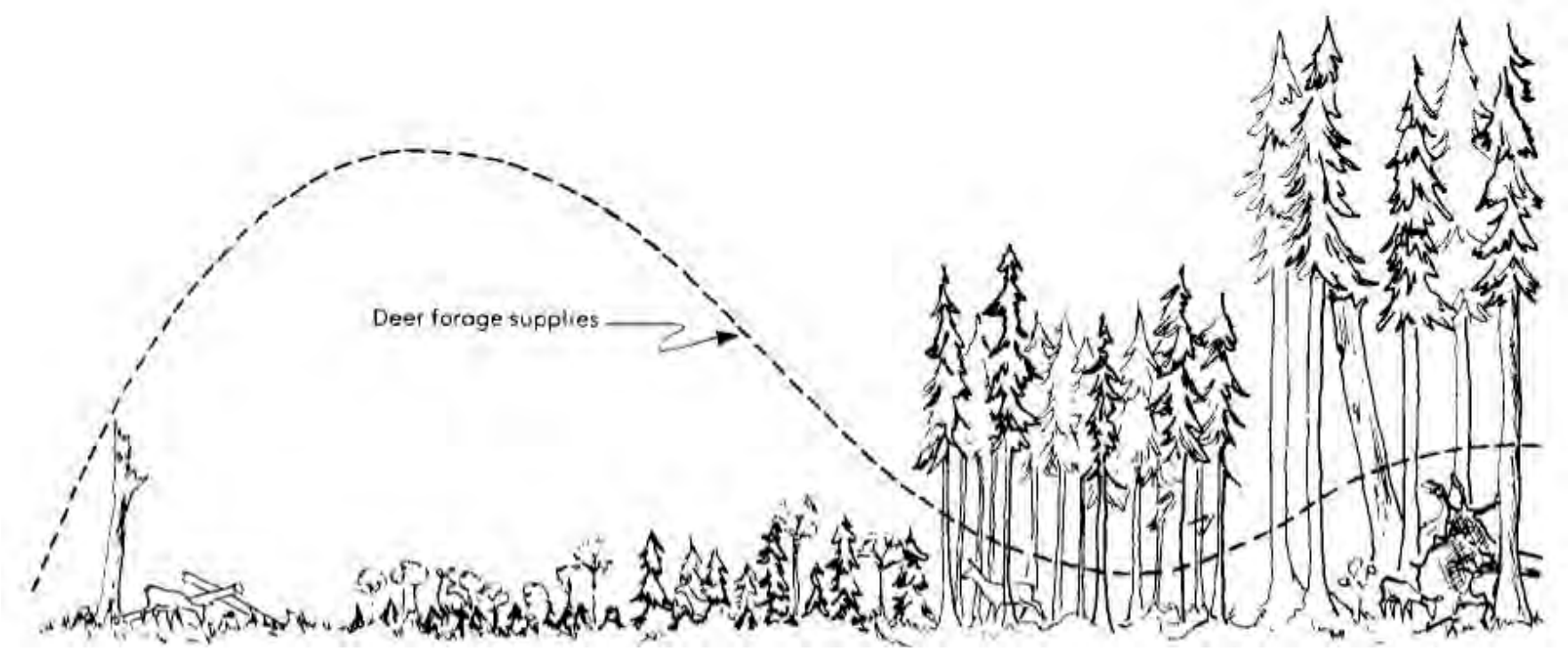
The potential influence of fire on the integrity of the watershed is discussed in more detail under Section 4.2-1 below.

Erosion and Sedimentation

Erosion and sedimentation can have a major influence on the biological integrity of a watershed. Properly functioning streams and rivers provide surface and subsurface water storage and exchange; groundwater recharge and discharge; sediment transport, storage, and deposition; nutrient storage and cycling; wildlife habitat and migration corridors; and water supply and water filtering. High levels of erosion and sedimentation can result in decreased water-retention capacity on forest lands, increased flood frequency, and rapid filling of reservoirs. Less obviously, sedimentation in small streams can affect biotic communities, reducing the diversity of fish and other animal communities and lowering the productivity of aquatic populations. This topic is discussed in greater detail in Sections 4.2-1 and 4.2-2.

Water Quality

Anecdotal information suggests that water quality within the sub-basin is supporting the designated beneficial uses. A general lack of water quality data (i.e., missing and unreliable data) makes it difficult to quantify the spatial and temporal range of water quality conditions. Within the sub-basin, the major human-caused disturbances that affect surface waters and their associated beneficial uses include both historic and modern disturbances such as transportation corridors, expansion of housing, grazing and animal keeping, timber harvest practices, railroad operations, mining, storm water runoff, sewage discharge, manufacturing and processing operations, and fish management practices (e.g., stocking and introduction of exotic species). Other important influences on water quality include dam building, diking, channelization, removal of woody debris, irrigation, and power generation (Minshall 1995). Like in any other watershed, these activities may be important to water quality and the integrity of the aquatic ecosystems, and the effects of each of these activities may be cumulative or even synergistic (Minshall 1995). The cumulative effect of land management activities is a critical component of an analysis intended to speak to watershed condition.



NEW CLEARCUT	SEEDLING CONIFER	ADVANCED REGENERATION	SECOND GROWTH TIMBER	OLD GROWTH FOREST
Forb – grass – sedge	Shrub – herb	Young tree – shrub	Minimum undergrowth	Moderate undergrowth
1 – 5 years	6 – 10	10 – 20	20 – 200	200+

Figure 4.1-1. Generalized representation of the relationship between deer forage supplies and the successional process as influenced by timber harvest and plant succession. Source: Wallmo and Schoen (1981).

Some large-scale disturbances affecting water quality are rapid and dramatic— for example, large-scale deforestation, fires, insect infestations, and plant disease outbreaks—and represent the upper end of variability within the system. For example, the sediment yield of the mainstem river is highest during large floods, and the main contributors tend to be unstable landforms with recent disturbances such as large, severe wildland fires. Other disturbances occur gradually over extended periods— for example, acidification, irrigation, timber harvest, mining, and, perhaps, global climate change— (Minshall 1995). Fast or slow, disturbances to the beneficial uses of aquatic habitat can result in effects on water quality, including changes in water temperature, sediment concentration, turbidity levels, nutrient levels, and concentrations of contaminants such as cadmium, copper, and zinc. In turn, these changes can lead to the alteration of the food base for aquatic and terrestrial species, loss of habitat, and decreases in the amount of safe water available for consumption, thus reducing biodiversity and ecosystem functioning and capacity.

Shasta Dam

Begun in the late 1930s, the construction of Shasta Dam and filling of Shasta Lake had a major impact on the watershed and the surrounding natural environment. For example, Shasta Dam prevented salmon from accessing the entire drainages of the upper Sacramento River as well as the McCloud and Pit rivers. Prior to dam construction, the upstream limit of Chinook salmon in the Sacramento River extended to the vicinity of present-day Lake Siskiyou (Yoshiyama et al. 1996).

The extirpation of salmon from the watershed may have been accompanied by a range of ecological impacts. Pacific salmon (*Oncorhynchus* spp.) accumulate marine-derived nutrients in their bodies as they grow to adulthood at sea. The salmon then carry these nutrients to the often nutrient-poor streams of their birth, where they are released during and after spawning. Extensive research indicates the importance of these marine-derived nutrients for the productivity of freshwater communities (Naiman et al. 2002). Juvenile salmon may also have exerted top down food-web control on invertebrate production and constituted an important prey source for native predatory fish and mammals in the upper watershed. The extent to which salmon served as drivers for watershed ecology in these and other capacities would have been in large part a function of historic run size and timing.

It is difficult to imagine what salmon abundances in the watershed might have been before commercial fishery records were kept and when major spawning streams were not blocked by Shasta Dam. Some perspective on the magnitude of salmon runs can be gained from run size estimates based on catch data for the peak decades—1870s to 1880s and 1900s to 1920s—of the commercial fishery. Yoshiyama (1998) has proposed that these estimates be viewed as hypothetical lower bounds for salmon abundances in the period when only native peoples were harvesting the runs. For all of the Sacramento River drainage, the Chinook salmon runs in aggregate were estimated from commercial records to have averaged 600,000 fish a year, perhaps reaching as many as 800,000 to 1 million spawners during the peak years of the commercial period before 1915 (Leidy et al. 1984 as cited in Yoshiyama et al. 1998).

Mining

As discussed in Section 2.2.3, mining has played a major role in the history of the watershed, particularly in the area around present-day Shasta Lake. The impacts of turn-of-the-century copper

mining on the biotic communities in this portion of the watershed were severe. The copper mining era also left a legacy of water quality problems associated with acid rock drainage (see Section 3.2.8). Acid mine drainage can result in a decrease in the pH range of the receiving waters, which can lead to the elimination of some aquatic species and the proliferation of other, more tolerant species; a reduction in density, biomass, and diversity of aquatic organisms; increases in abnormal behavior of aquatic organisms; and a reduction in the reproductive capacity of adult fish and the viability of their eggs (Martin and Platts 1981). At lower pH levels, the aquatic biota may be virtually eliminated.

Interspecific Interactions

The biological processes of competition among species for food and other resources and predation of one species on another (i.e., interspecific interactions) are known to shape the composition and structure of communities, as well as influence species distributions and local abundance. As discussed in Chapter 3, over the last 100 years, changes in species composition have occurred throughout the watershed for a variety of reasons (e.g., changes in fire regime, introduction of non-native species). Losses of large predators, such as the grizzly bear and wolverine, changed the dynamics within communities significantly, potentially affecting many other species along the food chain. In addition, many exotic species now occur in the basin (see Section 3.3.3), and some are aggressive competitors that can outcompete native species. Invasive species threaten the diversity and/or abundance of native species through competition for resources, predation, interbreeding with native populations, parasitism, transmission of diseases, or causing physical or chemical changes to the invaded habitat.

Castle Lake Research

In the headwaters portion of the watershed, one important interspecific interaction known to have a strong influence on habitat conditions is that between the invertebrate communities and stocked fish. In 2008, the Castle Lake Long Term Research Program began a 3-year in depth study of invertebrate production and flux in Castle Lake Basin. The study was designed specifically to characterize the benthic macroinvertebrate communities, as well as spatial and temporal trends in their distribution and abundance. Preliminary results from the study suggest a significant decrease in the abundance of emergent aquatic insects during stocked years vs. years when only self-sustaining fish populations were present in the lake (Jaquelyn Brownstein, unpublished data). The study is being carried out in collaboration with the USFS and complete results are expected to be available sometime mid 2010. Little or no current information is available on the aquatic insect communities of other lakes in the upper watershed. However, Castle Lake provides a generally suitable reference system (Dr. Sudeep Chandra personal communication), making it likely that these invertebrate communities would resemble those at Castle Lake as well as the response of those communities to stocking pressure, habitat degradation, and climate change.

Additionally, CDFG recently completed an environmental impact report on the impacts of stocking practices on aquatic ecosystems across California, including portions of the watershed.

Human Disturbance

In addition to the effects of human disturbance on fire regimes, water quality, and the physical resources identified above, human disturbances can greatly affect other factors influencing biological integrity, such as habitat fragmentation and vegetative community composition.

Habitat Fragmentation

For many species, the landscape is a mosaic of suitable and unsuitable habitat types. Environmental corridors are segments of land that provide a link between these different habitats while also providing cover. On a broader level, corridors also function as avenues along which wide-ranging animals can travel, plants can propagate, genetic interchange can occur, populations can move in response to environmental changes and natural disasters, and threatened species can be replenished from other areas. In California, environmental corridors often consist of riparian areas along streams, rivers, or other natural features. In addition, the rivers and streams themselves may serve as migration corridors for anadromous fish.

Wildlife occurring in the assessment area have highly variable home ranges and related habitat requirements. The need for migration or other movement within or among habitats also varies. Small rodents, for example, may have a small home range, being able to meet all their biological needs in an area less than 1/4-acre. However, large ungulates, such as black-tailed deer, may need a much larger area to meet all their biological needs. The presence of environmental corridors that allow movement between habitats is thus an important factor in the maintenance of wildlife populations and overall wildlife health.

Habitat conversion, commercial/residential development and related infrastructure and activities in the watershed are all factors that affect habitat size and location and the ability of wildlife to make use of habitats and persist in a given area. Roads, transmission lines, large tracts of residential homes, and commercial development may all result in partial or complete barriers to wildlife and they certainly fragment wildlife habitat. I-5 acts as almost a complete barrier to wildlife crossing due to the volume of traffic night and day (Whitley personal communication).

Resource Extraction

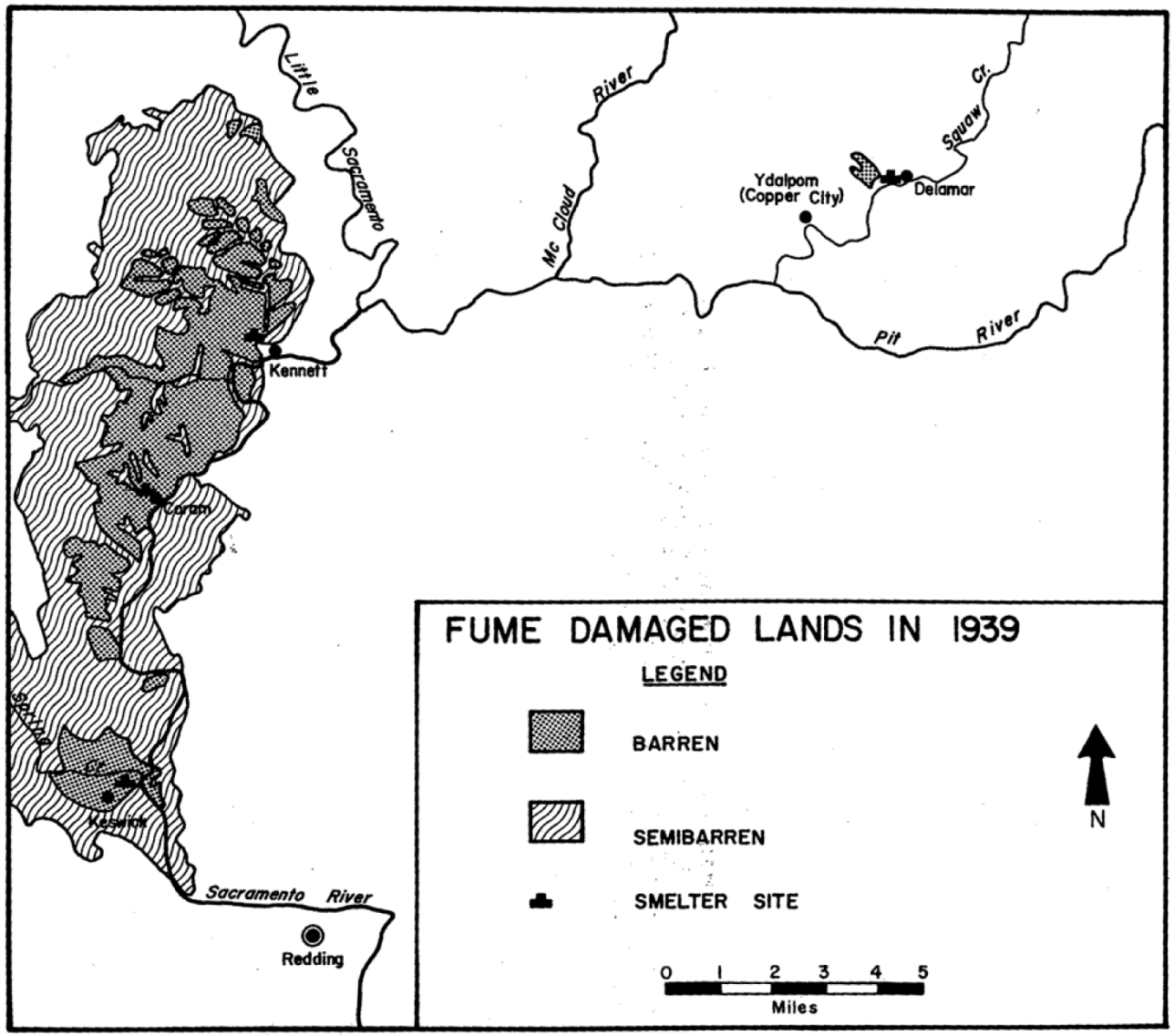
Vegetation composition, species diversity, water quality, and soil stability are all important aspects of biological integrity that can be affected by human disturbances associated with resource extraction. Because resource extraction activities, such as mining, have occurred on a large scale in the watershed, it is an important factor in evaluating watershed health.

Historic copper mining presents a good example of how resource extraction activities can influence the biological integrity of the watershed. As discussed above, mining has played a major role in the history of the lower portion of the watershed, and the impacts of turn-of-the-century copper mining on the biotic communities in the Shasta Lake portion of the watershed were severe. Conifer forests in the Mammoth Butte/Bohemotash Mountain Area were lost as a result of mining operations and pollution; the historic vegetation type could not re-establish itself in the changed landscape, which had been altered physically, chemically, and biologically because of copper mining activities. The change in watershed conditions resulted in a new vegetation regime over a large area. Chaparral

vegetation types replaced conifer forests and have perpetuated to this day (USDA Forest Service 2000). Figure 4.1-2 shows the extent of fume-damaged lands in the watershed. The following excerpt from Kristofors (1973) provides a brief summary of the effects of the smelters on hillslope erosion and vegetation.

> *"Before the smelters began operating, the mountains above the Sacramento River Canyon were covered with a lush coniferous forest. The major species of this forest were ponderosa pine and Douglas fir. At lower elevations along the river, the forest gave way to a chaparral belt of which white-leaf manzanita was the dominant species. Many trees were logged for mining operations before they were damaged by smelter fumes. Most of those which were left did not escape fume damage."*

> *"The smelter fumes upset the natural vegetation balance. Severe erosion resulted after large areas were denuded of vegetation. Topsoil was washed off of mountain slopes, making it difficult for conifers to regenerate naturally. After smelting operations ceased, manzanita was best able to reestablish dominance in devastated areas."*



Source: Kristofors, K.V. 1973. R:\Projects\51058 Upper Sac WA\Graphics\Final Figures\ArchiveCopper mining era in Shasta County, California 1896-1919, an environmental impact study. M.A. Thesis.

Appendix 4.1-2
Copper Mining Fume Damaged Land

4.2 Representative Watershed Interrelationships

This section highlights and describes two interrelationships among the primary factors influencing biological integrity in the watershed. Additionally, this section explores drivers (past and present) of biotic community condition. The points of intersection between biotic community condition, the drivers of that condition, and the primary watershed interrelationships then become the focus of the targeted management and stewardship opportunities summarized in Chapter 5.

4.2.1 Fire, Erosion, and Water Quality

As discussed above, fire suppression has changed the fire regime in the watershed from frequent low-intensity surface fires to infrequent stand-replacing fires. Large fires can pose a substantial risk to water quality as a result of causing a cascading sequence of flooding, accelerated erosion, channel scour, and increased sedimentation often related to water repellent soils (Figure 4.2-1), which can destroy productive habitats over large areas for years to decades (Rieman and Clayton 1999, Reeves et al. 2007). Here we analyze the potential interaction of fire, erosion, and water quality in a portion of the watershed to identify where biological integrity is most at risk.

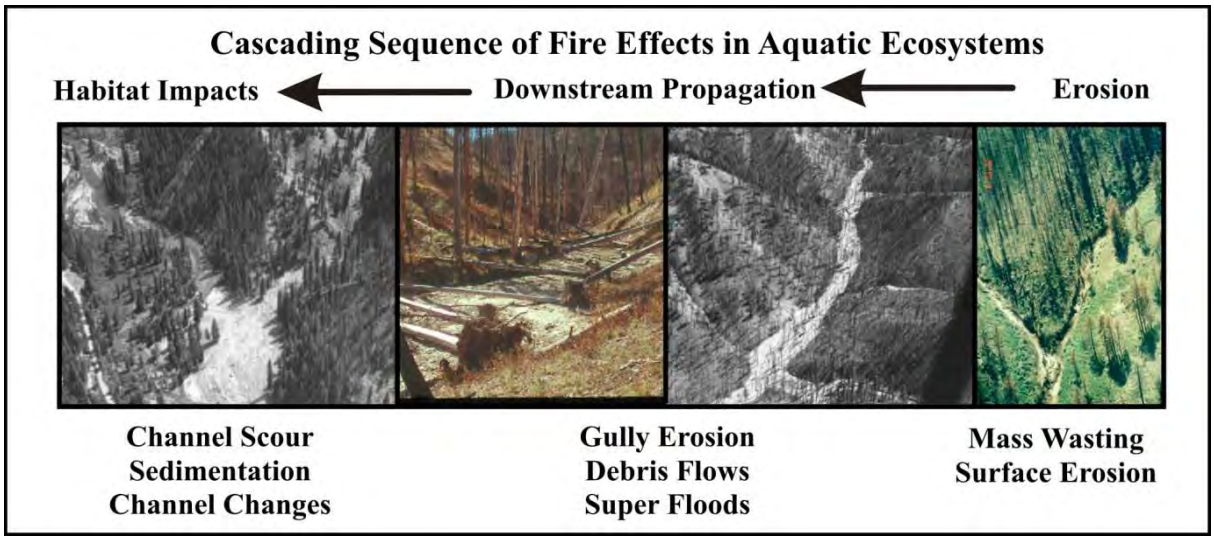


Figure 4.2-1. Cascading sequence of fire effects in aquatic ecosystems

In order to analyze the potential interaction of fire, erosion, and water quality in the watershed and identify areas where biological integrity is most likely to be severely affected by the occurrence of a fire, a fire behavior model (FlamMap) was used in combination with Water Erosion Prediction Project (WEPP) surface erosion technology (http://forest.moscowfsl.wsu.edu/engr/erodesw.html) within NetMap to identify locations of the greatest potential for post-fire flooding and erosion. The analysis was conducted in the upper portion of the watershed only. Although the fire-erosion-water quality analysis area used in this assessment covers only a small portion of the watershed, tools in NetMap could be used to conduct similar analyses throughout the upper Sacramento River watershed assessment area.

STNF staff provided information on the types and amounts of fuels in the upper watershed. Six fuel models were used in FlamMap: #1 (grass), #2 (grass/shrub), #3 (shrub), #4 (timber and understory), #5 (timber and litter) and #6 (slash). There is considerable spatial variability in fuel loading across the upper watershed (Figure 4.2-2). Most of the ridges and higher elevation areas are classified as shrub (including manzanita, among other plant species). Timber and litter are concentrated along valley bottoms and mid-slope areas.

Roads also have the potential to contribute to the interaction of fire, erosion, and water quality in the watershed. For example, drainage diversions—particularly if culverts and other drainage structures become plugged with sediment and woody debris following a fire—can lead to gullying, road surface erosion, and mass wasting. Thus, in the absence of information about locations of secondary drainage structures (e.g., relief culverts, dips, etc.), NetMap was used to calculate the maximum drainage diversion potential along road networks based on the slope and orientation of individual road segments that are located between the identified stream network (all channels, including headwaters).

Overall, the highest erosion potential (greater than approximately 200 tons per hectare (t/ha)) in the analysis area was found to be associated with areas of fuel categories 3 (shrub) and 5 (timber and litter) (Figure 4.2-2) and, thus, the highest flame length (generally greater than 50 feet) (Figure 4.2-3) and the steepest and most dissected topography. (See also discussion of Generic Erosion Potential in Chapter 3, Section 3.2.5.)

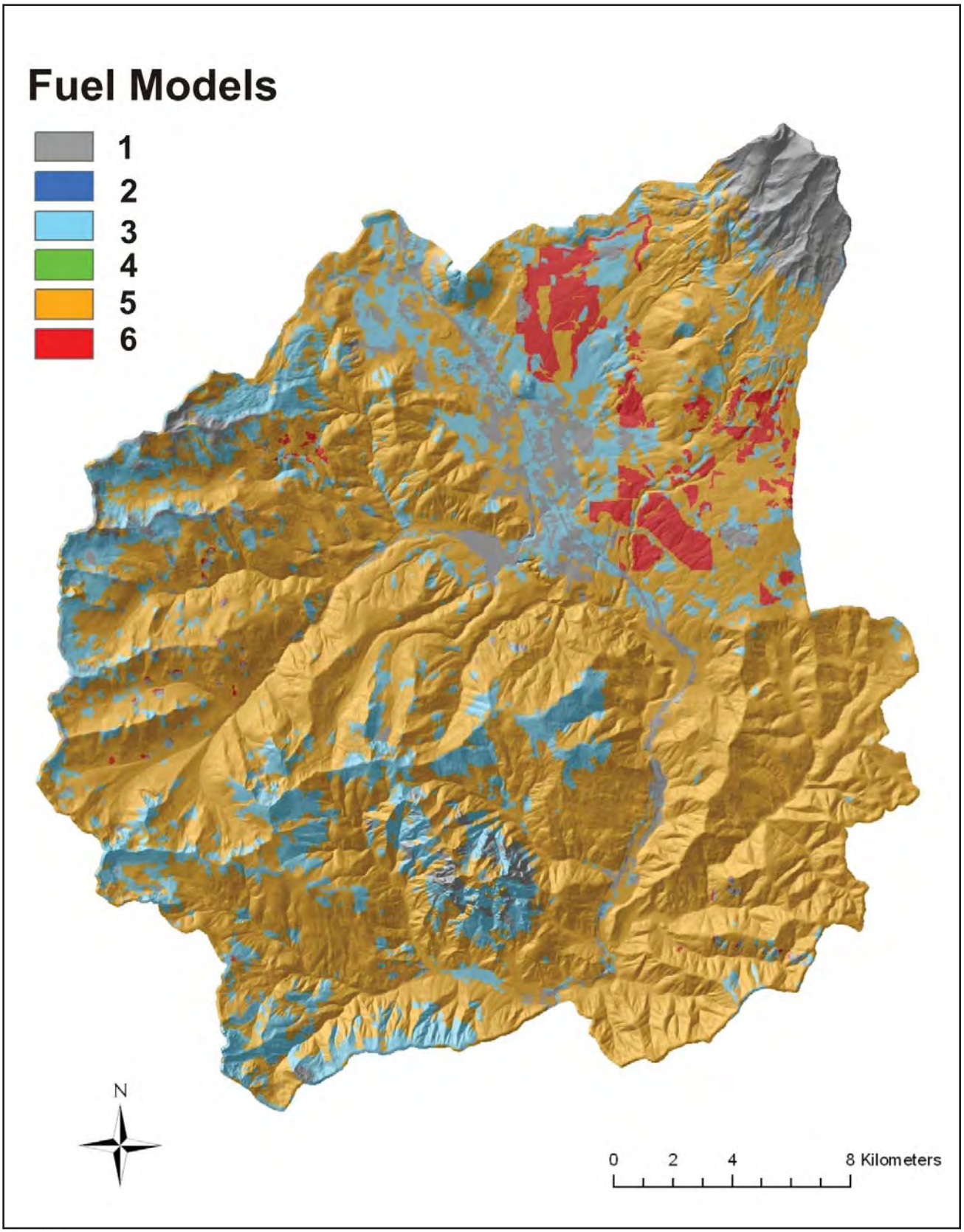
Predictions of post-fire erosion using WEPP reflects sediment yield (t/ha) that can be delivered to stream channels. In NetMap, WEPP sediment yield is predicted at the scale of individual slices of hillslopes (referred to as 'drainage wings') that correspond to individual 100-meter channel segments (e.g., Figure 4.2-4). The WEPP model predicts large spatial variability in erosion potential, from near 0 to more than 300 t/ha (Figure 4.2-5). The highest erosion potential is associated with the greatest fire intensity and the steepest topography.

The estimated post-fire sediment delivery to streams ranges from less than 15 t/ha to more than 124 t/ha (Figure 4.2-6). Channel segments that are predicted to receive the highest sediment yield (> 70 t/ha) are scattered across the analysis area.

Predictions of post-fire sediment yield were also compared to a channel sensitivity index (see Section 3.2.6, Figure 3.2-47) to further isolate those combinations of fuels and hillslope topographic conditions that could create conditions for intense erosion and lead to channel impacts that could be deleterious to aquatic life. In this illustrative exercise, overlaps between individual stream segments that have high post-fire sediment yield to channels (> 70 t/ha) and channel segments of high sensitivity (> 0.7 on a scale of 0 to 1) were identified (Figure 4.2-7).

Road drainage diversion potential in the analysis area is predicted to range from less than 100 meters to more than several kilometers. By overlaying the drainage diversion map with either the predicted fire intensity (Figure 4.2-3) or post-fire surface erosion (Figure 4.2-5) maps, areas of greatest concern were identified (Figure 4.2-8).

NetMap was also used to classify all roads according to the predicted mass wasting erosion potential (for the hillslope underlying the road; see Section 3.2-6). The resulting map of road gullying or landsliding potential reveals areas of concern that overlap with both fire severity potential and road



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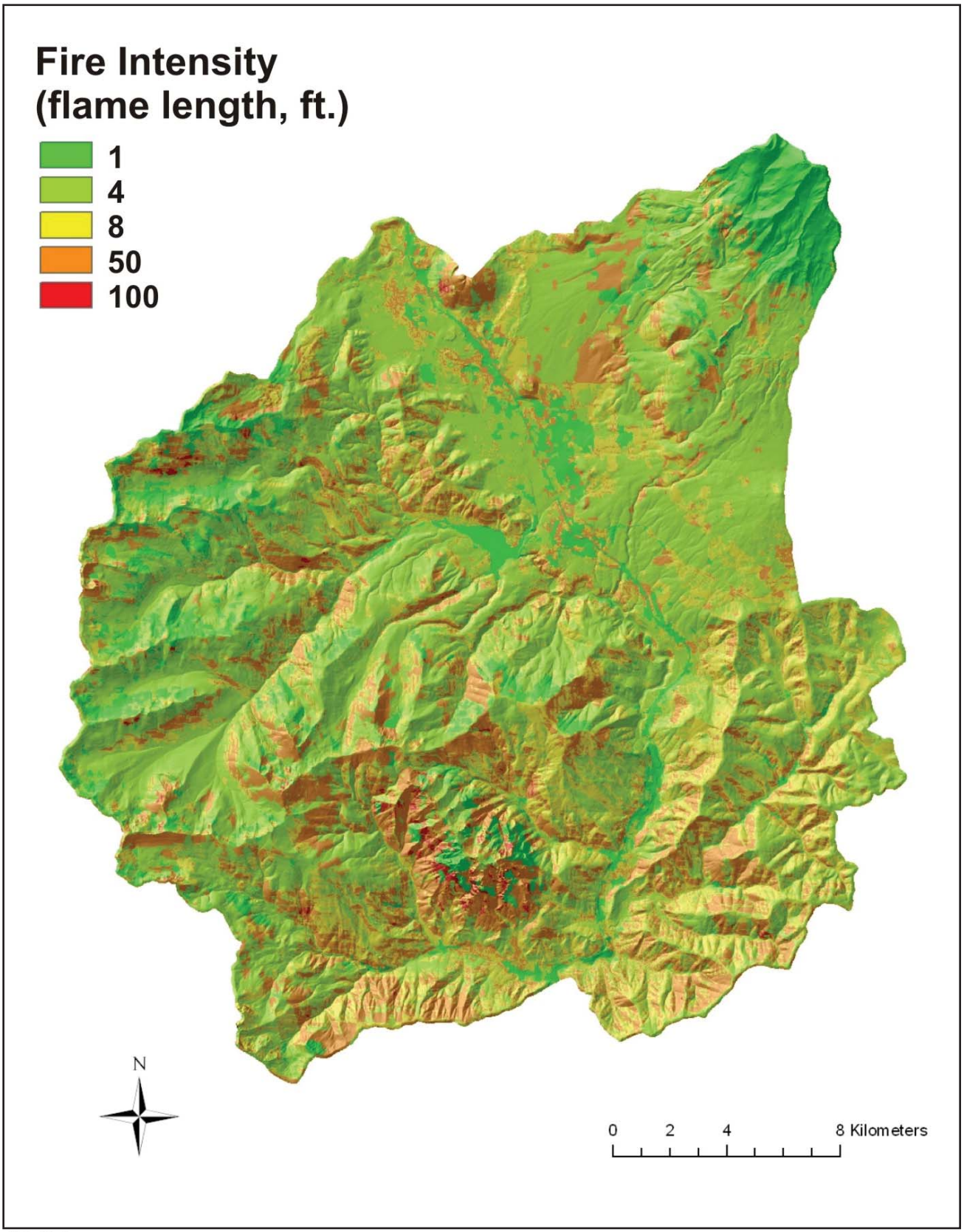
Fuel levels (flammable woody debris) vary significantly across the upper watershed. Six fuel models were used in Flammap, including #1 (grass), #2 (grass/shrub), #3 (shrub), #4 (timber and understory), #5 (timber and litter) and #6 (slash).

Figure 4.2-2
Modeled Fuel Levels
(Modeled results not field verified.)



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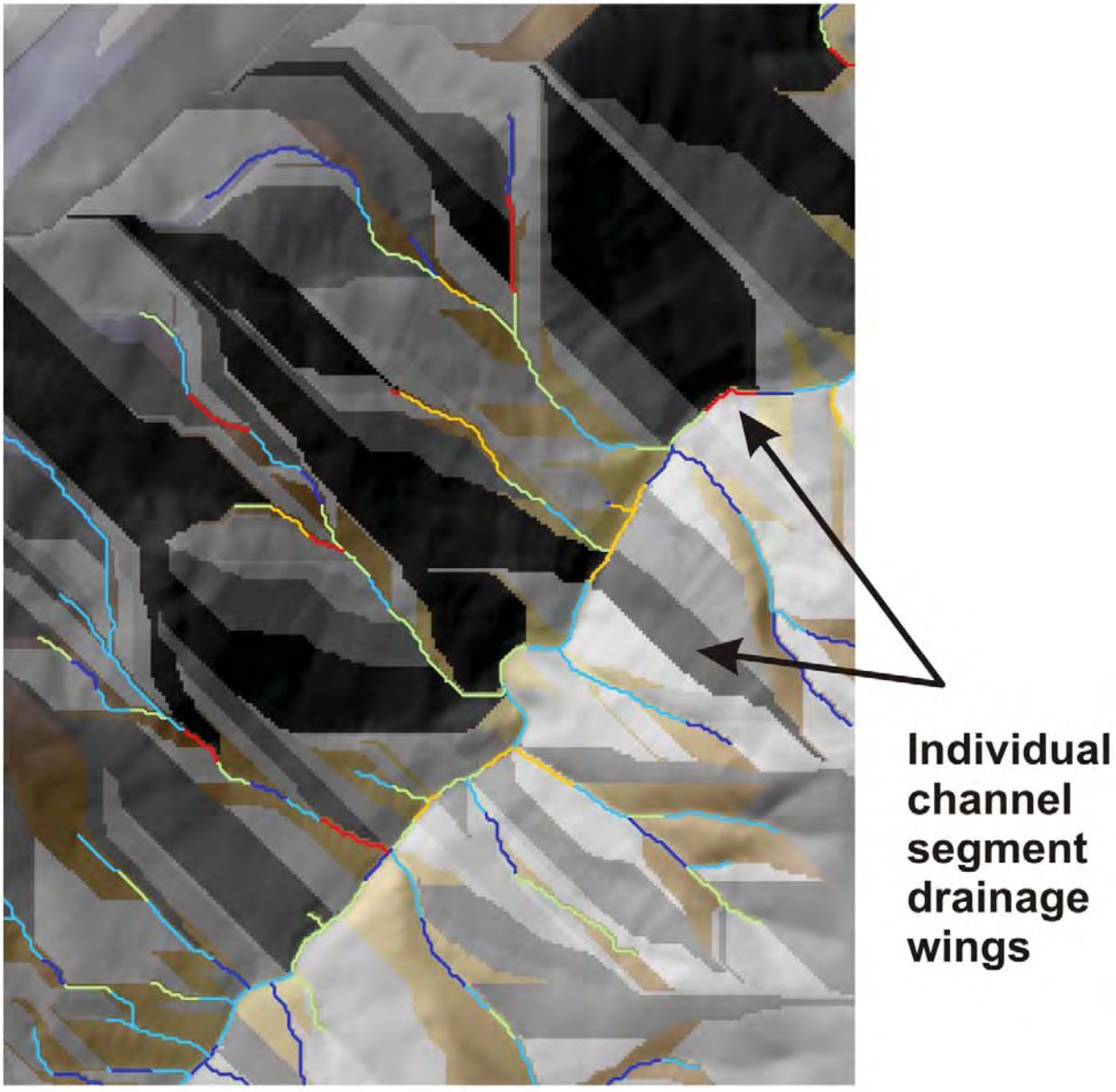
Potential fire intensity in units of flame length (in feet) is shown for the upper watershed.

Figure 4.2-3
Modeled Potential Fire Intensity
(Modeled results not field verified.)



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Individual 100-m stream segments (the average, with approximate range of between 20 and 200 m) that comprise the stream network in NetMap are used to identify the local hillslope contributing area (on both sides of stream valleys) that are associated with each segment. These 'drainage wings' can be comprised of multiple sections of varying hillslope gradient.

Figure 4.2-4
Modeled Individual Channel Segment Drainage Wings

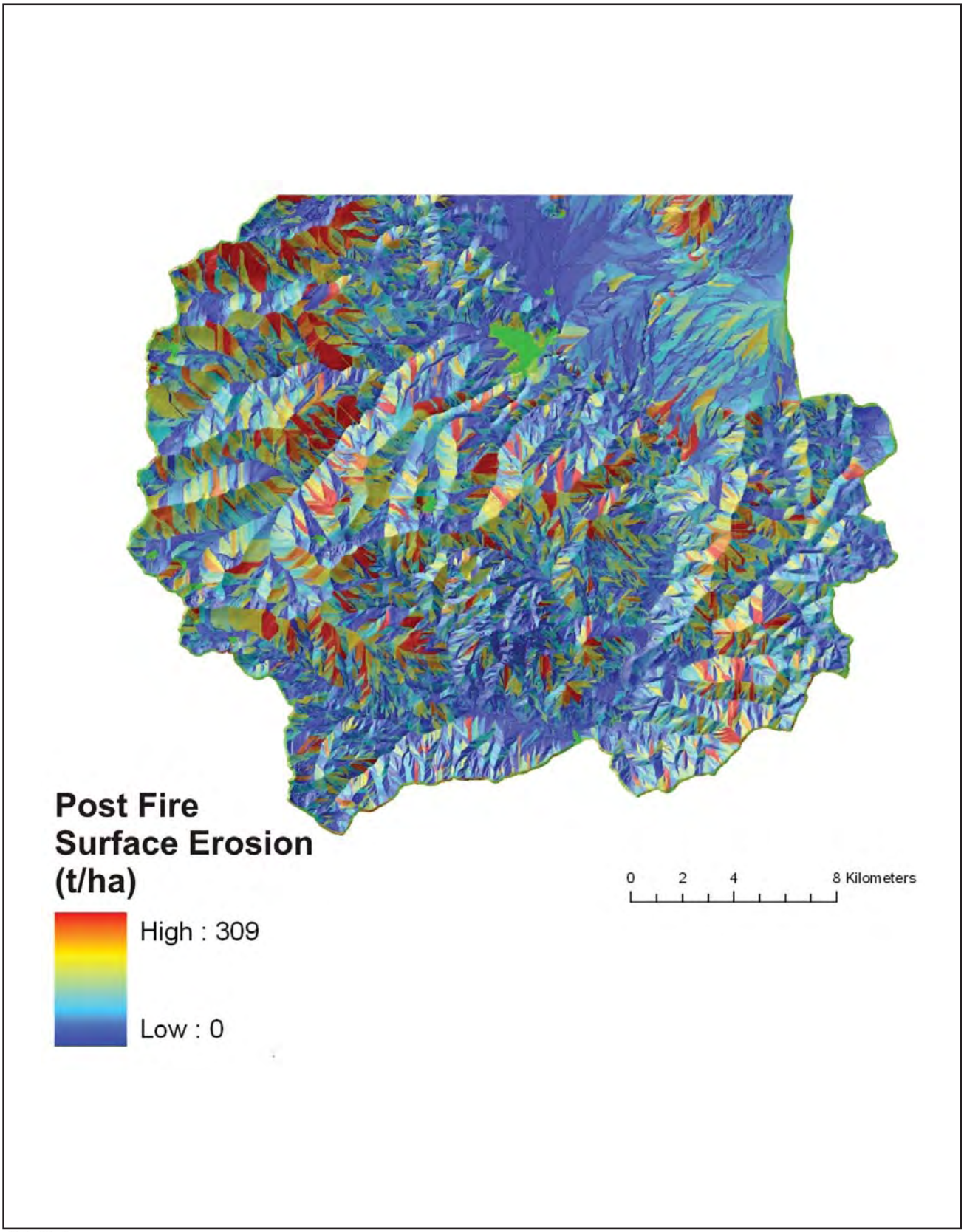

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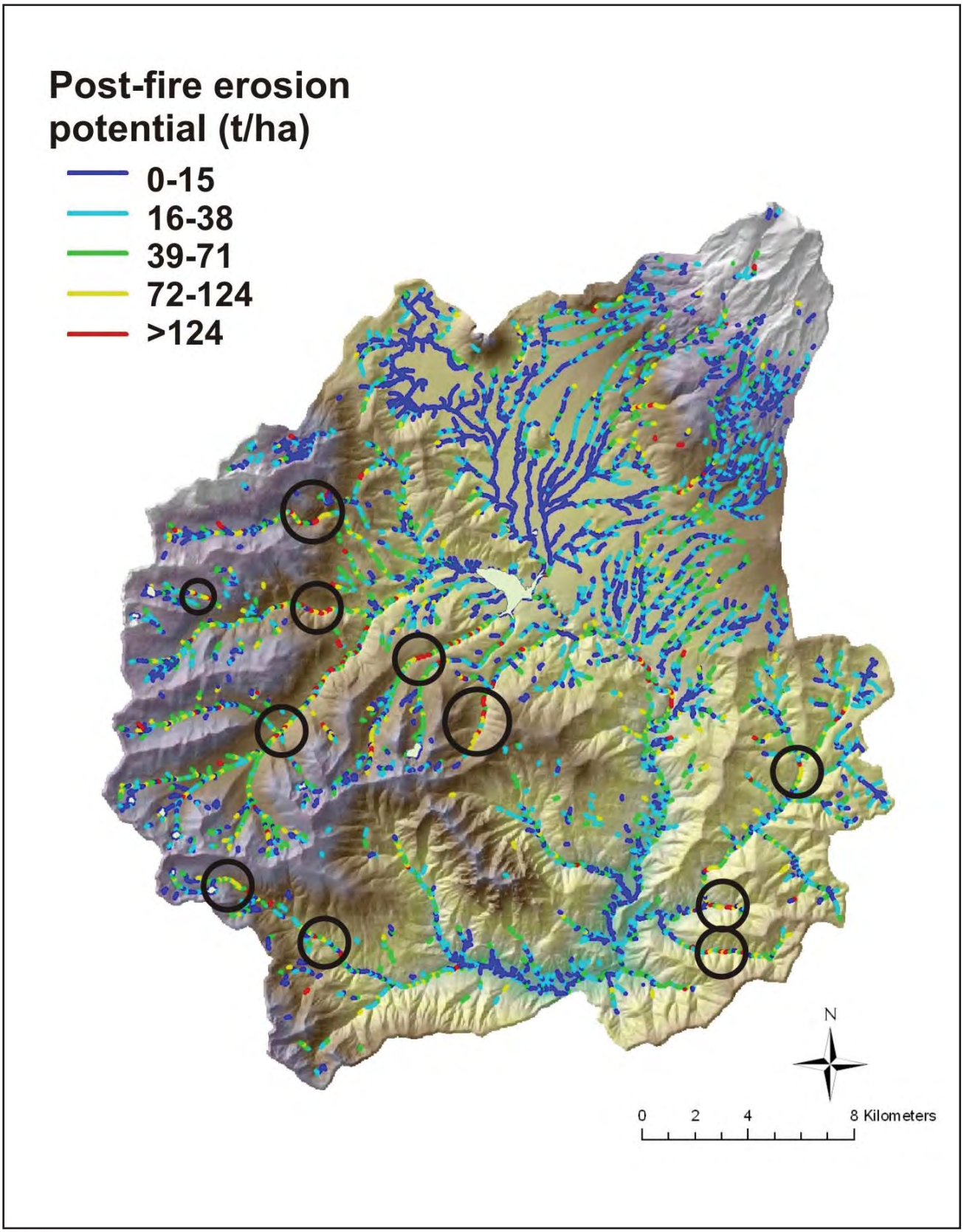
Figure 4.2-5
Modeled Predicted Post-Fire Surface Erosion Using the WEPP Model
(Modeled results not field verified.)



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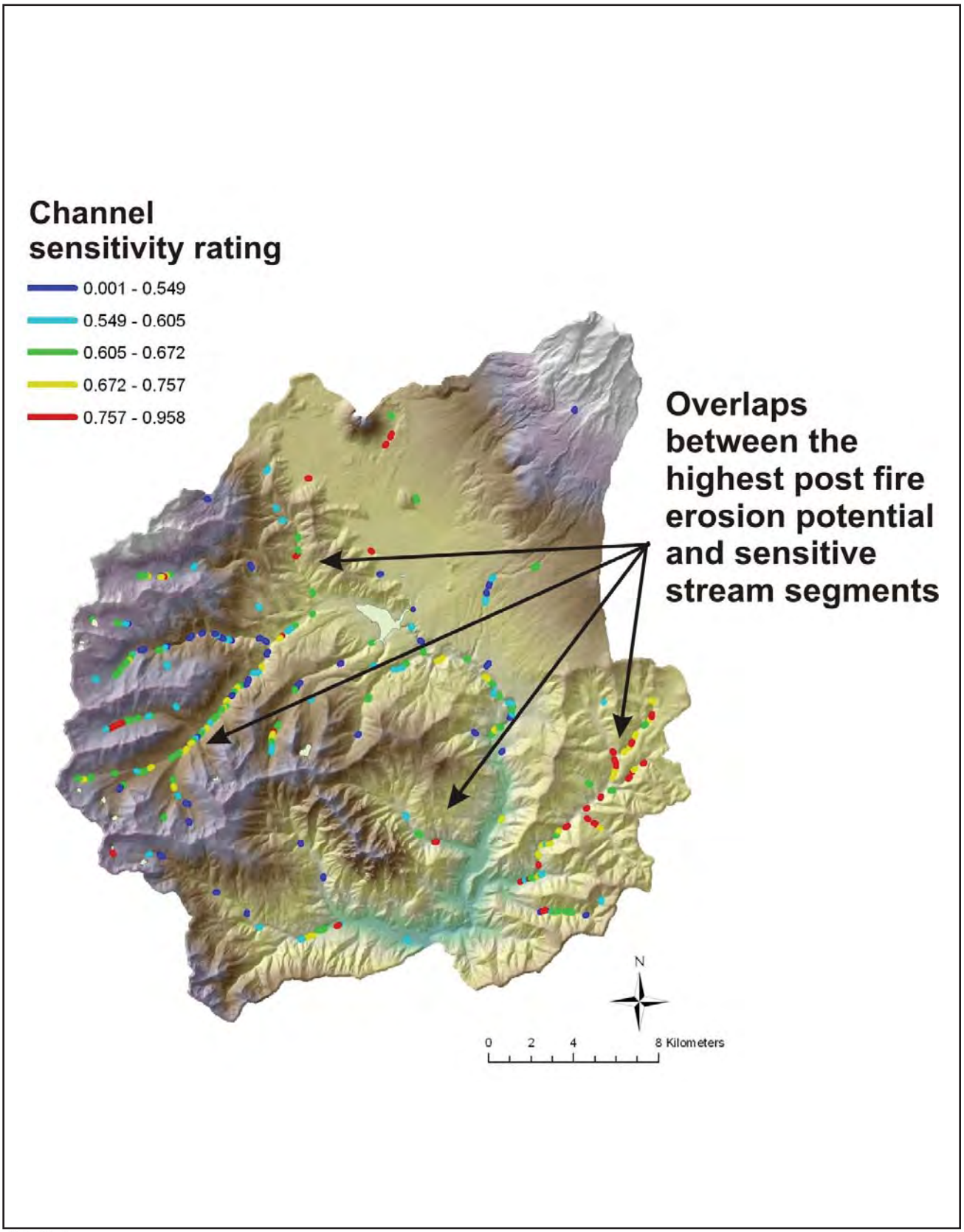
Areas of the highest erosion potential (> 70 t/ha) are denoted by circles.

Figure 4.2-6
Modeled Input of Sediment from Post-Fire Erosion at the Scale of Individual Stream Segments
(Modeled results not field verified.)



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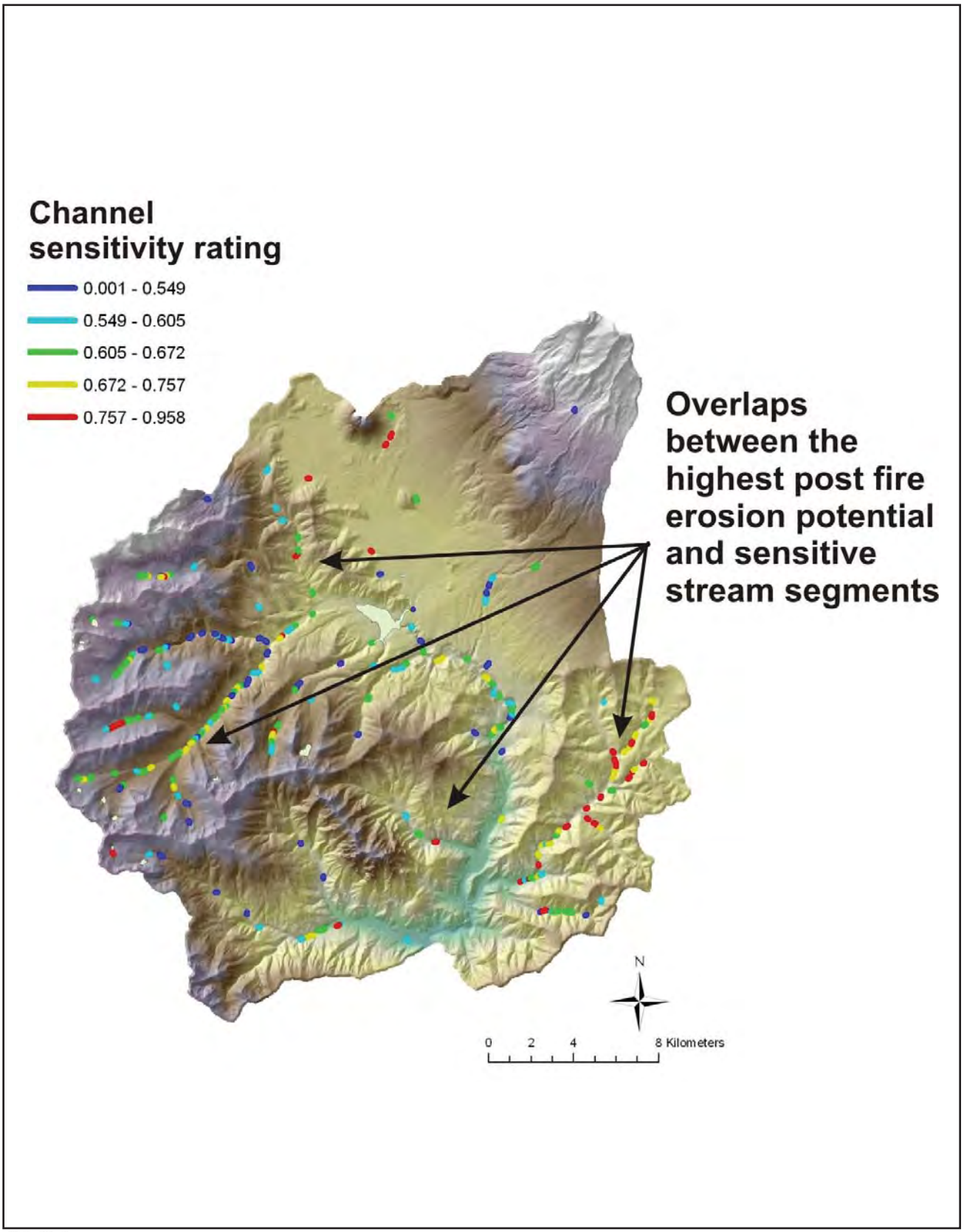
High sensitivity in this example refers to channels that could alter their morphology in response to large influxes of sediment following wildfires.

Figure 4.2-7
Modeled Areas Where Post-Fire Erosion of Greater than 70 t/ha Overlap with Sensitive Stream Segments (Sensitivity Index > 0.7)
(Modeled results not field verified.)



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Road segments that are at particular risk could be identified through estimating their potential for road drainage diversion (in NetMap) and then considering their location with respect to predicted fire intensity (or predicted surface erosion maps, e.g., Figure 4.2-5) (indicated by circles in the lower map).

Figure 4.2-8
Modeled Fire Intensity and Potential Road Drainage Diversion
(Modeled results not field verified.)

drainage diversion potential (Figure 3.2-16). Classifying road-stream crossings according to debris flow potential (based on the topographic attributes of the tributary sub-basin above the road crossing as well as the characteristics of the channel crossed by the road) can be used similarly. Areas along the road that are considered to have a combination of 1) high fire severity, 2) high drainage diversion potential, 3) high landslide or gully potential, and 4) high debris flow potential are illustrated in Figure 3.2-30.

4.2.2 Rainfall-Runoff, Erosion, and Water Quality

This section analyzes the potential interaction of rainfall-runoff, erosion, and water quality to help identify portions of the watershed where biological integrity may be most at risk from upslope erosion and instream sedimentation Excess sediment and metals are water quality concerns in the watershed assessment area that can potentially affect designated beneficial uses such as aquatic biota at small and large spatial and temporal scales, depending on the water year type and the extent of active erosion. The historic and present sediment load of the upper Sacramento River was difficult to determine given the paucity of reliable sediment data. For a detailed discussion and summary of the available turbidity data, see Appendix B.

The available information suggests that excess fine and coarse-sized sediment (silt versus gravel) and elevated turbidity levels are water quality concerns within the sub-basin (Central Valley Regional Water Quality Control Board, 2009). Water quality objectives for sediment and turbidity have been established within the sub-basin. Given the available sediment and turbidity data, this assessment was unable to compare the present levels relative to the applicable water quality objectives. During low flow conditions, the available data suggest that the sediment and turbidity levels are low with very little fine sediment in suspension (see Appendix B). There are very few turbidity data available for high flow conditions. However, anecdotal information (i.e., observations made during runoff) suggests that turbidity and sediment levels can be high during small and large flood events. For tributaries, the observed turbidity pulses tended to occur episodically. For example, depending on the time of year and storm type, different tributaries to the river will have high turbidity levels.

To date, the coarse sediment load of the river has not been measured, and few data are available concerning the extent of bed material deposition and storage within the mainstem river and tributaries. Observations made after large flood years, like the Flood of 1996, indicate that following large floods the amount of coarse sediment deposited instream increases substantially as a result of upslope erosion and sediment delivery over a wide spatial extent. A large delta has formed where the upper Sacramento River confluences with Shasta Lake, which clearly shows that the system has a moderate to high coarse sediment load.

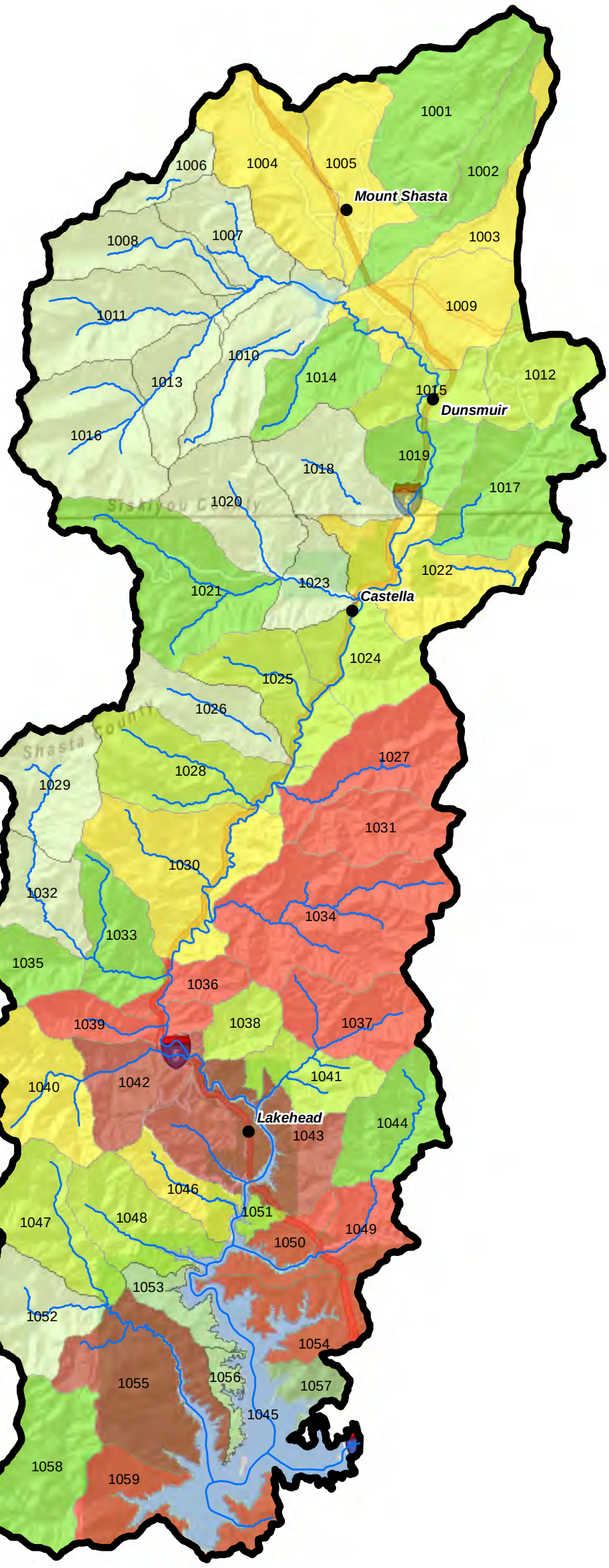
The University of California, Davis (2010) reports that there is a suspicion that excess metals delivered to the river from storm runoff and sewage seepage are threatening beneficial uses for the entire 36.4 mile reach above Shasta Lake. The lack of temporally and spatially distributed data for these metals makes it difficult to quantify the actual water quality conditions and the locations of the sources of these pollutants. One known source of these metals is from acid mine drainage from historic mining activities in the areas surrounding Shasta Lake (Figure 4.2-9). These areas were identified and assessed as part of the Upper Sacramento River TMDL (Regional Water Quality Board and California Environmental Protection Agency 2002).

The metals and sediment loads in a river the size of the upper Sacramento River typically are directly related to rainfall runoff-driven flood events and upslope erosion, and most of the material transport occurs during flood events as a function of stream flow. When metals that adsorb to fine sediment (i.e., clay-sized sediment particles) are eroded, they are transported downstream during these events. Areas enriched in these metals are known to occur in the sub-basin, especially in the lower watershed west of Shasta Lake. Cadmium, copper, and zinc, which occur naturally in several of the rhyolite rock types, are the metals of concern in the sub-basin. Most of the rock types present in the sub-basin are not enriched with these metals. Bedrock material and soil types that tend to be enriched with these metals include Bully Hill Rhyolite; and Balaklala Rhyolite. In the lower watershed, effluent from historic mining areas (e.g., the Golinsky mine) is a substantial source of metals and sediment. Since most of the rhyolite occurs in the lower watershed, this area of the sub-basin is the most likely source of metals-rich sediment. Other sources of these metals are also present in urban areas from, for example, storm-water runoff from parking lots and sewage effluent.

Sediment sources occur throughout the sub-basin; however, based on the available data and modeling completed as part of this assessment, sediment sources appear to be most common in the middle and lower watersheds. The landforms within this area appear to be inherently more prone to erosion, and the predicted local sediment yield could likely be related to precipitation patterns, vegetation, and rock type. NetMap modeling results indicate that there may be a greater Generic Erosion Potential (e.g., Figure 3.2-13) and shallow landslide and debris flow failure potential in the lower portion of the sub-basin than the upper portion. More often than not, this area experiences very intense rainfall events. For example, the 2-year 24-hour rainfall event is about 4 inches, and daily rainfall totals over 8 inches are not uncommon (see Figure 3.2-4). These intense rainfall patterns on steep erodible topography may lead to relatively high erosion rates and sediment delivery potential, especially following large disturbances to the vegetation and soils, such as from large, severe wildland fires.

A common source of fine and coarse sediment is from active landslides adjacent to stream channels. Commonly classified as inner gorge landslides, these features episodically deliver large pulses of sediment directly to the drainage network and also chronically erode for several years after initial failure. Several types of landslides occur within the sub-basin, including translational/rotational slides, earthflows (deep-seated), debris flows, debris slides, inner gorge landslides, and rock falls/slides. Most often these features occur naturally; however, disturbances caused by land use can increase landslide activity (California Department of Conservation 1999).

Within the assessment area, the average landslide density is about one active landslide per square mile of drainage area, but the geographic distribution of activity varies widely. The NetMap model predicts that the shallow landslide (e.g., debris flows) failure potential is highest in steep convergent topography with high hillslope–channel connectivity in the southeast portion of the lower watershed (Figure 3.2-16 and Figure 3.2-20). This area is within the rainfall zone; underlain by shale and graywacke (Cbg) rock types, it has the highest drainage density within the sub-basin (Figure 3.2-30 and Table 3.2-6). The NetMap model also predicts the likelihood of deep-seated landslides with the highest potential in the northeast portion of the middle watershed within the (Oum) rock type that is composed mainly of peridotite, an ultramafic igneous rock (Figure 3.2-30).



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North State Resources, Inc.

Upper Sacramento River Project

Figure 4.2-9
Runoff and Erosion Potential
(Modeled results not field verified.)

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Most of the "mapped" active landslides occur in the middle and lower parts of the watershed, with 26 percent in the peridotite (Oum) rock type, 20 percent in the shale and graywacke (Cbg) rock type, and 14 percent in the dike complex (Dc) rock type. Most of these landslides were mapped from aerial photographs, and some were ground truthed by the USFS (see Geomorphology GIS layer and meta-data). Upstream of Shasta Lake, there are at least 90 active landslides as mapped by the USFS, and there is likely an additional 50 active features along I-5 mapped as part of this assessment from the 2009 National Agriculture Imagery Program (NAIP) remote sensing images. Most of the mapped features appear to be debris flow amphitheaters or inner gorge failures. The types of features that occur along I-5 tend to be deep-seated earthflows, rock slides, and rock falls. As stated above, inner gorge landslides, by definition, directly deliver sediment to the drainage network, and where I-5 dissects inner gorge terrain, sediment is likely directly transformed to the drainage network. For non-inner gorge landslides, the probability of sediment delivery is higher for features that overlay the drainage network. Without more field data, it is difficult to quantify the actual sediment delivery from landslides in the sub-basin.

Ground disturbance caused by certain land use activities is known to exacerbate landslide activity (Sidle and Ochiai 2006). For active landslides, removal of underlying support is a common trigger mechanism in northern California (California Department of Conservation 1999). Road cuts that undercut unstable hillslopes and effectively remove a portion of the hillslope's lateral support commonly increase landslide activity. For example, removal of underlying support is common along the I-5 corridor, where excavation of material along the toe of large earthflows has increased landslide activity, especially within the Oum rock type. The mapped active landslide layer was overlaid with the road layer, showing that the majority of the mapped active landslides are within 100 feet of a road. It is unlikely that all of these features are triggered or affected by roads; however, some percentage of the active landslides may be affected by land use, especially along 1-5 and the railroad corridor. This assessment was unable to quantify the number of land use–related landslides, suggesting the need for field-based landslide inventories to better understand the extent of management-related landslide activity within the sub-basin.

Another potential source of sediment is when ground disturbance caused by land use activities accelerates rainfall runoff, fluvial erosion rates, and sediment delivery rates. This is especially common in steep topography susceptible to intense rainfall events (California Department of Fish and Game 2006). Unlike landslides, fluvial erosion tends to occur annually and is triggered by average precipitation and runoff events rather than extreme conditions. Using the available data and the NetMap model, this watershed assessment predicted areas with potentially accelerated erosion, hillslope–channel connectivity, and fluvial sediment delivery potential. The changes in rainfall-runoff patterns were predicted using the Equivalent Roaded Area (ERA) model, and fluvial erosion from roads was predicted using the WEPP road erosion model.

Over the past 200 years, the amount of impervious and erodible land area from roads and urban development has increased within the sub-basin to an average of 5 percent (Figure 3.2-48). I-5 alone covers at least 2 percent of the sub-basin and generates substantial quantities of fine sediment during rainfall-runoff events, especially just north of the DLT gauge, where the 2-year 24-hour rainfall event measured at Gibson is about 4 inches (Figure 3.2-4). Field observations made over the last decade during storm events along I-5 suggest that runoff from the freeway enters ditches and eventually small stream channels that confluence directly with the mainstem river. Ocular observations made

during storms indicate that visible pollutants like fine sediment, oil, and grease are suspended and transported with this runoff. During field erosion inventories along the Shasta Lake shoreline, it was observed that several storm drain channels downslope of the highway are degraded as a result of increased runoff. These inventories also observed that unless they had been hardened using engineering techniques, these ditches chronically erode sediment during storms.

Urban development has occurred in the middle and upper sub-basin directly adjacent to I-5. Urban areas are known to increase storm runoff, which, like road runoff, transports fine sediment and other pollutants. Typically, new development is the main sediment source within urban areas. Older neighborhoods, for example, typically have very few erosion problems. Relatively large urban footprints have been developed along the I-5 and railroad corridors between Lakehead and Black Butte Summit. The most intense urban development has occurred in the City of Mt. Shasta. As shown in Figure 3.2-48, the subwatersheds draining the Mount Shasta area have an ERA of almost 18 percent, mainly as a result of paved roads, roofs, parking lots, and driveways. However, this area likely is not a major source of sediment, since the landform types have less erosion potential (i.e., less rainfall, stable rock types, and gentler topography). Urban development in the middle of the sub-basin between Lakehead and Dunsmuir is occurring on more erodible landforms.

Timber harvest has occurred within the sub-basin since the late 1800s. Historically, large areas of the landscape adjacent to the railroad corridor were heavily harvested. Most of the upslope areas around Mt. Shasta and Dunsmuir were completely denuded of vegetation. Since then, timber harvest has progressively moved further from the railroad corridor upslope into steeper, less accessible areas. The rate of timber harvest on USFS lands has decreased since the mid 1990s. The historic and present rate of timber harvest on private lands is unknown, and the publicly available data for private land do not accurately represent the timber harvest history. Observations made as part of this assessment from the 2009 NAIP remote sensing images show that some areas are actually harvested but are not shown in the CDF database, and vice versa. This assessment did not have time to verify these data. Accurate timber harvest history data are needed to better understand the cumulative effects of land management within the sub-basin.

Using the results of the NetMap modeling, this assessment identified areas with potentially accelerated runoff, erosion, and sediment delivery (described in Appendix B). Results of this analysis indicate that some of the most intensive land use occurs in the area surrounding Mount Shasta, the area along the I-5 and railroad corridors, and in the middle watershed (Figure 3.2-48). The lack of accurate, publicly available timber harvest data for private lands prevented comparing the results of this analysis to the USFS ERA thresholds. For areas of the sub-basin covered by private timber lands, the ERA results reported herein are likely lower than the actual value. The relative ERA value was used to assign a rainfall-runoff potential.

The results of this exercise are shown in Figure 4.2-9 by watershed. The most intense land use has occurred in the middle portion of the sub-basin on landforms with high rainfall-runoff, erosion, and sediment delivery potential (Figure 4.2-9). Some of the subwatersheds have a higher risk of increased runoff than an erosion risk, whereas the subwatersheds that are north of Dunsmuir have a higher runoff risk than erosion risk. Downstream of Dunsmuir, there appears to be more road erosion risk in combination with impervious area created by roads. On the west side of Shasta Lake, two of the

subwatersheds are rated as having a high risk as result of ground disturbance caused by historic mining activities that are still actively eroding sediment.

4.2.3 Evaluating Watershed Stability after the Cantara Spill

On July 14, 1991, a Southern Pacific train derailed on a stretch of track known as the Cantara Loop while crossing the upper Sacramento River near Mount Shasta, just north of Dunsmuir. Approximately 19,000 gallons of metam sodium, a chemical typically used as a soil fumigant and herbicide, spilled into the Sacramento River. When metam sodium is released into the environment, it forms both liquid and gas compounds that are highly toxic to people, plants, and animals. Residents of the town of Dunsmuir were forced to evacuate, and contaminated water killed fish, other aquatic organisms, and plants. It also seeped into the soil, entering the shallow groundwater aquifers surrounding the riverbanks. Air, water, soil, plants, and animals along a 36-mile stretch of the Sacramento River were exposed to metam sodium.

CDFG's California Wildlife Habitats Relationship Program (California Department of Fish and Game 2008), which lists all native and introduced wildlife species known in California, indicates that the watershed supports up to 247 species of terrestrial wildlife, including 76 mammals, 17 reptiles, 14 amphibians, and 140 birds. Of these, 29 are identified as "river dependent"— dependent on the aquatic habitat elements that were virtually eliminated by the spill (Cantara Trustee Council 2007). Terrestrial wildlife species were affected not only by the contamination of their water supply, but also by the gases in the air. Here we review the response of fish and wildlife communities to the spill, their recovery rates, and their overall current conditions as possible indicators of the stability of the watershed.

Invertebrates

Aquatic Insects

In the central portion of the watershed, the single greatest influence on invertebrate communities in the last several decades is likely the Cantara Spill. Additionally, the bulk of the existing information on aquatic insects was gathered in response to the spill. All members of the aquatic insect communities were essentially eliminated by the spill (Cantara Trustee Council 2007).

Data from 1991 through 1993 and 1996 showed that, at that the end of that period, the composition of the aquatic insect community in the upper Sacramento River mainstem was still unstable, with significant changes continuing to occur (Department of Water Resources 1997). Specifically, opportunistic species initially dominated many of the monitored locations, especially those downstream from the spill site. However, the initial data also indicated development of comparable, though quite variable, numbers of organisms and species, and biomasses between monitoring stations upstream and downstream from the spill. By the second year of the study, the number of species in each order at monitoring stations affected by the spill appeared to be similar. Communities remained unstable, however, with rapid succession continuing.

Researchers hypothesized that the continued succession observed in the communities may have resulted from their continued adjustments to the affects of the spill or may have been a reaction to other factors that influenced the composition of the aquatic macroinvertebrate communities.

However, the fact that the community composition of riffles affected by the chemical spill differed from that of the upstream control station lead researchers to believe that recolonization was not yet complete (Department of Water Resources 1997).

Subsequent surveys conducted by DWR in 2001 revealed higher densities of a mayfly, stonefly, and caddisfly assemblage compared to midges and other flies in two out of six sample stations (Boullion 2006, Cantara Trustee Council 2007). In its final report, the Cantara Trustee Council pointed out that midges and other flies represent species groups that are more successful under conditions of poor water quality or stress while the mayfly, stonefly, caddisfly assemblage represents species groups that indicate high-quality aquatic conditions (Cantara Trustee Council 2007). Despite the Council's including this observation, seemingly as an indication of recovery, the conclusion of the 2001 DWR study could only hypothesize, not confirm, that recovery of these insect assemblages was complete, as continued population fluctuations could not be attributed to any specific driver (Boullion 2006).

Mollusks

Very little information on the fresh water mollusks of the Upper Sacramento watershed was available prior to the post-Cantara spill research performed to assess its impact and the system's recovery. Many of the genera present had not been well described or researched anywhere within their broad range, despite being locally abundant and easily collected in springs, streams, and rivers (Hershler et al. 2007).

Frest and Johannes (1997) provide a detailed summary of the presence, distribution, and habitat affinity of both bivalve and gastropod species in the mid-segment of the watershed. Of particular note in their report are accounts of 22 new taxa first described as part of the post-Cantara monitoring effort (though a few proved to be previously present in museum collections) (Frest and Johannes 1997). Many of the previously undescribed *Fluminicola* species, recorded during the post-spill monitoring, and general diversity and diversification in *Fluminicola* were also more recently described by Hershler and others (2007).

In the central portion of the watershed, initial CDFG surveys following the Cantara spill showed that mollusk densities were low at all sample locations affected by the spill, as compared to the control sites (Cantara Trustee Council 2007). While adequate baseline data did not (and do not) exist to thoroughly compare pre- and post-spill communities, the more rapid recolonization of generalists such as *Physella* after the spill (Cantara Trustee Council 2007) suggests the possibility of altered community composition as the result of the event. A reintroduction of several species was proposed following the Cantara spill, based on monitoring of population recovery (Frest and Johannes 1994). This proposed action, however, was never performed.

In addition to post-spill recovery dynamics, habitat degradation has perhaps the greatest potential to significantly influence mollusk communities in the central and lower watershed. Habitat degradation for mollusk communities would come primarily in the form of increased sedimentation and loss of suitable in stream substrate and structure (e.g. rocks and woody debris).

Crayfish

Crayfish presence and community condition have a complex and spatially variable range of potential implications for the ecology of the watershed. While the native Shasta crayfish existed in the watershed historically, their populations are believed to be largely extirpated from much of the watershed, and existing crayfish communities are composed of the introduced species.

In the headwaters (upper) segment of the watershed, what little information is available on crayfish distribution and population status suggests that there has been expansion and contraction of population size and range in different areas. The disappearance of this non-native species from Castle Lake may have reduced disturbance in the system, and there are no current reports of crayfish populations persisting in other lakes within the headwaters portion of the watershed. In the south fork of the Sacramento River, however, crayfish are currently present and appear anecdotally to be expanding. In addition to potential impacts on macrophytes and the productivity and structure of habitat, as was observed at Castle Lake (Elser et al. 1991), expanded crayfish populations in the upper watershed would also likely be exerting pressure on already compromised amphibian populations.

In the central portion of the watershed, crayfish populations were anecdotally reported to be well-established prior to the Cantara spill. Research on crayfish populations performed in response to the Cantara spill concluded in 1993 (Brett and Goldman 1993), and no detailed investigation of their distribution or abundance in any portion of the watershed has occurred since that time. Some additional limited corollary findings were also collected during post-spill population studies for riffle sculpin in which crayfish were also noted. The crayfish population was believed to have been completely eliminated by the spill (Brett and Goldman 1993). Recovery studies suggested, however, that following the spill, abundance was likely increasing slowly (Thomas R. Payne and Associates 2005). This was the conclusion proposed in the Cantara Trustee Council Final Report (Cantara Trustee Council 2007). Specifically, CDFG suggested that the crayfish population would recover over time as individuals migrated from tributaries into the mainstem and upstream from Shasta Lake (Cantara Trustee Council 2007). Researchers focused on crayfish monitoring after the spill concluded that because of factors such as small remaining populations in the watershed, slow rates of dispersal, and the potential for intense predatory pressure in the limited tributary refugia, crayfish population recovery in the mainstem would likely not occur for 10–15 years (Brett and Goldman 1993,1994). In response to this possibility, an extensive reintroduction was proposed (Brett and Goldman 1994). This, however, never occurred. Given the 10–15 year estimated time for recovery, it may be that populations in the region affected by the spill have returned to an equilibrium state, but that hypothesis is unconfirmed.

Fish

The rainbow trout population in the central portion of the mainstem of the Sacramento River was heavily affected by the Cantara spill, with an estimated 89,445 fish killed (Hankin et al. 1995). By 2000, however, it was concluded that the rainbow trout population in the river had likely recovered from the effects of the spill (Thomas R. Payne and Associates 2005). Based on 1992–2001 annual dive count data and CDFG electrofishing and creel survey data, rainbow trout populations appeared to be fluctuating within the range of natural variation by the end of the monitoring period. Additionally, it was predicted that those populations were not likely to expand much beyond the density of 1,000 to 3,000 juvenile and adult trout per mile (Thomas R. Payne and Associates 2005).

Native fish species were also heavily affected by the Cantara spill. Though much of the recovery effort and associated monitoring were focused on rainbow trout, a number of other native species were monitored to a greater or lesser extent, including riffle sculpin, pikeminnow, and Sacramento sucker. Surveys for these species concluded that the riffle sculpin population, hardest hit in terms of numbers with an estimated 187,905 dead (Hankin et al 1993), was growing, though populations still had not peaked as of 2001 (Cantara Trustee Council 2007; Thomas R. Payne and Associates 1992–2001). Pikeminnows approached peak densities by 1995 and subsequently fluctuated in abundance, although the fluctuations were not statistically significant (Thomas R. Payne and Associates 1992–2001). Sacramento sucker abundance indices did not peak until 1998 and subsequently declined (Cantara Trustee Council 2007; Thomas R. Payne and Associates 1992–2001). Surveys found relatively low densities and limited post-spill distributions of pikeminnows and suckers (Cantara Trustee Council 2007; Thomas R. Payne and Associates 1992–2001). Based on these findings and the fact that these species are known to be relatively slow reproducers, the Cantara Trustee Council, in its final report (2007), concluded that it may take additional years for these populations to reach full recovery.

While few populations of warm water introduced species have been tracked carefully over time, spotted bass populations were surveyed over multiple years following the Cantara spill as part of the recovery monitoring (Cantara Trustee Council 2007; Thomas R. Payne and Associates 1992–2001). Spotted bass densities were highest in 1995 (Thomas R. Payne and Associates 1992–2001). In its final report, the Cantara Trustee Council suggested that these high densities coinciding with the end of population growth might be indicative of a recovered equilibrium state post spill (Cantara Trustee Council 2007). If true, this would constitute a significantly faster recovery and return to equilibrium state than many of the other aquatic species affected by the spill, a distinction which in turn may carry implications for the relative recovery of those other aquatic species that directly compete or are predated upon by spotted bass.

Amphibians and Reptiles

The most comprehensive research on amphibians in the watershed was conducted in the central portion following the 1991 Cantara spill. Surveys in the central portion of the watershed were conducted between 1991 and 1994 on the Sacramento River mainstem and 28 of its tributaries. Findings from the study suggest that amphibian populations were significantly affected by the spill. This was the case not only in the mainstem, but also in the tributaries, and was a function of increased predation from river otters and other predators (Luke and Sterner 1995). Additionally, it was hypothesized that impacts on tributaries would slow repopulation of the mainstem (Luke and Sterner 1995). Estimated recovery times for species of interest ranged from 10–14 years for foothill yellow-legged frogs to 27–35 years for Pacific giant salamanders (Luke and Sterner 1995). Neither the ongoing status of these and other amphibian populations nor the degree of their recovery is known.

According to the *Final Report on the Recovery of the Upper Sacrament River – Subsequent to the 1991 Cantara Spill* (Cantara Trustee Council 2007), the impact on amphibian populations was quite different than on terrestrial reptiles, which were insignificantly affected by the spill (Morrison 1993; Luke and Sterner 2000a, 2000b).

Birds

Point Reyes Bird Observatory (PRBO) conducted post-spill surveys for riparian birds and ospreys. PRBO estimated that, as of 1996, the recovery of riparian birds was essentially complete, and osprey productivity would recover to baseline numbers by 1999 (Cantara Trustee Council 2007). According to the *Final Report on the Recovery of the Upper Sacrament River – Subsequent to the 1991 Cantara Spill* (Cantara Trustee Council 2007), by 1994, CDFG believed that osprey numbers in the upper Sacramento River canyon were possibly being limited by a lack of nest sites due to anthropogenic disturbances. Therefore, eight artificial platform nests were constructed in 1994 and 1995 and one additional platform was constructed in 2000 to enhance recovery (California Department of Fish and Game 1997). Production on the artificial nest platforms reached its highest (14 chicks from seven platforms) in 2004, proving that the nests were successful in boosting productivity. The first documented sighting of bald eagles nesting in the Sacramento River drainage, upstream of Shasta Lake, was in 1998. The pair of bald eagles used one of the platforms from 1998–2002; in 2005, they were found nesting in a live, natural tree just downstream.

Mammals

River-dependent and small mammal populations were minimally affected by the Cantara spill and quickly recovered to pre-spill conditions (Morrison 1993). However, bats were significantly affected. Studies conducted in 1994 (Rainey and Pierson 1996) showed that the recovery of bats from the spill was slow, and an additional study in 1996 (Rainey and Pierson 1997) suggested that the river was not sustaining bat populations as well as it had in 1992 or 1994. These results indicated the demography and density of the bat population were unstable. It was unknown whether the instability was due to long-term ongoing spill effects or natural year-to-year variation (Cantara Trustee Council 2007).

4.3 References

4.3.1 Literature Cited

Andreasen, J. K., R. V. O' Neill, R. F. Noss, and N. C. Slosser. 2001. Considerations for the development of a terrestrial index of ecological integrity. Ecological Indicators 1:21-35.

Boullion, T. 2006. Cantara project Sacramento River benthic macroinvertebrate sampling program - 2001 results progress report. Unpublished report submitted to the Cantara Program, California Department of Fish and game. California Department of Water Resources.

Brett, M. T. and C. R. Goldman. 1993. Crayfish population size and recolonization potential in the upper Sacramento River following the Cantara Vapaṃ spill. Unpublished report submitted to the California Department of Fish and Game. Ecological Associates.

———. 1994. Crayfish population size and recolonization potential in the upper Sacramento River following the Cantara Vapam spill - 1993 field sampling. Unpublished report to the California Department of Fish and Game. Ecological Research Associates.

California Data Exchange Center. 2010. Sacramento River at Delta turbidity data. http://cdec.water.ca.gov/cgiprogs/selectQuery?station_id=DLT&sensor_num=&dur_code=D&start_date=&end_date=now

California Department of Conservation. 1999. Factors affecting landslides in forested terrain. California Division of Mines and Geology, Note 50.

California Department of Fish and Game. 2008. CWHR version 8.2 personal computer program: California Department of Fish and Game, California Interagency Wildlife Task Group.

———. 2006. Upland erosion inventory and sediment control guidance, Part X. In: California salmonid stream habitat restoration manual, California Department of Fish and Game.

———. 1997. Osprey reproductive success in the Cantara spill impact zone: Results of the 1995 breeding season and summary of results 1991-1995. Unpublished final report. California Department of Fish and Game. January.

California Department of Fish and Game, USDA Forest Service, and Bureau of Land Management. 1998. Report to the Fish and Game Commission: As assessment of mule and black-tailed deer habitats and populations in California.

Cantara Trustee Council. 2007. Final report on the recovery of the upper Sacramento River - Subsequent to the 1991 Cantara Spill.

Central Valley Regional Water Quality Control Board. 2009. Water quality control plan (basin plan) for the Sacramento and San Joaquin River basin. California Regional Water Quality Control Board, Central Valley Region. Fourth Edition.

Department of Water Resources. 1997. Aquatic macroinvertebrate recovery assessment in the upper Sacramento River 1991-1996. State of California, The Resources Agency, Department of Water Resources. August 1997.

Elser, J. J., C. Junge, and C. R. Goldman. 1994. Population structure and ecological effects of the crayfish Pacifastacus leniusculus in Castle Lake, California. Great Basin Naturalist 54:162-169.

Frest, T. J. and E. J. Johannes. 1997. Upper Sacramento system freshwater mollusk monitoring, California with particular reference to the Cantara spill. 1996 yearly report. Deixis Consultants. Prepared for the Cantara Trustee Council. June 10, 1997.

Hankin, D. and D. McCanne. 1995. Estimation of the proportion of holdover hatchery-reared rainbow trout (*Oncorhynchus mykiss*) among the Cantara spill mortalities. Unpublished final report. Humboldt State University. January 1995.

Hershler, R., H. P. Liu, T. J. Frest, and E. J. Johannes. 2007. Extensive diversification of pebblesnails (Lithoglyphidae: Fluminicola) in the Upper Sacramento River Basin. Zoological Journal of the Linnean Society 149:371-422.

Luke, C. and D. Sterner. 1995. Cantara bridge chemical spill, 1994 aquatic amphibian survey. Unpublished final report prepared for California Department of Fish and Game. Biosystems Analysis, Inc.

———. 2000a. Possible effects of the Cantara spill on amphibian populations of the upper Sacramento River. *California Fish and Game* 86(1):41-60.

———. 2000b. Possible impacts of the Cantara spill on reptile populations along the upper Sacramento River. *California Fish and Game* 86(1):61-71.

Martin, S. B. and W. S. Platts. 1981. Influence of forest and rangeland management on anadromous fish habitat in western North America: Effects of mining. USDA Forest Service Anadromous Fish Habitat Program. Report No. GTR PNW-119. April 1981.

Minshall, G. W. 1995. Re-emergence of the importance of biology in water quality assessments. Water Resources Update 98:21-26.

Minshall, G. W., C. T. Robinson, and D. E. Lawrence. 1997. Immediate and mid term responses of lotic ecosystems in Yellowstone National Park, USA to wildfire. Canadian Journal Fisheries and Aquatic Sciences 54:2509-2525.

Morrison, M. 1993. Analysis and interpretation of the upper Sacramento River wildlife data: Cantara spill project. Unpublished report submitted to California Department of Fish and Game. University of California at Berkeley, Department of Forestry and Resource Management.

Naiman, R. J., R. E. Bilby, D. E. Schindler and J. M. Helfield 2002. Pacific Salmon, Nutrients, and the Dynamics of Freshwater and Riparian Ecosystems. Ecosystems. 5(4): 399-417.

Newcombe, C. P. and J. O. T. Jensen. 1996. Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Impact. North American J. Fisheries Management 16: 693-727.

Rainey, W. E. and E. D. Pierson. 1996. Cantara spill effects on bat populations of the Upper Sacramento River 1991-1995. Final report prepared for the Cantara Program, California Department of Fish and Game. University of California at Berkeley. December 1996.

———. 1997. Monitoring of bat populations on the upper Sacramento River: 1996. Final report prepared for the Cantara Program, California Department of Fish and Game. University of California.

Reeves, G. H., P. A. Bisson, B. E. Rieman, L. E. Benda. 2006. Postfire logging in riparian areas. Conservation Biology. 20(4):994-1004.

Rieman, B. and J. Clayton. 1999. Wildfire and native fish: Issues of forest health and conservation of sensitive species. Fisheries 22:6-15.

Shaffer, K. E. and W. F. Laudenslayer, Jr. 2006. Fire and animal interactions. In Fire in California's ecosystems, edited by N. G. Sugihara, J. W. van Wagtendonk, K. E. Shaffer, J. Fites-Kaufman and A. E. Thode. Los Angeles, California: University of California Press.

Sidle, R.C., and Ochiai, H., 2006. Landslides, Processes, Prediction, and Land Use. American Geophysical Union, Water Resources Monograph 18.

Sugihara, N. G., J. W. van Wagtendonk, K. E. Shaffer, J. Fites-Kaufman, and A. E. Thode, eds. 2006. Fire in California's ecosystems. Los Angeles, California: University of California Press.

Thomas R. Payne and Associates. 1992. Revised summary report describing fish distribution and abundance in the upper Sacramento River, June-July, 1992. Unpublished report. Thomas R. Payne and Associates.

———. 1993. Summary report describing fish distribution and abundance in the upper Sacramento River, September-October 1992. Unpublished report. Thomas R. Payne and Associates. February.

———. 1995. Assessment of riffle sculpin populations in the Upper Sacramento River following the 1991 Cantara spill - 1994 annual report prepared for the California Department of Fish and Game. Thomas R. Payne and Associates.

———. 1996. Recovery of fish populations in the upper Sacramento River following the 1991 Cantara spill. Unpublished report to the California Department of Fish and Game. TRPA. September.

———. 1999. A summary of the 1999 dive count recovery of fish populations in the upper Sacramento River. Unpublished final report prepared for the California Department of Fish and Game. Thomas R. Payne and Associates. August.

———. 2000. Recovery of fish populations in the Upper Sacramento River. A summary of the YR 2000 dive counts. Summary report to the California Department of Fish and Game, Redding, California. November 2000.

———. 2005. Recovery of fish populations in the upper Sacramento River following the 1991 Cantara spill. Unpublished final report to the Cantara Trustee Council, California Department of Fish and Game. TRPA.

U.C. Davis. 2010. Geospatial waterbody system. http://endeavor.des.ucdavis.edu/geowbs/ (assessed March 2010).

USDA Forest Service. 1999. Shasta-Trinity National Forest forest wide LSR assessment.

———. 2008. Shasta-Trinity National Forest. http://www.fs.fed.us/r5/shastatrinity/index.shtml (accessed 2008).

U.S. Environmental Protection Agency. 2007. Mad River total maximum daily loads (TMDL) for sediment and turbidity.

Wallmo, O. C. and Schoen. 1981. Forest management for deer. In *Mule and black-tailed deer of North America*, edited by O. C. Wallmo: Wildlife Management Institute, University of Nebraska Press.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 1996. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. In Sierra Nevada Ecosystem Project: Final Report to Congress vol. III. Davis, California: Centers for Water and Wildland Resources.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley Region of California. North American Journal of Fisheries Management 18:487-521.

4.3.2 Personal Communications

Chandra, S., Assistant Professor, Department of Natural Resources and Environmental Science, University of Nevada Reno. June 2008 - conversation with R. Henery, The River Exchange.

Whitley, D., Associate Environmental Planner, Caltrans. November 2008 - email to G. Bolen, North State Resources, Inc.

CHAPTER 5

Summary and Implications for Management

Chapter 5 Summary and Implications for Management

In this chapter, the key watershed conditions described in Chapter 3 and the interrelationships and mechanisms of change discussed in Chapter 4 are summarized, trends are discussed, and possible approaches to management are introduced. Management approaches range from strategies for further investigation and analysis to recommendations for specific actions to address or inform a particular need or opportunity in the sub-basin.

5.1 Summary of Key Watershed Conditions, Trends, and Management Opportunities

5.1.1 Fire and Fuels

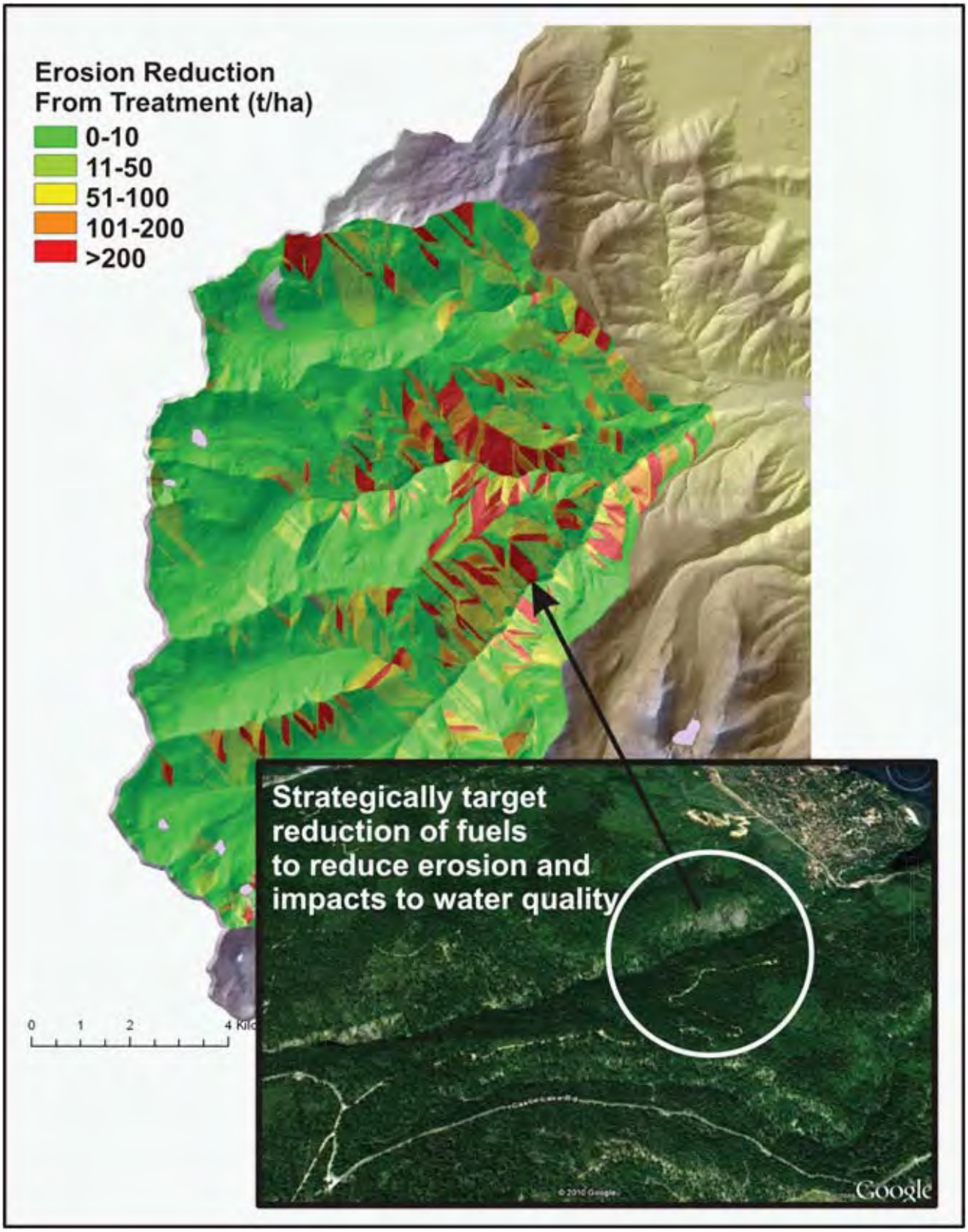
The environmental effects of numerous large fires pose a substantial risk to water quality and aquatic environments in the watershed. Cumulative impacts from the cascading sequence of flooding, accelerated erosion, channel scour, and increased sedimentation threaten to destroy productive habitats over large areas for years to decades (Rieman and Clayton 1999, Reeves et al. 2006). Overall, the highest erosion potential (more than approximately 200 t/ha) in the upper portion of the sub-basin is associated with areas of fuel categories 3 (shrub) and 5 (timber and litter) and the steepest and most dissected topography. The WEPP model predicts large spatial variability in erosion potential, from near zero to more than 300 t/ha, the highest erosion potential being associated with the greatest fire intensity and the steepest topography.

Management: Fire, Fuels, and Erosion

An erosion difference analysis was performed (Figure 5-1) to reveal where the greatest reduction in surface erosion might be achieved by reducing fuel loads. This information could be used to help strategically plan fuel reductions; it could also be used in concert with road-related and channel parameters (Figures 4.2-5, 4.2-9, and 4.2-10) to identify the most appropriate places to plan forest management activities to reduce the occurrence of large, intense fires.

Additionally, the information provided on flooding, erosion, and their potential effects (individually and combined) on water quality and aquatic ecosystems can and should be considered in the context of pre-fire planning. For example, thinning operations and fuels reduction in fire-prone, high fuel-load forest zones could be strategically located to reduce the potential for intense post-fire flooding and erosion and their deleterious effects on water quality and aquatic habitats.

This assessment identifies overlaps between individual stream segments that have high post-fire sediment yield to channels (>70 t/ha) and channel segments of high sensitivity (>0.7 on a scale of 0 to 1). Areas of overlap (Figure 4.2-7) can be used to strategically plan forestry activities to reduce fire intensity and to lessen accelerated post-fire erosion. This exercise could also be conducted using



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The surface erosion that is predicted to occur following vegetation treatment was subtracted from the pre treatment surface erosion prediction. The resultant 'erosion difference' map above illustrates where, in the demonstration area located above Lake Siskiyou, vegetation treatments that reduce fire intensity would have potentially the largest effect on erosion reduction.

Figure 5.1-1
Modeled Surface Erosion
(Modeled results not field verified.)

maps and data on fish (Appendix D), aquatic community biodiversity (Appendix I), or habitat quality (not prepared for this assessment except for anadromous fishes (Figures 5.1-2 and 5.1-3).

As a part of pre-fire planning, analysis of road segments that are at risk for drainage diversion, gullying, failure, or debris flows (following a fire) could be used for a targeted investigation of possible opportunities for road upgrading and maintenance to reduce the risk. Specifically, in cases where upgrading and maintenance opportunities have been identified on the ground, drainage relief structures could be upgraded or rolling dips created to reduce drainage diversion potential; culvert size could be increased; and areas of dense fuels located on hillslopes above sensitive road segments that are predicted to have potential for high fire severity and high erosion potential could be targeted for pre-fire thinning.

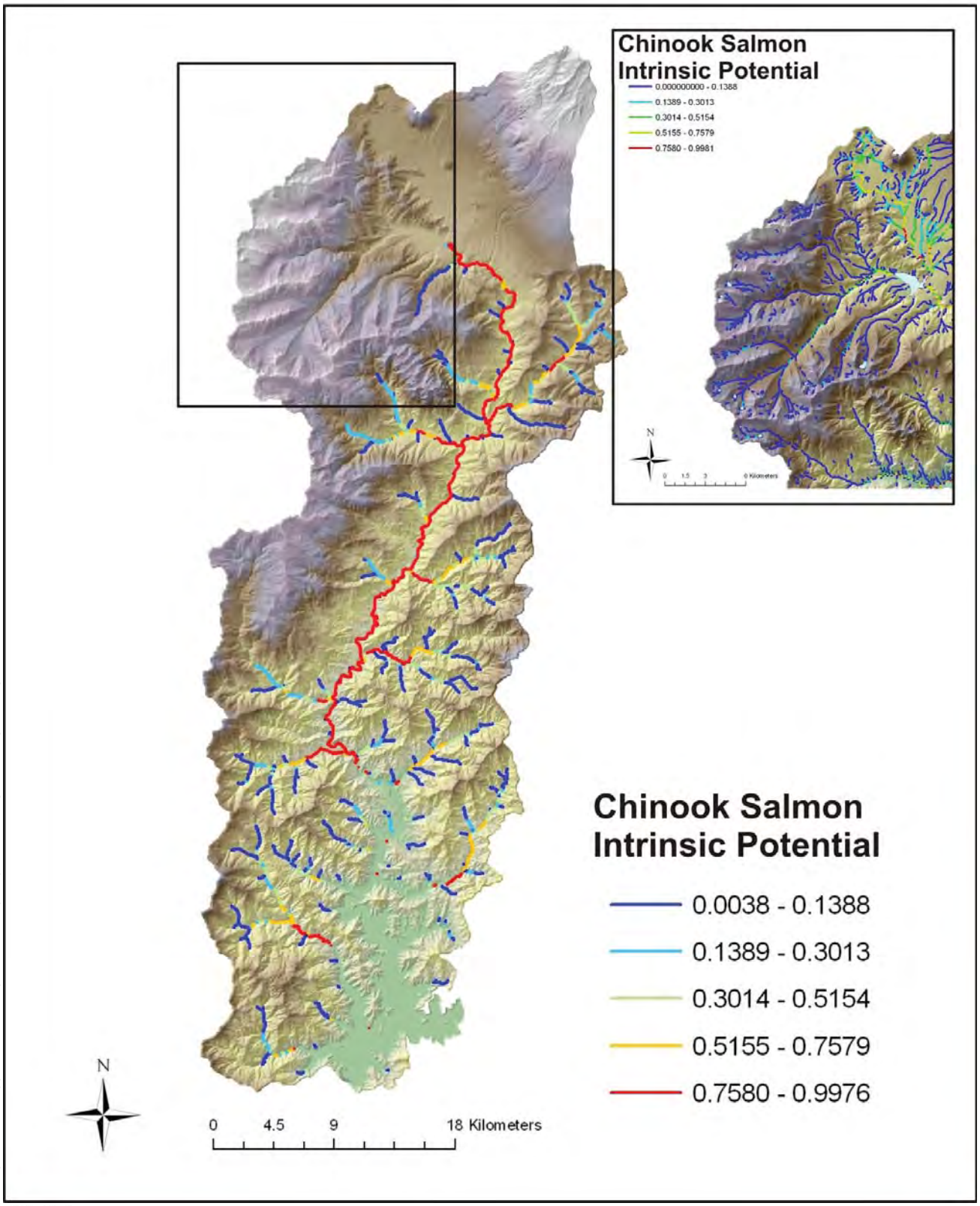
The analyses provided can also be applied in a post-fire management scenario (i.e., Burned Area Emergency Response [BAER]) to identify locations where spatial overlaps between high fire severity, surface erosion potential, drainage diversion potential, shallow failure, gully, and debris flow potential occur. Restoration efforts could then be focused in these more vulnerable areas. A priority list of road segments and road crossings within burned areas could then be developed and used to plan restoration and maintenance actions, such as road crossing removal, culvert upgrades, fill pull back, erosion control, and increased maintenance during large rainstorms or flood events

In the context of both pre- and post-fire planning (such as in the BAER process), it also may be useful to consider where roads can contribute to problems. This could include drainage diversions (particularly if culverts and other drainage structures become plugged with sediment and woody debris following a fire) that can lead to gullying, road surface erosion, and mass wasting. Additionally, in pre- and post-fire planning, areas identified to have high connectivity may warrant special attention, such as erosion mitigation strategies and larger buffers.

Although the fire-erosion-aquatic analysis included in this assessment covers only a small portion of the project area, tools in NetMap can be used to conduct similar analyses throughout the upper Sacramento River assessment area or in other nearby watersheds (for example, the McCloud River watershed).

5.1.2 Erosion, Sedimentation, and Water Quality

NetMap was used to model runoff and erosion potential by landform type summarized by watershed (Figure 4.2-9) to prioritize focus areas for monitoring, management, and restoration. For example, the three watersheds of the upper Sacramento River sub-basin show marked differences in the spatial distribution of the predicted generic erosion potential (GEP) (Figure 3.2-13). The lowest GEP values occur in the northern portion of the sub-basin and the highest values occur south of Castle Crags (Figure 3.2-14). The spatial pattern of hillslope gradient and convergence, represented by GEP, appears to be driven largely by precipitation patterns, vegetation, and rock type. Shallow landslide susceptibility analysis predicts an overall low density of unstable zones (particularly in the northern portion of the assessment area, e.g., Figure 3.2-16). Similar to GEP, the lowest potential for shallow landslides occurs in the northernmost section of the assessment area, and landslide potential increases down valley (Figure 3.2-16). Debris flow potential is also higher in the middle and lower portions of the watershed of the assessment area due to the steeper hillsides and higher drainage density (see



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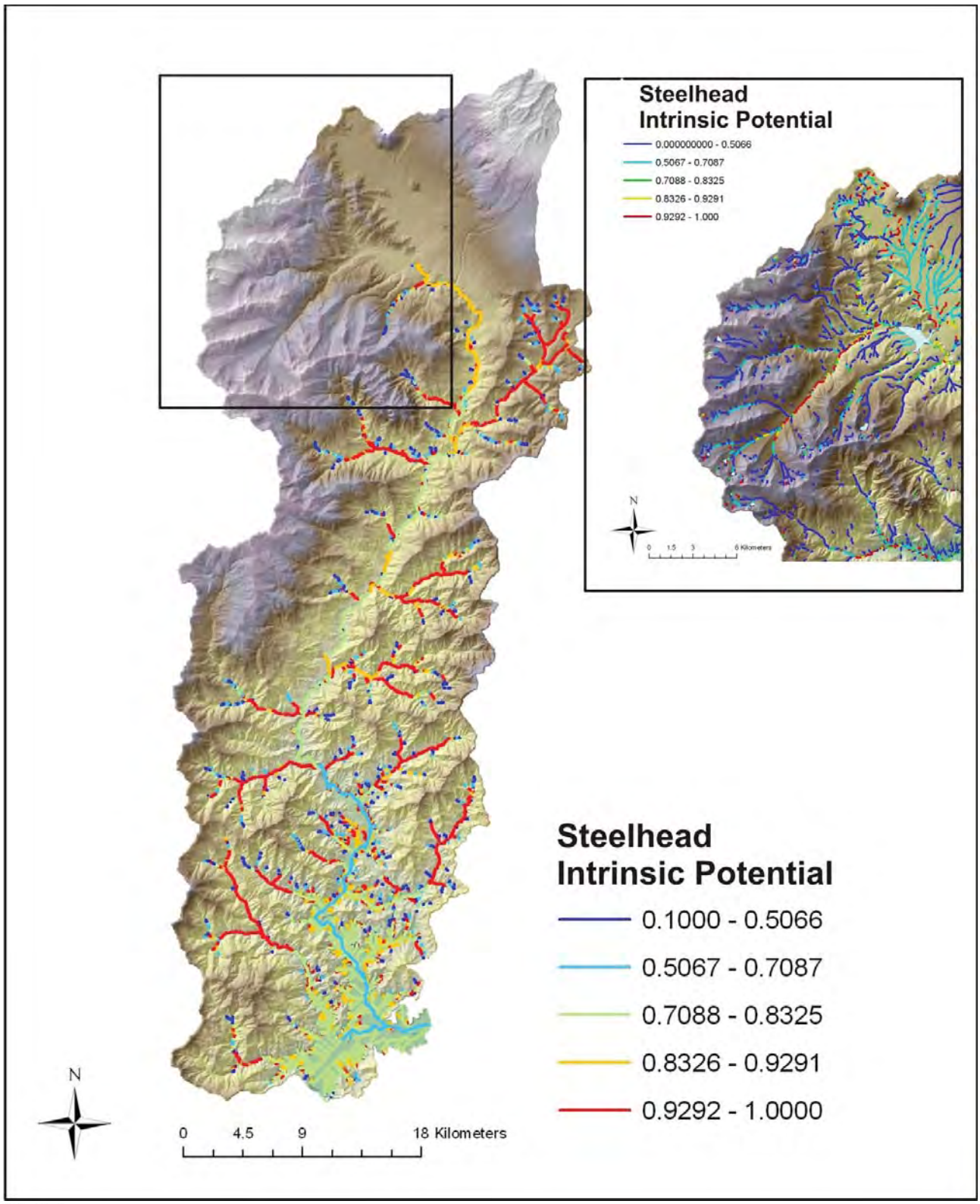
A model of intrinsic habitat potential for Chinook salmon (Agrawal et al. 2005) was applied to the upper Sacramento River project area to examine the historical extent of habitats prior to the Shasta Dam (1945).

Figure 5.1-2
Chinook Salmon
Modeled Intrinsic Potential
(Modeled results not field verified.)



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A model of intrinsic habitat potential for steelhead trout (Burnett et al. 2007) was applied to the upper Sacramento River project area to examine the historical extent of those habitats prior to the Shasta Dam (1945).

Figure 5.1-3
Modeled Steelhead Intrinsic Potential
(Modeled results not field verified.)

below) in those locations (Figure 3.2-20). Overall, sediment supply to stream channels is predicted to be lower in the northernmost watershed and increases in the middle and lower watershed (Figure 3.2-21).

The predictions for erosion and sediment delivery potential made using NetMap (Figure 3.2-21) have not been field verified and do not account for other erosion processes, such as streambank erosion and deep seated landslides. The predictions also do not account for erosion related to most land use activities, including urban areas (City of Mt. Shasta, Dunsmuir, etc.); timber harvest areas, and roads. The predicted sediment yield increases along the mid portion of the Sacramento River below Castle Crags due to the abundance of medium size tributaries with a relatively high sediment supply; most of these tributaries originate from the eastern side of the watershed in the mechanically weaker sedimentary rocks that are predicted to have a higher erosion rate (Figure 3.2-26).

The upper Sacramento River above Shasta Lake is not listed as water quality limited under Section 303(d) of the CWA (Central Valley Regional Water Quality Control Board 2006). All beneficial uses are listed as "Threatened" for the 36.4-mile reach described in the Basin Plan (UC Davis 2010). The threatened status is related to the suspicion that metals from stormwater runoff and storm sewers are degrading water quality and threatening beneficial uses. Significant impacts to water quality occurred in this reach, however, during and following the Cantara spill of herbicides in 1991 as well as through years of metals contamination from mine drainage near Shasta Lake.

Very few sediment or turbidity data are available to quantify sediment loads within the sub-basin. Most of the fine sediment and metals in the upper Sacramento River are transported during rainfall runoff events that occur between November and April over a period of several days to a week. Snowmelt, high-intensity rain, and rain on snow events all trigger the upslope erosion. Most of the fine sediment transported downstream is delivered to Shasta Lake or is deposited in lower gradient channels.

Management: Erosion, Sedimentation, and Water Quality

The NetMap modeled analysis of rainfall-runoff, erosion potential, and sediment delivery potential suggests that the middle and lower watershed pose the greatest risk of increased sediment supply to the drainage network, in turn suggesting that it is in these areas that wildfires and land use activities that increase erosion potential may have the greatest potential impacts on erosion and sediment supply to streams.

In addition to their application to pre- and post-burn fire management, erosion, sedimentation, and water quality–related analyses have many potential applications in watershed management. The analysis provided here, coupled with field analyses, could be used in site prioritization. Additionally, extra precaution could be taken when new roads are being constructed over areas predicted to have a high landslide potential.

The index of hillslope-channel connectivity, referring to the hydrologic (surface flow) connection between hillsides and stream channels, also has several potential applications in watershed resource management. Areas that are predicted to have a low hydrologic connectivity (and thus less sediment delivery) may pose a lower concern to land managers, whereas areas where connectivity is high might warrant attention to prevent sediment from entering stream channels.

The NetMap model was used to overlay the modeled road erosion potential within the sub-basin. Road system and stream network connections are apparent within all portions of the sub-basin. Within the upper watershed, the increased potential for runoff is greater than the erosion potential, whereas in the middle and lower portions of the watershed, the increased potential for erosion and sediment delivery is about twice as high. If accurate, the amount of road erosion predicted by the model would, for the highlighted reaches, be sufficient to indicate degradation as a result of excess erosion from roads. The actual conditions on the ground could not be verified as part of this assessment, and actual conditions may vary significantly. The products of this assessment could be used to evaluate further the spatial and temporal extent of land use impacts within the sub-basin. Focused field-verified stream morphology, substrate, and habitat data along with sediment source inventories along the road system could build on the modeled conditions, enhancing the accuracy and usefulness of the modeled data presented in this assessment. The results of this refinement process could then be used to identify watershed restoration priorities and eventually help with management strategies to reduce excess erosion within the sub-basin.

Data gaps identified during this assessment include the following by category:

- **Hydrology** – Lack of stream flow data for main tributaries to sub-basin. Major tributaries that should be monitored include the upper Sacramento above Lake Siskiyou, Soda Creek, the Castle Creek that flows through Castella, Flume Creek, and Slate Creek.

- **Water Quality –** Lack of reliable sediment and turbidity data. Even though several attempts have been made to collect sediment and turbidity data, very little reliable data have been produced. The 20-year record of turbidity data taken at the DLT gauge is unusable due to data quality issues. The sediment and turbidity data supposedly taken as part of the Cantara monitoring cannot be found. Recommend implementing a sediment and turbidity monitoring program that focuses on sampling runoff events that trigger small to large floods.

- **Landslide Inventory –** Lack of field -verified landslide inventory on public and private lands. Landslides appear to be an important component of the sediment load. Recommend implementing a landslide inventory of the sub-basin.

- **Land Use History –** Lack of reliable timber harvest data on private lands. This assessment discovered that the private timber harvest data reported on the California state website is not accurate and is unreliable in terms of the actual harvest that has occurred within the sub-basin. Rapid review of recent aerial photographs shows that where the database shows harvest there is none as of 2009, and there are areas that are harvested that are not shown in the timber harvest data base. Recommend implementing a project to compile accurate timber harvest history data.

5.1.3 Additional Influences on Landscape and Habitat

Channel/Habitat Sensitivity

Floods and increased erosion and sediment supply to streams can alter habitats, in some cases degrading them. Channels have different degrees of sensitivity to changes in flow and sediment supply. In general, channels of lower gradient have a greater sensitivity to fluctuations in discharge

and sediment supply (Sullivan et al. 1987). Lower gradient channels are more responsive to high flows and higher sediment supply, and they may aggrade and become laterally unstable, resulting in increased bank erosion. Such processes can negatively affect aquatic habitats by filling pools with sediment, by reducing summer low-flow levels (through increased inter-gravel flow), and by increasing fine sediment levels in substrates (Bisson et al. 1987).

An index of channel sensitivity was developed and modeled in the uppermost basin of the watershed. Geospatially predicted parameters of channel gradient, channel confinement (floodplain width/channel width), and tributary confluence effects (their decay downstream from confluences, e.g., Figure 3.2-45) were used. A commonly applied approach to modeling channel habitat characteristics (Morrison et al. 1998) was used in this exercise.

The model suggests significant spatial variability in channel sensitivity across the watershed (Figure 3.2-47). The steeper and more confined streams, particularly those segments located away from large tributary confluences, are predicted to have a low sensitivity. In contrast, lower gradient and unconfined reaches, particularly those located immediately downstream of large tributary confluences, have a higher sensitivity. For instance, the inset box in Figure 3.2-47 illustrates how channel sensitivity abruptly increases in the lower gradient and wider floodplain areas located immediately downstream of a large (high sediment supply) tributary (this area is also characterized by a large floodplain, see Figure 3.2-42).

An index of channel sensitivity could be used to identify which channels (and associated habitats) would be most vulnerable to increases in erosion and sediment supply, conditions that, for example, might follow wildfires or be associated with high levels of unregulated land use intensity.

Climate Change

At present, climate change does not appear to be a dominant driver of watershed trends and conditions. However, the portions of the sub-basin most likely to be affected under climate change scenarios such as larger single rainfall events, decreased snowpack, or increased runoff, are also in many cases those with steeper, more erosion-prone soils. Thus, the potential for direct climate change impacts to aquatic habitat could be compounded by an altered intensity of landscape processes.

At Dunsmuir, the five largest and lowest rainfall years on record occurred between 1973 and the present (37 years), and four of the five largest and lowest rainfall years on record occurred between 1983 and 2010 (27 years). In addition, between 1994 and 2009, rainfall amounts were above normal during 10 individual years. These data suggests that the area may be currently experiencing above-average precipitation amounts despite the three below-average years between 2007 and 2009. There also appears to be a slight warming trend that has been occurring between 2000 and the present. During this period, the average annual air temperature of the City of Mt. Shasta was nearly 5 percent above normal for the entire period.

Between 1997 and 2009, the trend has also been one of above-average snow depths for all sites, with a below-normal trend between 2006 and 2009. Between 1974 and the present, the trend in annual precipitation closely follows the trend in snow depth, where, if there was an above normal precipitation year, then there was an above normal snowpack the same year. Similarly, glacial

expansion on Mount Shasta appears to have been precipitation-dominated, with temperature serving as a secondary driver (Howat et al. 2007).

Despite climate change not appearing to drive current watershed conditions, historic and present trends in climate and precipitation provide important clues about the potential for future climate-driven changes to watershed landscape conditions and biotic communities.

In the upper Sacramento River sub-basin, and the Sacramento River canyon specifically, total annual precipitation decreases as elevation increases. The Lakehead/Lakeshore area (1,100 feet elevation) receives approximately 69 inches of combined precipitation, 10 more inches of precipitation than the Dunsmuir area (2,400 feet) receives in the form of rain and 17 more inches of precipitation than the City of Mt. Shasta (3,500 feet) receives (Figure 3.24: 24-hour rainfall). Twenty-four hour rainfall events in the sub-basin follow this same pattern.

Among the effects of this pattern are that the larger rainfall events in the sub-basin also occur in the lower portions of the sub-basin where erosion (GEP) is higher and there is greater sedimentation risk to streams. This effect reinforces the opportunity for focused, on-the-ground investigations of sedimentation risk in the lower reaches of the sub-basin. This is especially the case in sections of the lower watershed that (1) have high potential runoff and erosion, (2) support important or sensitive aquatic species or communities, and/or (3) contain fire-prone areas. Additionally, the potential for the climate to transition towards scenarios that include increased rain, decreased snowfall, and larger single rain events compounds the potential risks in these areas and suggests the opportunity for proactive on-the-ground investigation of potential risks and management opportunities.

5.1.4 Biotic Community Condition and Management

Both aquatic and terrestrial biotic communities in the sub-basin have experienced pressure over time. For terrestrial communities, habitat disturbance and destruction from human use has been, and continues to be, a cause for concern, as does the risk of large-scale habitat degradation during and following a fire. The Cantara spill does not appear to have had lasting impacts on riparian and terrestrial mammal communities other than bat populations, which were significantly affected. Additionally, though the extent of its impact is largely unknown, I-5 is believed to be a functional barrier to migration for many mammal species as well as the mechanism for an unknown number of fatalities each year of mammals, birds, and reptiles. Recently, researchers from the University of California, Davis, have initiated a project to track and quantify roadkill observations (http://wildlifecrossing.ucdavis.edu). This work, however, is still in its early stages. On the whole, relatively little is known about the current condition of many terrestrial animal populations in relation to many of these pressures.

By contrast, the suite of pressures on aquatic communities across the sub-basin, and their evolution and impacts over time, are better understood and have been more widely documented. Impacts to aquatic communities and the riparian and terrestrial food webs they support range from the introduction of exotic species to habitat degradation from land use and pollution.

Perhaps the most heavily compromised of the aquatic communities, both in terms of compound historic pressures and the impact of the Cantara spill, are the sub-basin's amphibian populations. Amphibian populations were severely affected by the Cantara spill, with estimated recovery times for

species of interest ranging from 10–14 years for foothill yellow-legged frogs to as much as 27–35 years for Pacific giant salamanders (Luke and Sterner 1995). However, even before the spill, amphibian populations, both in the area affected by the spill and in other portions of the sub-basin, were already under pressure.

The USFS concluded that both historic grazing in the sub-basin and fish introductions likely resulted in a decline in amphibian populations prior to the Cantara spill (USDA Forest Service 2001). While some rebound from grazing impacts may have occurred after grazing was terminated, pressures from stocking, the presence of pollutants in the environment, and predation by introduced species persist to this day. Most notable in terms of pressure from introduced species are predation by introduced and stocked trout, bullfrogs, and introduced crayfish (Kats and Ferrer 2003). All of these species are present in the sub-basin. In addition, predatory pressure from stocked fish and crayfish may be increasing as crayfish populations expand and increased fishing drives increased stocking, especially in the subalpine lakes of the headwaters.

Fish communities in the sub-basin have been the most heavily managed component of the aquatic ecosystem complex, and the condition of their populations reflect their diverse management history. In the upper watershed, native sucker and minnow populations appear to have vanished from the bulk of their former range, with only a limited number remaining, principally in Lake Siskiyou, and to a less extent in the lower portions of its main tributaries. Likely adding to the pressures experienced by the relic native fish species persisting in the headwaters are the expansion of introduced crayfish populations, continued competition and predation pressure from stocked hatchery reared rainbow trout, and self-sustaining populations of historically introduced brook trout.

In the middle watershed, wild rainbow trout populations appear to have rebounded from the sharp decline following the Cantara spill (Thomas R. Payne and Associates. 2005). Other native fish populations, however, are likely still in a recovery phase (Cantara Trustee Council 2007).

Even more significant than the Cantara spill in terms of long-term change to the fish community in the upper Sacramento River was the extirpation of anadromous Chinook salmon and steelhead that occurred with the construction of Shasta Dam. This event has had significant repercussions for the species themselves, contributing to multiple runs becoming federally listed under the Endangered Species Act subsequent to this loss of critical habitat. The broader impacts to river and riparian ecosystems resulting from the loss of salmon carcass input and fertilization remains unknown. However, given the rapidly mounting body of research highlighting the critical role of these marine-derived nutrients for salmon natal stream ecosystems, there is reason to believe that this impact was extremely significant in the past and may be still. Chinook salmon runs in the aggregate for the Sacramento River were estimated from commercial records to have averaged 600,000 fish a year, perhaps reaching as many as 800,000 to 1 million spawners during peak years before 1915 (Leidy et al. 1984 as cited in Yoshiyama et al. 1998). With an average adult body weight for Chinook salmon of 15.9 pounds (Bigler et al. 1996, Quinn 2005), carcass deposition for a tenth of this historic average would constitute close to a million pounds of nutrients input into the ecosystem annually.

Management of Biotic Communities

Opportunities for management and stewardship of biotic communities in the Upper Sacramento watershed and the riverine and riparian ecosystems that support them are many, and encompass (1)

direct management of biota, including reintroduction of native species, invasive species management, and modifications to existing stocking regimes; (2) management and stewardship of critical habitat and the physical and ecological processes that support species habitat relationships, including restoration of degraded or compromised habitat; and (3) focused research to gain a better understanding of the condition of aquatic species, the principle pressures on their populations, mechanisms of decline where it is occurring, and the geographic variability in their abundance and condition.

Direct Management

Direct management in the form of reintroduction may be necessary to achieve the recovery of native fish and amphibian populations in the upper watershed and amphibian populations in the middle watershed. In one case, reintroduction of amphibians was proposed in the wake of the Cantara spill, but it never happened. A detailed study of the condition of amphibians in the sub-basin is certainly warranted. This is the case not only because of the history of pressure on their populations, but also because some of the populations affected by the Cantara spill should now—19 years after the spill—be on the road to recovery based on post-spill research (Luke and Sterner 1995). Whatever the degree of their progress, it is unlikely that any of the sub-basin's affected amphibian populations will fully recover without parallel measures to protect their habitat and manage pressures from introduced predators. Management of invasive species likely exerting pressure on amphibian populations such as bullfrogs and crayfish would be costly, require ongoing effort, and be unlikely to succeed in the short term, given the proliferation of these species. Far more likely to be effective is alteration and, in some cases, termination of fish stocking regimes, perhaps coupled with fish removal in the subalpine lakes of the headwaters and other specific locations. Removal of introduced fish has proved an effective tool for restoring affected amphibian populations in other alpine lake systems in California (Knapp et al. 2006, Vredenburg 2004).

One little-explored opportunity for aquatic community recovery through direct management of species lies in the potential reintroduction of anadromous Chinook salmon to the upper watershed. In 2009, NMFS issued a draft recovery plan for federally listed Sacramento River Chinook salmon and steelhead populations that categorized restoration of access to suitable habitat that was available historically, including habitat above Shasta Dam, as a priority one action for recovery of these species (National Marine Fisheries Service 2009). While restoration of the upper watershed would likely create greater habitat availability for steelhead as a function of their superior ability to access and spawn in higher gradient steam reaches (National Marine Fisheries Service 2009), a growing body of research suggests that restoration of Chinook salmon, and the annual pulse of marine-derived nutrients, perhaps holds a potential for broader ecosystem-scale benefits as well as benefits for the species.

Findings from the NMFS report are still under review, and the feasibility of anadromous fish reintroduction to the upper watershed is still unknown. Nevertheless, in light of the historic significance of Chinook salmon and steelhead in the sub-basin, it is of interest to identify the potential habitats that exist above Shasta Dam in terms of their intrinsic potential to support these anadromous fish species should they be reintroduced. With this in mind, as a component of this assessment, models of intrinsic habitat potential for steelhead and Chinook (Burnett et al. 2007) were applied to the sub-basin using NetMap's "habitat creator tool." The modeling approach followed the procedure

described for calculating channel sensitivity. The three parameters for intrinsic potential for both fish species are channel gradient, channel confinement (valley width/channel width), and mean annual flow.

The predicted Chinook habitat potential reveals that the optimum Chinook habitat extended mostly along the mainstem Sacramento River and up into the lower portions of several of the largest tributaries (Figure 5.1-2). This is consistent with the view that large (mainstem) rivers are preferred habitat for Chinook spawning and rearing. In contrast, the best potential for steelhead habitat was found in the upper portions of the tributary basins, where channel gradients are steeper (Figure 5.1-3).

Management of Habitat and Supporting Processes

The potential for fire-driven erosion, as well as measured and potential impacts to water quality from land use-driven sedimentation, should be considered serious threats to ecosystem health and biodiversity management in the sub-basin. With this in mind, a range of opportunities exist for conserving critical habitat for aquatic communities through stewardship of the habitat itself, as well as the physical processes and landscape that support it.

Areas in the sub-basin known for being especially biodiverse (Appendix I), providing habitat for a species of concern (Figures 3.3-3 and 3.3-4), or supporting higher densities of a species whose population has been reduced or eliminated from other part of the sub-basin could be prioritized for research and management to promote the conservation and recovery of those species. By relating maps of species distributions with modeled land-use intensity (Figure 3.1-2) and modeled channel habitat sensitivity (Figure 3.2-47) provided in this assessment, specific areas of potentially low-intensity land use and sensitivity can be easily identified. Similarly, layering these analyses would also reveal biologically significant habitats with potentially higher levels of land use and channel sensitivity that should be prioritized for more in-depth investigation of potential habitat degradation, impacts to biotic communities, and associated opportunities for mitigation or restoration. In such cases, investigation of the habitat condition, mechanism of impact, and opportunities for mitigation and restoration should extend beyond the specific habitat to the surrounding landscape connected to it through physical processes.

5.2 References

Bigler, B. S., D. W. Welch, and J. H. Helle. 1996. A review of size trends among North Pacific salmon (Oncorhynchus spp.). Can. J. Fish. Aquat. Sci. 53:455-465.

Bisson, P. A., R. E. Bilby, M. D. Bryant, C. A. Dolloff, G. B. Grette, R. A. House, M. L. Murphy, K. V. Koski, and J. R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present, future. Pages 143-190 *in* E. O. Salo and T. W. Cundy, editors. Streamside Management: Forestry and Fisheries Interactions. University of Washington, College of Forest Resources, Contribution 57. University of Washington, Seattle.

Burnett, K. M., G. Reeves, D. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. Ecological Applications 17:66-80.

Central Valley Regional Water Quality Control Board. 2009. *Water quality control plan (basin plan) for the Sacramento and San Joaquin River basin.* California Regional Water Quality Control Board, Central Valley Region. Fourth Edition.

Howat, I. M., T. Slawek, P. Rhodes, K. Israel, and M. Snyder. 2007. A precipitation-dominated, mid-latitude glacier system: Mount Shasta, California. Climate Dynamics 28: 85-98

Kats, L. B. and R. P. Ferrer. 2003. Alien predators and amphibian declines: Review of two decades of science and the transition to conservation. *Diversity and Distributions* 9(2):99-110.

Knapp, R. A., D. M. Boiano, and V. T. Vredenburg. 2006. Removal of nonnative fish results in population expansion of a declining amphibian (mountain yellow-legged frog, *Rana muscosa*). Biological Conservation 135(1): 11-20.

Luke, C. and D. Sterner. 1995. Cantara bridge chemical spill, 1994 aquatic amphibian survey. Unpublished final report prepared for California Department of Fish and Game. Biosystems Analysis, Inc.

Minshall, G. W., C. T. Robinson, and D. E. Lawrence. 1997. Immediate and mid term responses of lotic ecosystems in Yellowstone National Park, USA to wildfire. Canadian Journal Fisheries and Aquatic Sciences 54:2509-2525.

Morrison, M., L., B. G. Marcot, and R. W. Mannan. 1998. Wildlife habitat relationships: concepts and applications. The University of Wisconsin Press, Madison, Wisconsin, USA.

National Marine Fisheries Service. 2009. Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead. Sacramento Protected Resources Division. October 2009.

Quinn, T. P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. American Fisheries Society, Bethesda, MD. 378p.

Reeves, G. H., P. A. Bisson, B. E. Rieman, L. E. Benda. 2006. Postfire logging in riparian areas. Conservation Biology. 20(4):994-1004.

Rieman, B. and J. Clayton. 1999. Wildfire and native fish: Issues of forest health and conservation of sensitive species. Fisheries 22:6-15.

Sullivan, K., T. E. Lisle, C. A. Dolloff, G. E. Grant, and L. M. Reid. 1987. Stream channels: the link between forests and fishes. Pages 39-97 *in* E. O. Salo and T. W. Cundy, editors. Streamside Management: Forestry and Fishery Interactions, Contribution Number 57. Institute of Forest Resources, University of Washington, Seattle, Washington.

Thomas R. Payne and Associates. 2005. Recovery of fish populations in the upper Sacramento River following the 1991 Cantara spill. Unpublished final report to the Cantara Trustee Council, California Department of Fish and Game.

U.C. Davis. 2010. Geospatial waterbody system. http://endeavor.des.ucdavis.edu/geowbs/ (assessed March 2010).

USDA Forest Service. 2001. Headwaters Sacramento River ecosystem analysis. USDA Forest Service, Mount Shasta Ranger District. January 01, 2001.

Vredenburg, V.T. 2004. Reversing introduced species effects: Experimental removal of introduced fish leads to rapid recovery of a declining frog. PNAS 101(20): 7646-7650

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley Region of California. North American Journal of Fisheries Management 18:487-521.

APPENDIX A

Fire History Methodology

Fire History Methodology

Fire history studies indicate that fire regimes in parts of the Klamath Mountains over the last few centuries fall into one of two periods characterized by distinctly different fire regimes: (1) the Native American period, which usually includes both the pre-historic and early European settlement period (for this assessment defined as prior to 1910), and (2) the fire suppression period (1910 to 2010) (Skinner et al. 2006). Fire history studies specific to the watershed are limited and generally focus on Douglas-fir dominated forests rather than the other types of vegetative communities prominent in the watershed (e.g., ponderosa pine-dominated forests, hardwoods, and chaparral). Therefore, discussion of the occurrence of fire in the watershed prior to the keeping of fire records (which began about 1922), in part, draws on the regional fire history of the Klamath Mountain and Southern Cascades regions to interpolate the conditions under which pre-suppression period fires burned and their effects on vegetation composition and structure. The following discussion describes the methodology used to ascertain the regions' fire regime (i.e., return intervals, severity, fire rotation[1]).

Relatively few fire history studies have been completed for the Klamath Mountains, and more specifically, the Upper Sacramento River Watershed. Not surprisingly, fire histories of the forest types that occur in the region have not been equally studied (Frost and Sweeney 2000). Commercially valuable mid-montane Douglas-fir and mixed conifer forests are more commonly the focus of most studies, than are the foothill/lower montane, upper montane/subalpine zones and forests associated with riparian areas. In addition, fire regime characteristics such as fire size and severity often are not characterized in studies of pre-settlement fires. Therefore, for the purpose of this assessment, the fire regime within the watershed has been largely extrapolated from fire history studies conducted in similar vegetation types and climates in neighboring forested regions (e.g., the Sierra Nevada, Cascades). The few published fire regime studies available specific to the Klamath Mountains and the vegetation types found in the watershed were reviewed and relevant information has been incorporated into this assessment.

Dendrochronology, or tree-ring analysis, is the primary method by which a fire history timeline has been established for the Klamath Mountains Region. However, the extent of the historic fire regime is limited by the longevity of the species being examined. Jeffrey pine and ponderosa pine, two of the most common tree species inhabiting the watershed have a life expectancy of about 400 to 600 years, while Douglas-fir, the other dominant species of the areas mid-montane forests, can live upwards of 750 years. Accordingly, fire frequency studies based on fire scar analyses are limited to the range of time involved.

Fire histories based on tree-ring analysis are generally derived using one of the three following methods: 1) single tree samples, 2) composites of multiple trees within a specific area, and 3) composites of multiple sites throughout a landscape (Skinner 1996). Multiple tree comparisons are used to not only build a historic fire frequency timeline, but depending on the scale at which the study was conducted, such comparisons can also indicate the spatial extent and landscape pattern of past fires. Cross-dated fire scars yield reconstructions that can be geographically resolved (i.e., the extent of the fire can be determined) and temporally precise (i.e., surface burns) (Whitlock et al. 2004). Stand ages provide reconstructions that are spatially specific yet less temporally precise (i.e., decadal resolution) than dated fire scars (Whitlock et al. 2004). An examination of tree-rings also can give a sense of stand

[1] *The length of time necessary to burn an area the size of a specific area (for example a watershed).*

establishment dates, the seasonality of burns, and general climate patterns (i.e., drought versus wet years). Fire scars appear as characteristic disruption and healing patterns of radial tree-ring growth, which can be correlated to a particular year or even to a particular season. Studies cited in this assessment that used tree-ring analysis to develop a chronology of fire frequency in the watershed used full and partial cross sections taken from stumps, downed logs, and snags having externally visible fire scars from multiple, mixed-species forested sites of <1–5 hectares (Taylor and Skinner 1998, Skinner 2001, Whitlock et al. 2004, Fry and Stephens 2006).

The primary limiting factor in the use of tree-ring analysis is often referred to as the "erasure effect" (Agee 1993, Whitlock et al. 2003). As old trees become progressively scarcer on the landscape, the fire-history data they contain is essentially "erased" (Whitlock et al. 2003). This attenuation reduces the likelihood of identifying old fire events, and consequently, most tree-ring studies show that fire events become less frequent as one goes back in time (Whitlock et al. 2003). Although tree-ring methods extend back to the age of the oldest living tree, this time span is not long enough to capture major changes in vegetation and climate, and the record is biased toward low-severity fire events that scar trees but do not kill them (Whitlock et al. 2003).

Paleoecological fire frequency studies, which can look back 1,000 years or more, utilized sediment cores taken from regional lake bottoms including Mumbo Lake (41º11′27″N, 122º30′36″W) and Cedar Lake (41º11′27″N, 122º27′49″W) (both of which are in the watershed) (Whitlock et al. 2004). Such studies make use of the fact that lakes are repositories for paleoenvironmental information. Charcoal is deposited into the lake via airborne fallout, streamflow, and surficial processes. Radiocarbon and lead-210 (^{210}Pb) dating provides a chronology for organic materials that are about 500 to 40,000 years old. Analytical error increases exponentially with age thus, fire chronologies based on charcoal records have decadal accuracy at best (Whitlock et al. 2004). However, trends shown by accumulations of charcoal in lake sediments can provide insight into the occurrence of high-severity burns, which when coupled with an analysis of pollen within the same sediment layer can be indicative of long-term changes in vegetation communities and climate (Skinner 1996; Whitlock et al. 2004). The study cited in this assessment that used lake sediment core charcoal analysis to ascertain variations in fuel loading and the occurrence of larger-scale fire events in the watershed, compared dendrochronological data to charcoal peaks to better ascertain the frequency and severity of fires on a broad spatial scale (Whitlock et al. 2004).

The influence of humans on the frequency and severity of fires in the watershed was determined through a review of scientific studies and historical accounts. Spatial and temporal determinations of historic fire in the watershed were made using Geographic Information System (GIS) layers provided by the U.S. Forest Service (USDA Forest Service 2008).

References

Frost, E. J. and R. Sweeney. 2000. Fire regimes, fire history and forest conditions in the Klamath-Siskiyou region: An overview and synthesis of knowledge. Prepared for the World Wildlife Fund, Klamath-Siskiyou Ecoregion Program by Wildwood Environmental Consulting. December 2000.

Fry, D. L. and S. L. Stephens. 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* 223:228-238.

Skinner, C. N., A. H. Taylor, and J. K. Agee. 2006. Klamath Mountains bioregion. In *Fire in California's ecosystems*, edited by N. G. Sugihara, J. W. van Wagtendonk, J. Fites-Kaufman, K. E. Shaffer and A. E. Thode. Berkeley, California: University of California Press.

Skinner, C. N. 2001. A tree-ring based fire history of riparian reserves in the Klamath Mountains. Paper read at California riparian systems: Processes and floodplains management, ecology, and restoration. Riparian Habitat and Floodplains Conference, March 12-15, 2001, at Sacramento, California.

Skinner, C. N. 1996. Toward an understanding of fire history information. Paper read at The Sixth Biennial Watershed Management Conference, at Lake Tahoe, California/Nevada.

Taylor, A. H. and C. N. Skinner. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. *Forest Ecology and Management* 111:285-301.

Whitlock, C., C. N. Skinner, P. J. Bartlein, T. Minckley, and J. A. Mohr. 2004. Comparison of charcoal and tree-ring records of recent fires in the eastern Klamath Mountains, California, USA. *Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere* 34:2110-2121.

USDA Forest Service. 2008. Fire hazard. GIS data layer.

Whitlock, C., S. H. Shafer, and J. Marlon. 2003. The role of climate and vegetation change in shaping past and future fire regimes in the northwestern U.S., and the implications for ecosystem management. *Forest Ecology and Management* 178:5-21.

APPENDIX B

Physical Processes Analysis Data Sources and Methods

Climate Analysis Data Sources and Methods

Data Sources

All climatic data were retrieved from of two sources:

- Western Regional Climate Center (WRCC): *http://www.wrcc.dri.edu/coopmap/*
- California Department of Water Resources California Data Exchange Center (CDEC): http://cdec.water.ca.gov/selectQuery.html

Climate data were compiled for multiple stations, as described below, for use in the figures and tables used as part of the assessment. The specific URL locations for all data utilized for this assessment are identified rather than showing the raw data.

Methods

Parametric statistics were used to summarize the available climatic data. Specific methods used are summarized by the type of data below.

Figure and Table Data Sources

Figure 3.2-2: Average Monthly and Annual Precipitation for City of Mt. Shasta, Dunsmuir, and Lakehead/Lakeshore

Data Sources

All historic data for this figure were retrieved from WRCC.

Lakeshore/Lakehead

- Lakeshore 2 monthly rainfall and snow fall data. POR: 7/1/1946 to7/31/1972 *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4709*
- Lakehead monthly rainfall and snowfall data. POR: 6/1/1998-8/31/2007 *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4683*

Dunsmuir

- Dunsmuir RS monthly rainfall and snow fall data. POR: 3/1/1906 to6/30/1978 *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2572*
- Dunsmuir Treatment Plant monthly rainfall and snowfall data. POR: 7/1/1978-12/31/2009 *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4683*

Mount Shasta

- Mount Shasta monthly rainfall and snow fall data. POR: 7/1/1948 to 12/31/2009 *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2572*

Methods

All monthly rainfall and snowfall summaries were generated by WRCC's web platform. Average monthly precipitation was determined by adding the monthly rainfall average and the average monthly snowfall average for each month of the year. Snowfall accumulation was converted to inches of precipitation by assuming that 8 inches of snowfall equals one inch of rainfall. If data from more than one weather station was used to calculate the average monthly precipitation for an area of the Subbasin, the individual monthly values from each station were multiplied by a weighted coefficient and then summed. The weighted coefficient was determined by calculating the portion of the total combined period of record that each station recorded. For example, if station #1 has 6 years of record and Station #2 has 4 years of record, Station #1 would have a weighted coefficient of 0.6 and Station #2 would have a weighted coefficient of 0.4. Then, the individual monthly values were multiplied by the corresponding coefficient and the monthly values for each weather station were summed together to determine average monthly values.

Table 3.2-1: Current and Historic Weather Monitoring Stations in the Upper Sacramento Watershed

Data Sources

- Western Regional Climate Center. *http://www.wrcc.dri.edu/coopmap/*
- California Department of Water Resources California Data Exchange Center *http://cdec.water.ca.gov/cgi-progs/mapper*

Methods

Web-based interactive station location maps were used to locate all weather stations geographically within the Subbasin boundaries. Station metadata such as period of record, location coordinates, and variables collected were identified in the site metadata link.

Figure 3.2-3: Annual Trend in Rainfall

Data Sources

All historic data for this figure were retrieved from WRCC.

Vollmers

- Vollmers monthly rainfall data. POR: 12/1/1937 to10/31/1975 *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca9386*

Dunsmuir

- Dunsmuir RS monthly rainfall data. POR: 3/1/1906 to6/30/1978 *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2572*

- Dunsmuir Treatment Plant monthly rainfall data. POR: 7/1/1978-12/31/2009 *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4683*

Mount Shasta

- Mount Shasta monthly rainfall data. POR: 7/1/1948 to 12/31/2009 *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2572*

Methods

All annual rainfall summaries (by month and year) were generated by WRCC's web platform and do not account for precipitation in the form of snow. Annual rainfall totals were plotted on the x-axis as a bar chart. The mean annual rainfall was determined for area by determining a simple average using all the annual rainfall totals for the period of record.

All data were summarized using parametric statistics, and all of the calculations were performed using mathematical functions in Excel. The cumulative departure from the mean statistical analysis technique was used to show basic time series trends. For example, for the rainfall data the curves are used to show dry periods (falling curve) versus wet periods (rising curve). The cumulative departure from the mean is calculated by subtracting the average annual value of a given population from the average annual value of each time step. The difference from the mean is calculated for each time step where an average water year would have a value of zero, a wetter than average water year would have a positive value, and a dry year would be negative. The difference from the mean is then summed from year to year for the period of record. So even though consecutive years may be above or below average, longer-term wetting and drying trends are realized.

Figure 3.24: 24-Hour Rainfall Frequency Curves

Data Sources

All historic data for this figure were retrieved from CDEC.

Gibson

- Gibson Maintenance Station daily incremental rainfall data. POR: 1/1/1989 to 4/7/2002

- *http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=GBS&sensor_num=&dur_code=D&start_date=&end_date=now*

- Gibson daily accumulated rainfall data. POR: 12/2/2005 to 1/1/2010. *http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=GIB&sensor_num=&dur_code=D&start_date=&end_date=now*

Dunsmuir

- Dunsmuir Treatment Plant daily accumulated rainfall data. POR: 1/1/1989-1/1/2010 *http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=DNM&sensor_num=&dur_code=D&start_date=&end_date=now*

Mount Shasta City

- Mount Shasta daily accumulated rainfall data. POR: 1/1/1989 to 1/1/2010 *http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=MSC*

Methods

The reoccurrence intervals of the maximum daily precipitation from three monitoring sites within the Subbasin were calculated using the Log Pearson Type III equation and graphical techniques. For each monitoring site, the 24 hour rainfall total were ranked from high to low, and the 69 highest daily rainfall amounts were used to generate the curve.

Figure 3.2-5: Annual Seasonal Snow Depth Trends

Data Sources

All historic data for this figure were retrieved from CDEC.

Slate Creek Snow Course

- Monthly, January – May, snow depth data. POR: 1945-2009 *http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=SLT*

Sand Flat Snow Course

- Dunsmuir RS monthly rainfall data. POR: 3/1/1906 to6/30/1978 *http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=SFT*

Mount Shasta

- Monthly, January – May, snow depth data. POR: 1945-2009 *http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=MSH*

Methods

All monthly snow depth summaries (by month an year) were generated by CDEC's web platform. Monthly snow depth measurements, taken between January and May, were used to calculate the mean annual snow depth for a specific year and were plotted on the x-axis as a bar chart.

Figure 3.2-6: Average Monthly Air Temperature Range for City of Mt. Shasta, Dunsmuir, and Lakehead/Lakeshore

Data Sources

All historic data for this figure were retrieved from WRCC.

Lakeshore/Lakehead

- Lakeshore 2 monthly air temperature data. POR: 7/1/1946 to7/31/1972
  http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4709

  Lakehead monthly air temperature data. POR: 6/1/1998-8/31/2007
  http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4683

Dunsmuir

- Dunsmuir RS monthly air temperature data. POR: 3/1/1906 to6/30/1978
  http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2572

- Dunsmuir Treatment Plant monthly air temperature data. POR: 7/1/1978-12/31/2009
  http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4683

Mount Shasta

- Mount Shasta monthly rainfall and snow fall data. POR: 7/1/1948 to 12/31/2009
  http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2572

Figure 3.2-7: Annual Air Temperature Trends

Data Sources

All historic data for this figure were retrieved from WRCC.

Gibson

- Gibson monthly air temperature data. POR: 1948 - 1972
  http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca9386

Dunsmuir

  Dunsmuir Treatment Plant monthly average air temperature data. POR: 1979 – 2009
  http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4683

Mount Shasta

- Mount Shasta monthly average air temperature data. POR 1948-2009
  http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca5983

Methods

All annual air temperature summaries (by month and year) were generated by WRCC's web platform. Monthly air temperature averages were used to calculate the mean air temperature of a specific year. Annual air temperature was plotted on the x-axis as a bar chart.

USWA Hydrology Analysis Data Sources and Methods

Streamflow Data Sources

There is only one streamflow gauge within the Subbasin: Sacramento River at Delta (Delta gauge). Daily average and peak streamflow values were downloaded from the US Geological Survey (USGS) web site: *http://waterdata.usgs.gov/nwis/nwisman/?site_no=11342000*

Streamflow Summary and Analysis Methods

Standard hydrological analysis techniques were used to summarize and analyze the available streamflow data as part of this assessment and follow methods described by McCuen (1998). Parametric statistics were used to summarize the available hydrologic data. Specific methods used are summarized by the type of data below.

Annual Water Statistics

The Indicators of Hydrologic Alteration (IHA) program was used to summarize the streamflow record taken at the Delta gauge. This assessment used parametric (i.e., mean and standard deviation) and non-parametric (percentiles) statistics to analyze trends and differences in daily and peak high and low flows (The Nature Conservancy 2005). The program is capable of analyzing and comparing different time periods within the time series data. This program was used to analyze the potential changes in low flow regimes from Box Canyon Dam and small and large flood frequency and magnitude for the period of record (i.e., since 1945).

Flood Frequency

The annual flood frequency method was used to calculate the probability of peak high streamflow for a given return period (i.e., reoccurrence interval). This analysis used the methods described by the US Water Resources Council (United States Water Resources Council 1981), and the Log Peason Type III equation was used. This equation uses the annual maximum peak daily discharge to calculate likelihood that a peak flow event (equaling or exceeding a certain magnitude) will occur in a given year. This equation and the graphical method (United States Water Resources Council 1981) were used to estimate the recurrence interval (the average period in years between peaks of a given size or larger), or exceedance probability (the percent chance a peak will be equaled or exceeded in any year) of a given flood event.

Equivalent Roaded Area Data Sources and Methods

Equivalent Roaded Area Data Sources

Publically available GIS data were used to create a land use footprint and Equivalent Roaded Area (ERA) layer. The ERA by land use type was included in this layer to include roads; urban areas, and railroads. Timber harvest was not included due to a lack of accurate, publically available data on private lands.

Equivalent Roaded Area Methods

The ERA of each land use feature included in the analysis was calculated using ERA coefficients (Haskins 1986). The ERA from timber harvest is typically increases the ERA substantially in watersheds with a moderate to high rate of timber harvest (McGurk and Fong 1995). The USFS has established Thresholds of Concern that are used an indicator of watershed condition. For catchment size watersheds, the USFS developed empirical relationships between the percent ERA and stream channel stability (Haskins 1983, McGurk and Fong 1995)

For roads, layers from the USFS, Siskiyou County, and Shasta County were merged to create one road layer showing private roads, public roads, railroads, and trails as mapped. The roads layers were merged as line features in GIS, which is assumed to be the most accurate road layer as of this assessment. This road layer is not exact where some roads are mapped and not present and vice versa. The error associated with the road layer is likely +/- 20 percent. Once the line layers were merged, the lines were turned into polygons by buffering the lines using an approximate road width. The assigned road width varies by road type as follows: railroad = 25 feet; highways = 20 feet; urban = 15 feet; forest (gravel) = 16 feet; forest = 8 feet; and trails = 1 feet.

For urban and other bare areas, the USGS impervious area layer (Yang et al. 2002) was assumed to represent the non road urban footprint and other infrastructure around I5 and the railroad. For the ERA calculation, these areas are assumed to be paved or covered in concrete and totally impervious (i.e., all the rainfall leaves the surface as runoff).

Road Erosion Risk Data Sources and Methods

Potential Road Erosion Data Sources

Publically available GIS data were used to create a road layer for the Subbasin. The bedrock geology, geomorphology, and soils layers available from the USFS were used to assign an erosion potential to each discrete road segment.

Rainfall-Runoff and Erosion Potential Methods

The rainfall-runoff and erosion potential was developed using output from the ERA and road erosion modeling efforts. Each Subwatershed within the Subbasin was assigned a relative rating the measures the potential of a given area within the Subbasin to have above background rainfall-runoff and erosion potential. Above background for this assessment means that the modeled rainfall runoff is created by

anthropogenic activities and is above what naturally runs of and erodes within a given landform type. The Subwatersheds were stratified based on landform type based on average watershed elevation, drainage density, and average stream gradient. The average watershed elevation is assumed to represent the difference between snowmelt versus rainfall-runoff driven flooding. For Subwatersheds with an average elevation greater than 4,000 feet, the runoff process is assumed to be a result of snowmelt. At lower elevations, below 4,000 feet, it is assumed to be rainfall runoff driven. Subwatersheds with a drainage density greater than 4 miles of stream per square mile of drainage area and an average stream gradient greater than 20 percent are assumed to have high drainage efficiency. The ERA and road erosion risk were then combined to assign a relative ranking intended to represent rainfall-runoff and erosion potential. Each Subwatershed was assigned a ranking from the following list:

- VL = very low potential for accelerated rainfall-runoff and erosion. Very little, if any, anthropogenic activities within the Subwatershed effecting runoff and erosion.
- L = low potential for accelerated rainfall-runoff and erosion. Very little anthropogenic activities within the Subwatershed effecting runoff and erosion.
- M = medium potential for accelerated rainfall-runoff and erosion. Moderate level of anthropogenic activities within the Subwatershed effecting runoff and erosion.
- MH = medium to high potential for accelerated rainfall-runoff and erosion. Moderate to high level of anthropogenic activities within the Subwatershed effecting runoff and erosion.
- H = high potential for accelerated rainfall-runoff and erosion. High level of anthropogenic activities within the Subwatershed effecting runoff and erosion.
- VH = very high potential for accelerated rainfall-runoff and erosion. Very high level of anthropogenic activities within the Subwatershed effecting runoff and erosion.

In the lower portion of the Subbasin around Shasta Lake, Subwatersheds with historic mining areas were ranked as high as a result of mining impacts even though they have relatively low ERA and road erosion potential.

Turbidity Data Sources

Biological Importance of Turbidity

This analysis focused on the turbidity water quality objective and salmonid beneficial uses. Turbidity is a measure of light penetration and is typically expressed in units of (Nephelometric [NTU] or Jackson [JTU] which are roughly equivalent (U.S. Environmental Protection Agency 1983). For this assessment, turbidity is also used as a surrogate for fine sediment. The effects of elevated turbidity on fish are well documented (Smith and Sykora 1976, Sigler et al. 1984, Berg 1982, Berg and Northcote 1985, and Bachman 1984). According to Central Valley Regional Water Quality Control Board (2009), the water quality objectives for turbidity in the Subbasin are as follows:

- Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses.
- Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits:
  - Where natural turbidity is less than 1 Nephelometric Turbidity Unit (NTU), controllable factors shall not cause downstream turbidity to exceed 2 NTU.
  - Where natural turbidity range is 1–5 NTU's, increases shall not exceed 1 NTU.
  - Where natural turbidity range is 5–50 NTU's, increases shall not exceed 20 percent.
  - Where natural turbidity range is 50–100 NTU's, increases shall not exceed 10 NTU's.
  - Where natural turbidity range is greater than 100 NTU's, increases shall not exceed 10 percent.

Available Turbidity Data

This assessment gathered and summarized all readily available turbidity data taken within the Subbasin. Turbidity data were available for two monitoring sites within the Subbasin. Publically available data are available for the Sacramento River at Delta (DLT) gauge on CDEC. SPI provided about eight years of turbidity data taken on Hazel Creek, a main tributary of the Subbasin in the middle Watershed. The turbidity and sediment data collected as part of the Cantara Spill monitoring could not be located as part of this assessment.

The longest record of usable turbidity data is a series of manual turbidity probe measurements taken at DLT about once a month from 1998 to 2010. There are also 20 years of continuous turbidity data available for DLT: however, the continuous data are not presently usable due to technical problems encountered with the probe (Greg Gotham, personal communication 2010). Most of the manual turbidity measurements were taken at base or average flow conditions. There were two measurements taken at flows greater than 4,000 cfs. For this assessment, these data were used to characterize low flow turbidity levels and were not used to characterize turbidity levels at higher flow regimes.

The manual measurements taken at the DLT gauge during average flow regimes (i.e., generally less than 4,000 cfs) for the last 13 years indicate that the average measured turbidity is 1.3 NTU with a minimum of 0 NTU and a maximum of 18 NTU. The corresponding average stream flow was 823 cfs, with a minimum of 192 cfs, and a maximum of 3,990 cfs. These data show that during average flow regimes the turbidity levels are low and likely meeting water quality objectives.

Within the Hazel Creek Subwatershed, SPI has continuously measured turbidity at one site every 15 minutes since 2003. Hazel Creek, a main tributary of the Subbasin, drains about 14,011 acres, or 4 percent of the Subbasin. The predicted average annual flow is 80 cfs or about 8.5 percent of the average annual flow. From 2003 to 2010 the average measured maximum daily turbidity is 4 NTU, with a

minimum of 0, and a maximum of 247 NTU. These data show that during average flow regimes the turbidity levels are low and likely meeting water quality objectives.

The instantaneous manual turbidity measurements from DLT were paired with the daily maximum measurements from Hazel Creek from 2003 to 2010. The average turbidity for this time period is 2.1 NTU at DLT and 1.5 NTU at Hazel Creek. Hazel Creek has a maximum of 44 NTU, and DLT has a maximum of 35 NTU. No correlation was found between the DLT and Hazel Creek sites (correlation coefficient of 0.54), and the turbidity measurements between the sites are not statistically related.

References

Literature Cited

Bachman, R. A. 1984. Foraging behavior of free-ranging wild and hatchery brown trout in a stream. Transactions of the American Fisheries Society 113:1-32.

Berg, L. 1982. The effect of exposure to short-term pulses of suspended sediment on the behavior of juvenile salmonids. Pages 177-196 in G. F. Hartman et al., editors. Proceedings of the Carnation Creek workshop: a ten-year review. Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, Canada.

Berg, L. and T. G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (Oncorhynchus kisutch) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42:1410-1417.

California Department of Fish and Game. 2006. Upland erosion inventory and sediment control guidance, Part X. In: California Salmonid Stream Habitat Restoration Manual, California Department of Fish and Game.

California Data Exchange Center. 2010. Sacramento River at Delta turbidity data. *http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=DLT&sensor_num=&dur_code=D&start_date=&end_date=now*

Central Valley Regional Water Quality Control Board. 2009. Water quality control plan (basin plan) for the Sacramento and San Joaquin River basin. California Regional Water Quality Control Board, Central Valley Region. Fourth Edition.

McGurk B. J. and D. R. Fong. 1995. Equivalent roaded area as a measure of cumulative effect of logging. Environmental-Management 31(1995): 609-621.

Haskins, D. M., 1983. An overview of the use of cumulative watershed impact analysis, Shasta-Trinity National Forest.

Haskins, D. M. 1986. A management model for evaluating cumulative watershed effects. In: Proceedings from the California Watershed Management Conference, West Sacramento, CA, November 18-20, 1986, pp. 125-130.

Luce, C. E. and T. A. Black. 1999. Sediment production from forest roads in western Oregon. Water Resources Research 35:2561-2570.

McCuen, R. H. 1998. Hydrologic analysis and design, second edition. Prentice-Hall, Inc., ISBN 0-13-134958-9.

MacDonald, L. H., 1999. Evaluating and managing cumulative effects: process and constraints. Environmental Management Vol. 000, No. 00, Pp. 1-18. DOI: 10.1007/s00267.

Newcombe, C. P. and J. O. T. Jensen. 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. North American J. Fisheries Management 16: 693-727.

Sigler, J. W. 1980. Effects of chronic turbidity on feeding, growth and social behavior of steelhead trout and coho salmon. Doctoral dissertation. University of Idaho, Moscow.

Sigler, J. W., T. C. Bjornn, and F. H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113:142-150.

Smith, F. J. and J. L. Sykora. 1976. Early developmental effects of lime-neutralized iron hydroxide suspensions on brook trout and coho salmon. Transactions of the American Fisheries Society 105:308-312.

The Nature Conservancy, 2005. Indicators of hydrologic alteration, version 7, user's manual.

U.S. Environmental Protection Agency. 1983. Turbidity. Pages 180.1-1-180.1-4 in Methods for chemical analysis of water and wastes. EPA, Office of Research and Development, Report 600/4-79-020, Cincinnati, Ohio.

United States Water Resources Council. 1981. Guidelines for determining flood flow.

Personal Communications

Greg Gotham, BOR Hydrographer. 2010 – conversation with J. Fitzgerald, North State Resources re quality of turbidity data.

Steve Bachmann, USFS Hydrologist. 2010 – conversation with J. Fitzgerald, North State Resources re observed rainfall-runoff and erosion patterns during storms.

APPENDIX C

Wildlife Species Potentially Occurring in the Watershed

Wildlife Species Potentially Occurring in the Watershed

Common Name	Scientific Name
acorn woodpecker	*Melanerpes formicivorus*
Allen's chipmunk	*Neotamias senex*
American badger	*Taxidea taxus*
American beaver	*Castor canadensis*
American coot	*Fulica americana*
American crow	*Corvus brachyrhynchos*
American dipper	*Cinclus mexicanus*
American goldfinch	*Carduelis tristis*
American kestrel	*Falco sparverius*
American marten	*Martes americana*
American mink	*Mustela vison*
American peregrine falcon	*Falco peregrinus anatum*
American pika	*Ochotona princeps*
American pipit	*Anthus rubrescens*
American robin	*Turdus migratorius*
Anna's hummingbird	*Calypte anna*
aquatic garter snake	*Thamnophis atratus*
ash-throated flycatcher	*Myiarchus cinerascens*
bald eagle	*Haliaeetus leucocephalus*
band-tailed pigeon	*Patagioenas fasciata*
barn owl	*Tyto alba*
barn swallow	*Hirundo rustica*
barred owl	*Strix baria*
belted kingfisher	*Megaceryle alcyon*
Bewick's wren	*Thryomanes bewickii*
big brown bat	*Eptesicus fuscus*
black bear	*Ursus americanus*
black phoebe	*Sayornis nigricans*
black salamander	*Aneides flavipunctatus*
black swift	*Cypseloides niger*
black-backed woodpecker	*Picoides arcticus*
black-headed grosbeak	*Pheucticus melanocephalus*
black-tailed deer	*Odocoileus hemionus*
black-tailed jackrabbit	*Lepus californicus*
black-throated gray warbler	*Dendroica nigrescens*
blue-gray gnatcatcher	*Polioptila caerulea*
bobcat	*Lynx rufus*
Botta's pocket gopher	*Thomomys bottae*
Brazilian free-tailed bat	*Tadarida brasiliensis*

Wildlife Species Potentially Occurring in the Watershed

Common Name	Scientific Name
Brewer's blackbird	*Euphagus cyanocephalus*
broad-footed mole	*Scapanus latimanus*
brown creeper	*Certhia americana*
brown-headed cowbird	*Molothrus ater*
brush mouse	*Peromyscus boylii*
brush rabbit	*Sylvilagus bachmani*
bufflehead	*Bucephala albeola*
bullfrog	*Rana catesbeiana*
Bullock's oriole	*Icterus bullockii*
burrowing owl	*Athene cunicularia*
bushtit	*Psaltriparus minimus*
bushy-tailed woodrat	*Neotoma cinerea*
California ground squirrel	*Spermophilus beecheyi*
California gull	*Larus californicus*
California kangaroo rat	*Dipodomys californicus*
California mountain kingsnake	*Lampropeltis zonata*
California myotis	*Myotis californicus*
California quail	*Callipepla californica*
California thrasher	*Toxostoma redivivum*
California towhee	*Pipilo crissalis*
California vole	*Microtus californicus*
California whipsnake	*Masticophis lateralis*
Calliope hummingbird	*Stellula calliope*
Canada goose	*Branta canadensis*
canyon wren	*Catherpes mexicanus*
Cascades frog	*Rana cascadae*
Cassin's finch	*Carpodacus cassinii*
Cassin's vireo	*Vireo cassinii*
cedar waxwing	*Bombycilla cedrorum*
chestnut-backed chickadee	*Poecile rufescens*
chipping sparrow	*Spizella passerina*
Clark's grebe	*Aechmophorus clarkii*
Clark's nutcracker	*Nucifraga columbiana*
cliff swallow	*Petrochelidon pyrrhonota*
common garter snake	*Thamnophis sirtalis*
common kingsnake	*Lampropeltis getula*
common merganser	*Mergus merganser*
common nighthawk	*Chordeiles minor*
common poorwill	*Phalaenoptilus nuttallii*

Common Name	Scientific Name
common porcupine	*Erethizon dorsatum*
common raven	*Corvus corax*
common yellowthroat	*Geothlypis trichas*
cooper's hawk	*Accipiter cooperii*
coyote	*Canis latrans*
creeping vole	*Microtus oregoni*
dark-eyed junco	*Junco hyemalis*
deer mouse	*Peromyscus maniculatus*
double-crested cormorant	*Phalacrocorax auritus*
Douglas' squirrel	*Tamiasciurus douglasii*
downy woodpecker	*Picoides pubescens*
dusky flycatcher	*Empidonax oberholseri*
dusky-footed woodrat	*Neotoma fuscipes*
eared grebe	*Podiceps nigricollis*
elk	*Cervus elaphus*
ensatina	*Ensatina eschscholtzii*
ermine	*Mustela erminea*
Eurasian wigeon	*Anas penelope*
European starling	*Sturnus vulgaris*
evening grosbeak	*Coccothraustes vespertinus*
ferruginous hawk	*Buteo regalis*
flammulated owl	*Otus flammeolus*
foothill yellow-legged frog	*Rana boylii*
fox sparrow	*Passerella iliaca*
fringed myotis	*Myotis thrysanodes*
gadwall	*Anas strepera*
golden eagle	*Aquila chrysaetos*
golden-crowned kinglet	*Regulus satrapa*
golden-crowned sparrow	*Zonotrichia atricapilla*
golden-mantled ground squirrel	*Spermophilus lateralis*
gopher snake	*Pituophis melanoleucus*
grasshopper sparrow	*Ammodramus savannarum*
gray fox	*Urocyon cinereoargenteus*
gray jay	*Perisoreus canadensis*
great blue heron	*Ardea herodias*
great horned owl	*Bubo virginianus*
greater white-fronted goose	*Anser albifrons*
green heron	*Butorides virescens*
green-tailed towhee	*Pipilo chlorurus*

Common Name	Scientific Name
green-winged teal	*Anas crecca*
hairy woodpecker	*Picoides villosus*
Hammond's flycatcher	*Empidonax hammondii*
Harris's sparrow	*Zonotrichia querula*
heather vole	*Phenacomys intermedius*
hermit thrush	*Catharus guttatus*
hermit warbler	*Dendroica occidentalis*
hoary bat	*Lasiurus cinereus*
hood merganser	*Lophodytes cucullatus*
house finch	*Carpodacus mexicanus*
house mouse	*Mus musculus*
house sparrow	*Passer domesticus*
house wren	*Troglodytes aedon*
Hutton's vireo	*Vireo huttoni*
killdeer	*Charadrius vociferus*
lazuli bunting	*Passerina amoena*
lesser goldfinch	*Carduelis psaltria*
lesser scaup	*Aythya affinis*
Lewis's woodpecker	*Melanerpes lewis*
Lincoln's sparrow	*Melospiza lincolnii*
little brown bat	*Myotis lucifugus*
loggerhead shrike	*Lanius ludovicianus*
long-eared myotis	*Myotis evotis*
long-eared owl	*Asio otus*
long-legged myotis	*Myotis volans*
long-tailed vole	*Microtus longicaudus*
long-tailed weasel	*Mustela trenata*
long-toed salamander	*Ambystoma macrodactylum*
MacGillivray's warbler	*Oporornis tolmiei*
mallard	*Anas platyrhynchos*
marsh wren	*Cistothorus palustris*
merlin	*Falco columbarius*
montane vole	*Microtus montanus*
mountain beaver	*Aplodontia rufa*
mountain bluebird	*Sialia currucoides*
mountain chickadee	*Poecile gambeli*
mountain cottontail	*Sylvilagus nuttallii*
mountain lion	*Puma concolor*
mountain pocket gopher	*Thomomys monticola*

Common Name	Scientific Name
mountain quail	*Oreotyx pictus*
mourning dove	*Zenaida macroura*
Nashville warbler	*Vermivora ruficapilla*
night snake	*Hypsiglena torquata*
northern alligator lizard	*Elgaria coerulea*
northern flicker	*Colaptes auratus*
northern flying squirrel	*Glaucomys sabrinus*
northern goshawk	*Accipiter gentilis*
northern mockingbird	*Mimus polyglottos*
northern pintail	*Anas acuta*
northern pygmy owl	*Glaucidium gnoma*
northern river otter	*Lontra canadensis*
northern rough-winged swallow	*Stelgidopteryx serripennis*
northern saw-whet owl	*Aegolius acadicus*
Nuttall's woodpecker	*Picoides nuttallii*
oak titmouse	*Baeolophus inornatus*
olive-sided flycatcher	*Contopus cooperi*
orange-crowned warbler	*Vermivora celata*
osprey	*Pandion haliaetus*
Pacific chorus frog	*Pseudacris regilla*
Pacific fisher	*Martes pennanti pacifica*
Pacific giant salamander	*Dicamptodon tenebrosus*
Pacific-slope flycatcher	*Empidonax difficilis*
pallid bat	*Antrozous pallidus*
pied-billed grebe	*Podilymbus podiceps*
pigmy short-horned lizard	*Phrynosoma douglassi*
pileated woodpecker	*Dryocopus pileatus*
pine siskin	*Carduelis pinus*
pinyon mouse	*Peromyscus truei*
prairie falcon	*Falco mexicanus*
purple finch	*Carpodacus purpureus*
purple martin	*Progne subis*
pygmy nuthatch	*Sitta pygmaea*
raccoon	*Procyon lotor*
racer	*Coluber constrictor*
red crossbill	*Loxia curvirostra*
red fox	*Vulpes vulpes*
red phalarope	*Phalaropus fulicarius*
red-breasted nuthatch	*Sitta canadensis*

Common Name	Scientific Name
red-breasted sapsucker	*Sphyrapicus ruber*
red-necked phalarope	*Phalaropus lobatus*
red-tailed hawk	*Buteo jamaicensis*
red-winged blackbird	*Agelaius phoeniceus*
ring-billed gull	*Larus delawarensis*
ringneck snake	*Diadophis punctatus*
ringtail	*Brassariscus astutus*
rock dove	*Columba livia*
rock wren	*Salpinctes obsoletus*
roughskin newt	*Taricha granulosa*
rubber boa	*Charina bottae*
ruby-crowned kinglet	*Regulus calendula*
ruddy duck	*Oxyura jamaicensis*
ruffed grouse	*Bonasa umbellus*
sagebrush lizard	*Sceloporus graciosus*
savannah sparrow	*Passerculus sandwichensis*
sharp-shinned hawk	*Accipiter striatus*
sharp-tail snake	*Contia tenuis*
Shasta salamander	*Hydromantes shastae*
shrew-mole	*Neurotrichus gibbsii*
silver-haired bat	*Lasionycteris noctivagans*
snowshoe hare	*Lepus americanus*
snowy egret	*Egretta thula*
song sparrow	*Melospiza melodia*
Sonoma chipmunk	*Tamias sonomae*
sooty grouse	*Dendragapus fuliginosus*
spotted bat	*Euderma maculatum*
spotted owl	*Strix occidentalis*
spotted sandpiper	*Actitis macularius*
spotted towhee	*Pipilo maculatus*
Steller's jay	*Cyanocitta stelleri*
striped skunk	*Mephitis mephitis*
striped racer	*Masticophis lateralis*
Swainson's thrush	*Catharus ustulatus*
Townsend's big-eared bat	*Corynorhinus townsendii*
Townsend's solitaire	*Myadestes townsendi*
tree swallow	*Tachycineta bicolor*
Trowbridge's shrew	*Sorex trowbridgii*
turkey vulture	*Cathartes aura*

Common Name	Scientific Name
vagrant shrew	*Sorex vagrans*
varied thrush	*Ixoreus naevius*
Vaux's swift	*Chaetura vauxi*
violet-green swallow	*Tachycineta thalassina*
Virginia opossum	*Didelphis virginiana*
warbling vireo	*Vireo gilvus*
water shrew	*Sorex palustris*
western bluebird	*Salia mexicana*
western fence lizard	*Sceloporus occidentalis*
western gray squirrel	*Sciurus griseus*
western grebe	*Aechmophorus occidentalis*
western harvest mouse	*Reithrodontomys megalotis*
western jumping mouse	*Zapus princeps*
western kingbird	*Tyrannus verticalis*
western mastiff bat	*Eumops perotis*
western meadowlark	*Sturnella neglecta*
western pipistrelle	*Pipistrellus hesperus*
western pocket gopher	*Thomomys mazama*
western pond turtle	*Actinemys marmorata*
western rattlesnake	*Crotalus viridis*
western red bat	*Lasiurus blossevillii*
western red-backed vole	*Clethrionomys californicu*
western screech owl	*Otus kennicottii*
western scrub-jay	*Aphelocoma californica*
western skink	*Eumeces skiltonianus*
western small-footed myotis	*Myotis ciliolabrum*
western spotted skunk	*Spilogale gracilis*
western tailed frog	*Ascaphus truei*
western tanager	*Piranga ludoviciana*
western terrestrial garter snake	*Thamnophis elegans*
western toad	*Buto boreas*
western whiptail	*Aspidoscelis tigris*
western wood-pewee	*Contopus sordidulus*
white-breasted nuthatch	*Sitta carolinensis*
white-crowned sparrow	*Zonotrichia leucophrys*
white-headed woodpecker	*Picoides albolarvatus*
white-throated sparrow	*Zonotrichia albicollis*
wild turkey	*Meleagris gallopavo*
Wilson's snipe	*Gallinago delicata*

Common Name	Scientific Name
Wilson's warbler	*Wilsonia pusilla*
winter wren	*Troglodytes troglodytes*
wood duck	*Aix sponsa*
wrentit	*Chamaea fasciata*
yellow warbler	*Dendroica petechia*
yellow-breasted chat	*Icteria virens*
yellow-headed blackbird	*Xanthocephalus xanthocephalus*
yellow-pine chipmunk	*Neotamias amoenus*
yellow-rumped warbler	*Dendroica coronata*
yuma myotis	*Myotis yumanensis*

APPENDIX D

Upper Sacramento River Watershed Fish Assemblage

Upper Sacramento River Watershed Fish Assemblage

		Salmonid Species				Native Species								Non-Native Species									
Sub-Region	**Stream/ Lake**	**BKT**	**BRT**	**CT**	**RBT**	**SD**	**SS**	**SPM**	**RS**	**HDH**	**ROS**	**SCB**	**STU**	**GNS**	**BG**	**CRA**	**LMB**	**SMB**	**SB**	**BNB**	**CCF**	**CRP**	**GLS**
Headwaters	Castle Lk.	X			X																		X
	Castle Lake Cr.				X									X									(X)
	Chipmunk Lk.	X			X																		
	Cliff Lks.	X			X																		
	Deer Cr.				X																		
	Fawn Cr.				X																		
	Grayrock Lks	X																					
	Gumboot Lk.				X																		
	Heart Lk.	X			X																		
	Lk. Siskiyou	X	X		X	(X)	(X)	(X)	(X)					X	X	X	X		X	X		X	X
	Lt. Castle Lk.	X			X																		
	Porcupine Lk.				X																		
	Sac R.M. Fk.				X	?	?	?	?														
	Sac R.S. Fk.	X			X	?	?	?	X														
	Sac R.N. Fk.				X	?	?	?	?														
	Sac R. Upper		X		X	?	?	?	?														
	Scott Camp Cr.	X			X									X									
	Scott Lk.				X																		
	Soapstone Cr.				X																		
	Timber Lk.	X																					
	Toad Lk.	X			X																		
Upper Sac																							
	Sac R		X		X		X	X	X	X		X							X		X		
	Ney Spg. Cr.				X				X														
	Stink Cr.				X				X														
	Big Canyon Cr.																						
	Hedge Cr.																						
	Bear Cr.				X																		
	Little Castle Cr.				X				X														

		Salmonid Species				Native Species								Non-Native Species									
Sub-Region	Stream/ Lake	BKT	BRT	CT	RBT	SD	SS	SPM	RS	HDH	ROS	SCB	STU	GNS	BG	CRA	LMB	SMB	SB	BNB	CCF	CRP	GLS
	Soda Cr.				X				X														
	Root Cr.				X				X														
	Fall Cr.				X																		
	Unnamed Cr. (FC-2)																						
	SF Castle Cr.				X				X														
	MF Castle Cr.				X				X														
	NF Castle Cr.				X				X														
	Castle Creek								X														
	Unnamed Cr. (S8-1)																						
	Sweetbriar Cr.																						
	Unnamed Cr. (CNT-1)																						
	Flume Cr.				X																		
	Mears Cr.				X																		
	SF Hazel Cr.				X				X														
	Hazel Cr.				X				X														
	SF Shotgun Cr.				X																		
	Shotgun Cr.				X				X														
	Unnamed Cr. (D-6)																						
	Boulder Cr.				X				X														
	North Salt Cr.				X	X			X														
	MF Salt Cr.																						
	Little Slate Cr.																						
	NF Slate Cr.																						
	SF Slate Cr.				X																		
	Slate Cr.				X				X														
	Whitlow Cr.				X				X														
	Clark's Gulch																						
	Mosquito Cr.																						

Upper Sacramento River Watershed Fish Assemblage

		Salmonid Species				Native Species								Non-Native Species									
Sub-Region	**Stream/ Lake**	**BKT**	**BRT**	**CT**	**RBT**	**SD**	**SS**	**SPM**	**RS**	**HDH**	**ROS**	**SCB**	**STU**	**GNS**	**BG**	**CRA**	**LMB**	**SMB**	**SB**	**BNB**	**CCF**	**CRP**	**GLS**
	Dog Cr.				X				X														
	Campbell Cr.																						
Lake Shasta																							
	Shasta Lake	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	(X)	X	X	X
	Big Backbone Cr.	(X)			X	(X)	(X)	(X)	(X)	(X)	(X)	(X)		(X)	(X)	(X)	(X)	(X)	(X)		(X)	(X)	(X)
	*Little Backbone Cr.																						
	Dry Fork Cr.				~																		
	Little Sugarloaf				~																		
	Elmore Cr.				~																		
	Alder Cr.				~																		
	Adler Cr.				~																		
	Sugarloaf Cr.	(X)			X	(X)	(X)	(X)	(X)	(X)	(X)	(X)		(X)	(X)	(X)	(X)	(X)	(X)		(X)	(X)	(X)
	Charlie Cr.				~																		
	Doney Cr.				~																		
	*Squaw Cr.																						
	Shoemaker Cr.				~																		
	Bull Cr.				~																		

*Biologically poor or dead as a result of impact from mine drainage.

Sources:

USDA Forest Service. 2001. Shasta-Trinity National Forest headwaters ecosystem analysis. USDA Forest Service. January 2001.

USDA Forest Service. 2000. Shasta Lake West watershed analysis. Prepared for USDA Forest Service, Shasta-McCloud Management Unit. October 11, 2000.

Miller, J. W., V. A. Whitman, K. M. Kawsuniak, P. B. Hendrix, and N. A. Rojek. 1996. 1994 stream surveys of the upper Sacramento River tributaries. Inland Fisheries draft administrative report. California Department of Fish and Game.

Moyle, P. B. 2002. *Inland fishes of California*. Davis, California: University of California Press.

Vander Zanden, M. J., S. Chandra, S. K. Park, Y. Vadeboncoeur, and C. R. Goldman. 2006. Efficiencies of benthic and pelagic trophic pathways in a subalpine lake. *Canadian Journal of Fisheries and Aquatic Sciences* 63:2608-2620.

Status Key Present: x Seasonal or Intermittent: ~ Likely but unconfirmed (x) Historically present but currently unconfirmed: ?

Fish Species Abbreviation Key

Category	Abbreviation	Common Name	Scientific Name
Salmonid			
	BKT	Brook Trout	*Salvelinus fontinalis*
	BRT	Brown Trout	*Salmo trutta*
	CHS	Chinook Salmon	*Oncorhynchus tshawytscha*
	KS	Kokanee Salmon	*Oncorhynchus nerka*
	RBT	Rainbow Trout	*Oncorhynchus mykiss*
Native			
	SD	Speckled Dace	*Rhinichthys osculus*
	SS	Sacramento Sucker	*Catostomus occidentalis*
	SPM	Sacramento Pikeminnow	*Ptychocheilus grandis*
	RS	Riffle Sculpin	*Cottus gulosus*
	HDH	Hardhead	*Mylopharodon conocephalus*
	ROS	Rough Sculpin	*Cottus asperrimus*
	SCB	Sacramento Blackfish	*Orthodon microlepidotus*
	STU	White Sturgeon	*Acipenser transmontanus*
Non-native			
	GNS	Green Sunfish	*Lepomis cyanellus*
	BG	Bluegill	*Lepomis macrochirus*
	CRA	Black Crappie	*Pomoxis nigromaculatus*
	LMB	Largemouth Bass	*Micropterus salmoides*
	SMB	Smallmouth Bass	*Micropterus dolomieui*
	SB	Spotted Bass	*Micropterus punctulatus*
	BNB	Brown Bullhead	*Ameiurus nebulosus*
	CCF	Channel Catfish	*Ictalurus punctatus*
	CRP	Carp	*Cyprinus carpio*
	GLS	Golden Shiner	*Notemigonus crysoleucas*

APPENDIX E

Region 5 Sensitive Plants, Lichens, and Fungi Known or Suspected to Occur on the Shasta-Trinity National Forest

Region 5 Sensitive Plants, Lichens, and Fungi Known or Suspected to Occur on the Shasta-Trinity National Forest

Sensitive Vascular Plants

*Ageratina shastensis**
Anisocarpa scabrida
*Arnica venosa**
Botrychium pinnatum
Botrychium virginianum
Calochortus longebarbatus var. *longebarbatus*
Calystegia atriplicifolia ssp. *buttensis*
Campanula shetleri
Campanula wilkinsiana
Chaenactis suffrutescens
Clarkia borealis ssp. *borealis*
Collomia larsenii
Cordylanthus tenuis ssp. *pallescens*
Cypripedium fasciculatum
Cypripedium montanum
Epilobium oreganum
Eriastrum brandegeae
Eriastrum tracyi
*Ericameria ophitidis**
Erigeron maniopotamicus
Eriogonum alpinum
*Eriogonum libertini**
Eriogonum ursinum var. *erubescens*
Erythronium citrinum var. *roderickii*
Frasera umpquaensis
Fritillaria eastwoodiae
Harmonia doris-nilesiae
Harmonia stebbinsii
Iliamna bakeri
Iliamna latibracteata
Ivesia longibracteata
Ivesia pickeringii
Leptosiphon nuttallii ssp. *howellii*
Lewisia cantelovii
Lupinus elmeri
Minuartia rosei
Minuartia stolonifera
Montia howellii
Neviusia cliftonii
Ophioglossum pusillum
Parnassia cirrata
Penstemon filiformis
Phacelia cookei
Phacelia greenei
Polemonium chartaceum
Raillardella pringlei
Rorippa columbiae
Sedum paradisum
Silene campanulata ssp. *campanulata*
Smilax jamesii

Sensitive Fungi

Collybia racemosa
Phaeocollybia gregaria
Sowerbyella rhenana (*Aleuria rhenana*)

Sensitive Bryophytes

Buxbaumia viridis
Meesia uliginosa
Mielichhoferia elongata
Ptilidium californicum

Sensitive Lichens

Peltigera hydrothyria

*Forest endemic, not Region 5 sensitive but treated as sensitive by Shasta-Trinity National Forest LRMP

APPENDIX F

Invasive Plants and Noxious Weeds
Known to Occur in the Upper Sacramento River Watershed

Invasive Plants and Noxious Weeds
Known to Occur in the Upper Sacramento River Watershed

Scientific Name **Common Name**	**Cal-IPC List Category[1]**	**CDFA List Category[2]**
Ailanthus altissima tree of heaven	Moderate	None
Avena barbata slender wild oats	Moderate	None
Avena fatua common wild oats	Moderate	None
Briza maxima rattlesnake grass	Limited	None
Bromus diandrus ripgut brome	Moderate	None
Bromus hordeaceus soft brome	Limited	None
Bromus tectorum cheatgrass	High	None
Cardaria chalapensis hairy whitetop	Moderate	B
Centaurea diffusa white knapweed	Moderate	A
Centaurea maculosa spotted knapweed	High	A
Centaurea solstitialis yellow star-thistle	High	C
Centaurea virgata var. squarrosa squarrose knapweed	Moderate	A
Chondrilla juncea rush skeleton weed	Moderate	A
Cirsium arvense Canada thistle	Moderate	B
Cirsium vulgare bull thistle	Moderate	None
Convolvulus arvensis field bindweed	Evaluated, not listed	C
Cynodon dactylon Bermuda grass	Moderate	C
Cystis scoparius Scotch broom	High	C
Erodium botrys longbeak stork's bill	Evaluated, not listed	None
Erodium cicutarium redstem stork's bill	Limited	None
Euphorbia esula leafy spurge	High-ALERT	A
Ficus carica fig	Moderate	None
Foeniculum vulgare fennel	High	None
Genista mospessulana French broom	High	C

Invasive Plants and Noxious Weeds
Known to Occur in the Upper Sacramento River Watershed

Scientific Name **Common Name**	**Cal-IPC List Category[1]**	**CDFA List Category[2]**
Hordeum marinum, H. murinum Mediterranean barley, hare barley, wall barley	Moderate	None
Hypericum perforatum common St. John's wort	Moderate	C
Isatis tinctoria Dyer's woad	Moderate	B
Linaria dalmatica dalmation toadflax	Moderate	A
Lolium multiflorum Italian ryegrass	Moderate	None
Nerium oleander oleander	Evaluated, not listed	None
Phytolacca americana pokeweed	None	None
Robinia pseudoacacia black locust	Limited	None
Rubus discolor Himalayan blackberry	High	None
Rubus laciniatus cutleaf blackberry	None	None
Rumex crispus curly dock	Limited	None
Senecio jacobaea tansy ragwort	Limited	B
Sorghum halepense Johnsongrass	None	C
Spartium junceum Spanish broom	High	None
Taeniatherum caput-medusae medusa-head	High	C
Torilis arvensis spreading hedgeparsley	Moderate	None
Verbascum thapsus common mullein	Limited	None
Vinca major periwinkle	Moderate	None
Vulpia myuros rat-tail fescue	Moderate	None

[1]Cal-IPC List Categories

High	These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.
Moderate	These species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
Limited	These species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

[2]CDFA List Categories

A	An organism of known economic importance subject to state (or commissioner when acting as a state agent) enforced action involving: eradication, quarantine, containment, rejection, or other holding action.
B	An organism of known economic importance subject to: eradication, containment, control or other holding action at the discretion of the individual county agricultural commissioner; or An organism of known economic importance subject to state endorsed holding action and eradication only when found in a nursery.
C	An organism subject to no state enforced action outside of nurseries except to retard spread. At the discretion of the commissioner; or an organism subject to no state enforced action except to provide for pest cleanliness in nurseries.
Q	An organism or disorder requiring temporary "A" action pending determination of a permanent rating. The organism is suspected to be of economic importance but its status is uncertain because of incomplete identification or inadequate information. In the case of an established infestation, at the discretion of the Assistant Director for Plant Industry, the Department will conduct surveys and will convene the Division Pest Study Team to determine a permanent rating.
D	No action.

APPENDIX G

Special-Status Wildlife Species Accounts

Hardhead (*Mylopharodon conocephalus*). California Species of Special Concern and Forest Service Sensitive. The hardhead is a freshwater fish native to California. Its distribution is limited to the Sacramento-San Joaquin river system. Hardhead are typically found in small to large streams in a low to mid-elevation environment. They may also inhabit lakes or reservoirs. Hardhead tend to prefer warmer temperatures than salmonids, thus it is usually found in clear deep streams with a slow but present flow (U.C. Cooperative Extension 2003). Spawning habitat is typically characterized by gravel and rocky substrate.

California floater (*Anodonta californiensis*). Forest Service Sensitive. The California floater is a freshwater mussel that is known to require a host fish for larval development and dispersal. Although western *Anodonta* are thought to be somewhat a generalist with respect to host fish requirements, these relationships have not been determined (Mock et al. 2004).

Shasta Hesperian (*Vespericola shasta*). Forest Service Sensitive. The Shasta hesperian is a terrestrial snail that is endemic to the Klamath Province, primarily in the vicinity of Shasta Lake, up to 3,000 feet in elevation (Bureau of Land Management 1999). It is generally found in moist bottom lands, such as riparian zones, springs, seeps, marshes, and in the mouths of caves. The Shasta hesperian has been recorded along the Sacramento Arm of the watershed.

Shasta Sideband (*Monadenia troglodytes troglodytes*). Forest Service Sensitive. The Shasta sideband is a terrestrial snail known only from Shasta County, California along the McCloud River Arm and near the Pit River Arm of Shasta Lake. It occurs in limestone areas, including caves, talus slopes, and other rocky areas that are open, brush-covered, or associated with pine-oak woodlands. Refuge sites do not need to have vegetative cover (Bureau of Land Management 1999). The Shasta sideband has not been recorded within the watershed.

Wintu Sideband (*Monadenia troglodytes wintu*). Forest Service Sensitive. The Wintu sideband is a terrestrial snail only known from Shasta County, California along the Pit River Arm of Shasta Lake over to Squaw Creek and at Mountain Gate. It occurs in limestone areas, including caves, talus slopes, and other rocky areas that are open, brush-covered, or associated with pine-oak woodlands. Refuge sites do not need to have vegetative cover (Bureau of Land Management 1999). This species is known to occur near Shasta Lake.

Shasta Chaparral (*Trilobopsis roperi*). Forest Service Sensitive. The Shasta chaparral is a terrestrial snail endemic to Shasta County, California. It may be found within approximately 330 feet of lightly to deeply shaded limestone rockslides, draws, or caves with a cover of shrubs or oak (Bureau of Land Management 1999). The species is known to occur near Shasta Lake.

Cascades Frog (*Rana cascadae*). California Species of Special Concern. Cascades frogs are known to have occurred at many of the sub-alpine lakes and along several of the major tributaries in the Headwaters portion of the watershed. Suitable habitat for the Cascades frog includes slow, permanent bodies of water surrounded by moist forested habitat with herbaceous cover for thermoregulation and predator avoidance. Cascades frogs are strongly tied to water and lake and tributary headwater habitat may be especially suitable for them (USDA Forest Service 2001).

A 1994 study on Cascades frogs documented an existing population between Gumboot Lake and 1/2 mile downstream (USDA Forest Service 2001). The current condition of this population as well as the presence and distribution of other populations in the Headwater potion of the watershed is, unknown. Locations where Cascades frogs have been reported include Gumboot Creek, Toad Lake, Cedar Lake and Cliff Lake, the North fork of Deer Creek and Fawn Creek (USDA Forest Service 2001) and several sites in the central portion of the watershed.

There is reason to believe that the intensive introduction and stocking of non-native salmonid species in the Headwaters portion of the watershed, as well as the widespread distribution of these fish within the watershed may have affected Cascades frog populations and may be continuing to affect these populations. In a study that spanned several adjacent portions of the Cascades frogs range within the Klamath-Siskiyou Bioregion (specifically, the Trinity Alps Wilderness, the Marble Mountains Wilderness, and the Russian River Wilderness), Welsh and others found that presence of Cascades frogs in subalpine aquatic habitats was strongly negatively correlated with the presence of introduced salmonids (Welsh et al 2006). Additionally, Cascades frogs were 3.7 times more likely to be found in fishless waters (Welsh et al. 2006). Welsh and others (2006) hypothesize that in addition to being palatable to fish, in part as the result of their lacking a chemical defense, the highly aquatic life histories of Cascades frogs make them especially susceptible to fish predation. With this in mind, the continued persistence or status of all Cascades frog populations in the Upper Sacramento River Watershed should be considered unknown.

Foothill Yellow-Legged Frog (*Rana boylii*). California Species of Special Concern and Forest Service Sensitive. The foothill yellow-legged frog is found in or near rocky streams in a variety of habitats, including valley-foothill hardwood, valley-foothill hardwood-conifer, valley-foothill riparian, ponderosa pine, mixed conifer, coastal scrub, mixed chaparral, and wet meadow types. Adults often bask on exposed rock surfaces near streams. When disturbed, they dive into the water and take refuge under submerged rocks or sediments. During periods of inactivity, especially during cold weather, individuals seek cover under rocks in the streams or on shore within a few meters of water. Unlike most other ranid frogs in California, this species is rarely encountered (even on rainy nights) far from permanent water. Tadpoles require water for at least three or four months while completing their aquatic development.

The species occurs in the Coast Ranges from the Oregon border south to the Transverse Mountains, in most of northern California west of the Cascade crest, and along the western flank of the Sierra south to Kern County. The species has been recorded in numerous locations throughout the watershed (California Department of Fish and Game 2008a).

Tailed Frog (*Ascaphus truei*). California Species of Special Concern. Much of all three subregions of the watershed fall within the tailed frog's natural elevational (0–6,000 feet) distribution as well as in both the southern and eastern portion of its known geographical range in California. Suitable habitat for tailed frogs is considered permanent, clear, cold (<15 °C) water in a steep drainage, bordered by a dense, moist forest habitat. Riffles with small, clean cobble are important for larval stage stages.

Though early life phases are based in the water, adult tailed frogs are primarily terrestrial and inefficient at underwater feeding (Metter 1964, Bury 1970, California Department of Fish and Game 1996). As

such, status of the riparian buffer is an important constituent of tailed frog habitat. Riparian buffer is also important because of its role in temperature control through shading. Water temperature is a critical determinant of tailed frog habitat as this species may have one of the lowest and narrowest ranges of tolerance for water temperature of all the world's frogs (Welsh 1990). The upper lethal limit for tailed frog eggs is reported at 18.5 °C and this is the lowest upper limit of any North American frog (Brown 1975).

Tailed frogs have been recorded in numerous locations in the central portion of the watershed (California Department of Fish and Game 2008a).

Western Pond Turtle (*Actinemys marmorata*). California Species of Special Concern. The western pond turtle is the only primarily aquatic reptile species in the watershed. Typical habitat for the turtle includes slow water aquatic habitat with available basking sites. Hatchlings require shallow water with dense submergent or short emergent vegetation. Females require an upland oviposition site near their aquatic site.

Though there is some anecdotal evidence of greater abundance historically, western pond turtles are present throughout the watershed, but more common in the central and lower portions. In the Headwaters, single sightings of individuals have been reported at Castle Lake and Cliff Lake. In the central portion of the watershed, western pond turtles are known to inhabit the mainstem of the Sacramento River. Surveys conducted in 1994 on 28 tributaries in the central portion of the watershed, however, recorded only a single occurrence of this species across all surveyed sites. The species has also been recorded around Shasta Lake (California Department of Fish and Game 2008a).

Long-eared Owl (*Asio otus*). California Species of Special Concern. The long-eared owl occurs as a permanent resident or winter visitor throughout much of the northern portion of the state. It requires wooded areas for roosting and breeding and often frequents riparian habitats. At higher elevations, this species can be found in dense conifer stands. The long-eared owl typically forages in open habitats, primarily for small rodents. The cause of this species' decline is unclear, although loss of riparian habitat may play a role. Conifer woodlands in the watershed provide suitable roosting habitat for this species.

Flammulated Owl (*Otus flammeolus*). USFWS Bird of Conservation Concern. Flammulated owls are tiny owls (~6 inches long) with a deep voice. They are typically found in montane forests, especially ponderosa pine, with intermediate canopy closures. Flammulated owls favor areas with small openings and edges and clearings with snags for nesting and roosting. They nest in cavities or woodpecker holes and feed almost exclusively on insects and arthropods. In the watershed, flammulated owls are summer residents in a variety of coniferous habitats.

Golden Eagle (*Aquila chrysaetos*). California Species of Special Concern, California Fully Protected, and USFWS Bird of Conservation Concern. Golden eagles are most common in rugged, open country bisected by canyons where there are ample nesting sites and food. They are a rare permanent resident or migrant throughout California but are more common in the foothills surrounding the Sierra Nevada and Coast Ranges and in the southern California deserts. Golden eagles nest on cliffs of all sizes and in the tops of large trees. They construct very large stick nests, sometimes exceeding 10 feet across (Zeiner et

al. 1990). The species forages on rabbits and larger rodents, but may also take birds and reptiles; some also feed on carrion.

American Peregrine Falcon (*Falco peregrinus*). California Fully Protected Species and USFWS Bird of Conservation Concern. The American peregrine falcon is known as one of the fastest flying birds of prey, feeding almost entirely on birds that it kills while in flight. These falcons nest primarily on high cliffs; however, they will also use human-made structures and occasionally tree cavities or the old nests of other raptors. In California, peregrine falcons are known to nest along the coast north of Santa Barbara, the northern Coast and Cascade ranges, and the Sierra Nevada. During winter and periods of migration, they can be found throughout most of the state. However, they are most likely to be encountered near wetland or aquatic habitats. Suitable habitat for the American peregrine falcon occurs in the watershed, and the species has been recorded nesting along the Sacramento River Arm of Shasta Lake (California Department of Fish and Game 2008a).

The American peregrine falcon was listed as endangered by the USFWS in 1970 and by the State of California in 1971. Intensive efforts to protect peregrine falcons were initiated by biologists from the Santa Cruz Predatory Bird Research Group in 1975. These efforts led to over 120 pairs of peregrine falcons by 1992 (Thelander and Crabtree 1994). The USFWS removed the American peregrine falcon from the endangered species list in 1999 and the State of California delisted it in 2009.

Northern Goshawk (*Accipiter gentilis*). California Species of Special Concern, Forest Service Sensitive, and USFWS Bird of Conservation Concern. The northern goshawk is found in dense, mature conifer and deciduous forests, interspersed with openings and riparian habitat. Nests are typically constructed on north-facing slopes near water. They prey mainly on birds and small mammals. In California, northern goshawks breed in the northern Coast Ranges and in the Sierra Nevada, Klamath, Cascade, and Warner Mountains. Northern goshawks have been recorded in the watershed (California Department of Fish and Game 2008a).

Ferruginous Hawk (*Buteo regalis*). USFWS Bird of Conservation Concern. The ferruginous hawk is a large, broad-winged hawk of open habitats. In the watershed, ferruginous hawks occur only as uncommon winter residents or migrants. Winter habitat includes areas with large, open tracts of grasslands, sparse shrub, or desert habitats where prey (e.g., small mammals such as rabbits and ground squirrels) is abundant.

Prairie Falcon (*Falco mexicanus*). USFWS Bird of Conservation Concern. The prairie falcon inhabits dry environments where cliffs or bluffs punctuate open plains and shrub-steppe deserts. Nests are typically built on a sheltered ledge of a cliff overlooking a large open area. It is a specialized predator of medium-sized mammals and birds. The prairie falcon is a year-round resident of suitable habitats in the watershed.

Lewis's Woodpecker (*Melanerpes lewis*). USFWS Bird of Conservation Concern. Lewis's woodpeckers inhabit open, deciduous and conifer habitats with a brushy understory and scattered snags and live trees for nesting and perching. They excavate cavities in snags or the dead part of live trees for nesting. Lewis's woodpeckers are opportunistic in their feeding habits, eating mostly insects in summer

but switching to nuts in the winter, which they often store in bark crevices for later consumption. This species may occur in the watershed as a summer resident and breeder.

White-headed Woodpecker (*Picoides albolarvatus*). USFWS Bird of Conservation Concern. The white-headed woodpecker is a yearlong resident in the watershed, occurring in mixed coniferous forests dominated by pine. Pine seeds are an important part of its diet through much of the year. Pairs excavate nests in snags, stumps, or the dead portions of living trees. Nests are often located within 10 feet of the ground (Garrett et al. 1996).

Black Swift (*Cypseloides niger*). California Species of Special Concern and USFWS Bird of Conservation Concern. Black swifts nest on ledges or shallow caves in steep rock faces and canyons, usually near or behind waterfalls, and in sea caves. If suitable habitat for breeding is present, they will forage for insects over a variety of habitats. Black swifts breed very locally in the Sierra Nevada and Cascade Range, including a portion of the watershed. The species was recorded nesting on the cliffs near Mossbrae Falls in 1976 and 1977 (California Department of Fish and Game 2008a).

Vaux's Swift (*Chaetura vauxi*). California Species of Special Concern. The Vaux's swift is a summer resident of northern California that forages over most terrains and habitats, commonly at lower levels in forest openings, above burns, and above rivers. The species roosts in large hollow trees and snags, most often in redwood and Douglas-fir but it may also use other conifers and, occasionally, chimneys and buildings.

Olive-sided Flycatcher (*Contopus cooperi*). California Species of Special Concern and USFWS Bird of Conservation Concern. Olive-sided flycatchers may occur as summer residents in a variety of forest and woodland habitats in the watershed. Preferred nesting habitat includes mixed conifer, montane hardwood-conifer, Douglas-fir, and red fir. They are most numerous where these forest habitats overlook canyons, meadows, lakes, or other open terrain. Olive-sided flycatchers prey almost exclusively on flying insects, especially bees.

Purple Martin (*Progne subis*). California Species of Special Concern. The purple martin is an uncommon summer resident of old-growth, multi-layered open forests in California. It primarily uses old woodpecker cavities for nesting, but will occasionally nest in boxes or under bridges. Purple martins forage for insects over a variety of habitats, including riparian areas and forests. The species has declined in numbers in recent decades due to competition with non-native species for nest cavities, the loss of riparian habitat, and the removal of snags. One of the few known nesting colonies of this species in interior California occurs along the Pit River Arm of Shasta Lake in snags that are submerged at full pool. The only other known purple martin breeding sites in interior northern California include scattered historical sites in Siskiyou and eastern Shasta Counties (Williams 1998) and recent known sites are from Lava Beds National Monument, and Lake Britton. Recent historical records also occur from locations in the McCloud Arm (Williams 1998). The Shasta Lake population represents between 14 and 51 percent of the interior northern California population (Lindstrand 2008) and included 21 pairs in 2008. However, this species has not been recorded breeding within the watershed.

California Yellow Warbler (*Dendroica petechia brewsteri*). California Species of Special Concern. The yellow warbler is a long-distance migrant, usually arriving in California in April and leaving by October. It is typically found in dense riparian deciduous habitats with cottonwoods, willows, alders, and other small trees and shrubs typical of open-canopy riparian woodlands. The species breeds from mid-April to early August, building an open cup nest in a tree or shrub. Foraging patterns typically involve gleaning and hovering for insects and spiders. Suitable habitat for this species occurs in the watershed.

Yellow-breasted Chat (*Icteria virens*); California Species of Special Concern. The yellow-breasted chat is a neotropical migrant that occurs in riparian or marsh habitats throughout California. It is found in dense, brushy thickets near water and in the thick understory of riparian woodlands. Forage patterns usually involve gleaning insects, spiders, and berries from the foliage of shrubs and low trees. Nests are often low to the ground in dense shrubs along streams. Yellow-breasted chats occur as summer breeding residents in the Sacramento River Valley and its tributaries. Suitable habitat for this species occurs in the watershed.

Loggerhead Shrike (*Lanius ludovicianus*). California Species of Special Concern and USFWS Bird of Conservation Concern. The loggerhead shrike prefers open habitats with scattered shrubs, trees, posts, fences, utility lines, or other perches located in open-canopied valley foothill hardwood, valley foothill hardwood-conifer, valley foothill riparian, pinyon-juniper, juniper, desert riparian, and Joshua tree habitats. Loggerhead shrikes skewer their prey to thorns or barbs on barbed-wire fences. The purpose of this trait may be to help kill the prey or to cache the food for later consumption. Suitable habitat for the loggerhead shrike occurs in the northern portion of the watershed.

American Marten (*Martes americana*). Forest Service Sensitive. Chiefly nocturnal, the American marten is mostly carnivorous, taking primarily small mammals, however it also consumes birds, insects, fruits, and fish. Breeding occurs in the summer with most litters born in March and April. The American marten is an uncommon to common, permanent resident of the North Coast regions and Sierra Nevada, Klamath, and Cascades Mountains (California Department of Fish and Game 2008b). It requires a variety of different-aged stands, particularly old-growth conifers and snags, which provide abundant cavities for denning and nesting. Martens tend to travel along ridgetops, and rarely move across large areas devoid of canopy cover. Small clearings, meadows, and riparian areas provide foraging habitats, particularly during snow-free periods. The availability of habitat with limited human use is also an important requirement for martens. The American marten has been recorded in the northern portion of the watershed (California Department of Fish and Game 2008a).

Oregon Snowshoe Hare (*Lepus americanus klamathensis*). California Species of Special Concern. The Oregon snowshoe hare is known only from the vicinity of Mt. Shasta, the Trinity Mountains, and one locality in the Warner Mountains (Williams 1986). In, California the snowshoe hare is primarily found in montane riparian habitats with thickets of alders and willow, and in stands of young conifers interspersed with chaparral. Dense cover is preferred either in under-story thickets of montane riparian habitats or in shrubby under stories of young conifer habitats.

The species is solitary except during the breeding season, from mid-February to July. Snowshoe hares are primarily crepuscular and nocturnal and active year round. They eat a variety of plant materials with

forage type varying by season. Succulent green vegetation is consumed when available; after the first frost, buds, twigs, evergreen needles, and bark form the bulk of the diet.

Townsend's big-eared bat (*Corynorhinus townsendii*). California Species of Special Concern and Forest Service Sensitive. The Townsend's big-eared bat has been reported in a wide variety of habitat types including coniferous forests, mixed mesophytic forests, deserts, native prairies, riparian communities, active agricultural areas, and coastal habitat types. Distribution is strongly correlated with the availability of caves and cave-like roosting habitat, including abandoned mines. It has also been reported to utilize buildings, bridges, rock crevices, and hollow trees as roost sites. Summer maternity colonies range in size from a few individuals to several hundred individuals. Winter hibernating colonies are composed of mixed-sexed groups, which can range in size from a single individual to colonies of several hundred animals (Piaggio and Sherwin 2005). The Townsend's big-eared bat primarily consumes moths that it captures while foraging in edge habitats along streams, adjacent to and within a variety of wooded habitats. These bats often travel large distances while foraging. NSR biologists observed the species during a survey of a limestone cave on the Big Backbone Creek Arm in June 2008.

Pallid Bat (*Antrozous pallidus*). California Species of Special Concern and Forest Service Sensitive. This medium-sized bat occurs throughout much of California. It prefers foraging on terrestrial arthropods in dry, open grasslands near water and rocky outcroppings or old structures. It may also occur in oak woodlands and at the edge of redwood forests along the coast. Roosting typically occurs in groups. Day and night roosts often occur in caves and mine tunnels. However, buildings and trees may also be used for day roosts. More open sites (e.g., buildings, porches, garages, and highway bridges) may be used for night roosts. Pallid bats are sensitive to human disturbances at roost sites.

Western Red Bat (*Lasiurus blossevillii*). Forest Service Sensitive. The western red bat is a migratory species occurring in California from Shasta County to the Mexican border, west of the Sierra Nevada/Cascade crest and deserts (California Department of Fish and Game 2008b). The species prefers sites with a mosaic of habitats that includes trees for roosting and open areas for foraging. Western red bats typically roost solitarily in dense tree foliage, particularly in willows, cottonwoods, and sycamores. Western red bats appear to be strongly associated with riparian habitats, particularly mature stands of cottonwood/sycamore (Pierson et al. 2006). Data also suggests that western red bat populations require fairly extensive stands (>164 feet wide) of riparian forest (Pierson et al. 2006). However, direct observations of roosting behavior in California are limited primarily to collections or sightings that have occurred in fruit orchards (Pierson et al. 2006). They forage over a wide assortment of habitat types for a variety of insects, but primarily feed on moths.

Spotted Bat (*Euderma maculatum*). California Species of Special Concern. In California, the spotted bat has a patchy distribution throughout the western portion of the state due to its dependence on rock-faced cliffs for roosting habitat. Roosts are found in small cracks in cliffs and rocky outcrops. The spotted bat forages over a variety of habitats, primarily for large moths. California spotted bats have been recorded in the northern half of the watershed (California Department of Fish and Game 2008a).

Western Mastiff Bat (*Eumops perotis*). California Species of Special Concern. The western mastiff bat, California's largest bat species, is an uncommon resident throughout its range in California. It ranges

from Central Mexico across the southwestern United States. In addition, recent surveys have extended the previously known range to the north in both Arizona and California (to within a few miles of the Oregon border) (Pierson and Siders 2005). Primarily a cliff dwelling species, roosts are found under exfoliating rock slabs and in similar crevices in large boulders and buildings (Pierson and Siders 2005). Roosts are generally high above the ground, usually allowing a clear vertical drop of at least 10 feet below the entrance for flight. This species has been recorded in the northern portion of the watershed (California Department of Fish and Game 2008a).

American Badger (*Taxidea taxus*). California Species of Special Concern. Badgers are highly specialized fossorial (adapted for burrowing or digging) mammals found throughout almost all of California. They are found in a range of habitats that contain friable soils and relatively open ground where they dig burrows in pursuit of prey and to create dens for cover and raising of young. Badgers are carnivorous, preying primarily on rodents.

Ring-tailed Cat (*Bassariscus astutus*). California Fully Protected Species. The ring-tailed cat occurs in various riparian habitats in and brush stands of most forest and shrub habitats. Nocturnal and primarily carnivorous, ring-tailed cats mainly eat small mammals but also feed on birds, reptiles, insects, and fruit. They forage on the ground, among rocks, and in trees, usually near water. Hollow trees and logs, cavities in rocky areas, and other recesses are used for cover. The ring-tailed cat is widely distributed in California.

References

Brown, H. A. 1975. Temperature and development of the tailed frog, *Ascaphus truei*. *Comp. Biochem. Physiol.* 50(a):397-405.

Bureau of Land Management. 1999. *Field guide to survey and manage terrestrial mollusk species from the Northwest Forest Plan*: Bureau of Land Management, Oregon State Office.

Bury, R. B. 1970. Food similarities in the tailed frog, *Ascaphus truei*, and the Olympic salamander, *Rhyacotriton olympicus*. *Copeia* 1:170-171.

California Department of Fish and Game. 2008a. California natural diversity database (CNDDB). http://www.dfg.ca.gov/biogeodata/ (accessed 2008).

California Department of Fish and Game. 2008b. CWHR version 8.2 personal computer program: California Department of Fish and Game, California Interagency Wildlife Task Group.

Cornell Lab of Ornithology, and American Ornithologists' Union. 2009. The birds of North American online. http://bna.birds.cornell.edu/bna/ (accessed January 2009).

Garrett, K. L., M. G. Raphael, and R. D. Dixaon. 1996. White-headed woodpecker (*Picoides albolarvatus*). http://bna.birds.cornell.edu/bna/species/252/articles/introduction (accessed January 2009).

Lindstrand, L. I. 2008. Purple martin distribution and nesting habitat characteristics at Shasta Lake, California. *Western Birds* 39(3):166-170.

Metter, D. E. 1964. A morphological and ecological comparison of two populations of the tailed frog, *Ascaphus truei* Stejnegar. *Copeia* 1:181-195.

Mock, K. E., J. C. Brim-Box, M. P. Miller, M. E. Downing, and W. R. Hoeh. 2004. Genetic diversity and divergence among freshwater mussel (Anodonta) populations in the Bonneville Basin of Utah. *Molecular Ecology* 13(5):1085-1098.

Piaggio, A. and R. Sherwin. 2005. *Corynorhinus townsendii* Townsend's big-eared bat. August 2007

Pierson, E. D. and M. S. Siders. 2005. *Eumops perotis*. Western mastiff bat. http://wbwg.org/species_accounts/molossidae/eupe.pdf (accessed August 28, 2007).

Pierson, E. D., W. E. Rainey, and C. Corben. 2006. Distribution and status of western red bats (*Lasiurus blossevillii*) in California. Prepared for Species Conservation and Recovery Program, Habitat Conservation Planning Branch, California Department of Fish and Game. April 15, 2004.

Thelander, C. G. and M. Crabtree. 1994. *A guide to California's endangered natural resources: Wildlife*. Santa Cruz, California: BioSystems Books.

U.C. Cooperative Extension. 2003. California fish website. Hardhead. http://calfish.ucdavis.edu/calfish/Hardhead.htm (accessed January 8, 2009).

USDA Forest Service. 2001. Headwaters Sacramento River ecosystem analysis. USDA Forest Service, Mount Shasta Ranger District. January 01, 2001.

Welsh, H. H., K. L. Pope, and D. Boiano. 2006. Sub-alpine amphibian distributions related to species palatability to non-native salmonids in the Klamath Mountains of northern California. *Diversity and Distributions* 12(3):298-309.

Welsh, H. H., Jr. 1990. Relictual amphibians and old-growth forests. *Conservation Biology* 4(3):309-319.

Williams, B. D. 1998. Distribution, habitat associations, and conservation of purple martins breeding in California, California State University, Sacramento, California.

Williams, D. F. 1986. Mammalian species of special concern in California. Prepared for the State of California, The Resources Agency, Department of Fish and Game. February 1986.

Zeiner, D. C., W. F. Laudenslayer Jr., K. E. Mayer, and M. White, eds. 1990. *California's wildlife. Volume II: Birds*. Sacramento, California: California Department of Fish and Game.

APPENDIX H

Neotropical Migrants Occurring on the Shasta-Trinity National Forest♦

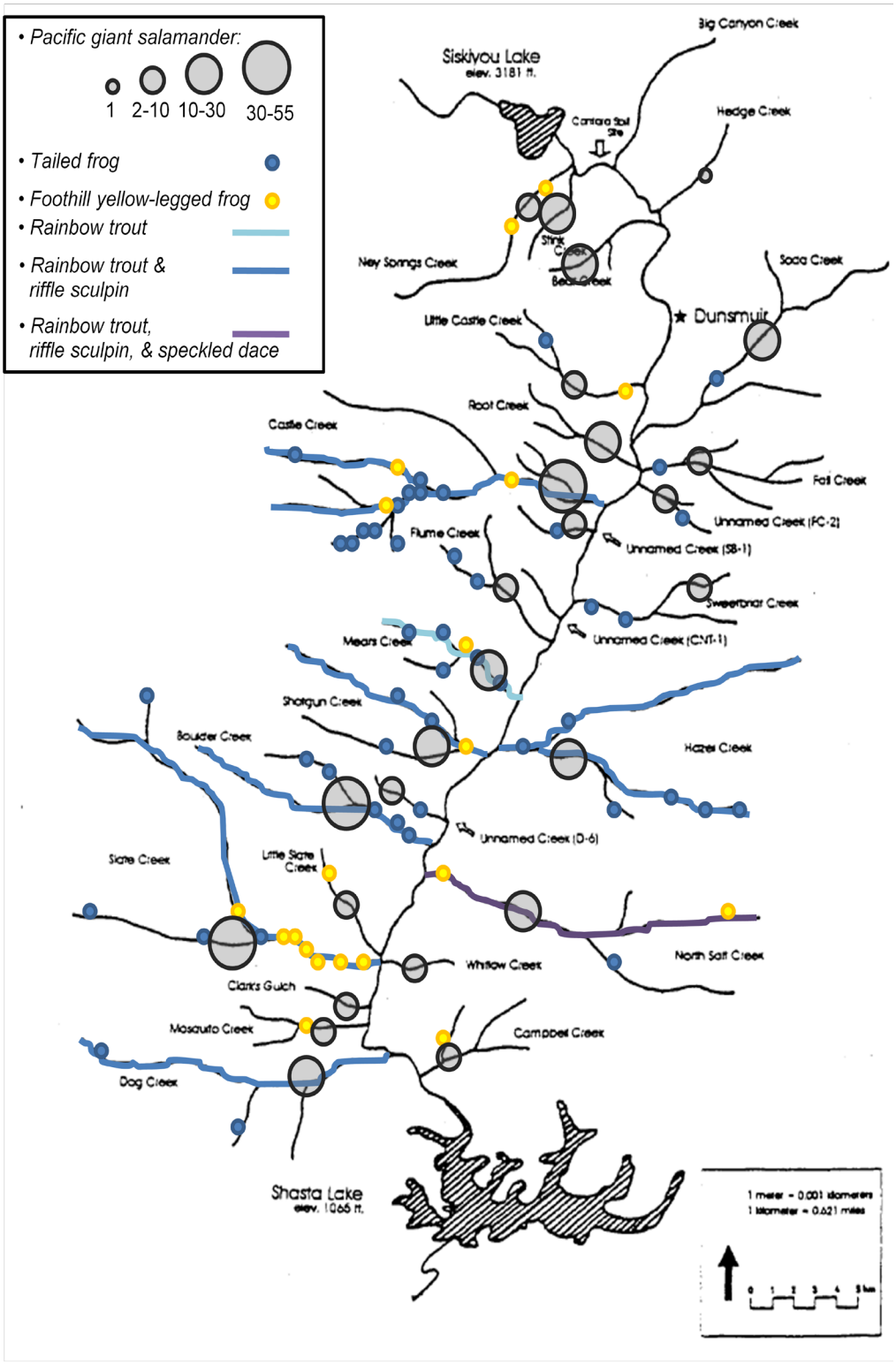
♦ Source: USDA Forest Service. 2008. Bird checklist Shasta-Trinity National Forest

Neotropical Migrants Occurring on the Shasta-Trinity National Forest

Allen's hummingbird
American goldfinch
American kestrel
American pipit
American robin
Anna's hummingbird
Ash-throated flycatcher
Band-tailed pigeon
Barn swallow
Belted kingfisher
Black swift
Black-chinned hummingbird
Black-headed grosbeak
Black-throated gray warbler
Blue-gray gnatcatcher
Brewer's blackbird
Brown-headed cowbird
Calliope hummingbird
Cassin's finch
Chipping sparrow
Cliff swallow
Common nighthawk
Common yellowthroat
Cooper's hawk
Dark-eyed junco
Dusky flycatcher
Ferruginous hawk
Flammulated owl
Golden eagle
Golden-crowned kinglet
Grasshopper sparrow
Gray flycatcher
Green-tailed towhee
Hammond's flycatcher
Hermit thrush
Hermit warbler
Hooded oriole
House wren
Lark sparrow
Lazuli bunting
Lesser goldfinch
Lewis's woodpecker
Lincoln's sparrow
MacGillivray's warbler
Marsh wren
Merlin
Northern rough-winged swallow
Nashville warbler
Northern goshawk
Northern harrier
Northern oriole
Olive-sided flycatcher
Orange-crowned warbler
Osprey
Pacific-slope flycatcher
Peregrine falcon
Pine siskin
Pinyon jay
Prairie falcon
Purple martin
Red-breasted sapsucker
Red-shouldered hawk
Red-tailed hawk
Red-winged blackbird
Rough-legged hawk
Ruby-crowned kinglet
Rufous hummingbird
Sage sparrow
Savannah sparrow
Sharp-shinned hawk
Solitary vireo
Spotted towhee

APPENDIX I

Sensitive Amphibian Species Locations in the Upper Sacramento River Watershed



Map of Upper Sacramento River tributaries below Box Canyon Dam, with sureveyed locations where sensitive amphibian species (tailed frog, foothill yellow-legged frog, and pacific giant salamander) and fish species (rainbow trout, riffle scuplin, and speckled dace) were found. Compiled from CDFG (1995, 1996, 2001).

APPENDIX J

Additional Comments from Arne Hultgren, Roseburg Resources Company

Additional Comments from Arne Hultgren, Roseburg Resources Company

- Chap 1: The development of a management strategy as a requisite goal is fairly unconventional practice. WA's typically detail structure & function of the water shed, simply stating the conditions.

- Ch.3 : Uses an outdated Fuel Model (Albini 1976) …is that really the latest and/or best available science?

- Use of "publically available" GIS without field verification casts doubt on accurate data; Examples of mis-mapped roads were noted at an interim meeting of the steering committee; the contractor was alerted to these data blows, yet the data was still used in subsequent modeling which drove ERA, EHR, and other modeled analysis.

- Ch. 3-133 Hydrology: Equivalent Roaded Area is an outdated metric of watershed health; it fails to account for types of road surfaces, types/efficacy of drainage facilities and structures. Further, it was altered in its use herein. The Appendix B-10 reference to McGurk & Fong (1995) is a 15-year old paper; methods used in the paper were not apparently the same as in the USWA; see B-7 insofar as road types were not defined, nor was proximity to watercourses, nor was the recovery period. The State Board of Forestry's Monitoring Study Group has a large body of more relevant research that was completely missed.

- Fig 3.2-49 uses a single "mean annual runoff"; good statistical practices also include a measure of central tendency; e.g. the variation over the past 20, 30, 50 or 100 years. Also the "cumulative departure" metric is meaningless unless there is a discrete event to accumulate from, that this graph supposedly correlated to.

- Ch. 3-54 Figures 3.2-2 & 3 – It makes no sense to display rainfall from 3 different sources as a stacked-bar graph, because this implies there is some type of implicit additive value, which there is not. These are independent measurements. As noted elsewhere, the mean without the standard deviation or the range is uninformative.

- 3-61 (including tables 3.2-2, 3, &4) Tables purport to represent air in the WA area, but these air basins include lands include Susanville, Sacramento, Alturas, Happy Camp and Yreka. They dwarf the WA area. The relevance to this WA is marginal.

- 3-65 Climate Change. Fails to note a rather important fact: that Mt. Shasta's glaciers are growing "It's a bit of an anomaly that they are growing, but it's not to be unexpected," said Ed Josberger, a glaciologist at the U.S. Geological Survey in Tacoma, Wash., who is currently studying retreating glaciers in Alaska and the northern Cascades of Washington." http://www.usatoday.com/tech/science/environment/2008-07-08-mt-shasta-growingglaciers_N.htm

- Fig 3.2-48 is based on modeled ERA and is not accurate. It should not be included. (see remarks above about weakness of this obsolete method and manner of application to this WA.)

- Ch. 3-133 Netmap modeling fails to account for, or calibrate to varied road surfaces (last sentence, extends to top of 134). Just plain incorrect. Asphalt, concrete, native surface or railroad grades have some demonstrable amount of infiltration. They are not impermeable in the scientific sense.

- 3-142 Table 3.2-10 displays monitoring components from the unavailable Cantara Spill data source, as noted in the Appendices "The turbidity and sediment data collected as part of the Cantara Spill monitoring could not be located as part of this assessment[B-9]."

- 3-142-143. Referenced SWCMP's sole monitoring point on the Sacramento River above Shasta Lake is the discredited turbidity sensor at DLT. As a result, reference to this program suggests greater oversight of the watershed by the SWCMP than may actually exist.

- Table 3.2-13 fails to use accepted stream temperature metrics, substituting instead single instantaneous measurement of mean, max and min. The Maximum Weekly Average Temperature (MWAT) is the customary measure as applied to biotics.

- 3-204-224. The reader would be better served if this, and the other 20 pages of citations were placed in the Appendices.

- 4-1. The belief that biological integrity is a constant baseline and is measureable is not a universally accepted premise among ecologists. The WA is not a place for unqualified speculation.

- 4-4. (Fig 4.1-1) Displays in a uniform fashion, varied intervals; 5-yrs, then 10-yrs, then 180-year; all have the same width; exaggerating the early seral stage and confusing to the reader.

- 4-5. Latter 2 paragraphs under heading 'Shasta Dam' is extremely speculative and should not be the purpose of a watershed assessment.

- Castle Lake, while unique, fails to sufficiently resemble the assemblages of a riverine system like the Upper Sacramento to constitute a reference body. These are 'apples and oranges'.

- B-9 Turbidity-the Turbidity data from DLT was so completely compromised, that it cannot be compared to the SPI Hazel Creek data, which originated from a calibrated, research grade station that received regular oversight. Contrast this to the DLT site where months elapsed between visits, and even then did not detect nor purge obviously errant readings or fix bad sensors.

- Points at top of B-9 are re-pasted facts from p. 3-141.