tification, Mini Poster 3. Mel-
ommunity Development, State
ment, http://www.dpcd.vic.gov

utritional Value of *Margaritifera*
published M.A. thesis, Eastern

Personal and Scientific Ac-
University.

America: An Encyclopedia.
ing, Inc.

Soil Survey. Map of Stevens
http://websoilsurvey.sc.egov

Chamokane Creek, Wash-
Washington and John Day
U.S. Geological Survey Water

ing Abundance, Structure
of the National Academy of
103–4107.

dy from Ozette. Unpub-
ersity, Pullman.

the American Southwest
tation, Southern Method-

6

Fire, Floodplains, and Fish

The Historic Ecology of the Lower Cosumnes River Watershed

MICHELLE L. STEVENS AND EMILIE M. ZELAZO

Jumping echoes of the rocks;
Squirrels turning somersaults;
Green leaves, dancing in the air;
Fishes, white as money-shells,
Running in the water; green, deep, and still.
Hi-ho, hi-ho, hi-hay!
Hi-ho, hi-ho, hi-hay!
Modoc puberty song

Jump, salmon, jump!
So you may see your uncle dance!
Coyote song to catch steelhead (Chumash), in H. W. Luthin, ed., *Surviving through the Days: Translations of Native California Stories and Songs* (2002)

For thousands of years, the California landscape has been tended and its resources sustainably harvested by its inhabitants. Prior to Euro-American settlement, California Native Americans manipulated the natural environment, particularly plant resources, to meet long-term cultural needs (Anderson 2005; Blackburn and Anderson 1993; Stevens 1999). In fact, indigenous people all over the world have been found to be key factors in influencing biodiversity, sustainability, and optimum resource utilization. Historical ecology focuses on this reciprocal interface between humans and the environment in order to further the understanding of landscape

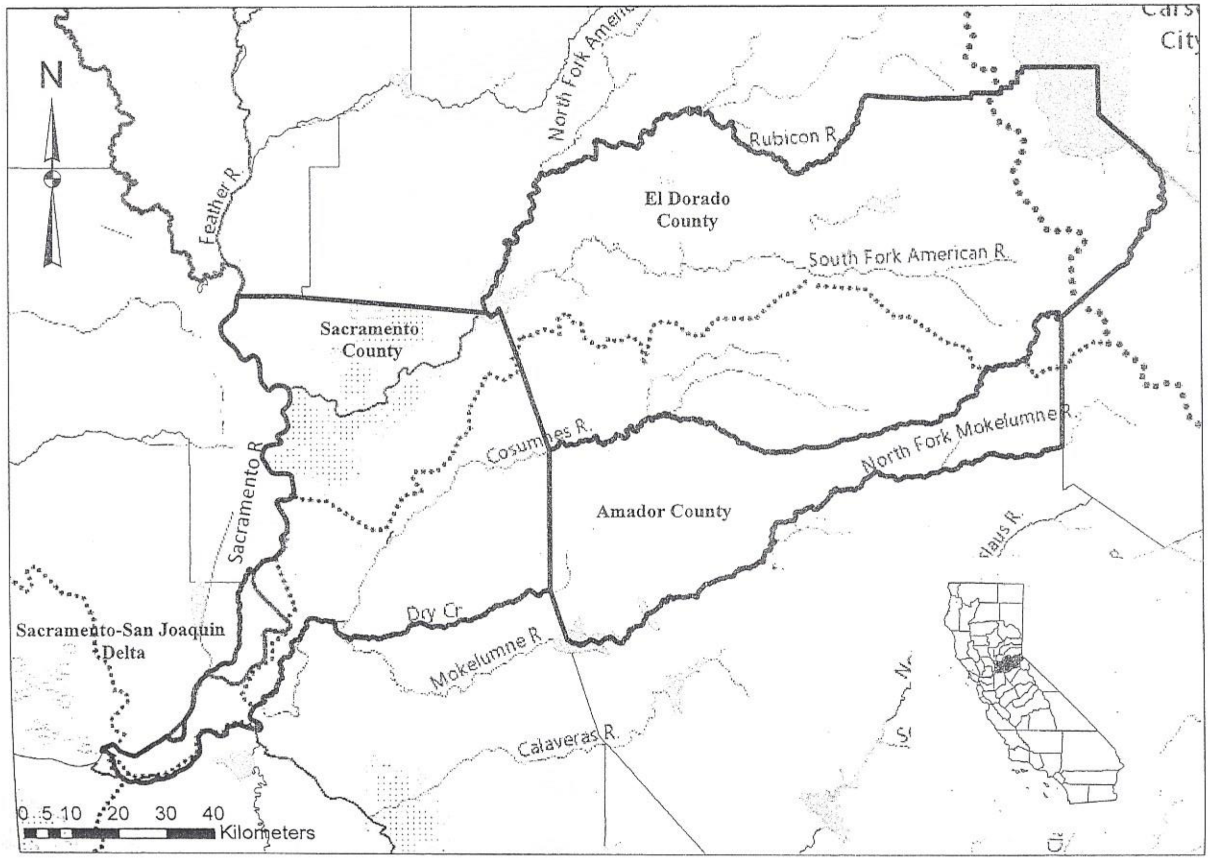


FIGURE 6.1. Overview of the Lower Cosumnes River study area and the Sacramento–San Joaquin Delta in California. Illus. by Emilie Zelazo.

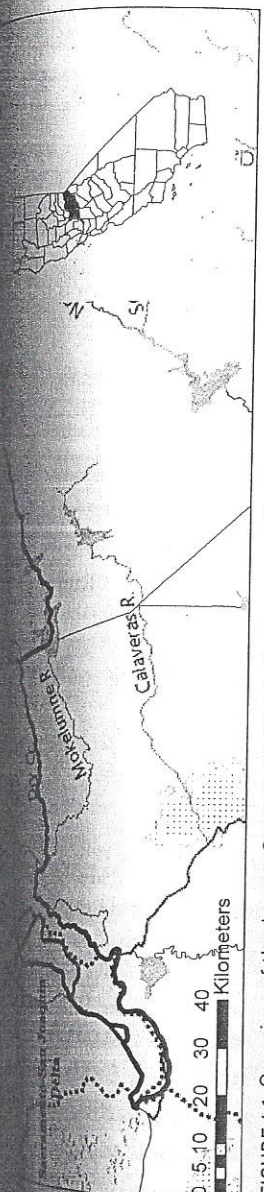


FIGURE 6.1. Overview of the Lower Cosumnes River study area and the Sacramento–San Joaquin Delta in California. Illus. by Emilie Zelazo.

transformations over time (Egan and Howell 2001; Grossinger 2001; Grossinger et al. 2006).

Although historical ecology does not typically incorporate both archaeological data and ethnoecology into an assessment of historic ecosystems, the archaeological record contains not only demographic information not found in most historical texts but also environmental information in the form of material culture, paleobotanical, and faunal remains. This chapter will explore ethnographic data, traditional knowledge, and archaeological fish faunal remains to reconstruct the landscape of the Lower Cosumnes River watershed prior to Euro-American settlement and alteration. The historical reconstruction proposed here will illustrate, within the limitations of the data, how past indigenous traditional management practices influenced both vegetation patterns and probable fish species distributions in the Lower Cosumnes River watershed.

Our hypothesis is that floodplain biodiversity and native fish productivity benefited from burning and other traditional management practices utilized by the Plains Miwok and other Native Californians for thousands of years. These practices may have enhanced floodplain rearing habitats, thereby increasing fish growth and reducing fish mortality. Traditional resource management has been demonstrated to do the following:

- increase habitat interspersion,
- create a more open and parklike riparian physiognomy,
- increase species diversity,
- reduce water lost to evapotranspiration,
- attenuate peak velocities and flood flows,
- increase late-season streamflows, and
- increase the production of desired resources through intermediate anthropogenic disturbance (Anderson 2005; Hankins 2005; Lewis 1973; Martinez 2000, 2002; Stevens 1999).

The Study Area: The Lower Cosumnes River Watershed

The Cosumnes River is located in the northeastern portion of the Sacramento–San Joaquin Delta of central California (see Figure 6.1). The Cosumnes River is 80 miles long. It flows from headwaters in the Sierra Nevada mountain range at an elevation of 2,400 meters to approximately sea level at its confluence with the Mokelumne River (Cosumnes River

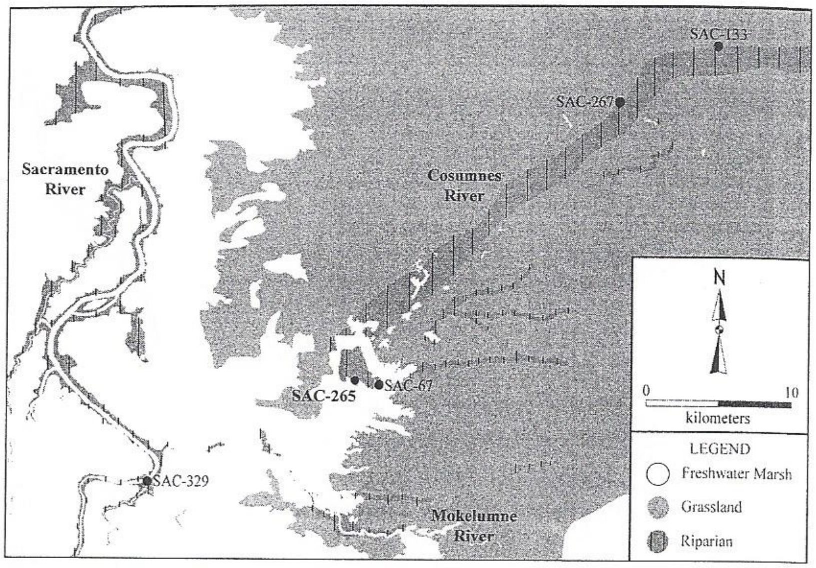


FIGURE 6.2. Pre-1900s California Central Valley historic vegetation map.

Preserve 2010a). The study area is defined as the lower portion of the Cosumnes River, from the edge of the Sierra Nevada foothills just east of Latrobe in the north to its confluence with the Mokelumne near the town of Thornton in the south. The Mokelumne River shortly after this juncture flows westward into the Sacramento–San Joaquin Delta (U.S. Geological Survey [USGS] 1979). The distance covered by the study area is approximately 45 linear miles, encompassing a little more than half of the length of the entire river. The pre-1900s historic vegetation map of the Central Valley is depicted in Figure 6.2, and an overview of the study area appears in Figure 6.3.

In recent years, the Cosumnes River has become a focus of conservation and restoration efforts. The Cosumnes River is the largest watercourse flowing in central California without a major dam on its main stem and has a presumed natural flow regime (Mount 1995; Mount et al. 2001; Moyle et al. 2003). Because of this less altered state, the Cosumnes River hydrogeology more closely reflects historic conditions and is often used as a reference area for the natural process restoration of more modified watercourses. The hydrogeomorphology of the Cosumnes River provides one of the most reliable templates of pre–Euro-American settlement riparian ecologies existing today, providing a facsimile of the world once inhabited

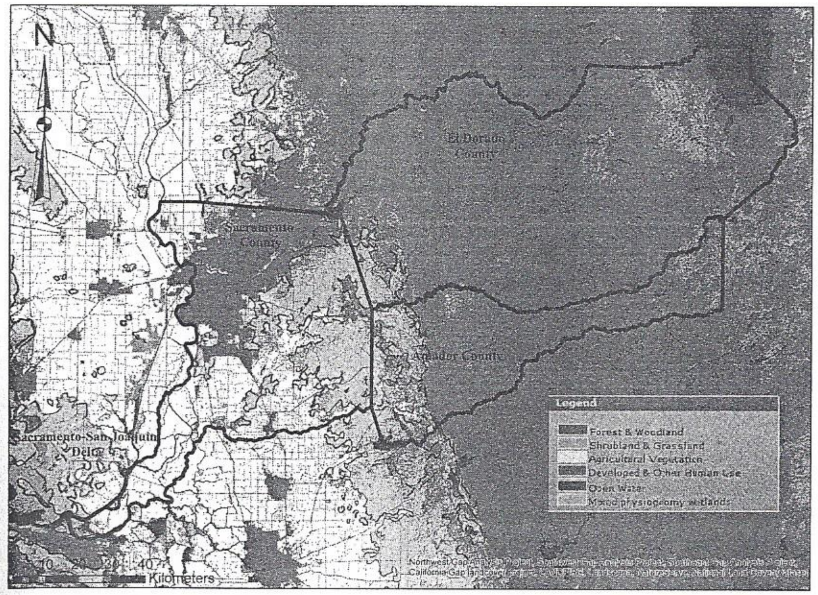


FIGURE 6.3 Overview of the study area.

by indigenous Plains Miwok (Bennyhoff 1977; Bouey and Waechter 1992; Johnson 1976; Kroeber 1925; Levy 1978).

Like many California watersheds, the Cosumnes River has a high amount of variability of flow on both a seasonal and an annual basis. Historically the Cosumnes River was a perennial stream, with flows in later summer being supported by the upwelling of groundwater (Moyle et al. 2003). However, the increased agricultural and rural use of groundwater has lowered groundwater levels as much as 30 meters in some reaches of the river, therefore reducing the amount of water available for late-summer flows (Mount et al. 2001). Due to the low elevation of its headwaters, much of the Cosumnes River watershed is fed by rainfall rather than by snowmelt (USGS 1979). This results in larger and flashier volumes of runoff than occur in snow-fed river systems.

Within the Lower Cosumnes River watershed, the adjacent riparian corridors and grasslands are subject to annual flooding, creating an interspersion of gallery riparian forest, oak woodland, permanent and seasonal wetlands, and aquatic habitats within the floodplain (Vahti and Greco 2007). High winter flows are a critical factor in the creation of the floodplains through the channelization process (Moyle et al. 2003), and several

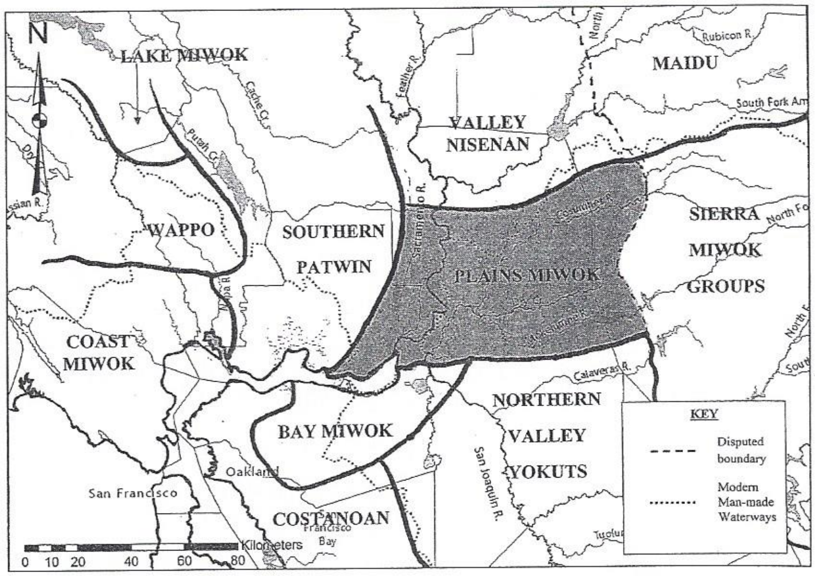


FIGURE 6.4. Plains Miwok territory map.

floodplains are hydrologically connected to the Cosumnes River in its lower region (Swenson et al. 2003). While the mean annual average flow is 529 cubic feet per second , peak winter discharges of as high as 54,000 cubic feet per second have been recorded for the Cosumnes (USGS 1979). During late summer and early fall the river often has no flow in its lower reaches, which can adversely impact fish survival.

The People of the Cosumnes River

The Archaeological Record

In its lower reaches, the Cosumnes River flows through one of the most biologically rich environments in the California Central Valley; this area supports a structurally diverse mosaic of vegetation types interspersed with aquatic habitats before merging with the Mokelumne River to flow into the Sacramento–San Joaquin Delta (Vahti and Greco 2007). This productive interspersion of gallery riparian forests, oak/woodland savannas, grasslands, freshwater marshes, and riverine and floodplain habitats was also home to groups of Native Californians who came to be known collectively as the Plains Miwok or Mewuk. Figure 6.4 illustrates the territories of Native Californians within the study area and the immediate vicinity.

Populations of close to 80,000 people have been estimated for the

Sacramento Valley prior to European arrival (Cook 1956). These estimates are based on the kinds of resources available and the size of each group's respective territories. For the Plains Miwok numbers potentially as high as 57 individuals per square mile along the streams and sloughs have been estimated for prehistoric times (Johnson 1976).

Archaeological sites in the study area are divided into temporal frameworks designated as the Early period (5000–2800 BP), the Middle period (2800–1200 BP), and the Late period (1200–100 BP). For this discussion, we will focus on the Late period, a time that encompasses the calendar dates of AD 750–1848 and which can be successfully linked to Plains Miwok occupation within the study area.

During Plains Miwok occupation, the study area's vegetation was dominated by open grasslands and vast freshwater marshes, with riparian forests along the natural levees of the major rivers (Central Valley Historic Mapping Project 1999; West et al. 2007). Palynological evidence suggests that the study area has supported the same vegetation pattern for the past 6,000 years (West et al. 2007). Further, dated peat deposits suggest that the eastern Sacramento–San Joaquin Delta margin stabilized 5,000 years ago, allowing for a resilient wetland plant community to become established (Pierce 1988).

There are at least 130 archaeological sites located within the northeastern Sacramento–San Joaquin Delta. Geomorphologically, nearly 50 percent of these sites are located on stream banks and natural levees near rivers such as the Cosumnes, Mokelumne, and Sacramento rivers; 17 percent of the sites are in the floodplain; 14 percent are at lakes, abandoned channels, sloughs, and marshes; 8 percent are on alluvial or marine sedimentary terraces; and 7 percent are found on top of Pleistocene aeolian sand dunes (Pierce 1988). As Figure 6.3 illustrates, the majority of Cosumnes River sites are located on either stream banks or natural levees.

Ethnography of the Plains Miwok

The Lower Cosumnes River was home to the Plains Miwok, a people with high cultural regard for the salmon fishery from the beginning of tribal memory to the present day. The river derives its name either from the Cosomne tribelet, which means the "People of the Salmon Place" in the Miwok language, or from the South-Central Miwok words for salmon, *kos'-sum* and *kis'-sum'mi* (Bennyhoff 1977; Latta 1977; Powers 1877). The

Cosomne village of Supu (possibly a variant of *Cosu* and meaning "Salmon Place") was located approximately two miles northeast of Bruceville, approximately nine miles above the mouth of the Cosumnes River (Bennyhoff 1977; Yoshiyama et al. 2001). Throughout its history, the Cosumnes River experienced a fall run of Chinook salmon. This run was extirpated from the Cosumnes River in 1988, and salmon remained absent at least through the 1990s (Yoshiyama et al. 2001). Then, sometime around 2000, the Chinook salmon returned to the Cosumnes River for spawning and rearing (Jeffres et al. 2008; Moyle et al. 2007).

Linguistic and archaeological evidence suggests that the ancestors of the Plains Miwok were resident in the central California delta region for at least 4,500 years (Golla 2007). The people of the Lower Cosumnes watershed who came to be collectively known as the Plains Miwok split off from other Miwok groups approximately 2,000 years ago (Levy 1978); the Plains Miwok are identified as one of the five Eastern Miwok groups who all spoke a subgroup of the Utian language. The traditional territory of the Plains Miwok can be roughly defined by the Deer Creek/Sloughhouse vicinity on the north, the edge of the Sierra Nevada foothills from Bridgehouse southward to present-day Camanche Reservoir on the east, both banks of the Lower Sacramento River to the western edge of the delta tidal plain in the Yolo basin on the west, and both banks of the Mokelumne River on the south (Bennyhoff 1977; Levy 1978). Plains Miwok territory is presented in Figure 6.4.

The Plains Miwok utilized much of what their land had to offer, indicated by archaeological deposits suggestive of a varied diet of many types of grass seeds, acorns, rabbits and hares, pronghorn, tule elk, deer, minnows, salmon, sturgeon, and numerous waterfowl (Barrett and Gifford 1933; Bennyhoff 1977; Kroeber 1925; Levy 1978). Much of the food consumed was cooked in earth ovens. Plains Miwok dwellings included conical semisubterranean houses, assembly or dance houses, sweat lodges, circular or rectangular ceremonial structures, grinding booths (similar to ramadas), acorn granaries, and hunting blinds (Bouey and Waechter 1992; Levy 1978).

Fishing Technologies

The efficiency, variation, and kinds of fishing technologies used by the Plains Miwok and other indigenous Californian groups in the lower hills along the large rivers indicate how important fishing was to their diet. The prominent fish species listed in ethnographies are salmon (*Oncorhynchus* spp.), sturgeon (*Acipenser* spp.), and lamprey eels (*Entosphenus tridentatus*). Fishing was performed from river- and stream banks or from tule rafts. Fishing technology included clay ball– and stone-weighted nets, weirs, seines (especially in the marshes), the toggle harpoon, bipointed fishhooks, spears, and poison from plants such as buckeye (*Aesculus californica*) and soaproot (*Chlorogalum pomeridianum*) (Barrett and Gifford 1933; Kroeber 1925; Levy 1978).

Barrett and Gifford (1933) describe four types of nets used by Miwok peoples, including the Plains Miwok. The first is a dip net with a circular opening and a very long pole that was used in the deep holes of rivers. The second kind, the *yo'ho*, was from six to eight feet wide and as much as 40 feet long and was usually placed across a river or lagoon. The fish would then be driven into the net, where they were caught by their gills or seized as the net was drawn ashore. The *yo'ho* was used in conjuncture with tule rafts to trap all types of fish, including salmon, and particularly in the slow waters of the delta "along rush-bordered rivers and marshes" (Barrett and Gifford 1933:188). The net's lower edges would be weighted with clay balls wrapped in leaves, and many such tule-impressed clay net weights are found in delta archaeological collections. The third type of net was the set net, referred to by the Plains Miwok as the *yû'gû*. This net was weighted with stones and set into a riffle or depressions of a stream. Vertical trigger strings would signal the watcher on the banks when fish were in the net. The net would then be raised; the fish, removed; and the net, reset. Sometimes divers would drive fish into this net from downstream. The last type was the *mōla'nna*, a casting net with a large circular opening that automatically spread wide as the net was cast onto the water. It was attached to a long rope that closed as it was drawn to the shore.

Material cultural remains found in archaeological collections indicate that fish nets required a tremendous amount of plant materials to construct. Many of the plant species used for net construction were maintained through the setting of annual fires. Large quantities of milkweed (*Asclepias speciosa, A. fasicularis, A. eriocarpa*) and Indian hemp (*Apocynum cannabinum*) were used to construct fishnets and fishline. Since no complete examples of Plains Miwok netting are known, correlatives can be based on known examples from neighboring groups. Washoe and Northern Paiute gill nets (with the dimensions of 1/16-inch two-ply cordage, 100-feet-×-4.5-feet-×-1.5-inch mesh) required 60,110 stalks; bag nets required 4,425 stalks; and A-frame dip/lift nets required 39,450 stalks (Anderson 1993; Lindstrom 1992).

In general, native plants used for textiles, such as milkweed and Indian hemp, produce the best-quality stems for fiber after being burned (Anderson 2005; Bates and Lee 1990). Stalks were harvested when dry in the fall, and fires would have been set after harvesting to stimulate the growth of new stems in the spring. Both milkweed and Indian hemp are relatively scarce in the contemporary riparian landscape. The widespread loss and degradation of riparian habitats has resulted in most native riparian understory species becoming relatively scarce. These species must have been in greater abundance in prehistoric times in order to support the construction of fishing nets and other textiles needed by large indigenous populations.

Aside from being caught with nets, salmon were speared with the two-pronged harpoon called a *sīla'nna* (Barrett and Gifford 1933). The harpoon head (or tip) was usually made of deer bone or antler and was secured to the shaft by a short, very strong leader of native string. Sturgeon were caught by a bipointed fishhook, *ya'lūtc,* and line; a "large sucker" was used as bait. Barrett and Gifford (1933) state that the hook-and-line method was usually performed from a tule raft. Lamprey eels were taken with ordinary fishnets, and no special eel net or trap has been reported as being used by Plains Miwok (Barrett and Gifford 1933).

Poisons made from plants were also used to procure fish. Mashed buckeye and soaproot were used as fish poisons (Barrett and Gifford 1933). Mashed soaproot was put into calm or standing water, and the stupefied fish would rise to the surface, where the Indians gathered them with baskets or dip nets (Kroeber 1925). Soaproot worked best in late summer when the water was low.

Traditional Resource Management

In order to support a sustainable harvest of their resources, the Plains Miwok actively tended the plants and animals of their land by employing various cultivation and harvesting techniques. Today, such techniques and practices are collectively called traditional resource management (TRM). TRM includes multiple species management, resource rotation, succession management, landscape patchiness management, and other ways to respond to and manage environmental uncertainty in order to optimize sustainable resource extraction (Berkes 1999; Berkes et al. 2000).

TRM practices by Native Californians include:

- annual burning of senescent vegetation to stimulate new growth and create microhabitats;
- multiple species management of plant resources, waterfowl, fish, bird eggs, insects, and small mammals;
- resource rotation;
- selective harvesting on a seasonal and phenological basis;
- spatial and temporal restriction of fish harvest during spawning; and
- landscape patchiness management (Anderson 2005; Hankins 2005; Stevens 1999, 2003, 2004a, 2004b).

These traditional practices have similarities to adaptive management, with its emphasis on feedback learning and its treatment of the uncertainty and unpredictability intrinsic to all ecosystems.

Prayer, thanksgiving, and asking permission to harvest are inherent components of traditional resource management, although the specifics vary among individuals and local traditions. Traditional relationships with plants include asking permission to harvest and gratitude for the opportunity to gather and tend plants in the area. Based on our experiences of gathering plant materials with present-day local Miwok (Mewuk) people, prayer and asking permission always occur before gathering, and thanks are always offered after gathering. TRM practices specific to Native California groups consist of harvesting techniques that utilize only a portion of the plant population, with all age classes left behind to reproduce.

Traditional ecological knowledge implies a reciprocal or kincentric relationship with the ecosystem. In 2000, Enrique Salmón described kincentric ecology as "the manner in which indigenous people view themselves as part of an extended ecological family that shares ancestry" (Anderson 2005:57). In terms of traditional land-management techniques, interactions resulting from kincentric ecology can enhance and preserve the ecosystems within which indigenous people have lived for centuries.

Fire

Fire was the most important TRM land-management tool on the pre-European landscape. Native American groups regularly and widely set fires in the Central Valley (Heady 1988; Lewis 1973; Thompson 1961). Sierra

Miwok Elder Bill Franklin told Dr. Kat Anderson what he had learned about burning from his father and grandfather. He said,

> They said the Indians used to burn in the fall—October and November. They set the fires from the bottom of the slope to decrease the snowpack, get rid of the debris so there's no fire danger and they burned in the hunting areas so there was more food for the deer. They burned every year and in the same areas. (Anderson 2005:148–149)

An 1848 account from the Sacramento Valley states,

> The plains are burned over every year by the Indians; and the consequence is, that the young trees, which would otherwise have grown into forests, are destroyed, and the large trees often killed. Nevertheless, the oak (Valley Oak), the plan tree (Sycamore), the ash (Oregon ash)...fringe the stream everywhere, and divide the country into beautiful glades and savannas.... [W]ithin the verge of the valley, grows a belt of oak trees, about three hundred yards wide.... [B]eyond this belt, on either side of the river, stand clumps of forests over the endless seas of grass that reach away to the distant mountains. (Stewart et al. 2002:306)

As reflected in the above statement, the quick, hot burning would kill oak seedlings in the grassland and inhibit their growth but would have a lesser effect on healthy established trees because of the adult oak's very thick, fire-adapted bark (Thompson 1961). The burning of tules in the freshwater marshes would have produced similar results, keeping them in pure stands and inhibiting the growth of willows and other water-tolerant trees on the swampy floodplains.

Annual burning also stimulated the production of plants used for fishing and basketry technology (Anderson 2005; Bibby 1996; Merrill 1923; Yamane and Aguilar 1997). Thousands of stalks of milkweed and Indian hemp, as well as other basketry and fiber materials, were required to support the material culture. These species are relatively uncommon today and not in the abundance necessary to support this level of technology (Stevens 1999). Therefore, traditional burning and kincentric tending practices helped to produce and sustain the plants needed for the material culture.

Removing senescent vegetation through burning and tending also maintained a more open and parklike physiognomy in the riparian corridor within the study area (Stevens 1999). Riparian corridors within the study area occur on natural levees (Katibah 1984; Thompson 1961; Vahti and Greco 2007). Breaks in the natural levees are used by young fish to enter and leave their floodplain nurseries when mature. Burning would have kept vegetation from blocking the natural levee breaks. The majority of indigenous groups within the study area also lived on the natural levees (Pierce 1988).

Last, burning in organic soils creates or enhances depressional microtopography, prolonging ponding and increasing habitat complexity in the floodplain (Sommer et al. 2001a; Sommer et al. 2001b). Indigenous burning of the floodplain is likely to have created openings in the substrate through the removal of surface organic material and oxidizing peat soils. Reducing decadent and senescent vegetation is also likely to have provided a good substrate for the eggs and larvae of floodplain spawning fish such as Sacramento splittail, Sacramento perch, and the extinct thicktail chub. Additionally, burning mobilizes nutrients, resulting in algal and zooplankton blooms, providing important nutrition for all species of native juvenile fish.

The Fish of the Cosumnes

Today the Cosumnes River is home to 41 species of fish, 14 of which are natives (Cosumnes River Preserve 2007). Table 6.1 lists the fish currently found in the Cosumnes River.

Fourteen native fish occurring in the Cosumnes River are found in the study area; 12 of these species are also found in the archaeological record. For the purposes of the following discussion, green and white sturgeon will be collapsed into the general category of sturgeon. Illustrations of the native fish found in the study area are provided in Figure 6.5.

The Pacific lamprey (*Entosphenus tridentatus*) and the prickly sculpin (*Cottus asper*) are the two native fish species in the contemporary fish assemblage missing from the archaeological record. The Pacific lamprey is an ancient anadromous agnathous fish with a skeleton that is not likely to preserve (McGinnis 2006; Wheeler and Jones 1989). The only semibony parts

TABLE 6.1. Cosumnes River Fish Species.

Common Name	Scientific Name
American shad	*Alosa sapidissima* [a]
Bigscale logperch	*Percina caprodes* [a]
Black bullhead	*Ictalurus melas* [a]
Bluegill	*Lepomis macrochirus* [a]
Brook trout	*Salvelinus fontinalis*
Brown bullhead	*Ameiurus nebulosus* [a]
Brown trout	*Salmo trutta*
California roach	*Lavinia symmetricus* [b]
Carp	*Cyprinus carpio* [a]
Channel catfish	*Ictalurus punctatus* [a]
Chinook salmon	*Oncorhynchus tshawytscha* [a,b]
Crappie (black)	*Pomoxis nigromaculatus* [a]
Crappie (white)	*Pomoxis annularis* [a]
Fathead minnow	*Pimephales promelas* [a]
Golden shiner	*Notemigonus crysoleucas* [a]
Goldfish	*Carassius auratus* [a]
Green sunfish	*Lepomis cyanellus* [a]
Hardhead	*Mylopharadon conocephalus* [b,c]
Hitch	*Lavinia exilicauda* [a,b]
Inland silverside	*Menidia beryllina* [a]
Largemouth bass	*Micropterus salmoides* [a]
Pacific lamprey	*Entosphenus tridentatus* [a,b]
Prickly sculpin	*Cottus asper* [a,b]
Rainbow trout	*Salmo gairdneri* [b]
Redear sunfish	*Lepomis microlophus* [a]
Redeye bass	*Micropterus coosae* [a]
Riffle sculpin	*Cottus gulosus* [b,c]
Sacramento pikeminnow	*Ptychocheilus grandis* [a,b]
Sacramento blackfish	*Orthodon microlepidotus* [a,b]
Sacramento sucker	*Catostomus occidentalis* [a,b]
Smallmouth bass	*Micropterus dolomieu*
Speckled dace	*Rhinichthys osculus* [b,c]
Splittail	*Pogonichthys macrolepidotus* [a,b]
Spotted bass	*Micropterus punctulatus* [a]
Striped bass	*Morone saxatilis* [a]
Threadfin shad	*Dorosoma petenense* [a]
Tule perch	*Hysterocarpus traski* [a,b]
Wagasaki	*Hypomesus nipponensis* [a]
Warmouth	*Lepomis gulosus* [a]
Western mosquitofish	*Gambusia affinis* [a]
White catfish	*Ameiurus catus* [a]

Source: Cosumnes River Preserve 2010b.

[a] Species found on the Cosumnes River Preserve.

[b] Native species.

[c] Likely extirpated.

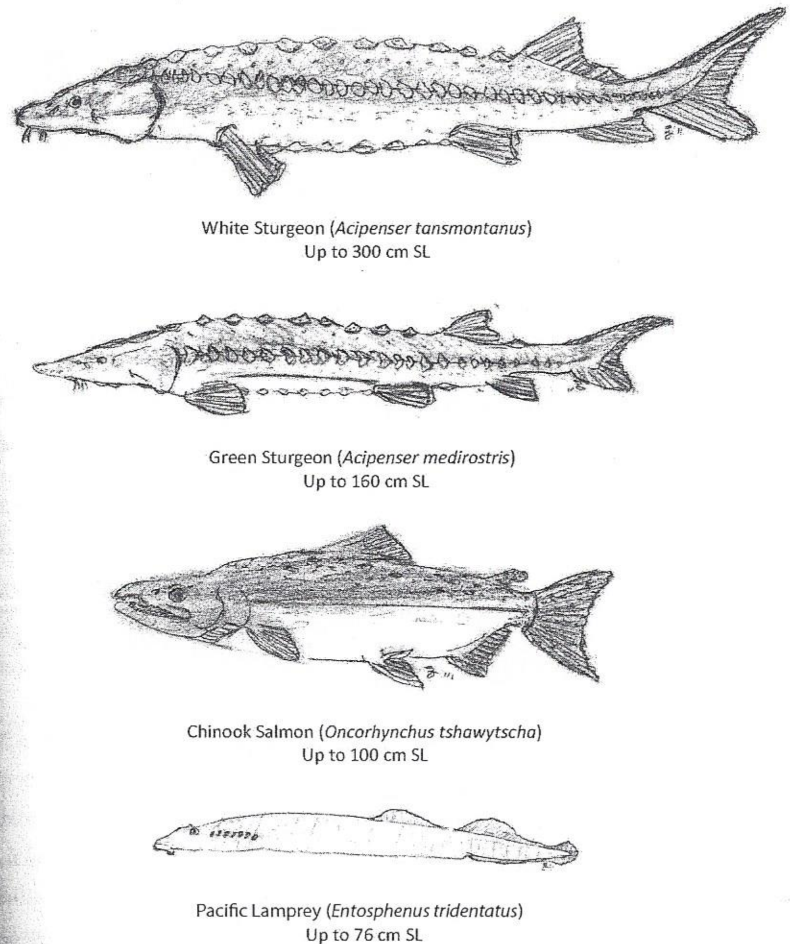


FIGURE 6.5A. Illustrations of native fish of the Cosumnes River found in the study area. SL = standard length. Illustrations not to scale (drawn by Emilie Zelazo).

of this fish are its keratinized teeth, which are also susceptible to decay. As such it is unlikely to preserve at all in the archaeological record; agnathans have rarely been recorded in the archaeological record even with the use of very fine-meshed sieves (Wheeler and Jones 1989).

The Central Valley prickly sculpin lives in freshwater and the San Francisco Estuary (Moyle 2002). Central Valley prickly sculpins are tiny fish, ranging in size from three to nine centimeters, with very small bones (McGinnis 2006; Moyle 2002). Even if these tiny fish were taken during aboriginal times, the small size of their bones would preclude recovery under

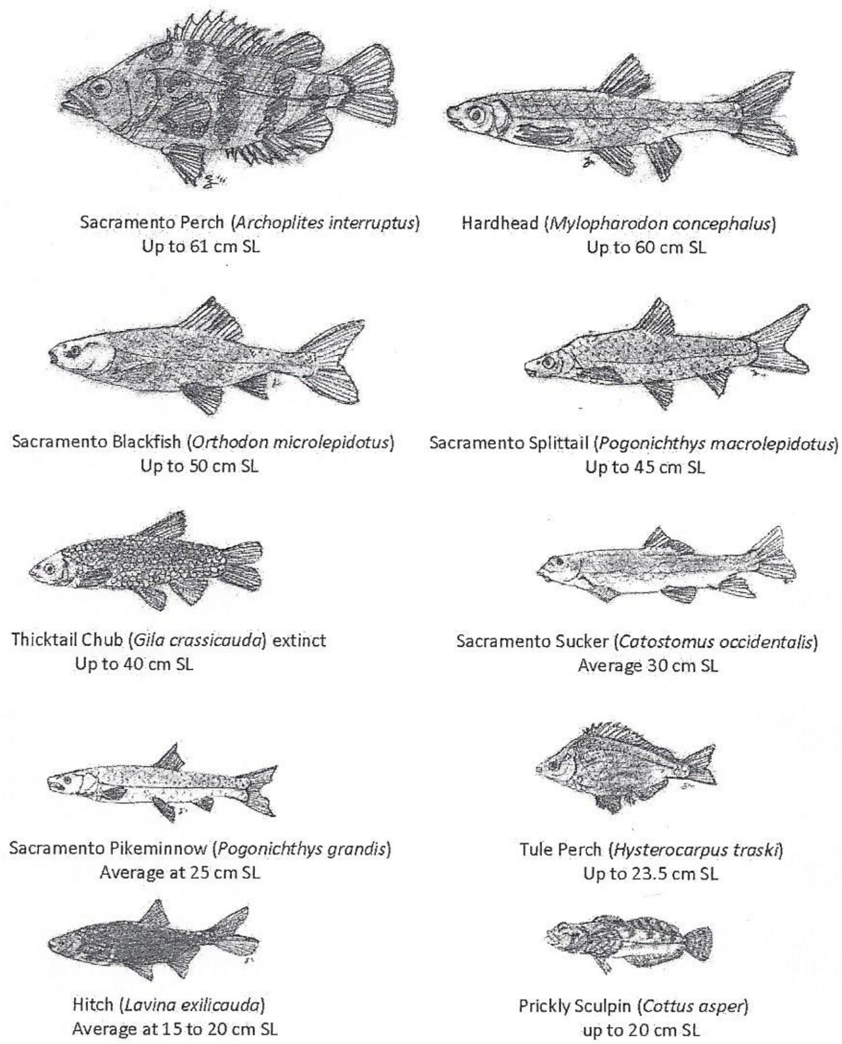


FIGURE 6.5B. Illustrations of native fish of the Cosumnes River found in the study area. SL = standard length. Illustrations not to scale (drawn by Emilie Zelazo).

the normal ⅛-inch screening methods used by archaeologists during excavation. There is ethnographic information citing Pacific lamprey capture and utilization (Barrett and Gifford 1933; Levy 1978), but no information concerning Native American usage of Central Valley prickly sculpin within the study area is available at this time. Therefore, only the Pacific lamprey will be included in the remaining discussion.

Currently, only a fall run of Chinook salmon (*Oncorhynchus tshawytscha*) is observed on the Cosumnes (P. B. Moyle, personal communication, November 29, 2010; Yoshiyama et al. 1996, 1998; Yoshiyama et al. 2001). Salmon require high flows for migration, and due to low-elevation drainage, the Cosumnes River only has suitable flows during late fall rains (Yoshiyama et al. 2001). Further, there is no indication, historically or otherwise, that a spring run of Chinook salmon ever occurred here. Thus, a fall run of Chinook salmon is assumed for Plains Miwok occupation of the Cosumnes River.

Three different types of fish habitats could be found at varying degrees throughout the year within the study area. Habitat settings are based both on the variation of river discharge between seasonal high flows and seasonal low flows and on the interspersion of upland, wetland, and aquatic habitats within the larger floodplain (Moyle et al. 2007). When combined, the three fish habitat settings for the study area are described as slow water, such as sloughs, marshes, lakes, and seasonal floodplains; fast water, such as those associated with the continuous flowing waters of riparian habitats; and varied water flow conditions containing both fast and slow water.

Native slow-water fish found in the archaeological record of the Lower Cosumnes River watershed are tule perch (*Hysterocarpus traski*), Sacramento perch (*Archoplites interruptus*), thicktail chub (*Gila crassicauda*), hitch (*Lavina exillicauda*) and Sacramento blackfish (*Orthodon microlepidotus*). Fast-water fish found include Pacific lamprey (*Entosphenus tridentatus*), hardhead (*Mylopharodon conocephalus*), fall-run Chinook salmon (*Oncorhynchus tshawytscha*), white sturgeon (*Acipenser transmontanus*), and green sturgeon (*Acipenser medirostris*). Fish preferring varied settings include Sacramento sucker (*Catostomus occidentalis*), Sacramento splittail (*Pogonichthys macrolepidotus*), and Sacramento pikeminnow (*Ptychocheilus grandis*); the Sacramento pikeminnow has also been referred to as the Sacramento squawfish.

All of these fish are found today in the Cosumnes River Preserve except Sacramento perch, which are no longer present throughout their native range but have been introduced elsewhere, and the thicktail chub, which is now extinct (Cosumnes River Preserve 2007; McGinnis 2006; Moyle, personal communication, November 29, 2010). Table 6.2 lists each of these native fish, their current status, pertinent characteristics, and the habitats they prefer throughout their life stages.

TABLE 6.2. Cosumnes River Native Fish Habitat Requirements.

Common Name	Scientific Name	Status	Setting	Adults
White sturgeon	*Acipenser transmontanus*	Healthy	Fast water	Bay, estuary, river
Green sturgeon	*Acipenser medirostris*	Threatened	Fast water	Ocean, river
Chinook (king) salmon	*Oncorhynchus tshawytscha*	Special concern	Fast water	Ocean, river
Pacific lamprey	*Entosphenus tridentatus*	Watch	Fast water	Various freshwater, estuary
Sacramento sucker	*Catostomus occidentalis*	Healthy	Varied	Various freshwater
Hardhead	*Mylopharodon conocephalus*	Watch	Fast water	River, stream
Sacramento blackfish	*Orthodon microlepidotus*	Healthy	Slow water	Delta sloughs, various freshwater
Hitch	*Lavinia exilicauda*	Watch	Slow water	Estuary, slow-flow freshwater
Sacramento pikeminnow	*Ptychocheilus grandis*	Healthy	Varied	Various freshwater
Sacramento splittail	*Pogonichthys macrolepidotus*	Special concern	Varied	Various freshwater, estuary, alkaline lakes
Thicktail chub	*Gila crassicauda*	Extinct	Slow water	Delta sloughs, backwaters, floodplain lakes
Sacramento perch	*Archoplites interruptus*	Special concern	Slow water	Various freshwater, saline and alkaline waters
Tule perch	*Hysterocarpus traski*	Healthy	Slow water	Estuary, various freshwater

Standard Length (cm)	Spawning (Eggs Laid)	Type of Spawning	Juveniles	Spawning Season	Present in Study Area Archaeology
Up to 300	River	Broadcast	Estuary	Late winter to summer	Yes, as general sturgeon
[illegible]	River	Broadcast	River, estuary	Spring to early summer	Yes, as general sturgeon
Up to 100	Stream, river	Nest	River, flood-plain, estuary	Fall to winter	Yes
Up to 76	Stream, river	Nest	Estuary	Spring to early summer	No
Average at [illegible]	Stream, some lakes	Broadcast	Stream, river margins, floodplain	Spring (use floodplain late in flood cycle in May)	Yes
Up to 60	Stream	Broadcast	Shallow stream margins, backwaters, floodplains	Spring	Yes
Up to 50	Lakes, rivers, backwaters, floodplain	Broadcast	Shallow lake, floodplains, river margins	Spring to early summer	Yes
Average at 15 to 20	Stream	Broadcast	Stream, lake margins, marsh, floodplains	Spring to early summer	Yes
Average at 25	Stream	Broadcast	Stream, river	Spring	Yes
Up to 45	Floodplain	Broadcast	Floodplain, sloughs	Late winter to early summer	Yes
Up to 40	Delta sloughs, floodplain	Broadcast	Unknown; assumed sloughs, shallow river margins, floodplain	Unknown; assumed spring	Yes
Up to 61	Shallow sloughs, river and lake margins, floodplain	Nest	Shallow river and lake margins, floodplain	Spring to summer	Yes
Up to 23	Live birth; various fresh-water, estuary	Live birth	Various freshwater, estuary	Summer	Yes

Habitat Utilization by Fish Life Stages

We hypothesize that traditional resource management enhanced floodplain habitats in a way that optimized conditions for juvenile fish. Table 6.2 lists the habitats used during the three life stages of native fish found in the archaeological and ethnographic record of the study area. The three life stages of native fish are (1) the spawning and egg-laying stage, (2) the fry or juvenile stage, and (3) the adult stage. Floodplains are used by many of these fish for growth and development in the juvenile stage, which is generally the most vulnerable point in native fish's life cycle.

It is important to note that floodplains must retain a passage to and from the fluvial systems that supply them. Within the study area, natural breaks found in the river levees provided fish passage. These breaks allow the exchange of fresh oxygenated water, keeping the floodplain ecosystem productive and healthy for juvenile fish (Moyle et al. 2007). Floodplain passageways also provide egress for older juvenile fish later in the year, preventing stranding and death as floodplains desiccate. The utilization of traditional resource-management practices such as burning enhanced floodplain rearing habitats by removing senescent vegetation, burning organic material in the upper soil layers, enhancing macroinvertebrate populations, and maintaining fish passage. Thus, traditional management practices enhanced fish growth and productivity, as well as reducing fish mortality.

A floodplain habitat is crucial to various stages of native California fish. Several native fish utilize the floodplain for spawning, and one native fish, the Sacramento splittail, is an obligate floodplain spawner. Endemic river spawners in the study area prefer to spawn upstream of floodplains, thereby allowing downstream currents to deliver their young to the floodplain for development in large numbers (Moyle et al. 2007). Twelve of the 14 native fish spawn within the spring months when the rainy season peaks and snowpacks begin to melt (see Table 6.2).

Native fish also have ecologically segregated life stages, which allow eggs, juveniles, and adult fish to exploit separate environments. This segregation reduces competition and predation and provides opportunities for increased growth and development. Floodplains provide an optimal nursery environment for the growth and development of young fish—and therefore a greater survival rate. Young fish of fast-water habitats enter the floodplain as larvae or small juveniles; these juveniles usually enter the floodplain early in the flooding cycle (early spring) in order to take advantage of zooplankton and large insect larvae. For example, Chinook salmon reared on Central Valley floodplains grew faster and achieved larger sizes than fish reared in the main river (Jeffres et al. 2008). Juvenile species of slow-water fish also have substantially faster growth and higher survival rates when they move to the floodplain late in the flood cycle as the water becomes warmer (Moyle et al. 2007).

The characteristics of high fecundity and large body size indicate that the environmental conditions present in California river floodplains are optimal for the growth and development of native fishes (Moyle 2002). Further, native fish have the ability to know when to leave the floodplain and avoid becoming stranded when floodplain pools dry up. Alien species lack this adaptation (Moyle 2002; Moyle et al. 2007).

The Archaeological Ichthyofaunal Record of the Cosumnes

Faunal remains from the study area's archaeological deposits dated from 5000 BP up to the historic era (ca. 1848) confirm that many of the historically observed fauna were also important to the prehistoric indigenous people's diet. In general, the archaeological and ethnographic record reveals that a wide variety of plants and animals were being consumed, including large amounts of grass seeds, roots, greens, insects, small mammals, waterfowl, and fish (Bennyhoff 1977). Salmon may be the most important and common fish cited, but direct archaeological evidence shows that many other different fish species made up the bulk of the indigenous diet in the study area. It has been estimated that fish species may have provided more than a third of the protein intake for most delta populations (Pierce 1988).

Fish remains from several archaeological sites occupied by the Plains Miwok located within the Lower Cosumnes River watershed can be used to help reconstruct the past ecology of the study area and serve as a reference to the mosaic of prehistoric delta ecological habitats. For this study, we have selected four Late period archaeological sites with well-preserved ichthyofaunal records to represent the study area. These sites are CA-SAC-329, CA-SAC-265, CA-SAC-267, and CA-SAC-133. Because the amount of ichthyofaunal remains identifiable to species varied at each site, percentages rounded to the nearest whole number will be used to discuss relative abundance. Figure 6.3 depicts an overview of the archaeological

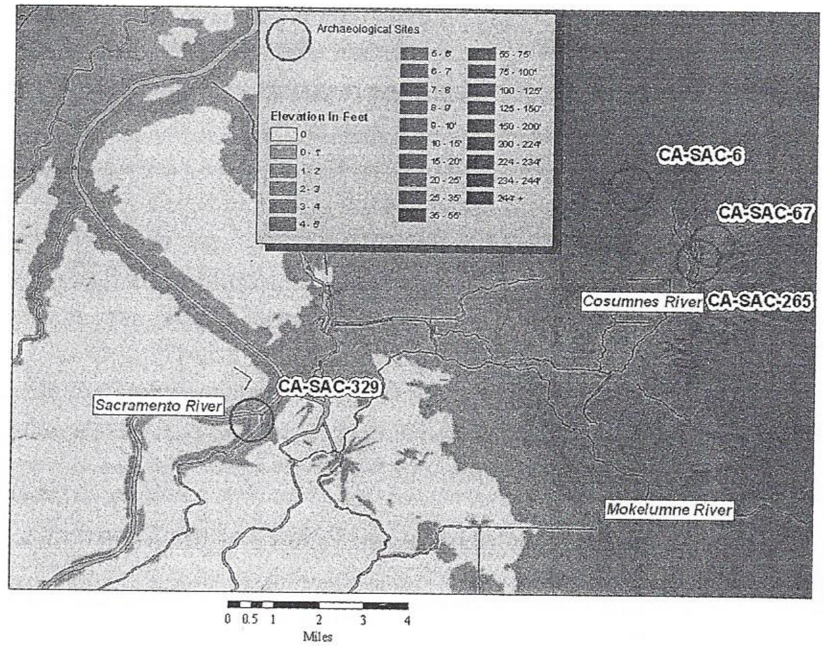


FIGURE 6.6. Site CA-SAC-329.

sites within the study area, and Figures 6.6 through 6.8 depict the general locations of each site discussed in this study.

CA-SAC-329

CA-SAC-329 is located on the southern bank of the Sacramento River at its junction with Georgiana Slough, within the historic confluence of the Cosumnes and Mokelumne rivers (see Figure 6.6). This site is described as a seasonal camp and is associated with a tule marsh habitat (Pierce 1988; Soule 1976). Occupation is dated from approximately AD 780 to 1600.

The faunal remains from this site show a predominance of slow-water fish species (see Figure 6.9). Sacramento perch composes more than half of the assemblage. Thicktail chub is the next most common species in the archaeological record, followed by Sacramento sucker and hitch. No salmon and very few sturgeon are accounted for. The location of CA-SAC-329, near a slough and marsh with a sandy substrate and away from the gravelly substrates of the upstream seasonal spawning grounds, could explain why salmon and sturgeon are underrepresented at this site. CA-SAC-329 is also the only site with tule perch remains, reflecting the lowland habitat preference of this species.

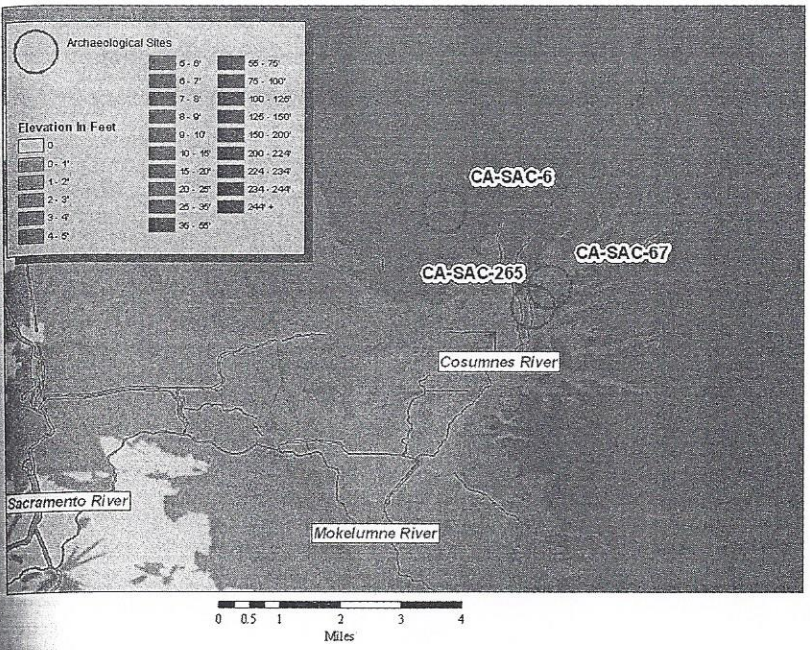


FIGURE 6.7. Site CA-SAC-265.

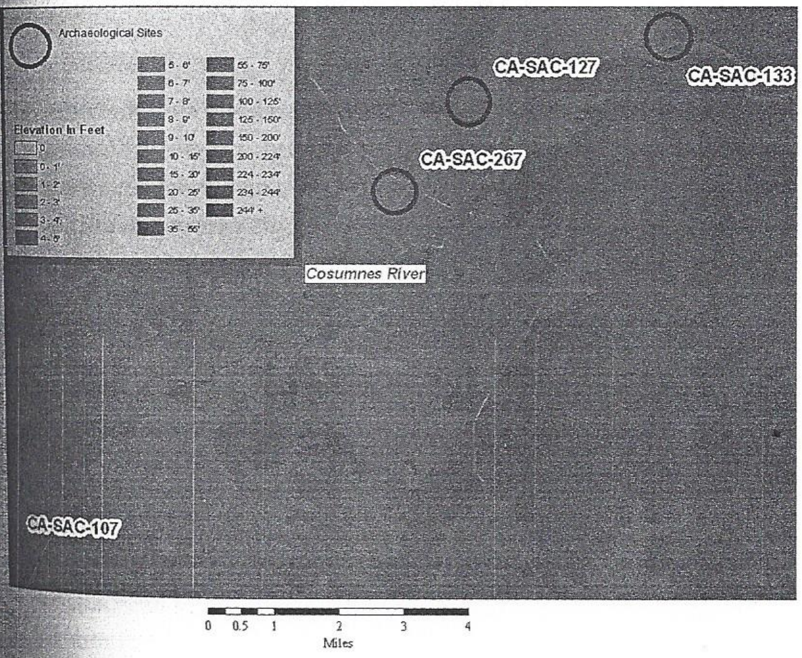
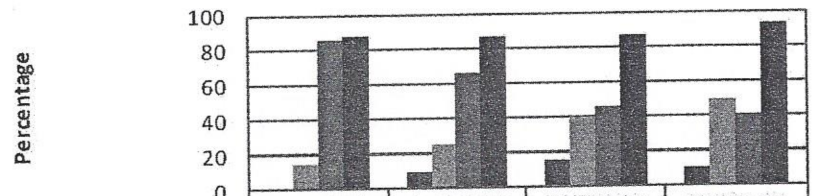


FIGURE 6.8. Sites CA-SAC-267 and CA-SAC-133.



	CA-SAC-329	CA-SAC-265	CA-SAC-267	CA-SAC-133
Fast-Water	1	9	15	10
Varied Setting	14	25	39	49
Slow-Water	85	66	46	41
Floodplain Juveniles	88	87	87	93

FIGURE 6.9. Fish species composition by site.

An assemblage dominated by slow-water fish species is consistent with the location of CA-SAC-329; 85 percent of the fish represented are slow-water fish. As stated above, the growth and development of juvenile native fish are enhanced when they can utilize floodplain resources. An examination of the fish assemblage species composition reveals that 88 percent of the fish assemblage represented at CA-SAC-329 most likely utilized the floodplains in their juvenile stage.

The predominance of Sacramento perch remains in the ichthyofaunal assemblage indicates that the species composition within the vicinity of Georgiana Slough has changed over time. Today Sacramento perch are no longer present here and are a species of special concern for California. The decline of this species is due to a combination of factors, including habitat destruction (particularly the draining of sloughs), reduction of aquatic plant beds, embryo predation by introduced species, and competition for food and space with other introduced species (Moyle 2002).

CA-SAC-265

CA-SAC-265 is described as a specialized fishing camp located on the south bank of Laguna Creek, just north of its confluence with the Cosumnes River (see Figure 6.7; Sheeders 1982). This location is a low-elevation grasslands habitat bordered by a large expanse of seasonal floodplains and sloughs. Before current conditions, this site would have been adjacent to the terminus of the tidal flood basin (Moyle et al. 2003).

The ichthyofaunal assemblage from CA-SAC-265 is slightly more varied than that from CA-SAC-329. Although it is still dominated by slow-water fish (66 percent), fast-water species constitute 9 percent of the assemblage, and varied-setting species compose 25 percent of the assemblage. The fish remains from CA-SAC-265 are dominated by Sacramento perch, followed by equal amounts of thicktail chub and Sacramento sucker. Other minnow species follow. Salmon are also present but only make up less than 5 percent of the assemblage. The habitat preferences of the fish species identified indicate that CA-SAC-265 was located at the interface of slow-water and fast-water environments. Species that would have utilized the floodplains as juveniles compose 87 percent of the CA-SAC-265 assemblage.

CA-SAC-267

CA-SAC-267 most likely represents the remains of a large village or ceremonial center. The site is located on a knoll along the edge of a high terrace just west of the Cosumnes River, 14 miles north of CA-SAC-265 (see Figure 6.8). The site contains the remains of several large cooking features, house pits, and a probable dance house (Johnson 1976). The site was occupied from approximately AD 500 until sometime between 1830 and 1840 (Morgan 2001).

The species composition for CA-SAC-267 indicates that the inhabitants were obtaining fish from a variety of habitats. Fish remains are dominated by Sacramento sucker, followed by Sacramento perch and Chinook salmon. The increase in salmon remains and in fast-water species in general is noteworthy. Together these species compose 15 percent of the assemblage, a figure almost double that found at CA-SAC-265. Despite this variety, 87 percent of the fish species found at CA-SAC-267 likely used floodplains as juveniles, supporting the assumption that healthy floodplains would have benefited multiple species of native fish.

CA-SAC-133

Although the archaeological deposit at CA-SAC-133 is slightly older than the previous sites discussed (AD 670–820), its archaeological assemblage is still relevant to our discussion. CA-SAC-133 is a village site located on a small mound adjacent to the Cosumnes River near the community of Sloughhouse, at the edge of the Sierra Nevada foothills. This location is above the floodplain formed by the Cosumnes River on the east and Deer

Creek on the west (see Figure 6.8). Similar to the case in other sites in the study area, 93 percent of the fish species represented most likely utilized the floodplain as juveniles.

The fish assemblage of CA-SAC-133 is 49 percent varied-setting species, the majority of which are Sacramento sucker. The amount of slow-water species is almost equal to that of varied-setting species, while fast-water species, the majority of which are Chinook salmon, represent only 10 percent of the assemblage. This result is unexpected because historical records document that the Chinook salmon migration went 34 miles up the Cosumnes and the best spawning beds were reported to be between Sloughhouse and Bridgehouse, located upstream to the west (Cosumnes, American, Bear, and Yuba Integrated Regional Water Management Plan 2010; Yoshiyama et al. 2001). Regardless of this finding, the fish species represented at CA-SAC-133 reflect the varied geographic placement of the site at an area where the Cosumnes River becomes more channelized and swifter but is also bordered by a large floodplain.

Conclusions: Reciprocal Relationships and the Water–People–Fish Connection

Based on this synthesis of multiple sources of information, traditional resource management of the riparian floodplain appears to have helped optimize habitat conditions for California native fish species, contributing to their ability to adapt to fluctuating environmental conditions and supply one-third of the study area population's diet for at least 1,100 years. The loss of traditional tending practices, compounded by widespread degradation of habitat, alteration of flows, and introduction of exotic species, has resulted in the catastrophic decline of most California native fish species. Minnows and other native fish that were originally abundant in lowland lakes, freshwater marshes, sloughs, and slow-moving sections of the river have diminished significantly from pre-European settlement numbers or disappeared. Just over 50 percent of the fish species present within the archaeological record for the study area are now either on watch status, threatened, of special concern, or extinct. The Sacramento perch, which composed 49 percent of the entire archaeological ichthyofaunal record presented here, is no longer present within the study area. The thicktail chub, which composed 13 percent of all the assemblages, is now extinct.

Chinook salmon and Pacific lampreys, which are profusely referred to in the ethnographic record, are listed as species of special concern and on watch status, respectively. Recent research has shown that salmon reared in seasonally inundated habitats, such as floodplains, with annual vegetation have higher growth rates (Jeffres et al. 2008; Sommer et al. 2001a; Sommer et al. 2001b). Such floodplains may have been available in areas adjacent to the Cosumnes River during prehistoric times; burning techniques practiced by Native Californians would have likely enhanced optimal habitats. Today, Chinook salmon have only recently returned to the Cosumnes River because restoration efforts have reestablished suitable habitats (Moyle et al. 2007). The return of salmon to the Cosumnes River does not negate the fact that the salmon runs traditionally managed and used as resources by Native Californians were extirpated after 1988.

The extent of burning as a keystone management tool in the indigenous landscape has been well documented (Anderson 2005; Hankins 2005; Lewis 1973; Martinez 2000, 2002; Vahti and Greco 2007). Burning of the floodplains within the study area not only helped rejuvenate vegetation stands important for the production of the indigenous material culture but also rejuvenated and nourished the soils and kept the floodplain clean and clear for the growth and development of juvenile fish. For over 90 percent of the fish considered in this discussion, a deep, open, oxygenated floodplain saturated with spring waters and teaming with insect larvae would have been an optimal environment for the rearing of juvenile fish: "Burning and grazing of tules was probably good for fish; the ranchers used to do this along Suisun Marsh, keeping areas open and more floodable at high tides" (Moyle, personal communication, November 29, 2010). Such a practice reflects a lesson already learned and well practiced by California's indigenous population.

In the timeless past, Miwok ancestors cared for and managed their ecosystem and conducted specific world-renewal ceremonies. We present our information in recognition and in honor of the California Indian cultures in the Cosumnes River watershed—namely, the Ione Band of Miwok Indians, the Sierra Native American Council, and the California Indian Basketweavers Association. We also recommend that this information be used for the conservation of native California fish species, for resource management of the Cosumnes River and the Sacramento–San Joaquin Delta, and as a template for cultural and ecological restoration of this valuable habitat complex.

Acknowledgments

We would like to thank Dr. Peter Moyle and Dr. Ron Yoshiyama, University of California, Davis, for their invaluable assistance and knowledge on fish ecology and historic ecology. We would also like to thank Scott Tidball, California State University, Sacramento, environmental studies student, for geographic information system data and help with Figures 6.1–6.4, 6.6–6.8. And we would like to thank Sandra Varela, California State University, Sacramento, student, for help with Table 6.2.

References Cited

Anderson, M. K.

1993 *Indian Fire-Based Management in the Sequoia–Mixed Conifer Forests of the Central and Southern Sierra Nevada*. Final report for cooperative agreement no. 8027-2-002. On file at the Yosemite Research Center, Yosemite National Park.

2005 *Tending the Wild: Native American Knowledge and the Management of California's Cultural Resources*. Berkeley: University of California Press.

Barrett, S. A., and E. W. Gifford

1933 Miwok Material Culture. *Bulletin of Milwaukee Public Museum* 2(4):117–276.

Bates, C. D., and M. J. Lee

1990 *Tradition and Innovation: A Basket History of the Indians of the Yosemite–Mono Lake Area*. Yosemite National Park: Yosemite Association.

Bennyhoff, J. A.

1977 *The Ethnogeography of the Plains Miwok*. Center for Archaeological Research at Davis Publication no. 5. Davis: University of California.

Berkes, F.

1999 *Sacred Ecology: Traditional Ecological Knowledge and Resource Management*. Philadelphia: Taylor and Francis Publishing.

Berkes, F., J. Colding, and C. Folke

2000 Rediscovery of Traditional Ecological Knowledge as Adaptive Management. *Ecological Applications* 10(5):1251–1262.

Bibby, B.

1996 *The Fine Art of California Indian Basketry*. Sacramento: Crocker Art Museum; and Berkeley: Heyday Books.

Blackburn, T. C., and K. Anderson, eds.

1993 *Before the Wilderness: Environmental Management by Native Californians*. Menlo Park: Ballena Press.

Bouey, P. D., and S. A. Waechter

1992 *Final Report on Phase II Test Excavations at CA-SAC-133 near Sloughhouse, Sacramento County, California*. Report prepared by the Far Western Anthropological Group, Davis, for contract no. 03G196/Task Order 1, December.

On file at the California Department of Transportation, District 3, Sacramento.

Central Valley Historic Mapping Project

1999 Pre-1900 (Base Map). Electronic document, http://www.gic.csuchico.edu/historic/4_1.html, accessed September 26, 2010.

Cook, S. F.

1956 *The Population of the California Indians, 1796–1970*. Berkeley: University of California Press.

Cosumnes, American, Bear, and Yuba Integrated Regional Water Management Plan

2010 Salmon and Steelhead in CABY Region Watersheds. Electronic document, http://cabyregion.org/projects-1/work-groups/fish-passage-and-habitat-improvement-project-development/western-placer-creeks-documents/salmon-and-steelhead-in-the-caby-region-watersheds/, accessed September 26, 2010.

Cosumnes River Preserve

2007 Cosumnes River Fish Species List. Electronic document, http://www.cosumnes.org/flora_fauna/Fish.pdf, accessed September 26, 2010.

2010a About Cosumnes River Preserve. Electronic document, http://www.cosumnes.org/about_crp/index.html, accessed September 19, 2010.

2010b Cosumnes River Fish Species List. Electronic document, http://cosumnes.org/documents/fish.pdf, accessed October 12, 2010.

Egan, D., and E. A. Howell, eds.

2001 *The Historical Ecology Handbook: A Restorationist's Guide to Reference Ecosystems*. Washington, DC: Society for Ecological Restoration, Island Press.

Golla, V.

2007 Linguistic Prehistory. In *California Prehistory: Colonization, Culture, and Complexity*. T. L. Jones and K. A. Klar, eds. Pp. 71–82. Plymouth, UK: AltaMira Press.

Grossinger, R. M.

2001 Documenting Local Landscape Change: The San Francisco Bay Area Historical Ecology Project. In *The Historical Ecology Handbook: A Restorationist's Guide to Reference Ecosystems*. Dave Egan and Evelyn A. Howell, eds. Pp. 425–442. Washington, DC: Island Press.

Grossinger, R. M., R. A. Askevold, and C. J. Striplen

2006 *Coyote Creek Watershed Historical Ecology Study: Historical Condition, Landscape Change, and Restoration Potential in the Eastern Santa Clara Valley, California*. San Francisco Estuary Institute Report no. 426. Report prepared for the Santa Clara Valley Water District, Oakland. Electronic document, http://www.sfei.org/sites/default/files/executive_summary_8.5x11_CoyoteCk_HE_SFEI_2006.pdf.

Hankins, D.

2005 Pyrogeography: Spatial and Temporal Relationships of Fire, Nature, and Culture. Unpublished Ph.D. dissertation, University of California, Davis.

Heady, H. F.

1988 Valley Grassland. In *Terrestrial Vegetation of California: New Expanded Edition*. Michael G. Barbour and Jack Major, eds. Pp. 491–514. California Native Plant Society Special Publication no. 9. Sacramento.

Jeffres, C. A., J. J. Opperman, and P. B. Moyle

2008 Ephemeral Floodplain Habitats Provide Best Growth Conditions for Juvenile Chinook Salmon in a California River. *Environmental Biology of Fishes* 83:449–458.

Johnson, J. J., ed.

1976 *Archaeological Investigations at the Blodgett Site (CA-SAC-267), Sloughhouse Locality, California*. Report on file at the North Central Information Center, Sacramento.

Katibah, E. F.

1984 A Brief History of Riparian Forests in the Central Valley of California. In *California Riparian Systems: Ecology, Conservation and Productive Management*. R. E. Warner and K. M. Hendrix, eds. Pp. 23–29. Berkeley: University of California Press.

Kroeber, A. L.

1925 *Handbook of the Indians of California*. Bureau of American Ethnology Bulletin 78. Washington, DC.

Latta, F. F.

1977 *Handbook of Yokuts Indians*. Santa Cruz, CA: Bear State Publishers.

Levy, R.

1978 Eastern Miwok. In *Handbook of North American Indians, vol. 8: California*. R. F. Heizer, ed. Pp. 398–413. Washington, DC: Smithsonian Institution.

Lewis, H. T.

1973 *Patterns of Indian Burning in California: Ecology and Ethnohistory*. Ramona, CA: Ballena Press.

Lindstrom, S.

1992 Great Basin Fisherfolk: Optimal Diet Breadth Modeling the Truckee River Aboriginal Subsistence Fishery. Unpublished Ph.D. dissertation, University of California, Davis.

Martinez, D.

2000 Traditional Ecological Knowledge, Ecosystem Science, and Environmental Management. *Ecological Applications* 10(5):1249–1250.

2002 *Traditional Indian Burning, Fire Hazard Reduction and Restoration Forestry*. Mendocino, CA: New Settler.

McGinnis, S. M.

2006 *Field Guide to Freshwater Fishes of California*. Berkeley: University of California Press.

Merrill, R. E.
1923 Plants Used in Basketry by the California Indians. *University of California Publications in American Archaeology and Ethnology* 20:215–242.
Morgan, S. M.
2001 Biological Distance Study of Four Late Horizon Central California Populations. Unpublished M.A. thesis, California State University, Sacramento.
Mount, J. F.
1995 *California Rivers and Streams: The Conflict between Fluvial Process and Land Use.* Berkeley: University of California Press.
Mount, J. F., G. E. Fogg, L. Kavvas, J. H. Fleckenstein, M. Anderson, Z. Chen, and E. Suzuki
2001 *Linked Surface Water Groundwater Model for the Cosumnes River Watershed: Hydrologic Evaluation of Management Options to Restore Fall Flows.* Final report, U.S. Fish and Wildlife Service, cooperative agreement no. 11332-8-J264. Sacramento.
Moyle, P. B.
2002 *Inland Fishes of California.* Rev. and expanded edition. Berkeley: University of California Press.
Moyle, P. B., P. K. Crain, and K. Whitener
2007 Patterns in the Use of a Restored California Floodplain by Native and Alien Fishes. *San Francisco Estuary and Watershed Science* 5(3):1–27. Electronic document, http://escholarship.org/uc/item/6fq2f838.
Moyle, P. B., P. K. Crain, K. Whitener, and J. Mount
2003 Alien Fishes in Natural Streams: Fish Distribution, Assemblage Structure, and Conservation in the Cosumnes River, California, USA. *Environmental Biology of Fishes* 68:143–162.
Pierce, P.
1988 A Geoarchaeological Analysis of the Prehistoric Sacramento–San Joaquin Delta, California. Unpublished M.A. research paper, University of California, Davis.
Powers, S.
1877 *Tribes of California.* Contributions to North American Ethnology, vol. 3. Washington, DC: Government Printing Office.
Salmón, E.
2000 Kincentric Ecology: Indigenous Perceptions of the Human–Nature Relationship. *Ecological Applications* 10:1327–1332.
Sheeders, D. J.
1982 An Archaeological Analysis of the Whaley Site, CA-SAC-265. Unpublished M.A. thesis, California State University, Sacramento.
Sommer, T. R., B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel
2001a California's Yolo Bypass: Evidence that Flood Control Can Be Compatible with Fisheries, Wetlands, Wildlife, and Agriculture. *Fisheries* 26:6–16.

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer
2001b Floodplain Rearing of Juvenile Chinook Salmon: Evidence of Enhanced Growth and Survival. *Canadian Journal of Fisheries and Aquatic Science* 58:325–333.

Soule, W. E.
1976 Archaeological Excavations at SAC-329 near Walnut Grove, Sacramento County, California. Unpublished MS on file at the Archaeological Research Center, California State University, Sacramento.

Stevens, M. L.
1999 The Ethnoecology and Autecology of White Root (*Carex barbarae*): Implications for Restoration. Unpublished Ph.D. dissertation, University of California, Davis.
2003 The Contribution of Traditional Resource Management (TRM) of White Root (*Carex barbarae Dewey, Cyperaceae*) by California Indians to Riparian Ecosystem Structure and Function. In *California Riparian Systems: Processes and Floodplain Management, Ecology, and Restoration*. 2001 Riparian Habitat and Floodplains Conference Proceedings. P. M. Faber, ed. Pp. 502–511. Sacramento: Riparian Habitat Joint Venture.
2004a Ethnoecology of Selected California Wetland Plants. *Fremontia* 32(4):7–13.
2004b White Root (*Carex barbarae*). *Fremontia* 32(4):3–6.

Stewart, O. C., H. T. Lewis, and K. Anderson
2002 *Forgotten Fires: Native Americans and the Transient Wilderness*. Norman: University of Oklahoma Press.

Swenson, R., K. Whitener, and M. Eaton
2003 Restoring Flood to Floodplains: Riparian and Floodplain Restoration at the Cosumnes River Preserve. In *California Riparian Systems: Processes and Floodplain Management, Ecology, and Restoration*. 2001 Riparian Habitat and Floodplains Conference Proceedings. P. M. Faber, ed. Pp. 224–229. Sacramento: Riparian Habitat Joint Venture.

Thompson, K.
1961 Riparian Forests of the Sacramento Valley, California. *Annals of the Association of American Geographers* 51(3):294–315.

U.S. Geological Survey
1979 *Water Resources Data for California, Water Year 1978, vol. 4: Northern Central Valley Basins and the Great Basin from Honey Lake to Oregon State Line*. U.S. Geological Survey Water Data Report CA-78-4. Sacramento.

Vahti, M. G., and S. E. Greco
2007 Riparian Vegetation of the Great Valley. In *Terrestrial Vegetation of California*. M. G. Barbour, T. Keeler-Wolf, and A. A. Schoenher, eds. Pp. 425–455. Berkeley: University of California Press.

West, G. J., W. Woolfenden, J. A. Wanket, and R. S. Anderson
2007 Late Pleistocene and Holocene Environments. In *California Prehistory: Col-*

onization, Culture, and Complexity. T. L. Jones and K. A. Klar, eds. Pp. 11–34. Plymouth, UK: AltaMira Press.

Wheeler, A., and A. K. G. Jones

1989 *Fishes*. Cambridge: Cambridge University Press.

Yamane, L., and D. Aguilar

1997 *Weaving a California Tradition: A Native American Basketmaker*. Minneapolis: Lerner Publications.

Yoshiyama, R. M., 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. Don C. Erman, ed., and the SNEP Team. Pp. 309–362. Davis: University of California Centers for Water and Wildland Resources.

1998 Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. *North American Journal of Fisheries Management* 18:487–521.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle

2001 Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California. In *Contributions to the Biology of Central Valley Salmonoids*, vol. 1. Randall L. Brown, ed. Pp. 71–176. State of California Department of Fish and Game Fish Bulletin 179. California Fish and Game, Sacramento.