HISTORICAL ECOLOGY
of the lower Santa Clara River, Ventura River, and Oxnard Plain:
an analysis of terrestrial, riverine, and coastal habitats

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HISTORICAL ECOLOGY PROGRAM
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Report and GIS layers are available on SFEI's website, at www.sfei.org/projects/VenturaHE.

Front cover, from left to right: Detail of cross section (by Jen Natali); 19th century Ventura River (Unknown ca. 1890, courtesy of the Museum of Ventura County); modern Santa Clara River (courtesy of Gretchen Coffman); diseño map (U.S. District Court ca. 1840c, courtesy of The Bancroft Library, UC Berkeley)

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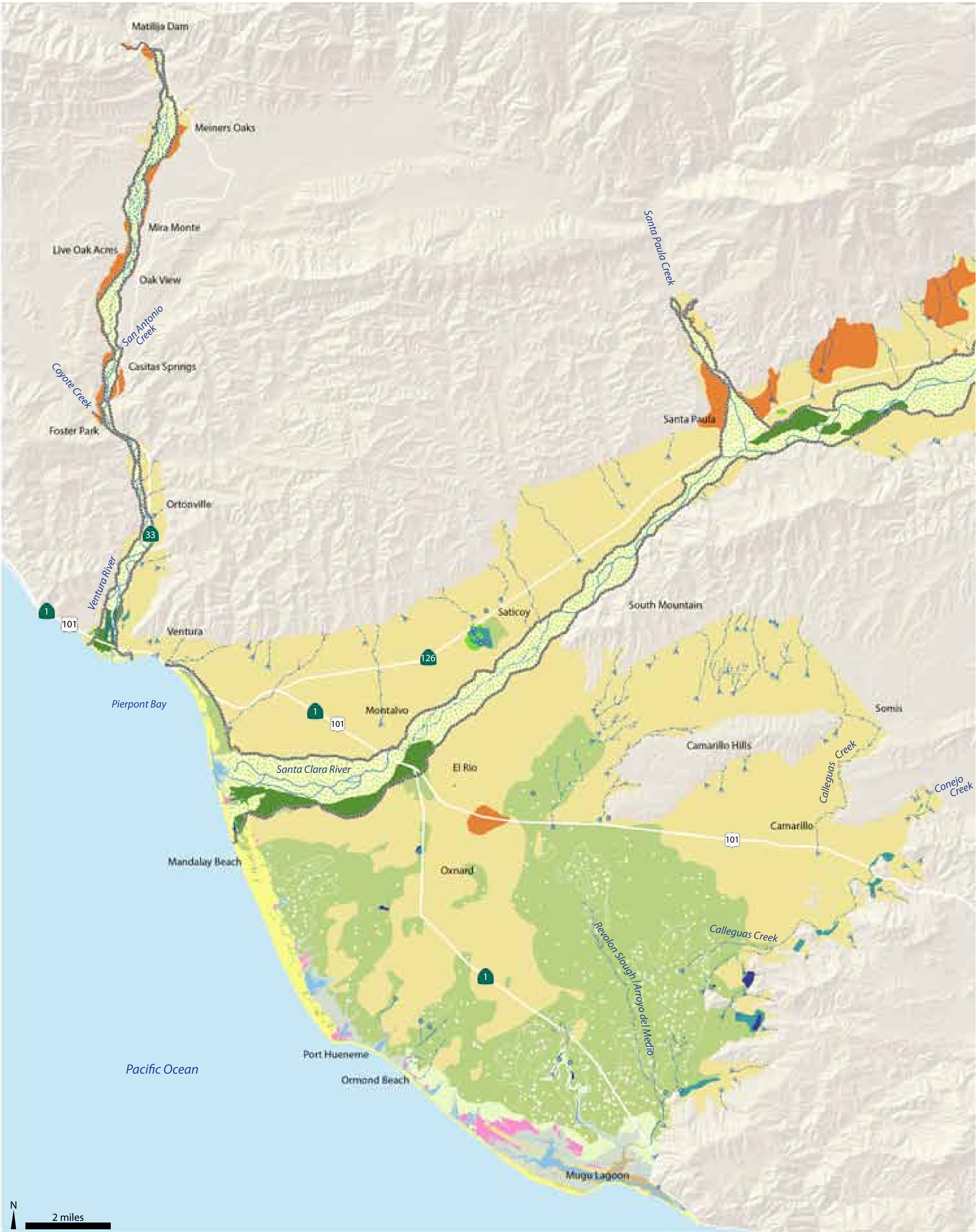
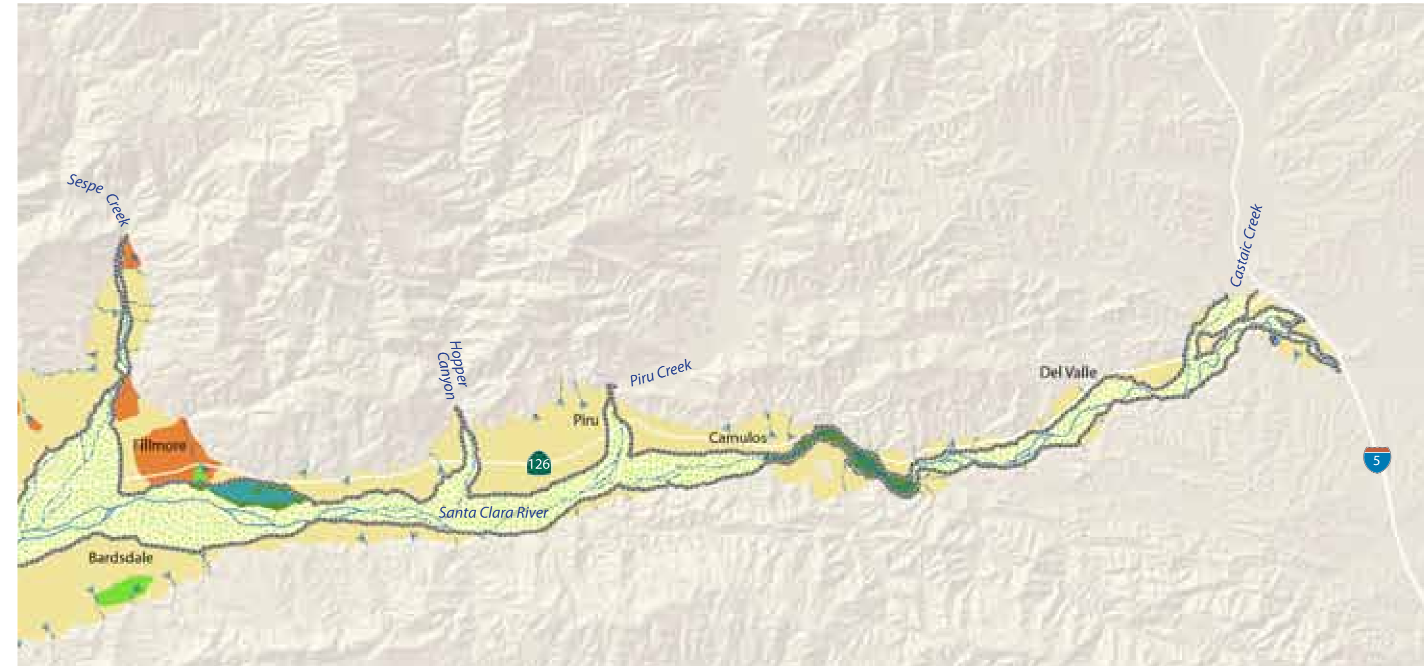




HISTORICAL CONDITIONS, EARLY 1800s

Coastal and Estuarine Habitats

- Ocean
- Beach/Dune
- Lagoon
- Tidal Flat
- Salt/Brackish Marsh and Tidal Marsh
- Salt Flat/Seasonal Pond/ Marsh Panne
- High Marsh Transition Zone

Palustrine and Terrestrial Habitat

- Perennial Freshwater Pond
- Valley Freshwater Marsh
- Willow Thicket
- Wet Meadow
- Alkali Meadow
- Alkali Meadow/Flat
- Oaks and Sycamores
- Grassland/Coastal Sage Scrub

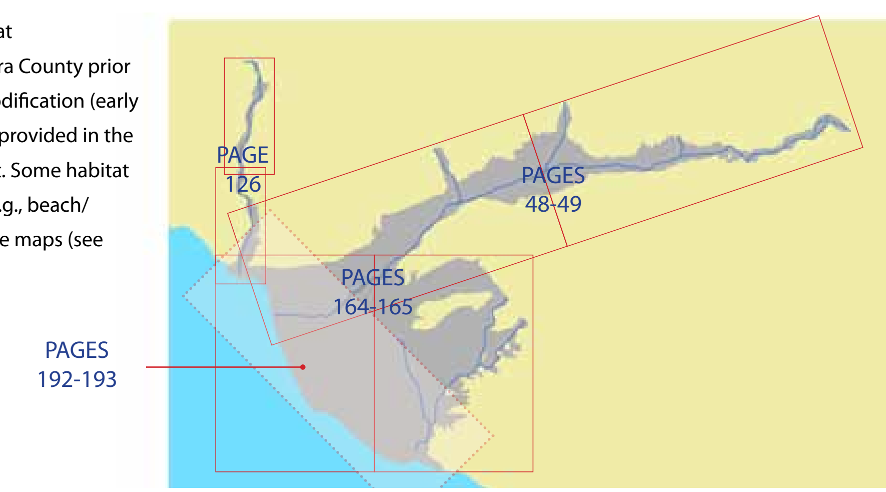
Characteristic Riparian Habitat

- Willow-Cottonwood Forested Wetland
- Other In-Channel Riparian

Hydrology

- Intermittent or Ephemeral
- Perennial
- Distributary
- Outer River Bank
- Spring

This map reconstructs the habitat characteristics of lowland Ventura County prior to significant Euro-American modification (early 1800s). More detailed views are provided in the map sections shown to the right. Some habitat classifications combined here (e.g., beach/dune) are separated in finer-scale maps (see pages at right).



Coastal Conservancy

The State Coastal Conservancy is proud to have funded this study of historical coastal wetlands, rivers, and other habitats of Ventura County. The project was led by the San Francisco Estuary Institute, the leading authority in the analysis of California coastal historical ecology. In this study, they have teamed with a number of experts on Southern California rivers and coastal wetlands, including Stillwater Sciences, Southern California Coastal Water Research Project, California State University Northridge, and other institutions.

This study uses history – namely, the interpretation and integration of historical documents with environmental sciences – to provide a new perspective on how the Ventura County landscape has changed since the early 19th century. Synthesizing over two centuries of local documents, this report and accompanying GIS layers significantly improve our understanding of the natural forces that have shaped the local landscape. The study provides guidelines and inspiration for improvement of the environmental health of this region, which is the goal of the Coastal Conservancy and the governmental agencies and conservation organizations who are our valued partners in Ventura County.

The work of the Coastal Conservancy is to protect, restore, and make accessible the lands and waters of the California coast. SFEI's study will assist us and our partners in several ways. First, it shows us what elements of Ventura County's natural heritage have been lost, and suggests where those might be recovered. Secondly, the study helps us understand the physical and ecological processes still influencing systems today, enabling us design more effective, cost-efficient projects. In fact, the study identifies a number of opportunities to take advantage of intact natural processes to make more self-sustaining projects. Finally, and perhaps most importantly, we hope this new information will involve the Ventura community in considering the natural history of their region and its potential for the future. What underlies the built environment of this area? Through this research, we can now discover and uncover what came before European settlement of Ventura County. Though it will never be the same again, much of this until-now forgotten landscape can be restored, along with the sights and sounds of the species that have long depended on it. These lessons from history can help us make our landscape healthier and more resilient in the coming decades.

This study is dedicated to the people of Ventura County, supporters and sustainers of our work together, so that they can better love and understand the place where they live.

Peter S. Brand

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State Coastal Conservancy

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CONTENTS

REGIONAL SUMMARY

Great changes have swept through Ventura County over the past 250 years. Willows and live oaks have been cut down, and eucalyptus and other non-native street trees have been planted. Wetlands have been drained and cultivated. Creeks have been straightened and connected to larger streams. Rivers have been hydrologically and ecologically altered by levees, flow diversions, and timber cutting, and have lost floodplain area to farms and cities.

Despite these changes, lowland Ventura County retains substantial high quality ecological resources, particularly in comparison to other, more urbanized, areas of coastal southern California. The two major rivers in the region—the Ventura and the Santa Clara—possess significant restoration potential. The Santa Clara River has remained unchannelized and relatively unregulated by dams, and as a result has retained much of its former reach-scale flow variability, geomorphic process, and riparian heterogeneity. The Ventura River, due in part to relatively limited urban development and floodplain encroachment, has also retained substantial portions of its former hydrologic and ecological patterns, despite the presence of Matilija and Casitas dams. Current management activities, such as the proposed removal of the dam and the Parkway projects ongoing on both rivers, recognize and take advantage of this potential.

This report documents the historical ecological and hydrological patterns and dynamics of the Ventura River valley, the lower Santa Clara River valley, the Oxnard Plain, and the Ventura County shoreline. To do so, we integrated hundreds of historical cartographic, textual, and visual accounts to create a heterogeneous but substantial dataset describing hydrologic, geomorphic, and riparian characteristics back to 1769—the date of the first non-native, land-based exploration of the region. These data were synthesized to provide detailed analysis of landscape-level pattern and process in the region prior to substantial Euro-American modifications, and to better understand the impacts of modifications over the past two and a half centuries. The goal of this process is to provide scientists and managers in Ventura County with detailed, readily accessible information about the region's historical ecological landscape, with particular focus on historical habitat patterns and riverine processes. (The report does not address the historical fauna of Ventura County in detail.)

Our findings reveal an ecologically diverse landscape, with vegetation and drainage patterns reflective of both underlying, long-term physical drivers and temporally and spatially dynamic processes. Valley floor habitats were relatively dry overall, with extensive open grasslands and scrublands predominating in the Santa Clara River valley, lower Ventura River valley, and large portions of the Oxnard Plain. Live oaks and sycamores colonized terraces in the Ventura River valley, in addition to many alluvial fan surfaces north of the Santa Clara River. With few exceptions (notably, Saticoy Springs), non-riparian wetlands were concentrated on the Oxnard Plain. This included coastal brackish and saline wetlands, freshwater ponds and marshes along the eastern foothills in the Calleguas Creek watershed, and (comprising the great majority of the total) the seasonal alkaline wetlands of the Oxnard Plain.

Wetland distribution on the plain has been largely shaped by the migration of the Santa Clara River over geologic time: the river deposited sediments that formed higher and drier zones above the alkaline lowland, which were colonized by grassland and scrub. This migration also created a pattern of coastal lagoon systems along the shoreline, leaving a legacy of perched and closed lagoons marking former river mouths (and separated from the ocean by dunes whose sediment was largely supplied by the river). At least three types of coastal estuarine systems are represented on the Ventura shoreline: seasonally or intermittently closing freshwater-brackish estuaries associated with the Santa Clara and Ventura river mouths, dune-dammed non-tidal lagoons associated with now-abandoned Santa Clara River mouths, and the large, more open wetland system at Mugu. These features formed a near-continuous sequence of coastal wetlands from Mugu Lagoon all the way to the Ventura River mouth: the eastern edge of the Ventura River floodplain was separated from the northwestern edge of the Santa Clara River floodplain (today's Ventura Marina area) by less than one mile.

Then as now, the Santa Clara River dominated the region; even its delta (the Oxnard Plain) was referred to as the lower Santa Clara River valley in the 19th century. Geologic and climatic parameters influenced the river's form and flow, creating a stream with reach-scale variability in channel morphology and the presence of summer surface water. In turn, these elements were linked to heterogeneous riparian patterns along the river, with nodes of broad willow-cottonwood riparian forest and in-channel wetlands separated by reaches characterized by scrub and patchy forest. As a result, riparian forest did not form a continuous corridor along the river, instead occurring in discrete patches corresponding to variations in groundwater-surface water interactions.

Like the Santa Clara, the Ventura River occupied a broad river corridor, with reach-scale variability in hydrology, morphology, and riparian patterns. The Ventura River also maintained large willow-cottonwood forests at its mouth, in addition to a dense riparian corridor along much of the perennial reaches. The intermittent reach of the river was characterized by in-channel live oaks, sycamores, and scrub on established bars and islands, a vegetation community not documented anywhere along the Santa Clara River mainstem.

The research described in this report is designed to provide insight into the Ventura County that once was. We have tried to bring our research alive such that current residents, scientists, and planners may inhabit—if briefly, and imaginatively—the landscape that early Chumash inhabited and later residents inherited. We document historical patterns, as well as the layers of use and modification accumulated over the past centuries, some of which is still evident today to the keen eye. We do not suggest that future restoration efforts should necessarily aim to recreate the former features discussed here, or that these patterns should directly dictate what should or should not be done. Instead, this report seeks to provide insight into the dynamics and processes that shaped—and in many cases, continue to shape—the Ventura landscape, and to be a tool for understanding the past and imagining the future. It is a starting point for conversations about the goals and values of restoration, providing guidelines and framework for what may be desirable or possible.

The primary findings of this study are summarized below, as well as at the end of each relevant chapter. Management implications may be found at the end of each chapter. Taken together with an understanding of modern conditions, these findings can support scientists and managers working to identify restoration opportunities in the Ventura region.

Santa Clara River and Valley

1. **The historical (early 1800s) Santa Clara River valley supported a diverse array of natural habitats,** from the willow groves and wetlands of Saticoy Springs to the sycamores and oaks found on alluvial fans near Santa Paula and Fillmore (page 51). However, the valley floor was dominated by grassland and coastal sage scrub, with trees occurring singly or in stands and along creeks and rivers. Valley oaks were not documented in the Ventura County portion of the valley.

2. **Most substantial freshwater wetland complexes occurred within the river corridor of the Santa Clara River, not on the valley floor (page 87).** A rich array of aquatic habitats were found within the river corridor, including ponds, sloughs, and freshwater marshes in perennial reaches, and a suite of saline and brackish aquatic habitats associated with the estuary at the river mouth.

3. **Prior to modification, most small tributaries did not connect to the Santa Clara River (page 76).** With few exceptions, intermittent small creeks commonly sank into their alluvial fans before reaching the Santa Clara River, a characteristic common to many intermittent tributaries across California. Rather than maintaining defined channels all the way to the river, these creeks were connected hydrologically to the river through subsurface flow and poorly defined, transitory surface channels. Most of these creeks have now been connected to the Santa Clara River though constructed channels, increasing valley drainage density (that is, stream length per unit area).

4. **From the late 19th to the early 20th century, the position of the Santa Clara River corridor remained relatively laterally stable (page 66).** Inter-annual variability in the relative vegetation cover of the active channel and bottomlands is evident in the historical record, with

widespread changes occurring after each major flood. However, our findings support the overall lateral stability of the river even through the St. Francis Dam break in 1928.

5. **In the relatively recent geologic past, the lower Santa Clara River shifted its outlet from near Point Hueneme to its present location (page 71).** While the date of this shift is not clear, it may have occurred in the past 200-500 years based on edaphic, ecological, and ethnographic evidence. This shift is reflected in historical alkalinity patterns on the Oxnard Plain (see page 177).

6. **The Santa Clara River was an interrupted perennial stream,** with alternating perennial and intermittent (summer dry) reaches (page 77). Only two intermittent reaches were clearly documented on the river, near Saticoy and Piru (though additional intermittent reaches may have been present). The location of perennial reaches was informed by a variety of factors, including artesian influence, tributary inputs, valley narrowing, and geologic constraints. Many of these factors continue to affect surface flow patterns today.

7. **The Santa Clara River supported a diverse mix of riparian species,** including trees such as sycamore, live oak, willow, cottonwood, box elder, and alder; scrub species such as scalebroom, buckwheat, mulefat, golden-aster, sagebrush, black sage, and cactus; and understory species such as wild grape and wild blackberry (page 83).

8. **Dense, persistent riparian forest and in-channel wetlands occurred in discrete patches along the Santa Clara River (page 85).** Rather than a continuous corridor, willow-cottonwood riparian forest was found at a few notable locations along the river, corresponding with areas of rising or perched groundwater. Other reaches supported a different matrix of non-vegetated riverwash, willow scrub, mulefat, and alluvial scrub. This longitudinal heterogeneity tied to patterns in groundwater-surface water interactions suggests that different restoration targets are appropriate for different reaches. It suggests nodes for riparian forest restoration centered around former persistent wetland riparian areas, as well as a focus on maintaining the water resources (rising groundwater) that would support these habitats.

9. **Alluvial scrub was a likely component of the driest portions of the Santa Clara River (page 92).** While more research is needed, compiled data suggest that alluvial scrub is a more suitable riparian restoration target for drier reaches (notably the Piru reach) than riparian forest.

10. **Live oaks and sycamores occurred frequently on the Santa Clara River river outer banks (page 85).** Numerous live oaks and sycamores were documented on high banks on the edge of the river corridor. Live oaks and sycamores documented within the river corridor occurred largely in Santa Paula and Sespe creeks (likely on higher bars or islands) and as individuals within large areas of willow-cottonwood forest on the mainstem Santa Clara River.

Ventura River and Valley

1. **The historical Ventura River valley supported a diverse array of natural habitats,** including valley freshwater marsh, grassland, coastal sage scrub, oaks, and sycamores (page 124). While we were unable to map the valley floor in detail, our data indicate a broad transition from grassland in the lower valley (Avenue area) to predominantly oaks, sycamores, and scrub above Foster Park to Matilija Dam. As in the Santa Clara River valley, valley oaks were not documented anywhere in the valley. Only one wetland feature was documented on the valley floor within the study area (not including Mirror Lake).

2. **Most substantial freshwater wetland complexes occurred within the Ventura River corridor.** Aquatic habitats such as ponds, sloughs, and freshwater marshes were likely found in many perennial reaches (page 138), and a suite of saline and brackish aquatic habitats was associated with the estuary at the river mouth.

3. **The Ventura River supported a broad range of riparian species,** including trees such as sycamore, live oak, willow, cottonwood, box elder, alder, and walnut; understory species such as wild grape, wild rose, and wild blackberry; and mulefat and alluvial scrub species (page 138).

4. **Unlike on the Santa Clara River, live oaks and sycamores were common within the river corridor of the Ventura River (page 138).** While on the Santa Clara River live oaks and sycamores were almost exclusively found bordering the river's high (outer) bank, both trees were common on benches, bars, and islands in the Ventura River channel, particularly in the intermittent Oak View reach.

5. **The Ventura River mouth has shifted location numerous times over the past several hundred years,** from the hills west of the river mouth to Figueroa Street in Ventura. Many of these former river mouth areas are still susceptible to flooding (page 130). A brackish lagoon, formerly at the site of what is now the Derby Club across from Seaside Park, marked the route of one of these former river mouths.

6. **The Ventura River was generally perennial for much of its length (page 135).** The uppermost reach (below the present-day location of Matilija Dam) consistently supported year-round surface water, as did the lower half of the river (below the San Antonio Creek confluence). In contrast, the middle reach, through the western Ojai Valley and downstream of Oak View, was typically dry during the summer. The precise extent and location of summer water fluctuated in response to annual variations in rainfall and runoff.

Oxnard Plain

1. **The Oxnard Plain supported a diverse array of habitats,** from the freshwater wetlands and lakes of the lower Calleguas watershed to the alkali meadows and flats, grassland, coastal sage scrub, and chaparral of the broader plain (page 174). Just under half of the plain supported alkali meadows and alkali flats, with the remainder mostly covered by grassland and coastal sage scrub.

2. **The distribution of these habitats reflected underlying physical processes and characteristics (page 163).** Topography, soils, geology, and groundwater availability were primary factors in determining historical habitat distribution.

3. **Few trees were found on the Oxnard Plain (page 174).** Only a small number of trees were documented on the plain by 19th century observers, mostly sycamores (and one live oak) on the sand and sandy loam soils marking the former route of the Santa Clara River to Point Hueneme.

4. **Few streams traversed the Oxnard Plain, particularly in its western portion (page 167).** The plain was notable for its extremely low drainage density (only 1.7 miles of creek per square mile). The few creeks and barrancas that did cross the plain were almost exclusively discontinuous, sinking into coarse alluvium or spreading into and across seasonally wet alkaline areas. Large sloughs such as Revolon Slough (a former channel of the Santa Clara River) formed the backbone of drainage for the central plain.

5. **Calleguas Creek did not maintain a defined channel across the Oxnard Plain,** instead spreading into a broad wash around present-day Highway 101 before re-emerging downslope near Conejo Creek (page 168). The creek terminated in a lake and distributary system near the current location of CSU Channel Islands. Calleguas Creek was hydrologically connected to Mugu Lagoon through shallow sloughs and sheet flow during floods.

6. **Calleguas and Conejo creeks were intermittent on the Oxnard Plain (page 168).** Though sources describe readily available water located below the surface in both creek beds, they are consistently described as dry for much of the year.

7. **Sources document a concentration of perennial freshwater wetlands, ponds, and lakes along the eastern margin of the Oxnard Plain,** particularly east of Conejo and Calleguas creeks (page 182). The majority of these wetlands occurred near the base of small alluvial valleys of creeks tributary to Calleguas and Conejo creeks, near contacts between alluvial deposits and the Conejo Volcanics of the western Santa Monica Mountains.

Ventura County Shoreline

1. **A diversity of coastal systems characterized the Ventura shoreline,** each with differing habitat patterns and hydrologic dynamics (page 191). The overall habitat distribution is well documented, though available historical sources only begin to indicate the range of coastal processes that created these patterns, from Mugu Lagoon to the backbarrier lagoons, dunes, salt flats, and tidal marshes of the Oxnard Plain.

2. **Coastal wetland habitats covered about 4,300 acres,** accounting for a large proportion of former Ventura County wetlands (page 191). Differences in freshwater input, extent of vegetative cover, and closure regime led to varying support functions for native fish and wildlife.

3. **Three distinct types of coastal estuarine systems characterized the Ventura County shoreline**: the freshwater-brackish, intermittently or seasonally closed estuaries of the Ventura and Santa Clara rivers; the non-tidal lagoon complexes marking former Santa Clara River mouths; and the large, more tidally-influenced wetland system at Mugu (page 191).

4. **The Ventura and Santa Clara River estuaries were periodically open to the Pacific Ocean (page 194)**. Regular, seasonal cycles of closure were documented for the Santa Clara River mouth. The Ventura River mouth closed only occasionally (less frequently than the Santa Clara River), reflecting its greater historical volume of summer flow in the lowest reach, steeper channel gradient near the mouth, and lesser wave exposure.

5. **The estuaries of both rivers also shared similar habitat mosaics (page 194).** Both rivers had fairly compressed estuaries, with the relatively limited saline and brackish wetland habitat near their mouths bordered by extensive freshwater habitats, most notably the willow-cottonwood forest and wetland documented at both mouths.

6. **McGrath Lake is a regionally significant feature,** unique because of its persistence over the past centuries and its freshwater character (page 203). Though the lake has persisted, its location has shifted substantially since the mid-1850s; only a small portion of its current area overlaps with its historical extent.

7. **An extensive suite of marsh, salt flats/pannes, and lagoons stretched from south of the Santa Clara River to the western edge of Mugu Lagoon (page 205).** Prior to drainage and agricultural expansion, these systems were a significant component of the Ventura County shoreline. They exhibited a range of habitat patterns based on variable salinity gradients and hydrologic inputs, from the spring-fed brackish Laguna Hueneme to the hypersaline Salinas near Point Hueneme.

8. **Mugu Lagoon was the largest wetland complex in Ventura County, and the site of a broad range of coastal wetland habitats,** including salt and brackish marshes, large salt flats, and extensive tidal channel networks (page 225). Dominant habitat cover was tidal marsh. There is some indication that the complex formerly extended substantially further inland than currently recognized. Its acreage has been dramatically reduced.

9. **Salt flats and high marsh transition zone were major components of Mugu Lagoon (page 228).** These transitional, high elevation habitats were particularly characteristic of the semi-arid climatic setting (Ferren et al. 2007), and have been disproportionately lost from this system. These features likely provided breeding habitat for shorebirds such as least tern and snowy plover (as small present-day remnants still do), as well as an inland migration zone for tidal marsh transgression in response to naturally rising sea level in the past.

ACKNOWLEDGEMENTS

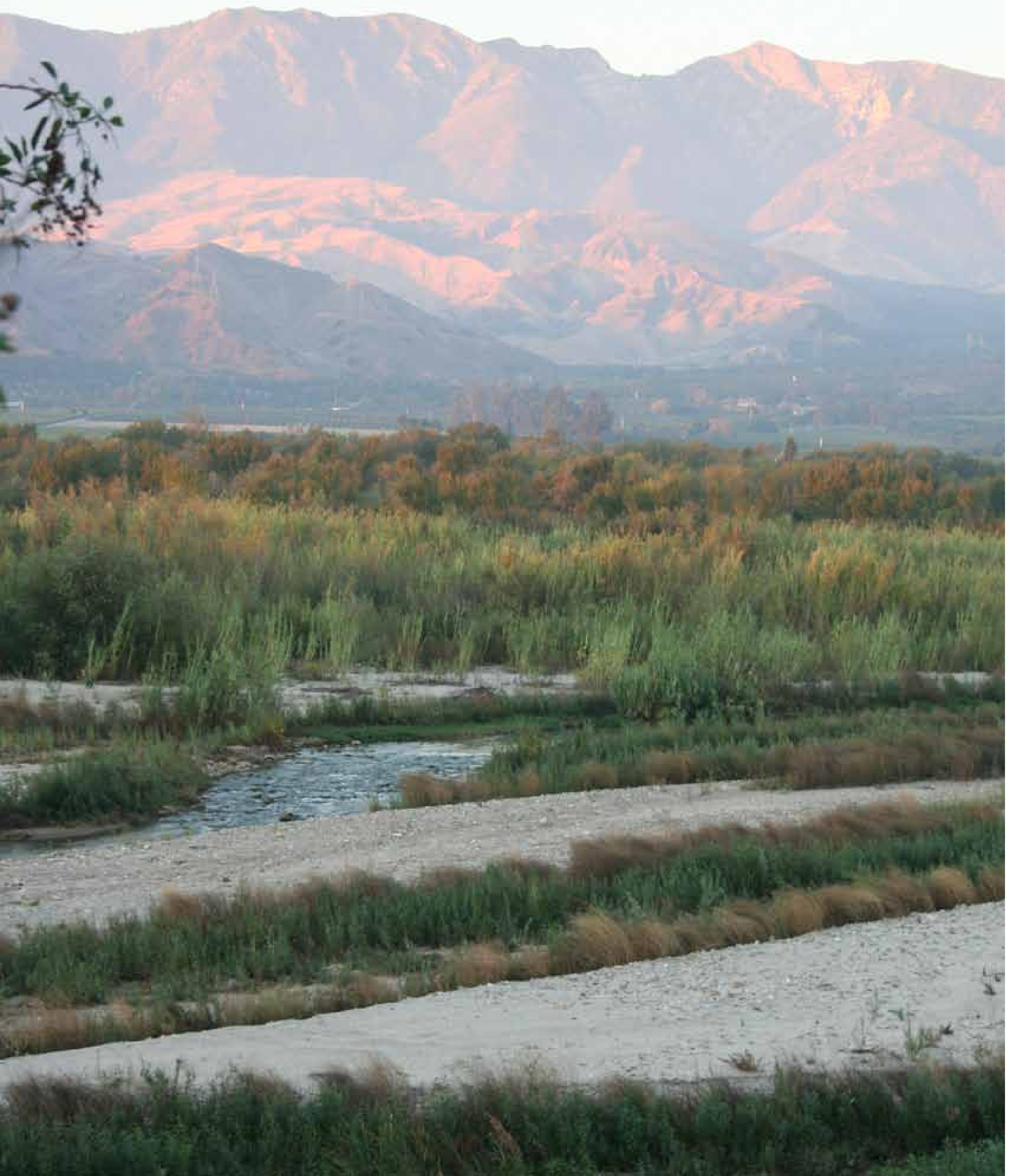
We would like to express our appreciation to the volunteers and staff at the historical societies, libraries, archives, and agencies where we gathered the data that form the backbone of this report. Particular thanks to Charles Johnson at the Museum of Ventura County, Jan Timbrook at the Santa Barbara Museum of Natural History, and Alex Williams at the Ventura County Surveyor's Office. We are also indebted to the volunteers and staff at the local historical societies and public libraries where we collected data, including the Ventura County Public Library, Camarillo Historical Society, Fillmore Historical Society, Ojai Valley Historical Society, Santa Paula Historical Society, Ventura County Surveyor's Office, and Ventura County Recorder's Office. Staff at The Bancroft Library, Water Resources Collections and Archives, Bureau of Land Management, California Historical Society, California State Library, Santa Barbara Museum of Natural History, Santa Barbara Mission Archive-Library, UC Santa Barbara Map and Imagery Library, and Huntington Library were also instrumental in the data collection effort.

Over the course of the project, a number of researchers contributed time and input to data collection and interpretation. Veronica Rojas and Michael Beland of CSU-Northridge collected data at many institutions in Southern California. Murray McEachron at United Water Conservation District, Mark Capelli at the National Marine Fisheries Service, and Mark Bandurraga at the Ventura County Watershed Protection District provided relevant contemporary literature and data layers. Assistance was also provided by a number of SFEI staff, including Chuck Striplen, Josh Collins, and Sarah Pearce.

We would like to thank our Technical Review Team for contributing their expertise to the interpretation and discussion of historical conditions and providing comments on the report. The group included Mark Capelli, Frank Davis, Tom Dudley, Dave Jacobs, Paula Schiffman, and Camm Swift. We also received support and advice from Bill Sears.

This project was funded by the California Coastal Conservancy. We would especially like to thank Peter Brand, our project manager at the Coastal Conservancy, who was critical to the success of the project.

I • STUDY OVERVIEW AND METHODS



Every day makes a little history or a few changes on the map.

—VENTURA FREE PRESS 1914

Introduction

This report synthesizes an array of historical records to document historical landscape patterns, ecological and hydrologic dynamics and trends, and environmental management opportunities in Ventura County lowland watersheds. This report and associated geo-database provide a spatially comprehensive dataset describing the historical distribution, abundance, and (where possible) functions of habitats of the Ventura River, lower Santa Clara River, and Oxnard Plain prior to significant Euro-American modification.

While substantial ecological resources still remain, the region has been subject to extensive modification over the past 250 years. Understanding the scope of these modifications, and the nature of the historical landscape patterns formerly present in the region, is not a trivial task. Regular hydrogeomorphic and ecological monitoring was not present in the county until the 20th century, and the data that do exist are idiosyncratic, challenging to interpret, and scattered in archives across the state. Despite these impediments, historical ecology is an essential component of crafting sound, site-specific environmental restoration objectives, which demand detailed data as the basis for management strategies. Without a detailed understanding of the former characteristics of the region—and how these characteristics changed in response to human alterations of the landscape—appropriate ecological and hydrological restoration targets can be difficult to determine.

This study was designed to support acquisition and restoration efforts by the California State Coastal Conservancy, in particular through the Santa Clara River Parkway project, Ormond Beach Wetlands Restoration project, and on the Ventura River through the nascent lower Ventura River Parkway plan. The characterization of historical ecological conditions developed here aims to inform these and other restoration and conservation opportunities throughout the region, helping managers develop strategies for choosing and designing restoration projects.

A previous report prepared for the Coastal Conservancy (Stillwater Sciences 2007b) analyzes the historical geomorphology of the Santa Clara River from 1938-2005. This current study extends this documentation of

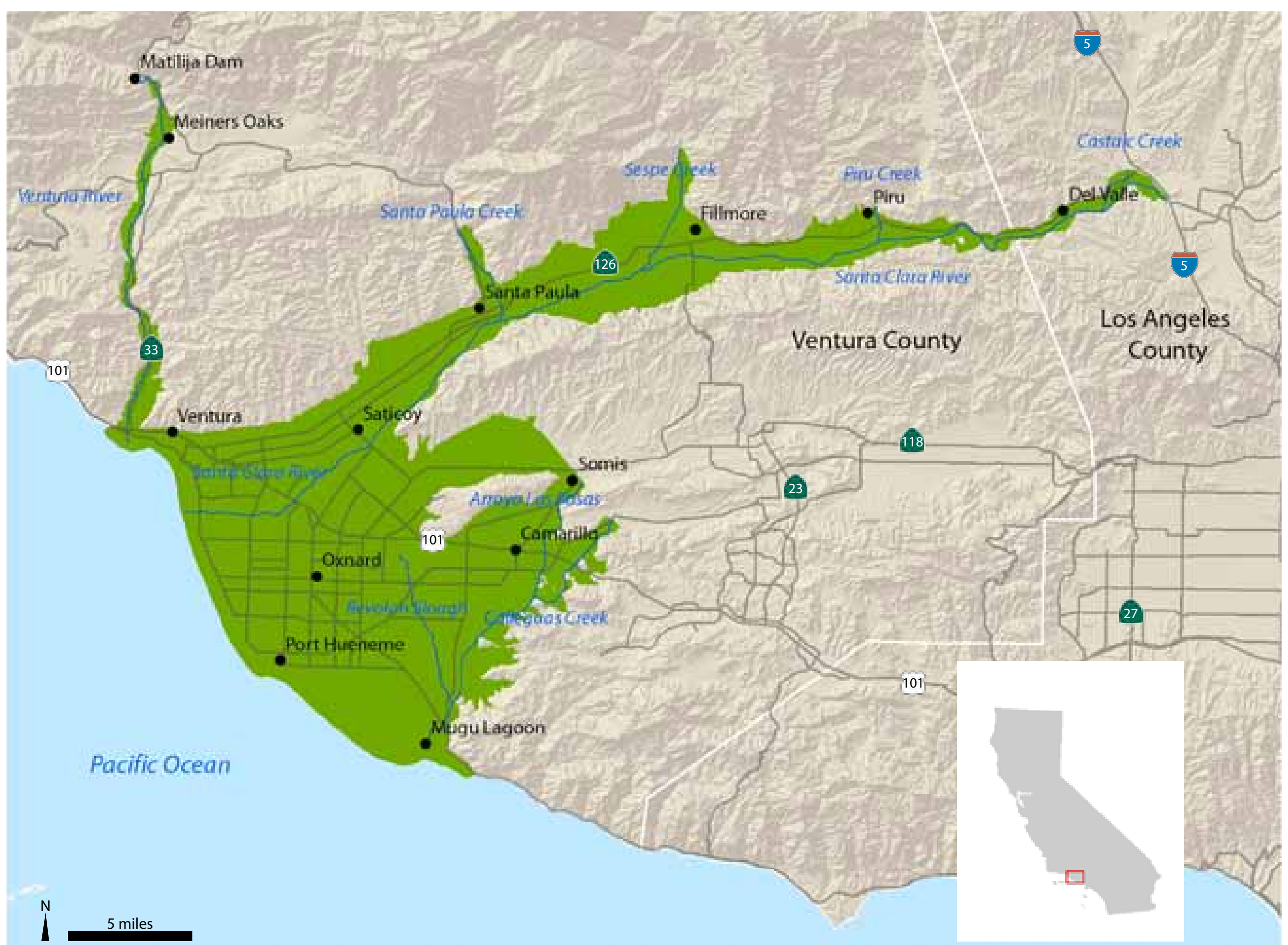
Fig. 1.1. Santa Clara River east of Santa Paula, looking north (November 2008; opposite page).

former river characteristics to include 1769-1938 by integrating historical cartographic, textual, and visual accounts to create a heterogeneous but substantial dataset describing hydrologic, geomorphic, and riparian characteristics back to 1769—the date of the first land-based European exploration of the region.

Regional Setting

This study focuses on the habitat and drainage patterns of the region's lowlands, where change has been most pronounced. The study area encompasses three major contiguous areas: the Ventura River, the lower Santa Clara River, and the Oxnard Plain (fig. 1.2). Specifically, the geographic scope is the Ventura River and valley from its mouth to the Matilija Dam (exclusive of the Ojai Valley), and the Santa Clara River and adjacent valley floor from its mouth to its intersection with Interstate 5 in Los Angeles County (including only the lowest reaches of major tributaries, and focused on the Ventura County portion of the valley). It also includes the lowlands and coastal margins south of the lower Santa Clara River, including the Oxnard Plain and lower Calleguas Creek watershed west of Somis and the edge of the Santa Monica Mountains and south of South Mountain.

Fig. 1.2. Study area and regional geographic context. The project area included the Ventura River to Matilija Dam, the Santa Clara River to Interstate 5 in Los Angeles County, and the Oxnard Plain.



Ventura County is geologically active, with substantial uplift and lateral displacement occurring related to the San Andreas fault system. The region experiences a Mediterranean climate (cool/mild wet winters and war warm dry summers), characterized by high inter- and intra-annual variability. Most precipitation occurs from November through March. There is significant regional variation in precipitation between drier, low-lying coastal areas and wetter, more mountainous parts of the county.

Land use and population trends have taken a radically different trajectory in Ventura County than in its more urban neighbors to the south, and the region is still relatively unmodified in comparison to the other large coastal watersheds of Southern California. Major population centers in the study area include Oxnard (over 200,000, the county's largest city), Ventura, and Camarillo. The total population of the county is just under 850,000 (Herdt 2010).

DESIGNING RESILIENT LANDSCAPES: HISTORICAL ECOLOGY, RESTORATION, AND CLIMATE CHANGE

Restoration goals should be informed by knowledge of landscape conditions before modern development. Historical ecology research improves our understanding of the habitats we seek to restore, including the physical and cultural processes that governed their former distribution. Studying the landscape under earlier, less impacted conditions facilitates a landscape perspective that addresses questions fundamental to the restoration planning process: What habitats were supported where, and why? Where have certain habitats persisted? How have landscape patterns and process changed over time? Most importantly, how do we choose appropriate restoration and management targets?

Historical ecology has particular relevance to these questions in the context of global climate change. The historical Southern California landscape was well adapted to a highly variable, episodic climatic regime, and buffered the effects of environmental extremes while providing diverse ecological functions. As we anticipate a more variable climate in the future, we can learn from the ways in which dynamic historical ecosystems were able to respond and adapt to extreme conditions in the past. For example, broad floodplain surfaces along the Santa Clara and Ventura rivers would have attenuated flood peaks and recharged groundwater during high flows, while side channels and pools in perennial reaches would have provided refugia critical to the survival of native fish and other wildlife during times of drought and floods. Recovering these attributes will make systems more resilient and adaptable to climate change.

Historical ecology is an essential component of restoration design, but it is not an answer in and of itself. It is a tool for scientists and managers seeking to understand and ameliorate the dramatic landscape changes of the past 250 years. When integrated with contemporary data and future projections, historical information helps identify restoration opportunities and develop realistic management strategies. Often these would not be recognized without a historical perspective. Though controls on habitat distribution such as land use and climate may change, others, such as topography and geology, remain relatively stable. Historical ecology helps us understand which characteristics supported native species of concern and how these can be recovered or enhanced. Understanding the landscape patterns and processes of the recent past can help us establish functional, resilient systems that improve the ecological health of the region.

Lowland Ventura County is dominated by the Santa Clara River and its delta, the Oxnard Plain. The Santa Clara River watershed is one of the largest coastal watersheds in Southern California, draining approximately 1,620 mi². The last 38 miles of the river run through Ventura County, southwest through the Santa Clara River valley and across the Oxnard Plain before reaching the ocean. The Santa Clara River is regionally significant because it is relatively unchannelized and unregulated by dams, and its watershed is not as densely or extensively urbanized as other systems of comparable size in Southern California. As a result, many habitats and processes no longer viable on other comparable systems are still intact to some degree on the Santa Clara River, and there is great potential to restore former ecological and hydrogeomorphic patterns and functions.

Report Structure

The report is divided into six chapters, each of which treats a different topic or geographic region. This introductory chapter describes the project's geographic setting and management context, data collection and mapping methodology, and our habitat and channel classification system. The second chapter includes a discussion of 19th and early 20th century trends in agricultural land use and irrigation practices in the region. The third chapter describes ecological patterns and riverine dynamics for the lower Santa Clara River and valley, and the fourth chapter discusses the same topics for the Ventura River and valley. The fifth chapter describes habitat and drainage network patterns on the Oxnard Plain, and the sixth chapter provides a brief treatment of the habitat patterns along the shoreline from the Ventura River mouth to Mugu Lagoon.

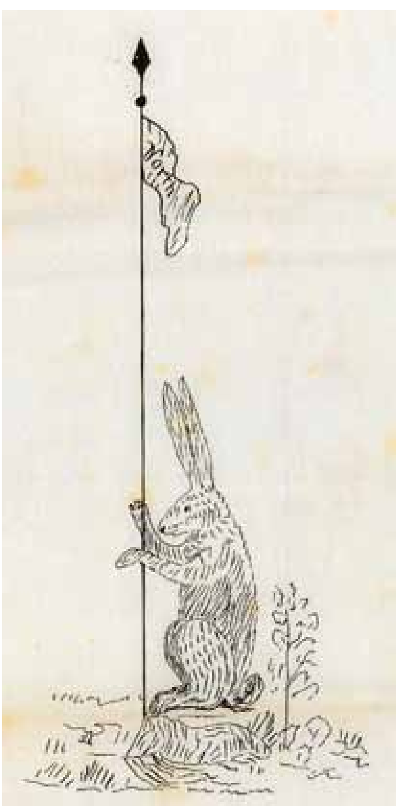


Fig. 1.3. Detail from a map of Rancho San Miguelito and the lower Ventura River, 1897. A jackrabbit serves as the compass, pointing north. (Barry 1897, courtesy of the Museum of Ventura County)

Methods

The discovery, organization, and interpretation of historical data forms the foundation of this project. The complex process through which data spanning disparate places and eras were synthesized for this study is outlined in this section.

Data Collection

A substantial variety and quantity of historical data are needed for accurate assessment of the historical landscape (Grossinger 2005). With this in mind, we assembled a diverse range of historical records spanning about two and a half centuries and compiled these data into a map of historical landscape patterns prior to substantial Euro-American modifications.

Assembled material includes: (1) textual data (e.g., Spanish explorers' accounts, Mexican land grant case court testimonies, General Land Office records, early travelogues, and county histories and reports); (2) maps (e.g., Mexican land grant maps, early city and county maps and surveys, US Department of Agriculture soil surveys, and U.S. Geological Survey maps); and (3) photography (ground-based, aerial, and oblique) and paintings.

To acquire these sources, we visited local historical archives, public libraries, county offices, and regional archives. In total, we visited twenty-seven source institutions across California to collect data (table 1.1). We also reviewed material available online and conducted searches of over twenty electronic sites and databases. We acquired scans, copies, or photographs of a diverse array of primary and secondary sources pertaining to the historical landscape of Ventura County (fig. 1.3; also see "Historical data for Ventura County" spread, pages 6-7).

We acquired full or partial copies of approximately 500 maps, 250 documents, and 500 photographs. These represent a small fraction of the documents reviewed at the archives themselves. While we reviewed

Local Historical Societies and Public Libraries
Camarillo Historical Society
Fillmore Historical Society
Museum of Ventura County
Ojai Valley Historical Society
Santa Paula Historical Society
Seabee Museum
United Water Archives
Ventura County Public Library
County Agencies
Santa Barbara County Recorder's Office
Santa Barbara County Surveyor's Office
Ventura County Recorder's Office
Ventura County Surveyor's Office
Regional Archives
Air Photo Archives, UCLA Department of Geography
The Bancroft Library, UC Berkeley
Bureau of Land Management
California Coastal Conservancy Archives
California Historical Society
California State Library
California State Railroad Archives
CSU Northridge Library
The Huntington Library
Los Angeles County Seaver Center
Mark H. Capelli Southern California Steelhead Watershed Archives, Davidson Library, UCSB
NARA Pacific Region
Santa Barbara Mission Archive-Library
Santa Barbara Museum of Natural History
UC Davis Map Collection
UC Santa Barbara Map and Imagery Library
Water Resources Collections and Archives
Western Foundation of Vertebrate Zoology
Whittier College

Table 1.1. Archives, libraries, and historical societies visited to collect data for the Ventura Historical Ecology study.

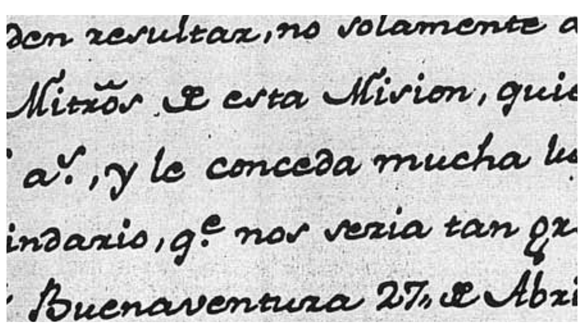
HISTORICAL DATA FOR VENTURA COUNTY

This study involved the collection and compilation of a wide array of historical sources, spanning mutliple centuries, languages, and formats. Historical documents form the backbone of our historical mapping and analysis, from Spanish-language explorer's journals (1769) and correspondence from the San Buenaventura Mission (ca. 1800) to soils mapping and aerial photography of the mid-20th century.

Since each source was produced by individuals in different social contexts and with variable goals, understanding the provenance of the sources we draw on is a fundamental starting point for understanding our findings. Shown below are examples and brief descriptions of some of the primary sources used in this study.

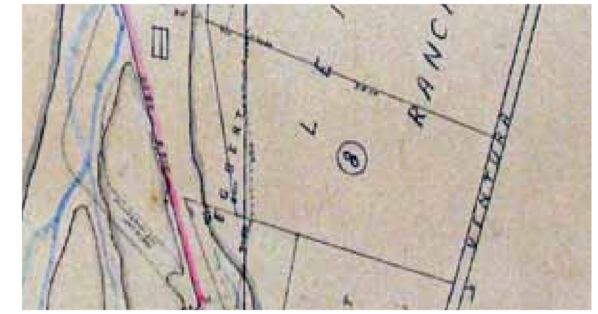
Mexican land grant sketches (1840s-1850s). As the Mission system disintegrated, influential Mexican citizens submitted claims to the government for land grants. A *diseño*, or rough sketch of the solicited property, was included with each claim. *Diseños* often show notable physical landmarks which would have served as boundaries or natural resources, such as creeks, wetlands, springs, and forests. While *diseños* are not as spatially accurate as subsequent surveys, they provide extremely early glimpses of former landscape features and patterns. (U.S. District Court ca. 1840d, courtesy of The Bancroft Library, UC Berkeley)

General Land Office Public Land Surveys (1853-1900). In areas not claimed through the land grant system, the U.S. Public Land Survey imposed a grid of straight lines on the landscape, dividing property into six-mile square townships. Each township was further subdivided into 36 one-mile sections, each section containing 640 acres. Surveyors methodically surveyed section lines along these transects, noting cultural and natural features they encountered along the way. Survey notes and plat maps from these surveys are useful for their ecological information. (Hoffman 1868d, courtesy of the Bureau of Land Management)



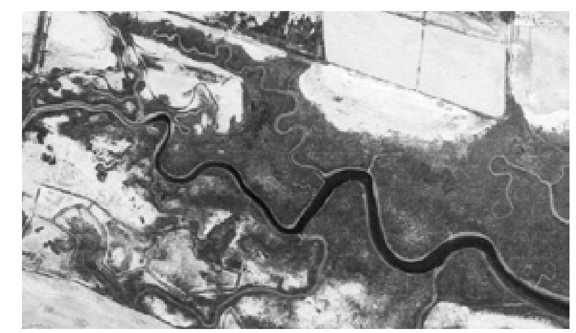
Textual accounts (1769-2011). Written accounts can provide a wealth of detailed information with nuance about landscape dynamics not available on maps. Spanish expeditions provide the earliest accounts; later sources such as land grant case testimonies, newspaper articles, ornithological records, county histories, and travelogues give rich perspectives from early visitors and residents. (text courtesy of the Santa Barbara Mission Archive-Library)

U.S. Coast and Geodetic Survey maps (1855-1934). The U.S. Coast and Geodetic Survey was established in 1807 by Thomas Jefferson to create navigation maps. Though the maps only cover the coastline and immediately adjacent areas, they are a highly valuable source because of their impressive detail and accuracy, scientific rigor, and relatively early survey dates. (Johnson 1855c, courtesy of the National Oceanographic and Atmospheric Administration)

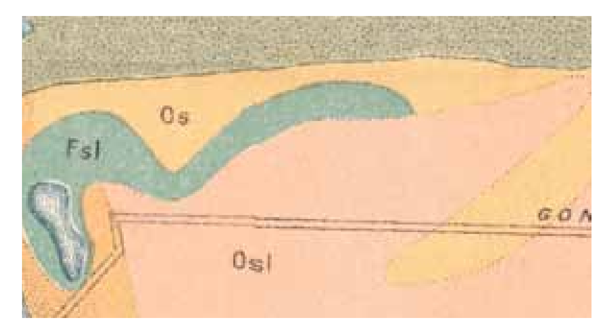


City and county surveys (1860-1930). Local surveyors produced abundant maps, including many surveys of individual parcels. These maps, often surveyed at a large scale, contain details not included in other regional mapping efforts such as sloughs and side channels, smaller ponds and wetlands, or clusters of trees. Though coverage is inconsistent, these maps are invaluable in constructing an understanding of local ecosystem dynamics. (Barry 1894, courtesy of the Ventura County Surveyor's Office)

U.S. Geological Survey topographic maps (1903-1943). Shortly after 1900, the USGS (established in 1879) began producing topographic quadrangles at 1:62,500 for the Ventura County region. Though the maps are relatively coarse, they provide some of the earliest consisent, comprehensive coverage for the entire region. (USGS 1904, courtesy of the CSU Northridge Geography Map Library)



Historical aerial photography (1927-1959). A Depression-era program to ensure crop stability and soil conservation practices resulted in extensive aerial photographic coverage for much of the county. The bulk of historical aerial imagery used in this study is from 1927 and 1938. While the photographs were taken after substantial modification, the photos nevertheless reveal relict ecological features, traces of which are often still present in the landscape. (Fairchild Aerial Surveys 1927, courtesy of Whittier College)



U.S. Department of Agriculture soil surveys (1901-1917). Early soil surveys were developed to describe variability in the agricultural viability of regional soils. These maps, and their accompanying reports, are a key source in the inference of historical habitat extent and location. Descriptions of soil properties and agricultural use can provide insight into former habitats, in particular providing spatially accurate detail on the extent of wet meadows and alkaline habitats. (Holmes and Mesmer 1901b)

Landscape photography (1860s-1950s). Historical photographs represent a category of diverse historical data that can provide extremely localized, accurate information. Photographs can capture the conditions of a given place and time in a manner that provides substantial detail about specific species presence and landscape structure. (Isensee 1928b, courtesy of Museum of Ventura County) thousands of documents for this study, historical research is never completely exhaustive, and the local historical record is extensive. Additional sources will undoubtedly surface showing ecological information that enrich the descriptions and information incorporated in this report. In particular, we were unable to focus substantial efforts on data collection for the major Santa Clara River tributaries (e.g., Santa Paula, Sespe, and Piru creeks) and the Los Angeles County portion of the Santa Clara River. As a result, it is likely that much more information exists detailing the historical landscape of these regions. Future research exploring other sources, such as early court cases and oral histories, may also reveal more detail about this area.

Data Compilation

Data compilation is the process of organizing the large volume of collected, heterogeneous data used in this study into more accessible formats for interpretation at the local and landscape scale. As part of this process, we read narrative sources and transcribed relevant quotes into one comprehensive document, georeferenced maps and spatially locatable quotes, and created large-scale maps, or "base maps," displaying compiled data onto which we transferred non-georeferenced data. High-priority maps were chosen for georeferencing based on their spatial resolution, mapping accuracy, and relevance (e.g., types of features shown and date of mapping). They were georeferenced to contemporary orthorectified aerial imagery (USDA 2005), using ESRI's ArcGIS 9.3.1 software. Approximately 150 maps were georeferenced.

One heavily used source was historical aerial photography, which required orthorectification and mosaicking of 238 aerial photographs into a comprehensive, continuous coverage of the entire study area (fig. 1.4). Aerials were acquired from a number of source institutions and spanned a number of different years. The earliest imagery (1927), used where available, makes up about one half of the entire photomosaic. Later imagery (from 1938, 1945, and 1959) was substituted where 1927 imagery was not available. The spatial consistency, accuracy, and high level of detail available made these an invaluable source for the project.

Relevant quotes were extracted from textual material and transcribed into a Microsoft Word document. Quotes were organized by broad geographic area (Santa Clara River valley, Ventura River valley, Oxnard Plain) and by subject (e.g., riparian vegetation, channel geometry, or wetland habitats). In addition, quotes pertaining to land use history, irrigation history, and climate were transcribed. Over 160 pages of quotes were transcribed. Of these quotes, about 240 were spatially specific enough to be locatable on our base maps. These were mapped and included in our project geographic information system (GIS) as an independent data layer.

In addition, we adapted methods developed by the Forest Landscape Ecology Lab at the University of Wisconsin-Madison that use GIS to store, display,

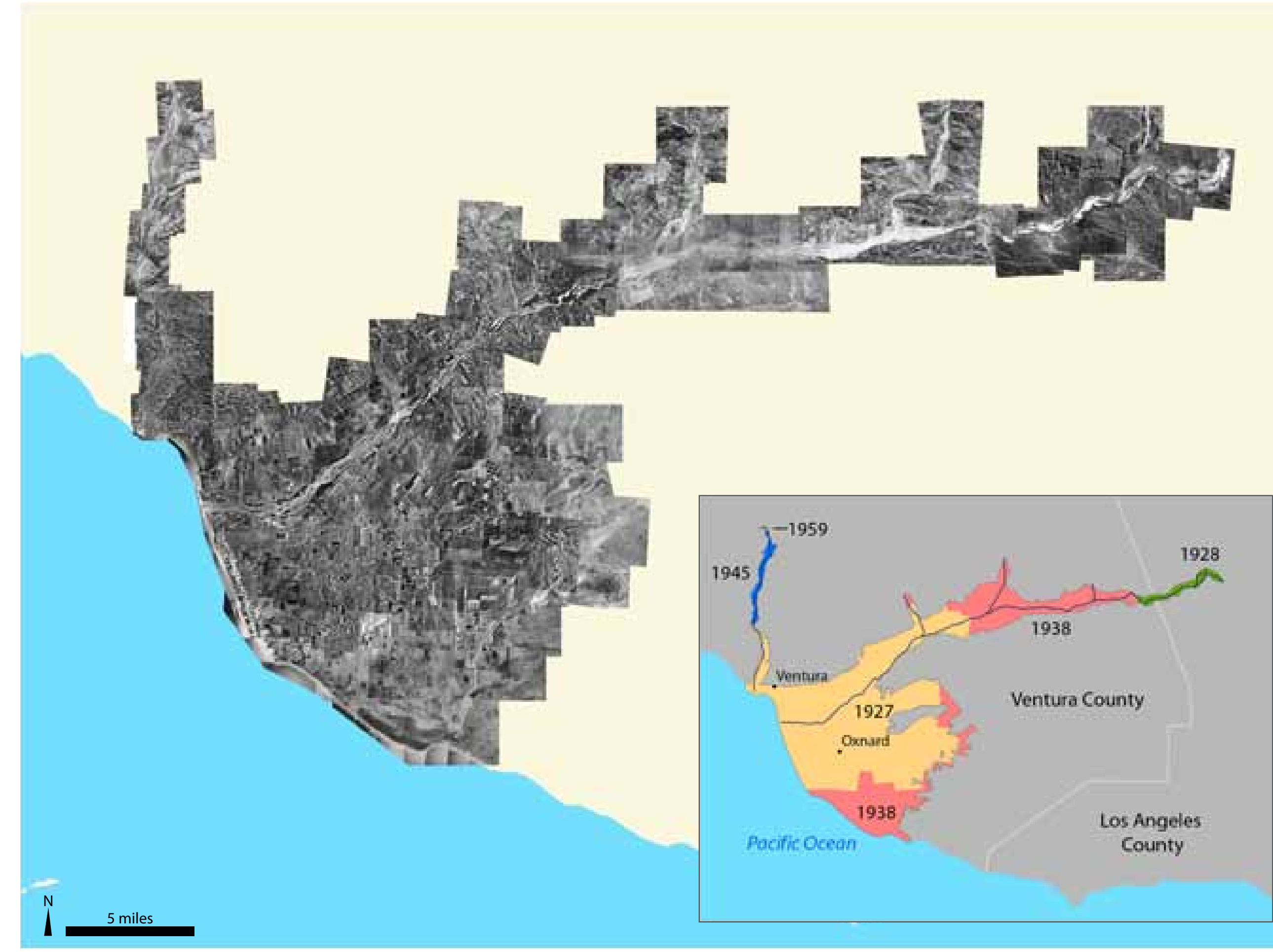


Fig. 1.4. Earliest date of aerial photo coverage. Two hundred and thirty-eight historical aerial photographs were orthorectified and mosaicked to provide continuous coverage of the study area. Aerials spanned from 1927-1959, with the bulk of photos from 1927 and 1938.

and analyze General Land Office (GLO) data obtained from the microfilm archives at the Bureau of Land Management Office in Sacramento, CA (Manies 1997, Radeloff et al. 1998, Sickley et al. 2000). For Ventura County, survey notes ranged from 1853-1900. Just under 1,700 data points collected from the General Land Office notes were included in this layer.

Data Interpretation

We examined historical data for evidence of landscape characteristics prior to significant Euro-American modification. Our goal was to map landscape features as they existed, on average, prior to and during the early decades of Euro-American settlement (1770s-1850s). Despite inter-annual and decadal variability, mean climatic characteristics during the period for which historical data were obtained (1769-1940s) were relatively stable (Lynch 1931, Dettinger et al. 1998; see also Haston and Michaelsen 1997). Many later sources (i.e., outside of the target time period) were found to record features that clearly corresponded to features documented by earlier sources, and thus provided more accurate mapping of these features. For example, a feature shown on an early source (e.g., a *diseño*) that confirms the general presence of the feature but not its location, could be confirmed and mapped from a later source (e.g., a historical aerial), despite surrounding land use changes.

Accurate interpretation of documents produced during different eras, using different methods or techniques, for differing purposes, and with different authors, surveyors, or artists can be challenging (Harley 1989, Grossinger and Askevold 2005). To address these issues, we interpreted collected data through an iterative process of source inter-calibration using GIS and other techniques. Our dataset of sources, often overlapping in geography and depiction, allowed us to compare an array of complementary documents, and in doing so assess the accuracy of individual documents and to promote accurate interpretation of landscape characteristics. This approach provided independent verification of the accuracy of original documents and our interpretation of them (Grossinger 2005, Grossinger et al. 2007). In addition, through this process we were able to take a large body of often subjective information (e.g., a traveler's description of the Santa Clara River) and form a reliable, comprehensive, and coherent body of data.

To ensure persistence and accurate interpretation, we documented each feature using multiple sources from varying years and authors where possible. In some cases, a high density of sources documenting a particular feature allowed for high mapping confidence of both presence and extent. However, many features are documented by only one source or simply may not have any specific early source that describes the habitat. In these cases extrapolation based on soil types, topography, hydrology, and general descriptions was necessary.

To document the mapping sources used and the classification and mapping accuracy certainty associated with individual features, we assigned a set of attributes including each feature's derivation and estimated certainty levels (table 1.2). Our confidence in a feature's interpretation (classification), size, and location was assigned as a set of three certainty levels based upon the number and quality of sources, and our experience with the particular aspects of each data source (following standards discussed in Grossinger et al. 2007). These attributes provide for data transparency and allows subsequent users to assess accuracy and identify original data sources.

Table 1.2. Certainty level standards used in the interpretation and mapping of historical features.

Certainty Level	Interpretation	Size	Location
High/ "Definite"	Feature definitely present before Euro-American modification	Mapped feature expected to be 90%-110% of actual feature size	Expected maximum horizontal displacement less than 50 meters (150 ft)
Medium/ "Probable"	Feature probably present before Euro-American modification	Mapped feature expected to be 50%-200% of actual feature size	Expected maximum horizontal displacement less than 150 meters (500 ft)
Low/ "Possible"	Feature possibly present before Euro-American modification	Mapped feature expected to be 25%-400% of actual feature size	Expected maximum horizontal displacement less than 500 meters (1,600 ft)

Mapping Methodology

We used a geographic information system (ESRI's ArcGIS 9.3.1 software) to interpret and synthesize our information into digitized data layers representing historical landscape characteristics of the lower Santa Clara River, the Oxnard Plain, and the Ventura River. GIS was used to collect, catalog, compile, digitize, analyze, and display our sources. By spatially relating sources from many time periods, we were able to examine habitat location and change through time (fig. 1.5). The relational database component of GIS allows for storage of many attributes about a single feature, which we used to integrate our disparate sources and document the provenance of our interpretation of the historical landscape. Using GIS, we were able to synthesize complex arrays of sources by assembling maps and narrative information from different periods, allowing us to assess each data source, more accurately map each feature, and better understand change over time.

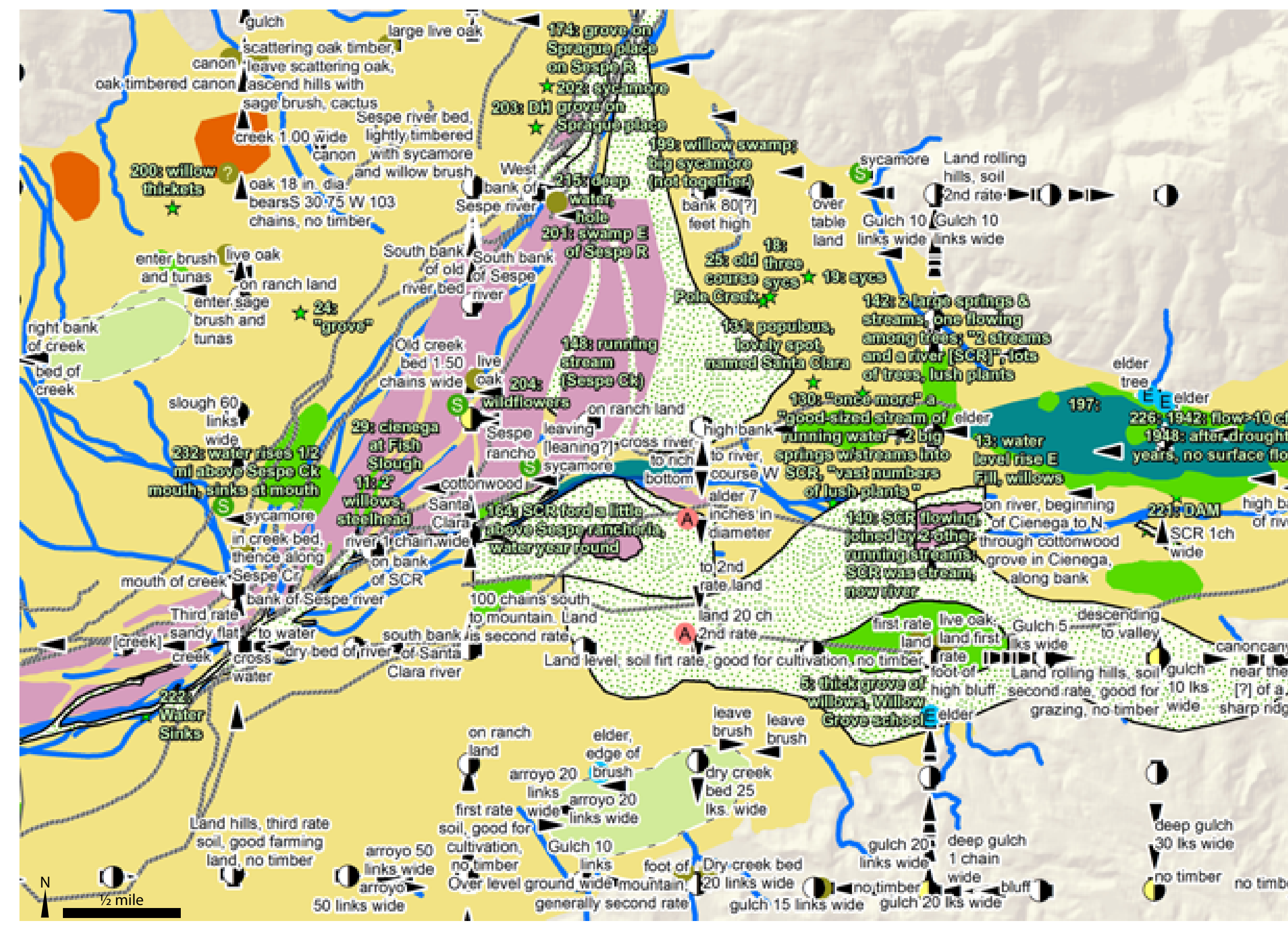


Fig. 1.5. Draft historical habitat and channel mapping at Santa Clara River-Sespe Creek confluence, early 1800s. Features from dozens of historical maps, texts, and photographs were digitized before being synthesized through an intensive process into one integrated map of the region's historical ecology.

The habitat map produced through this process depicts our understanding of landscape features as they existed before major Euro-American modifications (1770s-1850s; referred to as “early 1800s” for simplicity). Individual creek and habitat features were digitized from historical sources, and ultimately synthesized into the study area habitat map (included at the beginning of this report).

The primary purpose of the mapping process and resulting habitat map is to represent habitat diversity and heterogeneity at the watershed scale, leading to a better understanding of regional patterns and processes. While many individual habitat polygons have been mapped with precision (see table 1.2), others have higher error margins for their mapped size. Clearly, our dataset of disparate sources (each representing a different scale, time period, and level of accuracy) prevents mapping each area at the same level of detail. In addition, many former features were undoubtedly not documented by any historical source, and therefore were not mapped. However, these issues do not undermine the map’s usefulness as a tool to characterize and understand the region’s historical ecological patterns and the underlying processes that shaped them.

The following section outlines the methods used to integrate and synthesize data in GIS to depict broad classes of habitats on the map, both for the purpose of visual representation of historical habitats and channels and for analysis of the historical landscape. For more information on the accuracy of a particular habitat polygon, please refer to the GIS metadata.

RIVER CORRIDORS AND RIPARIAN HABITATS For the river systems (Santa Clara, Ventura) and major tributaries to the Santa Clara River (Santa Paula, Sespe, Hopper, and Piru), the entire river corridor (from outer bank to outer bank) was mapped as a polygon in the habitat layer (fig. 1.6). (Major tributaries to the Ventura River, such as Coyote, San Antonio, and Matilija creeks, were on the edge of the study area boundary and were not mapped as polygons.) This area includes the predominantly sandy active channel (mainstem; high disturbance) in addition to vegetated areas that show evidence of erosion/deposition (medium disturbance) and more densely vegetated areas that may be subject to flow during flood events, but without evidence of major erosion/deposition (low disturbance). Benches or bottomlands with evidence of flow during at least some flood events are also included. This definition of the river corridor was based on research conducted by Stillwater Sciences (2007b) for 1938-2005. More detailed definitions of riverine terms used in this report is can be found on page 61.

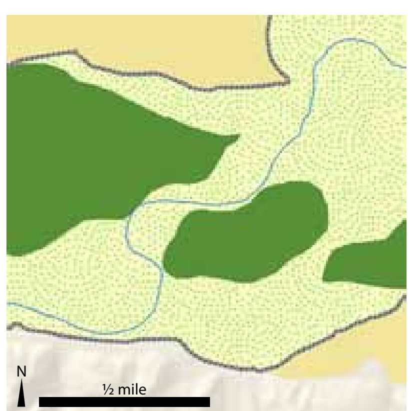


Fig. 1.6. Detail of mapping of outer river banks and river corridor extent. Outer banks were mapped as a broken black line, and river corridor extent with a green and yellow stippled pattern. (The dark green polygons are willow-cottonwood forested wetlands.)

We used Stillwater Sciences’ mapping as a starting point for defining the river corridor for the Santa Clara River (Stillwater Sciences 2007b). For other major channels, including the Ventura River, mapping from the earliest available historical aerial served as a base layer. These base layers were then modified where earlier historical sources showed clear evidence of a change in outer bank position. For more details on mapping

methodology for the river corridors of major streams, see the Santa Clara River morphology section (page 63).

For these main river corridors, the mainstem channel lines were mapped from the historical aerial photomosaic. Since the location of the low-flow channel would have changed regularly, these lines are only used to represent the presence of mainstem channels in the broadest sense, and do not indicate a persistent feature. They were mainly used as a tool to map seasonality for the Santa Clara and Ventura rivers and main tributaries. Stream seasonality (presence of summer flow) was mapped based on historical USGS mapping, and amended where earlier additional evidence was available.

In general, we did not develop detailed maps of riparian habitats (in-channel and on the outer bank), given their inconsistent documentation and their dynamic nature on a yearly or decadal scale. Riparian vegetation features represented on historical maps within the active channel and on the floodplain were difficult to interpret and impossible to map meaningfully, given inter-annual variability in distribution and characteristics. As a result, riparian vegetation such as live oaks along canyons at the edge of the valley were mapped as the surrounding habitat. In addition, riparian habitat in the active channel was subsumed under “other in-channel riparian” habitat. Historical riparian habitat patterns are described qualitatively in the text.

While many areas of riparian forest inside the active channel were ephemeral, shifting with major flood events, there were a few reaches of the river with large wetland riparian features whose presence was consistently documented through major flood events. These areas are notable in their extent (over 200 acres), their persistence over time (as documented by multiple historical sources), and their relative importance to early residents (as indicated by their prevalence in the historical record). These features are included in our habitat mapping as willow-cottonwood forested wetland.

CHANNELS All other watercourses (including Calleguas Creek and tributaries to the rivers and creeks mapped as polygons, as described above) were mapped as line features in ArcGIS (fig. 1.7). The contemporary National Hydrography Dataset (USGS 2004) was used as a basis for mapping the historical channel network. The NHD GIS layer was modified where historical sources (such as historical aerial photos or maps) clearly showed evidence of a historical plan form differing from the contemporary alignment. This process produced a depiction of our best understanding of the historical channel network based on earliest available source.

Contemporary stream lines were altered only where historical sources clearly indicated a different channel position or shape than that mapped by NHD (greater than 50 feet difference). This approach accounts for differences in mapping scale between historical and modern mapping, differences in georeferencing, and the accuracy of historical sources.

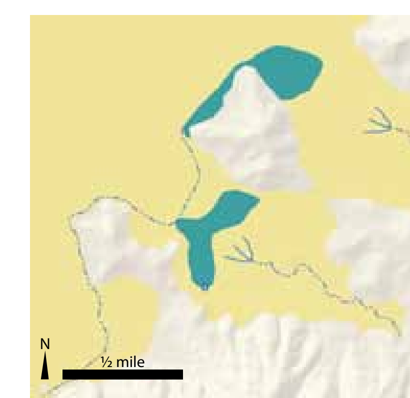


Fig. 1.7. Detail of channel mapping. Small creeks were mapped with a single line, dashed to indicate intermittent/ephemeral conditions. A forked symbol was used to indicate a distributary (that is, the point at which a creek spreads or sinks).

Although this method will not capture all changes in plan form, it allows us to more accurately analyze major changes in drainage density (stream length per unit area), connectivity, and total stream length while preventing us from over-mapping change. All editing was performed at a scale of 1:4,000.

To map the historical drainage network, we first compared NHD mapping and modern aerial imagery (USDA 2005) to early aerial imagery (1927-1959) to identify 20th century modifications. Engineered channel reaches, such as ditches and artificial flood control channels, were removed from the data set. To evaluate change predating the historical aerials, NHD mapping was compared with earlier maps depicting channel plan form. We also incorporated information from General Land Office (GLO) survey notes, other textual descriptions, topography, and early soils maps. (Contributing sources and certainty levels associated with each creek segment are recorded in the GIS attributes.)

Channels (over 500 feet long) depicted by a historical source but not present in NHD were included in the historical channel layer. To maintain a consistent depiction of channel density over time, we attempted to map channels roughly to the same level of detail as contemporary NHD mapping. As a result, our mapping excludes some small channels for which there is evidence in historical sources (such as small barrancas, creeks, or sloughs). In particular, a number of small channels visible in the historical aerial photomosaic, but of uncertain size or origin, were not included in our historical channel mapping. This approach allows for more accurate comparison between the historical stream layer and modern mapping.

Many channels historically lost definition on the alluvial plain rather than directly connecting to another channel. We represented the terminus, or distributary, of defined channels with a forked symbol on the habitat map. In cases where channels did connect to a large river (Santa Clara or Ventura river) or a major tributaries (Santa Paula, Sespe, Hopper Canyon, Piru, or Castaic creek), the channels were clipped to the historical outer channel banks layer, signifying probable connectivity to the mainstem.

WETLAND HABITATS We documented the extent and distribution of wetland types prior to significant Euro-American modification based on available historical evidence (fig. 1.8). Wetland types mapped include palustrine habitats (alkali meadow, alkali meadow/flat, wet meadow, valley freshwater marsh, perennial freshwater pond, willow thicket, and willow-cottonwood forested wetland) and also a number of coastal habitat types (see habitat crosswalk, table 1.3).

Salt-affected, seasonally-flooded alkali meadows covered large areas of the Oxnard Plain, and were by far the most extensive wetland habitat type in the region. Extent of alkali-associated habitats was mapped almost exclusively from historical soils maps (Holmes and Mesmer 1901b, Nelson et al. 1917). Alkali meadow was first mapped from the later historical soils map (Nelson et al. 1917), which shows large bodies of land with alkali present (designated with an "A") or alkali present "in spots" (designated with an "S," and covering most of the alkali-affected area). This mapping provided the general extent of alkali influence on the Oxnard Plain. A map of alkali extent accompanying the earlier soils report (Holmes and Mesmer 1901b), which distinguishes between six grades of alkali influence from 0.2% to over 3%, coarsely matches the extent of alkali-affected land as shown on the 1917 map, but provides much more resolution on the extent of highly affected (greater than 1% alkali) land. Highly affected alkaline areas, or alkali flats, were drawn from this map (the alkali meadow/flat category includes areas with 1% or greater alkali concentration in the top six feet of soil).

To map coastal features, we digitized and interpreted features from the earliest available U.S. Coast and Geodetic Survey (USCS) topographic sheets (T-sheets), from 1855 and 1857 (Johnson 1855b,c; Johnson 1857). High-resolution, full-color digital imagery of original T-sheets were obtained from the National Archives and Records Administration in College Park, Maryland (thanks to Dr. John Cloud of NOAA) and georeferenced. This work was completed as part of the Historical Wetlands of the Southern California Coast project, which contains further detail on the digitization and interpretation process for the T-sheets (see Grossinger et al. 2011). This mapping was then compared to additional sources (e.g., later T-sheet resurveys, independent historical maps, GLO survey notes, and other textual descriptions) and modified where appropriate.

Other wetland habitats were mapped from reliable, spatially explicit historical sources documenting the presence and extent of wet meadows, depressional marshes, ponds, and willow groves on the alluvial plains. Where multiple sources showed the same feature, evidence was synthesized to produce the most likely representation of historical feature. Topography, historical soils maps, and early aerial imagery were used to refine the shape and extent of wetland features in the absence of other available documentation.

This process undoubtedly under-represents the historical extent and distribution of wetland features. Some known wetland features are documented in the textual record or on coarse maps, but are ultimately not recorded with enough accuracy to render them mappable. Other wetlands were undoubtedly present, but were left undocumented by the available historical record. Subsequent research may reveal more information about the presence or location of additional wetland features.

DRYLAND HABITATS We documented the extent and distribution of dryland habitat types prior to significant Euro-American modification based on available historical evidence (fig. 1.9). Here we define "dryland" habitats to be well drained terrestrial habitats without regular cycles of flooding. Mapped terrestrial habitat classes include grassland/coastal

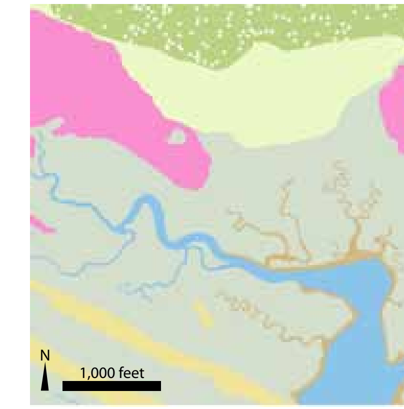


Fig. 1.8. Detail of wetland mapping, northwestern edge of Mugu Lagoon wetland complex. We mapped seasonal wetlands (such as alkali meadows, shown here in green with white stipple) in addition to perennial wetlands (such as the tidal marsh shown in grey-blue).

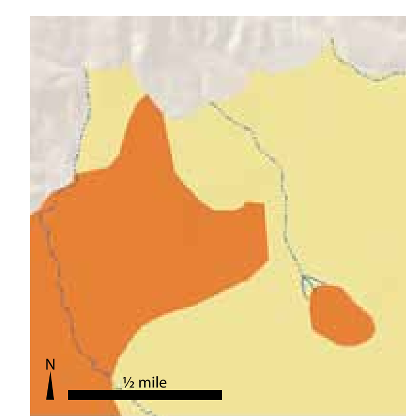


Fig. 1.9. Detail of dryland mapping. We mapped dryland habitats in a generalized fashion, including grassland/coastal scrub (in yellow) and oaks and sycamores (in orange).

sage scrub and oaks/sycamores (see habitat crosswalk, table 1.3). This layer provides the background into which we incorporated wetland and river corridor mapping.

Historical sources generally contained much less spatially explicit documentation of dryland habitat features (unlike for many wetland types, where multiple historical sources often document a single feature's location and characteristics). As a result, the goal of dryland habitat mapping was to produce a meaningful representation of patterns of dryland vegetation cover at the landscape scale. Given the lack of spatially specific information in most early sources, we relied predominantly on the few sources that did address dryland habitats, including GLO surveys, historical soil surveys, and historical aerial photography. Where available, textual descriptions, cartographic sources, and landscape photography provided additional support.

In particular, the GLO survey data provided early, detailed information about habitat boundaries and characteristics along survey lines. Later sources (such as historical soil surveys and aerial photography), in addition to edaphic or topographic information, were used to shape polygons in areas where a GLO transect was the only other source of evidence. In some cases, habitat boundaries were defined by the descriptive text associated with the soil surveys. These survyes often describe the native vegetation of the soil type, such as "brush and grass" on Yolo fine sandy loam or "scattered oak and brush" on Vina fine sandy loam (Nelson et al. 1920). Aerial photography was used to confirm the presence of trees identified by earlier sources and to map the extent of that area based on the vegetation pattern.

The "grassland/coastal sage scrub" class covers the majority of the study area (53%). It encompasses a wide range of subtypes of different moisture regimes and vegetation types. Our data suggest that the grassland/coastal sage scrub areas ranged from rich, relatively moist coastal prairie, to barren land, to dense scrub and cactus with little or no grass. This habitat type may also include areas of sparse tree cover or regions with small groves (below the minimum mapping unit, not locatable, or not documented by historical sources). We use the term "coastal sage scrub" because California sagebrush (*Artemisia californica*) was likely the predominating species. However, other chaparral or cactus species also occurred in many areas. In this report, we use grassland to mean a predominantly upland herbaceous cover, encompassing both forbland and coastal prairie types.

We were unable to map grassland and scrub separately at a consistent scale across the region, given the indistinct boundaries between types and the absence of early historical evidence for many parts of the study area. In addition, due to early invasions and the effects of grazing, dramatic changes in extent of grassland and scrub may have occurred shortly after European contact in the late 1700s, which complicates interpretation of

mid-1800s sources (see box on page 18). Generalized accounts of the Ventura County lowland describe it as largely dominated by herbaceous cover, and documentation of non-riparian trees was confined to a few select areas (see specific chapters for more details). To address this data gap, we used the grassland/coastal sage scrub habitat class as a default type when no historical evidence existed. As a result, this habitat classification often carries greater interpretation uncertainty than other mapped classes. This is captured in the GIS historical habitat layers.

The "oaks and sycamores" habitat type includes woodland or savanna areas supporting coast live oak (*Quercus agrifolia*) and/or California sycamore *(Platanus racemosa*). It was mapped in areas where tree cover was documented by historical sources (e.g., a GLO survey recording "timbered tableland" or "scattering oaks"; Thompson 1868, Craven 1874g). Polygon boundaries were drawn from a synthesis of historical aerial photography, soils and other historical maps, and textual data. In many of these instances, sycamores were explicitly mentioned (e.g., a map depicting "scattering oak and sycamore" or a GLO surveyor noting "scattering live oak and sycamore with undergrowth sage brush"; Hare 1876, Orcutt 1900); this information is included in the GIS metadata. The "oaks and sycamores" class would have included understory cover ranging from predominantly grassland to predominantly scrub, though this distinction is not represented in our mapping.

As for wetland habitat types, it is likely that mapping of these wooded areas is a conservative representation of extent, since trees were mapped only where there was supporting historical evidence. Some areas of this type are undoubtedly assigned grassland/coastal sage scrub as a default due to lack of documentation.

Inevitably, historical documents reveal more details about the historical landscape than is represented in the habitat map. For example, not all features noted by the GLO surveyors were subsequently mapped in the habitat layer, as some information was more detailed than our mapping standards allowed (e.g., an area with a small patch of cactus noted within grassland was all mapped as part of the grassland/coastal sage scrub class). As is the case with most ecosystems, transitions between woodland, scrub and low herbaceous cover were often gradual and diffuse, extending over broad areas. The habitat mapping represents regional-scale transitions as opposed to local-level detail (such as small groves, patches of scrub, or narrow zones of riparian oaks along ravines). Many of these local characteristics, though not mapped, are explored further in this report. Though the broad habitat classifications we use obscure some of the detail present in the historical record, they provide meaningful classification units that are comparable across the study area, allowing us to map at a consistent scale even in areas with relatively sparse documentation.

GRASSLAND, FORBLAND, OR COASTAL SAGE SCRUB?

The original composition of pre-contact herbaceous cover on Ventura County valley floor—indeed, across all of California—is far from clear. The historical dominance of perennial bunchgrasses in California grasslands has been hypothesized by many ecologists, and was the dominant theory for most of the 20th century (e.g., Clements 1934, Burcham 1956; see Bartolome et al. 2007 and Martinez 2010 for more detail). More recently, however, a number of researchers have proposed the historical prevalence of annual grasses and forbs in Southern California (the Los Angeles coastal prairie; see Mattoni and Longcore 1997, Schiffman 2005) and California as a whole (see Schiffman 2007, Minnich 2008). In the absence of precise, explicit historical evidence, we broadly refer in this report to the low herbaceous cover that dominated much of the Ventura County lowlands as "grasslands." These areas may have included perennial bunchgrasses and annual grasses, in addition to annual forbs and wildflowers and even some shrubs.

In our historical habitat mapping, we lumped these "grassland" habitats with the shrubbier coastal sage scrub. One reason for doing so is the ambiguity of the historical record. While habitat type is clearly indicated in a few areas by the historical record (for example, references to "cactus and sage brush" (Craven 1874f) or a "spacious plain, covered with grass" (Costansó and Browning 1992)), in most areas no such historical resolution exists.

A second reason for combining the herbaceous and shrub classes is the uncertainty surrounding impacts of Chumash land management practices, in particular the burning of grasslands. Widespread Chumash burning of grassland areas in the Santa Barbara Channel region has been exhaustively documented by Timbrook et al. (1982). Frequent (every 1-3 years) burning of valley grasslands, a technique used to increase yields of seeds and other foods during the late summer, would have maintained these areas at the expense of coastal sage scrub. Conversely, the suppression of burning practices in the late 1700s by Mission officials would have led to the encroachment of coastal sage scrub into former grassland areas.

The effects of Chumash burning practices on the extent and distribution of Ventura grasslands and shrublands further compounds the ambiguity surrounding each habitat's historical distribution in the county, and even calls into question the relevance of 19th century ecological observations for these habitat types. Heavy grazing pressures from Mission cattle in the late 1700s and early 1800s may have also distorted these observations. Since distinctions between grasslands and shrublands could not be consistently made across the entire study area, we chose to display the two communities together rather than risk making uninformed decisions.

The cessation of Chumash fire management, grazing impacts, and the introduction and invasion of exotic species all contributed to a rapid change in the character of Ventura grasslands by the early 19th century. Descriptions of widespread non-native cover, particularly wild oats (*Avena fatua*) and wild mustard (*Hirschfeldia incana/Brassica nigra*), were abundant during this time on lowlands across the study area: GLO surveyor Hancock (1854) repeatedly noted "dense mustard" and "belts of grass and mustard" on the Oxnard Plain; a description corroborated by other observers who saw "thickets of wild-mustard" (Roberts 1886), "thousands of acres actually overrun with wild mustard" (Rothrock 1876), a "vast forest of bee-haunted mustard-blooms" (Eames 1889), "meadow grass and wild oat" (*Daily Alta California* 1865), and "wild oats, wild burr-clover [*Medicago polymorpha*], and alfilaria [filaree; *Erodium cicutarium*]" (Storke 1891).

Timbrook et al. (1982) provides a list of grasses that were likely abundant in the Santa Barbara Channel region during active Chumash management. They include California brome (*Bromus carinatus*), ryegrasses (*Leymus [Elymus] condensatus, L. glaucus,* and *L. triticoides*), meadow barley (*Hordeum brachyantherum*), coast range melic (*Melica imperfecta*), bluegrass (*Poa secunda*), needlegrass (*Nassella pulchra, N. lepida,* and *N. cernua*), chia (*Salvia columbariae*), and red maids (*Calandrinia* spp.), among other grass and herb species.

Habitat and Channel Classification

We developed twenty different habitat types based on historical evidence and modern classification systems (table 1.3). These classes balance a desire to preserve the detail often available in the historical record, while creating meaningful classes that are comparable to contemporary classification systems and applicable across the entire study area. In some cases, the character of historical data creates difficulty in direct translation to a single contemporary vegetation class. We divided the 20 habitats or vegetation types into wetland, dryland, riparian, and coastal habitat types reflective of the historical ecology of the region (see table 1.3 for complete list). (In this report, we use the term "riparian" to refer exclusively to streamside vegetation.)

The following definitions provide brief explanation of the habitat types outlined in table 1.3. They are in large part derived from contemporary descriptions and classification systems outlined elsewhere (e.g., Ferren et al. 1990, 1995; Mertes et al. 1996; Holstein 2000; Ornduff et al. 2003; Barbour et al. 2007; Ferren et al. 2007; Grossinger et al. 2007; Stillwater Sciences 2007a,c; Coffman 2008; Orr et al. 2011). For more detailed descriptions of each type, please refer these documents.

Palustrine and Terrestrial Habitats

PERENNIAL FRESHWATER POND Freshwater ponds are permanently inundated, non-vegetated depressional areas containing year-round standing water. They often occur within larger complexes of marshland, willows, and seasonal wetlands.

VALLEY FRESHWATER MARSH Valley freshwater marshes can be associated with low-lying depressions and ponds, in-channel sloughs and areas of high groundwater, or groundwater-fed springs. They are flooded for most or all of the year, and are permanently saturated. Dominant plant species include bulrushes (*Scirpus [Schoenoplectus]* spp.), cattails (*Typha* spp.), sedges (*Carex* spp.), spikerushes (*Eleocharis* spp.), and rushes (*Juncus* spp.).

WILLOW THICKET This category includes stands of willow (*Salix* spp.) not found along rivers or creeks. It includes dense thickets dominated by shrub-sized willows with occasional larger trees (e.g., historically documented box elder; *Acer negundo*), in addition to willow "groves," which tended to include stands of more mature, established trees. Since willows are dependent on a relatively high groundwater table, these areas are often temporarily flooded.

WET MEADOW Wet meadows are temporarily or seasonally flooded grasslands characterized by poorly-drained, clay-rich soils. They can be flooded for days or weeks depending on precipitation and topography, and stay moist longer than adjacent, better-drained areas. The dominant plant species were probably rhizomatous ryegrasses (*Leymus* spp.), with a significant component of obligate and facultative wetland species such as wire rush

Table 1.3. Crosswalk between historical habitat type and modern classification systems.

Historical Habitat Type	California Terrestrial Natural Communities (CNDDB 2003)	Wetland Classification and Water Regime (Cowardin et al. 1979)/ USFWS Riparian Mapping System (2009)
Palustrine and Terrestrial Habitats		
Perennial Freshwater Pond	N/A	Palustrine permanently flooded wetland.
Valley Freshwater Marsh	Valley Freshwater Marsh (52.100.01)	Palustrine persistent emergent freshwater/saline wetland. Temporarily to permanently flooded, permanently saturated.
Willow Thicket	Scrub Willow (63.100.00), Willow Riparian Forests and Woodlands (61.200.00)	Palustrine forested wetland. Temporarily flooded, permanently saturated
Wet Meadow	Native Grassland (41.000.00); Meadows and Seeps not dominated by grasses (45.000.00)	Palustrine emergent wetland. Temporarily flooded, seasonally saturated.
Alkali Meadow	Alkali Meadow (45.500.00), Salt - Alkali Marsh (52.200.00), Saltgrass (41.200.00)	Palustrine emergent saline wetland. Temporarily to seasonally flooded, seasonally to permanently saturated.
Alkali Meadow/ Alkali Flat	Alkali Meadow (45.500.00), Alkali Playa Community (46.000.00), Saltgrass (41.200.00)	Temporarily to seasonally flooded, seasonally to permanently saturated.
Oaks and Sycamores	California Sycamore-Coast Live Oak (61.312.01), California Sycamore (61.310.00)	N/A
Grassland and Coastal Sage Scrub	Native Grassland (41.000.00); Venturan Coastal Scrub (32.190.00), Wildflower Field (41.290.00)	N/A
Characteristic Riparian Habitat Types		
Willow-Cottonwood Forested Wetland	Willow Riparian Forests and Woodlands (61.200.00), Black Cottonwood Riparian Forests and Woodlands (61.120.00), Southern Cottonwood-Willow Riparian (61.130.02), Marsh (52.100.00)	Riparian Forested Deciduous
Other In-Channel Riparian	Scrub Willow (63.100.00), California Buckwheat-Scalebroom (32.070.01), Mulefat Scrub (63.510.00), California Sycamore-Coast Live Oak (61.312.01), Willow Riparian Forests and Woodlands (61.200.00)	Riparian Scrub-Shrub Deciduous, Riparian Forested Deciduous/Evergreen
Coastal and Estuarine Habitats		
Beach/Dune	Coastal Dunes (21.000.00), Native Dunegrass (41.260.00)	N/A
Tidal Lagoon (mostly open?)	N/A	Estuarine subtidal, unconsolidated bottom
Tidal Lagoon (seasonally open)	N/A	Estuarine subtidal/Palustrine intermittently flooded. Unconsolidated bottom.
Non-tidal Lagoon	N/A	Estuarine subtidal/Palustrine intermittently flooded. Unconsolidated bottom.
Tidal Flat	N/A	Estuarine intertidal. Intermittently flooded, unconsolidated bottom.
Tidal Marsh	Coastal Brackish Marsh (51.100.02), Pickleweed Wetland (52.201.00)	Estuarine intertidal persistent emergent wetland. Temporarily to seasonally flooded, permanently saturated.
Seasonally Tidal Marsh	Coastal Brackish Marsh (51.100.02), Pickleweed Wetland (52.201.00)	Estuarine intertidal persistent emergent wetland. Seasonally flooded, permanently saturated.
Salt/Brackish Marsh	Coastal Brackish Marsh (51.100.02)	Estuarine intertidal persistent emergent wetland. Temporarily to seasonally flooded, permanently saturated.
Salt Flat/ Seasonal Pond	N/A	Estuarine intertidal. Intermittently flooded, unconsolidated bottom.
High Marsh Transition Zone	Saltgrass (41.200.00), Alkali Meadow (45.500.00)	Palustrine emergent or unconsolidated bed, possibly hypersaline at times

(*Juncus balticus*), irisleaf rush (*Juncus xiphiodes*), buttercup (*Ranunculus californicus*), and blue eyed grass (*Sisyrinchium bellum*).

ALKALI MEADOW Similar to wet meadows, alkali meadows are temporarily or seasonally flooded grasslands on poorly-drained, clay-rich soils. Unlike wet meadows, however, alkali meadows are characterized by salt-affected soils. The dominant vegetation is salt grass (*Distichlis spicata*), though other salt-tolerant species such as alkalki goldfields (*Lasthenia ferrisiae*), salt marsh birds beak (*Cordylanthus maritimus* ssp. *maritimus*), spreading alkali weed (*Cressa truxillensis*), shaggyfruit pepperweed (*Lepidium lasiocarpum*), and hairy gumweed (*Grindelia hirsutula*) may have also been present.

ALKALI MEADOW/FLAT Some alkali meadows were characterized by a particularly high degree of soil salinity (over 1% in the first 6 feet; Holmes and Mesmer 1901c). These areas are composed of a mosaic of alkali meadows and more sparsely vegetated alkali playas or flats (e.g., "scalds"). Saltgrass (*Distichlis spicata*) is still a significant component, but this category also includes large expanses of open, non-vegetated seasonally flooded areas (<10% plant cover) with local alkaline concentrations too high to support substantial vegetation.

OAKS AND SYCAMORES This classification includes areas not along active stream courses but with documented coast live oak (*Quercus agrifolia*) and/or California sycamore (*Platanus racemosa*). With few exceptions, the dominant tree is coast live oak. Shrubs and herbaceous cover were both documented below the canopy. Since it is unevenly specified by historical documents in this region, we were unable to specify tree density. These areas likely ranged from savanna to woodland densities. They occurred predominantly on well drained terraces and alluvial fans in the Ventura and Santa Clara river watersheds.

GRASSLAND/COASTAL SAGE SCRUB This is a general category encompassing herbaceous and shrub cover, mostly occupying well drained portions of the Ventura County alluvial valleys. Vegetation communities included in this category range from treeless herbaceous cover and coastal prairie (which may have included native perennial bunchgrasses and annual grasses, in addition to annual forbs, wildflowers and shrubs) to Venturan coastal sage scrub (including coyote brush (*Baccharis pilularis)* and California sagebrush (*Artemisia californica*)).

Riparian Habitats

WILLOW-COTTONWOOD FORESTED WETLAND This category includes large areas (over 200 acres) of wetland riparian habitat whose presence has transcended significant flood events of the late 19th and early 20th centuries. Each of these areas is well documented in the historical record as broad forested groves or marshes; many were even named (e.g., West Grove, East Grove, the Cienega). They are distinguished from other in-channel riparian areas by their size, their breadth (in some places over 3,300 ft wide), their persistence, and their notoriety. They are also described in the report as "persistent wetland riparian areas."

These areas included valley freshwater marsh and winter-deciduous riparian forest, with species extent and distribution varying by location. Some areas would have been predominantly forest stands on higher benches, while in other areas forest would have been interspersed with open wetland patches. Mixed willow forest (*Salix* spp., including arroyo willow, red willow, narrowleaf willow, sandbar willow, and shining willow), mulefat (*Baccharis salicifolia)*, black and Fremont cottonwoods (*Populus balsamifera* ssp. *trichocarpa* and *P. fremontii*), and occasional sycamores (*Platanus racemosa*) would have been present in varying proportions in these areas, in addition to wild grape (*Vitis Californica*), wild rose (*Rosa californica*), and California blackberry (*Rubus ursinus*). Freshwater marsh-associated species such as tule (*Scirpus* [*Schoenoplectus*] spp.), cattails (*Typha* spp.), sedges (*Carex* spp.), spikerushes (*Eleocharis* spp.), and rushes (*Juncus* spp.) were also present.

OTHER IN-CHANNEL RIPARIAN Since the variability of historical data precluded detailed riparian mapping for this study, most riparian habitats are included in this category. The character and distribution of these habitats varied with water availability and flood disturbance regime. At one extreme, areas of frequently flooded sandy riverwash occupied the lowest portions of the active channel, and were either unvegetated or sparsely vegetated with willow, mulefat, or alluvial scrub. At the other, established, infrequently flooded bars and islands along portions of lower Santa Paula Creek and the Ventura River supported stands of California sycamore and Coast live oak. Intermediate riparian habitats included willow forest, sycamore-alder-California bay forest (on the Ventura River; Mertes et al. 1996), mixed riparian forest, thickets of willow scrub and mulefat, and alluvial scrub (including mulefat, California buckwheat (*Eriogonum fasciculatum*), and scalebroom (*Lepidospartum squamatum*)). These patterns, while lumped in the GIS, are discussed extensively in the report.

Coastal Habitats

BEACH/DUNE Beaches and dunes are coastal habitats located immediately along the shoreline. Beaches and foredunes are sandy and sparsely vegetated, while backdunes are located inland from foredunes and are generally more stable and more densely vegetated. While foredune vegetation is mostly composed of forbs, backdunes also support some shrubs in addition to herbaceous cover.

Beach and foredune vegetation would have likely included sand verbena (*Abronia maritima*) and pink sand verbena (*Abronia umbellata*), beach bur (*Ambrosia chamissonis*), beach saltbush (*Atriplex leucophylla*), beach primrose (*Camissonia cheiranthifolia*), beach morning glory (*Calystegia soldanella*), dune lupine (*Lupinus chamissonis*), mock heather (*Ericameria ericoides*), dune buckwheat (*Eriogonum parvifolium*), and salt grass (*Distichlis spicata*). Backdunes would have likely supported coastal sagebrush (*Artemisia pycnocephala*), Heather goldbush (*Ericameria ericoides*), dune lupine (*Lupinus chamissonis*), and buckwheat (*Eriogonum* spp.), in addition to species also present in the foredune community. Scattered willows (probably *Salix lasiolepis*) were documented in dune swales south of McGrath lake.

TIDAL LAGOON (MOSTLY OPEN?) These are coastal bodies of water with a more frequent connection to the ocean, although precise historical closure dynamics are generally unknown. Subtidal communities of eelgrass (*Zostera marina*), Pacific eelgrass (*Zostera pacifica*), and surf-grass (*Phyllospadix torreyi*) occur in subtidal portions of estuarine lagoons.

TIDAL LAGOON (SEASONALLY OPEN) These are coastal bodies of water with a seasonal connection to the ocean. They are typically non-tidal during the summer, when the mouth is closed, and open during the winter, when greater freshwater flows breach the barrier.

NON-TIDAL LAGOON Mostly-closed tidal lagoons are coastal bodies of water with infrequent tidal connection. These lagoons may have salinity gradients ranging from fresh to brackish to saline, with freshwater inputs from springs and streams upslope and occasional tidal inputs. Through stratification, these lagoons may support distinct saline and fresh zones. Some lagoons may have occasionally dried out during the dry season.

TIDAL FLAT Tidal flats are unvegetated intertidal habitat, found on gradually sloping shorelines between estuarine open water and the lowest salt marshes. They are exposed between low and high tides.

TIDAL MARSH Tidal marshes occur along the perimeter of tidal lagoons, and are regularly inundated by the tides. Plant species distribution within the tidal marsh is determined largely by salinity and elevation (and thus inundation frequency); dominant plant species include Pacific cordgrass (*Spartina foliosa*), pickleweed (*Salicornia virginica*), and high marsh species such as saltgrass (*Distichlis spicata*), Parish's pickleweed (*Arthrocnemum subterminale*), and shoregrass (*Monanthochloe littoralis*).

SEASONALLY TIDAL MARSH Found adjacent to seasonally open tidal lagoons, seasonally tidal marsh shares similar vegetative characteristics to tidal marsh but with the addition of brackish emergent vegetation such as prairie bulrush (*Scirpus [Bolboschoenus] maritimus*), tule (*Scirpus [Schoenoplectus] californicus*), and cattail (*Typha domingensis*). Seasonally tidal marshes have brackish to saline hydrology, depending on season, elevation, and precipitation.

SALT/BRACKISH MARSH Found adjacent to non-tidal (mostly closed) lagoons, non-tidal brackish marsh hydrology originates largely from runoff and precipitation, with occasional dune overwash during large storm events contributing saline water. As a result, non-tidal brackish marshes can be fresher than the more marine-influenced tidal marshes, with corresponding shifts in vegetation distribution and frequency. The infrequent presence of an outlet can also make some non-tidal brackish marshes hypersaline. Dominant plant species probably overlap with high marsh plants (e.g., saltgrass), with additional presence of brackish-tolerant species such as bulrush (*Scirpus [Bolboschoenus]* spp.), tule (*Scirpus [Schoenoplectus] californicus*), and cattail (*Typha domingensis*). Little is known, however, about the pre-modification plant community of these marshes.

SALT FLAT/SEASONAL POND/MARSH PANNE Tidal marsh pannes or salt flats are unvegetated, open depressions within tidal marshes. They are irregularly or seasonally flooded. Their hydrology (alternately flooded and dry) and evaporate concentration precludes most plants from establishing. Some seasonal ponds may have occasionally retained open water year-round.

HIGH MARSH TRANSITION ZONE The high marsh transition zone is the ecotone between estuarine and terrestrial communities, with habitats intergrading between upland habitats and the tidally-influenced saline habitats of the coast. High tidal marsh species (e.g., saltgrass) overlap with alkali meadow species and freshwater (non-tidal) species. This area generally receives overflow by extreme high tides.

2 • HISTORICAL BACKGROUND AND CONTEXT

It was late in the afternoon of the next day ere we started for our seven miles ride to Saticoy. Our way led through the upper portion of one of the finest avenues in California…Clinging to the road on both sides are extensive orchards of apricot and walnut trees, while countless acres of beans stretch away to the mountains on one hand, and to the river on the other.

And to think! When I was a little girl this was all a vast forest of bee-haunted mustard-blooms, in which the traveler would get lost as easily as in an Indian jungle.

—NINETTA EAMES 1889,
TRAVELING FROM SANTA PAULA TO SATICOY;
AUTUMN DAYS IN VENTURA

Ventura County has a complex history of occupation, cultivation, and water use. Land and water use both reflect physical characteristics of the landscape (e.g., sugar beet cultivation indicates presence of alkaline soils) and affects landscape character (e.g., groundwater pumping decreases riverine flow). Because of this, understanding the cultural trends in the county is essential to interpretation of changes in landscape patterns and ecological function that have occurred over the past 250 years.

Since other reports have provided detailed histories of land and water use trends in the mid- to late 20th century (e.g., Schwartzberg and Moore 1995, AMEC 2004, Stillwater Sciences 2007b), we do not cover it again here (fig. 2.2). Instead, we focus on 19th- and early 20th-century trends in population, agriculture, irrigation, and resource use that provide context for the broad ecological and hydrologic changes occurring in the county concurrent with the changes detailed below.

Early Settlement History: Ventureño Chumash

The Chumash have been present in the Santa Barbara Channel region for about 9,000 years (Timbrook 2007). Ventureño Chumash occupied most of the study area, including the Ventura River valley, the Oxnard Plain, and the Santa Clara River valley to around Castaic (Van Valkenburgh 1935). The Uto-Aztecan Tataviam lived in the upper portion of the Santa Clara River watershed.

An estimated 15,000 Chumash lived in the Santa Barbara Channel area (including the Channel Islands) in 1769, at the time of Crespí's expedition

Fig. 2.1. Planting lima beans on the Dixie Thompson Ranch, near Ventura. This photo (opposite page), taken around the turn of the 20th century, shows a team in the process of planting lima beans, and is part of a series of such photos. Other photos in the sequence state that the rows were 1.75 miles long, and that teams could plant 150 acres a day. (Unknown ca. 1900c, courtesy of the Society of California Pioneers)

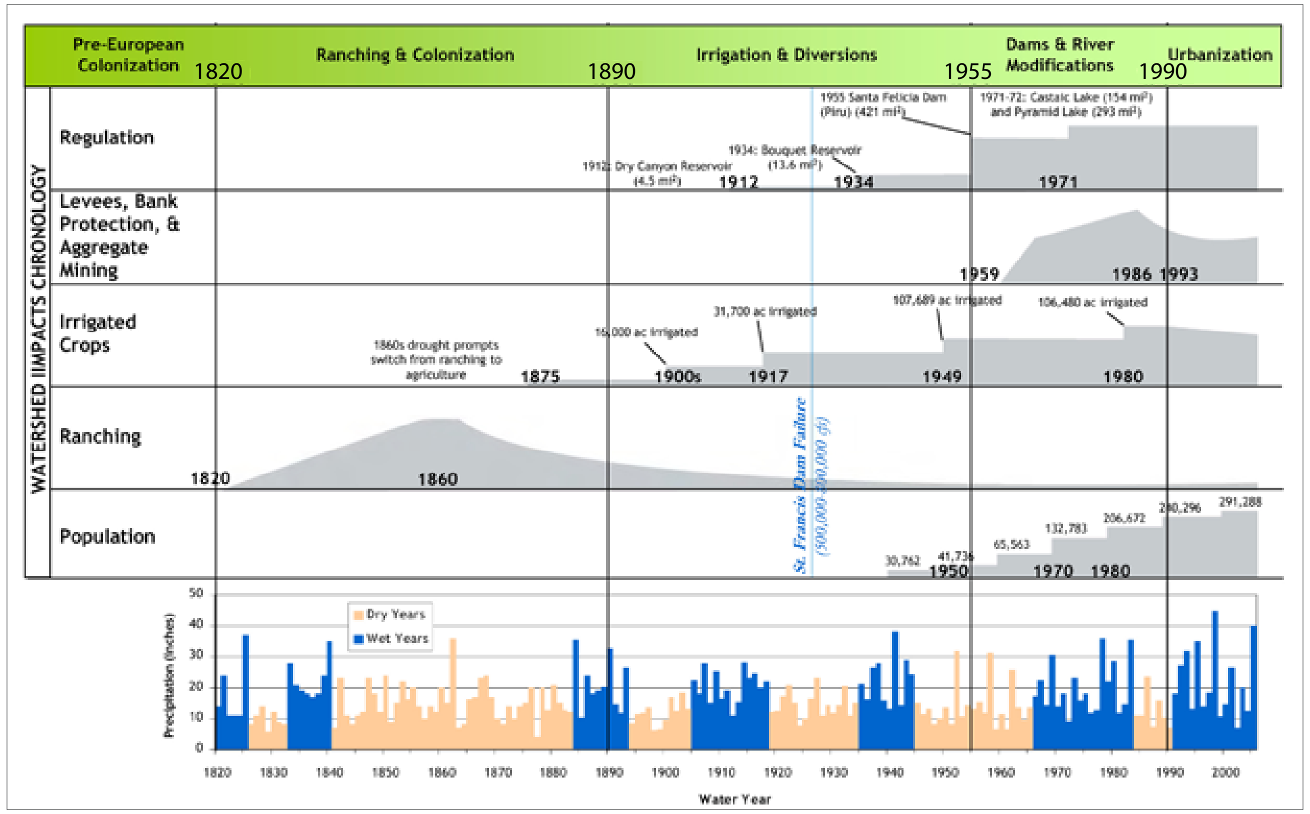


Fig. 2.2. Chronology of land and water use modifications, population, and precipitation on the lower Santa Clara River, 1820-2005. This graphic, produced by Stillwater Sciences (2007b), provides hydrologic and land use modification context useful in the interpretation of historical sources. (Precipitation data extended and adapted from Freeman (1968) by Stillwater Sciences (2007b); graphic courtesy of Stillwater Sciences)

(Timbrook et al. 1982). On a sea voyage in 1542, Juan Rodríguez Cabrillo noted a seaside town which he called Pueblo de las Canoas, a large village with many canoes (in Kelsey 1986). This site has been variably identified by researchers as near Mugu Lagoon (Wagner 1941, Kelsey 1986, King 2005) or near Ventura (Bancroft 1884, Davidson 1887, Bolton 1959; see Moriarty and Keistman 1963 and Kelsey 1986). When Crespí's party traveled through the Ventura region in 1769, they noted a number of large Chumash settlements: a village of about 200 near the confluence of Sespe Creek and the Santa Clara River (Costansó mentions that including this village, he saw 500 Chumash between Piru and Sespe); a village near the Santa Clara River at its confluence with Santa Paula Creek; a large village near Saticoy Springs; and a large village near Ventura (Costansó and Browning 1992, Crespí and Brown 2001).

A large number of other important settlement and use sites have been identified by archaeologists and ethnographers. In particular, ethnographer and linguist John Peabody Harrington worked closely with the Ventureño Chumash during the early 1910s, recording information about places and place names. Harrington's research documents a rich landscape of place names for springs, lagoons, and other natural features, as well as settlement sites. Sites of particular note recorded by Harrington and other researchers were located all over the county, including near Ventura, Matilija, Saticoy Springs, Montalvo, El Rio, Somis, Springville, Hueneme, Mugu, Santa Paula and Sespe creeks, Camulos, and Castaic (Harrington 1913e, Van Valkenburgh 1935).

The Chumash made extensive use of a wide variety of plant species in the county, as documented in detail by Timbrook (2007). Mission friar José Señán noted in a report that the Chumash at the Mission still ate the "wild seeds and fruits which they love dearly and cannot forget" (Señán 1822). In addition to supplying food sources, plants were also used for producing material items. Riparian plants along the Santa Clara River, such as carrizo grass (*Phragmites communis*), giant reed (*Arundo donax*), tule, and cattail were used by the Chumash to create housing, boats, and other objects (Schwartzberg and Moore 1995, Timbrook 2007). Tule from the mouths of the Santa Clara and Ventura rivers was used to thatch houses (Harrington 1986b), and canoes were stored in the tule marsh at the mouth of the Ventura River (Harrington 1986b, Timbrook 2007). (One of Harrington's informants recalled that canoe builders "bent tule that was growing there on both sides over the canoe" to shade the boat.)

Along the margin of the river Buenaventura are many small gardens belonging to the Indians, where they raise fruits and vegetables…

—ROBINSON 1846

Deliberate, systematic burning of coastal grassland was also used as a method to create food sources, as documented in the Santa Barbara Channel region by a number of historical accounts (cf. Timbrook et al. 1982). Santa Barbara Mission records from 1793 indicate that Chumash to the north of Ventura County frequently burned the region's grassland, complaining that the Chumash "set [fire] to the grazing lands every year" (Arrillaga 1793, in Stewart et al. 2002). The extent of these practices in the Ventura valley areas, and their effects on vegetation cover, are unknown. It is possible that cessation of native burning may have increased shrub cover in areas where burning may have favored bunchgrass species (e.g., on the alluvial portions of the Oxnard Plain). However, this is impossible to determine from our data set, and is complicated by the impacts of grazing in many areas during the first half of the 19th century, which likely served to inhibit shrub/scrub growth.

San Buenaventura Mission and the Ranching Era (1782-1877)

The San Buenaventura Mission was founded in 1782, introducing stock-raising and small-scale agriculture to what was to become Ventura County (fig. 2.3). Fruit trees and small gardens of vegetables such as melons, corn, and potatoes (Vancouver [1798]1984, Señán 1822) were planted near the Mission, along the lower Ventura River, and in the Santa Paula area (Bowman 1947). By the 1820s, the Mission also tended cultivated fields on the eastern portion of the Oxnard Plain, likely the Las Posas/Calleguas region (Uría 1828). ("Las Posas" means a "pool" or "water hole," features often associated with springs; Gudde and Bright 1998.)

Stock (notably cattle and sheep) ranged over large portions of the Mission property, including the Ventura and Santa Clara River valleys and large

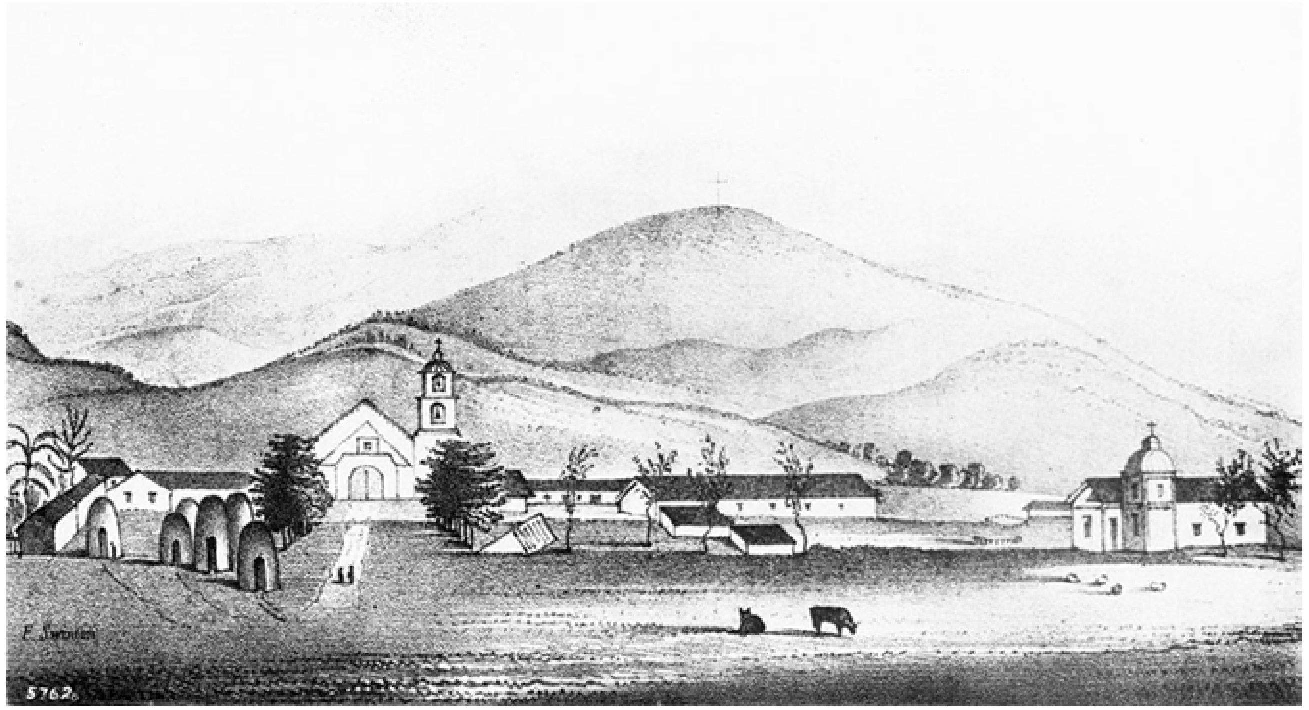


Fig. 2.3. Mission San Buenaventura, ca. 1829. This remarkably early sketch, from Alfred Robinson's book *Life in California*, shows the mission complex as it existed before secularization. Cows graze in the foreground, with what appear to be sheep further back. Two people are on the path to the church complex. In the book Robinson describes his visit to the mission: "At dinner the fare was sumptuous, and I was much amused at the eccentricity of the old Padre…After concluding our meal, we walked with him to the garden, where we found a fine fountain of excellent water, and an abundance of fruits and vegetables." (Text: Robinson [1846]1947; Image: Robinson ca. 1829, courtesy of the USC Digital Archive and the California Historical Society)

portions of the Oxnard Plain (Bowman 1947). The Mission's main site for grazing and breeding cattle was in the Sespe-Pole Creek region (modern day Fillmore; Señán 1822, Van Valkenburgh 1935), though significant numbers of cattle also grazed near Piru (which Señán called "the consolation of this Mission" for its benefit to cattle). Sheep were kept in four flocks in the Ventura River valley north of the Mission (Señán 1822) and also near the current location of the Olivas adobe near the Santa Clara River (Harrington 1913e). Fray José Señán described the extensive ranging of the Mission's cattle:

> The considerable numbers of animals belonging to this Mission do their grazing, in large part, just above the beach. When the pasture there is exhausted or dried up, the cattle go in search of more plentiful or better grazing elsewhere, following the beach inland and spreading out toward Mugú [Santa Paula]. The animals farthest from the beach make their way to a place called Saticoy, and when the grazing there is exhausted (that locality not being very productive and most of the growth being sword grass), they roam farther up to the meadows along the river and through a rather wide canyon into Sécpey, some bands of mares penetrating as far as Camulus. (Señán and Santa María 1804)

At the Mission's peak inventory in 1816, holdings included over 41,000 head of stock, including about 23,000 cattle and 12,000 sheep (Bowman 1947, California Missions Resource Center 2010). Around this time (1815), from 45 to 120 cows were slaughtered per week (Señán 1815). This provided an overabundance of meat, and since cows were kept predominantly for their tallow and hides this extra meat was simply discarded: "the large parts of the meat are taken in carts to the fields and burnt, since there is no one to collect them and there is plenty of fresh meat in the houses" (Señán 1815).

A drought around 1828-9 diminished the Mission's cattle and sheep herds (Lynch 1931, Smith 1972). After the secularization of the California Missions in 1834 holdings were further reduced, until by 1842 a traveler noted "at most, one thousand head of cattle, large and small"(de Mofras [1844]1937). (Interestingly, de Mofras also noted that at this time Mission fields were irrigated with water from the Santa Clara River.) The Mission was illegally sold in 1846 to José Arnaz.

By this time, though, former Mission territory had been largely divided into large ranchos amongst Spanish and Mexican families. By the time the Mission was sold in 1846, what was to become Ventura County had been divided into 19 ranchos (Triem 1985), many of which were heavily stocked with cattle. One resident recalled that in 1850 "the whole country was overrun with cattle…The cattle were so thick and plentiful in those days that vaqueros would have to go ahead of parties traveling through the country to clear the way for them" (Sheridan 1912). By 1860, there were more than 90,000 cattle and 65,000 sheep in Santa Barbara County (including Ventura County, which was not formed until 1873; Gregor 1953; fig. 2.4). (While the numbers cited above seem large, they account for modern-day Ventura and Santa Barbara counties, quite an extensive area.)

The drought of 1863-4 killed massive numbers of cattle all over California. Lack of pasture and water caused thousands of cattle to die of starvation, or be slaughtered in anticipation of the lack of food and water. In Santa Barbara County, a newspaper article noted that 18,000 cattle "have been slaughtered for their hides and tallow, and from one-third to one-half of the remainder have died by starvation" (*Daily Alta California* 1864). (Others report a much larger figure, stating that 2/3 of the County's cattle died; cf. Thompson and West [1883]1961.) This effectively marked the end of extensive cattle raising in the area. By the 1870 U.S. Census, only 10,000 cattle remained in Santa Barbara County (Gregor 1953).

As a result of this sharp decline in cattle numbers, after 1864 sheep ranching became the dominant land use in the region, in part because of their greater tolerance to drought. In 1870, about 190,000 sheep grazed in Santa Barbara County, nearly three times the number in the county a decade earlier. This was consistent with a wider statewide trend: while the 1850 census recorded under 20,000 sheep, by 1876 (the peak of the industry) there were over 6,400,000 sheep in the state being raised for meat and wool (Johnston and McCalla 2004).

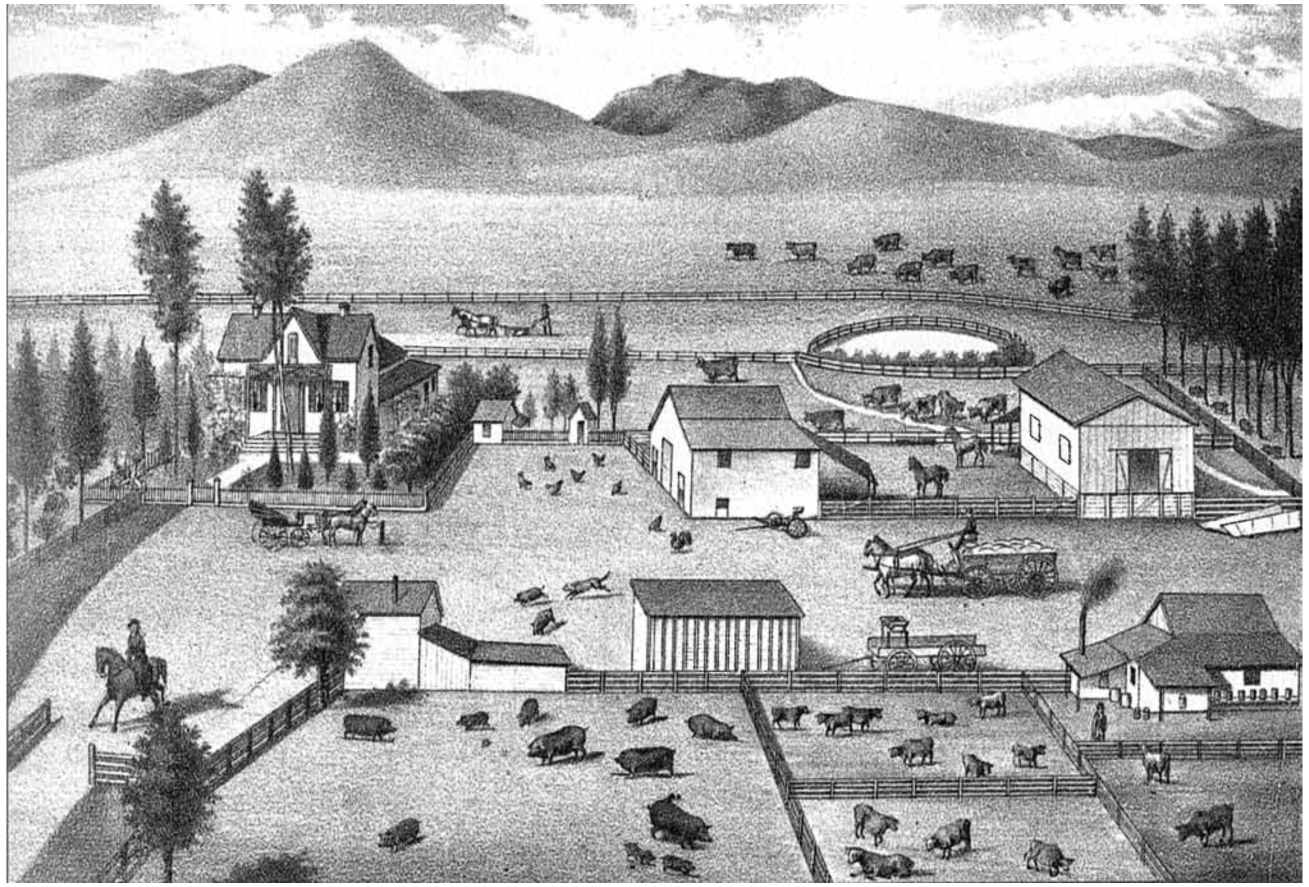


Fig. 2.4. Cattle, horses, pigs, and chickens on the George G. Sewell ranch near Santa Paula, 1881. Unfenced cattle graze in the background, and a dog chases a pig in the enclosure. The farm had 400 acres under cultivation and an additional 500 acres for grazing, including 1,000 hogs and 20 cattle. While the heyday of large cattle ranches had ended, this farm still had a number of stock. (Thompson and West [1883]1961)

The drought of 1877 marked the end of the large-scale stock raising in the county, and decimated the massive sheep flocks of the previous decade:

> The year 1877 was very dry. In Santa Barbara county, hay was forty dollars a ton. I have heard men say, with a sigh, "It was the dry year of '77 that broke me up. My sheep all died." Many a man grew gray that year, as he saw his living withering away. (Rindge 1898)

After this, Ventura County ranchers transitioned to grain farming. Large-scale sheep and cattle ranches, while still present in the county in reduced numbers, were largely pushed onto less desirable lands, either upland areas or uncultivatable or remote lands. An exception was in the upper (Los Angeles County) portion of the Santa Clara River valley, where cattle and sheep grazed near the river into the 20th century (Tait 1912) and still do today. In some areas, sheep and cattle pastured Ventura uplands most of the year, and in valley floor fields during the winter (Nelson et al. 1920, Gregor 1951).

The impact of early cattle and sheep grazing on historical lowland habitats in Ventura County is unknown. At the peak of Mission stock holdings in 1816, stock ranging densities in the county reached an estimated one head for every four to five acres of grazing land (Bowman 1947). This

may be considered a relatively low to moderate stocking density: in the late 19th century appropriate stocking densities for cattle in Southern California were considered to be five acres per head for "valley land," and approximately one acre per head for sheep (Bancroft et al. [1890]1970). Furthermore, these standards were based on American cattle, which were only introduced to Southern California by the 1860s (Adams 1946) and were much larger and required more forage than their Mexican counterparts (Cleland [1941]1990, Burcham 1956). The Mexican cattle ubiquitously raised by the Mission and early ranchos would have required less land than the above densities. Impacts of Mission-era cattle grazing were likely limited by the relatively small size and moderate grazing intensity of Mission-era cattle.

However, by the 1850s and 1860s it is possible that cattle and sheep grazing may have had significant effects on ecological and morphological processes in the county. Potential effects of early livestock grazing include alteration of the distribution and type of valley floor habitats (e.g., relative proportion of herbaceous cover and scrub and increased spread of invasive plant species), changes in rainfall runoff and erosion (and a resultant increased sediment supply to Ventura County waterways), and an increase in the depth and density of barrancas (Stillwater Sciences 2007b). These effects are treated only peripherally here (see pages 18 and 172).

A few sources do describe the effects of livestock on portions of the county's pasturelands. Hassard (1887) described some of the effects of the upland shepherding in Ventura County common subsequent to the drought of 1877: "herders… drive thousands of sheep over the government wild lands, and, when they have stripped a region, put the torch to the brush, to improve the pasturage for the next season." Rothrock (1876) described the immense changes wrought by sheep on the Conejo Ranch during the 1876 dry period, noting that

> Hitherto sheep-raising has been the principal interest of the ranch, and of this we had the most indubitable evidence in the appearance of the land, everywhere pastured off the very surface. How long it will take California to regain the rank pasturage the State once had is a question.

Up Sespe Canyon, Rothrock described "a country where in the most accessible spots the soil had been stripped of the meager supply of herbage it perhaps once possessed." While this was an exceptionally dry year, this type of heavy grazing would have likely altered the hydrodynamics of Ventura County streams.

Early Commercial Agricultural Development (1878-1920)

After the collapse of the large sheep ranchos of the 1860s and 1870s, farmers quickly began to switch to other livelihoods. Barley, which thrived in the foggy coastal areas better than other grains, had been cultivated on the Oxnard Plain since the 1860s (Storke 1891, Gregor 1953) and was a major crop of the Ventura lowland areas. Descriptions of the lower Santa

And '77, that ghastly year, child as I was, is still with me, when the relentless sun looked down from cloudless blue skies and set red in the west day after day, when the hills were dry and brown from year's end to year's end, and the lowing of cattle being driven out to the country and the bleating of the dying sheep filled my heart with sorrow…

—FRANCIS 1912

If the stranger ever wondered where Boston got its beans, he found out now, as the land fell away to the Pacific with the soil becoming richer and finer as it expanded into the broad plains of Santa Paula and Hueneme, green for miles with grain and springing corn and beans…

—VAN DYKE 1890

Clara Valley and Oxnard Plain from the mid- to late 1870s describe an agricultural landscape dominated by barley (and, to a lesser extent, corn on the moister portions of the plain):

> [traveling west from Conejo], we crossed the western end of the Santa Clara Valley, and found the farmers engaged in harvesting their barley… Large fields of good corn were seen. It was just in tassel, and gave abundant promise of a heavy crop. It is hardly overreaching to say that on that day we saw thousands of acres actually overrun with wild mustard, which attained a height often of 8 or 10 feet…In some places, indeed, it might well be doubted as to whether it was a mustard or barley field we were passing, both of which were luxuriant enough. (Rothrock 1876)

> [describing "the section east of the Santa Clara River"] As we drove through that region, it seemed as though we were gazing upon a vast sea of grain, and here and there a dark spot looming up like a distant island, and contrasting strongly with the billowy waves of green barley on every hand. The dark spots marked the tracts of corn ground… (Sheridan 1878)

Lima beans were first planted on the Oxnard Plain around 1875 (Storke 1891; fig. 2.5). Like barley, the beans grew well in the fog on non-alkaline lowland soils (Holmes and Mesmer 1901c, Gregor 1953). By the late 1880s, beans had become a major commercial crop for the region; one account describes "one vast field of green and gold—ripening wheat and barley and growing corn and beans" (Oge 1888). A few years later, beans had surpassed even barley in prominence; Ventura County was described in 1891 as "preeminently a bean county" (Storke 1891) and one observer noted "seemingly limitless stretches of beans" (Eames 1890). Oxnard sand and Oxnard sandy loam, the two major soil types mapped on the Oxnard Plain in 1901, were "when free from alkali…the very best for the growing of lima beans. Almost every foot of such land was planted to this crop year after year, with only an occasional crop of barley planted for rotation" (Holmes and Mesmer 1901c). Beans continued to be a major product on the Oxnard Plain well into the 20th century; in 1951 Ventura County produced over 25% of the large lima beans in the United States (Gregor 1953).

However, in 1898 the establishment of the Pacific Beet Sugar Company's sugar factory shifted the agricultural dynamics of the county (fig. 2.6). Sugar beets thrived on the plain's alkali soils, allowing cultivation of land which had previously been only slightly productive or not farmed at all:

> A few years ago only indifferent crops of barley were grown on the greater part of this soil which was considered practically worthless, as quite often the barley hay contained such a great amount of salt that stock would not eat it. Now a great deal of the alkaline portion of this soil is planted to sugar beets with surprising results. (Holmes and Mesmer 1901c)

Only three years after the creation of the factory and the city of Oxnard, sugar beets were considered second in importance in the county only to the bean (Holmes and Mesmer 1901c); in 1913 beets and beans were called "the staples of the county" (Chase 1913). Beets were grown on the low, alkali

Fig. 2.5. "Dixie Thompson's bean threshing," ca. 1899. Workers threshing beans on the Oxnard Plain. (Unknown ca. 1899, courtesy of the California State Library)

Fig. 2.6. Hauling wagon loads of beets on the Oxnard Plain, ca. 1900. (Unknown ca. 1900b, courtesy of Jeff Maulhardt)

land that would not support other crops, while beans were often grown on slightly higher alluvial deposits (Tait 1912). A crop rotation of beans and beets (or beets and barley on land too alkaline for beans) was often practiced in lowland areas, since the beans fixed nitrogen for the beets and the beets removed some alkali from the soil (Gregor 1953). Beans, beets, and barley remained the primary crops for the region until around 1920. By 1917, barley was only grown "on soils less desireable [sic] for other crops and in remote situations" (Nelson et al. 1920), and sugar beet planting peaked in 1919 (Schwartzberg and Moore 1995).

The extensive acreage of the Oxnard Plain meant that the agricutlural statistics for Ventura County essentially reflected the trends of the Oxnard Plain. Through the 1870s, 1880s, and 1890s, beans, beets, and barley were the dominant crops in the county. Barley and beans were also grown at this time in inland valley areas, in addition to wheat in areas not influenced by the coastal fog (such as the Ventura River valley; Hampton 2002).

The grain was knee-high, the groves were in bloom, the wildflowers carpeted all the fields.

—EDWARDS ROBERTS, 1886, SANTA PAULA

The lack of fruit culture in the region in the 1870s, and in particular on the Oxnard Plain, was notable to travelers used to seeing orchards in other parts of Southern California. In 1876, botanist J. T. Rothrock (1876) wrote that after traveling along the Oxnard Plain, "What more than anything else surprised me in the day's march was that no attention was paid to fruit-culture. I find recorded in my notes that not a single fruit-tree was seen that day. There was no apparent reason for this." The reason, of course, was the alkaline lowland nature of most of the plain.

While (as Rothrock observed) alkali concentrations and seasonal flooding precluded fruit culture on the plain in the 19th century, by the 1890s orchards began to proliferate in a few areas in the Santa Clara River valley. Early experiments in 1870s, notably around Santa Paula, had proven that walnuts and fruits (such as oranges, nectarines, peaches, and apricots) could succeed in the county (*Ventura Free Press* 1878a, Gregor 1953, Heil 1975, Hampton 2002). One newspaper mused that "some day the whole of the Santa Clara Valley will be a great fruit garden instead of, as now, a barley field" (*Ventura Signal* 1874a); another projected that by about 1880 the county would have fruit available to export (*Ventura Free Press* 1878a). However, fruit culture during this period was largely limited to the Santa Paula (and to some extent, Sespe) region; Rothrock (1876) noted that "With the exception of the Cumules [sic] Ranch…but little cultivation is attempted in the valley above Santa Paula."

By the mid-1880s, orchards had become more prevalent in the lower Santa Clara River valley (fig. 2.7). One traveler journeying upriver from Ventura described "level fields, some planted with grain and flax, others covered with fruit-groves" (Roberts 1886). Another noted "extensive orchards of apricot and walnut trees…[and] countless acres of beans" between Saticoy and Santa Paula (Eames 1889). ("And to think!" Eames further writes, "When I was a little girl this was all a vast forest of bee-haunted mustard-blooms, in which the traveler would get lost as easily as in an Indian jungle.") Residents of the county who had been present in the 1870s were amazed by the agricultural changes that had taken place in only a decade:

> The individual who viewed the broad, treeless, uncultivated extent of the Santa Clara valley of Ventura county, less than twelve years ago, would now marvel at the transformation that has been wrought during this comparatively short period in that flourishing section. (*Ventura Free Press* 1883a)

> Riding from Santa Paula to San Buenaventura a short time ago, I could not but mark the difference in the style of farming now, in the Santa Clara valley as compared with ten years ago. Then it was nearly all barley, and scarcely a clean field of that, so abundant was the mustard, sometimes taking possession of hundreds of acres. Now it is very different. Cultivated crops are raised to a great extent, and the land is considered too valuable to give over to weeds and everywhere is carefully farmed. Beans, corn, and flax are raised largely, and hundreds of acres have been put to fruit trees. (*Pacific Rural Press* 1886)

The expansion of the Southern Pacific Railroad to Ventura (1887) helped provide a wider market for the burgeoning commercial agriculture of the county and spurred development of both beans and orchards in the Santa Clara River valley (Warner 1891, Gregor 1953). Many towns sprung up along the railroad in the Santa Clara River valley, such as Montalvo, Fillmore, and Piru. While Ventura county was still considered "bean country," it was clear that fruit growing would be the next wave of agriculture in many parts of the valley (Storke 1891). In 1891, a *Ventura Free Press* article opined that "the days of raising barley, corn and potatoes for market, as in days gone by in the Fillmore, Sespe, and Bardsdale sections of Ventura county are numbered. It is essentially a fruit section and the past few years and particularly the past year has seen the convertion [sic] of fields, heretofore given up to the commoner cereals, planted to fruit trees" (*Ventura Free Press* 1891c).

Limoneira Company began growing citrus on a large scale around Santa Paula in 1890; by 1920, citrus had become a dominant crop of the region (Gregor 1953, Schwartzberg and Moore 1995). As artificial drainage (beginning in 1918) and irrigation began to lower the water table and decrease the alkalinity of parts of the Oxnard Plain in the 1930s and 1940s, farms in this area began to convert former beet and bean acreage to citrus and walnuts (Gregor 1953). For detailed information on agricultural trends after 1920, see Gregor (1951, 1952, 1953) and Schwartzberg and Moore (1995).

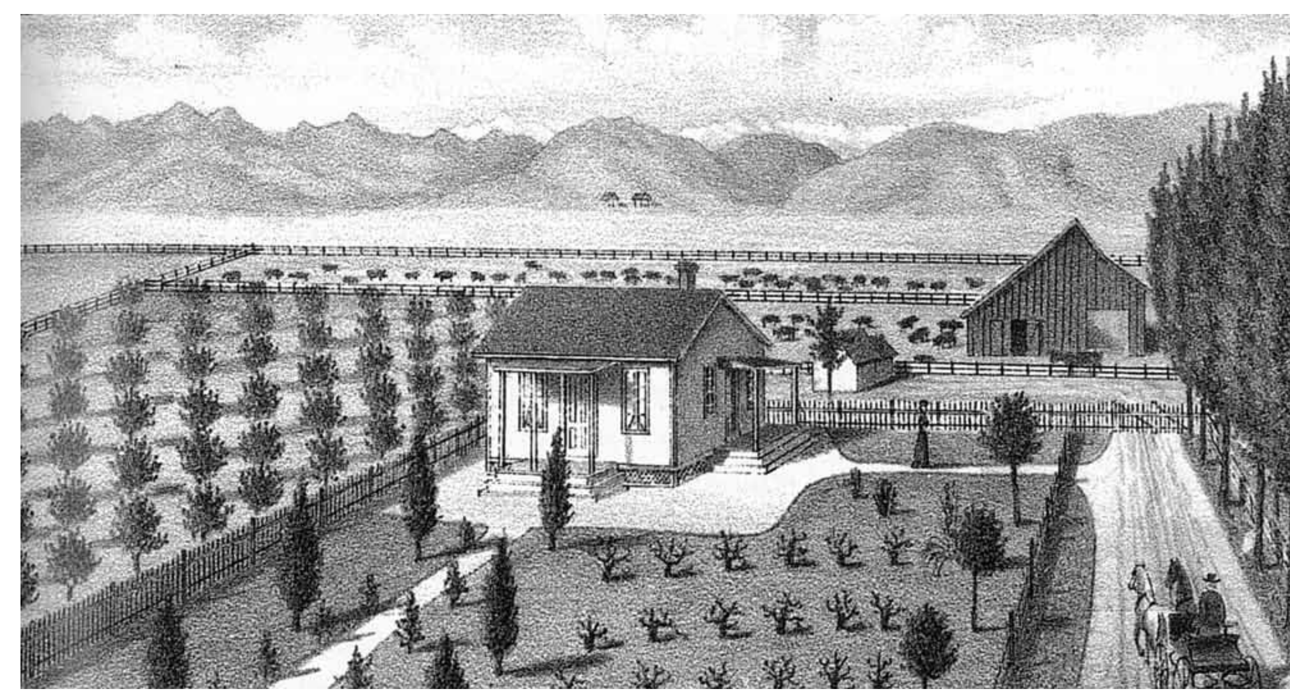


Fig. 2.7. Young orchard on J.H. McCutcheon's farm near Santa Paula, 1883. Young orchard trees—less than a decade old—are shown surrounding the McCutcheon home. Many of these orchards were planted on the site of the barley farms of the previous decade. (Thompson and West [1883]1961)

Hydromodifications: Surface Diversions and Groundwater Extraction

The history of irrigation in Ventura County has been extensively covered by others (Gregor 1953, Freeman 1968, Schwartzberg and Moore 1995). For detailed information on water use in the county, please refer to these texts. What we provide here is a brief overview of surface water use and groundwater extraction as context for the historical data discussed throughout the report.

To address the water needs of Mission residents and their fields, in the early 19th century (ca. 1805-1815) an aqueduct was built bringing water from the Ventura River near the confluence of San Antonio Creek to the Mission and its fields (CERES 2004). The aqueduct, which was destroyed during the floods of 1861-2 and 1866-7 (Greenwood and Browne 1963), was the predominant component of the larger Mission water system. In addition, the Mission used three reservoirs for water storage, two about three miles north of the Mission and one near Santa Paula (Uría 1828). The Mission also diverted water from Santa Paula Creek to irrigate fields in that area (Freeman 1968). Surveyor W. M. Johnson, in a U.S. Coast Survey report, notes that the Ventura River valley is "thoroughly irrigated by water from the river of the same name, which is carried to every part of it by means of ditches" (Johnson 1855a). Saticoy Springs also provided a year-round source of water (*Ventura Signal* 1871b, Freeman 1963).

The mission aqueduct supplied water to the city of Ventura through 1862; after its destruction during that year's floods, water was hauled in barrels from the river (Triem 1985). This was common practice after the secularization of the mission and before the extensive construction of ditches, when many early residents relied on surface water hauled from perennial reaches of Ventura County waterways for domestic use. Anticipating the completion of the Farmers Ditch, one newspaper article celebrated that residents of the area north of the Santa Clara River (around Ventura) "shall not have to buy barrels and haul water from the river or Saticoy twice a week or thrice—the year round" (*Ventura Signal* 1871b). (After its construction, if the Farmers Ditch failed to produce water—such as during the drought of 1876-7—residents would still resort to hauling water; *Ventura Signal* 1876b). Sheridan (1926) recounts that Egbert's Spring (north of downtown Ventura and east of the Ventura River; Barry 1894) used to provide water for domestic use for Ventura city during the early American period: "In the early days of the American occupation, the water of the spring was hauled on a wagon, in barrels, to the back doors of the residences of the settlers, at a cost of 25 cents per barrel. That was the drinking water of San Buenaventura." When artesian water was found on the Ventura side of the Santa Clara River in 1898, a newspaper article noted that "they have been hauling water in that vicinity for thirty years" (*Pacific Rural Press* 1898). Farmers on the Oxnard Plain also hauled water in barrels from the Santa Clara River (Gregor 1952).

From the mid-1860s on, more substantial development of surface water diversions occurred on Ventura County waterways. Flow from perennial reaches of rivers and creeks was transported to fields and for domestic use. An 1864 map of the Camulos area shows a ditch leading to fields and vineyards from the perennial reach of the Santa Clara River about a mile upstream (Sprague 1865). This was likely one of the first diversions from the river (Freeman 1968). By the end of the 1870s, however, an abundance of canals brought water to fields. While many of these ditches had their sources or heads on tributaries (notably Santa Paula, Sespe, and Piru for the Santa Clara River, and San Antonio Creek along the Ventura River), others tapped into the Santa Clara River and Ventura mainstems (Crawford 1896).

These ditches brought water often long distances from perennial reaches near Santa Paula and Sespe creeks down to fields and population centers in need of water (fig. 2.8). The Farmers Ditch (1871) was 16 miles long, and brought water along the north side of the Santa Clara River from a branch of the river above Santa Paula Creek down to Prince Barranca (Hall Canyon), just east of Ventura (*Ventura Signal* 1871b, Freeman 1968). (One old-timer recounted to Vern Freeman (1968) that any extra water from the ditch was "disposed of" in the barranca.) The Santa Clara Irrigating Company's ditch (1871) traveled 12 miles, bringing water to farmers

Fig. 2.8. Diversion ditch from Santa Paula Creek, ca. 1900. Surface diversions, such as this ditch taking water from Santa Paula Creek downvalley, brought water from areas with abundant surface flow to drier portions of the valley. (Unknown ca. 1900a, courtesy of the Santa Paula Historical Society)

At Satacoy [sic] we stopped for supper. From the excitement around the station and the water running down the street I thought an irrigating dam had sprung a leak; but a flowing artesian well had been struck instead, and its bursting forth had caused the commotion. These wells are the life of the country. There is much jealousy among rival settlements, and when one develops a copious flowing well it means beans, and walnuts; grain, vegetables and fruits, and the people shout with an exceeding joy thereat. They bite their thumbs at their envious neighbors and boast vaingloriously. This feeling is not known in the East, where the rain falls on all alike, and the land is all taken up. Here water rights go with the land, and when water in flowing quantities is found it means wealth to that section and the selling of land at good prices.

—KENDERDINE 1898

south of the river from near the west end of South Mountain (southeast of Saticoy) to near Hueneme (Freeman 1968). The Cienega Ditch (ca. 1874) diverted water from the river near the marsh (or *ciénega*) east of Fillmore. On the Ventura River, the Santa Ana Water Company built a ditch about seven miles long from the perennial reach around the Ventura River/San Antonio Creek confluence along the route of the old Mission aqueduct to supply water to the city of Ventura (Triem 1985).

The development of an artesian water supply on the Oxnard Plain beginning in the early 1870s changed the hydrologic landscape of Ventura's lowland areas. While several springs, wetlands, and ponds were present along the eastern boundary of the Plain (i.e., in the Calleguas Creek drainage), there was very little potable water available in the main section of the plain (Thompson and West [1883]1961; see Chapter 5), and artesian wells transformed the non-alkaline portions of the lowland into a desirable farming region. The first artesian well in the county that we found evidence for was drilled near Saticoy in 1868, and was only 18 feet deep (*Daily Alta California* Sept 16, 1868). On the Oxnard Plain, artesian wells were first drilled the same year the town of Hueneme was founded (1870). By 1871, artesian wells were proliferating on the Plain within the artesian zone, which included much of the plain (very roughly) below Highway 101 (Schuyler 1900, Lippincott ca. 1930; see fig. 5.3). Artesian wells were also drilled in the bed of Calleguas Creek (*Ventura Free Press* 1878c). By 1899, there were at least 200 artesian wells in the artesian belt south of the Santa Clara River (Schuyler 1899). While wells were also drilled in the Santa Clara River valley, these were largely reliant on pumping.

The effects of surface water diversions and artesian development on riverine flow and groundwater levels were noted by the early 1880s. Around 1894, all the dry season flow of Piru Creek was being diverted for irrigation (Lippincott ca. 1894). By 1912, it was asserted that all the summer surface flow of the Santa Clara River was diverted for irrigation (Tait 1912).

In addition, groundwater extraction likely contributed to changes in surface water levels, possibly shifting previously perennial stream reaches to intermittent flow (Hanson et al. 2009). An 1883 article from the *Ventura Free Press* described some of the perceived impacts of groundwater extraction on the Oxnard Plain. While it is unclear what role artesian wells on the plain actually played in causing these effects on groundwater levels, the effects are interesting in and of themselves:

> The people living on both sides of the Santa Clara, between where the water of the river at a point below Camulos Ranch down a short distance above the Sespe Creek, have been wondering why, their surface wells are failing year by year since about 1877—the time when the artesian well boring was begin [sic] on a large scale on the Colonia. Since the six large wells lately bored in the Las Posas, for the Hartman ditch, the water has sunk nearly 2 feet in these surface wells, and the Scienega, which was formerly a marsh, that would shake a rod from a man walking over it, is now dry enough to plow. The same volume of water is seen, below the Camulos Ranch, as in former years, and it is thought that the artesian well-boring on Colonia is these [sic] cause of the decrease of these surface wells in and about the Scienega. (Ventura Free Press 1883b)

The Colonia…Its abundant supply of water through its artesian wells give it an immense advantage over any part of the country.

—VENTURA SIGNAL 1876A

Similar effects were felt on the Oxnard Plain. By the turn of the century, coincident with the construction of the Pacific Beet Sugar Company's sugar factory in 1898, many artesian wells on the plain had begun to stop flowing (Freeman 1968). The construction of the factory caused a significant spike in water demand on the Plain, as wells were built to supply water needs for the factory and new town of Oxnard. That year, the *Ventura Free Press* noted the impending problem of declines in groundwater levels:

> The artesian water supply of this valley is soon to become an absorbing problem. Every year scores of new wells are being bored, often close together in the same artesian belt. The result is that wells which a few years ago gave a good flow have now ceased flowing and have to be pumped. The number of these must increase as the as the [sic] new wells increase. (*Ventura Free Press* 1898)

In 1900, the newspaper recorded that "quite a number of the Colonia artesian wells are falling of late on account of the factory wells running steady" (*Ventura Free Press* 1900). It was reported that factory water extractions caused a drop of five to ten feet in wells near Oxnard (Freeman 1968). As artesian water failed, water began to be pumped instead.

Through the 1910s and 1920s, groundwater levels in the Oxnard Plain and greater Santa Clara Valley continued to decrease (Freeman 1968). By the mid-20th century, summer surface flow in the Santa Clara River had sharply decreased; Gregor (1952) noted that the river was "dry most of the year." At this time, almost all (90%) of the Santa Clara Valley and Oxnard Plain's water demand was supplied by deep turbine pumps drawing groundwater (Freeman 1968). Urban development on the Oxnard Plain (and in other areas of the county) further strained groundwater resources.

Water Use and Irrigation

Ventura County was noted for its comparative lack of substantial irrigation development relative to other Southern California regions. On the Oxnard Plain, high groundwater tables and fog reduced the need for substantial irrigation of many crops (Rothrock 1876). In addition, the presence of alkali, coupled with a high groundwater table, impermeable clay subsurface soils, and extremely flat topography actually precluded irrigation over large swaths of the Oxnard Plain, since irrigation water only further saturated surface soils (Gregor 1953). Early farmers on the Plain understood this, and it was observed that they "do not irrigate more than they can avoid, for the reason…it brings the alkali to the surface" (Rothrock 1876).

For this reason, substantial crop irrigation lagged behind the development of large-scale agriculture in the county. The main crops of the 1880s—barley and beans, along with corn—were largely dry-farmed in the foggy, high groundwater table areas near the coast (Thompson and West [1883]1961, Gregor 1952, Swanson 1994).

In 1889, only about 1% of the county's farms were irrigated (Gregor 1952). This was a point of pride for some residents: "In Ventura County… as our farmers do not desire to get rich in a day, corn is planted after the winter rains are over, and but one crop a year is raised and that without irrigation" (Storke 1891). In 1893, citrus orchards near Fillmore were described as one of the "few irrigation enterprises in the county," while in other parts of the county even citrus was grown without irrigation (Brook 1893). By 1900 irrigation was still not widespread, though it was recognized that irrigation would increase the productivity of county cultivation: "the ease with which crops have generally been grown in this district without irrigation, has made the people indifferent to the advantages of skillful irrigation and chary of undertaking it…the prosperity and value of the greater portion of Southern California have been the result of irrigation" (Schuyler 1900).

The general sentiment expressed in historical texts that "irrigation is not used at all in Ventura County" (Storke 1891) was undoubtedly an overstatement, as some farmers irrigated crops during extremely dry years, or during the dry season to increase yields. Other crops were more predictably irrigated, such as alfalfa and (later) citrus. By the turn of the century, staple crops beans, beets, and barley were all irrigated in some sections of the county (Holmes and Mesmer 1901c).

By the 1910s, much of the Santa Clara River valley from Saticoy to Piru that was planted to orchards was under irrigation (Tait 1912). It was widely held that "all orchards are better for irrigation" (Unknown ca. 1909). Citrus was almost universally irrigated, and it was recognized that other fruits, walnuts, and beans would be more productive with irrigation. During this time, all of the citrus in the county, and about half of the walnuts and apricots, were irrigated, while only a quarter of the sugar beets and less than 1/5 of the beans were irrigated (Unknown 1914). For orchards, irrigation was focused mostly in the dry season (around May to September).

Irrigation is not extensively practiced in the area and is confined principally to the Santa Clara River Valley, a small part of the plains north of Oxnard, the lower part of the valley along the Ventura River… and part of the lands along Santa Paula, Sespe, and Piru Creeks.

—NELSON ET AL. 1920

However, even at this time irrigation was not practiced by the majority of Ventura County farmers, particularly on the Oxnard Plain. "The idea has prevailed in Ventura County," wrote Tait (1912), "especially on the coastal plain…that irrigation is not necessary and the success of the lima bean industry without irrigation has done much to divert attention from the development of the water resources of the county. Within the last few years more interest has been taken in irrigation." Irrigation was considered optional for most crops (excluding citrus) through the 1910s, though its role in increasing productivity was recognized (Nelson et al. 1920).

In 1918, extensive artificial drainage projects aimed at flushing out alkali salts began on the Oxnard Plain. Over the next years, these drainage projects leached salts out of alkaline areas on the plain (Gregor 1953). Coupled with the falling water table from groundwater extraction, many of these areas began to be non-alkaline and well drained enough to support tree crops, such as lemons and walnuts. These crops required irrigation, and the tile drains provided a drainage pathway for irrigation waters for these higher value crops.

The transition to irrigation occurred gradually over the 1920s and 1930s as orchards expanded over large sections of the county's cultivatable land. In the decade between 1919 and 1928, irrigated acreage in Ventura nearly tripled, from 31,700 to 86,700 acres. This was largely due to land use shifts on the Oxnard Plain as orchards became more common: by 1947, over 93% of the plain's irrigable area was irrigated (Gregor 1952, fig. 2.9).

The explosion in water demand for irrigation, along with increasing pressure for water rights from outside the watershed, drove many of the major water management developments of the mid-20th century (see fig. 2.2). The most notable examples include the formation of the Santa Clara Water Conservation District (1927) and its successor, United Water Conservation District (1950); the construction of spreading grounds beginning in 1928 to replenish groundwater supplies and water levels in Oxnard Plain wells; and the construction of dams including the short-lived St. Francis dam (1926, failed in 1928) and Bouquet Reservoir (1934) in the upper watershed, and Santa Felicia Dam (1955) on Piru Creek. The Freeman Diversion Dam, also used for groundwater recharge, was completed in 1991.

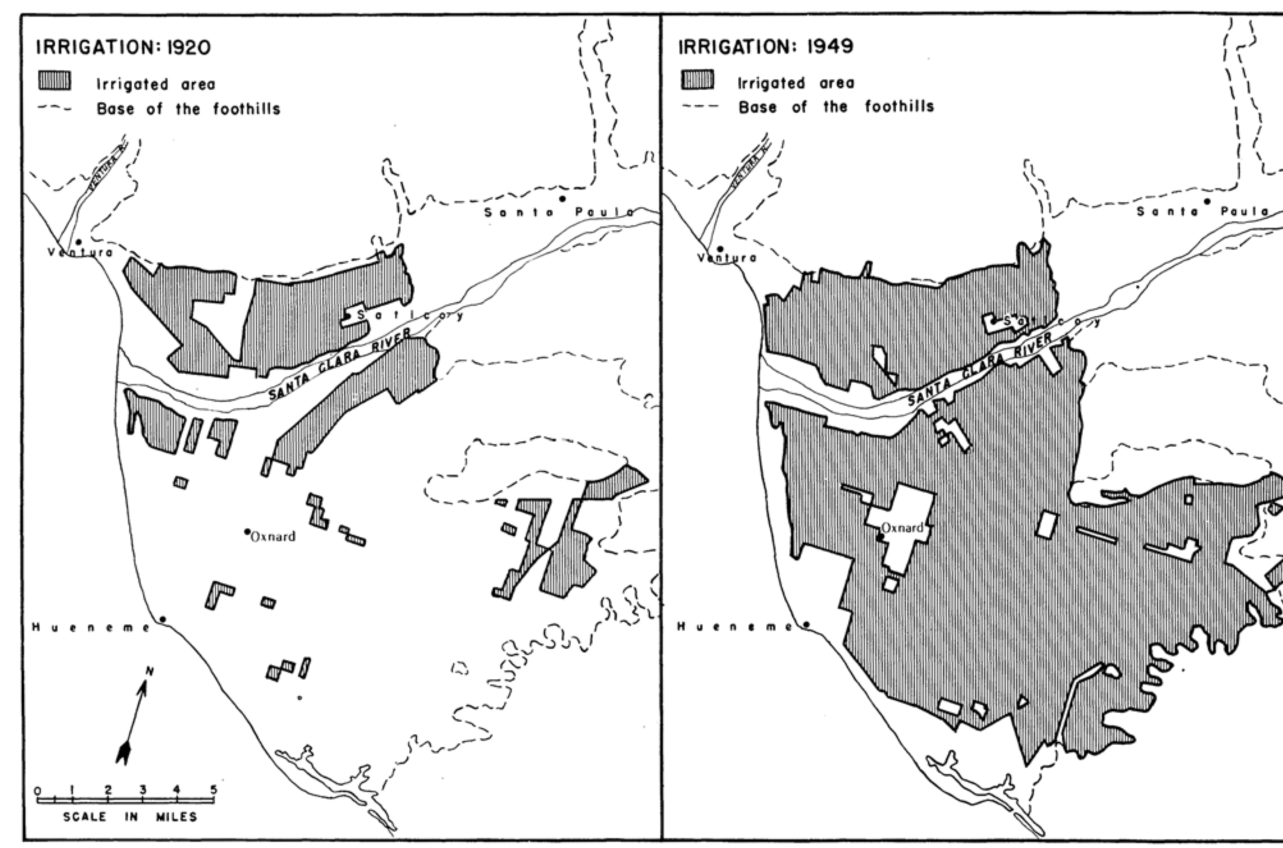
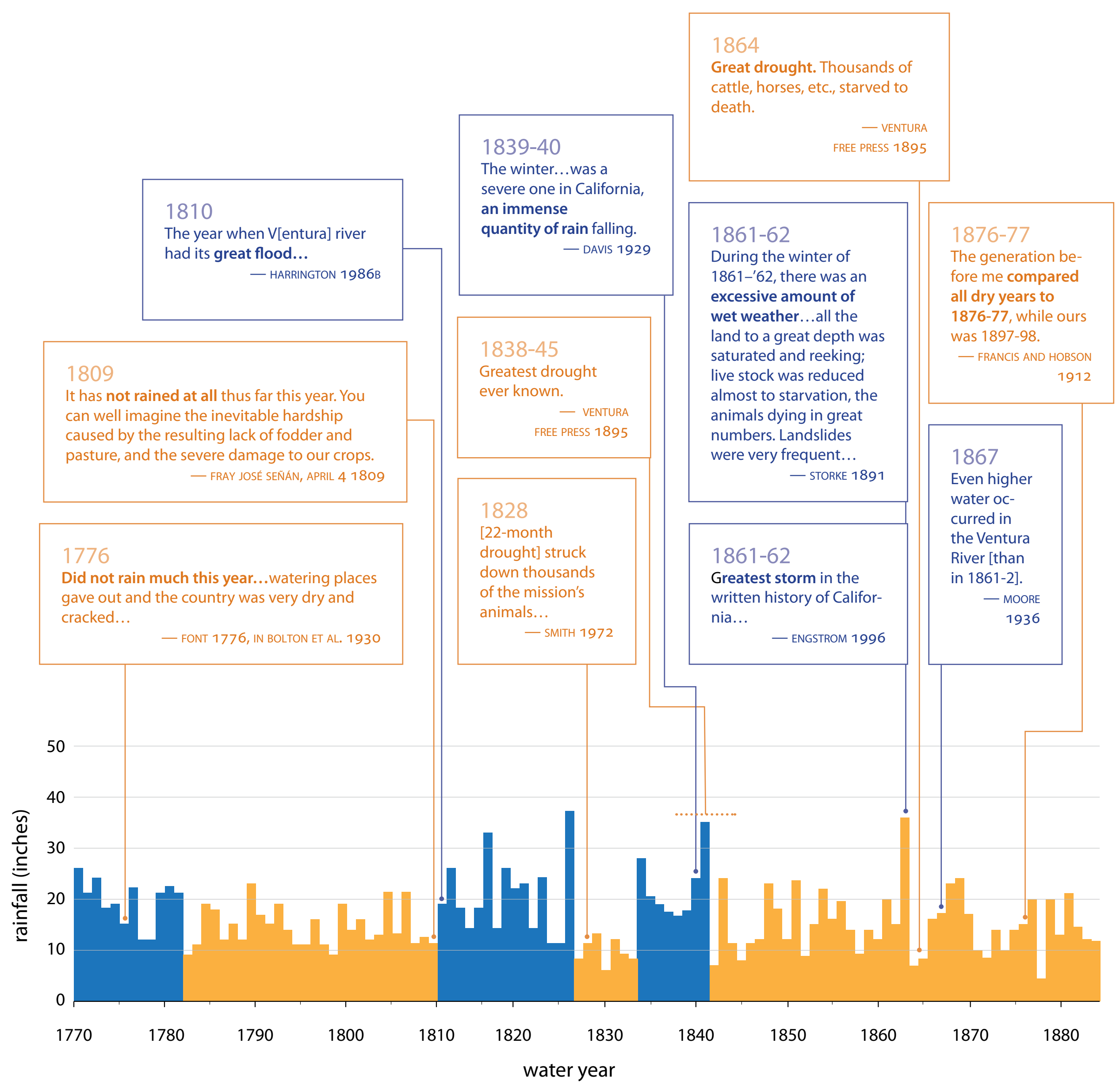


Fig 2.9. Extent of irrigated farms on the Oxnard Plain, 1920 and 1949. Irrigated acreage on the Oxnard Plain expanded rapidly from the 1920s through the 1940s. By 1947, over 93% of the Oxnard Plain's irrigable area was irrigated. (Gregor 1952)

FLOODING AND CLIMATE

An understanding of the timing of major floods and droughts is an important aspect of historical data interpretation, particularly in a semi-arid environment such as Ventura County where channel form and riparian vegetation distribution are controlled by large flood events. In addition, short-term variations in climate can influence native habitat patterns indirectly by affecting land use: droughts can instigate greater reliance on groundwater, new irrigation practices, or the failure or abandonment of a crop, while extreme winter floods can catalyze stream channelization efforts and levee construction. For these reasons, it is essential to consider climatic patterns when interpreting former ecology and land use history.

We used precipitation records compiled by Freeman (1968) and Stillwater Sciences (2007b) to understand patterns of wet and dry years, in addition to qualitative narrative accounts of notable floods and droughts that occurred prior to standardized precipitation and flow monitoring (fig. 2.10). There are also a number of excellent general



treatments of historical climate in Southern California which were consulted (cf. Lynch 1931, Engstrom 1996, Haston and Michaelsen 1997).

Overall, Lynch (1931) concludes that the average Southern California climate has remained stable since 1769. The following coarse information on notable floods and droughts recorded in the historical record is provided so that the reader can better understand the context in which the historical data presented in this report were interpreted.

Of additional particular note is the flood caused by the St. Francis Dam break on March 12, 1928. The dam, located on San Francisquito Creek, was completed in 1926 at part of the Los Angeles water supply and storage system. After the dam failure, the resulting flood swept down the Santa Clara River valley, causing extensive damage and killing more than 450 people before reaching the ocean.

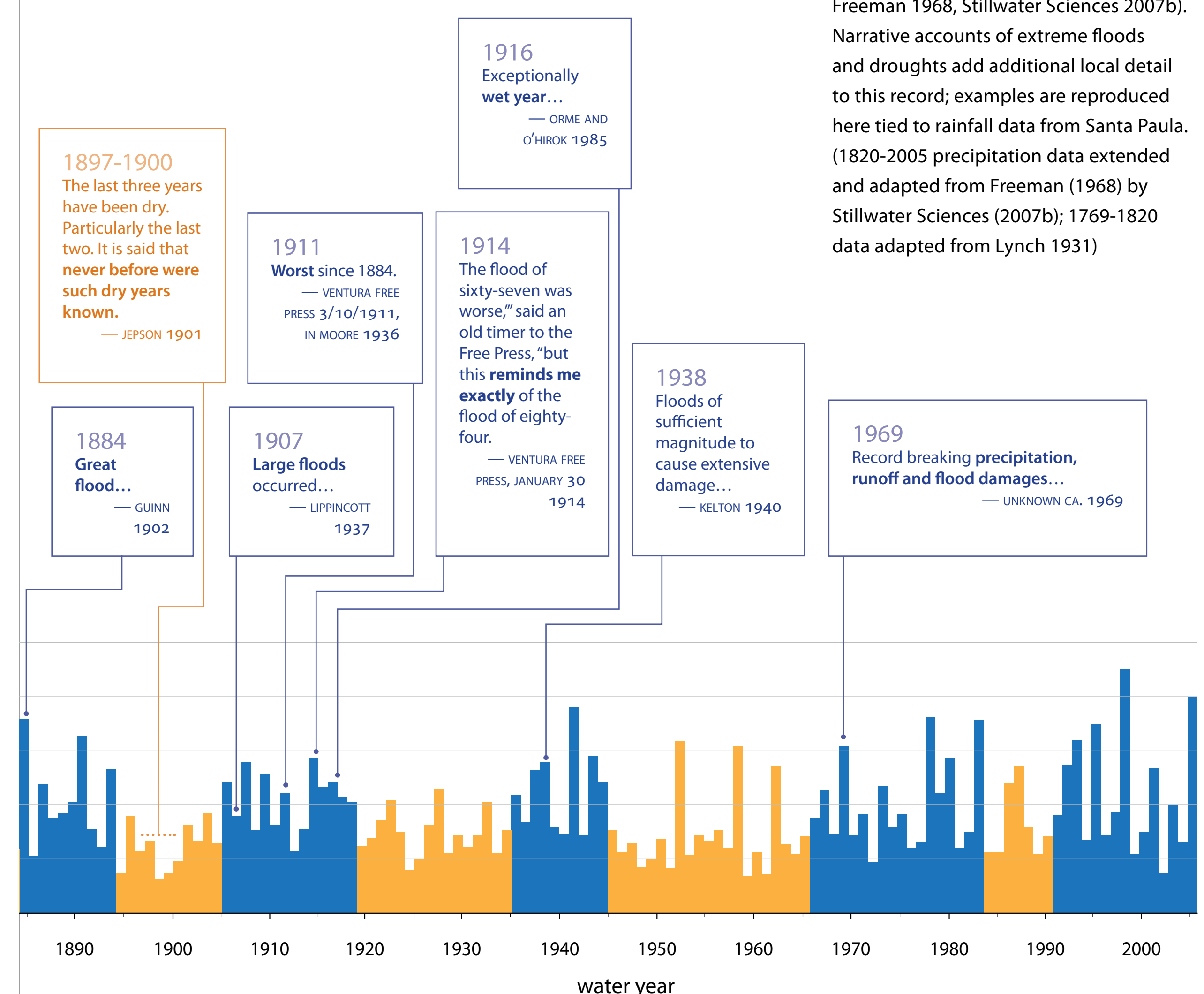


Fig. 2.10. Patterns of wet and dry years, 1769-2005. Cycles of dry periods (shown in orange) and wet periods (shown in blue) are well documented by the historical record (e.g., Lynch 1931, Freeman 1968, Stillwater Sciences 2007b). Narrative accounts of extreme floods and droughts add additional local detail to this record; examples are reproduced here tied to rainfall data from Santa Paula. (1820-2005 precipitation data extended and adapted from Freeman (1968) by Stillwater Sciences (2007b); 1769-1820 data adapted from Lynch 1931)

3 • SANTA CLARA RIVER AND VALLEY

Fig. 3.1. Lower Santa Clara river, 1934 (opposite page). The remnants of West Grove may be seen on the south side of the river (right side of image), in addition to braided channels and riverwash. (Fairchild Aerial Surveys 1934, courtesy of the Benjamin and Gladys Thomas Air Photo Archives, Spence and Fairchild Collections, UCLA Department of Geography)

Though Santa Clara on her buoyant breast
Bear neither steamer swift nor bellied sail--
No Palinurus, steering from the West,
Seeks shelter here from Neptune's threat'ning gale,--
Yet grandly on she flows through brake and dell,
Irriguous wide in many a sinuous line,
And Ceres sees with joy her banks o'erswell,
While Bacchus thanks her for his certain vine.
And there Vertumnus and Pomona, too,
Like timid lovers shrinking to the wood,
With bosky groves they shade the open view,
And gather freshness from the swelling flood.

—GOLD AND SUNSHINE: REMINISCENCES OF EARLY CALIFORNIA, AYERS 1922

Introduction

The Santa Clara River watershed is one of the largest coastal watersheds in Southern California, draining approximately 1,620 square miles and running 116 miles from its origin to the coast. Its headwaters are in the San Gabriel Mountains in northern Los Angeles County, and the lower portion of the river runs southwest though Ventura County before reaching the Oxnard Plain and draining to the Pacific Ocean.

The watershed is located within the Transverse Ranges geologic province, in a geologically active area west of the San Andreas Fault. The geology of the watershed includes younger, mostly marine-origin sedimentary rocks in the lower watershed, and older igneous and metamorphic rocks in the steep upper watershed. The sedimentary rocks of the lower watershed are generally poorly consolidated and highly deformed and fractured, making them highly erodible. Even the (generally relatively erosion-resistant) granites and other older rocks of the upper watershed are vulnerable to high erosion rates due to extensive fracturing, folding, and faulting (Orme 2005, Stillwater Sciences 2007b, Stillwater Sciences 2011). As a result, the watershed is subject to high rates of sediment production and transport. This is particularly true for the river's lower reaches (i.e., below Sespe Creek), where average sediment yield is roughly double the regional average (Warrick 2002).

This aspect of the river is intensified by the highly episodic, "flashy" nature of flood events on the river. Like other rivers in southern California, Santa Clara River flows are controlled by a Mediterranean climate, with peak flows in the rainy season and inter-annual variation of floods and droughts. Not only is precipitation mostly confined to the winter months, the majority of water and sediment in the system are transported during just a few high-intensity, short-duration events: on average, more than half the flow from the Santa Clara and Ventura rivers takes place over only three to six days of every year (Warrick 2002).

The Santa Clara River is regionally significant because it has largely retained this natural variability, and consequently substantial aspects of its natural form and processes are still remarkably intact. In contrast to other Southern California rivers of its size, the Santa Clara River maintains a regularly scoured sandy bed, braided channel form, and highly variable flows still controlled largely by patterns of precipitation and groundwater availability. Despite substantial changes such as decreases in sediment load due to impoundment by dams and the loss of floodplain area, the overall morphology, hydrology, and sediment transport on the river mirror its historical attributes. (About 37% of the Santa Clara River basin area is behind dams, though the corresponding decrease in sediment delivery to the mainstem has been somewhat smaller – 27%; Orme 2005.) The mainstem has no large storage dam, though it is regulated by the Vern Freeman Diversion which diverts a majority of the river's low flows.

As a result of this episodic hydrologic regime (and again, in contrast to other southern California rivers), the Santa Clara River has retained much of the longitudinal habitat heterogeneity that has been mostly lost on other systems due to land use pressures, flow regulation, and channelization. While many of the region's rivers have had peak flows capped by regulated dam releases for flood control, the active vegetation scouring and habitat variability present on the Santa Clara River provide some of the habitat complexity needed by native plant and animal communities. The river also provides a migration corridor for several endangered species, such as the southern steelhead trout (anadromous *Onchorynchus mykiss*).

The extent of urbanization in the Santa Clara River watershed is still relatively low, and as a result it supports a variety of plant communities ranging from evergreen and deciduous woodlands to fire-susceptible chaparral and grasslands. Much of the mountainous northern portion of the watershed is part of the Angeles National Forest and Los Padres National Forest. However, the lower watershed is dominated by orchards and row crop agriculture and developed urban areas.

This chapter explores the historical characteristics of the Santa Clara River and valley prior to major urban and agricultural modifications (fig. 3.2). In particular, we focus on the pre-modification hydrology, morphology, and ecology of the Santa Clara River, describing each historical attribute at a reach scale.

Santa Clara River reach designations

For purposes of comparison, we identified six reaches of the lower Santa Clara River (fig. 3.3). These reaches were broadly defined based on physical characteristics of the system such as topography, flow dynamics, tributary inputs, and geology (Bisson et al. 2006). They are designed to provide meaningful units of analysis for reach-level investigations of channel dynamics and morphology.

The six reaches were based on (and thus compatible with) Stillwater Sciences' (2007b) reach designations for the lower river. Stillwater Sciences identified 11 reaches from the river mouth to the Los Angeles County line (slightly west of our study area boundary). In most cases we preserved their reach boundaries, aggregating multiple (two to three) Stillwater reaches into one reach (see fig. 3.3, table 3.1). While these more general reach designations capture fewer detailed changes in channel characteristics (such as average slope), they do

Legend for historical habitats of the Santa Clara River and valley, early 1800s

Coastal and Estuarine Habitats
- Ocean
- Beach
- Dune
- Tidal Lagoon (seasonally open)
- Seasonally Tidal Marsh
- Salt Flat/Seasonal Pond/Marsh Panne
- High Marsh Transition Zone

Palustrine and Terrestrial Habitat
- Perennial Freshwater Pond
- Valley Freshwater Marsh
- Willow Thicket
- Wet Meadow
- Alkali Meadow
- Oaks and Sycamores
- Grassland/Coastal Sage Scrub

Characteristic Riparian Habitat
- Willow-Cottonwood Forested Wetland
- Other In-Channel Riparian

Hydrology
- Intermittent or Ephemeral
- Perennial
- Distributary
- Outer River Bank
- Spring

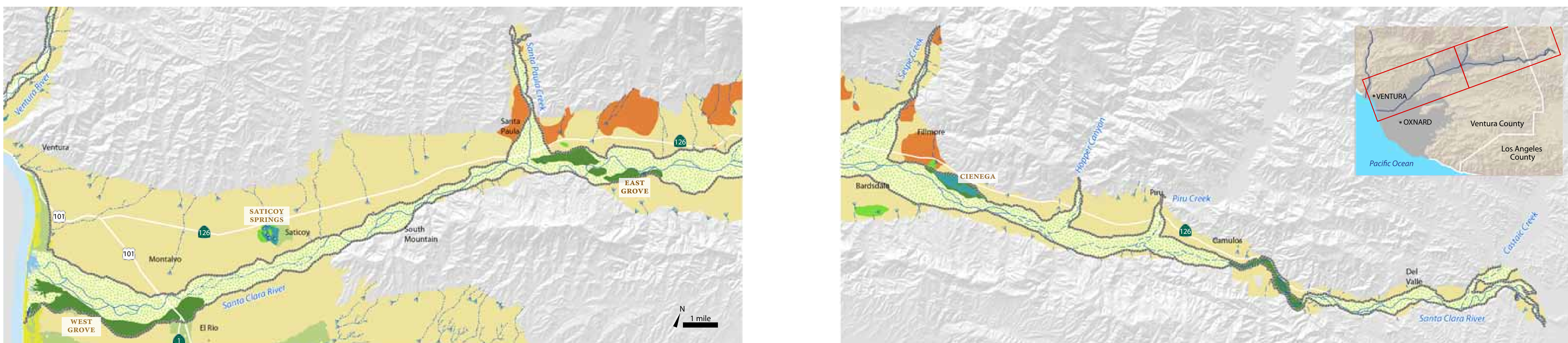


Fig. 3.2. Historical habitats of the Santa Clara River and valley, early 1800s. The Santa Clara River valley was dominated by broad, mostly treeless expanses of grassland and scrub. Trees, such as live oaks and sycamores, occurred on several alluvial fans north of the river and along many of the valley's tributaries, most of which sank into valley soils before reaching the Santa Clara River. A large wetland complex at Saticoy included willow groves, freshwater marsh, springs, and alkali meadow, and was the only significant wetland complex documented on the plain in the valley. Within the outer river banks, however, large areas of willow-cottonwood forest and freshwater wetlands marked areas of perennial flow and rising groundwater east of Camulos, at Fillmore (near the present-day fish hatchery), Santa Paula, and below the Highway 101 bridge.

Table 3.1. Upstream boundaries of Santa Clara River reaches (after Stillwater Sciences 2007b).

	Estuarine reach	**Oxnard reach**	**Santa Paula reach**	**Sespe reach**	**Piru reach**	**Del Valle reach**
Upstream end of reach	Harbor Blvd bridge	Freeman dam (roughly coincident with upper limit of summer dry reach)	Left bank impinges on South Mountain	Eastern edge of Cienega (upper limit of perennial reach)	2.5 miles east of Piru Creek (upper limit of summer dry reach)	Study area boundary

broadly distinguish between portions of the river with significant differences in hydrology, topography, and channel constriction and width.

While most of Stillwater Sciences' reach boundaries were preserved, one boundary (between our Sespe and Piru reaches) was modified from their original mapping. The reach boundary was moved approximately two miles east in order to reflect differences in the Sespe and Piru reaches and include the high-groundwater area near the old Sespe Cienega (Fillmore Fish Hatchery) in the Sespe reach. We also expanded Stillwater Sciences' last reach (upstream end at the Los Angeles County line) to include the area between the county line and Interstate 5.

From the coast upstream to Interstate 5, the six reaches of the river are designated as the Estuarine reach, the Oxnard reach, the Santa Paula reach, the Sespe reach, the Piru reach, and the Del Valle reach. Through this report, we will refer to these reaches, and use them as a practical scale at which to examine and analyze historical riverine processes and dynamics.

Fig. 3.3. Reaches of the Santa Clara River. We designated six reaches of the lower Santa Clara River as units of analysis for the following chapter. These reaches are aggregations of Stillwater Sciences' (2007b) more detailed reach designations for the river, with a few modifications to reflect historical conditions.

Valley Floor Habitats

Along much of the Santa Clara River, extensive alluvial fans from tributaries to the north have restricted the location of the river (pushing it southward, often directly up against the southern hills). Along with tectonic processes that have tilted the valley, this creates a sloping topography to the north of the river in places that has precluded the presence of depressional wetlands in many places on the valley floor. While there were a few exceptions (notably, the fault-controlled Saticoy Springs), the valley floor was generally composed of dryland features.

Many of these south-facing alluvial fans supported oaks, sycamores, and scrub, particularly between Santa Paula and Sespe creeks. Limited willow scrub habitat was also documented. The majority of the valley floor, however, supported extensive swaths of grassland and scrub. Trees occurred on south-facing alluvial fans, as well as within Santa Paula and Sespe creeks' banks, on the outer bank of the Santa Clara River, along many small creeks, and occasionally as individuals on the plain.

The following section outlines evidence for the composition and distribution of habitats on the Santa Clara River valley floor.

Dryland Habitats

For many 19th century observers, the Santa Clara River valley floor was notable for its sparse tree cover. With few exceptions (such as along watercourses, on some higher alluvial fans north of the river, and scattered sparsely across the plain), most of the valley was characterized by large expanses of grass and (in some areas) scrub. GLO surveys noted areas of "no timber" fifteen times across large portions of the valley from Santa

July 20 we entered Santa Clara Valley, and as we did so passed by a large flourishing mill which was evidently doing a good business. Well-tilled farms became more common, and there seemed to be still more room and water sufficient for a much larger population. The ground reaching down from the hills was a sage-brush covered slope, while on the flats bordering the river we found a greensward, much of which was made up of sour grass, that a mule will eat rather than starve. Earlier in the season it appears there is forage of a better character to be had in the valley. The water is alkaline, but less markedly so in the river.

—ROTHROCK 1876,
TRAVELING IN JULY 1875
FROM SESPE CREEK DOWNSTREAM

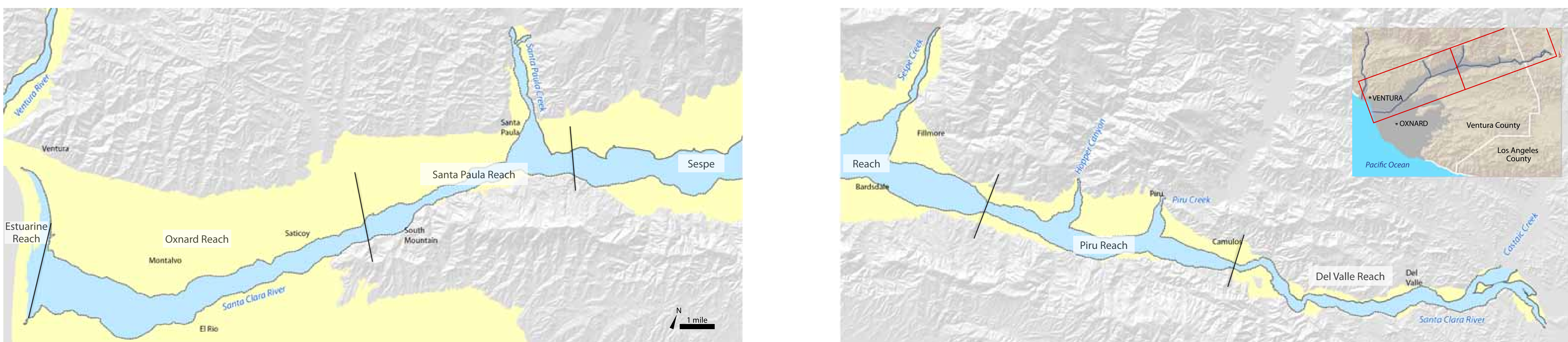


Fig. 3.4. The Fremont sycamore, still standing at the intersection of Highway 126 and Sycamore Road west of Sespe Creek, is a California Historical Landmark. According to the Office of Historic Preservation, the tree "has served as a resting place, a polling place, a temporary post office, and an outdoor chapel" (OHP 2011).

Paula to Piru (Craven 1874b,d,e,f,g); others described the valley as "treeless" (*Ventura Free Press* 1883a). An 1879 newspaper article described it as a "broad and prairie like valley" (*Ventura Signal* 1879, in Hampton 2002).

The general absence of trees meant one was able to see long distances over the plain in many places without interruption. The Fremont sycamore, a lone tree north of Highway 126 at Sycamore Road/Hall Road (fig. 3.4), was a landmark tree on the plain; one GLO survey sighted 1.5 miles across the plain to the tree, a remarkable distance away for such a survey (Craven 1874c). (The tree, named after General John C. Frémont, still stands today and is a California Historical Landmark. Modern Sycamore Road follows this line of sight to the tree, and forms the northwestern boundary of the Sespe Ranch.)

This aspect of the valley was documented in a number of ways, across much of its extent. Above Sespe Creek east to Newhall, Holton (1880) broadly described "much fine meadow" in the valley along the river. Between Sespe and Santa Paula creeks in 1769, Crespí noted that the valley was "very grass-grown with very tall broad grass," comparing it to similar grassy areas they had just traveled through east of Sespe Creek (Crespí and Brown 2001). In the same area over 100 years later, an observer noted flats covered with "a greensward, much of which was made up of sour grass, that a mule will eat rather than starve," though this may have been in the floodplain (see page 87; Rothrock 1876). The grassy nature of the lower valley was documented by early San Buenaventura Mission records, in a letter describing the grazing patterns of Mission animals in 1804 (for full quote, see page 30):

> The animals [cattle] farthest from the beach make their way to a place called Saticoy, and when the grazing there is exhausted (that locality not being very productive and most of the growth being sword grass), they roam farther up to the meadows along the river and through a rather wide canyon into Sécpey [Sespe], some bands of mares penetrating as far as Camulus. (Señán and Santa María 1804)

The region near Saticoy (other than near the springs themselves) was known for its lack of timber. In this area, Crespí recorded that "no trees are to be seen nearby" (he could see all the way to the easternmost edge of West Grove, more than 2.5 miles away; Crespí and Brown 2001). Engineer N. King observed "a great scarcity of both wood and water" in the region, "farmers having to haul both for miles" (King 1883). Cooper (1887) noted the area was "naturally prairie land, producing no trees," and an early newspaper article described impediments to early settlers from the "lack of timber and water" (*Daily Alta California* 1868).

These grasslands also included an abundance of wildflowers in many places, as noted by one traveler riding upvalley from Santa Paula to Camulos:

> Four of us drove, and one mounted on her pony rode beside us, and kept us well supplied with wild-flowers, of which there were acres along the roadside. Beyond the Sespe River they became more and more abundant. They covered the hillsides, and lay in great patches by the side of the road… Near where we stopped to eat our luncheon, in the shadow of a huge live-oak tree, the fields were carpeted with flowers of every imaginable color, – clover and buttercups, sunflowers and wild sweet-sage, thistle and cacti, – all girded by green grasses. (Roberts 1886)

In a few areas, sagebrush and scrub were also documented. In particular, the valley floor around the intermittently-flowing Piru reach of the Santa Clara River was notably drier than other parts of the valley, so much so that one traveler called it a "desert" (Eames 1889; see margin). GLO surveyor Craven (1874f) recorded "cactus and sage brush" in this area, just north of the Santa Clara River southwest of Piru. Patches of sagebrush and cactus were also documented on alluvial fans north of the river and west of Sespe Creek and in lower Santa Paula canyon (Hoffman 1868b,c; Craven 1874g). Undoubtedly many more patches of scrub were found in dry portions of the valley and on coarse alluvial fans.

However, a few scattered trees—mostly sycamores and live oaks—also dotted the grasslands. Crespí noted trees "here and there on the level" between Fillmore and Santa Paula; in the same area ornithologist Barton Evermann (1886) described live oaks "scattered irregularly over the valley." Reflecting their rarity, some of these individual trees and groves were used as landmarks or for gatherings; some even had names (see Jarrett 1983), like the Fremont sycamore mentioned earlier. These trees were not included in our mapping, but would have been notable landmarks on the otherwise mostly treeless plain.

Ethnographer J.P. Harrington's Chumash informants recollected a couple of places in the plain between Saticoy and Santa Paula, "with some aliso [sycamore] trees"; his informants gave him the name for a sycamore grove (Kats'antuk) and sycamore tree (Sapk'onil; Harrington 1913e). Other sycamores on the grassy plain are documented by GLO surveys (Norris 1853, Craven 1874c,g). (Though *aliso* literally means "alder," in Spanish California the term was universally used to refer to sycamores.)

We left the Camulos at an early hour the next morning. As we crossed the Piru, De Forest gazed curiously about him, at last remarking in his usual spiritless manner,

"It is always an enigma to me why Mr. Cook should have chosen this desert for his home, when he is right in sight of a place like Bardsdale."

"Why, just because it ***is*** *a desert, comparatively speaking," the Judge emphatically rejoined. "What Nature has not done for Bardsdale and Saticoy, man has already accomplished, and Mr. Cook's energy demands tremendous obstacles to overcome…"*

—NINETTA EAMES, FALL 1889

Fig. 3.5. Fourth of July picnic under oaks on Bill Boosey's ranch, ca. 1910. Fourth of July picnics and celebrations were often held in the Santa Paula area's sycamore and oak groves. These live oak trees are still standing (Henderson pers. comm.). (Unknown ca. 1910a, Courtesy of Santa Paula Historical Society)

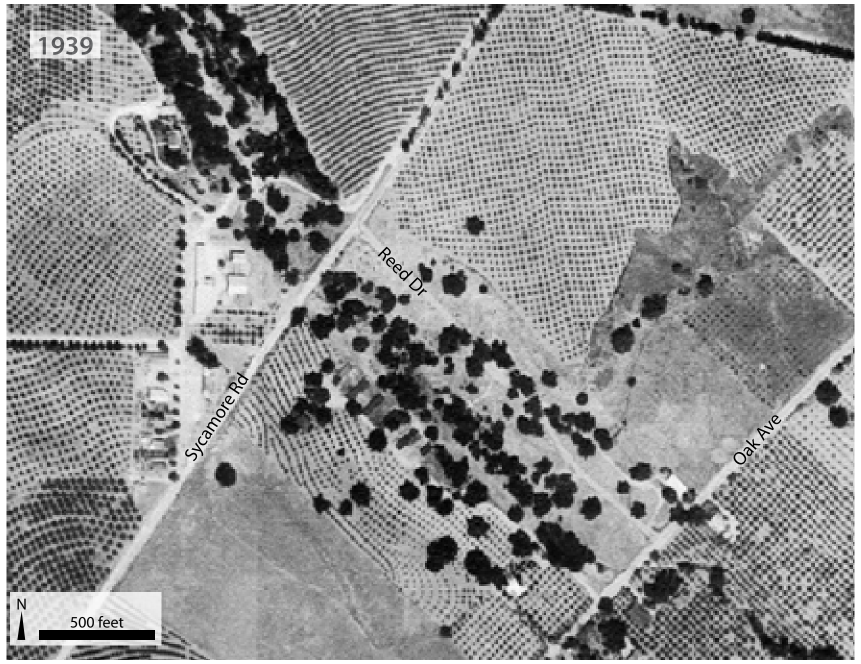


Fig. 3.6. Kenney Grove, 1939-2008. Kenny Grove is situated at the former distributary of a small creek, west of Sespe Creek and above Oak Avenue. Fourth of July picnics were common under these trees in the late 19th century. The trees, still present in 1938 (top), are currently an RV campground shaded by the oaks (bottom). (USDA 1938, courtesy of Ventura County)

Among the people in the east end of this county there has latterly been some quiet renewal of the agitation in favor of the purchase of Kenny Grove in the Sespe Canyon and its maintenance by the county for public park purposes…The grove is a very beautiful strip of woodland, situated in the center of a populous and growing section, and a public park is much needed there—and will be more needed with every passing year.

—VENTURA FREE PRESS 1909A

On the valley floor around Santa Paula and Sespe creeks, a number of live oak and sycamore groves provided shady locations for picnics and Fourth of July celebrations (fig. 3.5). Sprague's grove, a "beautiful sycamore grove" near Sprague's house and Sespe Creek, was one such gathering spot in the 1870s (*Ventura Signal* 1874b, Warring 1959, Jarrett 1983). Kenney Grove, a grove of live oaks between Sycamore Road and Oak Avenue west of Sespe Creek, was another in the 1880s and 1890s; today it is an RV campground owned by Ventura County (Ventura Free Press summary, 1888-1889, from Fillmore HS newspaper index; fig. 3.6). Other live oak and sycamore groves were also documented, including a live oak grove near Santa Paula Creek (*Ventura Free Press* 1879), a grove east of Fillmore called Sespe Grove (*Ventura Free Press* 1887b), and a sycamore grove northwest of the Sespe Creek-Santa Clara River confluence (Barry ca. 1890). Most of these groves were lacking spatially specific information and were thus not included in our habitat map.

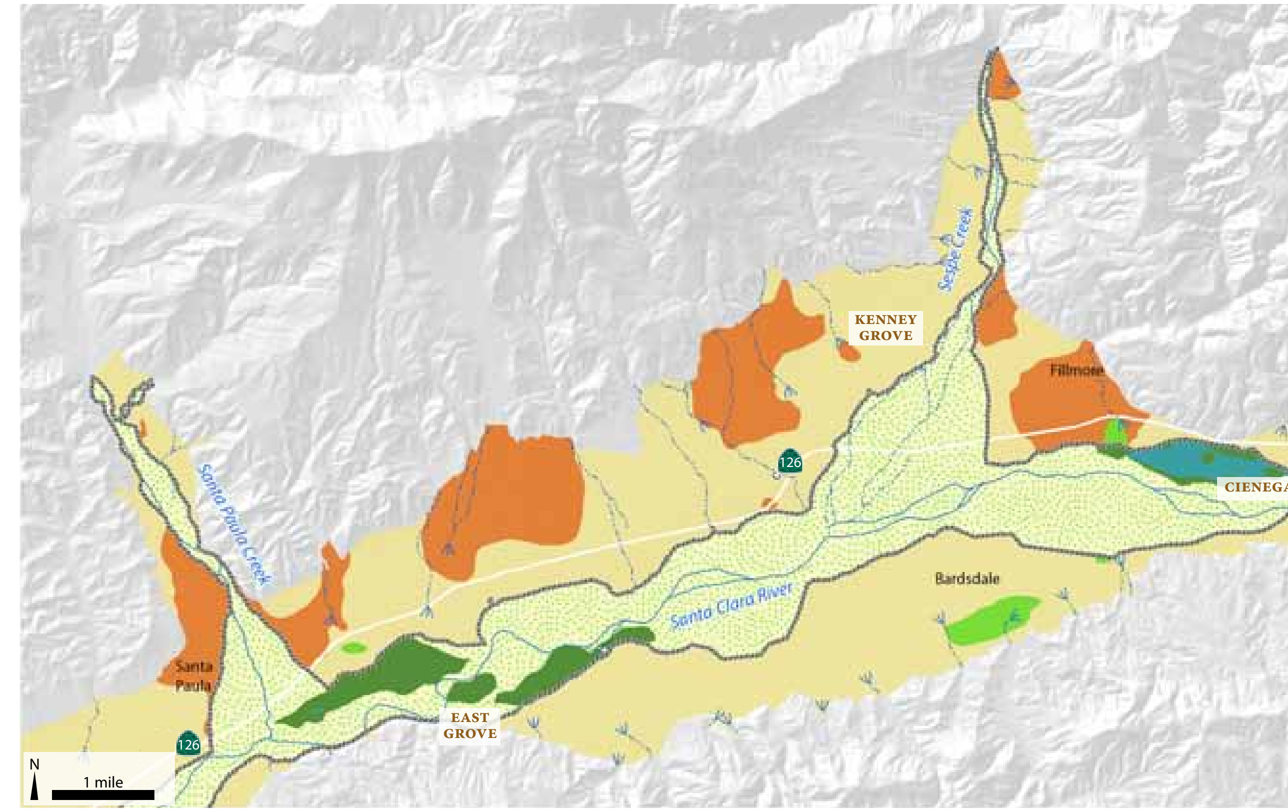


Fig. 3.7. Sycamores and oaks between Santa Paula and Sespe creeks. Scattered oaks and sycamores, documented by GLO, historical soils surveys, and early aerial photography, occupied coarse alluvial fans north of the Santa Clara River.

In addition to these isolated trees and groves, there were a few areas of denser tree cover on the valley floor. These timbered areas were documented exclusively on alluvial fans north of the Santa Clara River between Santa Paula and Sespe canyons (fig. 3.7). Using both GLO survey notes and historical aerial photography, we found that the gravelly fine sandy loam with stones (Yg) soil type from the historical soil survey (Nelson et al. 1917), prevalent on these alluvial fans, was well correlated with the documentation of historical oaks and sycamores. We subsequently used this soil type to delineate probable timbered areas (see page 15). GLO field notes for these areas describe "oak timber," "scattering oak timber," and "scattering live oak and sycamore with undergrowth sage brush" (Hoffman 1868c, Orcutt 1900).

The cities of Santa Paula and Fillmore, both established at least partly on this soil type, were both the sites of notable areas of live oaks and sycamores. A few notable sycamores in Fillmore have survived to the present day, many marking the former route of Pole Creek (Jarrett 1983; fig. 3.8). In Santa Paula, oaks and sycamores are still widespread, particularly in the northern part of the city (fig. 3.9). In addition to these trees, many other

Fig. 3.8 (top right). Sycamore on Kensington Street being trimmed, July 2008. This giant sycamore was part of a group of three sycamores on this block (Jarrett 1983).

Fig. 3.9 (above and bottom right). Oaks and sycamores are still common in this residential part of northern Santa Paula. (November 2008)

live oaks, sycamores, and other riparian trees were established within the banks of Santa Paula and Sespe creeks.

While many of these heritage trees have persisted—notably within the Santa Paula and Fillmore city limits—many were chopped down for firewood or to make way for orchards. One editorial in the *Ventura Free Press* lamented that "our native trees are rapidly disappearing under the sturdy blows of the wood chopper," advising residents to plant new trees to compensate for those lost (*Ventura Free Press* 1881). Even in the late 19th century, some valley residents recognized the value of these trees, and lamented their loss:

> Some one should protest against the cutting down of the trees in the Sespe grove. A street is being surveyed through it and some of the finest trees must be sacrificed. This grove ought to be purchased by the town and kept for a park. It seems a shame that the few accessible groves in the county should be ruthlessly cut down. (*Ventura Free Press* 1887a)

…beneath its native oaks soft glows the velvet sod of Santa Paula.

—ALEXANDER 1918

Notably, no valley oaks (*Quercus lobata*) were historically documented in the lower Santa Clara River valley, either as a riparian tree along the river or on the valley floor. We found no description of valley oaks by any of the region's travelers, botanists, or residents, despite abundant references to the presence of live oaks by these observers. This absence also holds true for the Ventura River and valley (excluding Ojai, which is not in our project area).

The absence of valley oaks is affirmed by the GLO survey notes for the region: in approximately 1,700 survey points collected over a span of 50 years by twelve separate surveyors, there is no mention of valley oaks. This stands in contrast to historical ecology studies performed elsewhere, where GLO surveyors consistently record the presence of valley oaks and differentiate between valley and live oaks (e.g., in northern California's Santa Clara Valley; cf. Grossinger et al. 2007, Beller et al. 2010, Whipple et al. 2010). This absence has also been observed on the Ventura County portion of the Santa Clara River today (Orr et al. 2011).

An exception may be the Los Angeles County portion of the Santa Clara River, at the uppermost edge of the project area. Spanish explorers Miguel Costansó and Juan Crespí, traveling together on the Portolá expedition in 1769, both made note of valley oaks near Castaic Junction: for example, Costansó noted "on the plain we saw many groves of poplars [Fremont cottonwood] and white [valley] oaks, which were very tall and large" (Costansó and Browning 1992, Crespí and Brown 2001). Valley oaks were (and still are) also found in the neighboring areas of Ojai Valley and Thousand Oaks (both just outside the project area), and in fact were emblematic of both areas. This historical distribution is coarsely consistent with the modern range map, which shows an extremely limited range for valley oaks in Ventura County (Pavlik et al. 1991, Ventura County Planning Division 2007). It is also consistent with the low salt tolerance of the species, which limits their presence in valleys opening directly to the ocean (Jepson 1923, Ogden 1979).

Wetland Habitats

Though substantial wetland riparian areas were present on the extensive bottomlands of the Santa Clara River channel (see page 94), outside of the channel there were few wetlands on the valley floor. Scattered willow groves and areas of drier willow scrub were clearly present in the vicinity of the Sespe Creek confluence, though the exact location of these groves is not well documented. These areas were described as "willow thickets" (Peyton 1915), "willow brush" (Hoffman 1868a,c), and "thick grove of willows"

(Jarrett 1983). Many features mapped as willow thickets would have included a variety of trees requiring relatively wet conditions, including alders, box elders, and cottonwoods in addition to willows.

On the south side of the Santa Clara River near Bardsdale, east of Chambersburg Road and north of Guiberson Road, an extensive willow grove served as a notable landmark for area residents. It was the site of a school, called Willow Grove, established after the 1884 flood stranded Cienega schoolhouse kids on the south side of the river (Jarrett 1983). Jarrett describes the significance of the grove:

> Another thick grove of willows grew on the south side of the Santa Clara just over the bank from Guiberson Road, so outstanding that people gave directions by saying, "go east—or west—from the willow grove."

Resident Carl Etkins (1965, in Freeman 1968) recalled that the irrigation pumping plant for the South Side Improvement Company was "fired with willow wood hauled from what was known at that time as the Grove," likely referring to this willow grove (or possibly a grove near the Cienega area north of the river). Flooding resulting from the 1928 St. Francis dam break wiped out the remains of this grove (Jarrett 1983).

A few other wetland complexes were mentioned in historical accounts, though without enough spatial accuracy to map. One of ethnographer John P. Harrington's informants described an extensive wetland in the Piru valley, a "great *cienega* that extends far up and down the creek" (Harrington 1913e). Eames (1889) described "verdant *ciénegas*" near Camulos, and Lopez (1854) notes "a *cienaga* [sic] or swamp" near Castaic. Though it is possible that these wetlands are in-channel features, they allude to the probable presence of many more wetland features — particularly in the Piru and Del Valle reaches — than were documented through our research.

SATICOY SPRINGS In contrast to the Oxnard Plain on the southern side of the Santa Clara River, the lowlands just to the north, on the opposite side of the river, contained few wetlands. This area was naturally steeper and more well drained than the south side of the river, as a result of alluvial fans emanating from the mouths of the series of canyons to the north. However, one distinctive wetland complex was found on the plain on the north side of lower Santa Clara River: Saticoy Springs. Groundwater emerged in an array of springs here, associated with a fault trace of the Country Club fault (Mann 1958), creating a series of springs, wetlands, willow thickets, and alkali meadows that were a noted source of water and wood through much of Ventura history (fig. 3.10).

This unusually large and reliable surface water source gave rise to a major Chumash village that remained at the site until the 1860s, and also served as a significant regional gathering place (Gudde and Bright 1998). One of Harrington's informants recalled that "the Saticoy Indians used to come to Saticoy springs because of the water. The last meeting of Indians was at Saticoy in 1869. Hundreds were there…" (Harrington 1986b). Crespí also recorded the water resources and extensive village located at the Saticoy site in 1769. He described "a good-sized village of very friendly heathens having, by our count, close to twenty very well built large round houses with grass roofs, with a spring close by it, flowing a bit, and the Santa Clara River a little over a musket shot away" (Crespí and Brown 2001).

Palustrine and Terrestrial Habitat

- Valley Freshwater Marsh
- Willow Thicket
- Alkali Meadow
- Grassland/Coastal Sage Scrub

Characteristic Riparian Habitat

- Other In-Channel Riparian

Hydrology

- Intermittent or Ephemeral
- Distributary
- Outer River Bank
- Spring

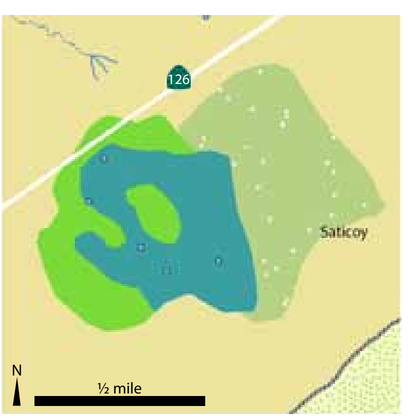


Fig. 3.10 Detail of Saticoy Springs, early 1800s. This 330 acre wetland complex was composed of springs, seasonal alkali meadows, and extensive willow groves and freshwater marsh.

The springs were recognized widely as a major landmark and water source for later settlers in the area (fig. 3.11). Their importance was so great that the Santa Clara River was sometimes called the "Saticoy River" even into the 20th century (Hittell 1874; Bancroft 1883; *Ventura Daily Democrat* 1902, in Browne 1974; Harrington 1913e). The Saticoy Springs area served as additional pasture for Mission animals when areas closer to the Mission were no longer available: "When the pasture there is exhausted or dried up, the cattle go in search of more plentiful or better grazing elsewhere…The animals furthest from the beach make their way to a place called Saticoy" (Señan and Santa María 1804). Modern American settlement in the area began when Jefferson Crane began to farm in the area in 1861 (Triem 1985, Gudde and Bright 1998). The springs were noted as a valuable aspect of the Saticoy area, described as "magnificent springs of pure water… said to be the finest in Ventura county" (*Ventura Signal* 1872).

Prior to major water infrastructure developments (such as widespread artesian development and canals bringing water from further upstream on the Santa Clara River), Saticoy Springs and the perennial portion of lower Santa Clara River were two of the primary sources of summer water for local settlers on the northern side of the river and across the western half of the Oxnard Plain (Cooper 1887, Holmes and Mesmer 1901c, Freeman 1963, fig. 3.12). Settlers north of the Santa Clara River depended on the Saticoy area as a primary water source, and would "buy barrels and haul water from the river or Saticoy twice a week or thrice—the year round…" (*Ventura Signal* 1871b; see also Freeman 1968).

Fig. 3.11. Detail of an early map showing Saticoy Springs at the crossroads of two thoroughfares. (Norway 1867, courtesy of the Ventura County Surveyor's Office)

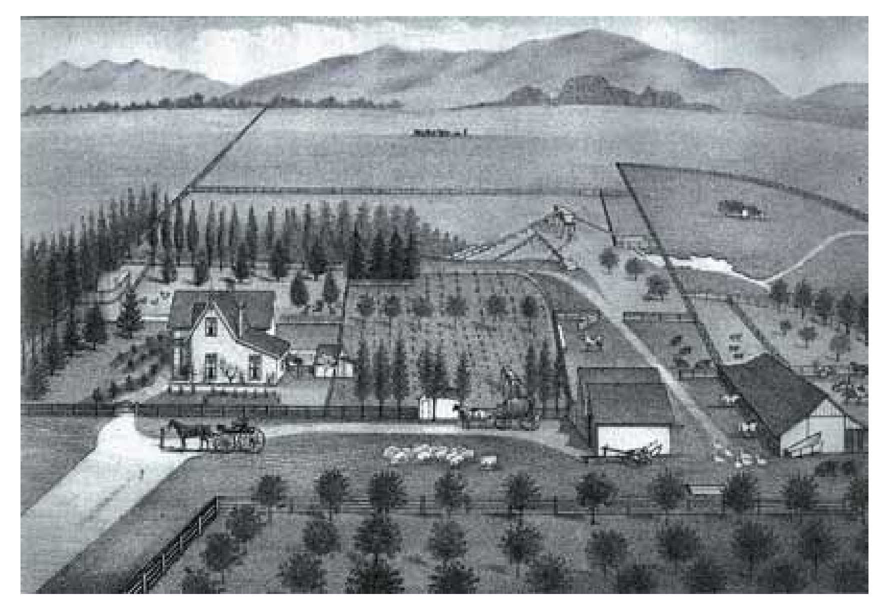


Fig. 3.12. "Residence & ranch of S.T. Wells, Saticoy," ca. 1883. This sketch shows a portion of S.T. Wells' property at Saticoy. His property included some of the springs, as can be seen at right in this image. (Thompson & West [1883]1961)

In contrast to the treeless, relatively dry grass and scrub land surrounding them, the Saticoy Springs were perennially wet, surrounded by a wetland mosaic which included 140 acres of alkali meadow as well as extensive freshwater marshes and willow groves and thickets. Cooper (1887) described the mosaic of freshwater marsh and willow thickets that he observed in 1872-73:

> At Saticoy, however, about 30 feet above the river-bed, springs issue from the edge of the 'mesa' or terrace for half a mile, constant in summer, and forming a considerable marsh, about half of which was then [1872-3] covered by willow groves, thirty or forty feet high, and uniting, the waters form a brook large enough to run a mill at all seasons, discharging within a mile, into the bed of the river.

Kimball (in Freeman 1968) described the patchwork of plant life in the Saticoy Springs area: "This extensive spring area was covered by a dense growth of willows, tules, berry vines and horse nettles. It was the finest kind of a park or playground for boys interested in birds' eggs, blackberries and licorice root." The marsh and willow groves at Saticoy also supported a variety of birds, including Bell's vireo (*Vireo bellii*, possibly least Bell's vireo), Hutton's vireo (*Vireo huttoni*), marsh wren (*Cistothorus palustris*), and yellow warbler (*Dendroica aestiva*) (Cooper 1887).

Channel Morphology

The lower Santa Clara River is a complex, dynamic, braided system. Large flood events are the major driver for morphologic change in the system and can transport substantial quantities of water and sediment over extremely short periods of time: from 1928 to 2000, the four days with the largest sediment discharge account for one quarter of the system's total discharge (Warrick 2002, Warrick et al. 2004).

In addition to natural flood events, the St. Francis Dam break (on San Francisquito Creek) created an immense flood wave that swept rapidly through the lower Santa Clara River on March 12, 1928. Peak discharges for the flood have been estimated at about 600,000 cubic feet per second (cfs) around the Ventura-Los Angeles County Line (Begnudelli and Sanders 2007), well over a 1,000 year recurrence interval flood under contemporary hydrology (Downs et al., submitted). The dam break, along with other large floods of the 19th and early 20th century (e.g., 1862, 1884, 1914), were often noted for the extensive damage caused to the infrastructure of the lower Santa Clara River valley. After each major flood, local newspapers were filled with accounts of washed out bridges, uprooted riparian trees, and eroded farmland.

These accounts pose questions about the spatial extent of erosion and deposition along the river during these storms. In particular, understanding the effects of natural floods (e.g., 1862 or 1884) and the dam break (1928) on the physical characteristics of the river is an essential component of our understanding of the historical morphology of the Santa Clara River, and how and where morphological change occurs in the system.

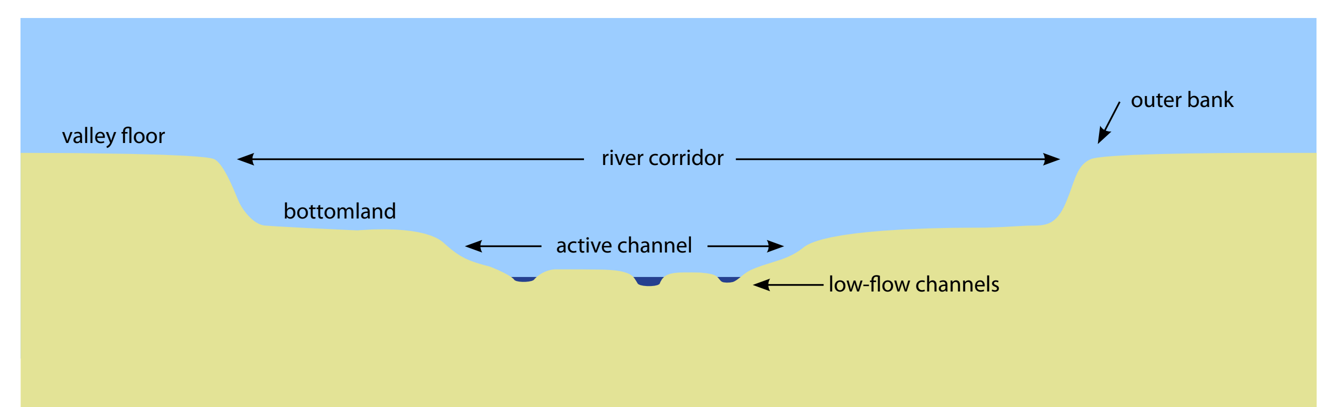
Our research suggests that while substantial change in channel morphology occurred within the outer banks of the river (on bottomlands and within the active channel), comparatively few major shifts in outer bank position occurred in the late 19th and early 20th centuries, even during major flood events. These findings, along with our methods, reach-specific examples of persistence and change, and a discussion of our results, are discussed in detail below. While we focus on plan form changes to the Santa Clara River (notably channel width), a general discussion of hydraulic geometry and channel form are also included in this section.

Hydrology and Geomorphology Terminology

A wide variety of geomorphic features are found within the outer banks of the Santa Clara River, each characterized by different hydrology (flooding frequency, depth to groundwater) and ecology (vegetation and habitat types). Concepts of bankfull discharge as defined for streams in more humid climates (i.e., formed by floods with a 1.5 to 2 year recurrence interval; Wolman and Leopold 1957) are not appropriate for this system, which is characterized by considerable extremes of flow and sediment discharge (Stillwater Sciences 2007b). To address this discrepancy, here we use terminology better suited to Santa Clara River geomorphology. For clarity and consistency, we define the terms below that will be used throughout the report. (For a visual representation of riverine terminology, see fig. 3.13.)

The *active channel* consists of the network of all low-flow channels and the sparsely vegetated or non-vegetated, often sandy bed of the river (Richard et al. 2005). This portion of the river is dynamic, and experiences significant water and sediment transport in most floods; Graf (2000) termed it the "high flow channel." It includes high disturbance areas that are scoured during high flows and have little to no vegetation, in addition to medium disturbance areas that support sparse, poorly established vegetation such as sand bars and islands (Stillwater Sciences 2007b). This is consistent with Stillwater Sciences' classification of active channel width. Nineteenth-century surveyors referred to the active channel area as the "sandy bottom" (Terrell 1861b, Thompson 1867), "sandy bed" (Hoffman 1868b, Norway 1878b, Barry 1892a), or "wash of river" (Norway 1878b).

Fig. 3.13. Generalized cross-section, showing riverine terminology used in this report. The active channel consists of the low-flow channels and sparsely vegetated riverwash. In many reaches the active channel is flanked by bottomland (floodplain) surfaces supporting riparian grassland, scrub, and trees. The entire river, from outer bank to outer bank, is referred to as the "river corridor."



Other early observers described the active channel as a "sandy and gravelly bed" (Cooper 1887) and a "sandy, shallow bed" (*Daily Alta California* 1868). Carrillo (1829, in Outland 1991) referred to the active channel as "worthless" *arenal*, or sandy area.

Above the active channel, within the outer banks of the river, *bottomland* surfaces supported scrubby to dense stands of vegetation. Though still subject to flows, these areas would have experienced minimal scour or deposition during most flood events. These areas correspond with Stillwater Sciences' low disturbance surfaces. "Bottomland" is not a common contemporary ecological term on the West Coast, though it is still widely used in the eastern United States to refer to a periodically flooded forested area (NRCS 2008). Some biogeomorphic literature also uses the term to refer to riverine surfaces above the active channel, though in a broader sense than is meant here (e.g., Scott et al. 1996, Hupp and Osterkamp 1996, Friedman and Lee 2002, Hupp and Bornette 2003, Osterkamp and Hupp 2010). In addition, the Department of Fish and Game's list of terrestrial natural communities in California recognizes "Riparian and Bottomland Habitat" as one of the primary categories of terrestrial vegetation (CDFG 2003). Early surveyors and residents commonly referred to these surfaces as "bottom" (e.g., Norris 1853, Thompson 1867, Craven 1874e), "river bottom" (*Ventura Free Press* 1876, Van Dyke 1890), or "bottom land" (Norway 1877, Hampton 2002, King 1883). (The active channel was also sometimes referred to as a bottom—though never bottomland—but was distinguished as the "sandy bottom"; e.g., Terrell 1861b, Thompson 1867, Thompson 1874.)

While portions of the bottomland certainly served as what today we would term the river's floodplain—that is, the area "overflowed during moderate flood events" (Leopold 1994)—not enough is known about flood frequency to delineate the boundaries of the floodplain. Broadly, the bottomland would have included both floodplain areas (flooded on average once every 1.5 years; Dunne and Leopold 1978) and flood-prone areas (subject to flooding). Some flood-prone portions of the bottomland would have been flooded only during relatively extreme events, such as the 1928 St. Francis Dam break or 1969 flood.

The entire river system, including the active channel and bottomlands (riparian corridor, floodplain, and flood-prone areas), is here defined as the *river corridor*. The river corridor refers to the entire width of the river between outer banks, and includes all high, medium, and low disturbance areas.

River Corridor Position and Stability

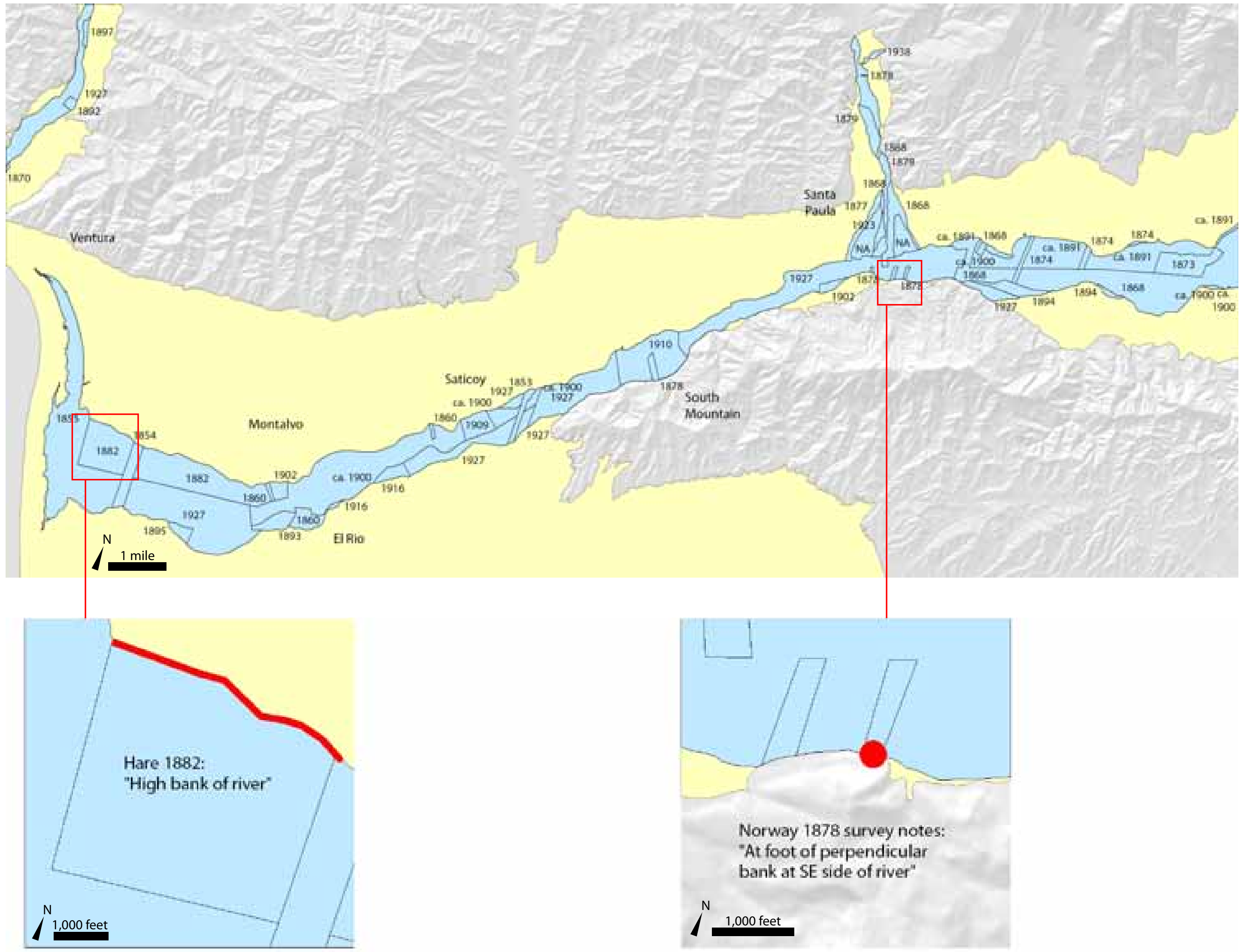
Some previous work has addressed questions of overall river corridor stability over the past two centuries. Based on historical and modern aerials, Stillwater Sciences (2007b) mapped the width of the active channel after major floods from 1938 to 2005. Their data analysis shows a substantially narrowed active channel by 2005 in many reaches, most notably in the lowest reaches of the river (due to encroachment on the channel by human modifications such as levee construction and agriculture). Overall, Stillwater Sciences found that the river corridor narrowed nearly 50% between 1938 and 2005.

Previous studies (Stillwater Sciences 2007b, 2011) have noted that the effects of the 1928 dam break are not obvious in a comparison of 1927 and 1929 aerial imagery. However, the morphology of the river before 1938 has not been established to date. To address questions of effects of pre-1938 floods, including the St. Francis Dam break, on active channel position and stability, we extended Stillwater Sciences' 1938 active channel mapping back to the earliest possible date for each length of stream. Through this process, we produced a map of outer bank position based on the earliest available source. This section describes our methods for mapping approximate 19th century outer bank position, as well as an assessment of two centuries of change.

BANK MAPPING METHODS For the Santa Clara River and main tributaries (Santa Paula, Sespe, Hopper, Piru, and Castaic), we mapped the entire river corridor (from outer bank to outer bank) in a GIS polygon layer. This area includes the sandy, active channel bed (mainstem; high disturbance) in addition to moderately vegetated areas (10-80% cover; Stillwater Sciences 2007b) that show evidence of erosion/deposition (medium disturbance) and more densely vegetated areas (>80%) that may be subject to flow during flood events, but without evidence of major erosion/deposition (low disturbance). Benches or bottomlands with evidence of flow during floods are also included. This definition of the river is consistent with research conducted by Stillwater Sciences for the period 1938-2005.

The river corridor polygon included in our historical mapping represents the earliest reliable source available for each length of stream (fig. 3.14). For the lower Santa Clara River, previous mapping of high, medium, and low disturbance areas from 1938 aerial imagery (Stillwater Sciences 2007b) was used as a starting point. This layer was then compared to earlier historical sources where available. Where earlier sources confirmed 1938 mapping, bank position was left unchanged. Where they showed a substantial change (greater than 150 feet) in bank position, the 1938 layer was modified to reflect the earlier source. In places where Stillwater Sciences was missing 1938 aerial coverage (and in Los Angeles County), we extended their mapping of the active channel. We also mapped the outer banks of the Ventura River and major tributaries of the Santa Clara River from historical aerials and other spatially accurate historical sources.

The primary sources used to complete this mapping were the historical aerial photomosaic (which includes 1927, 1938, 1945, and 1959 aerials; see fig. 1.4), historical survey maps, and General Land Office survey data. The bulk of early sources were from 1870-1900; however, relatively few early (pre-1900) sources were available for the river above the Piru Creek confluence. Over 40 historical sources were used to create the outer bank position for the Santa Clara River. Multiple additional sources were also



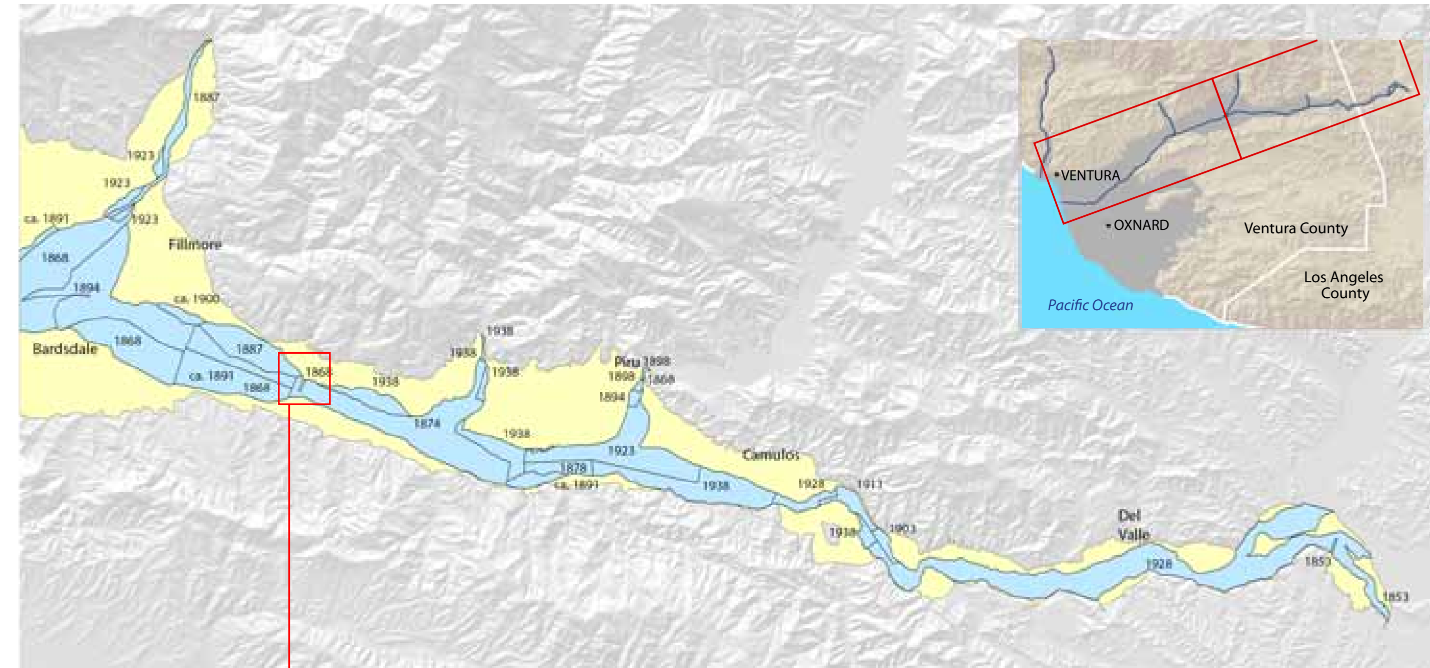


Fig. 3.14. Location of the Santa Clara River corridor by earliest available source, 1853-1938. We mapped the historical position of the outer bank, using the earliest data found for each stretch of the river. We found that while large flood events caused locally significant adjustments in outer bank position and total river corridor width, these changes were relatively small at a regional scale. Pull-out quotes provide examples of the types of sources used to map the historical river corridor.

used to delineate the historical outer bank positions of the Ventura River and major tributaries of the Santa Clara River. While 2005 LiDAR data were used to confirm the position of some portions of the bank, they were not used to map bank position where they were the only source available. This was done to avoid mapping terraces or bluffs that represent the geologic extent of the river (i.e., terraces no longer affected by floods by the 1800s) rather than the historical extent. However, this may have resulted in an underestimation of historical channel extent in some areas, as a number of scarps shown on the LiDAR were not included in our river corridor extent.

Interpretation of outer bank position from historical sources was often challenging. The outer bank was referred to as a "high bluff bank" or "bluff bank" (Thompson 1869, Norway 1878b), or simply the "high bank" (Craven 1874c,f). On some maps, both the edge of the sandy channel bed and the edge of the active channel were shown, facilitating interpretation of outer bank position. In addition, an outer bluff bank was often shown with hatch marks. However, the term "bank" was used differently by different surveyors, and could refer to either the outer bank or the boundary between the sandy channel bed and surrounding bottomlands. While auxiliary data (e.g., aerial photographs) were often used to determine the surveyor's intent, some of these data were ultimately not specific enough to be used. Through this process, we were able to develop a substantial, albeit partial, spatial dataset describing channel morphology between 1850 and 1927, including reliable mapping of the active channel area at a number of sites and times. This dataset allowed us to effectively sample the extent of change in active channel area for available locations and time sequences. While this process did not yield a comprehensive dataset of pre-1928 active channel location, it did provide confirmation in a number of places of channel position bracketing major flood events from 1862-1928.

A few areas are of known lower confidence. For example, the area east of Sespe Creek provides a conservative estimate of channel width; two GLO points at the same spot (Norris 1853, Craven 1874f) intimate that the channel extended an additional 1,400 feet to the north, but we chose not to extrapolate the entire section. For example, in cases where a map showed extensive bottomland for a portion of the river but no additional source showed the continuation of the feature upstream or downstream, we did not map the continuation of the bank. While it is likely that the outer bank continued, we had no historical data to confirm this. This resulted in a few jagged edges in our mapping where one source ends and no other shows the continuation of the feature. In addition, most of the Santa Clara River east of Piru Creek suffers from a lack of early data, and as a result is almost entirely mapped from the historical aerial. In general, this conservatism means that we may have undermapped river corridor extent in some places due to a lack of data. On the other hand, it should also be noted that in a few places (notably major tributaries to the Santa Clara River), outer bank mapping may represent multiple courses occupied by the creek but not historically occupied simultaneously, and thus may overrepresent the extent of river corridor at any given time.

It must be emphasized that this mapping is only an approximation of outer bank position for each system. A lack of data, or ambiguous data, often hindered interpretation. Futher external review and ground truthing of the mapping and comparison to modern conditions were outside the purview of this study, and will be essential before site-specific application.

RIVER CORRIDOR EXTENT While historical data support substantial changes in channel morphology within the active channel (e.g., in low-flow channel position and extent of young, in-channel riparian vegetation) on a frequent (year-to-year) basis, the position of the broader river corridor remained comparatively stable through the floods of the late 19th and early 20th centuries. Comparison with 1938 mapping shows significant changes in outer bank position in a few reaches. However, our analyses suggest that no extreme overall shifts in channel position or width occurred between the late 19th century (1870-1900) and 1938. Since many historical sources

confirm outer bank position before and after the 1884 flood (and a few before 1862), these data offer significant insight into flood effects on Santa Clara River morphology. In particular, our analyses imply that the geomorphic work of most large floods stays largely within the outer banks of the river, and that the position of these banks has until recently (1938) been broadly persistent over time.

Even the St. Francis Dam break appears to have had minimal long-term impact on the river's overall plan form configuration (fig. 3.15), despite noteworthy scour and extensive deposition at various locations along the river valley and the possibility that the gradient of the channel between the county line and Sespe Creek has been recovering ever since (Stillwater Sciences 2007b). Many riparian features persisted, as did the general width and appearance of the channel.

This conclusion is supported by recent research simulating flooding extent and discharge in the Santa Clara River valley after the dam break (Begnudelli and Sanders 2007). Modeling predicts a maximum discharge of about 1.5 million cfs at the dam and over 600,000 cfs around the county line. In the lower reaches of the river, however, modeled flow was only approximately 250,000 cfs (near Santa Paula) and about 140,000 cfs (at the river mouth). These figures imply that though the flood wave was equivalent to recurrence intervals of well over 1,000 years in the upper portion of the lower Santa Clara River, discharges attenuated rapidly downstream: by the river mouth the flood wave was calculated to be an event with only about a 20-year return period (Downs et al., submitted). These calculations validate the relative lack of documented large-scale plan form change.

Net loss in area between our earliest source mapping and 1938 conditions is 2,000 acres (fig. 3.16) or 13% of the 19th century area. (While it is possible that sediment deposition accounts for some of the

Fig. 3.15. Santa Clara River after the St. Francis dam break, 1928. This photograph was taken near Piru only five days after the failure of the St. Francis dam. (Isensee 1928a, courtesy of the Museum of Ventura County)

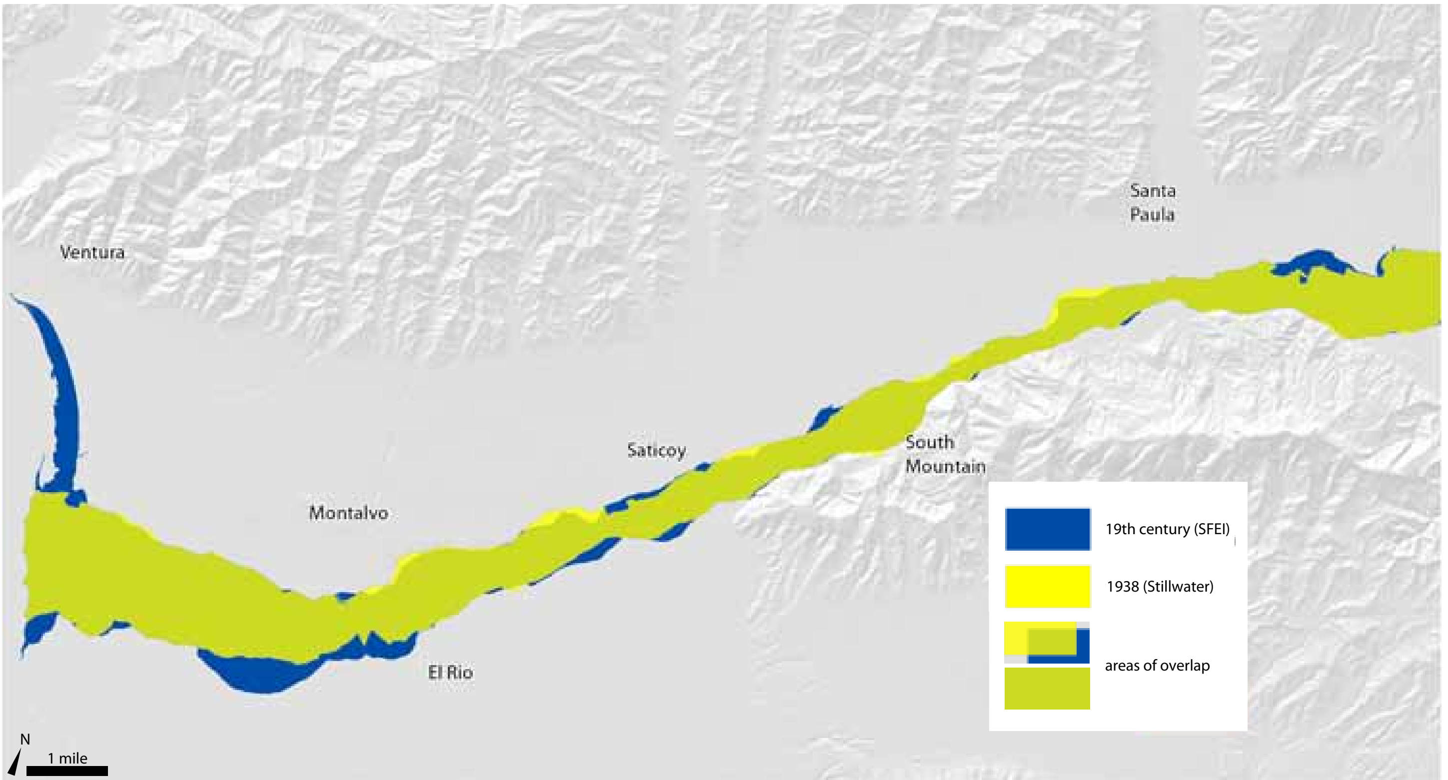


Fig. 3.16. River corridor extent and outer bank position, 19th century and 1938. By 1938, 13% (2,000 acres) of the river's former extent had been removed from the river's influence. Much of this lost river corridor was bottomland habitat near the river mouth and Sespe Creek. (1938 mapping from Stillwater Sciences 2007b)

channel narrowing by 1938, the bulk of this channel loss is from human encroachment on the river through cultivation, levee construction, etc.) While the data resolution is not sufficient to make reach-scale generalizations about stability, in many locations pre-1900s channel form coincides almost exactly with 1938 form (fig. 3.17).

In other reaches, however, comparisons between 19th century and 1938 mapping show substantial areas of channel change, on a scale of over 1,000 feet (fig. 3.18). The vegetated area south of the river in the Oxnard reach represents more than 2,300 feet of channel loss at its widest extent. The Sespe reach has been greatly constricted, especially the north bank just downstream of the Sespe confluence and in the Cienega (Fillmore Fish Hatchery) area. By 1938, bottomland areas in many portions of the Sespe reach extended 300-2,300 feet less far than they had in the 19th century.

It is important to note that while lateral migration of the Santa Clara River was relatively limited from the late 1800s to 1938, the character of many of the low-disturbance lands within the river corridor has changed dramatically over time. Many of these bottomlands were valued for agriculture (see Chapter 2 and pages 96-97), and by 1938 many were farmed. Our research suggests that much of the flooding damage occurred in these floodplain areas. While these areas may still have been hydrologically active in 1938 (i.e., subject to flow during flooding), many had lost substantial ecological value as riparian areas were replaced by farms and other uses.

The impressive stability of the SCR channel location over time, despite high intensity events such as 1862, 1884, and the St. Francis Dam break of 1928, suggests a channel with significant capacity to accommodate extreme events without significant lateral migration or changes in width. Though the channel has been significantly artificially narrowed at many spots, the largest plan form changes captured by our data set due to bank erosion were less than 1,700 feet. These types of changes, while immensely significant to local property owners, would have mostly represented very small proportions of the overall river.

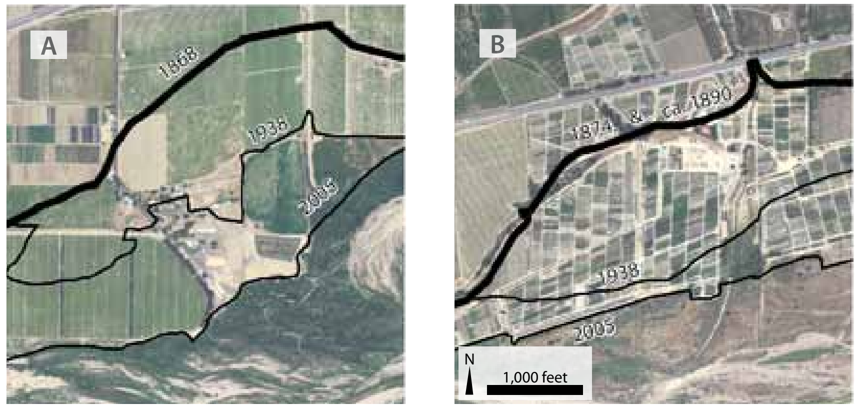
By 2005, 7,600 acres of bottomland had been lost from the river corridor, nearly half of the 19th century area of about 15,500 acres (fig. 3.19). These areas had been converted to agricultural or urban uses, and were no longer regularly flooded or considered part of the river (fig. 3.20). Development

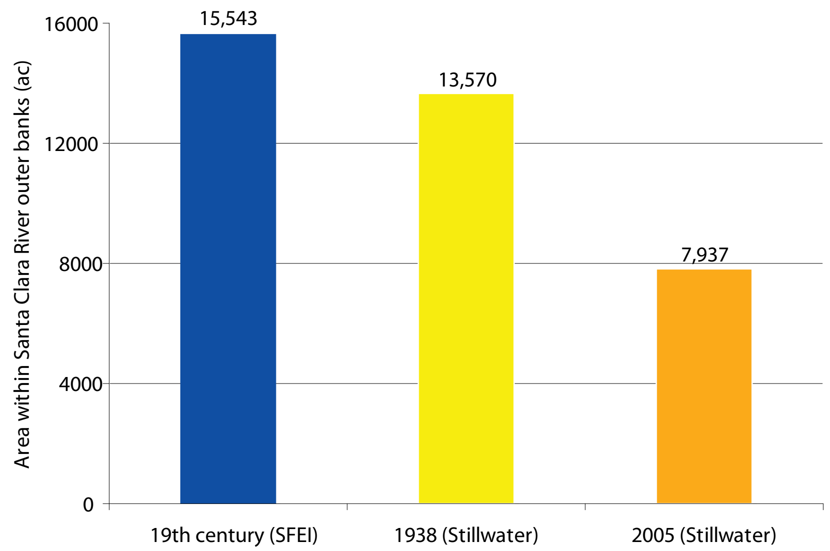
Fig. 3.17. Examples of historical persistence in bank location. In many locations along the river, the position of the outer bank remained quite stable over decades, despite intervening major floods (including the St. Francis Dam break of 1928). This is illustrated here in three reaches: south of the Sespe Creek confluence (left), at South Mountain (middle), and at the Olivas Adobe near the river mouth (right). In each case, early (1854-1882) evidence also confirms the early 20th century (1927-1938) bank position. In each instance, by 2005 bank position has shifted somewhat. (USDA 2009)

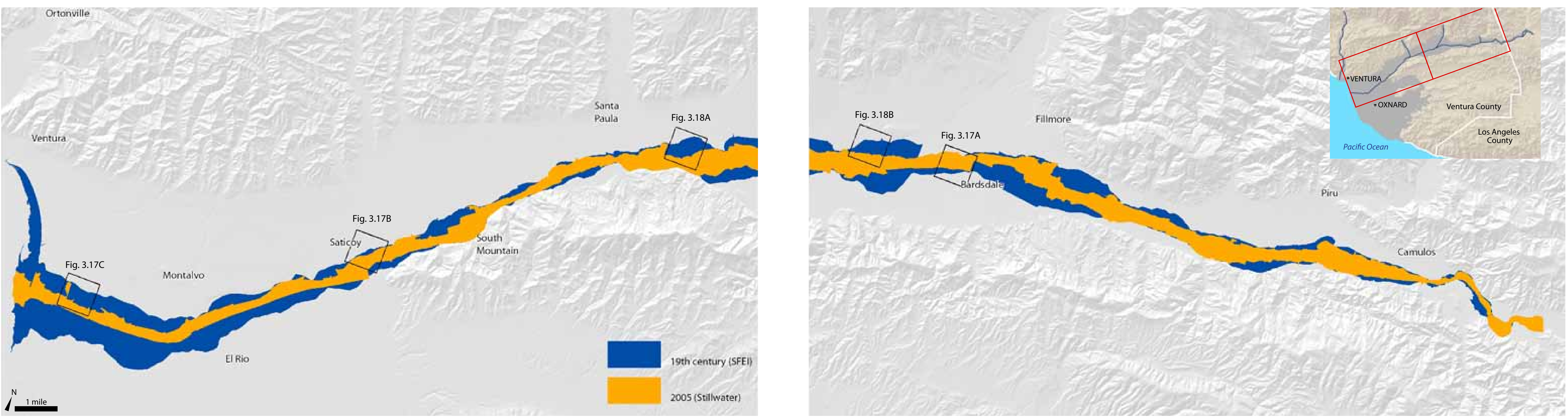
Fig. 3.18. Examples of historical change in bank location (top). In some places, bank position as documented by 19th century surveyors differed substantially from 1938 conditions, as shown here on the river west of the Sespe Creek confluence (left) and east of the Santa Paula Creek confluence (right). In each case, the river corridor had narrowed even further due to reclamation by 2009. (USDA 2009)

Fig. 3.19. (middle) From the 19th century to 1938, total river corridor area dropped only a little under 2,000 acres (13% loss), largely as a result of levee construction and agricultural encroachment on the channel. By 2005, over 7,600 acres had been lost, 49% of the original river corridor area. (1938 and 2005 data from Stillwater Sciences 2007b.)

Fig. 3.20. (bottom) River corridor extent and outer bank position, 19th century and 2005. By 2005, over 7,600 acres had been lost, 49 % of the original river corridor area. Much of the lost area was bottomland habitats, leveed and reclaimed for farming and other land uses. Documented change is concentrated particularly in the Oxnard and Estuarine reaches (below Saticoy) and between Santa Paula and Sespe creeks. (2005 mapping from Stillwater Sciences 2007b)







trends over the past two centuries have resulted in a loss of floodplain bottomland, while the more regularly flooded sandy channel bed has been largely preserved. Today's river has been shaped by multiple flood events over the past centuries, in addition to more recent anthropogenic activities.

LARGE-SCALE CHANNEL CHANGE A notable exception to the overall trend of channel stability is the migration of the Santa Clara River mouth from Point Hueneme to its present location, a shift of over six miles upcoast. Geologic maps and early aerial photography of the Oxnard Plain clearly show a former course of the Santa Clara River flowing through El Rio and Oxnard before entering the ocean just south of Hueneme, about six miles south of the current mouth of the river (fig 3.21; Fairchild Aerial Surveys 1927, Clahan 2003). This inactive, meandering channel was mapped by Parsons (2004); he termed it the Saviers paleochannel and identified it as the former course of the Santa Clara River.

A few references to the old channel of the Santa Clara River are present in the historical record. An article in the *Ventura Free Press* (1878b) notes that "many years ago the waters of the Santa Clara emptied into the sea only about half a mile below the wharf," though it is unclear whether this was common knowledge at the time. At this time the expression of the old channel on the plain was likely still clearly visible in many places (Fairchild Aerial Surveys 1927), so this may have been widely accepted. A few 20th century researchers have also recognized the presence of the old route of the river (Carty 1973, Brown 1981, King 2005).

Fig. 3.21. Large-scale changes in the lower Santa Clara River course on the Oxnard Plain. Geologic, archaeological, historical, and edaphic data all support the migration of the Santa Clara River over the Oxnard Plain over geologic time. Extreme floods coupled with sediment deposition triggered channel migration on the Santa Clara River delta (Oxnard Plain) and subsequent large-scale changes in river corridor location. The dashed black lines represent paleochannels; the most recently occupied former course of the river (Saviers paleochannel, labeled a) may have been active as recently as 1812. It can also be seen here how ecological patterns of the Oxnard Plain are dictated by the channel migration history, with grassland/sage scrub on higher surfaces marking natural levees along more recently occupied routes of the river. (Nelson et al. 1917, Fairchild Aerial Surveys 1927, Clahan 2003, Parsons 2004)

It is unknown when the paleochannel was last actively occupied. Based on analysis of offshore sediments near Hueneme, geologists have estimated that abandonment of the Saviers paleochannel occurred no more than 2,000 to 3,000 years ago (Romans et al. 2009). Ethnographic accounts suggest that the shift may have happened much more recently, within at least the oral historical record of the Ventureño Chumash. One archaeological report cited Fernando Librado (a star informant for anthropologist John P. Harrington) as saying that the 1812 earthquake was the cause of the shift in channel course (Parsons 2004). While we were unable to find this (or any) document mentioning a specific year for the shift, this interpretation is not contradicted by additional ethnographic evidence. Multiple places in Harrington's (ca. 1913) field notes reference a time when the Santa Clara River mouth was near Point Mugu (Harrington 1986a,b). (Point Mugu referred to the broader Ormond Beach-Mugu section of shoreline; Parsons 2004.)

> Mugu estero used to be the mouth of the Santa Clara River. (Harrington 1986a)
>
> Ponom [Chumash name for a pond and marsh north of Oxnard]… Means (1) "que hay que cuidar," he must guard (2) for they had fear that sometime the river of Santa Clara could change its course back to Point Mugu… (Harrington 1986a)
>
> The V. river first had its mouth many years ago at the foot of hills west of V. river valley. This was long ago. Then it changed to mitsqanaqan—then in 1810 (so the old men said) in a flood to its present location. Santa Clara River ran into Migu [sic] Laguna, but more recently changed. (Harrington 1986b)

This last quote seems to imply that the Santa Clara River changed course after 1810, though this is not substantiated by other documents. Regardless, these recollections point strongly to a channel shift in the recent past (e.g., roughly 200-500 years ago). It seems probable that if the channel had changed position 2-3,000 years ago, as posited by Romans et al. (2009), the event would no longer be in the cultural memory of early 20th century Ventureño Chumash descendents as a relatively "recent" change. This interpretation is supported by the historical (19th century) presence of occasional sycamore trees on the higher alluvial sediments of the paleochannel, indicating relatively recent occupation of the channel course.

Hydraulic Geometry and Channel Form

In comparison with channel width and stability, channel geometry is relatively poorly documented. Few early sources provide site-specific accounts of bank height or thalweg depth, and all but the broadest information on channel plan form is undocumented. A brief overview of these topics is provided here.

CHANGES WITHIN THE RIVER CORRIDOR While lateral changes in river corridor location were relatively limited on a year-to-year scale, within its outer banks the Santa Clara River was quite dynamic. High flows would regularly cause shifts in mainstem position, causing the river to reoccupy former channels or cut new ones within its corridor. The width and location of the active channel, the distribution and density of in-channel vegetation, and the position and extent of bottomland would have also shifted with each major flood (fig. 3.22). Shifts in relative riparian cover and the nature of the active channel were identified by early settlers describing the Santa Clara River:

> …the land which this season might be of some value for pasture or agriculture, might next summer be a bed of naked sand, for we know how capricious these streams are when flowing through a light sandy soil. I was informed by a gentleman residing in the Buenaventura, who had resided several years upon the Rancho of Sespe that he had seen the whole bed of the river covered with sand. (Hopkins 1871)

Other accounts also describe changes to the bottomland as a result of flooding (e.g., *Ventura Free Press* 1876, *Ventura Free Press* 1891b). Much of the low-lying riparian vegetation—willows and cottonwoods in or close to the active channel—would be uprooted from the river during major flood events. A few long-time residents of communities along the Santa Clara River noted that during significant floods of the late 19th and early 20th centuries, substantial portions of the riparian vegetation in the river would grow between major flood events, then be scoured out by flood waters:

> The reason that the 1884 flood seemed to be a very large flood is that the river was very heavily loaded with cottonwoods. Some of these cottonwoods were 50 or 60 feet high and had an undergrowth about eight feet high. (War Department 1938)

> [during 1884 floods] The banks of the Santa Clara River, the Sespe and Santa Paula Creek that had been lined with great oak, sycamores, and cottonwood trees, that had stood for centuries on their banks, had been swept bare… The Santa Clara River took out hundreds of acres of good land and left stones in its place. (Hardison, in Freeman 1968)

> I think a great part of the damage done by the floods is caused by the growth which has occurred in the streams over a period of many years. In 1914 this growth was all washed up and we have had 24 years [between 1914 and the 1938 flood] in which to grow alders, willows and cottonwoods. When a big freshet comes, it takes this debris down in great quantities. (War Department 1938)

This [flooding] is all caused by the Santa Clara river, which gets very high and changes its course to first one side and then another.

—VENTURA FREE PRESS 1891B

Much later accounts describe that between floods "much of the bed is overgrown with weeds and willows" (C.E. Grunsky Company 1925) and that "during the dry period these willows encroach on that stream, so that during a major flow there is not enough open channel available" (War Department 1938). These dynamics are discussed further in the riparian vegetation section (pages 96-97).

It should be noted that some sources indicate that land use changes within the valley and tributaries altered effects of floods, making the active channel and bottomlands more susceptible to large-scale changes than previously. This effect was identified by the early 1880s: in 1886, a resident of Ventura noted that "within the last four or five years the Santa Clara River and those of its tributaries whose sources have been stripped of timber and brush, now

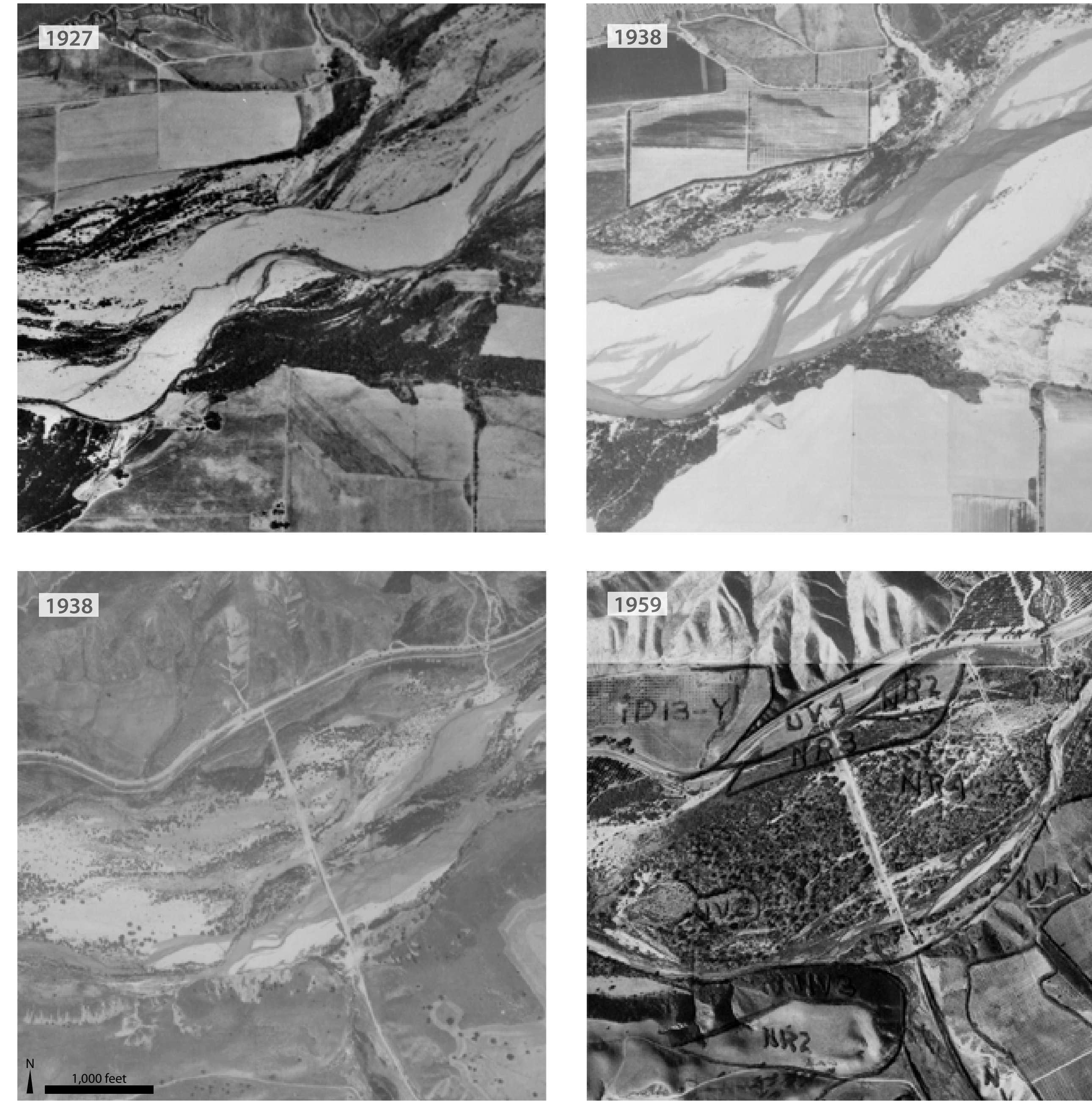


Fig. 3.22. Decadal-scale shifts in in-channel riparian vegetation and channel form. Major floods reworked the active channel and floodplain, creating new channel and vegetation patterns. Top images: Santa Clara River east of Santa Paula, 1927 and 1938. Bottom images: The river east of the Los Angeles County line, 1938 and 1959. (Fairchild Aerial Surveys 1927, courtesy of Whittier College; USDA 1938, courtesy of Ventura County; USDA 1959, California State University Northridge, Map Library)

run more violently and destructively than formerly. As a consequence, the Santa Clara Valley is being much injured by floods" (California State Board of Forestry 1886). It is possible that floods of the late 19th and early 20th century—in particular 1884, 1914, and 1938, in addition to the St. Francis Dam break—may have impacted in-channel riparian distribution and bank position stability more significantly than previous floods of record. However, these accounts are hard to interpret given the relatively short memory of these observers in comparison to longer (e.g., decadal scale) variations in climate and precipitation, and the observed effects may not be a direct result of changes in land use.

INCISION/CHANGES IN BED LEVEL Stillwater Sciences documented changes in bed elevation from 1949 to 2005 for the entire lower Santa Clara River (and back to 1929 between Santa Paula and Piru creeks), noting trends by reach in incision and aggradation. As is the case for many historical studies, however, we did not recover documents in the historical record to permit a comprehensive quantification of earlier trends in bed level. It is possible that human actions may have created local changes in bed level prior to 1929/1949. For example, changes associated with the St. Francis Dam break flood of 1928 may have caused incision of the Santa Clara River above Fillmore (Downs et al., submitted), or changes in hillslope vegetation associated with grazing and introduction of invasive species could have caused channel aggradation. However, it is also possible that regional bed level changes prior to the 20th century would have occurred primarily in response to avulsion of the lower reaches across the Oxnard Plain rather than as a response to human activity.

While no comprehensive data set detailing bed elevation exists for the period before 1929, scattered early observations provide limited evidence for changes in bed level since the 1700s. Notably, near Saticoy and Piru in 1769, Crespí noted that the active channel was quite shallow: "the bed does not lie very deep" (Piru, Crespí and Brown 2001) and "the bed must have a width of fifty varas [140 feet] of sand… very shallow and on a level with the land of this great plain" (Saticoy, in Crespí and Bolton 1927). Almost 100 years later, another traveler also described the Santa Clara River near Montalvo as having "a wide, sandy, shallow bed" and "low banks" (*Daily Alta California* 1868).

In some areas high bluff banks were (and still are) present, such as near the Olivas adobe (built 1837, enlarged in 1849) on the right (north) bank of the river near its mouth, where a bank 20 feet high (Hancock 1854) provided some protection from flooding. King (1883) also noted around Piru that "at some points the banks of the river are 20 ft high."

CONNECTIVITY TO MINOR TRIBUTARIES Prior to the widespread construction of channels connecting them to the Santa Clara River, most small creeks appear to have sunk into the coarse soils of their alluvial fans rather than maintaining a defined channel all the way to the river. In the 19th century, these small creeks would have mostly maintained a subsurface connection with the Santa Clara River, and possibly a brief seasonal surface connection through poorly defined channels in times of high water.

In contrast, in the present-day drainage network nearly every tributary is directly connected via engineered channels to the river. Even relatively small channels with limited flow are currently connected with the river's mainstem. This change is captured on numerous historical maps which show the unconnected streams disappearing on the valley floor (e.g., Holmes and Mesmer 1901b, USGS 1903a). In addition, many anthropogenic surface connections are striking on the historical (1927/1938) aerials for the river valley, which often clearly show the transitional point between the sinuous, natural upstream portion of a creek and the straight, engineered downstream portion. This systemic change has implications for the density of the drainage network of the valley and the speed at which water is delivered to the Santa Clara River. Increased drainage density has the potential to create higher flood peaks and bank erosion downstream, as well as reducing groundwater recharge (SFEI 2011).

Dry Season Flow

While some research has been conducted to determine the nature of flow on the Santa Clara River prior to significant Euro-American modifications (cf. Schwartzberg and Moore 1995, Nautilus Environmental 2005) and some researchers have speculated that perennial flow would have been present along much of or the entire river (Stillwater Sciences 2007b; see also Boughton et al. 2006 for general Southern California historical flow), little comprehensive research has been conducted to assess specific local historical conditions.

Information compiled from narrative accounts, maps, and photographs suggest that while substantial persistent, perennial reaches were present along much of the Santa Clara River, there were also extensive sections of consistently intermittent flow. From Crespí's journey in the summer of 1769 to water availability reports of the early 20th century, the historical record consistently defines certain reaches as intermittent, while others are commonly described as having water year round. These patterns in summer base flow reflect surface water-groundwater interactions, which are controlled broadly by groundwater basin location and the faults and structural variations in valley width and depth.

Crespí's River

Fortunately for current researchers, Spanish explorer Crespí's expedition traveled down the Santa Clara River from near Saugus to Saticoy in mid-August 1769, describing flow conditions in many places. Crespí observed that large portions of river maintained substantial summertime flow, while others were completely dry (fig. 3.23). Though 1769 was part of a relatively wet period, Crespí's descriptions appear representative of larger trends supported by additional sources, as discussed in detail below (Lynch 1931).

On the Santa Clara River above Camulos on August 10, 1769, Crespí recorded a "good-sized stream of running water following us ever onward," with cottonwoods, willows, grapevines, and live oaks along the channel (Crespí and Brown 2001). The river continued to have a "large flow of water" until just above Camulos the next day, where Crespí noted that

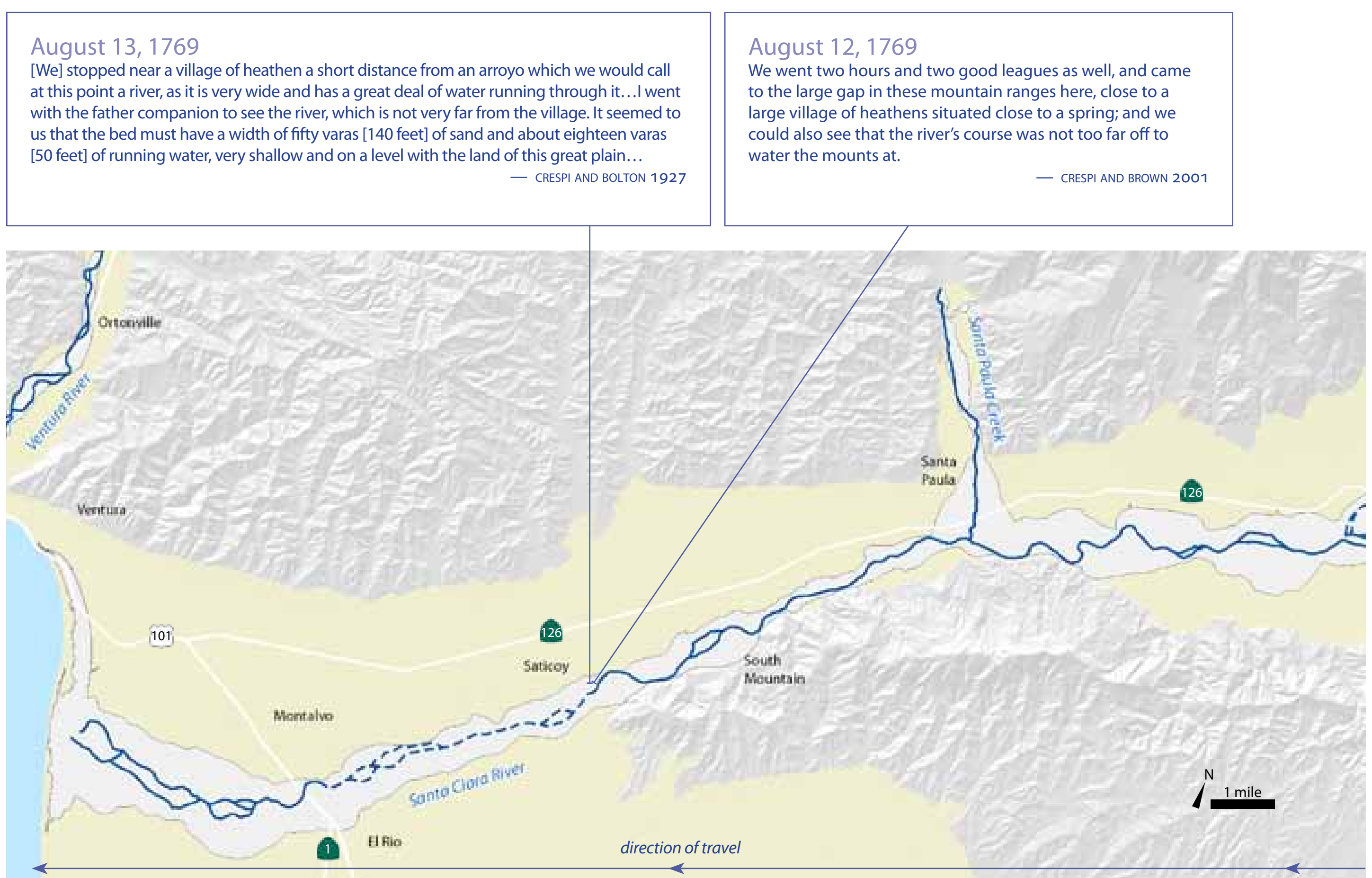
> After accompanying us with a good-sized flow of running water all during yesterday's march, the stream, shortly after we set out today, stopped flowing amid the great amounts of sand in the bed of this stream, seemingly sinking into its many sands; the bed is plainly over a hundred yards in width in spots, and must be a very full-flowing river at some seasons, as is shown by its many piles of drift and large banks of sand.

Approximately 9 miles later, around the widening of the valley east of Fillmore, Crespí noted that they "once more came across a good-sized stream of running water" that continued for "some leagues down the hollow." He made no more explicit mention of flow until around Saticoy, where he noted that the river was "not too far off to water the mounts at":

> The river bed here must be about fifty yards wide across the sand; the breadth of water flowing must have been about some eighteen yards, running very shallow—very good, pure water.

At this point Crespí ceased following the river, though he does note that the river "runs through this plain, flowing down onto it from the Santa Clara Hollow we have just come through, southwestward, and on out over the aforesaid plain here to empty into the sea."

Fig. 3.23. Crespí's River, August 1769. The Santa Clara River exhibited a pattern of alternating reaches of perennial and intermittent summer flow, as depicted below (dashed reaches are intermittent). These patterns were recorded in the observations of Spanish explorer Juan Crespí, travelling downstream along the river from August 10-13, 1769. Though Crespí's observations cannot all be placed precisely, they provide detailed, early observations of flow patterns on the river.



Supporting Evidence

Crespí's assessment of summer flow along the Santa Clara River is largely corroborated by other, later observations of flow characteristics (table 3.2). One late 19th century source estimated that the Santa Clara River was "dry for four-sevenths of its course during a part of the year" (Porter et al. 1882), a depiction that is overstated but roughly reflective of flow conditions portrayed by more specific accounts. More than 160 years later, Freeman (1930) described similar, if somewhat diminished, flow patterns along the river (see page 82).

In particular, the disappearance of summer flow around Camulos is well documented. Above Camulos (in the Del Valle reach), Freeman (1930) noted summer surface flow, and King (1883) observed an "ample supply of nice, clear water" when traveling in mid-October. Just above Camulos, however—where Crespí observed flow disappearing into the river bed — Freeman notes that "water begins to disappear," and a September 1858 survey of Camulos Ranch notes that the "river at this time is dry" (Hancock 1858). An early *diseño* shows the river disappearing a little after Camulos, and well before reaching Piru Creek. This transition is also captured by the

The ride back to the Camulos was one of the pleasantest features of the day…Farther to the east outspread the russet fields of the Newhall Rancho, a magnificent stretch of sixteen miles of valley, with the blue artery of the Santa Clara river running its entire length.

—NINETTA EAMES, EARLY FALL 1889, AUTUMN DAYS IN VENTURA

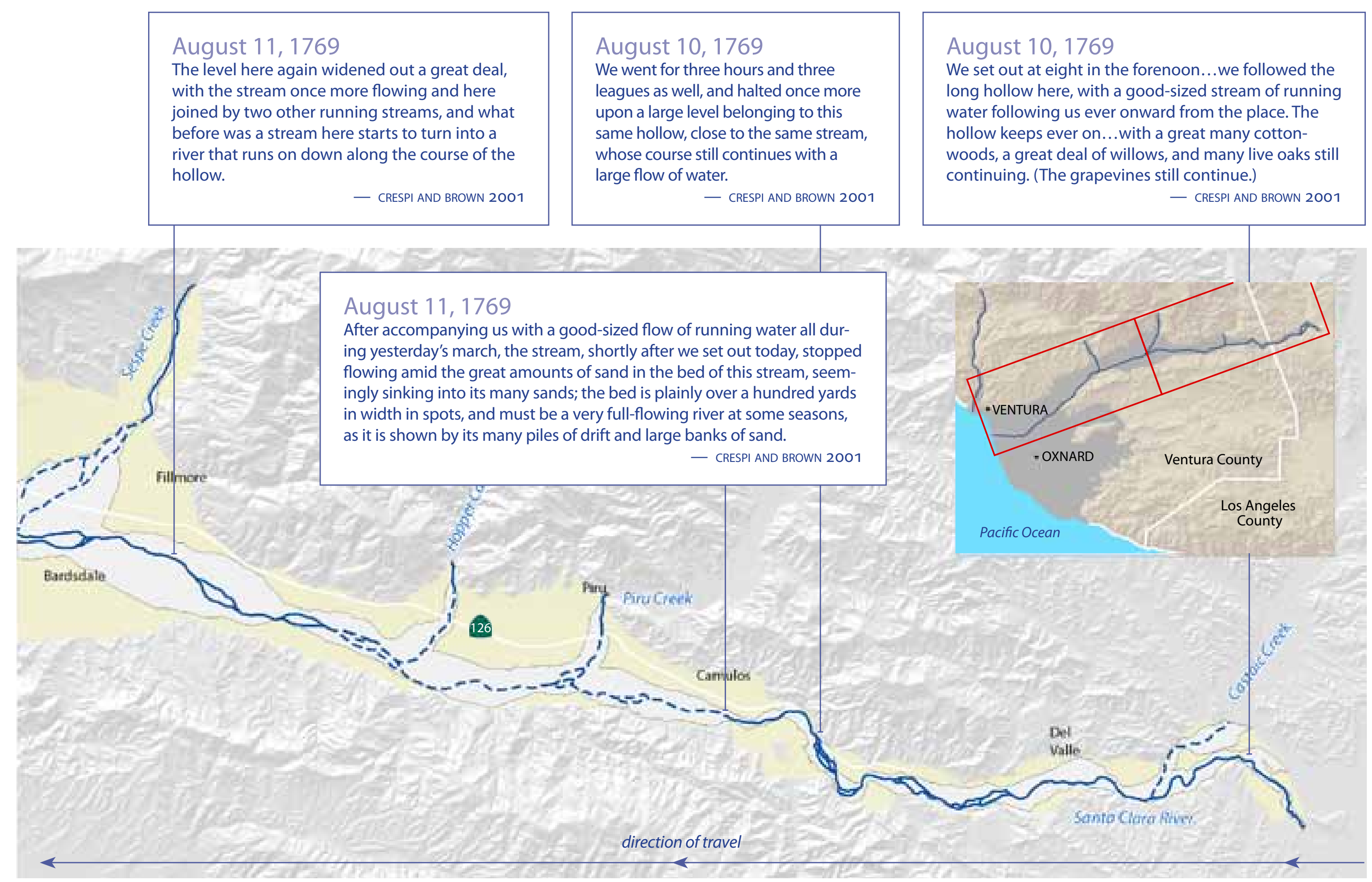


Table 3.2. Evidence of summer flow by reach on the Santa Clara River, 1769-1930.

Reach	Date	Evidence	Reference
Oxnard (river mouth)	early October 1855	"an insignificant stream, with but an inch or so of water in its channel."	Johnson 1855a
Oxnard (river mouth)	October 24, 1879	"somewhat rapid stream"	Bowers 1879, in Benson 1997
Oxnard (river mouth)	June 1, 1899	"running water"	Waud ca. 1899
Oxnard (river mouth)	September 1857	"nearly dry during the summer"	*Daily Alta California* 1857
Oxnard (101 crossing)	August 1868	"some water flowing where we crossed it, and quite a large body a few miles above"	*Daily Alta California* 1868
Oxnard (101 crossing)	June 18, 1883	"wide sandy bed where an emaciated stream reposes till revived by winter rains"	Seward [1883]1937
Oxnard (Saticoy)	Late summer/early fall 1889	"loitering along its sandy bed as if it were loth to reach the sea"	Eames 1889
Oxnard (Saticoy)	August 13, 1769	"the breadth of water flowing must have been about some eighteen yards, running very shallow"	Crespí and Brown 2001
Oxnard (Saticoy)	Summer 1872-3	"dry in summer for seven or eight miles"	Cooper 1887
Oxnard (Saticoy)	June 8, 1854	"water of Rio Santa Clara, current near 6 miles per hour and average depth 9 inches"	Hancock 1854
Santa Paula	Summer 1872-3	"Santa Clara River runs permanently"	Cooper 1887
Sespe (at Sespe Creek confluence)	October 12, 1853	"to water"	Norris 1853
Sespe (E of Fillmore)	August 11, 1769	"good-sized stream of running water"	Crespí and Brown 2001
Sespe (3 miles E of Bardsdale Bridge)	Summer	"water again comes to the surface"	Freeman 1930
Piru (~2 miles west of Piru)	October 1853	"the water of the river has sunk at this point"	Norris 1853
Piru (~1 mile west of Piru)	Oct 7-11, 1878	"dry bed of Santa Clara River"	Chillson 1878
Piru (3 miles east of Piru)	Summer	"water begins to disappear"	Freeman 1930
Piru (above Camulos)	August 11, 1769	"the stream…stopped flowing amid the great amounts of sand in the bed"	Crespí and Brown 2001
Piru	September 1, 1858	"river at this time is dry"	Hancock 1858
Del Valle	October 16, 1883	"ample supply of nice, clear water"	King 1883
Del Valle	August 10, 1769	"large flow of water"	Crespí and Brown 2001
Del Valle	Summer	"ground water…rises to flow along the surface"	Freeman 1930

USGS topographic quad from 1903 [Santa Susana], which shows a solid blue line in the sandy bed of the Santa Clara River (the conventional USGS symbol for a permanent stream) from west of Saugus to ½ mile east of Camulos, where a forked distributary represents the stream sinking into its sandy bed (fig. 3.24).

The Santa Clara River remained dry until above the confluence with Sespe Creek (about 1.5 miles east of the fish hatchery), where surface flow resumed (Freeman 1930). Around Fillmore, Fray Señán of Mission San Buenaventura noted that substantial summer water was present above Sespe Creek : "in time of flood or after heavy rains it is impossible to cross the river for 2 or 3 days…Throughout the rest of the year the river carries no small volume of water" (Señán 1804). Historical data are not abundant in the area around the Sespe confluence, though one surveyor does note water in the channel in early October (Norris 1853) and a few survey maps show diversion dams and summer (June) flow (Barry 1892b, Unknown 1894). Definitive descriptions of flow resume above Santa Paula Creek: around Santa Paula extending east toward Fillmore, ornithologist Cooper wrote that "the Santa Clara River runs permanently and a grove of poplars [cottonwoods; *Populus* spp.] and willows lines its marshy shores for several miles" (Cooper 1887).

Evidence for dry season flow is more ambivalent in the area around Montalvo and Saticoy, though it appears that this reach was most likely intermittent as water spread and sank into the coarse gravels of the Oxnard Plain below South Mountain. Cooper (1887), who spent time near Saticoy during 1872-3, described the river as completely dry during the summer along this reach:

> The Santa Clara River runs half a mile distant, but is dry in summer for seven or eight miles along that part of its course, leaving a wide, sandy and gravelly bed, destitute of vegetation except on a few higher patches where small poplar and willow trees grow, with low shrubbery, and which become islands in the high water of winter.

While most other historical accounts do describe the presence of some summer water in this reach, almost without exception they also mention the limited amount of water present (as opposed to the Santa Paula reach, where the river had abundant summer water). Just above Saticoy, near where Crespí described watering his mounts in the "very shallow" river in 1769, Freeman (1930) remarked that surface water "begins to disappear into the gravels beneath the Oxnard Plain," and an 1889 depiction of the river late in the dry season in the same area described it "loitering along its sandy bed as if it were loth to reach the sea" (Eames 1889). Also near Saticoy, General Land Office surveyor Henry Hancock reported in June 1853 a "current near 6 miles per hour and average depth 9 inches," indicating that by late summer flow would have been extremely shallow or nonexistent. Cooper's interpretation of the Saticoy-Montalvo area as summer dry is supported by USGS (1903a) historical mapping and Crespí's earlier observations that "no trees are to be seen nearby" in the area (Crespí and Brown 2001), indicating limited summer water availability.

Fig. 3.24. An early *diseño* (top) shows the Santa Clara River—which it calls the "Arroyo de la Soledad"—stopping abruptly before reaching Piru Creek (labeled on the *diseño* as "Q-R"). This corresponds to the well documented location of the loss of summer surface flow in this reach, near Camulos (which is labeled with a small hut and "O" on the *diseño*). A historical USGS quad (bottom) shows the loss of flow in the same location, around sixty years later. (Unknown ca. 1843, courtesy of John Johnson and Santa Clarita Valley History; USGS 1903b, courtesy of the CSU Northridge Map Library)

TRENDS IN SANTA CLARA RIVER HYDROLOGY

The Del Valle, Sespe, and Santa Paula reaches were consistently perennial across the historical record, with abundant summer water (as evidenced by the presence of other features as well, such as freshwater wetlands, ponds, and willow-cottonwood forest; see page 94). The Piru reach, on the other hand, was consistently drier. The upper Oxnard reach (around Saticoy) also appears to have had limited, if any, summer water. In semi-arid systems in the southwestern United States, this type of system—with alternating perennial and summer-dry reaches—is called an interrupted perennial river (Stromberg et al. 2005).

Many of the same physical factors that historically controlled summer surface flow are still relevant today, and as a result many of these hydrologic trends are reflected along the Santa Clara River today (UWCD and Castaic Lake Water Agency 1996). Valley narrowing and geologic constraints force groundwater to the surface at the transitions between groundwater basins in the Del Valle, Sespe, and Santa Paula reaches, while inputs from tributaries (in particular Sespe Creek, which is still unregulated) also help maintain surface flow. On the other hand, in the Piru reach and downstream of South Mountain surface water is quickly lost in the broad, unconfined alluvium. The reach of perennial flow at the river mouth coincides with extent of the former artesian zone (Lippincott ca. 1930), the lowest portion of which is currently affected by the City of Ventura's wastewater treatment plant.

However, the presence of surface water would have been readily impacted by surface diversions, groundwater extraction, and climatic variability. Thus while broad patterns in surface water availability have persisted to the present day, the factors listed above have impacted the extent and hydrology of perennial and intermittent reaches along the river. In particular, on the Oxnard Plain (where surface flow was already often shallow), summer water availability would have been very sensitive to changes in hydrology and water management. This would have been true in dry years (e.g., Cooper (1887) described summer-dry conditions around Saticoy in 1872-3, noting that the season had been "uncommonly dry"), as well as after impacts of flow diversions and groundwater extraction of the late 19th and early 20th century.

This sensitivity is reflected in changes in flow regimes in the river in the first part of the 20th century, most notably on the Oxnard Plain. By the beginning of the 20th century, portions of the river once considered perennial were described as seasonally dry: "For the greater part of the year both the Santa Clara and Ventura rivers are dry in their lower reaches" (Holmes and Mesmer 1901c). Cooper (1967) expanded this observation to the entire river, noting that both Ventura and Santa Clara river were "dry most of the time but carrying very heavy loads during occasional floods." Tait (1912) was even more explicit (and extreme) about the cause of this drying, stating that "all of the summer discharge of Santa Clara River is taken out for irrigation and about forty pumping plants take water from wells."

Engineer Vern Freeman, writing in 1930, provides more resolution to the mid-century state of summer flow on the river. Consistent with Crespí and other accounts, Freeman recorded that the Santa Clara River was perennial until a point about three miles east of Piru, and then again for extensive sections around Fillmore and Santa Paula. However, he does record a summer-dry reach not mentioned by Crespí or 19th century sources between Santa Paula and Sespe creeks, and does not mention any summer surface flow present on the Oxnard Plain (though Mann (1958) does note that "there is little further percolation" below the Highway 101 bridge, a formerly perennial reach). Contractions in the extent of summer water in the river by 1930 could be indications of the impacts of surface diversions and groundwater extraction.

Currently (2011), flow patterns on the river appear to broadly mirror historical trends. Of course, while physically-controlled rising groundwater patterns remain generally consistent, water impoundments, diversions, and releases continue to affect extent and location of summer water, in addition to the quantity of surface water in the perennial reaches and the relative dryness of the intermittent reaches.

Below the Montalvo (Highway 101) bridge and closer to the river mouth, early descriptions also indicate that while the river was likely perennial in most years, surface water was not as abundant as in perennial reaches upstream, and flowed shallowly over the Oxnard Plain. Surface water was perennially found where the zone of artesian water intersected the river in this lower reach (Lippincott ca. 1930). Johnson (1855a) recorded that in early October, the river was "an insignificant stream, with but an inch or so of water in its channel." This sentiment was echoed by numerous observers, who described minimal surface flow from Saticoy to the ocean: what Seward ([1883]1937) called "an emaciated stream." Davidson (1864) wrote that the river was "nearly dry during the summer, and terminates in lagoons and marshes," while a traveler crossing the river near its mouth (presumably the Montalvo crossing) in late August 1868 wrote that "There was some water flowing where we crossed it, and quite a large body a few miles above" (*Daily Alta California* 1868). Bowers (1879, in Benson 1997) called the river a "somewhat rapid stream" near the mouth in late October.

The water of the river at its low stages disappears in one stretch of the river to reappear in another.

—GRUNSKY 1925

Riparian Habitats and Ecology

Riparian vegetation along the Santa Clara River was historically heterogeneous and diverse. Habitat features commonly documented along the Santa Clara River include willow scrub, alluvial scrub, herbaceous cover, cottonwood-willow forest and woodland, freshwater marshes, and mature individual sycamores and oaks. Unlike the Ventura River, much of the Santa Clara River was characterized by the absence of mature stands of riparian woodland or forest, though there were a few notable exceptions along the river. While the historical data set generally lacks the resolution to map these riparian characteristics at a fine scale, emergent patterns are evident; these define the coarse-scale variation in riparian vegetation found along the river corridor. These broad associations between landform or topographic setting, river reach, and vegetation are discussed below.

Distinct vegetation patterns characterized the outer banks, bottomlands, and active channel of the Santa Clara River (for definition of terms see morphology section, page 61). Large live oaks and sycamores (documented between two to four feet diameter) were found along portions of the outer banks, removed from the regular overflow zone. Bottomland areas were primarily dominated by riverwash, herbaceous cover, and willow/riparian scrub, though in some perennial reaches densely vegetated, mature stands of willow-cottonwood forest and wetlands (which we term "persistent wetland riparian areas" or "willow-cottonwood forested wetlands"; see page 94) were prevalent. Within the active channel, scrub colonized bar and island surfaces slightly elevated above the mostly sandy (and sometimes gravelly) river bed. The river bed itself would have been often bare in the winter and early spring, and covered in herbaceous vegetation by summer. Sloughs and side channels supported in-channel valley freshwater and alkaline marshes (fig. 3.25). GLO notes confirm the position of riparian trees on distinct geomorphic surfaces: in the Santa Paula reach, one

Fig. 3.25. This image of the Santa Clara River west of Santa Paula was taken on March 17, 1928—only five days after the St. Francis Dam break swept through the Santa Clara River valley. The recent presence of high flows is evident in the low vegetation along the river, which is bent downstream in the direction of flow. Even after such a large event, riparian patterns are evident: live oaks are seen bordering the river, while the bottomland surfaces are dominated by low scrub. The active channel is largely unvegetated, having been recently scoured by the flood. (Isensee 1928b, courtesy of the Museum of Ventura County)

survey note describes a "large live oak on high bank of Santa Clara River" (Hoffman 1868b), while nearby a 16-inch diameter cottonwood was found at the "foot of [the] perpendicular bank" (Norway 1878b).

Riparian characteristics also varied broadly by reach, with well developed trees flanking some portions of the river, and little to no riparian cover in other reaches. This reach-level variability in vegetation was observed by early explorers, travelers, and surveyors. In the lower Oxnard, Santa Paula, and Sespe reaches, for example, the active channel was narrower, and substantial bottomlands—many supporting wetlands and dense riparian forests—developed along much of the river. In the wettest portions of these reaches, GLO surveyors recorded willows and a few alders and box elders on bottomland surfaces, along with live oaks and sycamores on the high banks (Norris 1853, Hoffman 1868b, Thompson 1869). In contrast, in the historically intermittent Piru reach bottomlands were narrow and sparsely vegetated, while sandy riverwash in the active channel spread almost bank to bank. This reach stands out for its lack of riparian trees recorded by GLO surveyors (only one sycamore 14 inches in diameter, and two "no timber" points).

As a result, riparian forest along the Santa Clara River did not create a continuous corridor (fig. 3.26, 3.27). In the perennial reaches, explorer Crespí's 1769 account describes the river with "a great many cottonwoods, a great deal of willows, and many live oaks" in addition to wild grapes (Del Valle reach), or with "vast numbers of lush plants (the grapevines still continue)" (Sespe reach), or with "trees on all the river bed…sycamores, live oaks, willows and white [Fremont] cottonwoods" (Santa Paula reach; Crespí and Brown 2001). Conversely, accounts of the river outside of these wetter reaches describe more dispersed trees. In the intermittent portion of the Oxnard reach near Saticoy, for example, Crespí notes that "no trees are to be seen nearby" (though he did see "a great deal of trees" near the shore; presumably West Grove in the perennial reach near the river mouth). One article describes the river with "no gigantic trees bordering its low banks, only a group of cottonwoods; and a clump of willows, here and there" (Clifford 1872), and another "small, isolated groves of cottonwoods and willows, with here and there an occasional sycamore" (Evermann 1886). One writer even called the Piru reach a "desert" (Eames 1889).

Beautiful, indeed, is the Valley of the Santa Clara. Graceful the limpid waters of the river, fringed with willow and cottonwood…

—*DAILY ALTA CALIFORNIA* 1865

These historical patterns—differences in riparian vegetation on different geomorphic surfaces, as well as longitudinal variations between reaches—are consistent with findings in other semi-arid streams and even with present-day patterns observed along the highly modified Santa Clara River. In general, water availability is considered to often be the strongest limiting factor in determining riparian vegetation composition and distribution in semi-arid streams (Hupp and Osterkamp 1996, Tabacchi et al. 1996, Lite et al. 2005, Sandercock et al. 2007, Stillwater Sciences 2007a, Osterkamp and Hupp 2010, Orr et al. 2011). Water availability varies laterally (depth to groundwater), as well as longitudinally based on geologic and topographic

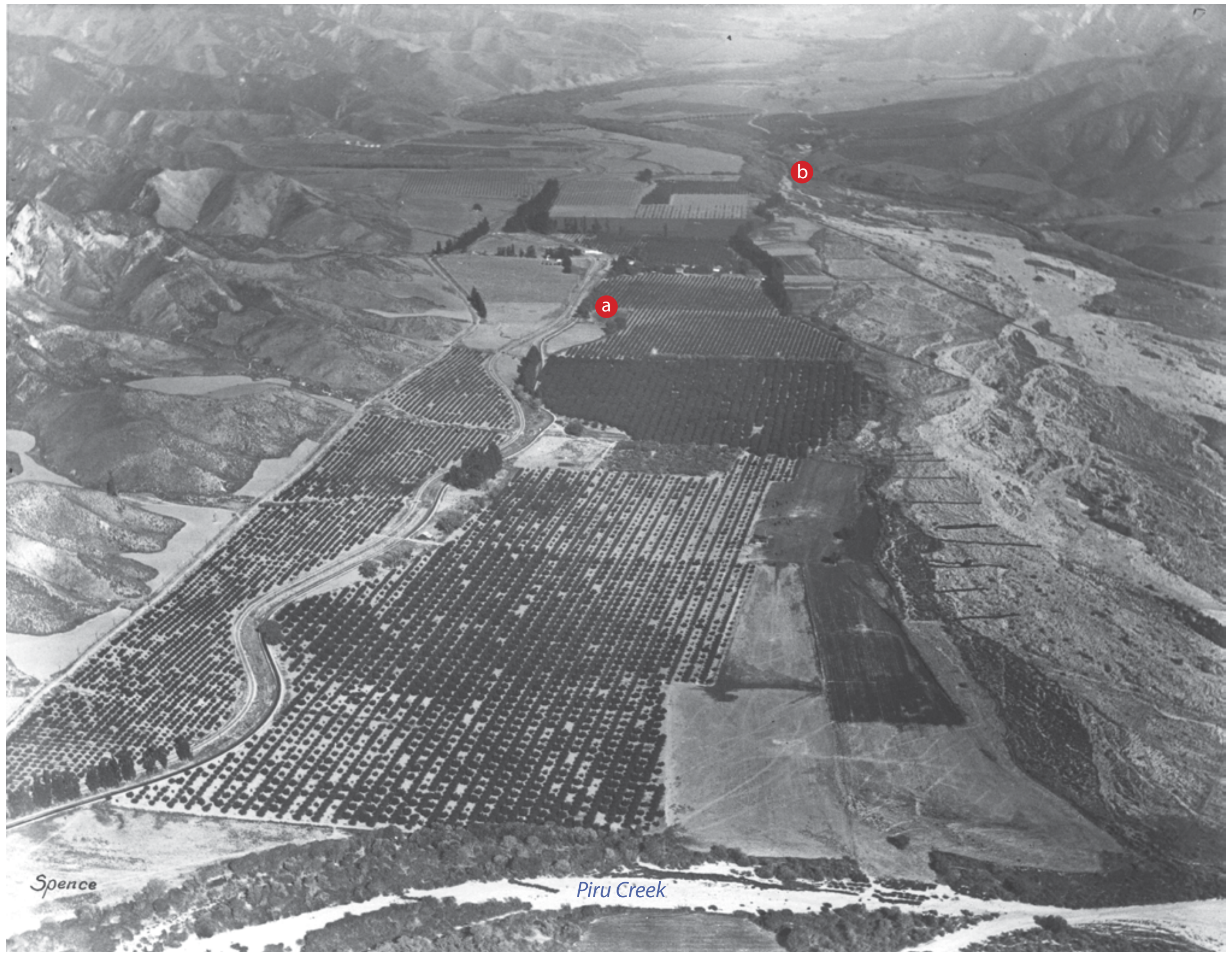


Fig. 3.26. Camulos Ranch in Piru, September 1924. Upstream of Camulos Ranch (marked a in the photograph), a continuous belt of riparian trees flanked the Santa Clara River. Downstream of the ranch, the river widened considerably; forest disappeared and was replaced by alluvial scrub and riverwash b. This ecological transition also marked a hydrologic one: the location of disappearance of summer surface water on the river. Piru Creek can be seen in the foreground. (Spence 1924, courtesy of Benjamin and Gladys Thomas Air Photo Archives, Spence and Fairchild Collections, UCLA, Department of Geography)

controls (e.g., depth to groundwater and to bedrock, depth of alluvium, and summer surface flow). As a result, variations in riparian characteristics across both gradients can be expected.

Longitudinally across different reaches of a semi-arid river, heterogeneous hydrology (in particular, presence of summer surface flow and depth to groundwater) can drive corresponding patterns of riparian vegetation (Tabacchi et al. 1996, Sandercock et al. 2007, Stillwater Sciences 2007a). This interaction between stream seasonality and vegetation can be clearly seen on the Santa Clara River, where the presence of mature willow-cottonwood riparian forest corresponds with perennial flow. This is what Sandercock et al. call "abrupt changes in patterns of riparian vegetation" along a longitudinal gradient. Similar patterns are still visible on the river today, though the extent of native riparian forest has been drastically reduced (Stillwater Sciences 2007a, Stillwater Sciences and URS Corporation 2007, Orr et al. 2011; see fig. 3.43).

Vegetation characteristics are also influenced by the lateral variations in hydrology and geomorphology across the river, though (as is the case for the Santa Clara River) patterns are often less distinct. Both groundwater availability and flood disturbance frequency, two of the primary driving

Fig. 3.27. This *diseño* captures a similar pattern of discontinuous riparian forest (shown here as closely spaced, small, circular trees) east of Piru Creek at a. Though the location of this transition is highly generalized, it is shown here east of Camulos and extending up what is likely Castaic Creek b in Los Angeles County. (U.S. District Court ca. 1840c, courtesy of The Bancroft Library, UC Berkeley)

factors in semi-arid systems, (Hupp and Osterkamp 1996, Lite et al. 2005, Stillwater Sciences 2007a), vary laterally across the river (increased depth to groundwater and decreased flood frequency with increasing distance and elevation from the active channel). As a result, the position of the bottomland surface plays a crucial role in determining the riparian vegetation able to colonize it (Bendix and Hupp 2000).

Unfortunately, however, the identification and characterization of fluvially-created bottomland surfaces in semi-arid systems can be challenging. High discharge, low recurrence floods contribute to the shape of the channel and riverine landforms. The morphology of these systems is complex and not easily characterized. Bottomland location and elevation can change quickly, and bottomland appearance may often resemble that of the active channel (Bendix and Hupp 2000, Sandercock et al. 2007). Osterkamp and Hupp (2010) refer to bottomlands as "shifting mosaics of landforms adjacent to stream channels." This morphologic complexity is matched by—and partially drives—spatially variable, heterogeneous patterns in riparian vegetation distribution seen in semi-arid streams. As a result, the interaction of vegetation with geomorphic processes in semi-arid systems is particularly complex and challenging to characterize.

The following sections describe more of the vegetation characteristics along the length of the Santa Clara River, as found in the active channel and bottomland surfaces. For the reasons detailed above, it is challenging—if not impossible—to provide much reach-level detail regarding the historical location of various in-channel habitat types. Instead, we provide broad characterizations of the suite of riparian habitats historically documented within the river corridor.

Bottomland and Active Channel Habitats

A variety of habitats were found within the active channel and bottomlands of the Santa Clara River, including willow scrub, alluvial scrub, herbaceous cover, freshwater wetlands, side channels, and sloughs (fig. 3.28). (Large persistent wetland riparian areas are discussed separately in the subsequent section; see page 94.) With the exception of the persistent wetland riparian

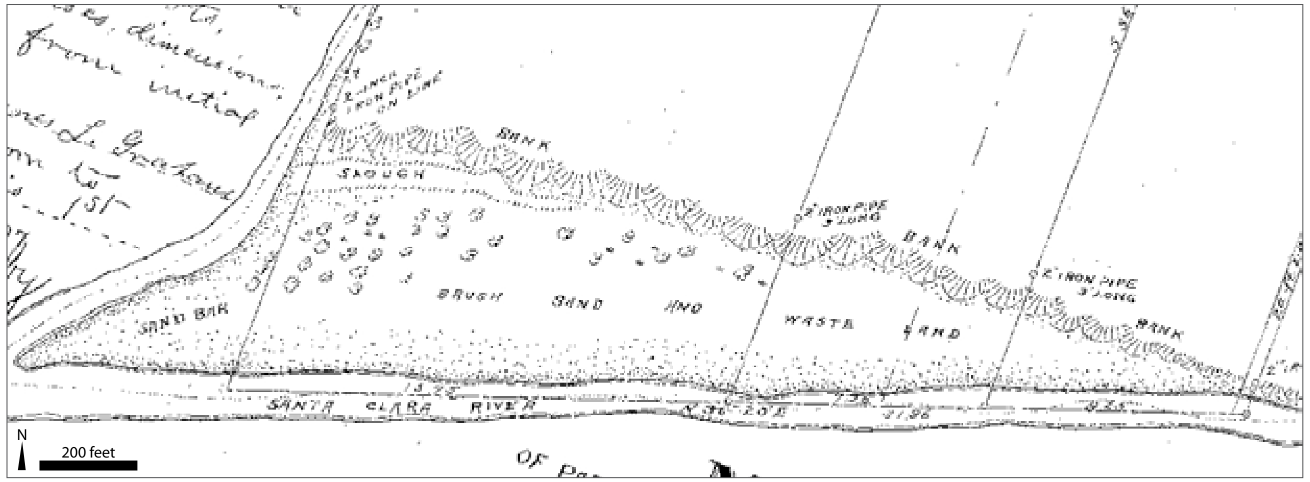


Figure 3.28. This 1897 map shows the variety of habitats found within the clearly delineated banks of the Santa Clara River, including a slough, "brush sand and waste land" with scattered willows, and a sand bar. Adams Barranca can be seen joining the river at left. (Orcutt 1897, courtesy of the Ventura County Surveyor's Office)

In this glad clime breathing is a refreshment, and the mere act of living a delight. The warm, healing winds, the glancing sunshine, the serpentine line of the river, stealing through its desert of sands…

—NINETTA EAMES, FALL 1889

areas, in-channel habitats are poorly documented in the historical record. Since the historical record rarely specifies whether a feature is in the active channel or on the bottomland (and given the challenges outlined above in characterizing bottomlands in semi-arid systems), the two are mostly undifferentiated, and we treat them together here.

Features in the active channel included the low-flow channel, as well as side channels and sloughs which carried water during floods. The channel itself is consistently described as being sandy riverwash, and almost completely unvegetated or covered in herbaceous vegetation, depending on the season (fig. 3.29). The 1917 soil survey describes the active channel of the river as composed of "sand and fine sand" (Nelson et al. 1920), and GLO quotes repeatedly characterize the river as "sandy bed" (e.g., Hoffman 1868b, Barry 1892a). One surveyor traveling through the Cienega area noted "leave swamp for sandy plain" as he entered the active channel, emphasizing the abrupt shift between moist bottomland and the active channel (Norris 1853). Near Camulos (upper Piru reach), explorer Crespí noted that the bed of the river has "piles of drift and large banks of sand" (though he also notes "large bottomlands of very good soil"; Crespí and Brown 2001). In some places, this riverwash occupied all or nearly all of the area between the outer banks, with no other recorded major habitats present in the active channel or on bottomland surfaces. Near Camulos, the soil survey shows nearly the entire width of the Santa Clara River dominated by riverwash, a swath about ½ mile wide which would likely have been treeless and vegetated with only herbaceous cover, with minimal or no bottomlands (fig. 3.30). The presence of extensive areas of riverwash and herbaceous cover clearly predates many human-induced disturbances to the river, including the St. Francis dam break.

Occupying a position in the river corridor above the active channel and thus less prone to overflow, bottomlands hosted a wide array of riparian habitats, from freshwater wetlands to alluvial scrub. Some bottomlands relatively high above the river in reaches with perennial flow supported mature cottonwood-willow forest (see page 94), while in other areas only sparse scrub would have been established.

Fig. 3.29. A view of the river corridor south of Santa Paula (top) looking south toward South Mountain, 1888. The sparsely vegetated active channel can be seen behind the town of Santa Paula, with strips of dense riparian vegetation on bottomlands along both sides of the river. (Unknown 1888; courtesy of the Santa Paula Historical Society)

Fig. 3.30. Santa Clara River east of Piru Creek, 1898 (bottom). This view of the Santa Clara River, captured during the State Mineralogist's 1898 field work, shows the broad expanses of sparsely vegetated riverwash characteristic of the Piru reach. The view is looking south east; Piru Creek can be seen coming into the Santa Clara River from the left. (Watts 1898, courtesy of the California State Archives)

In some areas, bottomlands may have closely resembled the active channel. The early soils report identifies a few slightly finer soils flanking the riverwash that correspond to bottomland habitats (e.g., Yolo sand and Yolo fine sand). Nelson notes that along the Santa Clara River, these soils "may resemble riverwash, from which they were separated, in many places, on the basis of slightly greater elevation and their growth of willow and vines," or that "in many places [Yolo fine sand] much resembles riverwash, except in its slightly higher position and its covering of brush and willow" (Nelson et al. 1920).

In other areas, the bottomland would have been clearly differentiated from the active channel, both by its position and its vegetation. While this was most evident in the persistent wetland riparian areas, bottomlands also supported an array of other habitats, including willow scrub, alluvial scrub, herbaceous cover, and wetlands and sloughs (fig. 3.31).

Willow trees and scrub were historically widespread along the Santa Clara River. Many maps show willows growing on what are apparently islands, side bars on the margin of the active channel, or higher benches within the banks of the river (e.g., Craven 1874h, Barry 1892b, Barry 1893, Stocker 1894, Barry 1898, Everett 1907, Unknown 1911). On these maps, willows are labeled as "heavy willow and cottonwood brush," "willow brush," "willow land," and simply as "willows" (Barry 1892b, Barry 1893, Stocker 1894, Waud ca. 1899, Waud 1916; fig. 3.32).

Narrative accounts also support the predominance of willow scrub (and the lack of established in-channel trees outside the wetland riparian areas) across most of the river. The historical soil survey describes riverwash in the active channel as "barren of vegetation except for small stands of sweet clover and willow over the least exposed parts" (Nelson et al. 1920). The Santa Clara River near Saticoy was described as "a wide, sandy and gravelly bed, destitute of vegetation except on a few higher patches where small poplar [black cottonwood] and willow trees grow, with low shrubbery, and which become islands in the high water of winter" (Cooper 1887). GLO survey notes record a "small patch of willow" downstream of Saticoy (Hancock 1854), and east of Santa Paula the channel "covered with willow brush" (Craven 1874e). The only GLO survey trees found within the bottomlands or active channel were within persistent wetland riparian areas or near the confluence of the Sespe and Santa Paula creeks with the Santa Clara River, areas with many established islands that would have protected these trees from floods. By contrast, many large, mature sycamores and live oaks grew along the outer bank of the Santa Clara River. (These habitats are not represented on the historical habitat map.)

These areas would have also supported an array of willow-scrub associated plants, including arroyo willow (*Salix lasiolepis*), narrowleaf or sandbar willow (*Salix exigua*), red willow (*Salix laevigata*), and mulefat (*Baccharis salicifolia*). These species composed the "low shrubbery" mentioned by Cooper (1887). Early court testimony describes the river near Sespe as covered with mulefat:

> As to the character of this river bed, I find that some portions of it are dry barren sand; on some portions, and perhaps the larger portion, there is a growth resembling the willow, called, as I understand by the Californians 'Guatamote,' [mulefat] generally but a few feet high. (Hopkins 1871)

In addition to willow scrub, several maps also show wetland features and sloughs in portions of perennial reaches outside of the persistent wetland riparian areas. Near the mouth of the Santa Clara River, on the north bank, maps show a marsh, sloughs, alkali land, and willows (Waud ca. 1899, San Miguel Company 1906, Nelson et al. 1917). Further upstream, a 1907 map shows a narrow strip of marsh along the Santa Clara River near Saticoy (Everett 1907), and just above the confluence of the Santa Clara River with Sespe an 1892 map shows sloughs and the low-flow channel flanked with "cienega [wetland] grass" (Barry 1892b; see also Barry and Isham 1894,

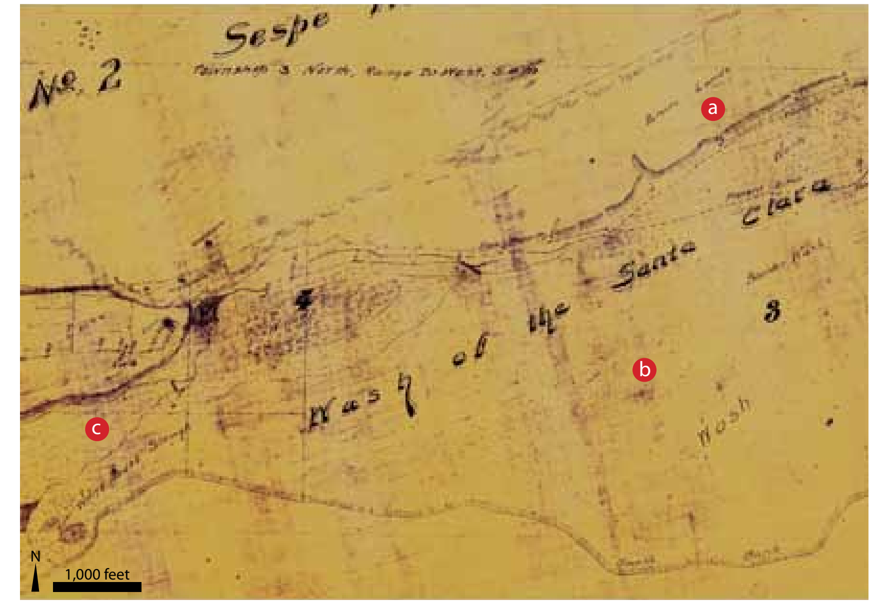


Fig. 3.31. This portion of a map showing the river immediately downstream of the confluence with the Sespe shows "Bottom Lands" (a) sitting above a break in slope, at a higher elevation than the "Wash" of the Santa Clara River (b). Ponds and a slough (the upstream end of East Grove, (c)) and willows are also noted. (Stocker 1894, courtesy of the Museum of Ventura County)

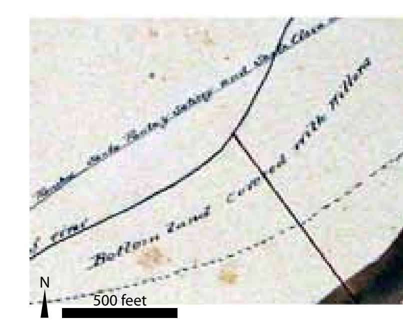


Fig. 3.32. Above the Highway 101 bridge, "bottom land covered with willows" was found on the protected bars at curves in the river. (Barry 1893, courtesy of the Ventura County Surveyor's Office)

QUICKSAND AND THE SANTA CLARA RIVER BED

Historical accounts consistently describe the bed of the Santa Clara River as sandy, with only scattered accounts referring to coarser substrate. In addition, a number of travelers mentioned the presence of quicksand in the active channel. Bowers (1879, in Benson 1997) described the river bed near the mouth in late October as "a mass of shifting quicksands"; more than 30 years later Chase (1913) was warned to not ford the river on the Oxnard Plain in late spring due to "possible trouble with quicksand." Sarah Eliot Blanchard, who grew up near Santa Paula in the late 19th century, recalled trouble with quicksand near Montalvo (Blanchard 1961), and Jarrett (1983) wrote that in the Bardsdale area residents layered bean straw in the active channel to preclude wagons fording the river from sinking in. Accounts like these provide insight into the nature of sediment transported by the river, as well as the availability of near-surface water on the river in these reaches during late spring to early fall.

Stocker 1894). East of Santa Paula near East Grove, two maps depict a lagoon beside a strip of either marsh or herbaceous cover (the symbol is unfortunately ambiguous in both maps; Unknown ca. 1890a, Power 1892). There were undoubtedly many more small wetlands within the banks of the Santa Clara River not documented by the historical record, for example in side channels and sloughs. These small, in-channel wetlands would have provided valuable habitat for a variety of aquatic and terrestrial wildlife species.

Alkali is present in large quantities in the lands bordering the coast and is also found in the low lands along the river.

—TAIT 1912

A likely exception to the ubiquity of willow scrub and mulefat across the Santa Clara River is the intermittent Piru reach. While few details have survived about the character of the scrub in this reach of the river, it is clear that the limited availability of summer water would have been the major factor shaping riparian characteristics in this area, and it is unlikely that the groundwater table was high enough for willow establishment or sustained growth. As a result, we hypothesize the presence of alluvial scrub in this reach. Alluvial scrub, found across Southern California systems, is typically characterized by scale broom (*Lepidospartum squamatum*), California buckwheat (*Eriogonum fasciculatum*), and mulefat (*Baccharis salicifolia*) (Hanes et al. 1989). This vegetation type is characterized on the San Gabriel River floodplain by Smith (1980) and as scalebroom scrub by Magney (1992), who notes that development of alluvial scrub in stream floodplains is encouraged by limited flooding frequency (only every 5-10 years). Analysis of vegetation patterns, flood dynamics, and other environmental factors along the Santa Clara River (Stillwater Sciences 2007a), the upper Santa Ana River (Burke et al. 2007), and various other Southern California rivers (Hanes et al. 1989) suggests there may be a general succession pattern with scale broom, California buckwheat, mulefat, and golden-aster (*Heterotheca* species) as indicators of early successional stages, and with species such as sagebrush (*Artemisia californica* or *A. tridentata*), black sage (*Salvia mellifera*), and cactus (*Opuntia* spp.) more characteristic of later successional stages.

This interpretation of historical presence of alluvial scrub is consistent with sagebrush and cactus recorded by GLO surveyors on the high bank of the river (Craven 1874f). It is also supported by modern vegetation classification and mapping (Stillwater Sciences 2007a, Stillwater Sciences and URS Corporation 2007, Orr et al. 2011), which records areas of scalebroom scrub and patches of other related vegetation types that are often considered to be components of Southern California alluvial scrub (e.g., *Artemisia tridentata*, *Atriplex lentiformis*, *Pluchea sericea*, *Salvia mellifera*, and *Yucca whipplei* vegetation alliances) in the Piru reach and along lower Sespe Creek near its confluence with the Santa Clara River. Smaller unmapped patches of sparse alluvial scrub dominated by sessileflower false goldenaster (*Heterotheca sessiliflora*) and scale broom (*Lepidospartum squamatum*) are also currently observed on bar features upstream of the Freeman Diversion Dam (Orr pers. comm.)

FISH SLOUGH

Along the Santa Clara River, the most heavily documented slough in the historical record is Fish Slough. Located in Sespe Creek at its confluence with the Santa Clara River, Fish Slough was the site of an in-channel wetland complex and (as per the name) fishing spot for steelhead trout in the early 20th century (Jarrett 1983; fig. 3.33). It was also the site of late 19th-century irrigation diversions (Crawford 1896). Large willows—up to 2 feet in diameter –grew in Fish Slough, as well as watercress (Jarrett 1983).

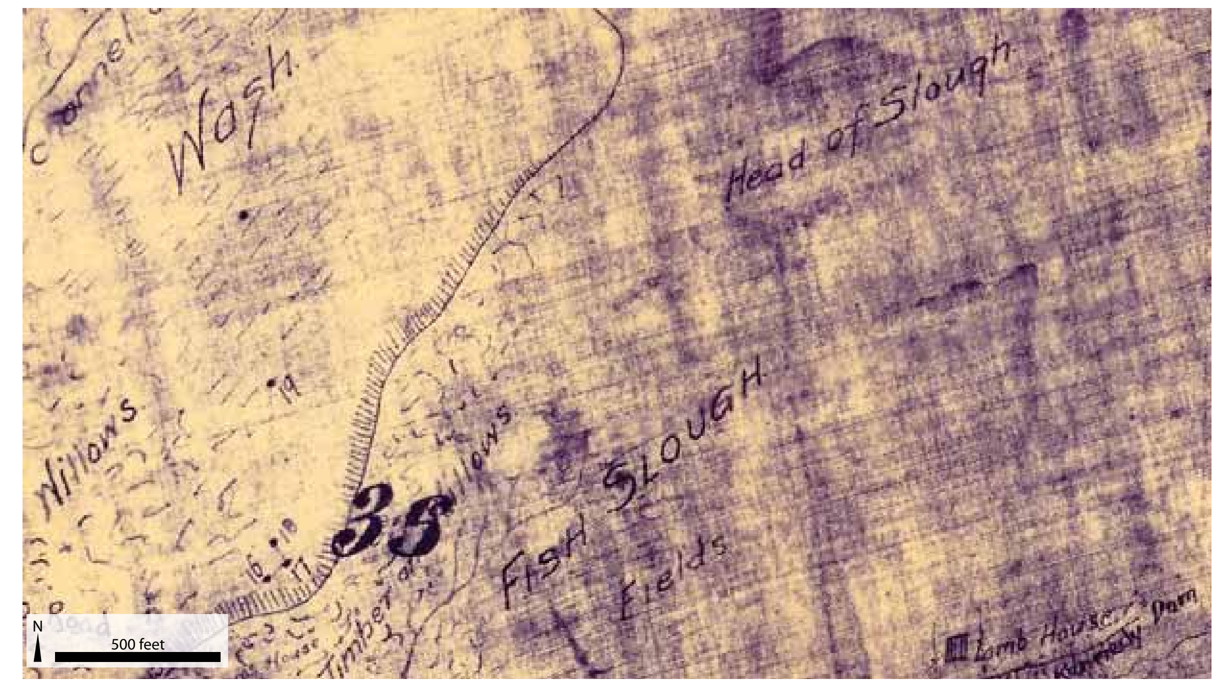


Fig. 3.33. Fish Slough complex, 1894. This map of the Santa Clara River-Sespe confluence shows the whole length of Fish Slough, extending about half a mile upstream on Sespe Creek. (Stocker 1894, courtesy of the Museum of Ventura County)

In addition, a number of quotes and maps also indicate the prevalence of herbaceous cover within the river corridor. In the *Overland Monthly,* Clifford (1872) described the Santa Clara River "gilding through its even, grassy fields," while another traveler wrote of "much fine meadow" along the river near the Los Angeles County line (Holton 1880). Near Camulos, an early account described "low, reed-grown banks" (Roberts 1886), while near Sespe, one observer reported that "…on the flats bordering the river we found a greensward, much of which was made up of sour grass, that a mule will eat rather than starve" (Rothrock 1876). Near Santa Paula, Crespí described the river "with a great deal of green flats along its bank" (Crespí and Brown 2001).

The river bank on each side is composed to a considerable extent of sandy plain or 'arenal'…arable and pasture land form on each side of the river a comparatively narrow strip…

—SMITH AND STUART 1871

This grass was also valuable as forage for livestock. The 1871 court case for Sespe Rancho hinged on whether the lands within the banks of the Santa Clara River were valuable, and repeated testimony described how settlers used these lands as pasture for their livestock, especially during dry periods when forage elsewhere was limited (see pages 96-97). Mission-era accounts also describe

Fig. 3.34. Detail of a "willow swamp" at the confluence of Santa Paula Creek and the Santa Clara River. Though the map is coarse, this appears to be an early representation of East Grove. The cartographer also drew a "swamp" on the Santa Clara River east of Sespe Creek (the Cienega, not shown here). (Unknown ca. 1860, courtesy of The Bancroft Library, UC Berkeley)

The river was whirling along to the sea through banks clad in long grass, wild-rose, and sweetbrier, with tangles of wild-grape overshadowed by willow, cottonwood, and sycamore, and its mica sands sparkling like flakes of gold as they rolled over in its swift waters.

—VAN DYKE 1890,
SPEAKING OF THE DEL VALLE REACH

the desirability of these lands for cattle, noting that when there was no more pasturage near the Mission and on the Oxnard Plain, cattle would "roam farther up to the meadows along the river" to graze (Senán 1804).

Persistent Wetland Riparian Areas

In addition to the array of bottomland habitats described above, large areas of freshwater wetland and willow-cottonwood riparian forest were also documented on bottomlands along the river. These habitats, which we call "persistent wetland riparian areas," were found in perennial reaches of the Santa Clara River and occupied bottomland surfaces that were less frequently disturbed by flooding than other in-channel habitats. Because of the abundance of water and timber, they were often significant cultural areas, and as a result are often well documented in the historical record (fig. 3.34).

"Persistent wetland riparian areas" were unusually large (aggregate size over 200 acres) areas of wetland riparian habitat whose presence transcended significant flood events of the late 19th and early 20th centuries. While other areas of riparian forest were present inside the river corridor, they were more variable, shifting in location and extent with major flood events.

The following section characterizes the four documented persistent wetland riparian areas historically found along the lower Santa Clara River. These areas include: south of the river from the Highway 101 crossing to the mouth, east of Santa Paula, east of Fillmore, and east of Camulos. While it is possible that additional large wetland riparian features persisted elsewhere, insufficient documentation exists to confirm their presence.

WEST GROVE (SANTA CLARA RIVER MOUTH RIPARIAN FOREST) Along the south side of the Santa Clara River, a substantial, continuous strip of riparian vegetation extended from the river mouth to around the Highway 101 bridge about three miles upstream. This section of riparian forest covered about 1,200 acres. It was particularly notable to early travelers and settlers given the lack of other timber on the Oxnard Plain, and is included in many early maps of area as a prominent feature of the plain.

In 1769, Crespí noticed this grove from afar as his expedition traveled along the Santa Clara River near Saticoy: "Though no trees are to be seen nearby, a great deal of trees was visible afar off where we thought the shore must be close by" (Crespí and Brown 2001). The earliest map found that depicts the grove, drawn in the 1840s, shows a continuous willow grove (*sausal*) extending from the river mouth beyond the current location of the Highway 101 bridge (already labeled *camino,* or road, on the map) at a more or less continuous width (fig. 3.35). The map also shows willows extending along the south side of the road. While this map is clearly only a rough sketch of features on the Oxnard Plain, it does include the *sausal* as one of the key landmarks of the plain.

While they do not accurately depict the extent of the grove, other early maps confirm its presence south of the river, indicating its prominence

Fig. 3.35. Riparian forest (West Grove) on the lower Santa Clara River, 1840-1852. An early map (top, 1840s) shows extensive riparian willows (labeled *sausal*) along the south side of the river, extending beyond and along the camino (now Highway 101). About a decade later (1852), the grove is still a major landmark on the south side of the river (bottom). (U.S. District Court ca. 1840e, Ardisson 1852; courtesy of The Bancroft Library, UC Berkeley)

as a landmark on the Oxnard Plain (e.g., Reed ca. 1871). Another early map (Ardisson 1852) shows a continuous strip of trees of consistent width along the river (see fig. 3.35). While this map does not show the road crossing, the scale indicates that the trees are present along the river for about three miles, roughly the distance from the river mouth to about a mile downstream of the Highway 101 bridge. This estimation of the grove's extent is corroborated by Cooper (1887), who described a grove in 1872-73 beginning three to four miles west of Saticoy (either just above or just below the bridge) and extending "along the south bank of the river for three miles." Cooper called this grove West Grove (as opposed to the East Grove near Santa Paula), a name we have adopted here. The name also affirms the discontinuity of riparian forest along the river.

Later observers also made note of this riparian forest, providing more detail on species composition: a mix of willows, cottonwoods, sycamores, and live oaks. While the *diseño* labeled the grove a *sausal* (willow grove), Brewer ([1930]1974) noted "a grove of cottonwoods which came nearer to a forest than anything I have yet seen here" in March 1861. Another traveler described "a considerable body of willow, cotton-wood and some sycamore" (*Daily Alta California* 1868). Cooper (1887), describing the grove in 1872-73, noted "poplars, willows, and stunted live-oaks" (Cooper's poplars were likely black cottonwood (*Populus balsamifera ssp.*

TRANSFORMATION OF THE BOTTOMLAND

…the bed of the Santa Clara River is not entirely waste land…a large portion of said river bed affords fine pasture land, and a considerable portion has been cultivated and farmed successfully during the last season in corn and other crops…

—RANDOLPH ET AL. 1870

Differences in native vegetation and disturbance regimes along Santa Clara River bottomlands were reflected in variations in the agricultural value of the bottomlands. Persistent wetland riparian areas boasted dense vegetation, a relatively low depth to groundwater, and fertile sediments deposited during occasional flooding. In contrast, bottomlands along other parts of the river were often sandy and used primarily for grazing or hardy annual crops. Even in these less fertile regions of the river, access to water for irrigation made bottomlands attractive places to farm and pasture livestock in an otherwise largely arid valley:

> …were it not for the pasture which said river bed has afforded Mr. Moore could not have well kept his sheep alive on said Ranch the present season. I have known crops of corn and vegetables raised in said river bed this season… (Qualls 1871)

Fertile pockets of bottomland were widely recognized by early settlers, many of whom took advantage of what the river's bottomlands had to offer. South of the Santa Clara River mouth in West Grove, landholders cleared portions of the bottomlands for cultivation:

> …about 40 acres of the rich bottom is now being cleared off and will be farmed this coming season…the Santa Clara river with its fine timber and rich bottom lands form the northern boundary; in this timber wild blackberries are found in great profusion and of good quality… (*Ventura Signal* 1879, in Hampton 2002)

On the south side of the river above Highway 101 near West Grove, a newspaper columnist described a "low bottom to the left moist and good for crops of various kinds," in contrast to the scrubby, drier land on the valley floor (*Daily Alta California* 1868). Around Piru, explorer Crespí noted "large bottomlands of very good soil that could be cultivated by irrigation" (Crespí and Brown 2001). General Land Office surveyor Craven (1874f) described their value for raising corn and barley along the river between Fillmore and Piru, noting that "during the winter seasons the freshets cause the Santa Clara river to rise and overflow the old river bed and it has the effect of improving the land making it easier to cultivate and more productive."

In less fertile regions, or regions that were more regularly flooded, it appears that most agriculture took place outside of our mapped outer banks, in areas that could still benefit from the irrigation water provided by the river but were better protected from floods (Petit 1925). Within the outer banks, farming could only be practiced for portions of the year:

> In the rainy season the bed of the river is overflowed with water, consequently no one could settle on or live on the land in the river bed during the rainy season…in the summer season they can raise their crops on the lands in the bed of the Santa Clara River. (Stuart 1871)

Bottomland farms date at least to the middle of the 19th century. An early map from the 1840s shows an irrigated field on bottomland just east of Timber Canyon, on the north side of the river between Santa Paula and Sespe creeks (U.S. District Court ca. 1840d; see fig. 3.39). Early farmers planted seasonal crops, such as beans, sugar beets, alfalfa, and potatoes, which allowed them to retreat during the wet season, with orchards planted only on "better drained areas" (Nelson et al. 1920).

By the 1870s, large portions of forested bottomland were in the process of being cleared and planted to these crops (and later, even orchards in some places). One writer described "fields of deep alfalfa along the river bottom" in upper Ventura County (Van Dyke 1890), and another noted that "the orchards crowd down to the very bed of the river" (Eames 1889) in the Camulos region. These lands were often irrigated. However, even these seasonal crops were sometimes destroyed by flooding; during the 1884 flood, one resident recalled "many small alfalfa fields and garden patches on the river bottom that could be irrigated from the river that were entirely wiped out" (Hardison, in Freeman 1968). As farmers began to establish more permanent cultivation, bottomland development remained vulnerable to these events: "The high water of two weeks ago did a good deal of damage in the river bottom, washing away fences etc." (*Ventura Free Press* 1876).

The value of these lands was at the heart of one of the most infamous land squabbles in Ventura County history, between Thomas More and other settlers in the Sespe area. In claiming the two leagues of land allocated to him by the court, More wanted to claim land on either side of the Santa Clara River while excluding the river bed itself, in order to maximize land holdings outside the river while still retaining control of the river's water and bottomlands. To justify doing so, More argued (as did Carrillo, the grant's previous owner) that the river bottom lands were worthless since they were sandy and frequently flooded and scoured by the river, and therefore should not be included in the grant (Carrillo 1829, in Outland 1991). The settlers, however, argued that these lands were extremely valuable as grazing and agricultural land, testifying that they were "fine pasture land" (Randolph et al. 1870), "equally valuable to any lands upon said Ranch of Sespe" (Herrett 1871) and were used in the dry season for cultivation (Stuart 1871). Ultimately, More's claim to the river bed was denied by the U.S. Supreme Court, and the land was opened to settlers against More's wishes. The conflict culminated in More's murder in 1877.

Through the 20th century, levees constructed along the lower Santa Clara River enhanced farmers' ability to cultivate in these areas (fig. 3.36). At the mouth of the Santa Clara River, levees bordering the active channel of the river have contributed to the elimination of West Grove, allowing cultivation to cover this fertile land.

During the winter seasons the freshets cause the Santa Clara river to rise and overflow the old river bed and it has the effect of improving the land making it easier to cultivate and more productive.

—CRAVEN 1874F

Fig. 3.36. This bottomland surface west of the Sespe Creek confluence remained uncultivated in the late 19th century, as shown here in this 1894 map (left). By 1938, the surface had been converted to mostly walnut, orange, and lemon orchards. The area is still farmed today (right). (Stocker 1894, courtesy of the Museum of Ventura County; USDA 2009)

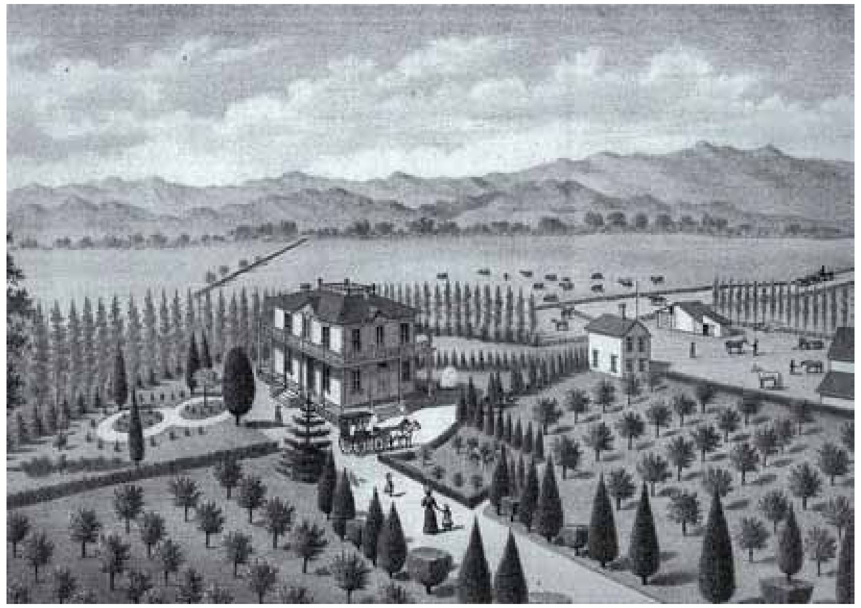


Fig. 3.37. John Scarlett's ranch abutted the south bank of the Santa Clara River, just east of McGrath's oceanfront property. Scarlett's ranch included a large portion of the forested bottomland (West Grove) along the river, as can be seen in the background in this image. The *Ventura Signal* (1879, in Hampton 2002) printed that "the Santa Clara river with its fine timber and rich bottom lands form the northern boundary; in this timber wild blackberries are found in great profusion." (Thompson and West [1883]1961)

Mr. Adolf Camarillo says that the lowlands south of Ventura used to contain many sycamores. The whole country there (the lowlands south of Ventura) used to be called in Sp[anish] Monte de San Pedro. It has since that time been grubbed out. There used to be tule sloughs and willowy places.

—Adolfo Camarillo, interviewed by John F. Harrington ca. 1913 (Harrington 1986b)

trichocarpa; Stillwater Sciences 2007a, Orr et al. 2011). Henry Hancock (1854), surveying a GLO transect across the river and through the grove in 1854, noted discrete cottonwood groves and willow groves within the larger riparian zone (fig. 3.37).

In addition to riparian forest, West Grove contained a matrix of open areas, dense underbrush, and low ponds and sloughs. Cooper (1887) described the grove as "partly open and partly crowded with dense shrubbery." The early U.S. Coast Survey T-sheet captures this characteristic in the westernmost part of the grove, showing open, grassy areas between denser thickets (Johnson 1855b, c). Another source describes the presence of dense undergrowth in the grove:

> …the Santa Clara river with its fine timber and rich bottom lands form the northern boundary [of the property]; in this timber wild blackberries are found in great profusion and of good quality… (Ventura Signal 1879, in Hampton 2002)

This diverse, heterogeneous riparian area would have provided habitat for a number of wildlife species (RHJV 2004, Stillwater Sciences 2007c). Cooper (1887) called West Grove "the most productive bird-hunting locality I found in the valley," and Evermann (1886) described numerous birds found in the willow and cottonwood thickets at the mouth of the river, including Rufous hummingbird (*Selasphorus rufus*) and Wilson's warbler (*Wilsonia pusilla*). Wilson's warbler, which Evermann describes as "abundant in the willows near the mouths of the Santa Clara and San Buenaventura Rivers," is also a common species found in many western willow thickets today (Otahal 1998, Cornell Lab of Ornithology 2009).

Mapping of West Grove (see page 48) was based on a few detailed sources which depicted the location and width of parts of the grove with spatial accuracy. A USCS T-sheet (Johnson 1855c; fig. 3.38) shows dense thickets approximately 3,700 feet wide at the mouth of the river, and GLO surveyors

ARUNDO ON THE SANTA CLARA RIVER

Today, the non-native giant reed (*Arundo donax*, commonly referred to as Arundo) has colonized large portions of the Santa Clara River and Ventura River floodplains and Calleguas Creek. Arundo often forms dense, massive stands along the river, displacing native riparian vegetation and limiting bird species and other wildlife abundance in invaded areas (Stillwater Sciences 2007c).

In addition to direct habitat displacement, Arundo negatively impacts streams in a number of ways. It has the potential to cause large-scale changes in stream morphology and hydrology by lowering groundwater levels, slowing the downstream transfer of sediment, and impeding flows (Dudley 2000, Coffman et al. 2004, Coffman 2007). In addition, it has increased the susceptibility of riparian corridors to wildfires, potentially creating a positive feedback cycle wherein more frequent fires promote more intensive Arundo growth (Coffman et al. 2010).

The timing of Arundo's arrival to Ventura County is unknown. It was described as "plentiful" along the Los Angeles River by 1820, where it was used to roof houses (Robbins et al. 1951). Given its proximity to and early use by the San Buenaventura Mission, a similar introduction history is possible along the Santa Clara River. This is potentially supported by Chumash ethnographic records, which describe Arundo as "Carrizo de Castilla" (that is, large grass from the Spaniards) or "European bamboo" (Timbrook 2007; Timbrook also provides an excellent treatment of the Chumash and Spanish uses for Arundo).

However, though it is possible that Arundo was present very early in both the Ventura and Santa Clara river watersheds, no definitive evidence was found confirming its presence or absence in the 18th and 19th centuries. Although Arundo may have been present along the Santa Clara River or Ventura River by the early 1800s (if not before), its widespread expansion in riparian ecosystems appears to be relatively recent, corresponding to widespread colonization following the floods of 1969 (Bell 1997, Coffman 2007). This is consistent with the absence of Arundo in historical descriptions of riparian character, which implies either the absence or limited distribution of Arundo along the river.

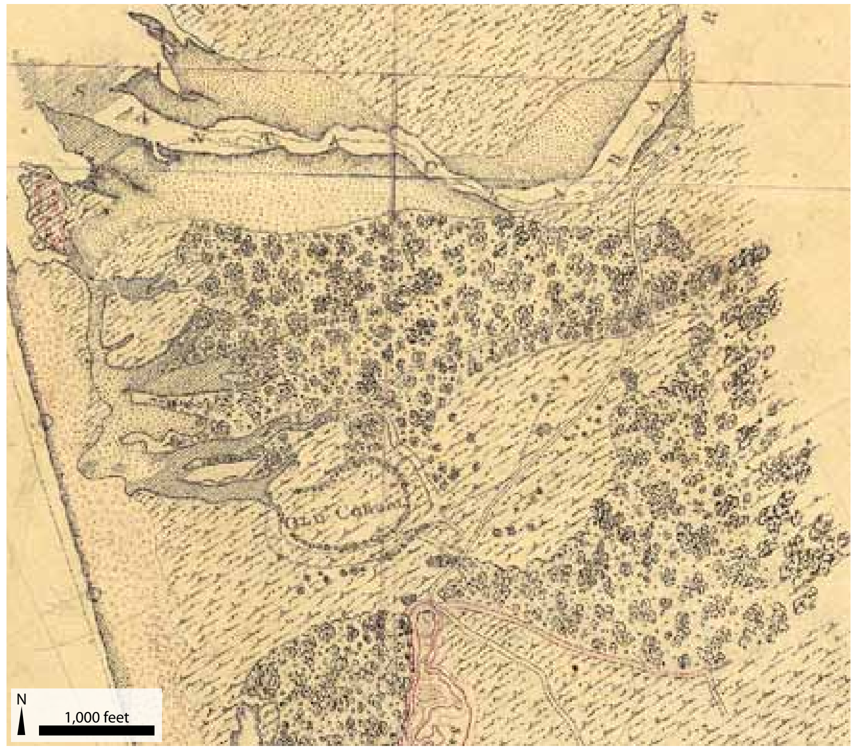
(Terrell 1861b, Thompson 1867) crossed 2,600 feet of "thick timber" at the highway bridge. These two sources provide riparian zone width on either side of the forest. County survey maps (e.g., Barry 1893) and the historical aerial mosaic were used to complete the mapping process. There is some indication that the upstream portion of the forest was wider than mapped; an earlier GLO survey (Hancock 1854) took a bearing on a tree on the "north end of the timber of Rio Santa Clara" that implies that the timber was much wider than we have mapped. Since he gives no precise location, we have not mapped this wider zone at the top of the forested area. However, this would seem to be supported by the early *diseño* which also shows vegetation extending east along the road (see fig. 3.35a).

…the first [left] bank…yet presents the original forest of willow and other trees as shown upon the diseño… -

—Reed 1871

As the above evidence shows, West Grove persisted in extent and location through the major flood events of the second half of the 19th century (e.g., 1861-62, 1867-68, and 1874-75). However, the forest is mostly absent in 20th century images of the lower river due to agricultural reclamation. The 1927 aerial imagery shows a dense (albeit narrower than in the GLO survey) stand of trees north of the Highway 101 bridge, but only scattered

Fig. 3.38. Santa Clara River mouth, 1855. This early USCS survey shows the westernmost end of West Grove as it stood in 1855. Dense stands of trees surround an open area (including an "old corral"). Auxiliary sources describe the grove as a mix of willows, cottonwoods, and sycamores. (Johnson 1855c, courtesy of the National Oceanographic and Atmospheric Administration)



patches of forest remain downstream, and the area appears to have been heavily reworked. Oblique photographs from the 1930s through 1950s show similar patterns: patches of vegetation are narrower, more scattered along the south side of the river, or are completely absent (Fairchild Aerial Surveys 1934, Spence Air Photos 1952). Interestingly, in some of these later photographs riparian trees appear to have colonized the northern side of the river (e.g., Fairchild Aerial Surveys 1934; see fig. 3.1). This shift may have been in response to infrastructure development which redirected flows southward, creating a more protected surface on the north side of the river.

While the forest had mostly disappeared by 1927, the outline of the low-disturbance bottomland is still visible on an aerial image. By 2005, nearly all traces of the forested area had disappeared into farmland, housing, a landfill, and golf course, and the area had been largely cut off from the river by a levee built by the Army Corps of Engineers in 1961 (Stillwater Sciences 2007b; see fig. 3.41).

EAST GROVE (SANTA PAULA WETLANDS) Another prominent area of mixed riparian willow-cottonwood forest occurred just east of the Santa Clara River's confluence with Santa Paula Creek. At least two large sections of forest were present, one on each side of the river, with a probable extent of 620 acres. These forests included willow and cottonwood stands and freshwater marshes within the outer banks of the river.

These forests appear to be among the most substantial and persistent sections of riparian forest/wetland along the lower river. They are depicted by a number of early cartographers as a large area with both dense trees and surface water; one map (Unknown ca. 1860) labels the area "willow swamp,"

WILDLIFE IN THE HISTORICAL LANDSCAPE

This report focuses on establishing the ecological and hydrological characteristics of the historical landscape. Interpreting this environmental setting with respect to the needs of native species of concern and other wildlife is an intensive, challenging process, and is not addressed here. A key next step is to work with experts to translate relevant findings into ecological functions and wildlife presence probabilities (e.g., Goals Project 1999, Sanderson 2009). This task involves both detailed interpretation of historical faunal records and interpretation of historical habitats and hydrology to project the probable former wildlife species support functions of the region.

It is clear that the Santa Clara River habitat mosaic supported a rich faunal community of native fish and wildlife species, which have been appreciated—and often exploited—by many generations of residents and visitors. While not covered here, based on our historical reconstruction we can speculate about the kinds of species support functions provided by the matrix of riverine habitats. For example, birds such as endangered least Bell's vireo (*Vireo bellii pusillus*), yellow-billed cuckoo (*Coccyzus americanus*), and southwestern willow flycatcher (*Empidonax traillii extimus*) would have likely utilized areas such as West Grove (river mouth) and East Grove (Santa Paula) as breeding habitat; some of these species are still supported on the river today (Stillwater Sciences 2007c, 2008). The presence of perennial ponds and sloughs in areas of rising groundwater suggests these reaches may have supported California red-legged frog (*Rana draytonii*) and western pond turtle (*Clemys marmorata*). Tidewater goby (*Ecuyclogobius newberryi*), a brackish water species indigenous to California estuaries, would have utilized the lagoon at the Santa Clara River estuary (USFWS 2005).

In addition, the Santa Clara River basin has been cited as one of the most important potential areas for southern steelhead habitat restoration today (Boughton et al. 2006). Recent research (e.g., Stoecker and Kelley 2005, Boughton et al. 2006, Pearse and Garza 2008, NOAA/NMFS 2009) supports the conclusion that the river was a historically important corridor for the federally endangered Southern California steelhead (*Oncorhynchus mykiss*). The floodplain and wetland habitats along the river and estuary would have likely been important rearing habitats for outmigrant juveniles, as has been documented on other systems (e.g., Sommer et al. 2001, Henning et al. 2006). For example, one early description stated that a type of trout, presumably adult steelhead, was found "in the scienegas [sic] and along the Santa Clara River where the watercress abounds" (Ventura Free Press 1878d), referring to the rising groundwater reaches. The use of refugia in perennial reaches, even on streams with significant summer-dry portions, is consistent with studies of intermittent stream use by anadromous steelhead for spawning and rearing (Ventura County Fish and Game Commission 1973, McEwan 2001, Boughton and Garza 2008; see also Ebersole et al. 2006, Wigington et al. 2006 for Coho salmon use of intermittent streams).

The habitat complexes associated with the seasonally closed river mouth would have provided important rearing habitat for salmonids and other fishes, as has been shown for other California estuaries (Bond 2006, Hayes et al. 2008). Though the use of river mouth estuaries by Southern California steelhead is poorly understood, even today the Santa Clara River estuary has been found to support rearing steelhead (Kelley 2008).

An understanding of the historical support functions provided by the river and its tributaries is a key component of effective restoration. There is a need for a richer and scientifically-based evaluation of former habitat support functions, and current potential for rare/listed wildlife species. Further research, along with additional interpretation of the findings presented here in the context of contemporary ecological research, may more thoroughly explore the ecological functions of these former landscape features.

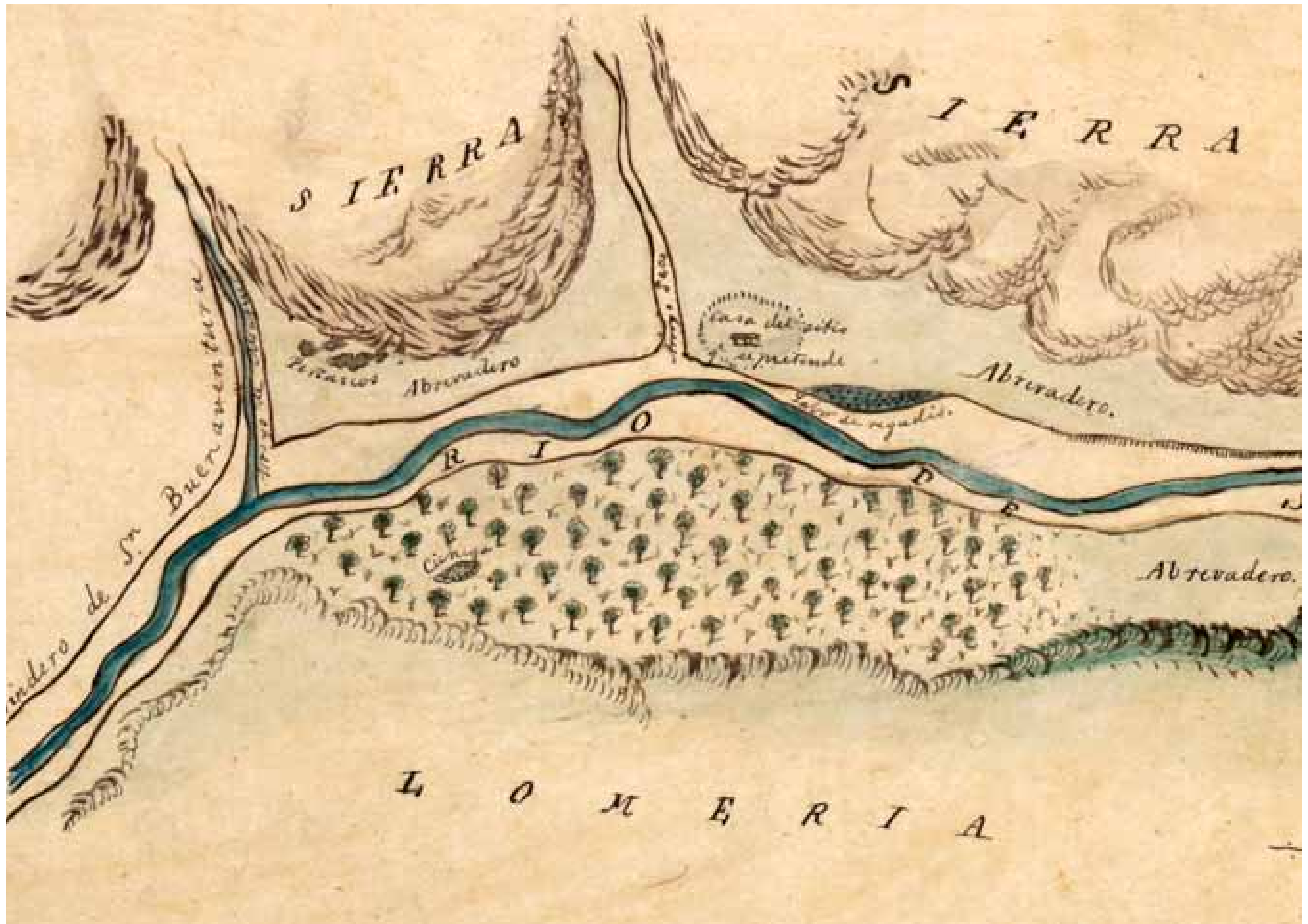


Fig. 3.39. This early map shows a number of in-channel features along the Santa Clara River, including an extensive forest south of the channel with a smaller *ciénega* (marsh) amongst the trees (East Grove, east of Santa Paula Creek/Arroyo de Mupu), and another eponymous *ciénega* (the Cienega) east of Sespe Creek/Río de Sespe. A bottomland field is shown as *labor de regadío* (irrigated field). (U.S. District Court ca. 1840d, courtesy of The Bancroft Library, UC Berkeley)

and a *diseño* (U.S. District Court ca. 1840d) shows a smaller *ciénega* within an extensive forested area south of the river (fig. 3.39). However, neither map gives detailed information on the extent or specific location of the forest-wetland complex.

Fortunately, a number of GLO survey lines also cross this area, and these surveys both support the existence of these large forest complexes and help define their historical extent. Five surveyors crossed this area when conducting surveys in 1853, 1868, 1869, 1874, and 1892. The terms they use to describe the riparian community depict a dense forest with often saturated soils and wetlands: "cottonwood and willow swamp" (Norris 1853), "willow brush" (Hoffman 1868c, Craven 1874e), "bottom land covered with willows" (Craven 1874e), or simply "swamp" (Norris 1853, Craven 1874e). Hoffman (1868a) notes "sandy and muddy" areas in the riparian area, and at one point is "in deep mud."

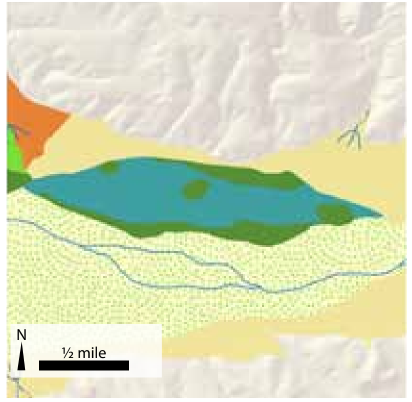
While the size and extent has shifted over time, riparian forest has been consistently present in this area. A surveyor in the late 1870s mapped a "dense growth of young willows" (Norway 1878c), and one survey map from the 1890s shows patches of willows between the sandy wash of the river and the cultivated bottomlands above (Stocker 1894). Other maps from this era depict wetland areas and small ponds in the river bed (Unknown ca. 1890a, Power 1892, Stocker 1894). A few ornithological

records from near Santa Paula also support the presence of willows and marsh: a Traill's flycatcher (*Empidonax traillii*) was found in a "nest situated in a willow tree among the willows bordering the Santa Clara river" (Burt 1904), and a common yellowthroat (*Geothlypis trichas*) was found with a "nest of marsh grass, leaves and straws" (Badger 1919). (The recorded Traill's flycatcher was most likely a Southwestern willow flycatcher, currently a federally endangered subspecies.)

The 1938 aerial imagery shows large sections of forest, and a 1948 ornithology journal noted "a large grove of mixed willow and cottonwood trees" about three miles east of Santa Paula (Peyton 1948). Extensive riparian forest was still present in the vicinity in 2005, though the boundaries had shifted (see page 105).

FILLMORE CIENEGA An extensive freshwater wetland complex was located southeast of Fillmore, south of Highway 126 and north of the Santa Clara River and at the present site of the Fillmore Fish Hatchery. This wetland complex, known locally as the "Cienega" (Spanish for marsh), included approximately 340 acres of freshwater marsh, tules, and willow groves.

Maps and narrative accounts of the Cienega area describe a variety of habitats within the wetland complex, including mixed groves of willows,



Palustrine and Terrestrial Habitat

Valley Freshwater Marsh

Oaks and Sycamores

Grassland/Coastal Sage Scrub

Characteristic Riparian Habitat

Willow-Cottonwood Forested Wetland

Other In-Channel Riparian

Hydrology

Intermittent or Ephemeral

Perennial

Distributary

Outer River Bank

Fig. 3.40. Detail of Cienega, early 1800s. This in-channel wetland complex, located just east of the town of Fillmore, was a matrix of freshwater wetland and riparian forest.

alders, and cottonwoods (fig. 3.40). "Willow timber" was observed along the northern bank of the Santa Clara River, and "cienega and tules" further toward the middle of the marsh (Barry 1898). Jarrett (1983) recalls "2 feet in diameter" willows at Cienega. Hoffman (1868d) noted a series of box elders (*Acer negundo var. californicum*) on the slightly higher northern and western boundary of the marsh, and describes the Cienega as a "cienega and cottonwood grove" (Hoffman 1868d). The willow groves of the Cienega area likely extended west of the Cienega itself into "willow brush" between the Pole Creek fan and the Cienega (Craven 1874f,h).

Like Saticoy Springs and the Santa Paula marshes, the Cienega was a major landmark and water supply source in the otherwise relatively dry Santa Clara River Valley. A settlement at the Cienega (including post office and school, both established in the mid-1870s) predates the town of Fillmore, which was established in 1887 when the railroad was built through the area (Fillmore Historical Society 1989, Durham 2001). The Cienega corresponded with an area of rising water and perennial flow in the Santa Clara River, and was the site of a number of surface water diversions for agricultural irrigation. The South Side Improvement Company, organized in 1887, and the Cienega Water Company, established in 1910, both diverted surface water from the Santa Clara River at the Cienega and provided water to the Bardsdale and Fillmore areas on both sides of the river (Freeman 1968).

The Cienega and willow groves around Fillmore were disappearing as early as the 1880s. The *Ventura Free Press* attributed the drying of the Cienega to artesian development on Oxnard Plain: "the Sciênega [sic], which was formerly a marsh, that would shake a rod from a man walking over it, is now dry enough to plow" (*Ventura Free Press* 1883b). An 1887 *Free Press* article called for protests regarding the cutting of trees in Sespe Grove (*Ventura Free Press* 1887a). By 1925, parts of the former Cienega were planted to alfalfa, a relative rarity by that time in a region dominated by oranges and lemons (Petit 1925); the 1938 aerial imagery shows the area partially planted to orchards, while a portion of the area is still densely covered with vegetation (USDA 1938). The Fillmore Fish Hatchery was established in 1940 within the original boundaries of the Cienega, an area then recognized as having high groundwater and surface flow in the Santa Clara River (Leitritz 1970). By 2005, the majority of the area was farmed, though a few patches of cottonwood-willow forest remain adjacent to the riverbed within the boundaries of the historical Cienega (Stillwater Sciences and URS Corporation 2007).

DEL VALLE RIPARIAN FOREST Above Camulos, a fourth willow-cottonwood forest flanked the Santa Clara River. Though this was a less populated area, and thus is less well documented in the historical record, it is clear that substantial riparian forest was found on this area's bottomlands. The Del Valle forest marked a reach of perennial flow in a very narrow portion of the valley.

Early travelers in the area noted lush, dense vegetation along the river. Crespí, traveling in 1769, described the bottomlands as "a good extent of soil alongside the stream; with a great many cottonwoods, a great deal of willows, and many live oaks still continuing" (Crespí and Brown 2001). He also noted wild grapes (*Vitis californica*) along the stream. This description is corroborated by another traveler more than 120 years later, who described the river in this reach with "banks clad in long grass, wild-rose, and sweetbrier, with tangles of wild-grape overshadowed by willow, cottonwood, and sycamore" (Van Dyke 1890). At the lowest end of the reach, near Camulos, one account describes "clumps of willows and groves of wide-spreading sycamores" (Parkinson 1894).

This riparian forest is still visible in early 20th century oblique photography, and is particularly notable in contrast to the intermittent, sparsely vegetated Piru reach immediately downstream (see fig. 3.26). However, the area was highly affected by the St. Francis dam break in 1928 (Isensee 1928a; see fig. 3.15). It is likely that the forest's upstream extent was much further east than we were able to map it, possibly extending well past the Los Angeles County line as it does today. Further research at Los Angeles County archives may help confirm the upstream extent of this riparian corridor.

The river is generally on the south side of the valley + is very tortuous in its course + what might be termed the bottom land is apparently very rich from the rankness of its vegetation.

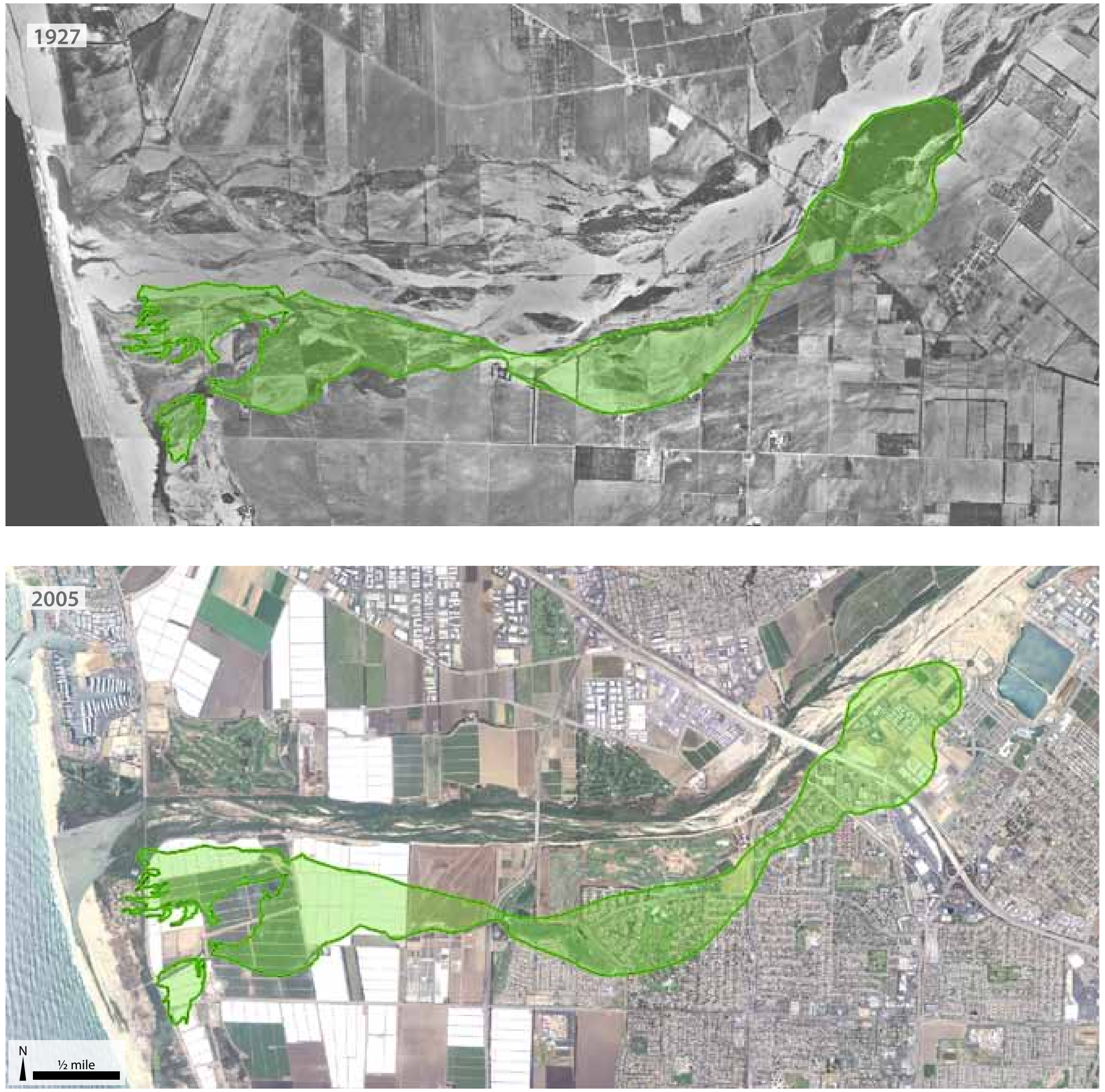
—KING 1883, OCTOBER 16, 1883, SPEAKING OF THE DEL VALLE REACH

Riparian Vegetation on the Santa Clara River Today

There has been a substantial loss of historical floodplain habitat due to the urban development and agricultural intensification of the 19th and 20th centuries. Riparian trees have been cut for fuel, cleared to make space for fertile bottomland agriculture, or killed by the lowering of the water table due to groundwater extraction. This trend is consistent with other central and southern California rivers, where similar effects have been documented (see Boughton et al. 2006).

The loss of vegetation is evident in a comparison of past and present willow-cottonwood forest below Highway 101 (near the river mouth), in the area formerly known as West Grove. This reach has been highly altered by floodplain development and constricted by levee construction, resulting in the near-complete loss of the most extensive historical grove of willow-cottonwood forest (approximately 1,200 acres; fig. 3.41). Near Fillmore, most of the 340 acre Cienega has also been converted to agriculture, though it clearly still experiences high groundwater levels (fig. 3.42). The riparian corridor is further threatened by the introduction of non-native plants, with the greatest threat currently posed by the extensive invasion of Arundo throughout the lower river.

Precise loss of riparian forest on the Santa Clara River over the past few centuries is impossible to calculate. The historical riparian mapping generated in this study is limited and coarse, and includes only prominent willow-cottonwood forest and wetland areas in four discrete nodes along the river (rather than detailed mapping of the entire corridor). In contrast,



West Grove, historical extent

Fig. 3.41. Lower Santa Clara river, 1927 (top) and 2005 (bottom). By the 20th century, the majority of the original 1,200 acres of forest along the southern side of the Santa Clara River had disappeared. (Fairchild Aerial Surveys 1927, courtesy of Whittier College; USDA 2005)

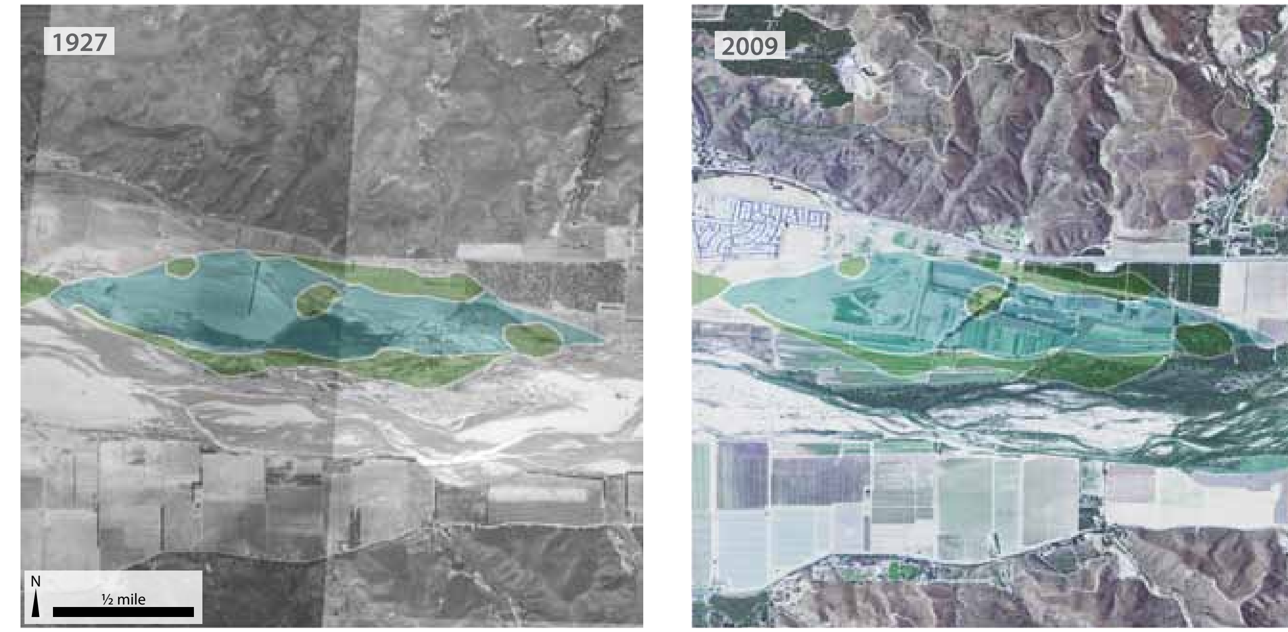


Fig. 3.42. Cienega, 1927 (left) and 2009 (right). As early as 1927, most of the original extent of the Cienega had been cleared. The former Cienega site is now the location of the Fillmore Fish Hatchery and crops tolerant of high groundwater conditions (e.g., watercress). Very little of the original Cienega extent remains, though substantial forest is found in the river corridor to the south. (Fairchild Aerial Surveys 1927, courtesy of Whittier College; USDA 2009)

Cienega, historical extent

the modern vegetation survey (Stillwater Sciences and URS Corporation 2007) was conducted at a finer spatial resolution and includes the entire river. These issues are compounded by the temporal variability of vegetation extent and distribution on the river over time, particularly associated with floods. A rough comparison is possible, however. In total, approximately 2,540 acres of willow-cottonwood forested wetland and valley freshwater marsh were present in the four persistent riparian areas in the early 19th century, compared to about 1,380 acres of mixed riparian forest and cottonwood-willow forest surveyed for the contemporary (2005) mapping (Stillwater Sciences and URS Corporation 2007; fig. 3.43). This represents a loss of 46%. The true percentage loss of riparian forest is likely far higher, since the historical figure does not account for riparian forest outside of the mapped persistent historical riparian areas.

Despite these changes, in comparison to other California lowland alluvial rivers the Santa Clara River still maintains a relatively high proportion of floodplain with native riparian vegetation and riverwash habitats (Orr et al. 2011). Valuable nodes of high quality native vegetation are still present in many reaches, reflecting the distribution of former forests. In particular, stands of willow-cottonwood forest still track gaining reaches and reaches with shallow groundwater, and occupy historical locations. Hedrick Ranch Nature Area, a reserve that supports willow-cottonwood forested wetland and occupies a portion of the former East Grove east of the Santa Paula Creek confluence. Current nodes of willow-cottonwood forest also exist southeast of Fillmore near the Fillmore Fish Hatchery (corresponding to the historical Cienega area) and between Camulos and Del Valle along the upper river (historical Del Valle area).

In addition, plant communities associated with rare Southern California alluvial scrub are still found in intermittent reaches of the river today (e.g., the Piru reach). Sagebrush (*Artemisia tridentata*), California buckwheat (*Eriogonum fasciculatum*), and chaparral yucca (*Yucca whipplei)* vegetation alliances have been observed in reaches with high depth to groundwater, where historical observations recorded cactus and sagebrush. Alluvial scrub vegetation, once common in Southern California, has been greatly reduced from its historical extent (Smith 1980, Hanes et al. 1989, Burk et al. 2007, Rundel 2007, Sawyer et al. 2009). In concert with contemporary fieldwork and analysis, it may be possible for local and regional groups to incorporate these rare vegetation types into conservation and restoration efforts for the Santa Clara River corridor.

The Santa Clara River has experienced tremendous loss in riparian floodplain habitat (particularly persistent riparian forest) in many reaches over the past few centuries. Nevertheless, comparison of historical and contemporary ecology reveals that the largest present-day patches of riparian forest today occur in areas that historically supported much larger stands of willow-cottonwood forested wetland and mixed riparian forest. Though today's nodes represent only a fraction of former riparian extent, they suggest substantial opportunity for riparian conservation and restoration in these areas. Restoration efforts at one of these nodes (Hedrick Ranch Nature Area) have been highly successful, with willow-cottonwood forest regenerating rapidly (Coffman, pers. comm.)

This research highlights that the underlying hydrologic and geomorphic processes driving the distribution of riparian forest nodes are still intact, at least in some form, today. Maintaining and enhancing the current hydrologic regime of the Santa Clara River so it remains reflective of the natural, unmodified regime may be critical for maintaining desired river and riparian-floodplain habitat, ecosystem functioning, and resilience.

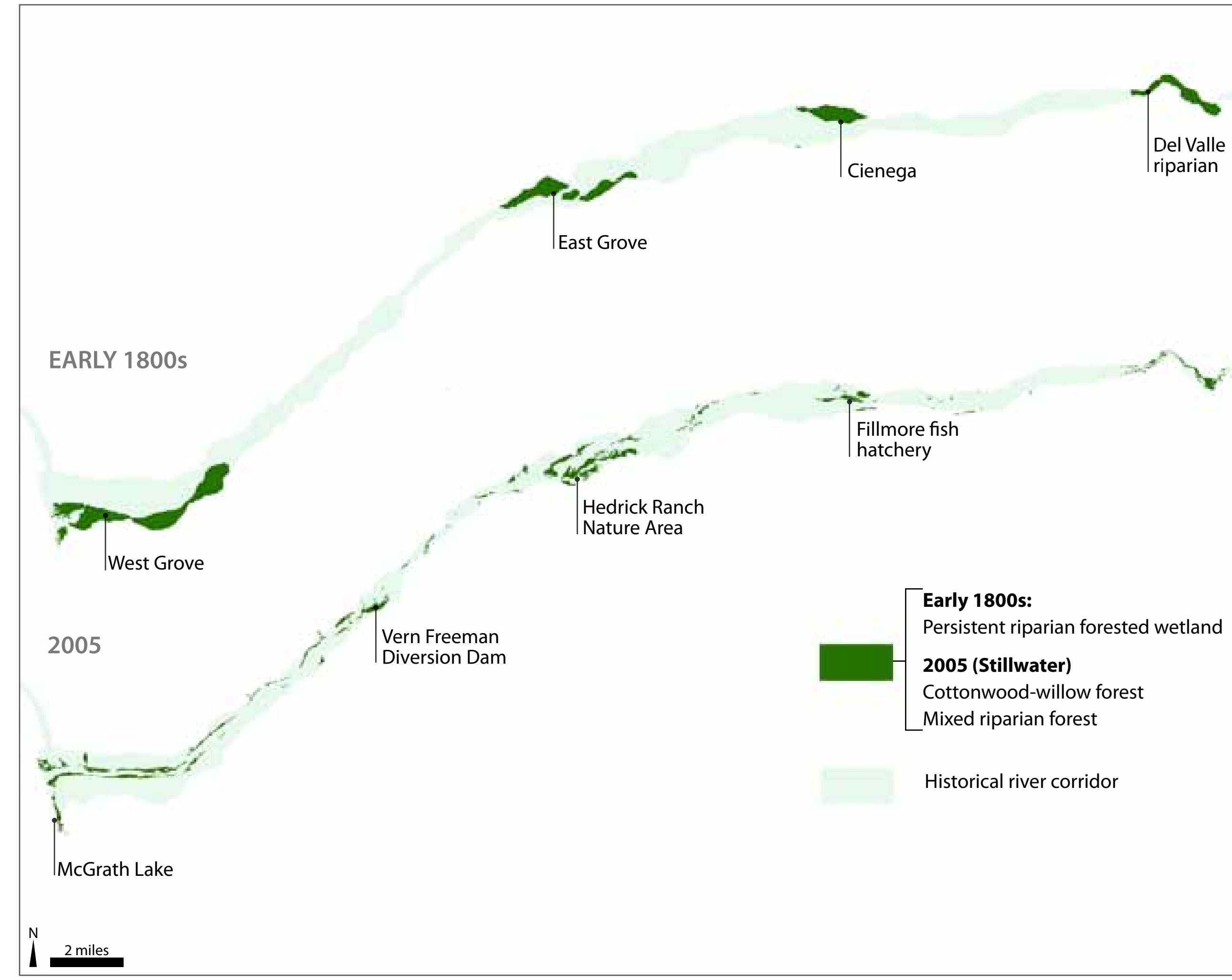


Fig. 3.43. Distribution of riparian forest on the Santa Clara River, early 1800s and 2005. The current (2005) distribution of mixed riparian and cottonwood-willow forest on the Santa Clara River closely mirrors the former distribution patterns of similar habitats in "nodes" along the river. Though the extent of these habitats has been sharply reduced, the persistence of these nodes over the past 200 years suggests relatively intact groundwater patterns and the potential for additional recovery.

Riverine transformation and synthesis

Two centuries ago, the Santa Clara River exhibited remarkable ecological, hydrologic, and geomorphic heterogeneity over the lower fifty miles of its course. In this chapter we documented this diversity, identifying patterns and characteristics of the historical river. This section synthesizes the foregoing descriptions of physical and ecological properties of the river in three sample reaches to provide a more comprehensive, integrative understanding of properties of the river both longitudinally and temporally. We also provide a summary of our Santa Clara River findings and the implications of our research for management strategies in the watershed today.

The Santa Clara River changes dramatically longitudinally, as well as throughout time. We chose three river reaches to illustrate both of these concepts in section: the river mouth, Santa Paula reach, and Piru reach (fig. 3.44). The cross-sections and accompanying plan form representations illustrate the historical hydrology, morphology, and ecology of the river in three very different locations in the mid-to-late 19th century (1853-1892). We also produced cross-sections presenting conditions in these reaches

Fig. 3.44. Locations of illustrated cross sections on Santa Clara River. The easternmost reach is just downstream of the Piru confluence, and is characterized by intermittent flow and sparse, scrubby vegetation. The middle reach is just upstream of the town of Santa Paula, an area of rising groundwater historically characterized by multiple channels and marshes bounded by willow-cottonwood forests. The westernmost cross-section depicts the mouth of the river. This area has changed from a broad deltaic formation with seasonal lagoons surrounded by grasses and willow-cottonwood forest to a narrow single-thread channel with levees protecting a golf course on the north bank and agricultural operations on the south.

during the mid-20th century (1927-1938) and early 21st century (2005) to depict the impacts of land use changes over this time. These dates reflect data availability for each reach, in addition to a desire to juxtapose years with comparable flood dynamics (both 1938 and 2005 sets of aerial images show the active channel after large flood events on the Santa Clara River). Taken together, these reaches represent the variability in vegetation and flow characteristics along the river.

We used a variety of methods and sources to produce 19th century cross-sections where no historical elevational data were available. We extracted the physical form for the three cross-sections from the 2005 LiDAR data from Ventura County, using these modern data for elevations and valley width (and making adjustments, such as removing anachronistic levees, as needed for the historical renderings). We used the 2005 NAIP imagery to locate land use changes, vegetation and channel features on the modern cross sections, augmenting this interpretation with modern riparian mapping by Stillwater Sciences/URS. For the mid-20th century snapshot, we used the 1927 and 1938 aerial photos to map land use patterns and channel changes onto the cross section. Finally, in order to graphically illustrate the 19th century cross-sections, we used USCS T-sheets (for the river mouth), GLO notes from several land surveyors, and the historical habitat mapping.

Though the channel forms, vegetation and land use patterns have changed drastically since the mid- to late-19th century, historical long profile data (Stillwater Sciences 2007b) indicated that there had not been continuous or reach-wide incision or aggradation in these three locations since the mid-20th century. Stillwater Sciences' research indicates net changes in bed elevation for the two upstream cross sections between 1949 and 2005 as ranging from –2 feet to +5 feet. The cross section at the mouth experienced a general trend in downcutting of 4 feet during the time period examined; however, the scale of our cross-section was too large to effectively illustrate this. As such, we decided not to show bed elevation change as an important feature in the cross sections, since for most of the reaches depicted there was no conclusive evidence for systemic degradational or aggradational patterns.

These cross sections are only a snapshot of patterns at narrow locations and points in time within the watershed, though we believe they offer representative glimpses of temporal and spatial change in three different reaches of the Santa Clara River. Bear in mind that they are purely conceptual in nature, and are not intended to represent exact landscape patterns (e.g., tree density or marsh extent).

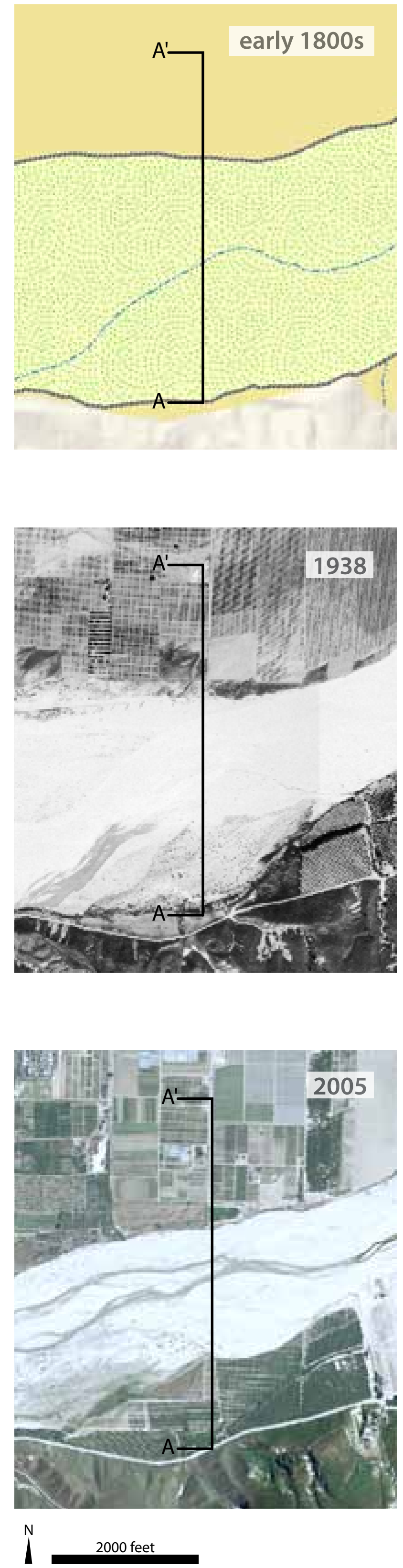
PIRU REACH

This reach of the Santa Clara River was intermittent, consistently drying out during the summer. Throughout the past 150 years, it has been characterized by a broad, sandy active channel and sparse scrub vegetation. Though its overall character has remained relatively stable over time, changes to the river corridor have occurred.

Surveyor H.S. Craven (1874f) walked north along this transect on March 12, 1874, documenting conditions along the river and valley 1.5 miles downstream of the Piru confluence. Craven noted "rocky" and sandy portions of the river bed, describing the active channel as a dry "sandy plain." He described no vegetation in the channel, but noted cactus and sagebrush growing on the northern (right) bank between the river and the agricultural fields of the valley. He also noted ploughed fields and a house not far from the north bank of the river.

Though the river corridor maintained most of its width between 1874 and 1938, aerial photography reveals several distinct changes. Most notably, the scrub recorded in Craven's 19th century survey notes had been cleared and replaced by orchard plantings, though limited xeric vegetation remained and washy arcuate patterns in the aerial image indicate that the plot was either recently ploughed or recently flooded.

Similar hydrology and vegetation persist today, though invasive giant reed (*Arundo donax* or Arundo) is now present and the river corridor has narrowed due to agricultural development on the floodplain. Between 1938 and 2005, the most drastic change was the addition of orchards on the south bank between Guiberson Road and the active channel, resulting in the constriction of river corridor width by 43% from 1874. The riverbed remains sandy and actively scoured, with some alluvial scrub and Arundo in 2005. Orchards and nurseries continue to occupy the right side of the river.



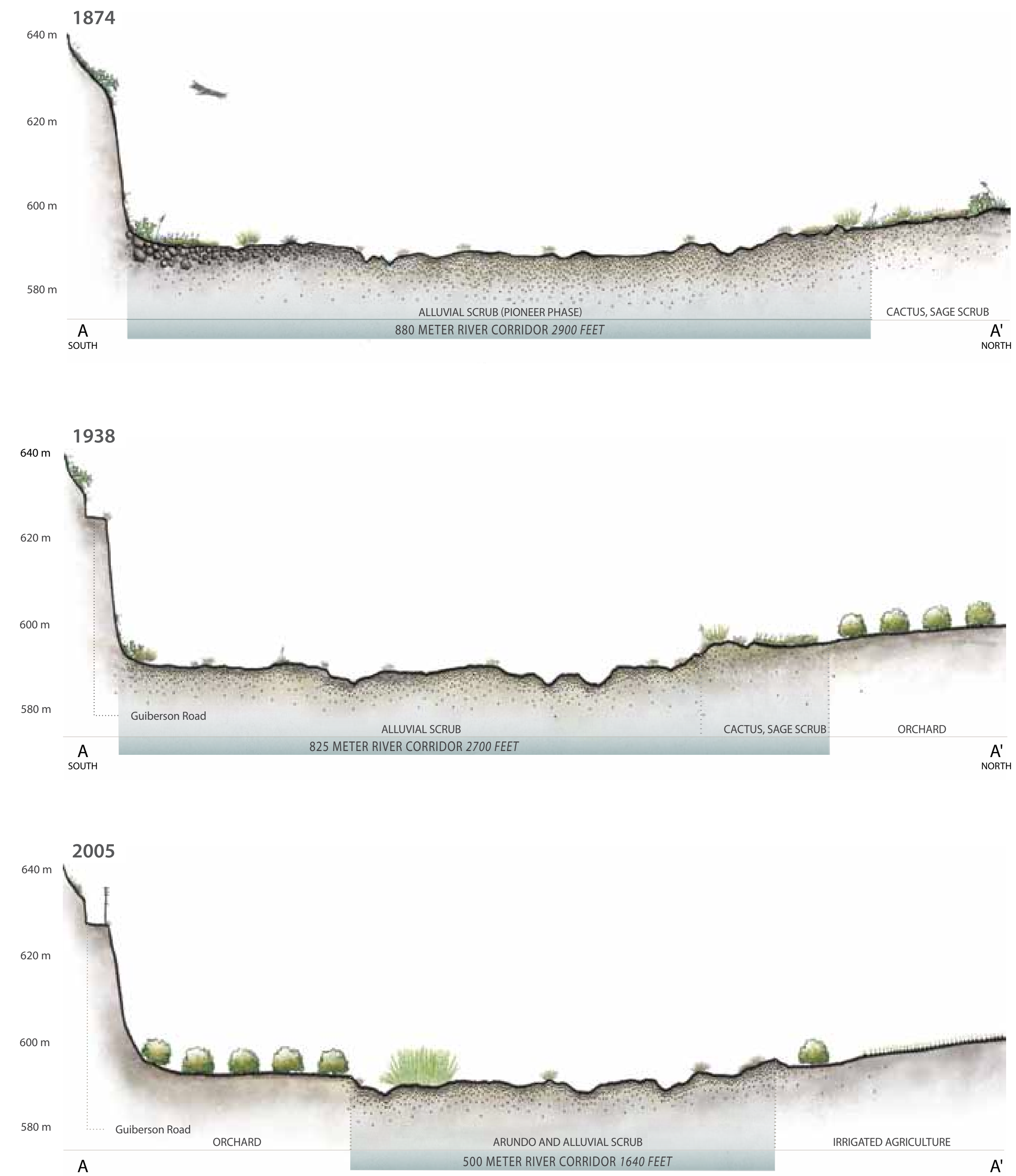


Fig. 3.45. Historical cross-sections at Piru, 1874-2005. This series shows the Santa Clara River west of Piru, between Piru Creek and Hopper Canyon. This intermittent reach was characterized by a broad active channel dominated by sand and scrub vegetation. Similar hydrology and vegetation persist today, though Arundo is now present and the river corridor has narrowed due to agricultural development on the floodplain. Cross-sections are drawn with 5x vertical exaggeration. (Craven 1874f; USDA 1938, courtesy of Ventura County; USDA 2005; Stillwater Sciences and URS Corporation 2007. Cross-sections produced by Jen Natali)

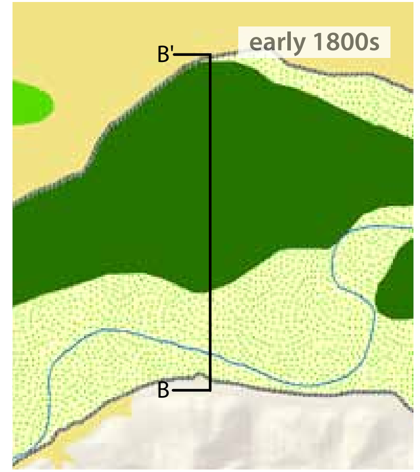
SANTA PAULA REACH

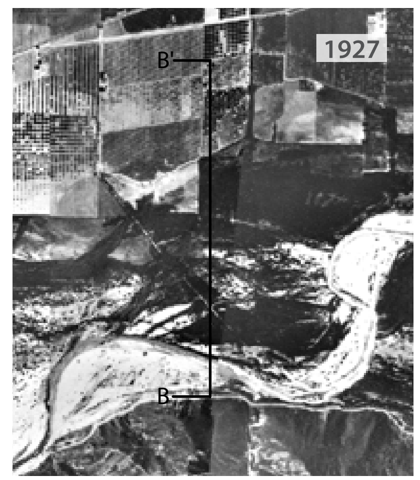
Just east of the Santa Paula Creek-Santa Clara River confluence, rising groundwater created an extensive zone of willow-cottonwood forest and freshwater wetlands situated on the river's bottomlands. Though the riparian forest in this area has been whittled away to make room for agricultural fields over the past century, substantial willow-cottonwood forest is still present in this reach, and the reach's former hydrology (gaining reach, perennial surface flow) is still intact.

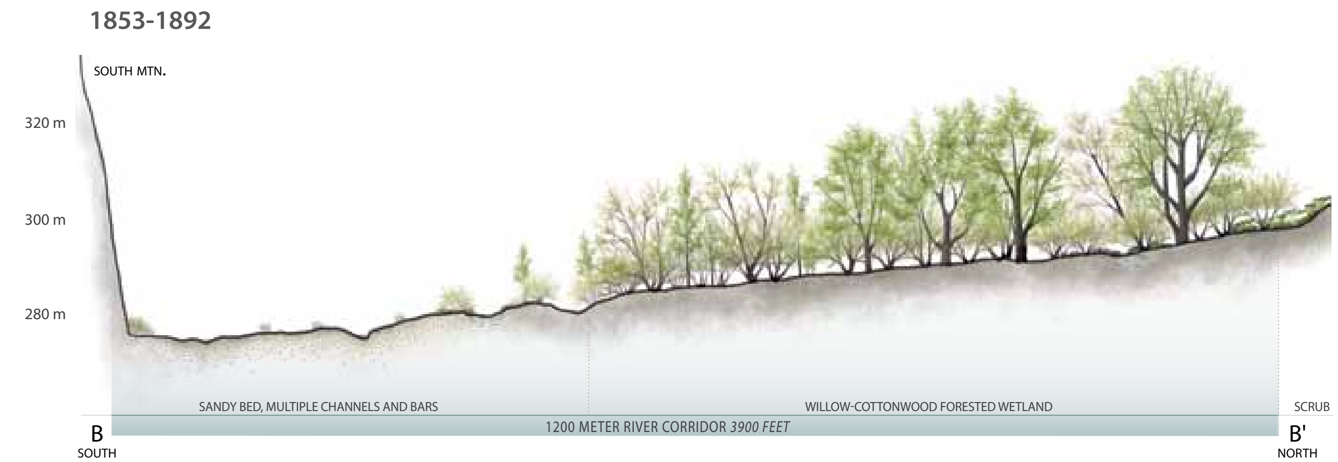
Several surveyors took evocative notes along the same transect between 1853 and 1892, and their efforts are compiled in this illustrative cross-section (Norris 1853, Hoffman 1868b, Thompson 1869, Barry 1892a). Their notes record bottomland covered with willow scrub, willow-cottonwood forest, and freshwater marsh below the northern bluff bank, and an active channel with multiple shifting mainstem channels and bars. Though the surveys span 40 years, they are consistent in their descriptions of entering and exiting a "cottonwood and willow swamp" (Norris 1853), sandy and muddy substrates (including an area of "deep mud"; Hoffman 1868b), and mature timber and scrub on the north bank. This is part of East Grove (see page 100).

By the time the 1927 aerial photos were taken, some of the cottonwood and willow forest had been cleared and drained, and replaced with bottomland farms and orchards. Substantial dense riparian forest remained, though the river corridor width shrunk by just over 30%.

By 2005, the formerly 3,900 foot wide river corridor had been constrained to about 1,600 feet across, an overall loss of 58%. Orchards and other agricultural developments have replaced much of the former forest.







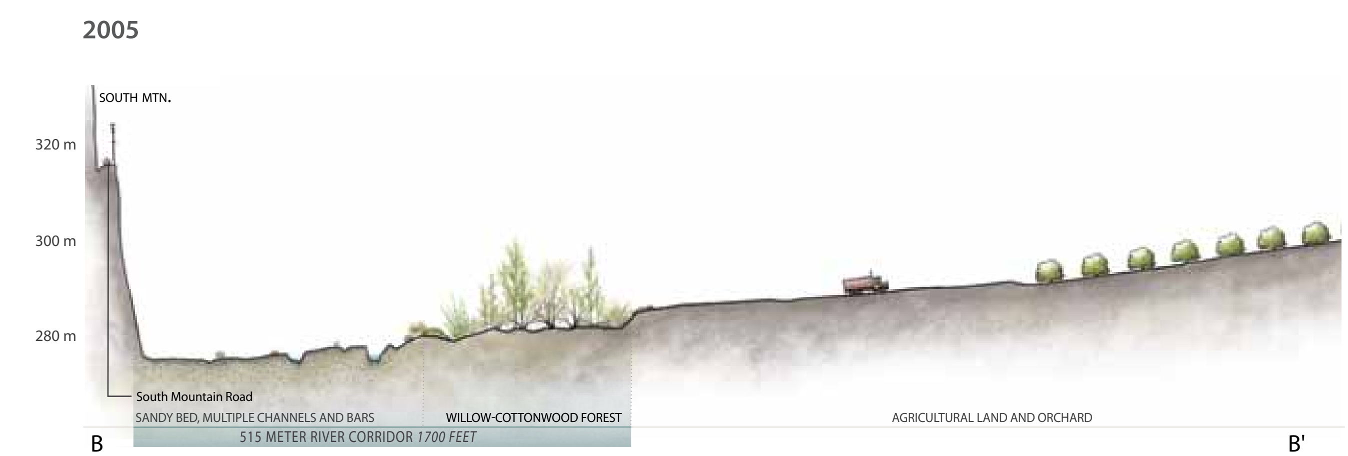


Fig. 3.46. Historical cross-sections at Santa Paula, 1853-2005. This series of cross-sections shows the Santa Clara River east of the Santa Paula Creek confluence, where the south bank of the river abuts South Mountain. The transect is in a perennial reach of rising groundwater, characterized in the 19th century by extensive willow-cottonwood forests and freshwater wetlands. Substantial willow-cottonwood forest remains in the area today, though much diminished from former extent. The earliest cross-section is derived from a composite of GLO surveys spanning the second half of the 19th century. Cross-sections are drawn with 5x vertical exaggeration. (Norris 1853; Hoffman 1868b; Thompson 1869; Barry 1892a; Fairchild Aerial Surveys 1927, courtesy of Whittier College; USDA 2005; Stillwater Sciences and URS Corporation 2007. Cross-sections produced by Jen Natali)

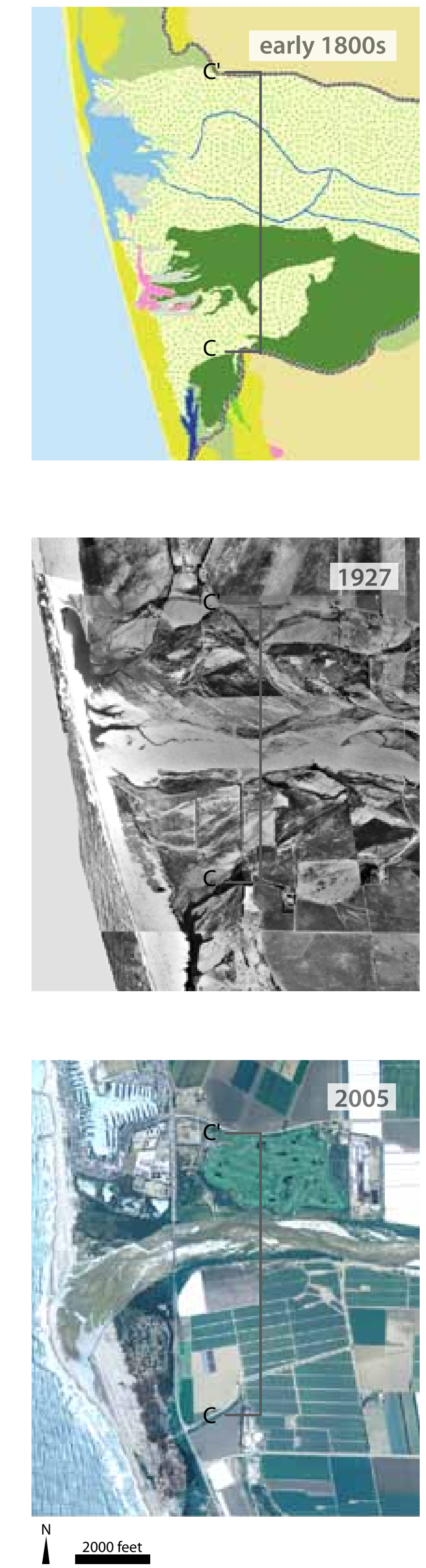
MOUTH OF SANTA CLARA RIVER (OXNARD REACH)

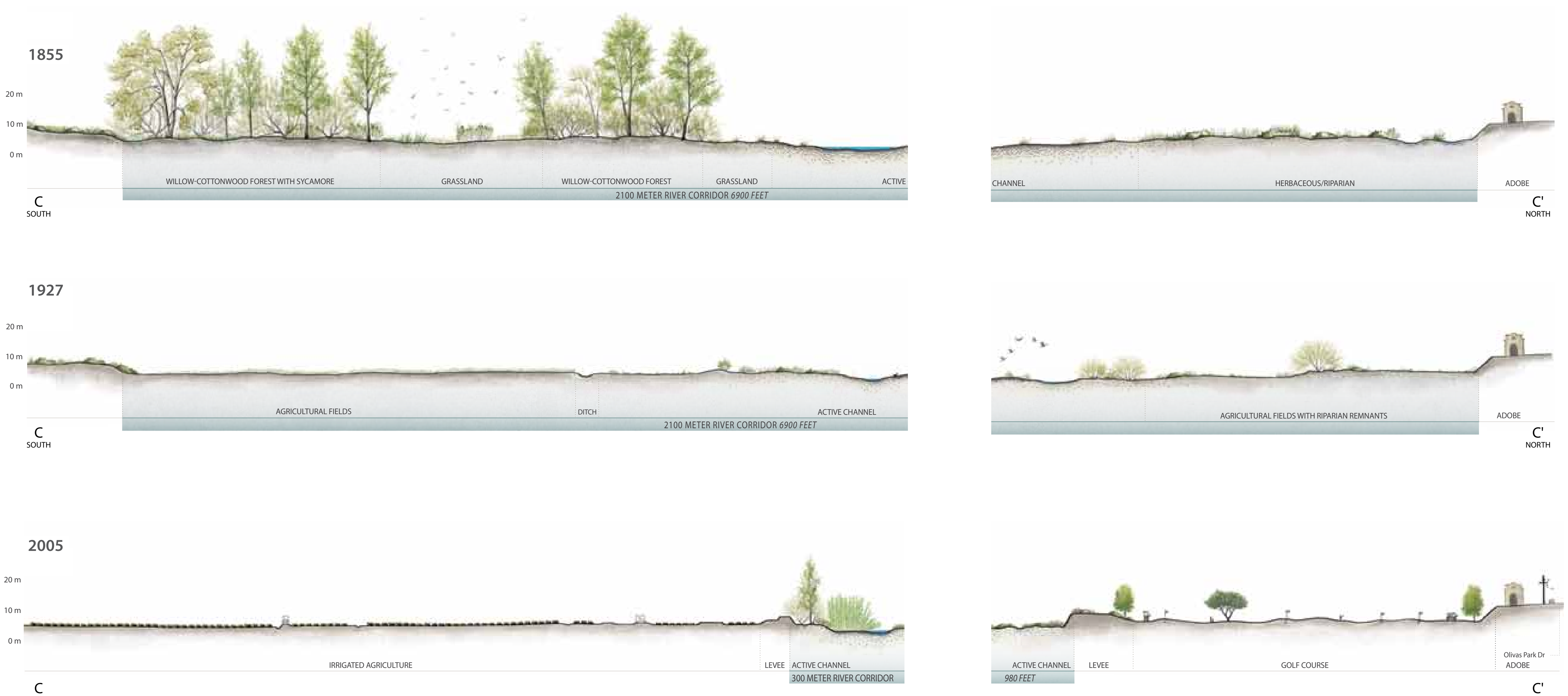
The Santa Clara River mouth south of Highway 101 has experienced dramatic changes over the 19th and 20th centuries, including the near-complete loss of West Grove and the contraction of river corridor width by over 85%. The reach has been transformed from a broad estuarine delta about 1.25 miles wide to a narrow river corridor separated by levees from intensive agricultural and recreational uses. The Olivas adobe (pictured on the right bluff bank), built in 1837 and enlarged in 1849 (OHP 2011), has stood watch over these changes.

Early surveyor's notes describe cottonwood and willow "belts" and "groves" near the mouth (Hancock 1854). These descriptions are corroborated by the 1855 T-sheet, which depicts dense willow-cottonwood forest south of the active channel, and broad distributary channels and grassland to the north. This area maintained shallow summer surface flow due to perched groundwater conditions.

Over 70 years later, in 1927, most of West Grove had been cleared for agriculture. Broad floodplain areas on both sides of the active channel were subdivided into farmland, and irrigation ditches and levees are evident. However, patterns visible on the aerial affirm that much of this area (particularly on the south side) continued to be regularly flooded. By 2005 levees bound the river, including a levee on the south side of the river originally built by the Army Corps in 1961 (Stillwater Sciences 2007b). Levees and land use constrain the formerly 6,900 foot wide river to a 1,000 foot corridor. Intensive agriculture and the Olivas Park golf course inhabit the former floodplain. Herbaceous cover, willow-cottonwood forest, and invasive *Arundo donax* flank the mainstem.

Fig. 3.47. Historical cross-sections at the Santa Clara River mouth, 1855-2005. This time series shows the Santa Clara River at its mouth, about 3.5 miles downstream from the Highway 101 bridge. A large willow-cottonwood forest and wetland complex dominated the left bank (south side) of the river from above the bridge all the way to the river mouth, a distance of over four miles. Very little of this once-expansive forest remains today. The earliest cross-section is derived from GLO notes and the mid-19th century T-sheet drawn for the river mouth by the U.S. Coast Survey. Cross-sections are drawn with 5x vertical exaggeration. (Hancock 1854; Johnson 1855c, courtesy of the National Oceanographic and Atmospheric Administration; Fairchild Aerial Surveys 1927, courtesy of Whittier College; USDA 2005; Stillwater Sciences and URS Corporation 2007. Cross-sections produced by Jen Natali)





CONCEPTUALIZING THE SANTA CLARA RIVER

Part of the challenge of developing viable restoration and conservation strategies for highly fragmented rivers is simply gaining enough perspective to think about them accurately (Montgomery 2008). Forming a clear vision of the processes at play in these systems is an instrumental part of developing restoration plans with a high likelihood of success and public acceptance (Palmer et al. 2005, Hanley et al. 2009, Greiner 2010). The historical record for the Santa Clara River provides some of the perspective necessary for thinking about its future.

From historical data, we can see that the river was neither a continuously perennial stream uniformly lined with riparian forest, nor simply a dry, scrubby wash with little established vegetation. Instead, its hydrology and vegetation were more heterogeneous than either endpoint, though it embodied aspects of both. Some seemingly barren reaches of today's river—where one might question whether two centuries of water diversions and deforestation had completely altered the river's character—are in fact remnants of historically summer-dry, scrub and riverwash-dominated reaches. Conversely, reaches with rising groundwater supported much more lush riparian and wetland vegetation than one might expect to find in semi-arid Southern California, in close proximity to drier portions of the river.

Remarkably, and despite large-scale changes to the landscape, upon close examination many of these patterns are still expressed today. Geologic controls still influence hydrology in places like the Sespe and Piru narrows, creating nodes of high groundwater across the length of the river. These areas may still be conducive to the recovery of certain groundwater-dependent riparian and aquatic habitats.

In addition to documenting historical patterns, it is also instructive to think about historical riverine dynamics. While we often focus on the episodic, variable nature of Southern California streams in this study, we found that overall ecological and hydrologic patterns along the river were historically quite stable, persisting across major flood events. More historically stable forest and bottomland habitats have been largely eliminated, leaving only the mostly sandy active channel in many places. The legacy of this transformation from a broad, topographically complex channel with the capacity to accomodate large flows to a narrower, more confined channel is a more homogeneous river with increased sensitivity to episodic events and reduced potential for the establishment of diverse and persistent floodplain habitats, particularly in the lower reaches.

SUMMARY OF FINDINGS

The following findings represent some of the significant conclusions drawn from our research and analysis. Taken together with an understanding of modern conditions, these findings can support scientists and managers working to identify restoration opportunities in the Santa Clara River valley.

1. **The historical (early 1800s) Santa Clara River valley supported a diverse array of natural habitats,** from the willow groves and wetlands of Saticoy Springs to the sycamores and oaks found on alluvial fans near Santa Paula and Fillmore. However, the valley floor was dominated by grassland and coastal sage scrub, with trees occurring singly or in stands and along creeks and rivers. Valley oaks were not documented in the Ventura County portion of the valley.

2. **Most substantial freshwater wetland complexes occurred within the river corridor of the Santa Clara River, not on the valley floor.** A rich array of aquatic habitats were found within the river corridor, including ponds, sloughs, and freshwater marshes in perennial reaches, and a suite of saline and brackish aquatic habitats associated with the estuary at the river mouth.

3. **Prior to modification, most small tributaries did not connect to the Santa Clara River.** With few exceptions, intermittent small creeks commonly sank into their alluvial fans before reaching the Santa Clara River, a characteristic common to many intermittent tributaries across California. Rather than maintaining defined channels all the way to the river, these creeks were connected hydrologically to the river through subsurface flow and poorly defined, transitory surface channels. Most of these creeks have now been connected to the Santa Clara River though constructed channels, increasing valley drainage density (that is, stream length per unit area).

4. **From the late 19th to the early 20th century, the position of the Santa Clara River corridor remained relatively laterally stable.** Inter-annual variability in the relative vegetation cover of the active channel and bottomlands is evident in the historical record, with widespread changes occurring after each major flood. However, our findings support the overall lateral stability of the river even through the St. Francis Dam break in 1928.

5. **In the relatively recent geologic past, the lower Santa Clara River shifted its outlet from near Point Hueneme to its present location.** While the date of this shift is not clear, it may have occurred in the past 200-500 years based on edaphic, ecological, and ethnographic evidence. This shift is reflected in historical alkalinity patterns on the Oxnard Plain (see page 177).

6. **The Santa Clara River was an interrupted perennial stream,** with alternating perennial and intermittent (summer dry) reaches. Only two intermittent reaches were clearly documented on the river, near Saticoy and Piru (though additional intermittent reaches may have been present). The location of perennial reaches was informed by a variety of factors, including artesian influence, tributary inputs, valley narrowing, and geologic constraints. Many of these factors continue to affect surface flow patterns today.

7. **The Santa Clara River supported a diverse mix of riparian species,** including trees such as sycamore, live oak, willow, cottonwood, box elder, and alder; scrub species such as scalebroom, buckwheat, mulefat, golden-aster, sagebrush, black sage, and cactus; and understory species such as wild grape and wild blackberry.

8. **Dense, persistent riparian forest and in-channel wetlands occurred in discrete patches along the Santa Clara River.** Rather than a continuous corridor, willow-cottonwood riparian forest was found at a few notable locations along the river, corresponding with areas of

rising or perched groundwater. Other reaches supported a different matrix of non-vegetated riverwash, willow scrub, mulefat, and alluvial scrub. This longitudinal heterogeneity tied to patterns in groundwater-surface water interactions suggests that different restoration targets are appropriate for different reaches. It suggests nodes for riparian forest restoration centered around former persistent wetland riparian areas, as well as a focus on maintaining the water resources (rising groundwater) that would support these habitats.

9. **Alluvial scrub was a likely component of the driest portions of the Santa Clara River.** While more research is needed, compiled data suggest that alluvial scrub is a more suitable riparian restoration target for drier reaches (notably the Piru reach) than riparian forest.

10. **Live oaks and sycamores occurred frequently on the Santa Clara River river outer banks.** Numerous live oaks and sycamores were documented on high banks on the edge of the river corridor. Live oaks and sycamores documented within the river corridor occurred largely in Santa Paula and Sespe creeks (likely on higher bars or islands) and as individuals within large areas of willow-cottonwood forest on the mainstem Santa Clara River.

Management Implications

- **Though the Santa Clara River has undergone substantial transformations over the past 250 years,** many of the underlying physical parameters and processes have remained intact, particularly in comparison to other Southern California rivers. These characteristics create an unusually rich array of management possibilities for the river regarding the conservation and restoration of ecological patterns and habitat value.
- **Maintaining the hydrologic heterogeneity of the Santa Clara River is an essential component of conserving ecological diversity.** Groundwater availability (and by extension, summer flow) is clearly a primary driver in the distribution and composition of riparian habitat. Disturbance from winter floods, via scour or sediment deposition, is also an important driver of riparian vegetation dynamics.
- **Riparian restoration targets should be assessed at a reach scale.** Different suites of species were supported historically in different reaches. Willow-cottonwood forest was not found continuously along the river, and is not an appropriate or feasible restoration target for the entire river. For example, alluvial scrub may be a more appropriate target in the Piru reach, and conservation activities may support the preservation of this regionally rare habitat type.

- **Reaches with rising groundwater present unique opportunities for riparian forest restoration.** Many wetland species support functions are concentrated in areas with dense riparian forest and rising groundwater. Managers may choose to prioritize restoration of willow-cottonwood forest and in-channel wetlands in these places, if contemporary assessment shows restoration to be viable. This includes former floodplain surfaces on the south side of the river near its mouth, the region east of the Santa Paula Creek confluence, and the former Cienega (Fillmore fish hatchery) area.
- **Ecological values of intermittent reaches of the river should also be protected.** Conservation of historical aspects of these reaches should be considered in project design and water management.
- **Groundwater management is an essential component of maintaining the heterogeneity of the Santa Clara River riparian corridor.** To the extent feasible, managing surface and groundwater resources to mimic historical hydrologic patterns preserves the viability of riparian restoration at the reach scale.
- **The lateral extent of the river corridor has decreased dramatically in some reaches from the 19th century to the 21st.** Different land uses have encroached on the former river corridor, claiming many of the less frequently flooded bottomland surfaces. The river currently occupies only a small portion of its former area; almost 50% of its former area has been lost. What remains is largely the much more dynamic active river channel. The removal of many of these more stable portions of the river may have influenced our perception of the river system, emphasizing its dynamic nature rather than its overall stability. This suggests a possible conservation focus on reoccupation of former floodplain areas. Riparian and river restoration projects should consider this large portion of the valley formerly part of the river. If these floodplain surfaces are still accessible in high flows, they may provide ecosystem functions and resilience and help managers design restoration strategies with increased chances of success.

4 • VENTURA RIVER AND VALLEY

For the entire distance we closely followed the Ventura River, a clear, dashing mountain stream bordered by hundreds of splendid oaks whose branches frequently met over our heads. We crossed the stream many times, fording it in a few places, and passed many lovely sylvan glades—ideal spots for picnic or camp.

— THOMAS DOWLER MURPHY 1921, TRAVELING FROM VENTURA TO OJAI

Introduction

The Ventura River drains approximately 230 square miles, emptying into the Pacific Ocean just west of the city of Ventura. The headwaters rise in the western Transverse Ranges, some of the youngest and most tectonically active mountains in North America with uplift rates as high as 0.2 to 0.3 inches/year. The resulting steep slopes and the relatively weak exposed sedimentary layers lead to high sediment production, landslide potential, and erosion rates (Scott and Williams 1978, Warrick and Mertes 2009, Cluer 2010).

The Ventura River ranges from steeper slope, step-pool formations with large boulders in the headwaters, to lower slope distributary channels emptying into the Ventura River estuary at the coast. Unlike the Santa Clara River, the Ventura River valley is narrow, and in many places the river occupies much of the valley floor. Upland portions of the watershed are predominantly covered in chaparral scrub, while riparian species occupy the river and its tributary corridors.

The Ventura River watershed experiences a Mediterranean climate, with 90% of the rain falling in the wet season between November and April. However, inter-annual variability is high and cycles of wet years and dry years often span decades. This climatic variability suggests an extremely variable hydrologic regime, similar to the Santa Clara River. Steep slopes in the upper watershed offer shorter lag time for surface water paths to channels, leading to quick flash floods which spread out in the broader portions of the watershed. These floods, common on the Ventura River, provide scour and habitat complexity, as well as flushing sediment through the system. With expanded urbanization and agricultural uses in the lower part of the watershed, levees have been built to confine flooding through urban and agricultural lands, and increased urban runoff and groundwater pollution have impacted water quality.

Together, Matilija Dam (built in 1948) and Casitas Dam/Robles Diversion (1959) block about 37% of the Ventura River watershed. They have broad effects on sediment transport, impeding over half of all sediment delivery

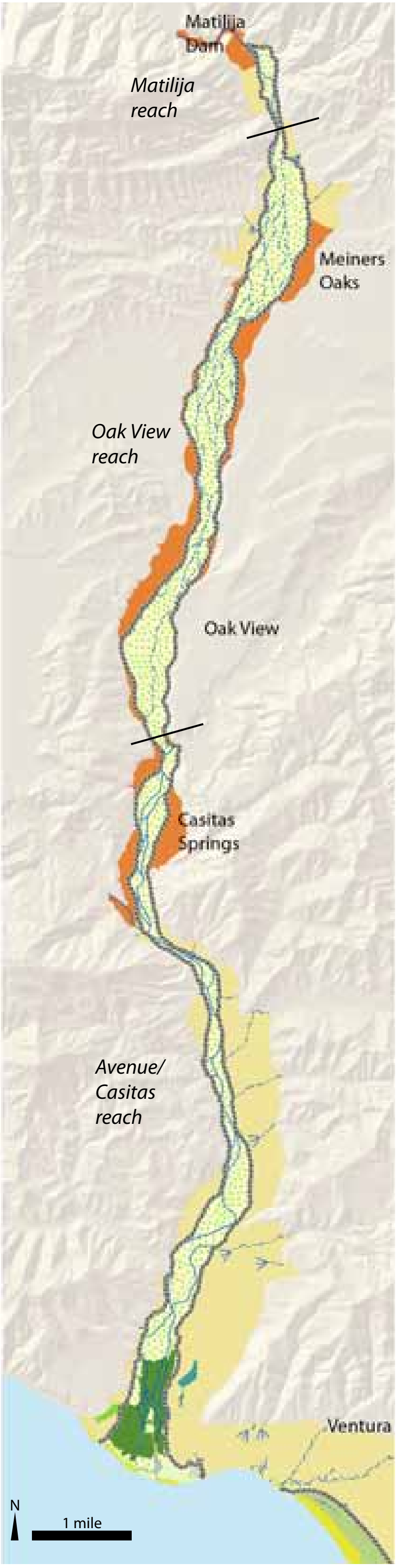


Fig. 4.2. Ventura River reach divisions. We divided the river into three reaches, based on hydrological and ecological characteristics: the uppermost Matilija Reach, the middle Oak View reach, and the lower Avenue/Casitas reach.

(Orme 2005). The Matilija Dam was originally built for flood control purposes; however, the reservoir has filled up with sediment almost completely. The dam is slated for removal, and studies have shown that it has altered flow regimes and geomorphic processes downstream, as well as acting as a barrier for migratory fish species in the watershed.

This chapter explores the historical characteristics of the Ventura River and valley prior to major urban and agricultural modifications. In particular, we focus on the pre-modification hydrology, morphology, and ecology of the river, describing each historical attribute at a reach scale. In contrast to the Santa Clara River, the Ventura River valley was lightly settled and traveled in the 19th century (with the exception of the canyon resorts of the upper Matilija canyon and the Ojai valley, both outside the purview of this report). As a result, there is much less documentation available concerning the historical character of the Ventura River.

Ventura River reach designations

We divided the Ventura River into three broadly defined reaches (fig. 4.2 and table 4.1). These reaches were defined based on the hydrology and ecological characteristics of the system. They are designed to provide meaningful units of analysis to facilitate reach-level understanding of channel dynamics and morphology.

Valley Floor Habitats

We mapped three types of habitats on the Ventura valley floor: grassland/coastal sage scrub, oaks and sycamores, and valley freshwater marsh (fig. 4.3). Grassland/coastal sage scrub was the most prevalent habitat type. In contrast to the Santa Clara River valley, which was dominated by grassland/coastal sage scrub, our mapping suggests that oaks and sycamores composed a relatively high proportion of the Ventura River valley floor. Only one freshwater marsh (17 acres) was mapped in the project area, occupying a depression to the east of the Ventura River and demarcating a former route of the river.

Broadly, grassland was most prevalent in the lower Ventura River valley, extending about six miles upvalley before transitioning to denser tree cover in the middle (Oak View) reach. Scrubland and oaks were documented north of Meiners Oaks. The following section describes these patterns and transitions in more detail.

Dryland Habitats

Unlike the Santa Clara River valley, the Ventura River valley was dominated by the natural corridor of the river. Early accounts of the river valley are filled with descriptions of its riparian vegetation, while very few sources explicitly document vegetation characteristics of the non-riparian valley floor. As a result, this section provides only coarse descriptions of regional

ecological patterns. While not mapped in detail, the Ventura River corridor contained much of the valley's heterogeneity and is depicted in sources as a complex mix of oak, sycamore and scrubland (Norway 1877; Lippincott 1903). Descriptions of bottomland and other riparian characteristics are addressed in the Riparian Habitats section (see page 138).

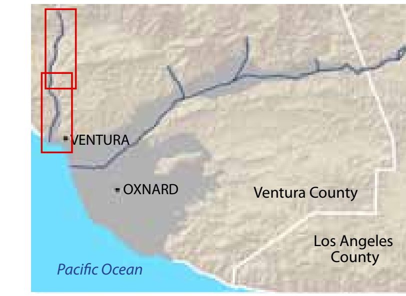
In spite of these impediments, general patterns of valley floor vegetation do emerge. Historical sources, in particular early maps and GLO survey notes, suggest that scrub-dominated cover extended downstream of the narrow, wooded Matilija canyon to the vicinity of Meiners Oaks, where oaks again became more prominent. Below Foster Park, sources indicate that the valley was dominated by herbaceous cover all the way to the river mouth. These areas are described in detail below.

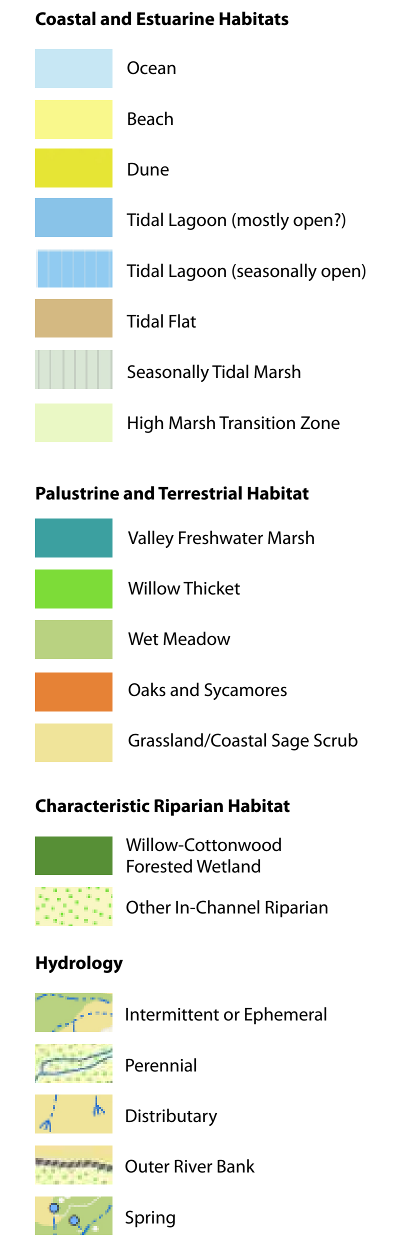
Downstream from the narrow canyon just below the present Matilija dam, the valley floor in the Matilija reach appears to have been dominated by scrub. In contrast to heavy timber described in reaches to the south, GLO surveyor Norway (1878a) noted, "dense brush" on the table land east of the Santa Ynez mountains. On another line a little more than a mile further south, the same surveyor distinguished between the "brushy table land" he just passed through and the "timbered bottom"—the bottomlands of the Ventura River (Norway 1877). As supporting evidence, relatively few trees are present along this reach in the historical aerials compared to timbered areas farther south.

South of Meiners Oaks, and extending to Foster Park, live oaks (and sycamores) became more numerous. For much of this reach (Oak View), the comparatively broad river corridor encompasses almost the entire narrow valley. Observations such as "timbered tableland" (Thompson 1868) and "valley mostly timber" (Norway 1877) are a clear contrast to the descriptions of scrub farther north. Dense tree cover is evident in the historical aerial photography and, in some places where oaks have been cleared for development, earlier GLO surveys note "heavy oak timber" (Norway 1877). Sycamores also appear to have dominated the tree cover in some places (fig. 4.4; Hare 1876). In the Foster Park area, at the southern extent of mapped woodland, a notable area of sycamores and oaks has served as a gathering place since before Mission times (see Riparian Habitats section for more information on Foster Park). As in the Santa Clara River valley, the historical record contains no descriptions of valley

Table 4.1. Upstream boundaries of Ventura River reaches.

	Avenue/Casitas reach	Oak View reach	Matilija reach
Upstream end of reach:	San Antonio Creek confluence	Near Cozy Ojai Road	Matilija dam





Legend for **Fig. 4.3** (map on following page).

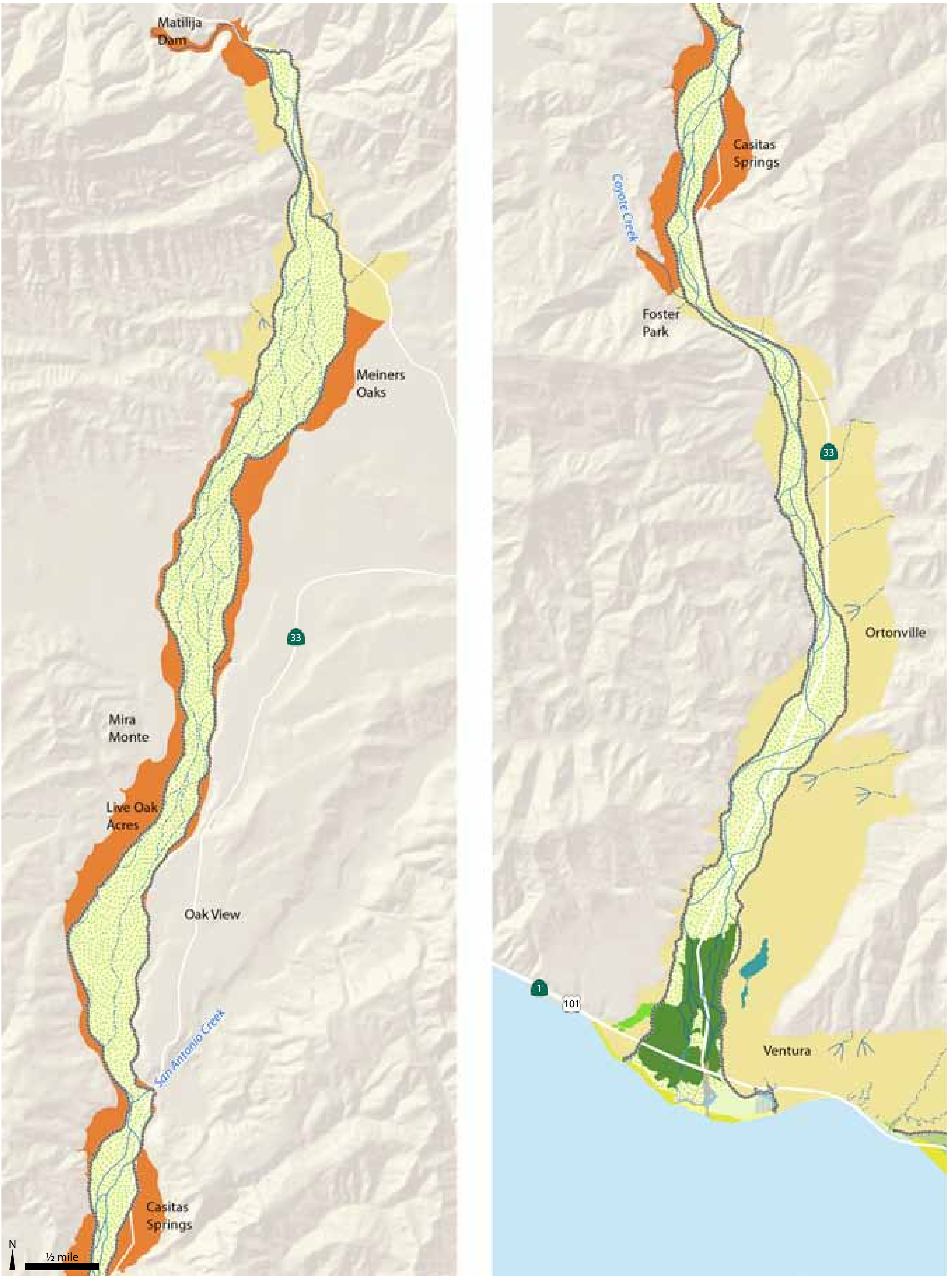


Fig. 4.3 .Historical habitats of the Ventura River valley, early 1800s. The Ventura River corridor was broad, in places occupying a large proportion of the valley floor. Live oaks, sycamores, and scrub were prevalent in the upper valley, while grassland was more common in the lower valley.

oaks in the Ventura River valley by any of the region's travelers, botanists, or residents, despite abundant references to the presence of live oaks by these observers (see page 57). (Ojai Valley, outside our project area, is a notable exception.)

Below Foster Park, historical evidence suggests relatively sparse tree cover in comparison to the wooded reach upstream. Vegetation characteristics changed notably in the Avenue area, where the Ventura River valley begins to open to the ocean. While mapped as the same general habitat type (grassland/coastal sage scrub) as the valley floor in the upper Ventura River reaches, the Avenue/Casitas area was likely more predominantly covered by grasses and forbs as opposed to scrub.

Explorer Crespí noted this distinction between the rich grasslands of the lower valley and the woodlands of the upper river valley in 1769:

> At this spot where we stopped in the hollow [Ventura River valley] close to the shore, there is a great deal of very good grass-grown level soil trending north and south, very nearly a league's worth [about 3 miles], it may be, of it, backward from the shore. Its width of smooth level soil must be about a quarter-league, and in some spots, where not so smooth, it may reach half a league, while the country opens out a great deal, further up to northward, with a great many hollows of naturally watered soil and a great amount of live-oak groves. (Crespí and Brown 2001)

The relatively early Leighton (1862) map corroborates Crespí's description of largely herbaceous cover, depicting trees along the canyons while leaving table lands mostly bare of trees. Textual sources also describe a fertile, grassy region north of the river mouth; Brewer noted that the Avenue region was a "pretty valley, green, grassy, and rich" in 1861 (Brewer [1930]1974), and Thompson and West ([1883]1961) called it an area of "unsurpassed richness." In 1856, a traveler to the Mission found the lower river valley "fine green country" with "plenty of grass" (Miller 1856, in Weber 1978). Roughly contemporary with many of these observations, the U.S. Coast Survey mapped the Ventura River mouth, also depicting herbaceous cover outside of the river corridor (Johnson 1855c; see fig. 4.20).

Overall, however, the habitat map may significantly underestimate historical oak woodland extent as a result of methods that default to grassland/coastal sage scrub in the absence of spatially explicit data. The descriptions and maps cited above suggest that, in contrast to the dominance of grass and scrub on the Santa Clara valley floor, oak and scrub may have been the dominant vegetation complex on the Ventura River valley floor above Foster Park.

Wetland Habitats

Only one freshwater wetland complex was documented on the Ventura River valley floor outside of the river corridor. (This does not include the lake at Figueroa Street on the coast, which is treated separately; see page

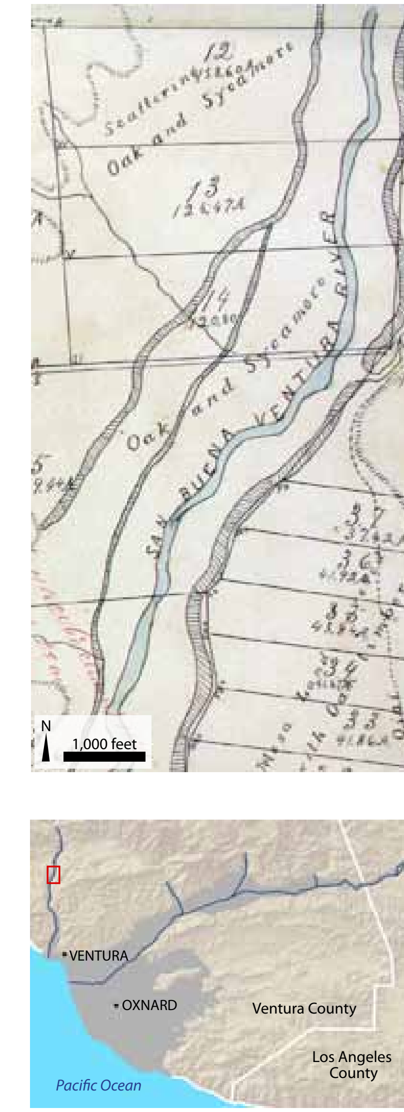


Fig. 4.4. Ventura River in the vicinity of present day Oak View, 1876. This late-1800s map depicts sycamores and oaks occupying the river corridor, as well as "scattering oak and sycamore" on the valley floor between the high bank and the scrub-covered mountains to the west. (Hare 1876, courtesy of the Ventura County Surveyor's Office)

196. It also does not include Mirror Lake, a wetland feature formerly situated east of the Ventura River between Mira Monte and Oak View, just outside the project area.)

The complex, over 16 acres in extent, occurred in a topographical low spot east of the Ventura River along modern-day Olive Street for ½ mile between West Park Row Avenue to the south and Bell Avenue to the north. It marked a portion of a former route of the Ventura River. It was documented on the 1855 T-sheet, but had disappeared by the 1870 resurvey (Johnson 1855c, Greenwell and Forney 1870; see fig. 4.20). Further research may reveal other freshwater wetlands in the Ventura valley whose presence was unrecorded by the historical documents we uncovered.

Channel Morphology

The Ventura River dominates the majority of the Ventura River valley, with multiple braided channels transporting water and sediment across its broad floodplain. Active uplift, steep slopes, and unconsolidated marine sediments give the Ventura River an extremely high sediment load, one of the highest per unit area in the United States (U.S. Army Corps 2004, Greimann 2006). These same conditions produce coarse substrate and the river's braided form, as channels shift location frequently (Keller and Capelli 1992).

In this section, we review the historical physical characteristics of the Ventura River, including lateral extent and stability, in-channel features, and changes in bed elevation. Since there are relatively few data available (especially in comparison to the Santa Clara River), these topics are only briefly reviewed below.

River Corridor Position and Stability

The Ventura River corridor (including the active channel, in addition to bottomland areas susceptible to flooding) was mapped using similar methods as for the Santa Clara River, with the earliest reliable source available for each section of the river used to map outer bank position in a GIS polygon layer (fig. 4.5). Historical aerials (from 1927 and 1945) were the primary sources used to complete the mapping, though a few earlier maps were also incorporated. This methodology is described in more detail in the Santa Clara River section (see page 63).

The overflow area of Ventura River is well-defined and includes nearly all the valley floor between the mesas and low hills on each side.

— KELTON 1940

Since no contemporary mapping of the river corridor was available, we were unable to quantify changes in extent from this mapping to the present. However, contemporary aerial imagery reveals a few places where levees have limited river corridor extent (such as along the lower river west of Ventura), and where agriculture or development has encroached into the corridor (e.g., at Live Oak Acres and along Meyers Road near Meiners Oaks). In other reaches, such as near southern Oak View, the river corridor appears relatively unchanged.

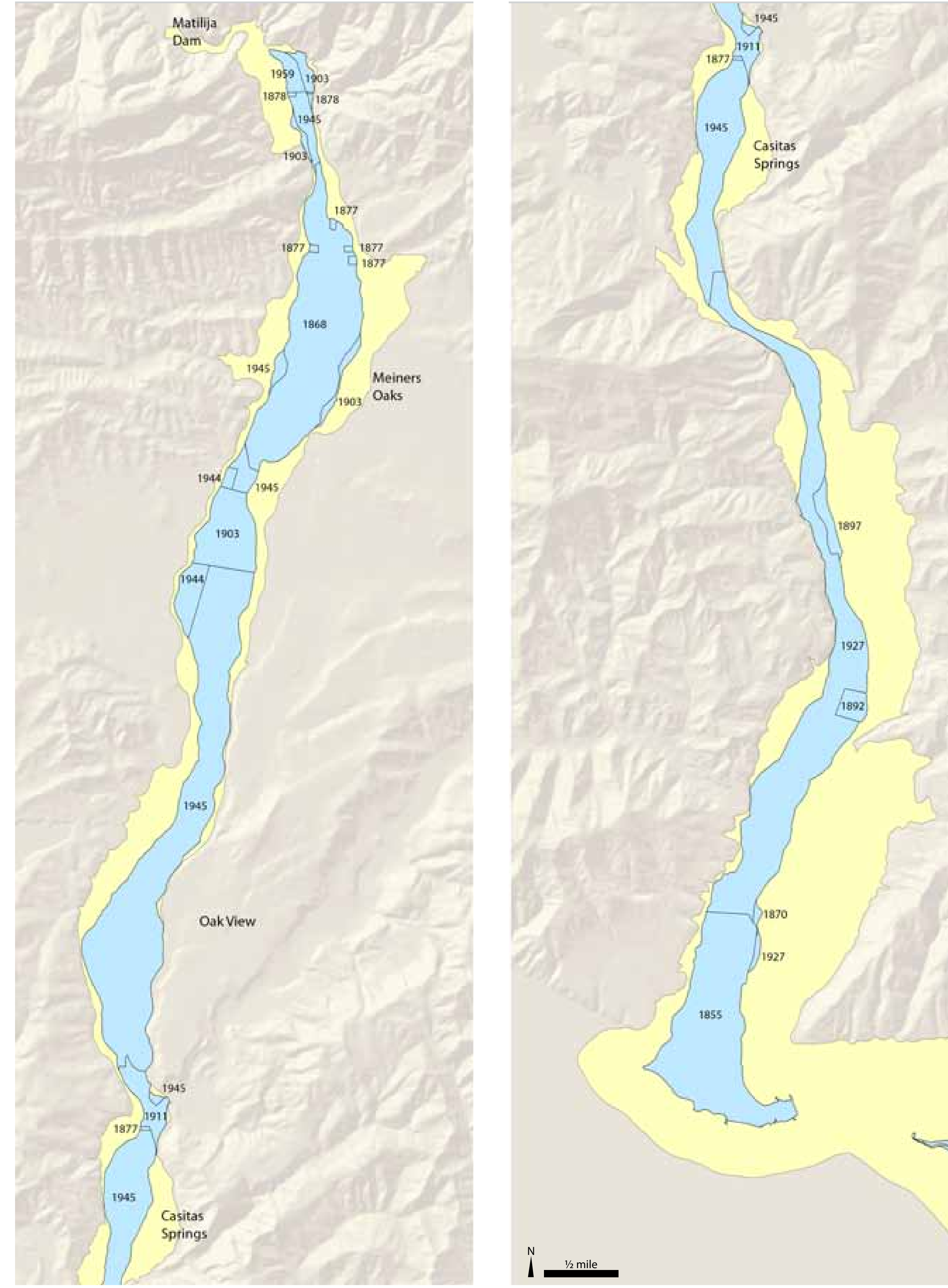


Fig. 4.5. Location of the Ventura River corridor by earliest available source, 1855-1959. We mapped the historical position of the outer bank using the earliest available data for each stretch of the river.

LARGE-SCALE CHANNEL CHANGE Within the river corridor, mainstem and distributary channel location changed frequently with flood events, as the river reoccupied old channels and formed new ones. In addition, historical sources indicate that a few major floods caused large-scale changes in the position of the Ventura River's outlet to the ocean. Interviews with long-time Chumash residents indicate a series of significant changes in the location of the river mouth over about a 1.5 mile stretch of the shoreline, from the hills west of the river mouth to Figueroa Street in Ventura. These accounts describe that the mouth of the river used to be far to the west of its present location: "The V.[entura] river first had its mouth many years ago at the foot of hills west of V. river valley. This was long ago" (Harrington 1986b). (The informant also noted that a "tule patch" at this former river mouth was formerly used to store canoes.)

Accounts state that the river mouth then shifted about 1.5 miles east, to what is now Seaside Park east of the Ventura County Fairgrounds (Sheridan 1912, Harrington 1986a, Harrington 1986b). In the 19th century, a lake here marked the former outlet of the river (see page 196). A number of statements describe the character of this former river mouth:

> The Ventura River used to empty into the ocean where the estero is now situated by the bathhouse west of the Ventura wharf, east of the present mouth of the river. The old Ventura canoe builders used to leave their canoes at that place (ancient mouth of the river)…They bent tule that was growing there on both sides over the canoe…and thus make a shade for the canoe. (Harrington 1986b)

> …in 1825 the Ventura River had its channel where now is Ventura Avenue, and that it emptied to the sea where the slough is, just east of the old racetrack grounds. It followed a course through what are now the courthouse grounds. All the land beyond to the Taylor Hills was good farming land. (Sheridan 1912)

This lake and former river mouth were also the site of a Chumash village, Mitsqanaqan. One of ethnographer John P. Harrington's informants recalled that Mitsqanaqan did not expand west of the lake because "it was said by the old Indians that the vicinity west of the lake was the mouth of the river and that the river was likely to shift its course" (Harrington 1986b).

For the first time in 12 years, Seaside Park was yesterday under water… flood waters forced campers to pack their belongings…The tennis courts, the picnic grounds and the race tracks were all under water.

— VENTURA DAILY POST, 4/8/1926, IN MOORE 1936

In the early 19th century, accounts state that the river mouth shifted from the Seaside Park location westward, closer to its current location. The date at which this shift occurred is not clear: one source states that it occurred in 1810 (Harrington 1986b), while another source inferred that it occurred later, likely during the floods of 1825 (Sheridan 1912). Many smaller changes in the river outlet location have been documented since. One source describes the shift from near Seaside Park first to the west, then slightly back toward the east:

> The mouth of the Ventura river used long ago to be at Mitsqanakan. Then it shifted to a place some distance west of its present mouth, where the little railroad bridge is west of the big railroad bridge. Then it shifted to its present location. (Harrington 1986a)

Early maps of the river mouth, in particular the T-sheets of 1855 and 1870, document the position of the river mouth in the mid-19th century. While locations differ slightly, they are within about 500 feet of each other, in contrast to the earlier large-scale changes. A later map shows the river mouth in the same location as the 1855 T-sheet (Barry 1894).

Later channel changes due to flooding often mirrored the extent or location of these former mouths. During the 1867 floods, the river reoccupied its former outlet near Mitsqanaqan, and "all of what is now Seaside Park became a lake" (Sheridan, in Moore 1936). The river similarly reoccupied this course during the extreme floods of 1884; in addition, the *Ventura Signal* reported that to the west "the river formed a new channel on the Taylor Ranch, over near the mountain by cutting through the great body of land which of recent years has been cleared of its thick growth" (*Ventura Signal* 1884 and Sol Sheridan, in Moore 1936). In 1909, the *Ventura Free Press* reported that the "mouth of the river is at the extreme western point of the lake, a quarter of a mile further to the westward than it has ever been known to be…almost as far west as the big sandhills between the Taylor ranch pasture and the ocean" (*Ventura Free Press* 1909b). A February 1992 flood also reoccupied a former distributary channel (Keller and Capelli 1992, Capelli 1993).

Hydraulic Geometry and Channel Form

PATTERNS IN THE RIVER CORRIDOR A variety of different features were documented in the historical record within the outer banks of the Ventura River. In-channel characteristics such as bottomlands, islands and bars, substrate, mainstem channel patterns, and pool locations were all noted, and are described below.

Within the flood plain of the Ventura River the main stream meanders widely, and the immense amount of debris carried by floods causes rapid and destructive shifts of the current. The stream channels generally are too ill-defined, limited in capacity, and unstable in character to give a definite indication of future flood stages.

— KELTON 1940

Some reaches of the river were relatively narrow (e.g., in Matilija Canyon or below Foster Park); these areas were often characterized by a relatively narrow active channel flanked by dense mixed riparian forest. In other reaches, however, multiple mainstem channels surrounded by riverwash threaded around established vegetated bars and islands. A few early maps capture this complex in-channel pattern, depicting networks of washy, broad channels and islands (Barry 1894, Barry 1897, Waud 1903, Everett n.d.; fig. 4.6). The size and quantity of sediment entering the river helped form the multiple braided channels that would often shift location within the river corridor in a major flood. A 1940 flood control report stated that mainstem channels were "ill-defined" and "unstable" (Kelton 1940).

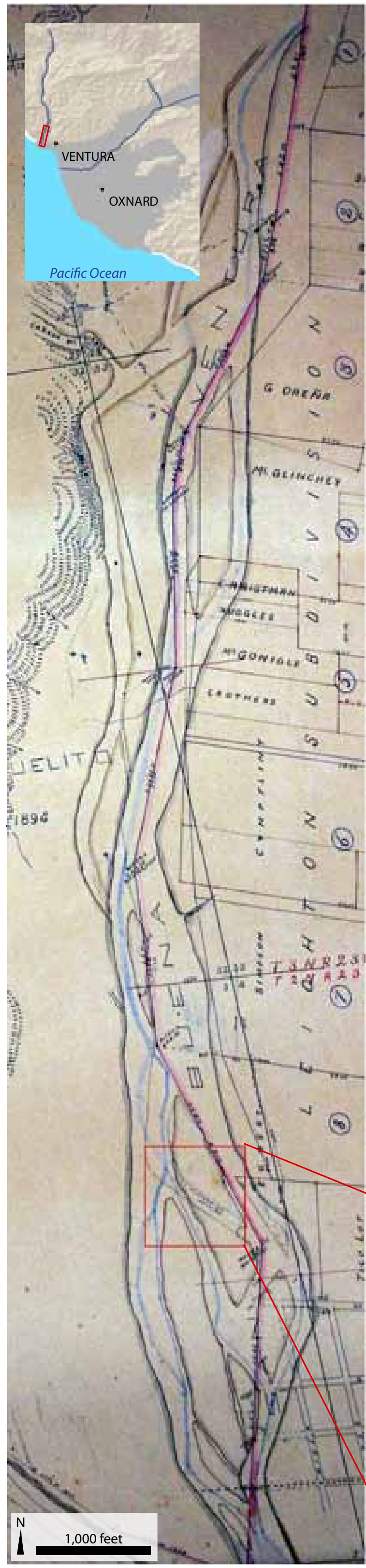
The most notable aspect of these maps is the presence of large, well defined islands; on these maps coarse depictions of the area of individual islands ranges from less than one to over 35 acres. Other sources also describe islands in the river: a *Ventura Free Press* article refers to "rocky islets" near the mouth, and an early soils map shows gravelly and bouldery islands west of Ojai (fig. 4.7). One long-time resident described camping in the early 20th century on an island at the confluence of Coyote Creek and the Ventura River:

> The parks became very popular. On what became known as the "Island," between Coyote Creek and the Ventura River, many Ventura people established camps and spent the summer there. The same was allowed east of the river. Each summer we built a temporary dam in the river to make a swimming pool. (Percy 1957)

The likely location of this island is documented in early 20th century maps of the area (Everett 1908, Unknown ca. 1910e).

In addition to islands, the presence of bottomland surfaces similar to those documented on the Santa Clara River is consistently recorded on the Ventura River. GLO surveyors crossing the river note the "river bottom" or "bottom lands" as they enter the floodplain (Thompson 1868, Norway 1877, 1878a). In many places this land, slightly higher than the washy active channel, was used for pasture, or cleared and cultivated for annual crops such as alfalfa (Lippincott 1903).

One notable difference between the Santa Clara River and Ventura River was the size of substrate in the channel, a characteristic shaped by the Ventura River's steeper channel gradient. Gravel, cobbles, and boulders were commonly found in all reaches of the Ventura River; in contrast the Santa Clara River was dominated by sand. (This is still the case today: intertidal cobble substrate, a notable and relatively rare feature along the California coast, is found at the Ventura River delta and supports a variety of marine plants and invertebrates; Ferren et al 1990, Capelli 2010.) At the river mouth in August 1769, Crespí wrote that the river "gave us some trouble on account of the stones and the large amount of water which ran above them" (Crespí and Bolton 1927). An article during the 1884 floods described a new channel at the river mouth "cut through a solid bed of boulders packed in sand" (*Ventura Signal* 1884, in Moore 1936), and a T-sheet resurvey noted "gravel and boulders" (Kelsh 1933a). Further upstream, an 1887 account describes the head of the intermittent reach, where "gravel spreads far over the desolate bottom" (Hassard 1887). Many historical landscape photographs of the



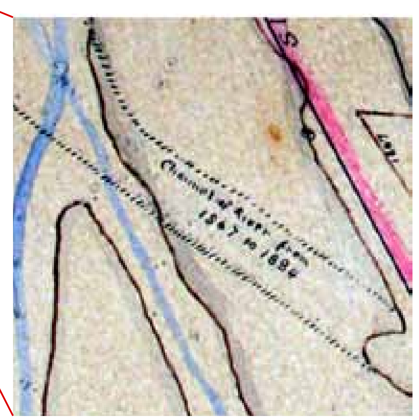


Fig. 4.6. Islands in the Ventura River channel, 1894. This 1894 map shows continuous islands, some over 20 acres in extent, stretching up the first three miles of the river from its mouth. The documented extent of islands extends at least another two miles upstream (Barry 1897). The detail at left shows channel change as a result of the 1884 floods as captured by the surveyor. (Barry 1894, courtesy of the Ventura County Surveyor's Office)

river show coarse substrate on the river bed (fig. 4.8). While some of these photographs were taken after floods and thus may somewhat overemphasize the relative proportion of cobbles and boulders to finer substrate, they still reveal an overall trend toward coarse bed material.

Favorite childhood swimming holes were recalled by long-time residents along the Ventura River mainstem (another feature not well represented on the Santa Clara River, at least by the historical record). J.H. Morrison, who was born in 1887 and grew up on the lower Ventura River, described his favorite swimming holes in the 1890s:

> The shallow mill pond [from the Rose Flour Mill] furnished a fine swimming-hole which we small boys shared with Mrs. Orton's ducks until we graduated to Big Rock, Mays, Dumond's or any one of several deep pools along the river. (Morrison 1959)

Additional swimming holes on the lower Ventura River (below Foster Park) were described by current Ventura residents as part of the Lower Ventura River Parkway vision plan (606 Studio 2008).

INCISION/CHANGES IN BED LEVEL Only fragmentary evidence was uncovered regarding historical trends in bed elevation on the Ventura River. As for the Santa Clara River, there may be additional elevational data (such as cross-sections, surveys for bridge construction, and as-builts) available to study incision rates over time. Obtaining and analyzing these data, though outside the scope of this study, would futher the discussion about historical changes in bed level.

Before the construction of Matilija Dam in 1947, high sediment loads and large, episodic flood events created cyclical changes in bed level, as elevation increased with sediment delivery and deposition only to be scoured out during large floods. This dynamic was captured by descriptions of large floods of the late 19th and early 20th centuries. A 1909 flood was reported to "have washed out the bed of the entire stream to an unparalleled depth below the old bed" near the river mouth (*Ventura Free Press* 1909b). The *Ventura Free Press* (1885) reported that flooding in 1885 did not extend as far as the flooding of 1884, "owing to the deepening and widening of channels by previous floods." A similar process contributed to the minor effects of the 1916 floods following the heavy floods of 1914, since "the flood of 1914 had divested an exceptionally wide channel of all brush and trees and at the same time had deepened the same course so that the waters [of 1916] met with a minimum of diverting resistance" (Moore 1936). Scouring during the flooding of 1914 was so extensive that as late as 1937, it was reported that "the high waters in 1914 cut the channel so deep that since that time it has given you no trouble" (Moore 1937). One witness quantified this incision at Foster Park, testifying that a channel eight to nine feet below the "ordinary stream bed" was created during the 1914 floods (Moore 1937). General trends were also described in the same document:

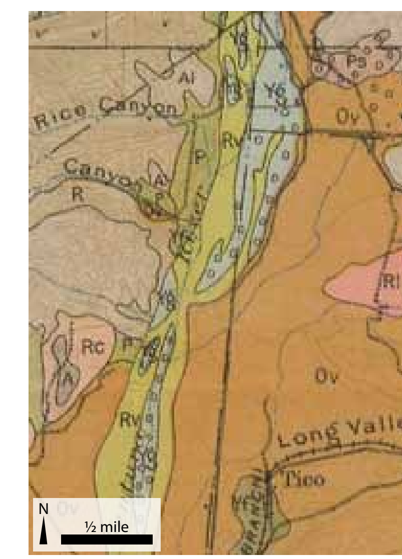


Fig. 4.7. Islands in the Ventura River, 1917. The 1917 soil map shows islands surrounded by riverwash (Rv) over a three mile stretch west of the Ojai Valley. The islands are composed of coarse Yolo gravelly and bouldery fine sandy loam (Yg), a soil type documented to support live oaks and sycamores on alluvial fans in the Santa Clara River valley. (Nelson 1917)

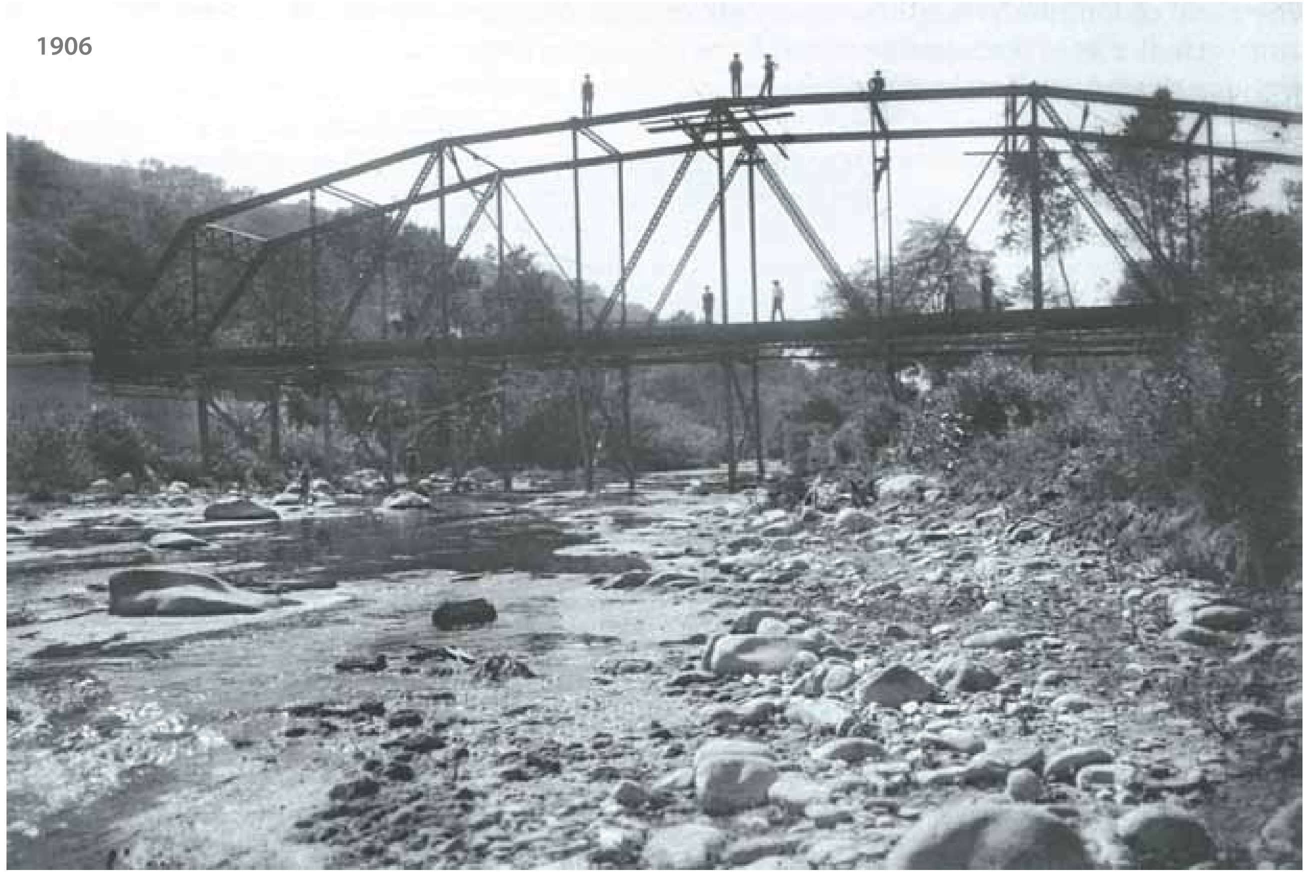


Fig. 4.8. These images of the Ventura River at Foster Park (top, ca. 1906) and at Main Street in Ventura (bottom, 1916) show the abundant cobbles and boulders characteristic of the river bed even nearly at the estuary. (Unknown ca. 1906, courtesy of Craig Held; Unknown 1916, courtesy of the Museum of Ventura County)

> Chairman Cruse: "Generally speaking is the Ventura River a scouring river or a flooding river, that is to say, do floods scour the river bed, or is the river bed spread out over large areas?"
>
> Mr. Ryan: "I notice the elevation at Casitas Pass has been lowered and I believe in all these California rivers they are, and I know there is a deposit in the center of the Ventura River at the lower end which is filled up, and in the main channel down several miles they are inclined to scour, that is what we found last year." (Moore 1937)

Dry Season Flow

Unlike the Santa Clara River, there is little early (pre-1900), reach-specific evidence for summer flow conditions on the Ventura River. Early explorers only described conditions at the river mouth, while other observers made comments about the river's water supply that provide only a general picture of early conditions. In August 1769, Crespí noted an "abundance of water" and a stony river bed near the ocean (Crespí and Bolton 1927). Mission Father Señán (1817) also described an "abundance of water from the San Buenaventura River." One eager writer described the river as "a clear brawling stream singing down in the summer months by way of a succession of pools and rapids where the trout lie hidden" (Unknown ca. 1909).

Other early generalizations on flow conditions emphasize the aridity of the region and the lack of water in the river. One article asserts that the Santa Clara and Ventura rivers "sink during the summer, before they reach the ocean" (*Daily Alta California* 1864). Holmes and Mesmer (1901c) also describe both rivers as "dry in their lower reaches," retaining only a "small summer supply for irrigation." Though these statements do not reflect average conditions as described by more reliable sources on the lower Ventura (or Santa Clara) River, they do illustrate the general presence of dry reaches on the river.

Both descriptions of the Ventura River—as an abundant source of water, and as an arid stream—have some element of truth. Documentation of flow conditions on the Ventura River consistently depicts three reaches with distinct summer flow regimes within the study area. These reaches are depicted on the historical topographic quad for the river (USGS 1903c; fig. 4.9). The first perennial reach extends from beyond the northern edge of the study area (Matilija Hot Springs) downstream to around the Cozy Dell Canyon (Matilija reach). Below this, the Ventura River valley begins to open up into the head of the Ojai Valley, and the river is intermittent until below

Fig. 4.9. Intermittent and perennial reaches on the Ventura River, 1903. The early USGS topographic quadrangle depicts summer flow conditions on the Ventura River. A solid line indicates perennial flow, while a dashed line signals an intermittent reach. The quad shows the river as about half perennial and half intermittent. (USGS 1903c, courtesy of the Los Angeles Central Library)

Oak View and the river's confluence with San Antonio Creek (Oak View reach). Last, perennial flow is shown from just above the San Antonio Creek confluence downstream to the ocean (Avenue/Casitas reach). However, the precise extent and location of summer water would have fluctuated in response to annual variations in rainfall and runoff. During wet years or series of wet years, reaches with perennial flow would have extended both spatially and temporally, while during dry years intermittent reaches may have been more extensive and would have lost surface flow earlier in the season.

This representation of Ventura River summer flow is supported by numerous additional early sources. Early photographs from the Matilija Hot Springs area show shallow riffles running over a cobble and boulder-strewn river (see fig. 4.10). Ditches brought water downstream from the perennial Matilija reach to irrigate bottomland alfalfa and orange orchards located in the intermittent reach of the river below (Waud 1903, Lippincott 1903). A GLO surveyor noted water in the river in late September 1878, south of the current intersection of Camino Cielo and Rice Road (Norway 1878a).

Shortly after leaving the confined lower reaches of Matilija Canyon, the river spread out into the broad alluvial plains of the Ojai and Santa Ana valleys. This marked a transition between the lush, perennial Matilija Canyon and the scrubby, drier upper Ventura River, as one traveler observed in early June, 1887:

> …we found ourselves at the mouth of…the Matilija Cañon…A rapid brook runs down the canon, shrinking into the deserted bed of what must once have been a broad river, and here and there the gravel spreads far over the desolate bottom. But soon after entering the ravine, the eye is relieved by patches of wood and verdure which at short intervals break in upon the sand. (Hassard 1887)

Storke (1891) also noted that in comparison to the upper Ventura River, the river "flows more tranquilly when it reaches the table-like lands of the Ojai and Santa Ana ranchos" (the intermittent reach) until it "gathers volume from the water of the San Antonio and Coyote creeks" (the beginning of the lower perennial reach).

Below its confluence with perennial San Antonio Creek, the Ventura River flowed year-round once more. About 500 feet below its confluence with San Antonio Creek in August 1877, GLO surveyor Norway (1877) noted that the Ventura River had substantial water present—16 feet wide. (This was one of the driest years on record, so the presence of summer water is particularly meaningful; see fig. 2.10.) The river around the Coyote Creek confluence was a popular area for summer camping and swimming trips (Percy 1957). In "Autumn Days in Ventura," the author described the river below the San Antonio Creek confluence in early fall:

> Before we had reached the wooded cañon of the San Antonio creek, a full moon gave a magical unreality to our surroundings. The stately trees were roofed with wild grapevines from root to crown. They were sentinel towers along the path, and the argent flash of water here and there among them was the blazoned shield of many a silent guard! A dozen times or more we forded the rushing stream. (Eames 1890)

Steady summer flow continued further downstream toward the town of Ventura. (One possible exception is a short reach, less than a mile long, around Casitas Springs, which is mapped on the historical quad as perennial but appears to be scrubby and sparsely vegetated in 1940s aerial imagery.) At Casitas (Foster Park), shallow water flowed over the river's gravel/boulder bottom. One man who grew up on the lower river around the turn of the century described abundant water in swimming holes and other pools along the river when he was young (Morrison 1959). Near the river mouth in mid-August 1769, Crespí described the river as a "very large stream or river where there is a vast amount of fresh water" (Crespí and Brown 2001), though Roberts (1886) noted that the river was often "shallow and easily forded." An alternate version of Crespí's manuscript provides additional detail about summer (August) flow near the ocean:

> They have informed me that this is a river that is split into two branches; that there is not a great deal of water running where we saw it; that the other branch, which is running to the westwards, must have a bed with about eight or ten yards' width of running water that came up to the hocks of the mounts when they went into it to drink. (Crespí and Brown 2001)

The San Buenaventura Mission stone aqueduct brought water from around the San Antonio Creek confluence to Ventura for domestic and irrigation purposes until it was destroyed during the floods of 1861-62 (Triem 1985). This may indicate more abundant or reliable water up near the San Antonio confluence, rather than further down toward the Mission.

God has provided this Mission with an abundance of water from the San Buenaventura River and the streams that flow into it.

— FRAY JOSÉ SEÑÁN 1817

Similar patterns are noted in the mid-20th century, though many accounts indicate an extension in the length of the intermittent reach. A 1937 report described the river as "absolutely dry during at least six months of the year" between Kennedy Canyon and the Coyote Creek confluence (Moore 1937). While this is slightly longer than the intermittent reach as depicted on the 1903 USGS map, it demonstrates that these reaches were largely still preserved into the late 1930s. Cooper (1967) noted more extreme conditions, describing the Ventura River as "dry most of the time," and long-time residents' fond recollections of formerly abundant flow also indicate drier conditions by the late 1950s than were historically present in the river:

> That was in the days when the Ventura River and Coyote Creek flowed water all year. (Percy 1957)

> …it is hoped that any who read this will be convinced that at one time there was water and plenty of it, in the Ventura River. (Morrison 1959)

Residents in the 1970s confirmed the presence of the Oak View summer-dry reach, stating that the reach often had "little or no surface water in the river-bed during the summer" (Ventura County Fish and

[T]he Ventura River…is the southernmost stream of California not muddy and alkaline at its mouth.

— GILL 1881

Game Commission 1973). However, the same report also noted that impoundments, diversions, and wells had contributed to the drying of reaches which had historically maintained surface flow during the summer. Anthropogenic changes in the stream hydrograph, in addition to climatic conditions (see pages 44-45), may have exacerbated the aridity of this intermittent reach beyond earlier conditions. These observations are consistent with the development of major water infrastructure on the river, such as Matilija dam (completed in 1948) and the Los Robles diversion dam and Lake Casitas (completed in 1959). The trend would have been compounded by a mid-century period of low rainfall (see fig. 2.10).

Riparian Habitats and Ecology

In contrast to the Santa Clara River, visitors to the Ventura River commented consistently on the abundance of trees found along the river. In a letter written in 1770, Juan Crespí described that along the Ventura River "there are large groves of willows, cottonwoods, and alders, plenty of oaks for firewood, and plenty of stone for building" (Crespí and Bolton 1927). A 1921 booster article boasted the Ventura River was "bordered by hundreds of splendid oaks whose branches frequently met over our heads" and had "many lovely sylvan glades—ideal spots for picnic or camp" (Murphy 1921).

Portions of the Ventura River were characterized by the presence of large stands of live oaks and sycamores in addition to the ubiquitous scrub—not just on the outer bank (as was largely the case on the Santa Clara River), but also on established islands within the river corridor. This, along with extensive sections of dense willow-cottonwood forest along some portions of the river, formed a riparian corridor that in many ways contrasted with patterns documented along the Santa Clara River.

The outer river banks, bottomlands, and active channel of the Ventura River exhibited distinct vegetation patterns (for definition of terms see page 61). While lone sycamores and live oaks on the outer bank of the Santa Clara River were often notable features in the sparsely forested valley, many of the riparian trees on the Ventura River merged into the surrounding upland live oaks and sycamores. Bottomland areas on the Ventura River were colonized by dense mixed riparian and willow-cottonwood forest in many portions of perennial reaches, while oaks, sycamores and alluvial/willow scrub composed bottomland vegetation in the intermittent reach. The active channel itself formed a largely non-vegetated matrix of scrub, boulders, cobbles, gravel, and sand, similar to the Santa Clara River active channel though with coarser substrate. In many portions of the river, well developed islands above the active channel supported vegetation similar to that found on bottomland surfaces.

As on the Santa Clara River, riparian vegetation varied both laterally and longitudinally, as expected for a semi-arid stream (see page 85). Riparian habitats along the Ventura River were broadly divided into three reaches,

reflecting shifts in hydrology (summer flow, depth to groundwater) and variations in geomorphology (surface elevation, flood frequency). Directly below the present-day Matilija Dam, a short (about two mile) perennial reach was presumably flanked by mixed riparian forest in Matilija canyon, which transitioned to scrubbier cover as the canyon opened up somewhat below the Camino Cielo Road crossing (Matilija reach). As the canyon opened onto the broad flats at the head of the Ojai Valley and the river sank into its bed, riparian vegetation transitioned to a mix of sycamores, live oaks, and scrub (Oak View reach). Beginning at the confluence of San Antonio Creek with the Ventura River, a second perennial reach stretched eight miles to the ocean, and was characterized primarily by mixed riparian forest with patches of scrub and a large, persistent area of willow-cottonwood forest and in-channel wetlands at the mouth of the river (Avenue/Casitas reach). These coarse reach-scale differences in riparian habitat are described in detail below.

Of course, the morphologic complexity created by islands, side channels, and bottomlands would have created many small-scale variations in vegetation distribution, character, and density along the length of the river complicating—and presumably sometimes contradicting—the broad patterns discussed above. In particular, there may have been additional persistent wetland riparian areas historically present on the river but not documented, and at the sub-reach level there were likely short intermittent stretches along the perennial reaches of the river (or vice versa). The descriptions below do not preclude these finer-scale patterns.

In addition, though described patterns appear consistent between 19th century accounts and 20th century photographs, the Ventura River was a dynamic system, and the proportion and distribution of scrub and trees would have shifted from year to year, perhaps changing dramatically during major flood events. This was recalled in relation to the flooding of 1825, when "trees and villages were washed away" around Ortonville (Jones 1938, in Freeman 1968). It was also documented for the 1914 flood:

> If you go up the river now [1937], every tree in that river bed is 23 years of age, just exactly. There wasn't a tree left in the entire river bottom following the flood of 1914 from Foster Park in the main channel clear up to Live Oak Acres. There is a heavy growth of willow, sycamore, cottonwood and alder trees. An alder tree is a very short lived tree so the alder trees suddenly die; when they get 8 or 10 inches in diameter, they all fall and become debris in the channel. (Hollingsworth, in Moore 1937)

Matilija Reach

Extending downstream of the present-day Matilija Dam through the Matilija Canyon and down to the head of the Ojai Valley, the uppermost portion of this reach was confined (in contrast to the more broad, braided pattern at the downstream end of the reach). In the narrow canyon, the riverbed was "a mass of fallen rock and bowlders" (Roberts 1886), without the broad bottomlands found elsewhere along the Ventura River. Another account describes seeing, upon entering Matilija Canyon, "patches of wood and verdure which at short intervals break in upon the sand" (Hassard 1887). A number of sandbar willows (*Salix exigua*) were recorded in Matilija Canyon just upstream of the study area (Bracelin 1932). Early images of the canyon corroborate these descriptions of the confined portion of the river (fig. 4.10).

Less is known about the character of downstream portion of the Matilija reach, after the river exits the most confined portion of the canyon. Historical aerials (Ventura County 1945) show prevalent scrub in the broader channel.

Oak View Reach

For six miles along the Ventura River—from the top of the Ojai Valley near Meiners Oaks, past Oak View and Live Oak Acres, to the confluence of the river with San Antonio Creek above Casitas Springs—the river corridor supported abundant scrub, in addition to substantial areas of live oaks and sycamores colonizing islands and other bottomland surfaces within the river's banks. Riparian patterns in this intermittent reach were notably different from those found on the Santa Clara River mainstem, where substantial in-channel tree cover was not documented (apart from the persistent wetland areas).

The presence of scrub and trees (overwhelmingly live oaks and sycamores) in this reach is described by a number of narrative and textual accounts. The upper portion of the reach, at the transition to a broad, washy river from Matilija Canyon, was especially commented upon (fig. 4.11). Sheridan (1886) described that the "river rushes out across a broad sycamore dotted flat" from the canyon, and Roberts (1886) described the river here as "overgrown with brush, sycamores, and oaks." The early presence of oaks and sycamores is corroborated by GLO survey notes, which describe a "timbered bottom" and "bottom land with heavy oak & sycamore timber" (Norway 1877). The few GLO bearing trees documented in this reach also generally support this description (two live oaks 10 and 48 inches in diameter, and one sycamore 20 inches in diameter; Norway 1877).

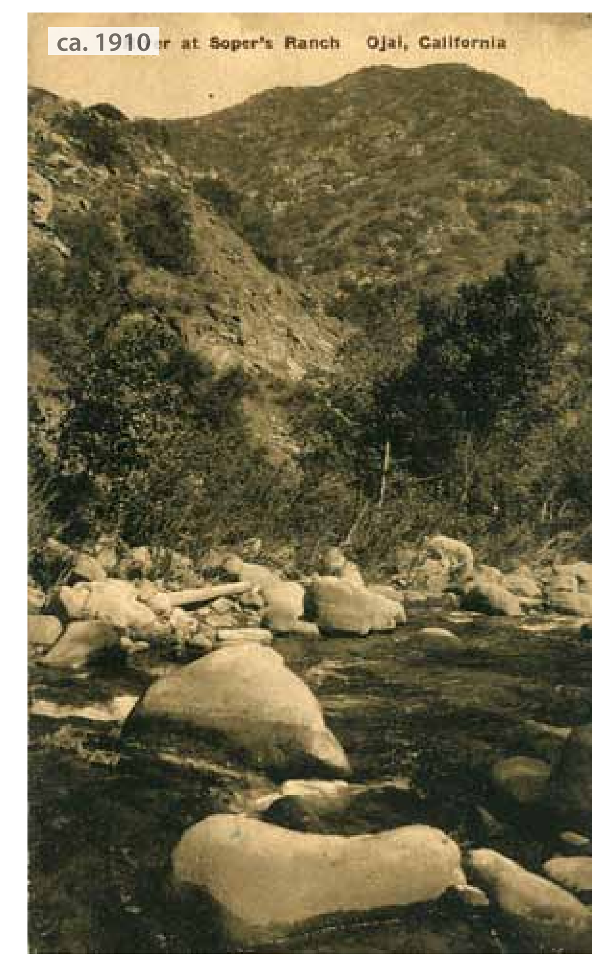
Leave riverwash, enter bottom land with heavy oak & sycamore timber…

— NORWAY 1877, BETWEEN OAK VIEW AND CASITAS SPRINGS

Early maps of the reach also show a mixture of scrubland, oaks, and sycamore. An 1876 map marks "oak and sycamore" near Live Oak Acres toward the bottom of the intermittent reach (Hare 1876). Upstream near Meiners Oaks, a map along two miles of the river shows a combination of oaks, scrub, and grasses present in the river corridor between patches of cultivation, labeling bottomlands "oaks and brush," "oaks, brush & grasses," "oaks (12" to 18" diam)," and simply "brush" (Lippincott 1903; fig. 4.12). Aerial images from the 1940s also show oaks and scrub.

Species data provide additional details on scrub composition in the Oak View reach in the mid-20th century. Chaparral whitethorn (*Ceanothus leucodermis*) was collected in a "wash" of the Ventura River below Meiners

Fig. 4.10. Two views of the upper Ventura River, ca. 1910. These two postcards, both dating from the first years of the 20th century, show the boulder-filled channel of the river in lower Matilija Canyon. The photograph at top was taken at Matilija Hot Springs, just below Matilija dam. The photograph at right was taken less than a half mile downstream. Note the narrow fringe of mulefat, willow scrub, and trees (likely alder, cottonwood, and sycamore). (Unknown ca. 1910b, d)



Oaks (Hoffmann 1932b), and slender woolly buckwheat (*Eriogonum gracile*) and chaparral yucca (*Hesperoyucca whipplei*) were collected in the river near Oak View (Pollard 1963a, 1969). Mulefat was also documented (*Baccharis salicifolia*; Pollard 1944). These records imply the presence of alluvial scrub; it is likely that a mixture of willow and alluvial scrub was present through this reach (fig. 4.13).

Avenue/Casitas Reach

Below Oak View and near its confluence with San Antonio Creek the Ventura River became perennial again, with an accompanying shift in vegetation. This reach was characterized by a matrix of often dense mixed riparian forest, riverwash, and scrub. (One possible exception is a short one mile reach at Casitas Springs, which looks much more like the intermittent reach described above on the 1945 aerial imagery.)

Strongly supporting the concept of dense riparian forest in this reach, an 1840s *diseño* of the Cañada Larga ranch shows a continuous riparian corridor stretching the three miles from near Foster Park to Gosnell Hill/Cañada de San Joaquin (fig. 4.14). The riparian corridor is shown of variable width, including a short reach of oaks south of Cañada Larga and a lot of other trees (interpreted as willow-cottonwood forest). This map is supported by

Fig. 4.11. "Looking west across Ventura River, mouth of Matilija Canyon," February 1930. This photograph, part of the Wieslander Vegetation Type Mapping Project of the late 1920s and early 1930s, shows low scrub flanking riverwash along a shallow, broad channel in the intermittent reach of the river. It was taken approximately one mile below the mouth of Matilija canyon, looking west toward the site of the current Robles Diversion Dam (Capelli pers. comm.). (Clar 1930, courtesy of the Marian Koshland Bioscience and Natural Resources Library, UC Berkeley)

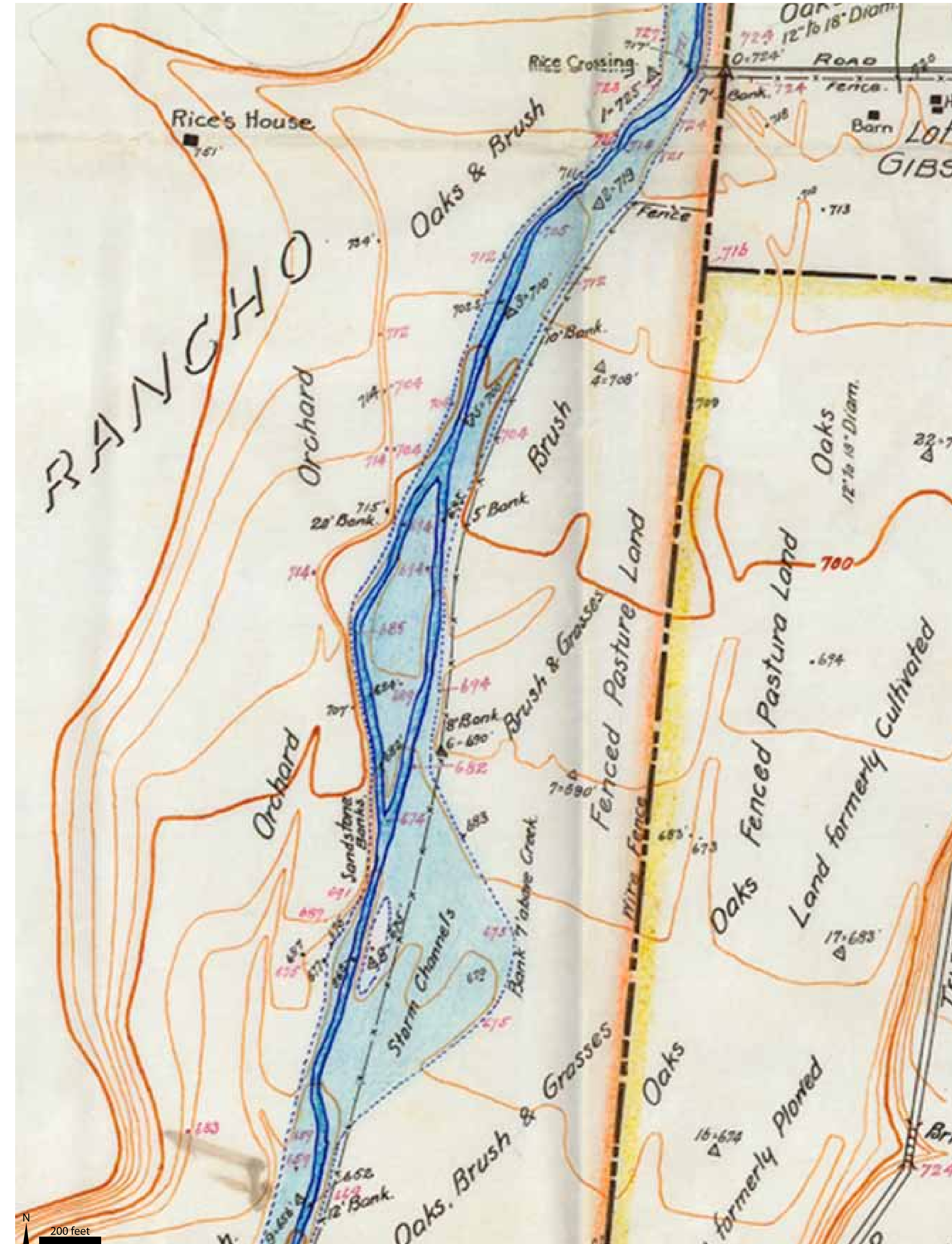


Figure 4.12. Vegetation in the Ventura River, 1903. This map of the river in the intermittent reach near Meiners Oaks shows local-scale variation of riparian vegetation, including oaks, sycamore, and brush, within its outer banks. It is evident from this map that many portions of the bottomland had already been cleared or fenced for pasture. (Lippincott 1903, courtesy of the Museum of Ventura County)

Fig. 4.13. Ventura River at Live Oak Acres. The oblique aerial photograph (top), taken in June 1938, shows characteristic riparian patterns in the Oak View reach. Sparsely vegetated riverwash composes the active channel, flanked by dense scrub on bottomlands. Further away from the active channel, more mature live oaks colonized higher river surfaces. Seven years later, the aerial photograph of the same place in 1945 (left) shows similar patterns of riverwash, scrub, and trees. (Spence Air Photos 1938, courtesy of the Benjamin and Gladys Thomas Air Photo Archives, UCLA Department of Geography; Ventura County 1945, courtesy of UCSB Map and Imagery Library)

Fig. 4.14. Dense riparian corridor along the Ventura River, ca. 1840. An early depiction of the Ventura River for three miles below Foster Park shows continuous riparian forest flanking the river, of variable—and in many places, substantial—width. A small area of oaks is shown along one portion of the river (below the "I"); the small check marks that line the river are interpreted as mixed riparian forest. (U.S. District Court ca. 1840b, courtesy of The Bancroft Library, UC Berkeley)

FOSTER PARK

Within the lower perennial reach of the Ventura River, Foster Park was particularly noted and admired for its riparian trees. The park, created in 1908, is the site of many of the historical data describing the Ventura River, including photographs, specimen records, and textual descriptions. According to one historian, the Foster Park area had been used by both Chumash and Mission fathers (Sheridan 1926). Images of this area show thick stands of trees and scrub growing over cobbles along the river, similar to today (figs. 4.15, 4.16).

Between 1932 and 1972, many plant specimens were collected at Foster Park. While most of these records are too late to be considered unambiguously historically relevant, they do provide a general sense of the wetland character of the reach. Species archived from this location indicate the presence of a diverse willow woodland with three species of willow (*Salix exigua, S. lucida,* and *S. laevigata)*, along with mulefat (Pollard 1946, 1960, 1968, 1972). Obligate wetland species are also recorded, including stream orchid (*Epipactis gigantea*; Canterbury 1939), seep monkey flower (*Mimulus guttatus*, Pollard 1964), least duckweed (*Lemna minuta*, recorded in a "pool in willow thicket"; Pollard 1962, 1965), and water speedwell (*Veronica anagallis-aquatica*, Broughton 1967), indicating presence of surface water through large portions of the year. These plants are described as being in a "willow thicket" or in "shaded pools under willows." Other records document the presence of an alluvial scrub community in portions of the floodplain (e.g., *Eastern Mojave buckwheat/Eriogonum fasciculatum var. foliolosum*; Pollard 1963a).

The diversity of species present in the Foster Park area is further illustrated by a number of ornithological records, which note both the bird collected and the nature of the locality where the bird was found. Records from the early 20th century describe many Allen's hummingbirds (*Selasphorus alleni*) in addition to black-headed grosbeak (*Pheucticus melanocephalus*), yellow-breasted chat (*Icteria virens longicauda*), and warbling vireo (*Vireo gilvus*) (Canfield 1919, 1920; Canfield and King 1919, King and Huey 1919, Huey 1920). Many of these species had nest sites recorded in "thickets" of wild rose, wild grape, or blackberry. One hummingbird was found in a blackberry thicket "completely shaded by grove of tall cottonwoods," while another was found on "an elder bush in dense willow woods" (Canfield 1920, Huey 1920).

Fig. 4.15. Ventura River at Foster Park looking north from the bridge, July 2008. Cottonwoods and willows flank the river, and willows, mulefat, and Arundo colonize coarse bars and islands.

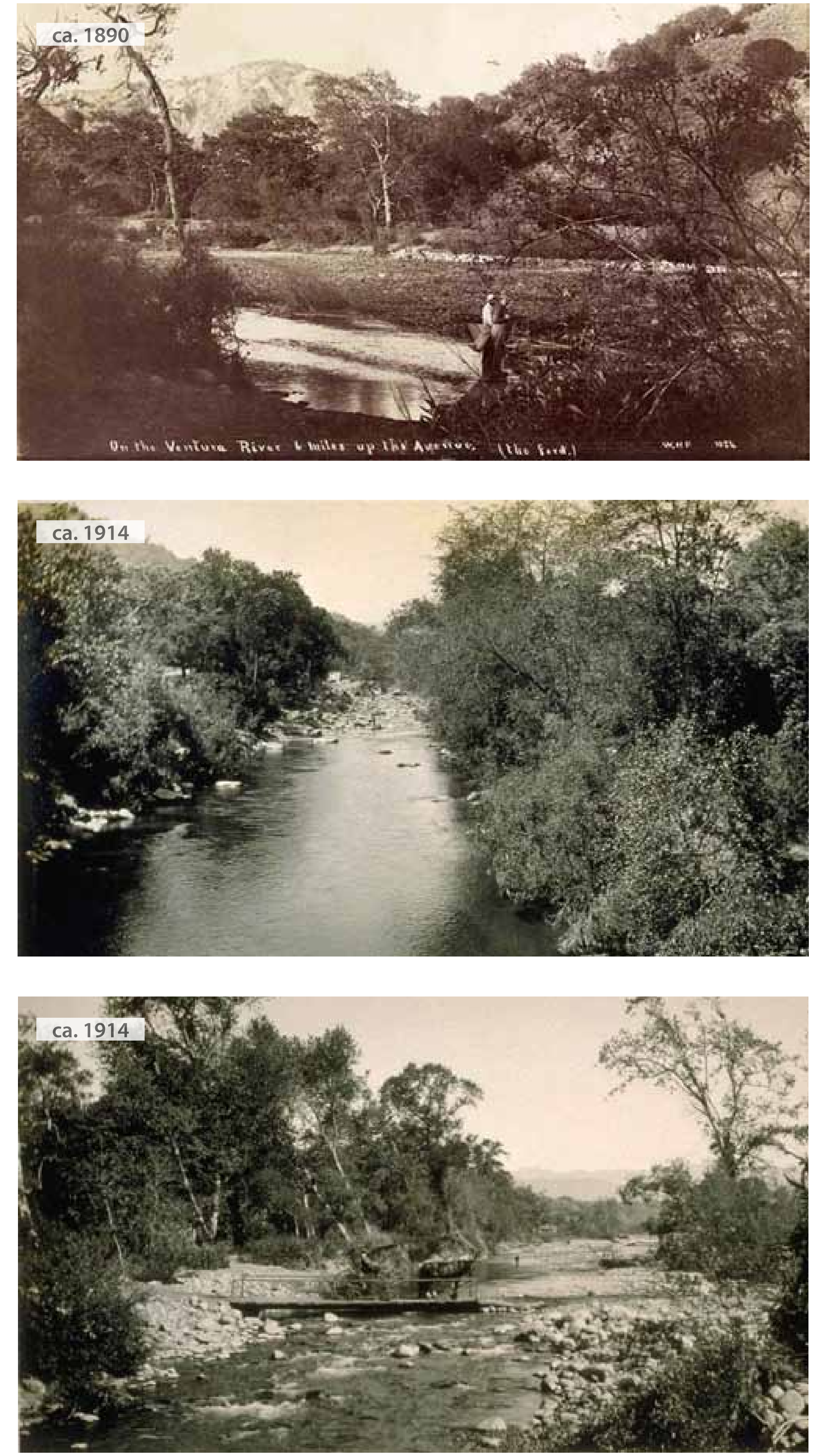


Figure 4.16. Three images of riparian vegetation near Foster Park/Casitas, ca. 1890-1914. Top: "On the Ventura River 6 miles up the Avenue (the ford)," ca. 1890. Middle: "Looking up Ventura River from the Bridge," ca. 1914. Bottom: "Casitas – View of Ventura River Crossing," ca. 1914. These images show three versions of the riparian corridor in the vicinity of Foster Park, including sycamore, live oak, willow, cottonwood, and alder. (Fletcher ca. 1890, courtesy of the California State Library; Unknown ca. 1914a and 1914b, courtesy of The Bancroft Library, UC Berkeley)

> *…the good Padres gathered their neophytes under the trees of the present Foster Park, and called them to their daily prayers and their daily tasks beneath the whispering leaves of the sturdy sycamores and live oaks.*
>
> — SHERIDAN 1926

Fig. 4.17. A section of riparian corridor 1.5 miles south of Foster Park. Broad, dense riparian forest present in 1927 (left) and 1945 (middle) has been converted to agriculture by 2009 (right). (Fairchild Aerial Surveys 1927, courtesy of Whittier College; Ventura County 1945, courtesy of UC Santa Barbara Map and Imagery Library; USDA 2009)

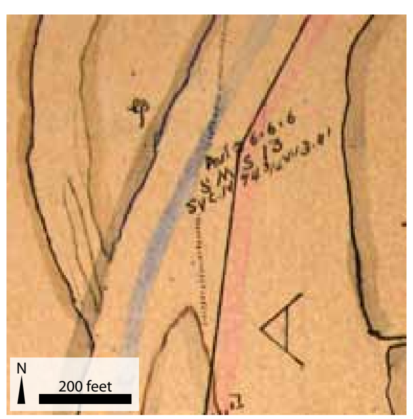


Fig. 4.18. Sycamore on island in the Ventura River, 1894. West of lower Ventura Avenue (and just above the persistent wetland riparian area at the river mouth), this small depiction shows a 24 inch diameter sycamore above the active channel of the river. (Barry 1894, courtesy of the Ventura County Surveyor's Office)

aerial imagery from 100 years later, which still shows many stretches of dense mixed riparian corridor (fig. 4.17). Photographs of this reach show a corridor of dense trees and scrub, particularly in the Foster Park area (see spread, pages 146-147).

A variety of species were documented within the mixed riparian forest. Bottomland trees in this reach included willows, sycamores, alders, box elders, cottonwoods, oaks, and walnuts, in addition to wild grapes and blackberries. A traveler in fall 1890 described "stately trees…roofed with wild grapevines" (Eames 1890), and a newspaper account from 1874 waxed poetic on the beauty of this stretch of the Ventura River:

> Our way for miles was through a shaded canyon, down which coursed a clear stream, bordered by willows and sycamores, whose light-green foliage contrasted well with the dark green of the wild walnut, by which they were thickly interspersed. Wild grape vines trailed in the greatest profusion over every place that offered a support for their clinging tendrils… (*Ventura Signal* 1874b)

This is corroborated by a 20th cenutry specimen of wild grape (*Vitis girdiana*) collected in a "poplar [cottonwood] grove" at the Ventura River-San Antonio Creek confluence (Pollard 1969).

Seven sycamores from eight inches to three feet diameter were used as bearing trees by early surveyors, in addition to a cottonwood tree (30 inches in diameter) and live oaks (20-24 inches in diameter) (Barry 1897, Unknown ca. 1910c). Some sycamores (up to 24 inches in diameter) were found within the channel, suggesting relative stability of islands or other bottomland surfaces (fig. 4.18). In 1937, the channel south of the Casitas bridge was "heavily wooded with cottonwood trees and other growths

STEELHEAD ON THE VENTURA RIVER

The historical habitats of the Ventura River undoubtedly supported a wide variety of aquatic and terrestrial wildlife species, including some that currently have special status designations or are considered locally extirpated. This aspect of the region's historical ecology is not covered in the report (see box on the Santa Clara River, page 101, for more information).

However, given the regional importance of the Ventura River's historical steelhead and trout fishery, it must at least be noted here. Prior to the protracted drought of the late 1940s and the construction of Matilija Dam in 1948, the Ventura River system supported one of the most consistent, abundant runs of the federally endangered Southern California steelhead in the region (Ventura County Fish and Game Commission 1973, Capelli 1974, Capelli 2004, Boughton et al. 2006, Titus et al. 2010). Up to that time, the river supported an important recreational steelhead and trout fishery. In addition to the mainstem river, the estuary would have been important for rearing steelhead and providing habitat for other native fishes.

Numerous early accounts describe large quantities of steelhead and trout in the river. One of the Ventureño Chumash residents interviewed by John P. Harrington recalled in 1913 that formerly "the salmon were very numerous in the Ventura river," while traveler Alfred Robinson wrote that around 1829 "salmon of excellent quality are sometimes taken in the river" (Robinson [1846]1947, Harrington 1986b). Chase (1913) noted that "from May to October the breakfast tables of Ventura need never go troutless."

of that character" (Moore 1937). Additionally, the presence of scrub is documented by much later plant collections, in which two varieties of buckwheat (*Eriogonum fasciculatum* var. *foliolosum* and *E. cinereum*) were documented near Ortonville (Pollard 1961).

River Mouth

We mapped one persistent wetland riparian area on the Ventura River, at the river mouth. This area supported dense willow-cottonwood riparian forest, valley freshwater marsh, and tidal lagoons and marshes. It could be considered a subset of the broader Avenue/Casitas reach designation, highlighting a large area whose persistence is well documented by early sources. Like similar persistent wetland riparian areas on the Santa Clara River, it is large (over 200 acres), broad, and is documented to have persisted over time. Since portions of this grove were adjacent to the city of Ventura and visible to travelers passing through Ventura on their way up- or downcoast, there are multiple descriptions characterizing it. It is mentioned by explorer Crespí, who described in 1769 that "a great many trees are to be seen on this river bed, willows, cottonwoods, and live oaks (sycamores). There are vast numbers of rose bushes at this hollow" and six months later, in 1770: "a vast amount of willow trees, cottonwoods, and a few sycamores and live oaks" (Crespí and Brown 2001). Over 70 years later, GLO surveyor Norris (1853) noted a "willow swamp" in the area. Many other 19th and early 20th century accounts also refer to the willows at the river mouth, describing a river with "willow-fringed banks" (Darmoore 1873) and "willows festooned by wild grape vines and clematis" (Francis and Hobson 1912) that "creeps

Fig. 4.19. Willows on the Ventura River, 1877 (above). A subset of the forest depicted on the T-sheets is shown in this bird's-eye view lithograph. The view is looking northwest across the river and Main Street in the city of Ventura, drawn seven years after the T-sheet re-survey. It further confirms the presence of trees, although the area appears reduced from the initial T-sheet depictions. (Glover 1877**,** courtesy of the California Historical Society)

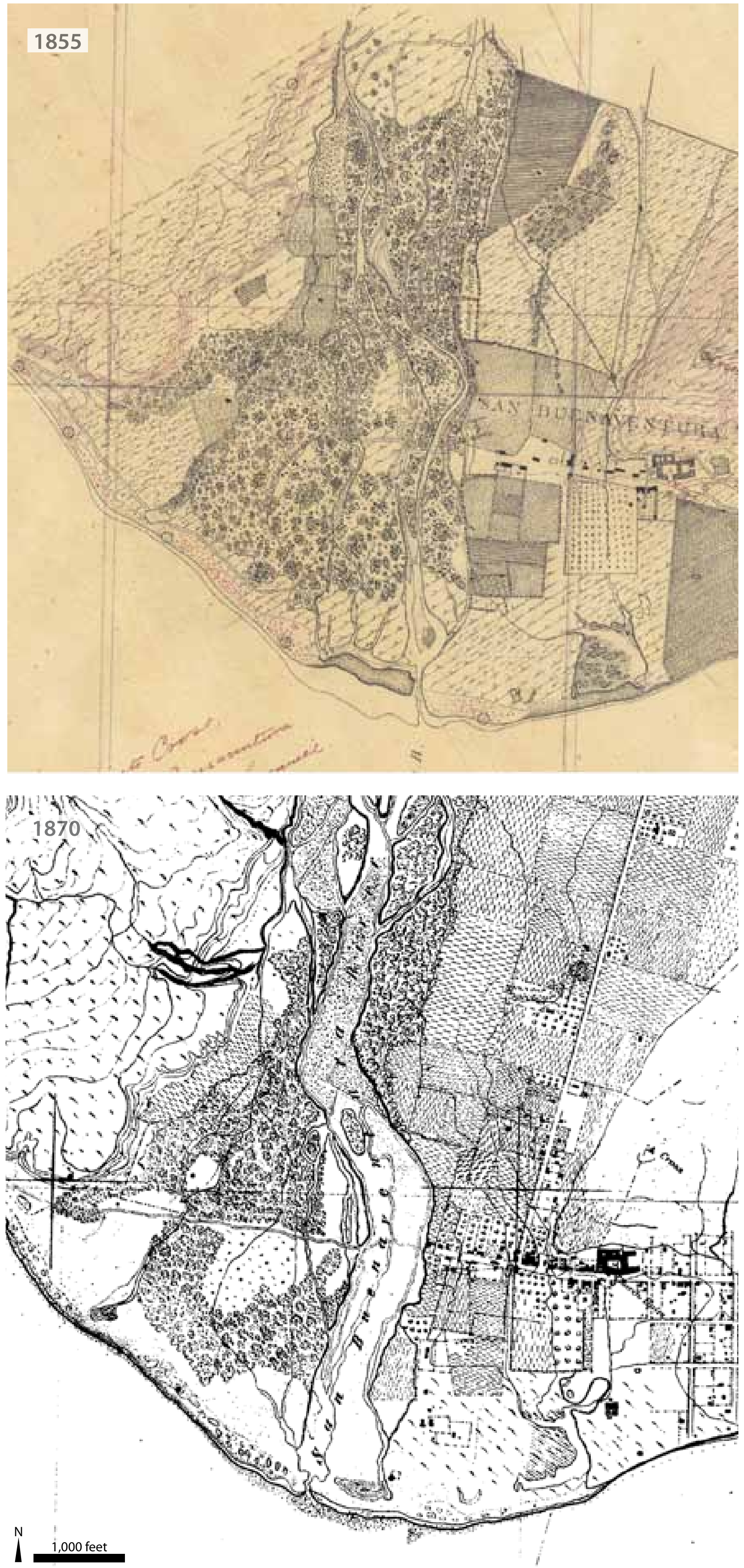


Fig. 4.20. **Riparian forest at the mouth of the Ventura River,** 1855 and 1870. While the initial survey of the Ventura River mouth by the U.S. Coast Survey (top right) provides evidence of the extent of willow-cottonwood forest at the mouth of the river, the re-survey 15 years later (bottom right) shows that, alhtough trees have been scoured near the main channel, the feature transcended the floods of 1861-2. Dense trees near the mouth of the river taper towards the northern edge of the map. (The freshwater wetland marking a former river route can be seen on the earlier map just north of the nascent city of San Buenaventura; it was almost completely gone by 1870.) (Johnson 1855c, Greenwell and Forney 1870; courtesy of NOAA)

lazily out from the grove of alders and willows" (Holder 1906). Early maps also show willows in the area (Leighton 1862, Everett n.d.).

The most persuasive evidence, however, comes from an early T-sheet and resurvey depicting vegetation at the river mouth (Johnson 1855c, Greenwell and Forney 1870; figs. 4.19, 4.20). Since these maps bracket the huge floods of 1861-2, they offer significant evidence of the feature's resilience over time. For a detailed discussion of more recent ecological characteristics of the Ventura River mouth and estuary, see Ferren et al. (1990).

Riverine transformation and synthesis

The Ventura River historically exhibited a diverse suite of ecological, hydrologic, and geomorphic characteristics. This section synthesizes the patterns documented in this chapter to provide a more integrative, visual understanding of riverine properties both longitudinally and through time (fig. 4.22). We also provide a summary of our findings and the implications of our research for management strategies in the watershed today.

We focus here on three sample reaches chosen to illustrate these concepts in cross-section: an upstream reach at Meiners Oaks (fig. 4.23), an intermediate reach at Casitas (fig. 4.24), and a lower reach near the river mouth (fig. 4.25). The transects and accompanying plan form representations illustrate the historical hydrology, morphology, and ecology of the river in these three very different locations in the 19th and early 20th centuries (1853-1903). We also produced cross-sections presenting conditions in these reaches during the mid-20th century (1927-1945) and early 21st century (2005) to depict the impacts of changing land use over this time. Taken together, these reaches represent a broad variability in vegetation and flow characteristics along the river.

We used a variety of historical sources to develop these cross-sections. Our own historical mapping, General Land Office survey notes, a U.S. Coast Survey T-sheet, and a county surveyor's map formed the backbone of our historical transects, and aerial imagery (from 1927, 1945, and 2005) were used to interpret land use changes, vegetation, and channel features on the intermediate and modern cross sections.

In the absence of historical elevational data, we used modern (2005) LiDAR data as the starting point for historical elevations and valley width, making adjustments as needed for the historical renderings (e.g., removing anachronistic road cuts and levees). As a result, the following cross-sections necessarily focus more on changes in floodplain extent and character than on changes in bed elevation.

While these cross sections are only a snapshot of patterns at narrow locations and points in time within the watershed, we believe they offer representative glimpses of temporal and spatial change in three different parts of the Ventura River. Bear in mind that they are purely conceptual in nature, and are not intended to represent exact landscape patterns (e.g., tree density or marsh extent).

Fig. 4.21. Looking over the Ventura River from the Main Street bridge near its mouth, February 2011.

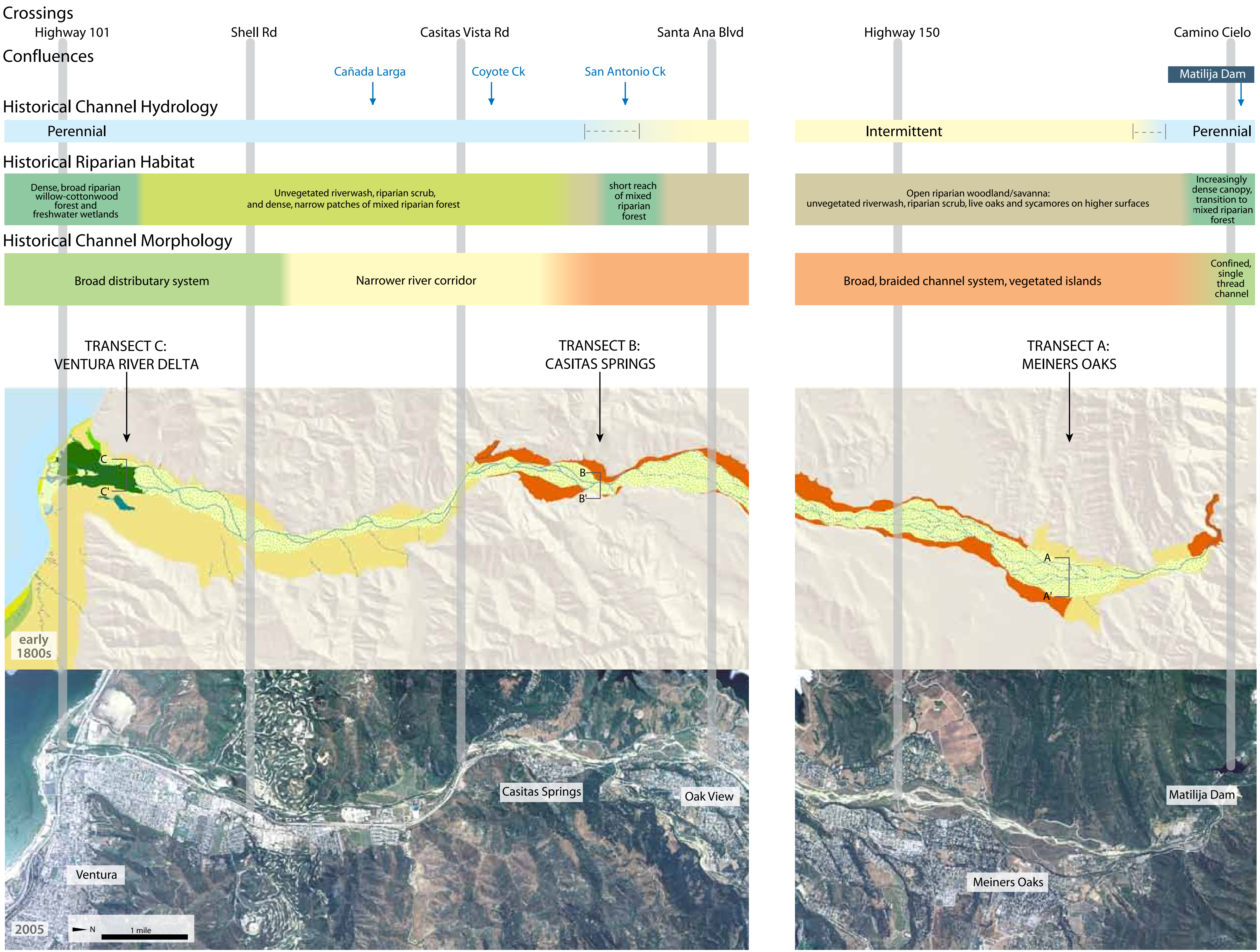


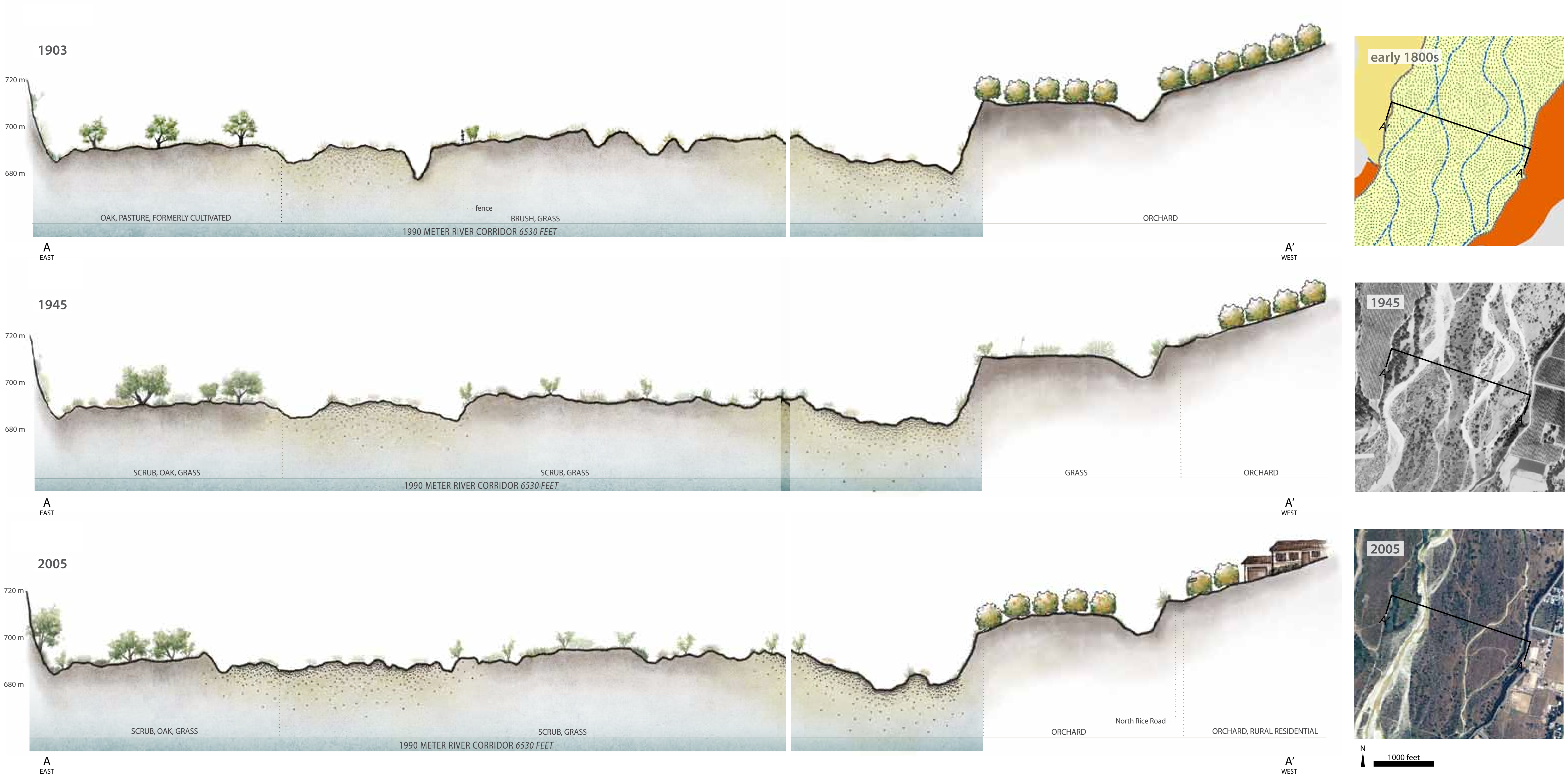
Figure 4.22. Historical characteristics of the Ventura River by reach. This diagram shows how fundamental attributes of the Ventura River varied by reach. The close relationships evident in this diagram between riverine hydrology, ecology, and morphology indicate the interrelated nature of these characteristics. Transitions between reaches were gradual, with variable locations through time. The locations of the three transects (following pages) are also indicated here.

MEINERS OAKS REACH

This reach is located near the town of Meiners Oaks, downstream from where the river exits its canyon and spreads out across the upper Ventura River valley. The area was historically characterized by a broad, braided channel with intermittent flow. Two maps from the turn of the century (1903) record the detailed vegetation (oaks, scrub, and grasses), topography, and braided channel patterns for this reach. At this time there were already multiple early uses of the river; the surveyors recorded orchards and cattle fences crossing the stream and describe in-channel areas as lands formerly used for grazing and cultivation.

By 1945, some of the orchards had been moved away from the river, though the overall character appears largely unchanged in the historical aerial. The same is true in 2005. This area is now part of the Ventura River/Rancho El Nido Preserve.

Fig. 4.23. Historical cross-sections at Meiners Oaks, 1903-2005. This time series shows the Ventura River just west of the town of Meiners Oaks, in a broad, braided section of the river about 2 miles north of the Highway 150 bridge. Broad patterns in river corridor width and ecology have remained remarkably consistent in this reach over time. Cross-sections are drawn with 5x vertical exaggeration. (Waud 1903 and Lippincott 1903, courtesy of the Museum of Ventura County; USDA 1945, courtesy of the UC Santa Barbara Map and Imagery Library; USDA 2005. Cross-sections produced by Jen Natali)

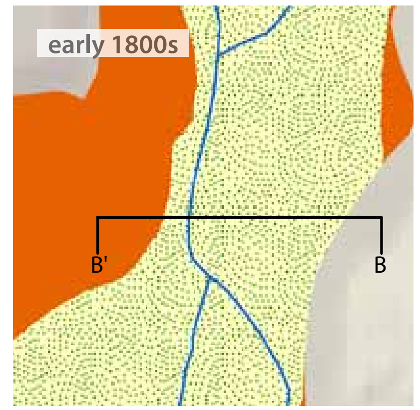


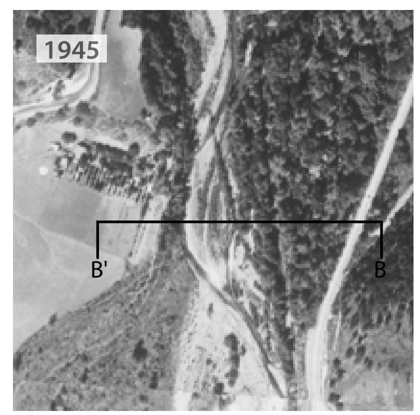
CASITAS REACH

This cross section is located between the present day towns of Oak View and Casitas Springs immediately downstream of the confluence with San Antonio Creek. The toes of two hills narrow the valley here, pinching the river slightly and narrowing the river corridor.

On August 3 and 4, 1877, surveyor W.H. Norway walked this transect; his survey forms the basis of the eariest cross section. Norway described the active channel as "riverwash" 460 feet wide, with a low-flow channel 16 feet wide carrying summer water toward the ocean. (This is especially notable given that 1877 was a severe drought year in the region.) On the eastern side of the river between the active channel and the hills, he noted "heavy oak & sycamore timber" on the "bottomland" surface. He also documented early modifications, including the wagon road connecting Ventura and Ojai and paralleling the river on the western side, and a fence separating agricultural fields from the river on the west bank.

Surprisingly, aerial photos from 1945 show evidently little change in riparian composition and river corridor extent from the snapshot provided by Norway in the late 1870s. The wagon road route remained, replaced by a branch line of the Southern Pacific Railroad. Broad, dense riparian forest still characterized the eastern bank. The most severe modifications occurred in the second half of the 20th century, when a levee on the west bank was constructed and the wagon road remnant transformed into several highways, including Highway 33 and the Ojai Valley Trail Road. Significant riparian forest (willows near the channel, and oaks and sycamores on the eastern floodplain) remains, though it is bisected by the Ojai Valley Trail and Highway 33.





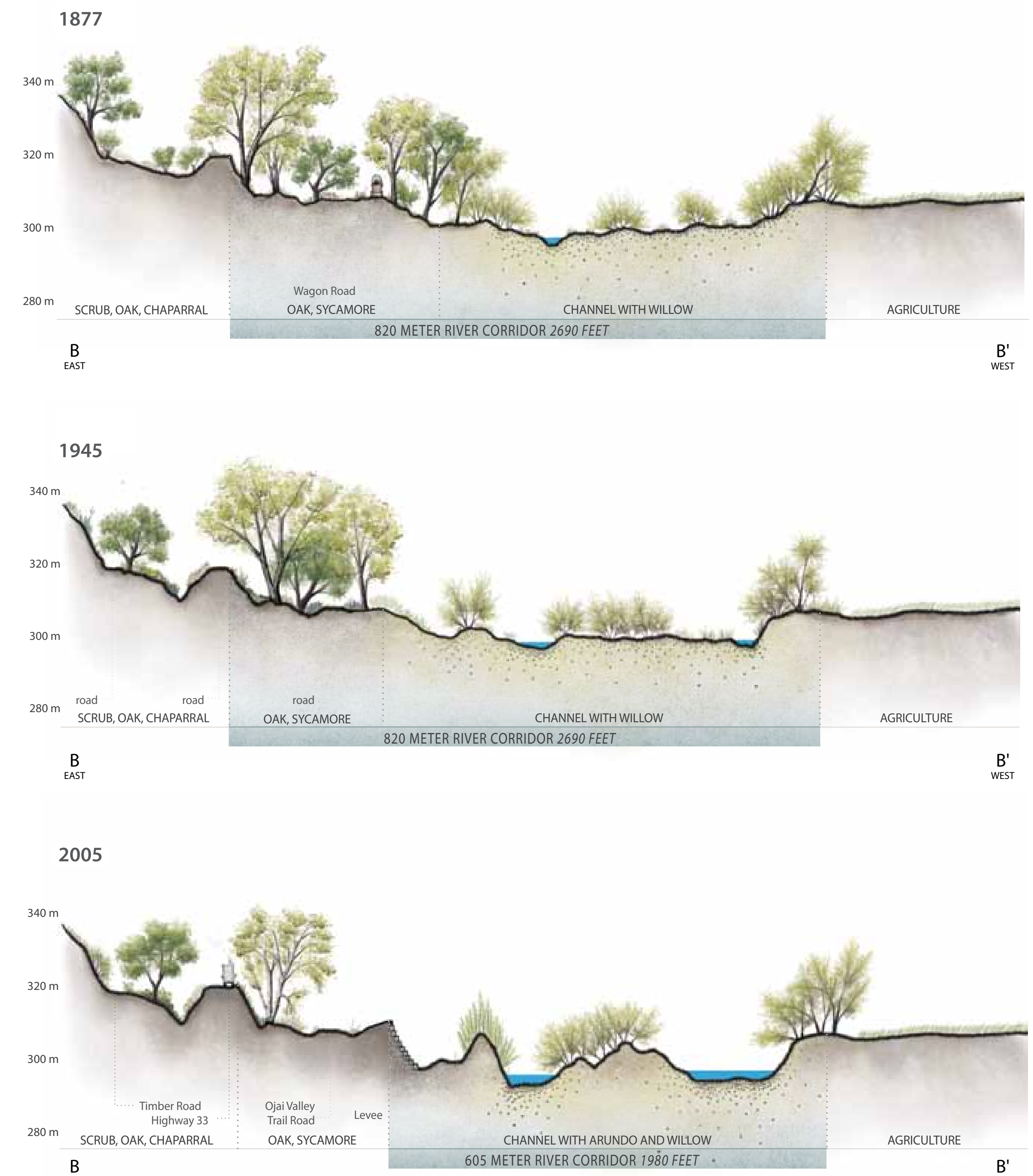


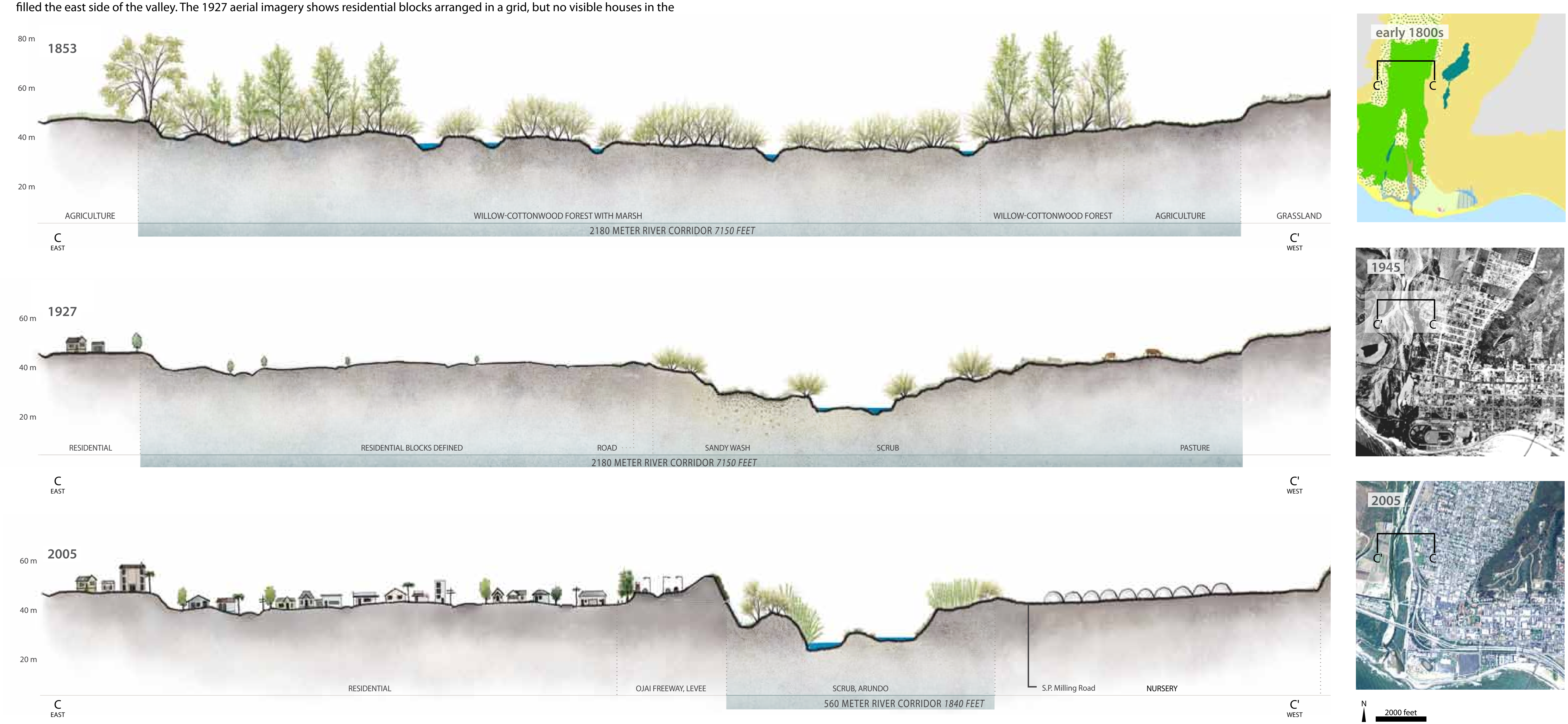
Fig. 4.24. Historical cross-sections at Casitas, 1877-2005. This series of cross-sections shows the Ventura River south of the San Antonio Creek confluence. The transect is in a reach with perennial flow, a relatively narrow river corridor (in comparison to other reaches of the river), and historically abundant live oak and sycamore. Like the Meiners Oaks reach to the north, this reach has retained many of its historical characteristics. Cross-sections are drawn with 5x vertical exaggeration. (Norway 1877; USDA 1945, courtesy of the UC Santa Barbara Map and Imagery Library; USDA 2005. Cross-sections produced by Jen Natali)

VENTURA RIVER DELTA

This cross section captures the dramatic changes over time at the mouth of the Ventura River, about ½ mile upstream of the current Highway 101 crossing. The T-sheet for this area, surveyed in summer 1855, depicts a broad (over 1.2 miles wide) river corridor dominated by interconnecting distributary channels and dense riparian forest. This is corroborated by a GLO survey conducted two years earlier in October 1853, when surveyor Robert Norris noted crossing four channels in the midst of what he termed a "willow swamp." Grassland and some early cultivation bounded the river in the "first rate land in bottom." The 1870 T-sheet resurvey confirms the continued presence of the riparian forest and marsh through the later 19th century (Greenwell and Forney 1870).

Between 1860 and 1930 the population of the city of San Buenaventura increased more than 18-fold, from around 600 residents to over 11,000. (From 1920 to 1930 alone the population of the city almost tripled; California State Department of Finance 2003.) Riparian forest area had severely decreased by 1927, and residential housing blocks encroached into the floodplain and filled the east side of the valley. The 1927 aerial imagery shows residential blocks arranged in a grid, but no visible houses in the river corridor. This may be a snapshot of a post-flood period of rebuilding, or it may be the beginning of a rapid urbanization of the lower watershed. By 2005, the city of Ventura had expanded fully into the floodplain of the river, fortified by a levee and bounded by the Ojai Freeway. *Arundo donax* has established on both sides of the narrowed river corridor; it was described as "well established for many miles along the river" as early as 1945 (Henry Pollard, in Ferren et al. 1990). Industrial agriculture and nurseries have replaced pasture on the west bank of the river.

Fig. 4.25. Historical cross-sections at the Ventura River mouth, 1853-2005. This time series shows the Ventura River at its mouth, about ½ mile upstream from the Highway 101 bridge. The area was dominated by broad willow-cottonwood forest and shallow, multi-thread distributary channels. By the early 20th century, the floodplain had been converted into a much narrower, leveed channel to make way for northward expansion from the town of Ventura. The earliest cross-section is derived from GLO notes and the mid-19th century T-sheet drawn of the river mouth by the U.S. Coast Survey. Cross-sections are drawn with 5x vertical exaggeration. (Norris 1853, Johnson 1855c, courtesy of the National Oceanographic and Atmospheric Administration; Fairchild Aerial Surveys 1927, courtesy of Whittier College; USDA 2005. Cross-sections produced by Jen Natali)



SUMMARY OF FINDINGS

The following findings represent some of the significant conclusions drawn from our research and analysis. Combined with an understanding of modern conditions, these findings can support scientists and managers working to identify restoration opportunities in the Ventura River valley. Further comparison with contemporary Ventura River corridor mapping may help identify and quantify changes over time.

1. **The historical Ventura River valley supported a diverse array of natural habitats,** including valley freshwater marsh, grassland, coastal sage scrub, oaks, and sycamores. While we were unable to map the valley floor in detail, our data indicate a broad transition from grassland in the lower valley (Avenue area) to predominantly oaks, sycamores, and scrub above Foster Park to Matilija Dam. As in the Santa Clara River valley, valley oaks were not documented anywhere in the valley. Only one wetland feature was documented on the valley floor within the study area (not including Mirror Lake).

2. **Most substantial freshwater wetland complexes occurred within the Ventura River corridor.** Aquatic habitats such as ponds, sloughs, and freshwater marshes were likely found in many perennial reaches, and a suite of saline and brackish aquatic habitats was associated with the estuary at the river mouth.

3. **The Ventura River supported a broad range of riparian species,** including trees such as sycamore, live oak, willow, cottonwood, box elder, alder, and walnut; understory species such as wild grape, wild rose, and wild blackberry; and mulefat and alluvial scrub species.

4. **Unlike on the Santa Clara River, live oaks and sycamores were common within the river corridor of the Ventura River.** While on the Santa Clara River live oaks and sycamores were almost exclusively found bordering the river's high (outer) bank, both trees were common on benches, bars, and islands in the Ventura River channel, particularly in the intermittent Oak View reach.

5. **The Ventura River mouth has shifted location numerous times over the past several hundred years,** from the hills west of the river mouth to Figueroa Street in Ventura. Many of these former river mouth areas are still susceptible to flooding. A brackish lagoon, formerly at the site of what is now the Derby Club across from Seaside Park, marked the route of one of these former river mouths.

6. **The Ventura River was generally perennial for much of its length.** The uppermost reach (below the present-day location of Matilija Dam) consistently supported year-round surface water, as did the lower half of the river (below the San Antonio Creek confluence). In contrast, the middle reach, through the western Ojai Valley and downstream of Oak View, was typically dry during the summer. The precise extent and location of summer water fluctuated in response to annual variations in rainfall and runoff.

Management Implications

- **Restoration of historical riparian habitats that have been degraded or eliminated should be considered.** Despite extensive modification, the Ventura River has retained significant habitat features, such as willow-cottonwood riparian forest remnants on the Ventura River delta and alluvial scrub in the intermittent reach near Oak View. Preservation of remnants such as these, which could serve as nodes for river restoration, is an important component of maintaining the ecological diversity of the river.

- **Riparian restoration goals should be reach-specific.** Each of the three reaches of the Ventura River we examined were characterized by different patterns of flow and riparian vegetation, providing valuable information on potential restoration targets that may be realistic for a given reach.

- **Maintaining the hydrologic heterogeneity of the Ventura River is an essential component of conserving ecological diversity.** Groundwater availability (and by extension, summer flow) is clearly a primary driver in the distribution and composition of riparian habitat.

Fig. 4.26. Ventura River at the Rancho El Nido Preserve, February 2011.

5 • OXNARD PLAIN AND CALLEGUAS CREEK

In time we went down a long, steep hill [Conejo Grade], then across a wide valley that supported a rank growth of vegetation, and came to a Mission called San Buena Ventura (good luck).

— MANLY 1894

Introduction

At first glance the Oxnard Plain appears to be an unvarying, homogeneous plain with relatively little ecological variation between expanding cities and intensive agriculture. These changes in land use mask its underlying complexity, however. In recent times the plain exhibited a complex mosaic of habitats and channels, remnants of which are still evident today.

What is now called the Oxnard Plain was known by many other names before the town of Oxnard was founded in 1898. Many early travelers did not refer to it by name, instead considering it to be the westernmost portion of the Santa Clara River valley and referring to it only as "the plain" (Crespí 1769, in Crespí and Brown 2001; Bryant 1848; Geological Survey of California 1865; Brewer [1930]1974). Those that did name the plain called it the Saticoy Plain (Hilgard 1884; the Santa Clara River was also sometimes called the Saticoy River) or the Hueneme Plain (Diller 1915).

The Oxnard Plain is a remarkably flat (under 1% slope), broad, surface, with 111 square miles sloping very gently from the hills to the coastline. With further examination, the plain reveals subtle variations in topography, soils, and hydrology that supported diverse natural habitats (fig. 5.2). We discuss these overarching factors broadly below.

First, variations in the concentration of soil salts, from both tidal flows and seasonal evaporation, created patterns of saline tidal and alkaline upland habitats that covered a large portion (43%) of the plain. The extent of alkali influence stretched far inland, following topographic lows to the west of the Camarillo Hills and near the Calleguas Creek/Revolon Slough drainages (see fig. 5.10).

Second, prominent springs related to geologic contacts, topographic depressions, and artesian conditions created zones of freshwater influence on the plain. Since relatively few watercourses traversed the Oxnard Plain, these were important sources for early settlers. On the eastern plain, lakes, wetlands, and springs in foothill valleys east of Calleguas and Conejo creeks provided a dominant freshwater influence (in addition to the creek itself). On the western portion of the plain, the presence of artesian water,

Fig. 5.1. Simomo (Spring Hill), looking west across the Oxnard Plain (opposite page). This picture, taking in 1932 as part of ethnographer J. P. Harrington's research on the Chumash, shows the edge of a small hill at what was formerly a Chumash village site. The site was well known for its flowing springs. It is now on the Broome Ranch. Note prickly pear cactus (*Opuntia* sp.) on hill in foreground. (Harrington 1932, Courtesy of the Smithsonian Institution)

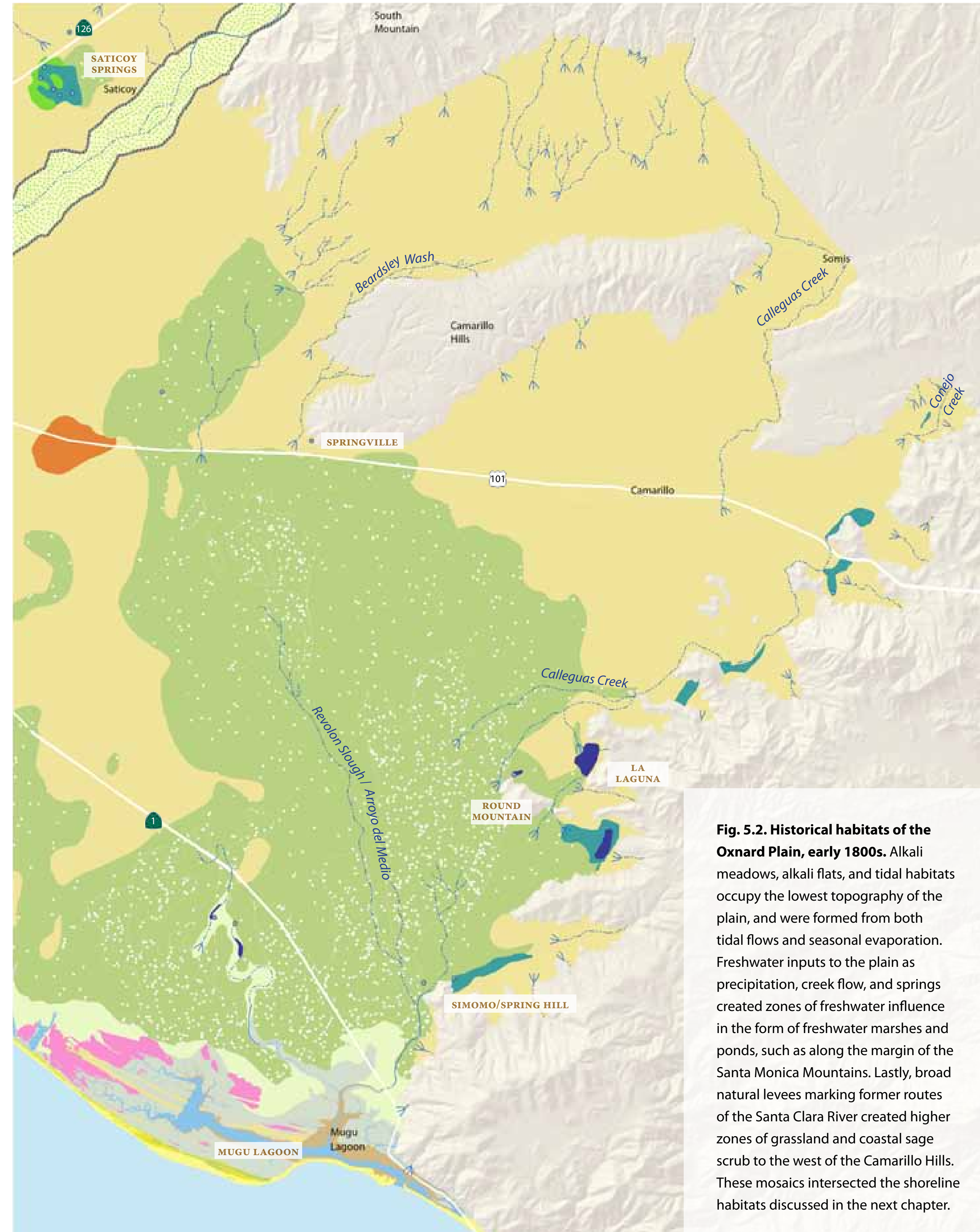


Fig. 5.2. Historical habitats of the Oxnard Plain, early 1800s. Alkali meadows, alkali flats, and tidal habitats occupy the lowest topography of the plain, and were formed from both tidal flows and seasonal evaporation. Freshwater inputs to the plain as precipitation, creek flow, and springs created zones of freshwater influence in the form of freshwater marshes and ponds, such as along the margin of the Santa Monica Mountains. Lastly, broad natural levees marking former routes of the Santa Clara River created higher zones of grassland and coastal sage scrub to the west of the Camarillo Hills. These mosaics intersected the shoreline habitats discussed in the next chapter.

along with surface water accumulations in topographic depressions, was an important source of fresh water for 19th century farmers and settlers on the plain.

Much of the Oxnard Plain was subject to artesian conditions, even well into the 20th century (fig. 5.3; Schuyler 1900, Lippincott ca. 1930; see page 38). Long-time residents recalled that “in the old days the water level was right at the surface” on the central Oxnard Plain, an aspect of the plain’s hydrology that manifested as springs, ponds and marshes, and later in the successful development of artesian wells (Bloom 1959). Even in areas outside the artesian zone, abundant water was recorded just below the surface in many places; a GLO surveyor recorded that in March 1874 in the area around the Camarillo Hills there was “no running water but there is a

Fig. 5.3. Extent of artesian conditions, 1900 (in purple) and ca.1930 (in yellow). Though both are somewhat coarse delineations, they do suggest some shrinking of the artesian zone in the first quarter of the 20th century. (Schuyler 1900 and Lippincott ca. 1930, courtesy of the Water Resources Collections and Archives)

plenty by digging” (Craven 1874a). Surveyor George Tolman (1873) made a similar observation in May 1873 regarding the same region, noting that there was “no running water, but good water to be had by digging from 30 to 60 feet.”

Third, the distribution of coarse sediment on the plain reveals aspects of its history, and helped shape its ecology. In particular, lobes of coarse sediment trace former routes of the Santa Clara River across the plain in recent geological time, marking paths of the river to the Mugu Lagoon area and (more recently) to just south of Point Hueneme. This legacy of the Santa Clara River created higher, well drained former natural levees on younger soils that supported a variety of non-alkaline dryland habitats, including grassland, coastal sage scrub, and a few sycamores. In addition, sediment deposited on the eastern plain during floods (as overbank flow and in portions of Calleguas Creek with no well defined channel) shaped the character of the eastern plain.

Few towns were established on the Oxnard Plain prior to the development of the Southern Pacific railroad around the turn of the 20th century; the early settlement patterns that predate the railroad reflect the ecological and hydrologic patterns of the plain described above. Hueneme was formally established in 1870, but an American settlement at the site dates at least to the 1850s (Johnson 1855b). The community was within the Oxnard Plain artesian zone, and was situated at the mouth of the submarine canyon used for shipping agricultural products. (Chumash occupation of the region at Point Hueneme, meaning “sleeping place,” dates even earlier; the site was used by native residents of the Channel Islands as an overnight rest stop during mainland trading expeditions; Applegate 1974.) Springville, a predecessor of Camarillo located at the western edge of the Camarillo Hills, was a farming community situated near a spring whose name clearly identifies the town’s reason for being. Oxnard began as a company town for the sugar beet processing factory, which was built in 1897 to process the beets grown on the region’s extensive alkali meadows. The city of Oxnard itself, however, was built on the non-alkaline, higher (and therefore less likely to flood) alluvium which marked a former route of the Santa Clara River.

Calleguas Creek and other watercourses

The former scarcity of defined channels on the plain, especially in the western half, is striking. Very few substantial watercourses traversed the western plain. On the eastern Oxnard Plain, creeks flowing off the Santa Monica mountains generally did not connect directly into Calleguas Creek, instead spreading out shortly after exiting their canyons onto the valley floor. Defined creeks and sloughs (including Calleguas Creek, Conejo Creek, and Revolon Slough) gave the plain a drainage density of only 1.7 miles of creek per square mile, a figure which has been greatly increased today (fig. 5.4). Instead, water traveled to the ocean through shallow, undefined surface sloughs and swales and through subsurface flow.

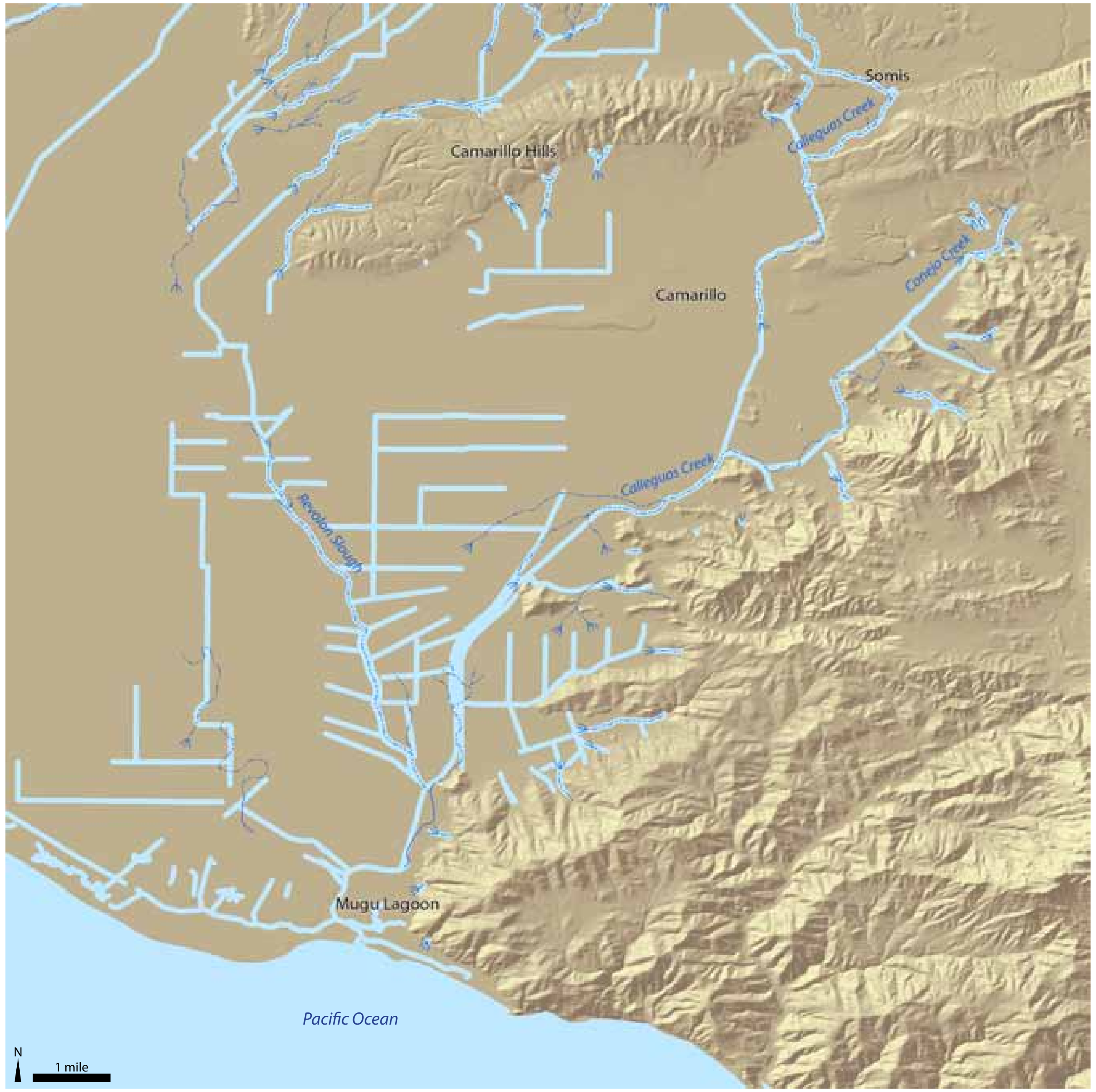


Fig. 5.4. Historical and modern drainage network of the eastern Oxnard Plain, early 1800s and 2005. The creation of new channels, such as drainage and irrigation ditches, has greatly increased the hydrologic connectivity of the eastern plain. Notably, Calleguas Creek now connects to Mugu Lagoon, and Beardsley Wash has been connected to Revolon Slough.

Calleguas Creek

Calleguas Creek drains a watershed of 343 square miles in the eastern portion of the county. Watercourses within the study area that currently drain into Calleguas Creek include Revolon Slough, Conejo Creek, and Arroyo Las Posas (the upstream continuation of Calleguas Creek). As late as the early 1900s, Calleguas Creek was known by many other names (e.g., Arroyo Simi or Guadalasca Creek), though it was most commonly referred to as Calleguas or Las Posas Creek (Norway 1860, Bard 1870a, *Ventura Signal* 1871a, Thompson and West [1883]1961, Holmes and Mesmer 1901b). Calleguas Creek enters the study area near Somis and currently has an outlet to the ocean through Mugu Lagoon.

Calleguas Creek did not maintain a defined channel from Somis to Mugu Lagoon across the Oxnard Plain prior to channelization in the late 19th and early 20th centuries. Though this has been widely recognized by researchers and managers in the watershed, little concrete evidence has emerged defining the date of early channelization efforts. The date most often suggested is 1884, though no direct evidence is cited (Steffen 1982, Onuf 1987, Swanson 1994, USACE 2000). Calleguas Creek Watershed Management Plan (Unknown 2004) states that Calleguas Creek was connected to Conejo Creek by 1889, though again no citation is given.

In addition to ambiguity surrounding the date of early modifications, no consensus has emerged regarding the location of the original terminus of the creek. The Calleguas Creek Watershed Management Plan states that no channel existed in the mid-1800s as far north as Camarillo, but provides no reference. One report (CH2MHill 2010) says it never reaches the ocean, but does not specify location of distributary.

Our findings are largely consistent with these statements. Unfortunately, we were also unable to find direct evidence of the timing of 19th century channelization projects. Attempts to pin down the precise date of channelization are complicated by contradictions in early maps: for example, some maps drawn at a coarse scale show a generalized, meandering channel through this area (Norway 1860, Hare 1875), while others show conflicting depictions of the creek despite similar survey dates (such as the soils map and geological maps surveyed in the same year; Holmes and Mesmer 1901b, USGS 1904). In addition, early ditching efforts were undoubtedly repeatedly washed out during floods, compounding the mapping confusion.

However, historical maps and textual evidence clearly support the early discontinuous nature of the creek, and its subsequent channelization (fig. 5.5). These sources indicate that Calleguas Creek maintained a defined channel to around the Highway 101 crossing, then emerged again (possibly more associated with the Conejo Creek drainage) at the current confluence of Calleguas and Conejo creeks. The creek maintained a defined channel for a short distance (approximately 2.5 miles) before terminating in a lagoon and distributary channels north of Round Mountain and CSU Channel Islands (see page 186). GLO surveyors crossing the creek recorded widths of approximately 165-230 feet at a point along the creek north of Highway 101 (east of the intersection of Highway 34 and Las Posas Road in Camarillo; Tolman 1873), and about 20-30 feet for the southern articulation of the

Fig. 5.5. Prior to channelization, Calleguas Creek maintained a defined channel only above Highway 101 (a) and for a few miles above CSU Channel Islands (labeled here at (b)). Note also the freshwater wetlands, ponds, and springs along the foothills on the eastern edge of the Oxnard Plain.

Coastal and Estuarine Habitats
- Tidal Lagoon (mostly open?)
- Tidal Flat
- Tidal Marsh
- High Marsh Transition Zone

Palustrine and Terrestrial Habitat
- Perennial Freshwater Pond
- Valley Freshwater Marsh
- Alkali Meadow
- Alkali Meadow/Flat
- Grassland/Coastal Sage Scrub

Hydrology
- Intermittent or Ephemeral
- Perennial
- Distributary
- Outer River Bank
- Spring

creek near CSU Channel Islands and northeast of the Camrosa storage ponds (Terrell 1861a).

Below Highway 101, Calleguas Creek spread into a broad, sandy wash with no defined channel until the Conejo Creek confluence. Norway (1860) described the “wash of Las Posas [Calleguas] Creek” near present-day Highway 101, though the wash was so diffuse that surveyor Henry Hancock, traveling east across the plain in June 1854 and crossing the modern alignment of Calleguas Creek near Calleguas Road (¾ mile south of Highway 101), did not mention the creek, instead noting only that there he crossed a mile-long transect of dense chaparral near where the creek runs today (Hancock 1854). An early soils map and aerial photography of this area also support the absence of a defined channel; as late as 1927 patterns of multiple routes of overflow are still visible (Nelson et al. 1917, Fairchild Aerial Surveys 1927; fig. 5.6).

South of Round Mountain, Calleugas Creek was seasonally connected to Mugu Lagoon through subsurface flow, overland flow during floods, and multiple discontinuous sloughs, swales and wetlands draining into Revolon Slough. Lugo (1855) described the connection between the lake at the terminus of Calleguas Creek and Mugu Lagoon: “In the dry season of the year, it [the lake] is very small, in the rainy season it extends down to the beach where it has an outlet” (Lugo 1855). This description is corroborated by early surveyors, who described what is now Calleguas Creek near Laguna Road only as “overflowed ground” (Terrell 1861a, Thompson 1867). The distributary channel network below the creek’s terminus is also captured by an early GLO survey, which crossed one of these shallow swales six feet wide and described it using the Southern term “bayou,” implying a marsh channel with slow-moving water (Washington 1853). Other overflow channels are visible on early aerial photography (Fairchild Aerial Surveys 1927, USDA 1938).

While some early maps show Calleguas Creek having a defined channel connecting it to Mugu Lagoon (e.g., Bard 1870b, Reed ca. 1871), a literal interpretation of these maps is not supported by other textual, aerial, and cartographic evidence. Rather, these maps were likely depicting the hydrologic connection between the creek and the lagoon, which would have been connected though swales and overland flow during wet weather. Other, more detailed maps show Calleguas Creek terminating before reaching Mugu Lagoon (e.g., Terrell 1861a, Holmes and Mesmer 1901b). Two maps produced in the early 1900s (1917 and 1919) even differ on the location of Calleguas Creek south of Round Mountain, unusual for such relatively late sources and suggesting the absence of a distinct, defined channel even then (Nelson et al. 1917, Petit 1919).

The lack of a defined channel meant that during major floods, water (and sediment) would spread out over large areas of the Oxnard Plain. This was recognized by early farmers, who could often use the fertile sediment to their advantage. During much of the year, however, it appears that

[Arroyo Las Posas] drains a large territory, most of which lies within the survey, but it has no well-defined channel and carries water only during very wet periods. It empties into the ocean through Calleguas Creek, near Mugu Point, and because of its choked channel sometimes causes damage to part of the Oxnard Plains by overflow.

— NELSON ET AL. 1920

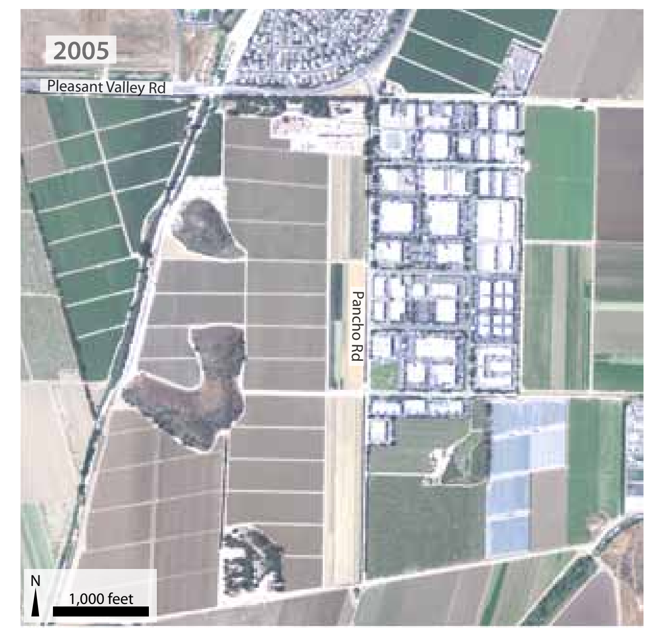


Fig. 5.6. Calleguas Creek south of Highway 101, 1927-2005. In 1927 (top left), a dense network of ephemeral distributary channels a is visible to the east of the clearly engineered channel of Calleguas Creek b, separated by low hills. By 1938 (top right), these channels are no longer visible; the land may have been graded. Agricultural farms occupy the area in 2005 (bottom left). (Fairchild Aerial Surveys 1927, courtesy of Whittier College; USDA 1938, courtesy of Ventura County; USDA 2005)

Calleguas Creek was dry. Descriptions of Calleguas Creek from the first half of the 20th century describe the creek as almost always dry (Holmes and Mesmer 1901c, Nelson et al. 1920, Gregor 1952). However, there is little information on the hydrologic characteristics of Calleguas Creek before major land and water use modifications (e.g., widespread drilling of artesian wells) occurred. When surveyor Terrell (1861a) crossed Calleguas Creek east of the Camarillo Hills in January 1861, he noted that it was “a dry creek”; surveyor Tolman (1873) noted the same on Calleguas Creek north of Round Mountain in April 1873. These quotes imply that portions of the creek may have even been ephemeral, with flow only after storms. The lack of water in Calleguas Creek was vehemently asserted in a letter written to the *Pacific Rural Press* from a county resident in 1877. In response to the

The silt loam on the Calleguas Ranch receives a fresh coating every year by the floods from Arroyo Santa Rosa [Conejo Creek].

— HOLMES AND MESMER 1901C

WERE THERE BARRANCAS IN VENTURA COUNTY BEFORE THERE WERE CATTLE?

On our way we came to several of those large, deep ravines, commonly called in this country 'barancas [sic],' and of which the timid have a special dread. The first two are bridged, and also the fourth one; but the third, the deepest, widest and most dangerous of all, is graded.

— VENTURA SIGNAL 1871A

Ventura County has numerous barrancas, particularly north of the Camarillo hills, in Ventura, and between Ventura and Santa Paula. Barrancas, also identified as ravines, gullies, or dry creeks, are channels characterized by steep banks and deep beds. They are often formed during severe storms, when water induces erosion and gully incision. Since barranca formation induced by flooding can be exacerbated by land uses such as deforestation and grazing, the question arises as to whether the barrancas in Ventura County predate the Mission era, particularly with respect to the introduction of grazing sheep and cattle.

Early explorers on the Portolá expedition (1769) do reference features that were likely barrancas. Costansó recorded "a road broken by streams and gullies" (*zanjones* in the original Spanish) between Santa Paula and Sespe creeks (Costansó and Browning 1992). On the same expedition, Crespí described traveling through a "dry creek bed" with its bed "a bit deep down" between Saticoy and Ventura; the Chumash they encountered led the party through the channel as a means of travel (Crespí and Brown 2001).

Historical records point to many deep barrancas present in the 1850s. While these documents do not predate land use impacts, they do predate the substantial flooding of 1861-2 as well as intensive regional agricultural development. In Ventura, Sanjon Barranca and Prince Barranca were both documented on the 1855 T-sheet (Johnson 1855c) and recorded by GLO surveys as "dry gulch" and "dry bed of creek" as early as 1853. To the south, Arundell Barranca and Harmon Barranca were also partially captured by the early T-sheet; Arundell Barranca was recorded as a "deep gulch" (Hancock 1854) and "dry gulch…about 25 feet deep" (Norris 1853) by early GLO surveys. Hancock (1853) also recorded numerous barrancas north of the Camarillo hills, including one 80 feet deep.

The formation of new barrancas is documented by a few historical sources. Mission friar Señán wrote that near Saticoy, a new barranca had formed—"mui [sic] ancho, hondo, y acantilado" (very wide, deep, and steep)—since the "año de los temblores," the earthquakes of 1812 (Señán and Vitoria 1822). He noted that the barranca had formed from a previously much smaller stream. The *Ventura Free Press* noted new barrancas formed as a result of the flooding of 1914, and implied barranca formation in earlier 19th century floods:

> New barrancas in hills. On the crest of the hill back of R.E. Brakey's home there appeared today several breaks in the soil indicating that nature had started some new barrancas; the land has slipped in several places and in years to come future cloudbursts will keep up their erosive work until there will be some topography that does not exist at this time. Our children's children will then say, doubtless, that this or that ravine started one night in January, 1914, in just about the same way as we say that something or other took place in 1884, 1875, or 1867. Verily every day makes a little history or a few changes on the map. (*Ventura Free Press* 1914)

In addition, the 1862 floods were said to have caused gully formation on San Diego County hillslopes; it is likely that similar formation of new features and incision of existing ones also occurred in Ventura County during these floods (Engstrom 1996).

While data are inconclusive, it is likely that at least some barrancas predate heavy grazing impacts, while others would have been formed during subsequent flood events and would have been influenced by these land use changes. Certainly their form was altered during the 20th century: many of the barrancas that today run off South Mountain or the Camarillo Hills and connect into Beardsley Wash and Calleguas Creek, for example, historically ended shortly after leaving their canyons.

Rural Press' assertions that Calleguas Creek and the Santa Clara River dried up due to deforestation, he wrote that "Los [sic] Posas creek rises in a big spring, and there is not a particle of evidence that it has ever averaged a greater flow per annum than it does now" (Bristol 1877).

There are a few recorded instances of wells dug in the dry bed of Calleguas Creek east of Somis and elsewhere on the Las Posas rancho in the 1870s and 1890s, suggesting ample subsurface flow (*Ventura Free Press* 1878c, Schuyler 1890). One traveler made a point to visit the wells sunk in the bed of Arroyo Las Posas in the fall of 1890:

> After a delectable lunch, we rode down to the bed of the creek to see the artesian wells. There are several of them within a few rods of each other. (Eames 1890)

Some mention is also made of use of surface water to irrigate in the early spring (*Ventura Free Press* 1877).

In the spring of 1877, while looking at vast fields of barley perishing before his eyes, Mr. Peter Rice… selected a spot in the then dry bed of the Calleguas Creek and commenced sinking an artesian well. At a depth of about 80 feet a fine flow of water was struck."

— VENTURA FREE PRESS 1878C

Very few data were found addressing riparian characteristics along Calleguas Creek. Almost no trees are recorded by GLO surveyors in the area, with the exception of a cluster of three sycamore trees in the bed of Conejo Creek at the Calleguas Creek confluence (Terrell 1861a).

Conejo Creek

Conejo Creek lost definition only about a mile after entering Pleasant Valley and the Oxnard Plain. Like Calleguas Creek, it also reformed a channel further downslope, less than ½ mile south of the Highway 101 crossing. The mouth of this lower channel connected to the historical head of lower Calleguas Creek, suggesting that lower Calleguas Creek may have had a greater historical connection to Conejo Creek than upper Calleguas.

Revolon Slough

Revolon Slough, also known as Arroyo del Medio ("creek of the middle"; Norway 1860), was one of the few natural drainages on the Oxnard Plain between Calleguas Creek and the Santa Clara River. Revolon Slough had its source just below the modern intersection of East Fifth Street and Pleasant Valley Road east of Oxnard (Norway 1860, USGS 1904), and drained into the sloughs above Mugu Lagoon (fig. 5.7).

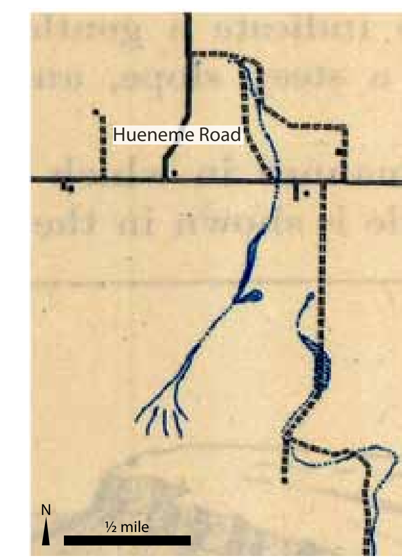


Fig. 5.7. Channels west of Revolon Slough, 1904. Disconnected sloughs west of Revolon Slough carried water from the central Oxnard Plain into Mugu Lagoon. Broader ponded areas are shown within the channel on this early USGS quad. Highway 1 now runs to the north of this complex. A willow thicket currently occupies an undeveloped segment of the meanders at lower right. (USGS 1904, courtesy of California State University Northridge Map Library)

Revolon Slough was notable as a former course of the Santa Clara River (see page 71) and as the predominant watercourse draining the central Oxnard Plain. While the slough ran through the heart of the region's alkali meadows, the natural levees to either side of the slough were not affected by alkalinity, created what Holmes and Mesmer (1901c) called "an oasis in the broad alkali flat." Farmers took advantage of the slough to drain and flush strongly alkaline lands. Over time, an extensive drainage network was created, connecting Calleguas Creek and (much later) Beardsley Wash into Revolon Slough and providing a direct outlet to the ocean through Mugu Lagoon where there was formerly none. These modifications drastically increased the drainage density of the central Oxnard Plain (see fig. 5.4).

Oxnard Plain habitats

The suite of habitats on the Oxnard Plain varied considerably from those historically found elsewhere in the study area. The majority of non-riverine wetland habitats in study area occurred on the Oxnard Plain and along the shoreline, mostly as seasonally inundated alkali meadow, extensive swaths of which covered most of the eastern (and portions of the western) plain.

Unfortunately, the habitats that dominated the Oxnard Plain are not well documented in the historical record. Many early travelers heading north from Los Angeles came down the Santa Clara River valley before heading to the city of Ventura and up the coast. Those that did cross the Oxnard Plain, such as botanist William Brewer or gold-seeker William Manly, often devoted no more than a sentence or two to the twelve mile journey across the plain, stopping only to elaborate once they reached the Santa Clara River or Ventura city. As a result, evidence for habitats on the plain is fragmentary, and often from a later date than in other regions of the county.

This section describes patterns of dryland and wetland habitat distribution on the Oxnard Plain. For descriptions of shoreline habitats, see the Ventura County Shoreline chapter (page 190).

Dryland Habitats

Though low-lying alkali meadow lands dominated much of the Oxnard Plain, higher, better-drained dryland habitats predominated on the northeastern plain (around the Camarillo Hills) and in broad fingers stretching south from the Santa Clara River, including El Rio and much of present-day Oxnard (see fig. 5.2). These coarser, higher deposits south of the river were built up by the Santa Clara River itself, and mark former courses of the river from a time when its outlet was near Mugu Lagoon or, more recently, Point Hueneme.

Early travelers crossing the Oxnard Plain were struck by the lack of trees across such an extensive area. Explorer Juan Crespí recorded in 1769 that “no trees are to be seen nearby” in the Saticoy area (Crespí and Brown 2001). Seven years later explorer Juan Bautista de Anza and his party, traveling down the Conejo Grade and across the Oxnard Plain, were forced to travel across the entire plain before camping at the Santa Clara River; they noted that it was “impossible to halt before this for lack of firewood” (Bolton et al. 1930). One hundred years later, this deficit was still a prominent aspect of the plain. One newspaper article reported that timber would be taken from the Ventura River to supply residents of “the timberless portion of the lower Santa Clara Valley” (as the Oxnard Plain was considered; *Daily Alta California* 1868). Another article from the same paper and year, describing a trip across the Oxnard Plain west toward the Santa Clara River, provided more detail on the lack of timber on the plain:

> Third day journeyed southwesterly ten miles, and struck the sea; thence fifteen more northerly to near the mouth of the Santa Clara, and up the lower bottom of that stream to camping ground in the enclosure of Mr. Pierpont. The route all the way lay over the Colonia…No spring, nor running water throughout the day’s drive, nor any trees until reaching the vicinity of the Santa Clara, where a considerable body of willow, cotton-wood and some sycamore is growing. (*Daily Alta California* 1868)

These general impressions are corroborated by an 1873 GLO survey, which recorded no timber in the Camarillo area (Tolman 1873).

While the general lack of trees on the plain was clearly documented, unfortunately the actual vegetation of the Oxnard Plain was not well captured by historical sources. The sources that do address the type of vegetation on the plain describe grassy areas interspersed with scrub and, occasionally, sycamores and live oaks.

Many accounts refer in various ways to the grassy nature of the Oxnard Plain. Crespí provides the earliest description of the plain in 1769; upon rounding the end of South Mountain and viewing the plain for the first time, he described it as “a large extent…of very grass-grown flat land, widest in extent from east to west” (Crespí and Brown 2001). William Brewer, traveling across the entire plain as chief botanist of the Geological Survey of California in March 1861, also described “a fine grassy plain, with here and there a gentle green knoll” (Brewer [1930]1974). (GLO surveyor Henry Hancock (1853) also noted these knolls, recording “low sand hills covered with vegetation.”) William Manly (who sometime in the winter of 1849-50 also traversed the plain from the Conejo Grade westward) described it as “a wide valley that supported a rank growth of vegetation” (Manly 1894). These general quotes are corroborated by more site-specific descriptions of “good pasturage” (Hancock 1854), “rich prairie” (Washington 1853), “alternating…belts of grass and mustard” (Hancock 1854), and “finest meadow grass and wild oat” (*Daily Alta California* 1865). It is worth noting, however, that it is unclear whether these early observations recording “grass” were referring to the alkali meadow (much of which would have also appeared “grassy”) or dryland areas. In addition, non-native mustard (*Hirschfeldia incana*/*Brassica nigra*) and wild oats (*Avena* spp.) had already colonized large portions of the plain (Hancock 1854).

A few sources note areas of scrub, or timber. South of the Camarillo hills (east of the present location of Camarillo), GLO surveyors recorded a large area of scrub, describing “worthless shrubbery,” “scattering chaparral,” “open chaparral,” “chamisal,” and “wild sage” (Hancock 1854; fig. 5.8). Terrell (1861a,b) noted prickly pear cactus (*Opuntia* spp.) on both the eastern and western sides of the plain. The occurrence of trees was even more sparsely mentioned. Costansó, an engineer on the Portolá expedition of 1769, described a “spacious plain, covered with grass and with some trees, extending to the south and west as far as the sea” (Costansó and Browning 1992). GLO surveys record an area a little under a mile wide of “scattering timber” (presumably sycamores and/or live oaks) along what

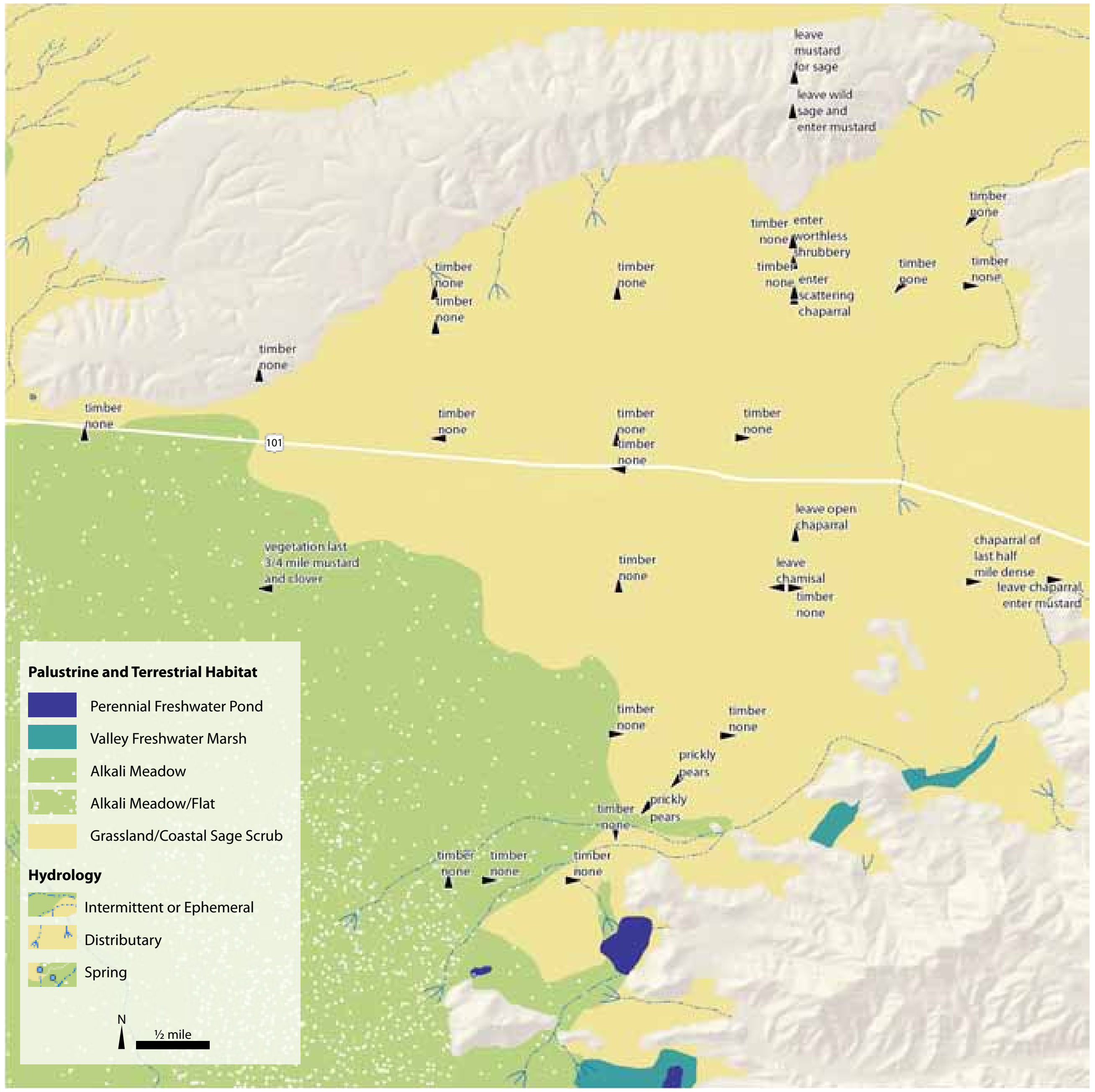


Fig. 5.8. Early evidence for historical vegetation near Camarillo, 1853-1873. General Land Office surveyors noted large areas covered in scrub, while noting no bearing trees. These quotes provide a glimpse into the variation in land cover represented by the grassland/coastal sage scrub habitat class. (The arrows represent direction of travel.) (Hancock 1854, Terrell 1861a, Tolman 1873; courtesy of the Bureau of Land Management)

is now Highway 101 just east of El Rio (Terrell 1861b, Thompson 1867). In the same area, a "grove" (species unspecified) and a few individual sycamore trees were recorded (Stow 1878 in tree layer, Power 1891). In general, however, few trees were found on the plain: the GLO survey notes only record one bearing tree on the plain, a live oak in the scattered timber mentioned above (Hancock 1854). (The only other bearing trees noted on the plain were one sycamore in the bed of Conejo Creek, and two sycamores on the edge of the valley just north of the Conejo Grade.)

On the eastern side of the Oxnard Plain near Camarillo, one sycamore in particular was recognized as an important feature: the Palo Alto (fig. 5.9). The Palo Alto, or tall tree, was the name of a lone sycamore near Camarillo.

According to one of John P. Harrington's informants, 19th century ranchers who had lost cattle would "climb this tree to see the cattle they were looking for," though it had been cut down by the early 20th century (Harrington 1913e). The tree was so well known that it was a key descriptor of the Mission's area holdings upon their sale in the 1840s: "…the Laguna Hueneme [the lagoon southeast of Hueneme], Palo Alto, the cultivated fields of Santa Paula, [and] the Mission Cañon [Ventura River valley]" (Weber 1978).

The late date, spatial resolution, and sparseness of the historical record preclude drawing conclusions about the nature of vegetation on the plain prior to the establishment of the Mission. The lack of early documentation is compounded by early impacts to the original vegetation of the plain from grazing, suppression of Chumash burning, and the arrival of non-native species such as wild oats and mustard (see page 18). As a result, the data presented here for the most part characterize the Oxnard Plain after substantial modifications; it is not clear which portions of this characterization are relevant to pre-Mission conditions.

Fig. 5.9. Lone sycamore tree on the Oxnard Plain near Camarillo, ca. 1840. This was one of the few large trees on the eastern Oxnard Plain. It was used as a lookout in the 19th century by ranchers looking for their lost cattle. By the early 20th century, it had been cut down. (U.S. District Court ca. 1840e, courtesy of The Bancroft Library, UC Berkeley)

Alkali Meadows and Alkali Flats

With the exception of the far eastern plain and slightly higher ground created by old paths of the Santa Clara River, the majority of the Oxnard Plain consisted of salt-affected, seasonally wet or flooded lowlands that could be considered alkali meadows, flats, or alkaline grasslands (fig. 5.10).

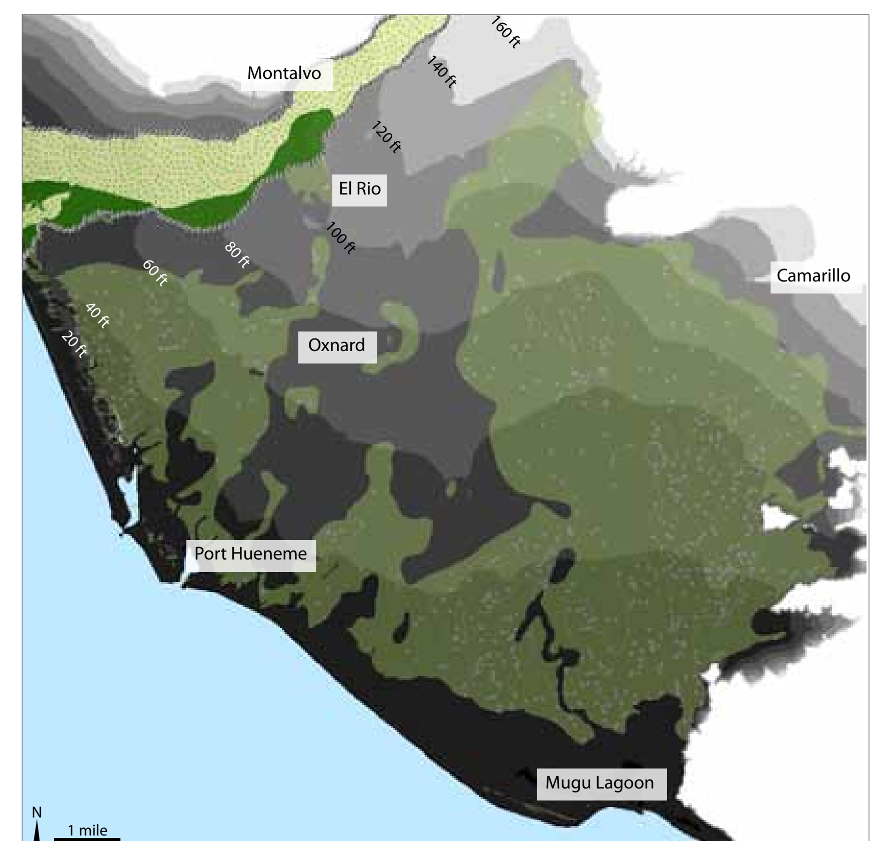


Fig. 5.10. This contour map shows the topography of the Oxnard Plain, with an overlay of mapped historical extent of alkali meadow and alkali meadow/flat. While the entire plain is extremely flat, these contours show lower elevations extending futher inland west of the Camarillo Hills, matching the furthest inland extent of alkali meadow, and reflecting the spatial extent of the Santa Clara River's alluvial fan.

We identified 30,240 acres of the Oxnard Plain with significantly salt-affected soils, approximately 43% of the entire area of the plain. These areas were found almost exclusively on the Oxnard Plain, with a small area also present at Saticoy.

Unlike other seasonally flooded alkaline areas in California (e.g., Soap Lake in the San Francisco Bay Area's Santa Clara Valley; Grossinger et al. 2008), the vast alkali meadows of the Oxnard Plain were not produced by clay surface soils with limited drainage. Rather, a high water table coupled with subsurface salts, limited subdrainage, and few surface drainages in the central Oxnard Plain created seasonally wet, alkaline conditions. As a result, salts were able to be flushed with successful drainage and irrigation.

Alkali conditions were comprehensively documented by the 1901 and 1917 soils surveys (Holmes and Mesmer 1901a,c; Nelson et al. 1917), which distinguished these areas because of their limited agricultural use. Indicators used by the soil surveys include salt-tolerant plants, surface salt deposits, and areas bare of vegetation—all of which are also indicative of alkali meadow character. These maps were instrumental in our reconstruction of alkali meadow and flat distribution on the plain.

The presence of certain crops (e.g., alfalfa, sugar beets, and asparagus) and poor crop growth were also clues to the presence of alkali, since few crops were able to withstand even relatively low amounts of soil alkalinity. The development of Oxnard as a national center for beet processing affirms the strong alkali influence on the local landscape since beets, while less valuable than other contemporary crops, were one of the few products that be could be successfully grown in alkaline areas (Gregor 1953). Before the sugar factory was established by Pacific Beet Sugar Company in Oxnard in 1898, the main crops grown on the plain were beans (especially lima beans, grown since 1875) and barley (since the 1860s; Gregor 1953). However, the salt-affected soils were often not well adapted to growing barley, often producing "indifferent crops of barley… quite often the barley hay contained such a great amount of salt that stock would not eat it" (Holmes and Mesmer 1901c).

Descending the ridge, we saw the surveyors of the new railroad working near the base of sandstone cliffs. Turning down a dusty road we passed a salt grass flat, on whose upper border there huddled a singular collection of buildings… This gentleman liked the looks of these bright stretches of salt grass…

— NINETTA EAMES, FALL 1890, EASTERN OXNARD PLAIN

While sugar beets created a profitable industry on much of the previously unfarmable plain, even sugar beets were not salt-adapted enough to successfully grow in some areas: "a great deal of this land is too alkaline even to raise beets, and it will have to be reclaimed before it can produce any useful crop" (Holmes and Mesmer 1901c). These were the most strongly alkaline areas (over 1% alkali), where "alkali weeds and salt grass alone are able to subsist, but do not afford much pasturage" (fig. 5.11; see page 180).

Early descriptions of the Oxnard Plain reinforce this interpretation of the plain as a largely treeless, alkaline lowland. In 1769, Crespí described it as a "large plain of very low, very grass-grown land" and "almost entirely level and very grass-grown soil" (Crespí and Brown 2001). Upon entering the plain near Saticoy, he noted that "no trees are to be seen nearby" except

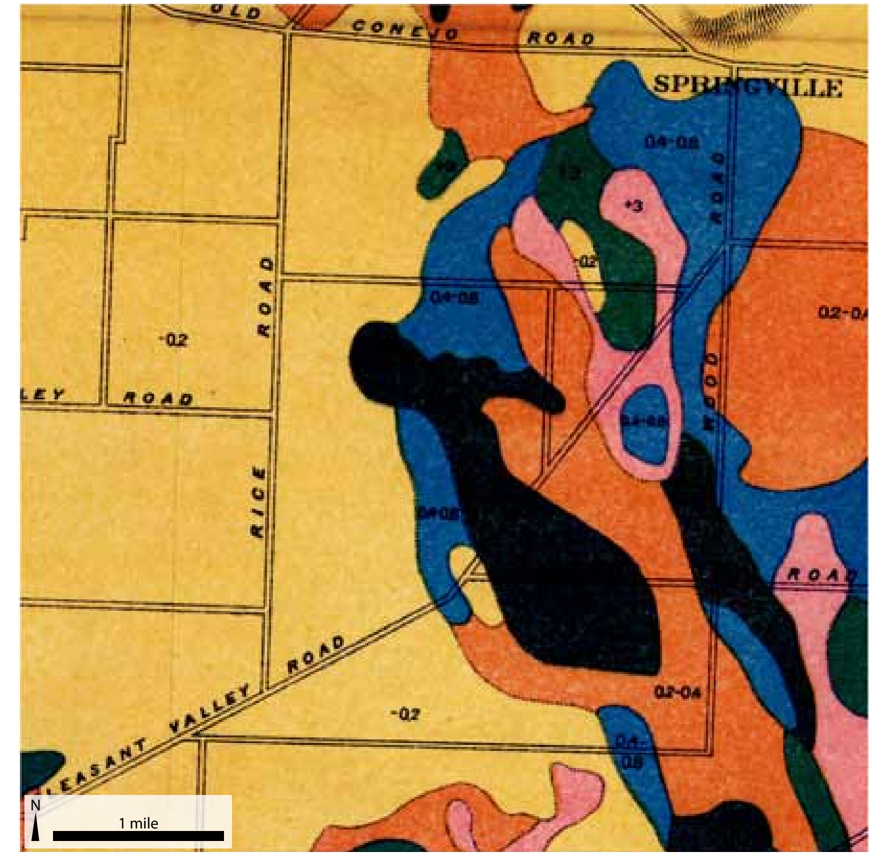


Fig. 5.11. Alkali concentrations on the Oxnard Plain, 1901. Various concentrations of alkali in the first 6 feet of the soil column were measured in the soil near the historical head of Revolon Slough (east of Oxnard and southwest of the Camarillo Hills). Concentrations of less than 0.2% were not considered to be affected by alkali, while concentrations of 0.2%-1% were mapped as alkali meadow. The most strongly alkaline areas, with concentrations over 1%, were described in the soils report as unfarmable areas where "alkali weeds and salt grass alone are able to subsist," and were mapped as alkali meadow/flat. (Holmes and Mesmer 1901a, courtesy of The Bancroft Library, UC Berkeley)

riparian vegetation along the Santa Clara River near the shore. Brewer ([1930]1974) described the plain in early spring 1861 as "a fine grassy plain, with here and there a gentle green knoll, with a few dry creeks or alkaline ponds." Notably, no bearing trees were recorded by surveyors in areas mapped as alkaline.

In a few areas, early General Land Office surveyors explicitly note salts present in such high concentrations that it was attributed to tide overflow, though the area was 3.5 miles from the upper extent of tidal influence at Point Mugu (Washington 1853). Some of these areas may represent places flooded by perched conditions along the shoreline (see page 232). In other areas, however, surveyors crossing the alkali meadow do not directly comment on the alkalinity, suggesting that many of these areas were likely well vegetated, possibly with a mix of alkaline and non-alkaline species. It is possible that portions of what we have designated alkali meadow, while chemically alkaline in subsurface soils, did not maintain an ecological expression in the form of saltgrass and other salt-tolerant species.

Alkali meadows are recognized today as a relatively rare native grassland type (Holstein 2000, CNDDB 2010). The characteristic vegetation was salt grass (*Distichlis spicata*; Holmes and Mesmer 1901c), though other salt-tolerant species such as alkalki goldfields (*Lasthenia ferrisiae*), salt marsh birds beak (*Cordylanthus maritimus* ssp. *maritimus*), spreading alkali weed (*Cressa truxillensis*), shaggyfruit pepperweed (*Lepidium lasiocarpum*), and

DISTINGUISHING ALKALI MEADOWS FROM ALKALI FLATS

In California, early soil surveyors generally attempted to distinguish and map different degrees of alkaline impact to local soils. While their intent was to determine the potential agricultural productivity of the land, their mapping also provides valuable ecological information. Surveys consistently recognize alkali effects on crop selection and productivity at >0.2% total salinity (in the top six feet of soil; e.g., Holmes and Mesmer 1901a,c; Carpenter and Cosby 1939), mapping these areas as alkali affected. On the least strongly-affected alkaline land (0.2-0.6%), beets, barley, and often alfalfa were grown. On more salt-affected land (0.6-1%), "salt grass and plants native to the alkali plains thrive and afford pasturage" (Holmes and Mesmer 1901c). We translate these areas, which typically display a significant proportion of salt-tolerant vegetation and some bare spots, as alkali meadow.

In addition, the early surveys consistently attempt to distinguish areas with more severe alkalinity levels that effectively preclude agricultural use other than sparse pasture. The associated alkalinity level for these extreme effects varies substantially among regions due to other soil conditions, for example from >0.4% in the Modesto-Turlock area (Sweet et al. 1908) to >1% on the Oxnard Plain (Holmes and Mesmer 1901a,c; Nelson et al. 1917). These higher alkalinity levels, which affect agricultural vegetation, also appear to have ecological significance. Holmes and Mesmer (1901c) describe that on the Oxnard Plain in areas with 1-3% alkali "alkali weeds and salt grass alone are able to subsist, but do not afford much pasturage," indicating sparse alkali vegetation with substantial bare ground (fig. 5.12). We translate these areas of extreme alkalinity, described as having a greater proportion of bare areas or alkali flats, as alkali meadow/flat. We use this habitat type to note the probable presence of significant seasonally wet hyperhaline flats, as well as other potential ecological differences from the surrounding alkali meadows.

Fig. 5.12. "Alkali flat in the Delta portion of the Ventura area," ca. 1901. This turn of the century photograph of the Oxnard Plain shows what the soil survey terms "alkali flat," a region with >1% alkalinity. Some alkali vegetation is shown among substantial bare, cracked ground. (Holmes and Mesmer 1901c)

hairy gumweed (*Grindelia hirsutula*) may have also been present. A GLO surveyor noted "salt weed and salt grass" (Hancock 1854) in an alkali area near Revolon Slough, referring to *Distichlis* and possibly *Cressa truxillensis*. Early botanical specimens found near Oxnard are salt-tolerant species: Davy (1901) recorded saltmarsh bird's beak (*Cordylanthus maritimus subsp. maritimus*) and Condit (1908) reported spreading alkaliweed (*Cressa truxillensis*) on alkaline soils near Oxnard.

Much of the alkaline-affected area falls within the extent of artesian conditions, as mapped by Schuyler (1900) and Lippincott (ca. 1930), suggesting a high degree of soil moisture. The widespread presence of saltgrass—a strong indicator of near-surface groundwater (Le Bihan 1944)—also reinforces the seasonally wet character of these areas. This is supported in at least one location by GLO surveyors, who described the alkali meadow northwest of Round Mountain as "overflowed ground" in January 1861 and September 1867; it is not clear whether they meant that the land was flooded at the time of survey, or that the land was seasonally flooded (Terrell 1861a, Thompson 1867).

This alkaline land is poorly drained, water being in most places not more than 10 feet below the surface and at certain seasons of the year much nearer.

— HOLMES AND MESMER 1901C

We would expect these alkali flat areas to have an extremely high proportion of salt-tolerant vegetation, but with potentially reduced diversity. For example, Mann et al. (1911) note in the Woodland region of northern California that gumplant (*Grindelia camporum*) and tarweed (*Centromadia pungens*) are limited to the more moderate alkalinity levels. At the tidal marsh margin, these areas can probably be considered equivalent to the "high marsh transition zone" (e.g., Ferren et al. 2007) with a component of euryhaline flats.

Perennial Wetlands

Wetlands occurred in three major places on the Oxnard Plain: tidal wetlands along the coast, freshwater wetlands in side valleys along the eastern side of the valley between Calleguas Creek and the hills, and in patches around Oxnard south of the Santa Clara River. In this section, we discuss the freshwater wetlands of the plain (see page 205 for treatment of coastal wetlands).

In total, we mapped 440 acres of freshwater wetlands and ponds on the Oxnard Plain. Since many features mapped as freshwater wetlands were at the alkali margins, some likely also had brackish components as part of the transition between alkali meadow and non-alkaline areas.

OXNARD AREA WETLANDS Within the alkali meadow, a mosaic of freshwater and brackish ponds, sloughs, and marshes existed in old stream and slough courses and other very low or poorly drained areas. Early travelers on the Oxnard Plain noted alkaline surface water, as did later residents: the Geological Survey of California (1865) remarked that "all the water seen on the plain was alkaline, except that of the Santa Clara River" while Thompson and West ([1883]1961) wrote that "[t]he surface water on the Colonia Rancho [which includes most of the Oxnard Plain] is generally unfit for household use." While these are undoubtedly overgeneralizations, they do reflect the general alkaline character of the plain. Brewer (1930) also observed alkaline ponds in the spring of 1861.

However, not all surface water on the Oxnard Plain was brackish. Some freshwater areas existed within the alkaline matrix, often fed by springs or created by pools of rainwater that collected in low areas. Haydock (1971) recalled that waterfowl (geese and ducks) would overwinter in freshwater areas in swales:

> The swales scattered over the valley where winter rains collected the fresh water had great attraction for them, especially for the ducks. One of these pools was in the southwest part of the Hill Ranch and covered several acres. A swale on the west side of the boulevard started about three quarters of a mile north of town [Oxnard] and ran through what is now the heart of town down to this pool. In front of the Harvey home just north of town was a smaller pool. Tules were usually to be found in these pools. Ducks frequented these pools at night, and many remained through the day if undisturbed.

The first pool mentioned above by Haydock (located on the southwest part of the Hill Ranch) was also mentioned by Bloom (1959) as a "four or five acre lake…that some years lasted all summer" and that attracted flocks of hundreds of geese. The lake is still visible in oblique aerial photography from circa 1950 as a mottled, darker area (fig. 5.13).

Also of note was Ponom or Ponomo, a pond and marsh north of Oxnard (the second, smaller pool mentioned by Haydock). The pond was noted as early as the 1840s (fig. 5.14), and was described as a "pond of fresh water" (Bard 1869) and a "tule pond" (Bloom 1959). Ponom was also a significant Chumash site, noted by Harrington's informants as a place with "a ciénega, tular and some sauces" (marsh, tules, and willows; Harrington 1913b). The name "ponom" was reported to mean "hay que cuidar" (one must be careful), because "they had fear that sometime the river of Santa Clara could change its course back to Point Mugu" (Harrington 1986a).

Undoubtedly, there were additional, less well documented wetlands historically present on the plain. In particular, one early map shows a large "sienega [sic]" south of the Santa Clara River on the plain, but without enough precision to map (U.S. District Court ca. 1840e; see fig. 5.14). Another large area that may have been a large wetland or wet meadow was shown on a later map south of the river with a somewhat characteristic wetland symbol, but more information is needed to resolve nature of this feature (Power 1891).

CALLEGUAS WETLANDS In contrast to the rest of the Oxnard Plain, the region immediately surrounding Calleguas and Conejo creeks had a more developed drainage network and contained many more freshwater wetland features. Along the eastern edge of the Oxnard Plain, a high groundwater table coupled with extremely low, flat terrain and a contact between alluvium and Conejo Volcanics extrusions gave rise to a series

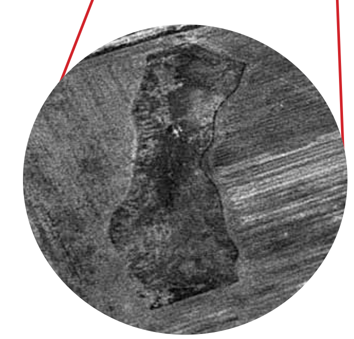


Fig. 5.13. Though it appears to be dry at the time of the photo, this dark, oblong, kidney-shaped outline—now in the middle of the city of Oxnard, northeast of the intersection of South Ventura and West Wooley roads—marks the location of the former pool on Hill Ranch. It is still discernible on this ca. 1950 oblique aerial photograph. (Spence Air Photos ca. 1950, courtesy of the Benjamin and Gladys Thomas Air Photo Archives, Spence and Fairchild Collections, UCLA Department of Geography)

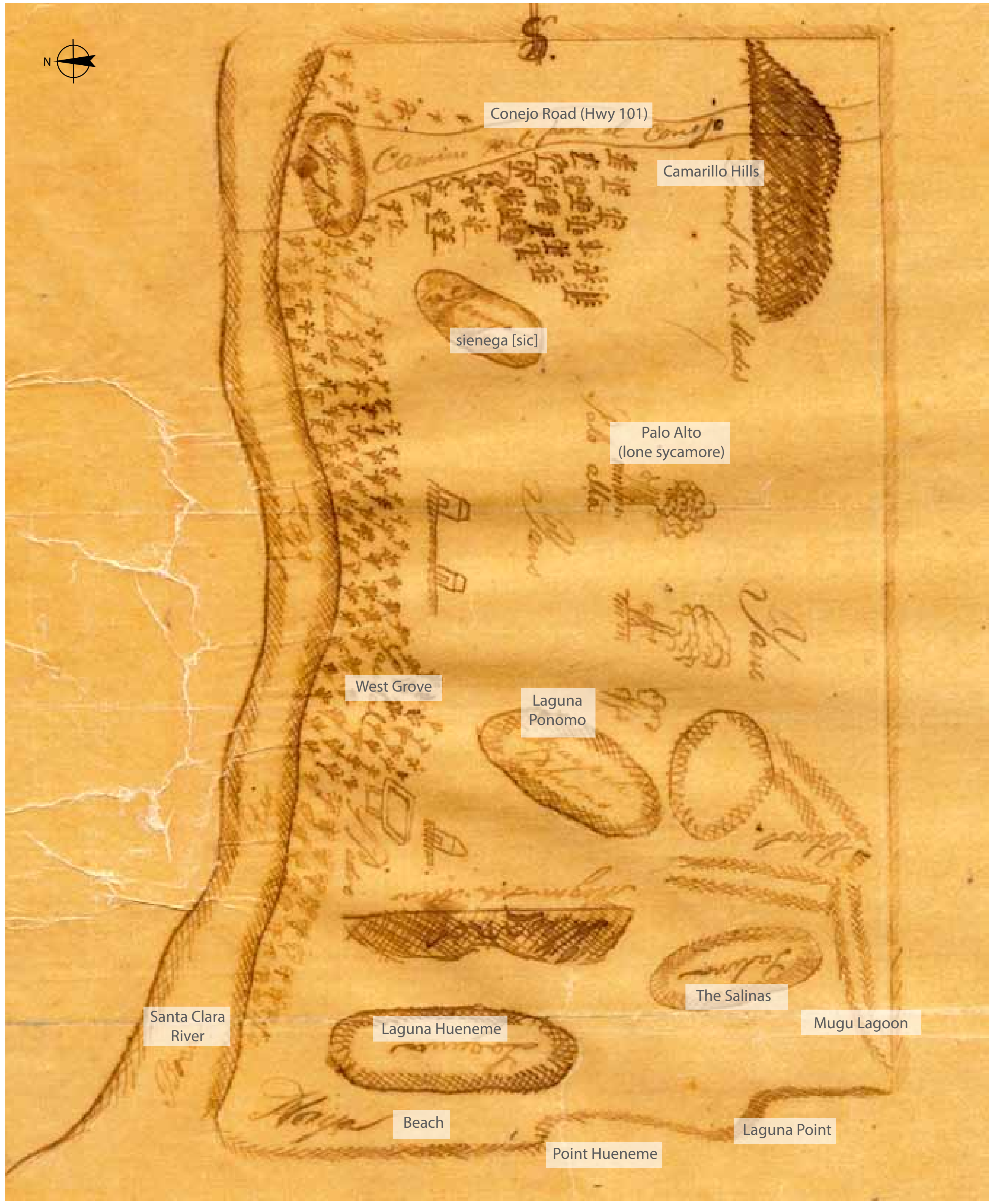


Fig. 5.14. Landmarks of the Oxnard Plain, ca. 1840. This remarkable *diseño* compresses what the cartographer perceived to be the most important features of the deltaic Oxnard Plain into one compact, rectangular drawing. While the distances are inaccurate, the relative position of features drawn on the plain is broadly correct. We were ultimately able to map some of these features, though others—such as the *ciénega* (wetland) south of Highway 101—remain mysterious. Laguna Ponomo is here shown just east of Laguna Hueneme, though later depositions record that the pond is "about five miles due north of the laguna called Hueneme" (Bard 1869). (U.S. District Court ca. 1840e, courtesy of The Bancroft Library, UC Berkeley)

of groundwater-fed seeps, springs, lakes, and marshes along substantial portions of the small foothill valleys of the Calleguas watershed (see fig. 5.5). Many of these springs occurred at the contact between alluvial loams of the valley floor and the older, largely volcanic upland bedrock, and some are likely associated with regional faulting (Tan et al. 2004) and possible impoundment behind alluvial deposits from Calleguas and Conejo creeks. We estimate that this area had about 400 acres of wetlands. Many of these areas served as major cultural landmarks in an otherwise relatively dry, alkaline area, and influenced the location of Chumash and early Spanish/Mexican and American settlements in the area.

Significant areas with springs in this region included Round Mountain (also known as Sat'wiwa or Sierrita de la Laguna; Terrell 1861a, Thompson 1867, Harrington 1913a), the small hill immediately to the north of Mugu Lagoon (not named, but near a village and spring historically called Simo'mo or Big Springs; Bowers 1879 in Benson 1997; Lugo 1855), and the southwestern point of the Camarillo Hills (near the historical location of Springville). Each of these three hills served as landmarks and places of settlement throughout the historical record. The springs at Simo'mo, for example, served as the site of the Chumash village of the same name, while the springs at Round Mountain formed a freshwater lake that gave Guadalasca Rancho its alternate name (La Laguna, Thompson 1869) and was the site of the grantee's home (by "the watering place called Guadalasca"; Lugo 1855). The spring at the nose of the Camarillo Hills was called Las Posas ("the watering holes" or "pools"), and helped name both the American settlement of Springville and the Mexican Rancho, Las Posas:

> It [Las Posas Rancho] has only one spring stream of water that of Las Posas which although very abundant is so deep that some labor is necessary to get its water out. Consequently it cannot be hoped that it will serve for irrigation and is only useful as a watering place for cattle. (Carrillo 1833)

Early inhabitants of the Calleguas Creek area used these springs and lakes as water sources for domestic water, crop irrigation, and cattle. The lake at Round Mountain was described as a primary source of water on Guadalasca Rancho by the grantee (Yorba 1837), and wet foothill valleys on Las Posas Rancho were also used as watering places for cattle (Tico 1834).

A considerable portion of this rancho [Calleguas] has living springs upon it…

— THOMPSON AND WEST [1883]1961

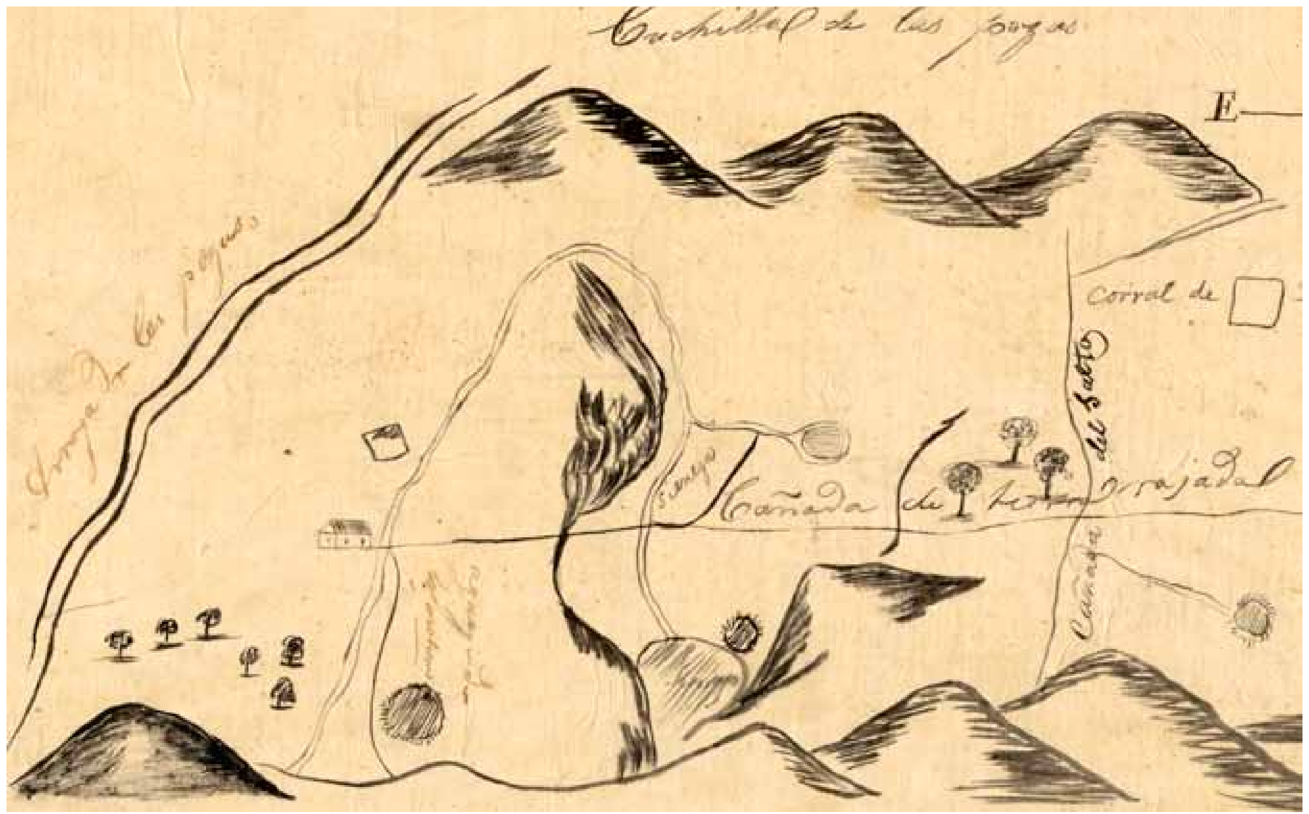
Ponds and wetlands were found in nearly every pocket valley between Mugu Lagoon and Pleasant Valley. Many occurred at the mouths of distributaries, along Conejo Creek, or coincident with springs. On Las Posas Rancho, some of these low valleys were "dependant [sic] on the seasons," presumably referring to variable utility due to seasonal flooding and the summer dry season (Tico 1834).

This pattern is confirmed by an early *diseño* of Calleguas Rancho (roughly the Pleasant Valley area; U.S. District Court ca. 1840a; fig. 5.15). The map shows a series of wetlands (*sienegas* [sic]) and springs up against the hills east of Calleguas Creek (Arroyo de las Posas). While the *diseño*

Fig. 5.15. **While this ca. 1840s *diseño* is very schematic**, it provides a generalized picture of the landscape of springs and wetlands present between Calleguas Creek ("Arroyo de las Pozas") and the Santa Monica Mountains. It depicts springs (shown as dark circles with small radiating lines) flowing into small creeks and wetlands (labeled "sienega" [sic]). One wetland shown is up against the base of the hills, while the other is just upstream of the confluence of two creeks. (U.S. District Court ca. 1840a, courtesy of The Bancroft Library, UC Berkeley)

is roughly drawn, it does depict the same pattern shown on our habitat map, suggesting that these wetlands and springs were persistent, historical features.

One notable feature was the freshwater lake at the terminus of Calleguas Creek (fig. 5.16). South of the lake, Calleguas Creek ceased to have a defined channel, instead connecting to Mugu Lagoon through a series of swales and wetlands. Guadalasca Rancho, on which the lake was located, was alternatively known as the Laguna Rancho: "The old Californians familiarly call the 'Guadalasca' the 'Laguna' (Thompson 1873, in Thompson 1869). In addition to flow from Calleguas Creek, two springs in the area—one called Guadalasca—formed the lake (Lugo 1855). The lake was described as the "only considerable watering place" on the



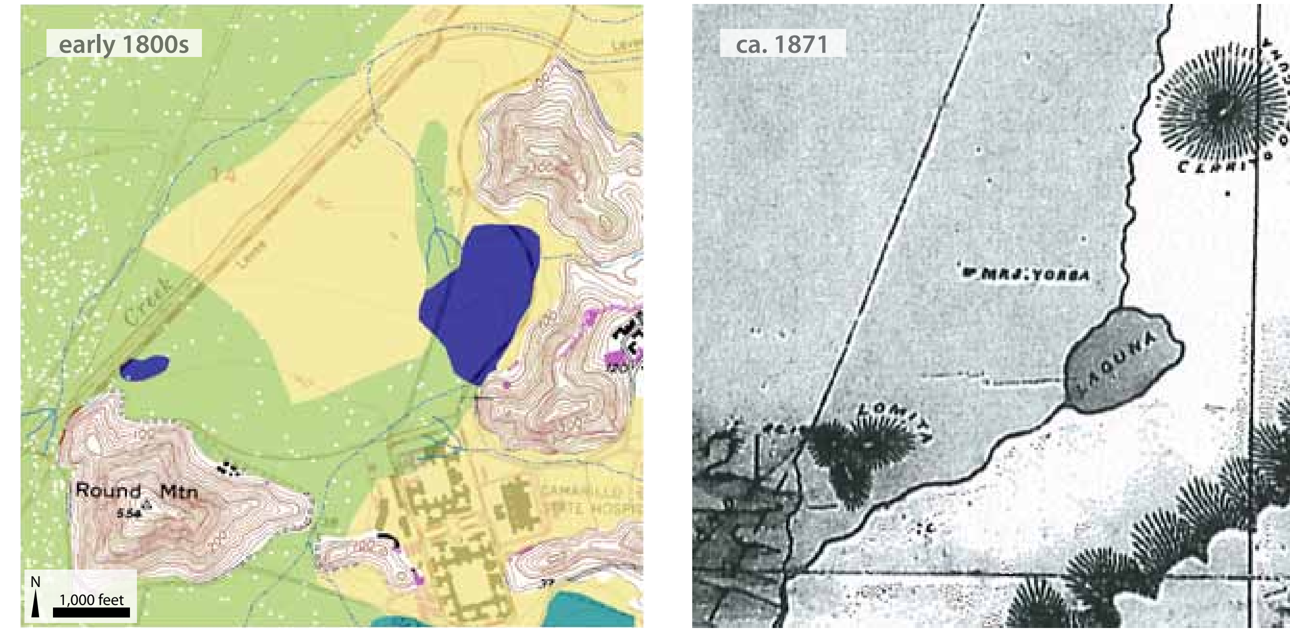


Fig. 5.16. The Laguna. Historically one of the most prominent features on the Oxnard Plain, this lake was the namesake for the Guadalasca or Laguna Rancho. It was located at the terminus of Calleguas Creek; below the laguna series of shallow sloughs and overflow connected the creek to Mugu Lagoon. Historical mapping of the lagoon is shown at left; an early map of the lake is at right. (Reed ca. 1871, courtesy of The Bancroft Library, UC Berkeley)

Palustrine and Terrestrial Habitat

Perennial Freshwater Pond
Valley Freshwater Marsh
Alkali Meadow
Alkali Meadow/Flat
Grassland/Coastal Sage Scrub

Hydrology

Intermittent or Ephemeral
Distributary

Guadalasca Rancho (Yorba 1837). During the wet season, overflow from the lake ran toward Mugu Lagoon both to the west and to the east of Round Mountain.

Likely as a legacy of this ecological history, some of these former wetland valleys, which were presumably relatively unattractive for development, are now parks and other public uses. Portions of the Camarillo Springs Golf Course and the area upslope of the Camrosa Water District storage ponds, for example, are located on areas mapped as former wetlands. Previous studies have recognized some wetland restoration potential in these areas (David Magney Environmental Consulting 2000), which constitute the greatest concentration of documented freshwater wetlands in the study area.

SUMMARY OF FINDINGS

The following findings represent some of the significant conclusions drawn from our research and analysis. Combined with an understanding of modern conditions, these findings can support scientists and managers working to identify restoration opportunities on the Oxnard Plain and in the lower Calleguas Creek watershed.

1. **The Oxnard Plain supported a diverse array of habitats,** from the freshwater wetlands and lakes of the lower Calleguas watershed to the alkali meadows and flats, grassland, coastal sage scrub, and chaparral of the broader plain. Just under half of the plain supported alkali meadows and alkali flats, with the remainder mostly covered by grassland and coastal sage scrub.

2. **The distribution of these habitats reflected underlying physical processes and characteristics.** Topography, soils, geology, and groundwater availability were primary factors in determining historical habitat distribution.

3. **Few trees were found on the Oxnard Plain.** Only a small number of trees were documented on the plain by 19th century observers, mostly sycamores (and one live oak) on the sand and sandy loam soils marking the former route of the Santa Clara River to Point Hueneme.

4. **Few streams traversed the Oxnard Plain, particularly in its western portion.** The plain was notable for its extremely low drainage density (only 1.7 miles of creek per square mile). The few creeks and barrancas that did cross the plain were almost exclusively discontinuous, sinking into coarse alluvium or spreading into and across seasonally wet alkaline areas. Large sloughs such as Revolon Slough (a former channel of the Santa Clara River) formed the backbone of drainage for the central plain.

5. **Calleguas Creek did not maintain a defined channel across the Oxnard Plain,** instead spreading into a broad wash around present-day Highway 101 before re-emerging downslope near Conejo Creek. The creek terminated in a lake and distributary system near the current location of CSU Channel Islands. Calleguas Creek was hydrologically connected to Mugu Lagoon through shallow sloughs and sheet flow during floods.

6. **Calleguas and Conejo creeks were intermittent on the Oxnard Plain.** Though sources describe readily available water located below the surface in both creek beds, they are consistently described as dry for much of the year.

7. **Sources document a concentration of perennial freshwater wetlands, ponds, and lakes along the eastern margin of the Oxnard Plain,** particularly east of Conejo and Calleguas creeks. The majority of these wetlands occurred near the base of small alluvial valleys of creeks tributary to Calleguas and Conejo creeks, near contacts between alluvial deposits and the Conejo Volcanics of the western Santa Monica Mountains.

Management Considerations

- **Former wetland locations in the Calleguas Creek watershed offer a number of potentially viable sites that should be considered for restoration.** Many of these sites, still located on agricultural land, may be appropriate locations for future wetland restoration projects.

- **Some of these former wetland locations have already been identified through previous research as potential floodplain restoration sites.** The large freshwater lake at the historical distributary of Calleguas Creek for which the Guadalasca/Laguna Rancho was named coincides with one of the sites identified for potential restoration in the Calleguas Creek Watershed Restoration Plan (David Magney Environmental Consulting 2000), which also includes Calleguas Creek and floodplain north of CSU Channel Islands and the Camrosa Water District facilities. In addition, Magney's conceptual wetland restoration design for Calleguas Creek at Camarillo Regional Park may have the potential to incorporate historical wetland habitat behind the Camrosa Water District storage ponds (fig. 5.17). Similar opportunities may exist at the site on Conejo Creek at Winding Brook Farm, where additional freshwater wetlands were documented. Future restoration activities at these sites could take advantage of the unique historical and hydrologic aspects of this area in designing floodplain characteristics.

- **Drainage density of the Oxnard Plain has greatly increased** with the construction of artificial drainage networks, creating more direct conduits between ocean and upland. This expansion of the drainage network has implications for contemporary distribution and residence time of water and sediment on the plain and should be considered in creek restoration projects, particularly in constructed reaches not historically present. For example, the historical form of Calleguas Creek helps explain current sedimentation issues downslope of Lewis Road.

- **Physical factors such as topography, soils, geology, and groundwater availability are still primary factors affecting contemporary habitat distribution.** An understanding of how these drivers contributed to historical habitat patterns is an essential component of the success of restoration projects.

Fig. 5.17. Camrosa Water District storage ponds, 2008. The area behind these storage ponds, formerly the site of a freshwater marsh complex, may be a potential location for wetland habitat restoration.

6 • VENTURA COUNTY SHORELINE

Where the plain meets the eastern mountain
is the Laguna Mugu, with extensive marshes and a low,
narrow sand beach, with a slight tidal opening
as if the [Santa Clara] river may at one time have
emptied here.

—DAVIDSON 1897

Introduction

Nineteenth century Ventura County exhibited a complex and heterogeneous shoreline, with a variety of habitats and morphologies associated with different estuarine and wetland systems and different formative processes (fig. 6.2). At the Ventura River mouth, willow-cottonwood forest transitioned into a small, intermittently closed lagoon, while a culturally significant beach-dammed freshwater wetland complex occupied a former river mouth to the east. A distinctive seasonal wetland area—the Pierpont lowlands—extended in a broad arc from Ventura to the Santa Clara River mouth, nearly connecting the eastern edge of the Ventura River corridor to the northwestern edge of the Santa Clara River (they were separated by less than one mile). Here sand dunes trapped Santa Clara River floodwaters and valley seepage in a recently prograded portion of the shoreline, creating a large area of seasonally inundated meadow. At the Santa Clara River mouth, willow swamps bordered a small seasonal estuary similar in form and function to the Ventura River delta (and including a freshwater wetland complex, McGrath Lake). To the south, a series of at least nine elongate lagoons—some brackish, some saline—incised the Oxnard Plain shoreline, marking former mouths of the meandering Santa Clara River. Usually blocked from the tides by substantial beaches and dunes, the water source for these lagoons was a varying mix of saline (through dune overwash and seepage) and fresh water (from precipitation, runoff, and springs). As a result, the lagoon complexes supported a gradient of heterogeneous habitats ranging from freshwater to brackish to saline, including vegetated marsh, salt flat, and open water. At the southern edge of the Oxnard Plain, Mugu Lagoon represented by far the largest coastal wetland system in the county, with extensive subtidal, tidal flat, tidal marsh, and salt flat habitat.

Recent research by Grossinger et al. (2011) puts these patterns within a Southern California regional context. The study examined these wetlands in the context of broader Southern California coastal wetlands, drawing conclusions about broad categories of estuarine systems in the region (see Grossinger et al. 2011 for more information). Ventura County historically represented at least three distinct estuarine habitat mosaics or archetypes: the compressed estuaries merging into broad riparian forest associated

Fig. 6.1. Mugu Lagoon from the east, 1923. This oblique aerial image of Mugu Lagoon shows habitats of the eastern arm of Mugu, including tidal flat, salt marsh, and the lagoon itself. The patterns shown bear a striking resemblance to those shown on the T-sheet, surveyed over 50 years earlier. (Harrington 1923a, courtesy of the Smithsonian Institution)

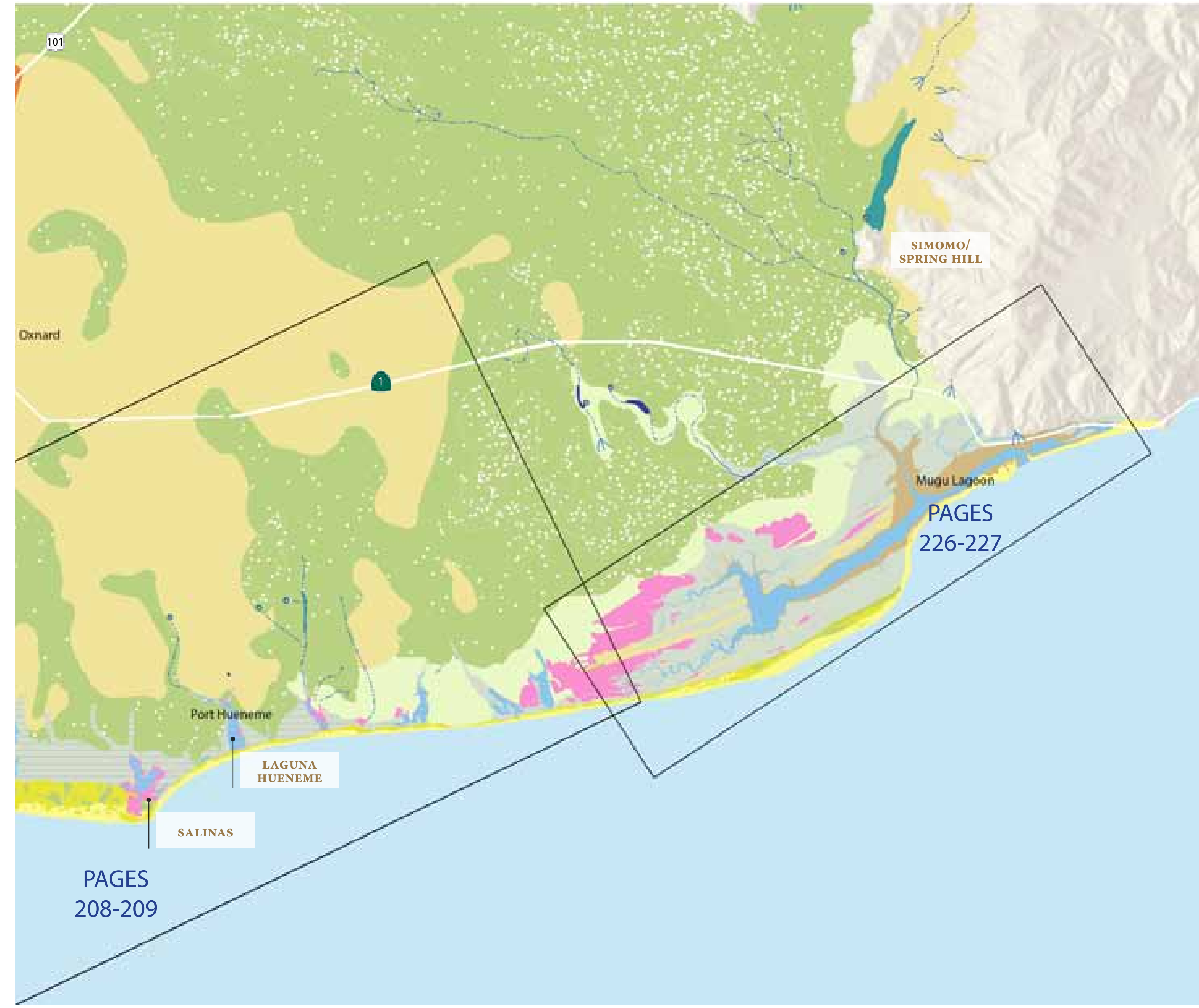


Fig. 6.2. Habitats of the Ventura County shoreline, early 1800s. At least three general types of coastal systems, or coastal archetypes, can be identified along the Ventura shoreline: freshwater-brackish estuaries associated with the Santa Clara and Ventura river mouths, dune-dammed non-tidal lagoon systems (with associated salt/brackish marsh and salt flats) marking former Santa Clara River mouths, and the large coastal wetland system at Point Mugu.

Coastal and Estuarine Habitats

- Ocean
- Beach
- Dune
- Tidal Lagoon (mostly open?)
- Tidal Lagoon (seasonally open)
- Non-Tidal Lagoon
- Tidal Flat
- Tidal Marsh
- Seasonally Tidal Marsh
- Salt/Brackish Marsh
- Salt Flat/Seasonal Pond/Marsh Panne
- High Marsh Transition Zone

Palustrine and Terrestrial Habitat

- Perennial Freshwater Pond
- Valley Freshwater Marsh
- Willow Thicket
- Wet Meadow
- Alkali Meadow
- Alkali Meadow/Flat
- Oaks and Sycamores
- Grassland/Coastal Sage Scrub

Characteristic Riparian Habitat

- Willow-Cottonwood Forested Wetland
- Other In-Channel Riparian

Hydrology

- Intermittent or Ephemeral
- Perennial
- Distributary
- Outer River Bank
- Spring

with the high-energy Ventura and Santa Clara river mouths and substantial freshwater influences; the distinctive Oxnard plain backbarrier lagoons associated with now-abandoned Santa Clara River mouths; and the large tidal wetland system at Mugu. These environments, exhibiting spatial and temporal variation in vegetation type, extent and duration of open water, salinity, and tidal connection, supported distinct mosaics of native species.

The following chapter provides a historical perspective on the patterns and characteristics of Ventura's coastal features, including the Ventura River delta, the Santa Clara River mouth, the county's backbarrier lagoons, and Mugu Lagoon.

Ventura River Delta

The Ventura River and floodplain empty into the ocean west of the city of Ventura. Historically, the estuary consisted of a large willow-cottonwood riparian forest with numerous distributary channels, a tidal lagoon and tidal flat, salt marsh, high marsh transition zone, and a number of small seasonal ponds within the marsh (fig. 6.3). Similar habitat patterns largely persisted on the T-sheet resurvey (Greenwell and Forney 1870). By the 1933 resurvey, however, most of the estuarine features were no longer depicted, including the former lagoons, marsh, and willow-cottonwood forest (Kelsh 1933a). Only limited trees (labeled "camping grounds in grove," south of the 1855 extent of forest) and salt marsh are depicted on this later survey.

The old Ventura canoe builders stored their canoes in the tule marsh at the mouth of the Ventura River. They cut and piled up tule stems so the canoe could rest out of the water, and bent the tule growing on both sides over the canoe as a sunshade. The tips of the tule stalks interlaced like the fingers of clasped hands, and a pole was laid on top to hold them in that position.

—TIMBROOK 2007

Apart from the T-sheets, there are limited data available describing the historical character of the Ventura River estuary. Ethnographer John P. Harrington's informants recalled tule marsh at the mouth of the river, where tule was collected and canoes were stored (Calendaria Valenzuela, in Hudson and Blackburn 1984; Timbrook 2007). These canoes were used on the lagoon at the Ventura River mouth (Simplicio Pico, in Hudson and Blackburn 1984). Wire rush (*Juncus balticus*) and Indian rush (*J. textilis*) were found in the sand dunes at the river mouth as well as "in the *montes*" and "at Sauzal," both designations that probably refer to the willow-cottonwood forest at the mouth (Blackburn 1963, Timbrook 2007).

Herbarium specimen records also describe the presence of this suite of marsh, flat, lagoon, and dune habitat at the Ventura River mouth, although most records are relatively late. The earliest collection, made by William Brewer in March 1861, describes the estuary and marsh as the "swamp by camp" (he collected distant phacelia [*Phacelia distans*]; Brewer [1930]1974).

Specimens collected in the dune community included marsh jaumea (*Jaumea carnosa*), beach saltbush (*Atriplex leucophylla*), California saltbush (*Atriplex californica*), branching phacelia (*Phacelia ramossissima*), Menzies' goldenbush (*Isocoma menziesii*), sawtooth goldenbush (*Hazardia squarrosa*), silver bur ragweed (*Ambrosia chamissonis*), pink sand verbena (*Abronia umbellata*), and red sand verbena (*A. maritima*) (Pollard 1945, Hagerty 1950, Pollard 1962, 1963b, 1964). A more detailed exploration of 20th century botanical specimens can be found in Ferren et al. (1990).

Fig. 6.3. Habitats of the Ventura River mouth, early 1800s. Extensive riparian willow-cottonwood forest and estuarine habitat characterized the Ventura River floodplain at its mouth.

Limited available evidence suggests that the Ventura River mouth did not close as regularly during the summer as did the Santa Clara River mouth, perhaps reflective of greater perennial flow in the lower reach in addition to lesser wave exposure. Based on the classification system of Jacobs et al. (2010), the river was a small to medium watershed in a prograding, low exposure (south facing) setting, with hydraulic estuarine formation, and would therefore be expected to be fully open or have subtidal closure more than half the time, with periodic closure up to and above high-high tide.

This analysis is supported by historical accounts. The earliest T-sheets for the two mouths, produced during the same year and the same (summer) season, show the Santa Clara River mouth separated from the ocean by a narrow barrier, while the lagoon at the Ventura River mouth maintained a narrow outlet. A GLO surveyor, surveying along the beach on July 1, 1869, noted crossing the "outlet of the mouth" of the river (Thompson 1869). The earliest evidence comes from the journal of explorer Juan Crespí in mid-August 1769 and May 1770. Crespí observed that the river "reached to the sea" in August, though at high tide there was no perceptible flow and an inlet was created (Crespí and Brown 2001). In May of the following year, however, his party was able to observe the river at low tide, and Crespí noted that "where we saw it the other time, it was not flowing but instead was ponded up and turning into an inlet; the tide was low this time, it was flowing almost as far as the very shore."

The mouth did close, though closure dynamics are uncertain and not well documented. Timing, duration, and frequency of closure would have likely varied with yearly oscillations in rainfall, as well as with anthropogenic changes in flow in the lower river over time. The only historical evidence found that directly addresses the question is a newspaper article from 1909, describing a season with abnormally high flow:

> The mouth of the Ventura river presents a sight more remarkable than for thirty years past. Indeed, not the oldest inhabitant can remember when it was just exactly as it is at present. There is a great volume of water still coming down from the mountains, and this is of a very beautiful dark green color. It has gathered in a great lagoon below the bridge, the lake presenting a frontage of almost a quarter of a mile to the ocean. Between the sea and the lagoon are piled up great masses of rock, of all sizes, tons and tons of it, and the waves run up on this at high tide, although they do not get over into the lake. The mouth of the river is at the extreme western point of the lake, a quarter of a mile further to the westward than it has ever been known to be…The stream shows small signs of closing up this summer, and very likely will not be closed. But if the lagoon remains as now, there will be plenty of duck shooting and lots of water for boating and for the boys to swim in. The lagoon in fact is deeper than it has been in years. The flood seems to have washed out the bed of the entire stream to an unparalleled depth below the old bed. (*Ventura Free Press* 1909b)

One notable feature in the Ventura River delta was a brackish lake to the west of the end of Figueroa Street. The lake marked a former outlet of the river, and covered about 2.5 acres of open water and 9 acres of marsh. This lake and former river mouth were also the site of a Chumash village, Mitsqanaqan. (See page 130 for more information on channel change at the mouth of the Ventura River.)

…there used to be a lake, but the lake is gone now. This was not an estero, nor did the water come from the river, but seeped in from sea through the sand.

—HARRINGTON 1913E

On the earliest (1855) T-sheet, the lake is shown occupying a low spot behind a narrow beach, not connected with the ocean and with substantial surrounding marsh (Johnson 1855c; fig. 6.4). It is documented similarly on the 1870 resurvey, though with a larger amount of open water adjacent to the beach. An unrelated survey from May 1868, however, shows a small lake with marsh in this vicinity with a clear connection to the ocean (Bard 1868). If this is indeed the same body of water, then the lake may have had at least an intermittent connection to the ocean.

The lake is vividly described by Chumash residents interviewed by John P. Harrington in the early 20th century. Though at the time they were interviewed the lake no longer existed, his informants recalled what it had been like decades earlier (fig. 6.5). The lake was called Tsikatskats (with variable spellings in Harrington's notes), which was translated by his informants as "sweet water running below," presumably referring to

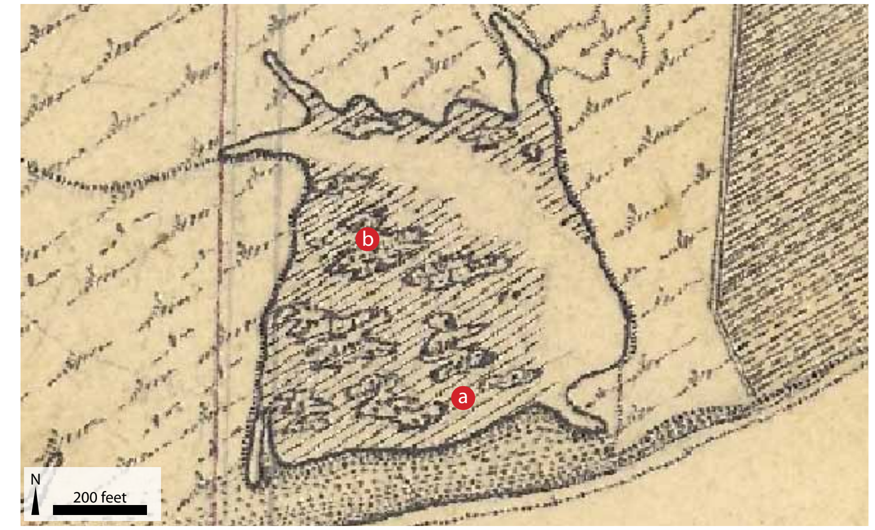


Fig. 6.4. Lake east of the Ventura River, 1855. This small brackish lake marked the easternmost extent of the historical Ventura River floodplain, and was surrounded by extensive tule marsh (shown by the closely spaced lines in the marsh on this map a). Though the symbol within the marsh is non-standard b, we interpret it to be patches of grassy cover, such as saltgrass or seasonally inundated meadow. (Johnson 1855c, courtesy of the National Oceanographic and Atmospheric Administration)

Fig. 6.5. Tsikatskats, the lake at the end of Figueroa Street. This photograph, taken in the fall of 1923, shows the remnant of what was once a well known brackish lake in the Ventura River floodplain. What are likely cattails (*Typha latifolia*) are visible in the foreground, along with stands of alkali bulrush (*Scirpus* [*Bolboschoenus*] *maritimus*) and bulrush/tule (*Scirpus [Schoenoplectus] californicus*; see particularly the matted vegetation to the right of the open water). Pickleweed (*Salicornia virginica*) dominates the foreground. (Harrington 1923b, courtesy of the Smithsonian Institution; plant interpretation, Baye pers. comm.)

Fig. 6.6. Two views looking across the city of Ventura to the shoreline. A circa 1875 image (top), taken from the hill behind Mission San Buenaventura facing southwest, shows the low floodplain area east of the Ventura River. A portion of what is likely Tsikatskats lake can be seen in the distance, at a. A nearly identical view (below), taken about eight years later, shows the same area in flood. What appears to be a small seasonal pond or panne, corresponding in shape to one depicted on the T-sheet 28 years earlier, can be seen at b. (This feature is visible on fig. 6.3 as the leftmost salt flat/seasonal pond/marsh panne, shown in pink.) (Unknown ca. 1875, Pierce ca. 1883; courtesy of the California Historical Society)

groundwater from the Ventura River found beneath an otherwise brackish lake (Harrington 1986a,b). It was described as a "pool of brackish water," surrounded by abundant tule (Harrington 1986b):

> The former lake situated where the pool of water is now situated, west of the lower end of Figueroa St. was called in V. tciqatcqatc, meaning "sweet water running below". There used to be much tule there where the tule is now. The lake was where the water is now. (Harrington 1986b)

The lake, only present as a small pond/slough complex in 1913 as described by Harrington's informants, was barely visible on the 1927 aerial imagery, and left unmapped on the 1933 T-sheet resurvey. The area, historically part of the Ventura River delta, continued to flood well into the 20th century (fig. 6.6). It has remained in relatively unintensive use even today (it is now the parking lot across from Seaside Park at the Derby Club).

Santa Clara River Mouth

The mouth of the Santa Clara River encompassed a diverse array of freshwater, brackish, and saline habitats. A seasonally open tidal lagoon, bordered by tidal marsh, formed the outlet of the river. To the north and south, alkaline/saline habitats (e.g., alkali meadows and salt flats) as well as abundant freshwater habitats (wet meadows, willow-cottonwood forests, and a freshwater lake and surrounding marsh) were also present (fig. 6.7 and 6.8). Under Jacobs et al.'s (2010) definitions, the Santa Clara River mouth regularly closed above high-high tide or perched, with seasonal breaching and opening to the subtidal level. This closure pattern reflects the river mouth's exposure to wave action in addition to freshwater inputs from the watershed.

> *I would state here that there is one peculiarity in the creeks and many of the rivers and small esteros on the southern coast of California, and that is that in the dry seasons the creeks and rivers sink before they get to the ocean, and their mouths are closed or filled up with drifting sand…*
>
> — UNKNOWN CA. 1869

The seasonality of the estuary is well documented by historical accounts. The earliest detailed depiction of the lagoon at the river mouth, surveyed during the 1855 summer field season, shows the lagoon separated from the sea by a narrow beach (Johnson 1855c). In a report associated with this survey, Johnson explains that though at the time of writing (October 1) the lagoon was not connected with the ocean, "after the rains of winter begin, it…has water enough to break through the narrow sand-beach at present separating it from the sea" (Johnson 1855a). A subsequent U.S. Coast Survey report supports this, stating that "in the rainy season a volume of water is brought down having sufficient force to break through the narrow sand beach and flow into the ocean" (*Daily Alta California* 1857; a direct quote from Davidson 1864). These descriptions are corroborated by other (albeit less precise) 19th century sources, which also describe a lagoon with "no visible communication with the sea, save when in winter the floods tear away the intervening wall of sand" (Thompson and West [1883]1961; see also Storke 1891) and a river "blocked up by sandhills in summer" (Cooper 1887).

Maps also support this variability: some cartographers showing the lagoon open to the ocean, while others show no connection. One early sketch shows a narrow "salt laguna" at the mouth of the river, with no connection to the ocean (Unknown ca. 1870). Another much later map also shows a large, disconnected lagoon (Farrell 1935). However, other maps show the lagoon with a clear tidal connection (e.g., Stow 1877, Schuyler 1900, Holmes and Mesmer 1901b, Kelsh 1933b; fig. 6.9). The earliest topographic quad and a historical soil survey contain an intermediate depiction, showing thin blue lines connecting the lagoon to the ocean (USGS 1904,

Fig. 6.7. Habitats of the Santa Clara River mouth, early 1800s. A seasonally open tidal lagoon, tidal marsh, alkali meadows, and salt flats, as well as abundant freshwater habitats (wet meadows, willow-cottonwood forests, and a freshwater lake/surrounding marsh) characterized the mouth.

Fig. 6.8. Habitats of the Santa Clara River mouth, here overlaid on a modern aerial image, illustrate the former extent of estuarine and riparian habitats. (USDA 2009)

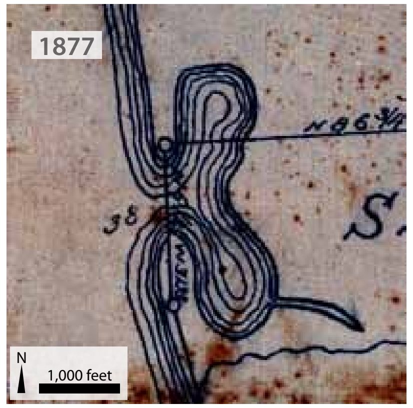


Fig. 6.9. Seasonally tidal lagoon at the mouth of the Santa Clara River, 1877. An early depiction of the lagoon open to the ocean. (Stow 1877, courtesy of the Museum of Ventura County)

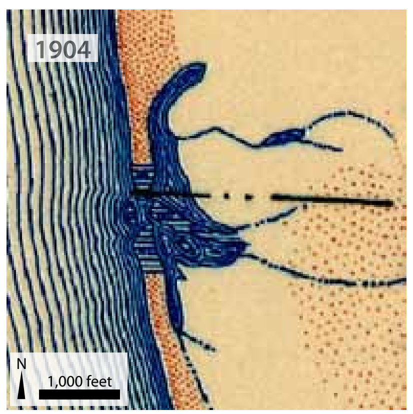


Fig. 6.10. Seasonally tidal lagoon at the mouth of the Santa Clara River, 1904. Rather than showing the lagoon as open or closed, this historical topographic quad uses thin blue lines perpendicular to the coastline to represent the connection between the lagoon and the ocean. (USGS 1904, courtesy of CSU Northridge Geography Map Library)

Nelson et al. 1917; fig. 6.10). Unfortunately, none of these maps specify the season of survey.

The T-sheet resurvey for the river mouth, conducted in January and February 1933, supplies a detailed depiction of the lagoon in winter, and provides a useful counterpoint to the summer survey of 1855. In the resurvey, the lagoon is open through a narrow breach in the sand (Kelsh 1933b). The surveying party describe the closure dynamics in the accompanying descriptive report:

> In dry weather this river mouth is practically or wholly closed. At the time of the survey (Jan-Feb 33) a steady shallow stream about 25 M. [80 feet]wide was flowing as shown, but when place was visited in October for additional notes on recent developments the mouth was closed. (Kelsh and Green 1934c)

This description is consistent with roughly contemporary descriptions of the lagoon from engineer C. E. Grunsky, who writes that "during the summer and fall, and, occasionally, throughout the entire year, the mouth of the river is blocked by a barrier of beach sand piled up by the ocean waves" (C.E. Grunsky Company 1925). He also explains some of the steps local landowners were taking to diminish the size of the lagoon:

> The mouth of the river is closed to the ocean for a considerable period of time each year by a barrier of sand which is thrown up by the ocean waves. The crest of this barrier is usually at such a height that when the river begins to flow in early winter its water accumulates behind the same to a height which the landowners in the vicinity find undesirable. An artificial cut is then made through the barrier and the ponded water escapes. If there is abundant rainfall and a fair amount of runoff the cut is kept open by the flowing water. If there is but little water to be discharged into the ocean the cut may be repeatedly closed by the ocean storms in a single season.

The limited available evidence describing tules, cattails, willows, and pondweed suggests substantial freshwater influence on the Santa Clara River estuary. The presence of perennial flow in the lowest reach of the river (see chapter 3) and persistent summer closure have the potential to create strong freshwater-brackish zones in the lagoon and surrounding wetlands (ESA PWA et al. 2011). The willow-cottonwood forest of West Grove also suggests freshwater conditions. A birder documented a "tule-bordered lagoon" near the mouth, as well as numerous sloughs with "a dense growth of pondweed [*Stuckenia pectinata/Potamogeton pectinatus*]" (Hoffmann 1921, 1926). Cooper, describing a visit to the river mouth in early spring of a dry year (1872), still noted fresh conditions, as well as the presumed inter-annual variability of habitats at the mouth:

> On May 10, 1872, I visited the mouth of the river purposely to see what birds bred there, but I found only a Mallard sitting among the cat-tails in the wettest part of the marsh, most of which seemed too dry for safety… Cattle grazed all over the marshes…The advantages for birds to breed there must vary much in different years. (Cooper 1887)

Fig. 6.11. This 1947 view of the coastline around the Santa Clara River mouth shows McGrath Lake (a) to the south of the closed river mouth (b) and the Pierpont lowlands to the north, together composing the low, broad floodplain of the river at its mouth. The city of Ventura can be seen in the background. (Spence Air Photos 1947, courtesy of the Benjamin and Gladys Thomas Air Photo Archives, UCLA Department of Geography)

In addition to West Grove, substantial freshwater habitat was present in the form of freshwater McGrath Lake and the extensive, seasonally flooded wet meadow covering the Pierpont lowlands (what today is the low-lying area around the Ventura harbor; fig. 6.11). These floodplain areas would have been inundated during extreme floods by the Santa Clara River.

McGrath Lake is one of the few remaining coastal water bodies on the Oxnard Plain shoreline, though its origins are different than the mostly closed, brackish/saline tidal lagoons historically to the south (and derived from ancient river flows). Unlike these lagoons, McGrath was a freshwater lake, with hydrologic inputs derived primarily from active surface flows from the Santa Clara River and groundwater. The lake is shown on the region's T-sheet, labeled "fresh water" (Johnson 1855b; fig. 6.12). The lake as shown here was 8 acres, with 5 acres of fringing freshwater marsh. The lake occurred in a low spot between parallel ridges of sand dunes, and was also surrounded by willow thickets and seasonally inundated grassland. Cooper

Quite a number of persons were down in McGrath's bottoms last Sunday 'a blackberrying,' but the crop seemed to be very light this year…

—Ventura Free Press 1891a

Fig. 6.12. McGrath Lake, 1855. The lake occurs at the boundary of two T-sheets, and is mapped by both. On this sheet, covering the area from McGrath Lake to Hueneme, the lake is labeled "fresh water," a rarity on the Oxnard Plain. (Johnson 1855b, courtesy of the National Oceanic and Atmospheric Administration)

Third day journeyed southwesterly ten miles, and struck the sea; thence fifteen more northerly to near the mouth of the Santa Clara, and up the lower bottom of that stream to camping ground in the enclosure of Mr. Pierpont.

—*Daily Alta California* 1868

(1967) described stands of tule (*Scirpus [Schoenoplectus]* spp.) associated with the lake.

For whatever reason, the historical record is mostly silent on McGrath Lake, though it was likely the site of many summer excursions in the late 19th and early 20th centuries. One record, from a 1910 newspaper article identifying potential park locations on the Oxnard Plain, describes the lake as part of the larger habitat community at the site, noting that "another spot that is a very fine one for the people of Oxnard and community would be at the McGrath Grove, a willow grove beside a fine lake, the property of the Dominick McGrath estate and the scene of numerous picnics" (*Oxnard Courier* 1910).

Though the appellation has persisted, the precise location of the lake has shifted substantially over the past 150 years. What was historically considered to be McGrath Lake is currently predominantly willow-cottonwood forest and developed land; only the tail of the historical lake overlaps with the current lake-marsh complex (fig. 6.13). It is unclear when this shift occurred, though it had clearly happened by the time the first aerial imagery was flown (1927) and the T-sheet resurveyed (1933). Both sources show an extent of open water almost identical to what was present in 2005, with a large area of marsh north of the lake and covering the lake's former position (Fairchild Aerial Surveys 1927, Kelsh 1933b). Overall, the extent of the lake has increased from eight acres in 1857 to fifteen acres in 2005.

To the north of the mainstem Santa Clara River, the Pierpont lowlands were a broad, low coastal flat extending more than 2.5 miles northward, nearly to the Ventura River, and comprising the westernmost extent of the Santa Clara River delta (fig. 6.14). Located between sand dunes and a bluff marking a former coastline, the flat trapped water from the Santa Clara River during floods, creating a large area of seasonally inundated wet meadow. This feature of the Pierpont area is captured by the early T-sheet survey, where "overflowed during winter" is written across the entire plain. The feature is a result of progradation, as Ventura River sediments were deposited north of the convex Santa Clara River mouth (Putnam 1942).

By the turn of the 20th century, the seasonal wetland between the dunes and the bluff was under cultivation with beets and barley, though the area must have still been frequently flooded (Waud ca. 1899). By the late 1920s, the northern portion of the lowlands had been subdivided and a few houses built on the wetland and dunes, though evidently not without trouble—the T-sheet records that "small streets beyond those shown [are] buried in sand" (Fairchild Aerial Surveys 1927, Kelsh 1933b; see fig. 6.14). This area is what would become the modern subdivision at Pierpont Bay, north of the Ventura Marina. Flooding is still an issue in portions of the Pierpont area, and wetlands are still present at Alessandro Lagoon at the northeastern end of the lowlands (see fig. 6.29).

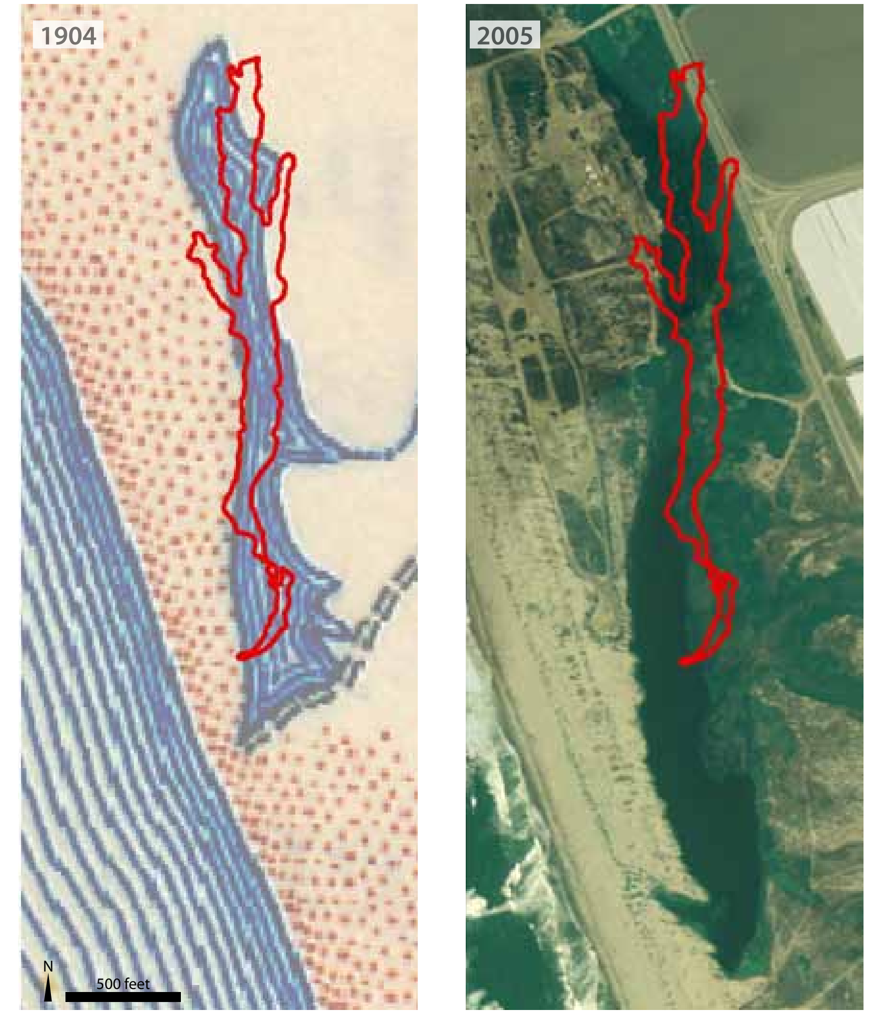


Fig. 6.13. Comparison of historical and modern location and extent of McGrath Lake. Between 1855 and 2005, McGrath Lake has shifted about 1,500 feet to the south. However, the extent of open water appears broadly comparable. The 1904 historical topographic quadrangle (at left) shows the lake covering a broad extent roughly comparable to the 1855 mapping (shown in red outline). (USGS 1904, courtesy of CSU Northridge Map Library; USDA 2005)

Oxnard Plain Shoreline

From the mouth of the Santa Clara River to Mugu Lagoon, a broad barrier beach-dune system characterized the Ventura shoreline. Like the Oxnard Plain itself, this system—and the associated series of backbarrier lagoons and wetlands extending for nine miles downcoast—were formed by the Santa Clara River, each lagoon marking a former mouth of the river and dunes indicating the Ventura and Santa Clara rivers' ample sediment supply. These non-tidal lagoon complexes covered a total of 1,000 acres with open water and associated marsh habitats (compared to Mugu Lagoon's 2,550 acres), collectively making them the second largest coastal wetland area in Ventura County (fig. 6.15). (These acreages do not include the adjacent high marsh transition zone, which accounts for an additional 1,640 acres of wetland habitat.) A combination of coastal development (including dredging and drainage), with the reduction of sediment supply from the

Fig. 6.14. Between 1855 and 2005, the seasonally inundated lowlands at Pierpont have been heavily developed. The beginnings of a street grid can faintly be seen on the historical aerial in the dunes (middle); this same street pattern has persisted to the present day (right). Today, this area includes the Ventura Harbor. Note that a subdivision shown on the northern part of the Pierpont lowlands is now part of San Buenaventura State Beach. (Johnson 1855c, courtesy of the National Oceanographic and Atmospheric Administration; Fairchild Aerial Surveys 1927, courtesy of Whittier College; USDA 2005)

Ventura and Santa Clara River watersheds, has drastically altered this portion of the shoreline (Orme 2005).

Broadly, the lagoon complexes shared multiple characteristics. Most had high marsh to open water ratios, and were dominated by extensive areas of vegetated emergent wetlands rather than open water. They also shared similar tidal dynamics, since each lagoon maintained little to no tidal access and most were blocked by substantial sand dunes. However, in other respects the systems were quite heterogeneous, with a broad array of variable ecological and hydrological expressions. In particular, the salinity concentrations and degree of seasonal inundation both varied widely across systems, in turn implying variations in lagoon depth and the quantity and source of hydrologic inputs. In addition to this inter-lagoon complexity, each lagoon complex also experienced yearly fluctuations in salinity and degree of inundation. As a result of these broad variations by year, season, and lagoon, early sources can be challenging to interpret.

Despite fragmentary historical documentation, many of these similarities and distinctions are captured by early accounts. While fine distinctions (e.g., perennially inundated lagoon versus seasonal pond) may be challenging to make with the available data, the overall characterization of the Oxnard Plain shoreline as a region with a matrix of perennial lagoons, seasonal ponds and salt flats, and salt/brackish marsh is very clear. These four factors—ecology, tidal access, seasonality, and salinity—are explored in detail below.

Deponent avers that there are numerous salt ponds along the whole length of coast from the mouth of the river Santa Clara to the south west corner of the rancho…

–BARD 1869

While they are typically thought of as lagoons, most (65%) of the aggregate area was vegetated marsh, as shown by the USCS T-sheet (Johnson 1855b, 1857). Seasonally flooded salt flats composed another significant proportion of the total area. (Our mapping shows 12% of the total area as salt flat, though this extent might have increased in dry years.) As is the case for other coastal wetland systems in Ventura County, however, little detailed documentation exists describing the historical plant community composition of these lagoon complexes. The idiosyncratic data we discovered mostly describes the Hueneme area, and emphasizes the marshy nature of these systems. Documented plants from narrative accounts include Indian rush (*Juncus textilis*) and a "salt grass point" in the Hueneme area (Eames 1889, Blackburn 1963). Early botanical specimens were collected at Hueneme from both brackish and salt marsh habitats, including obligate wetland species such as Virginia glasswort (*Salicornia virginica*), saltmarsh baccharis (*Baccharis douglasii*), salt sandspurry (*Spergularia marina*), the currently rare species saltmarsh bird's-beak (*Cordylanthus maritimus* ssp. *maritimus*), and the federally endangered Ventura marsh milkvetch (*Astragalus pycnostachyus* var. *lanosissimus*) (Kline 1924, Peirson 1925, Craig 1927, Purer 1935). A few accounts also describe the abundant waterfowl found around these lagoons, especially in the winter, such as "flocks of wild duck" (Eames 1889) and "many thousands" of geese and ducks (Haydock 1971). One account, from a journal entry describing an outing in March 1902, records more detail:

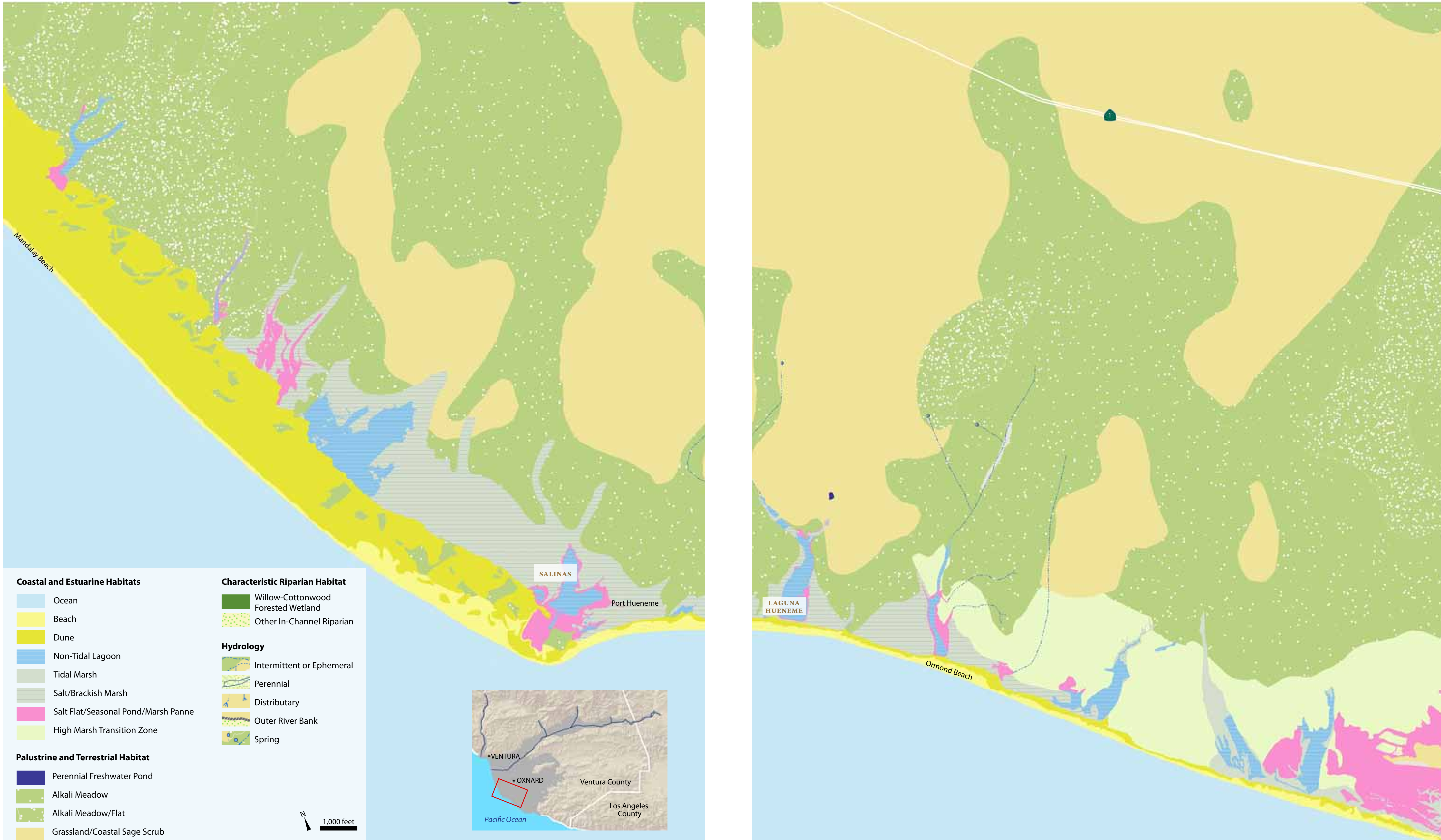


Fig. 6.15. A series of backbarrier lagoons, salt flats, and marshes stretched from south of the Santa Clara River mouth all the way to Mugu Lagoon (the western edge of which is at the right edge of this spread). Separated from the ocean by often extensive dunes, these systems were characterized by variable salinity, seasonality, and habitat proportions. (See fig. 6.24 for the modern aerial of this area.)

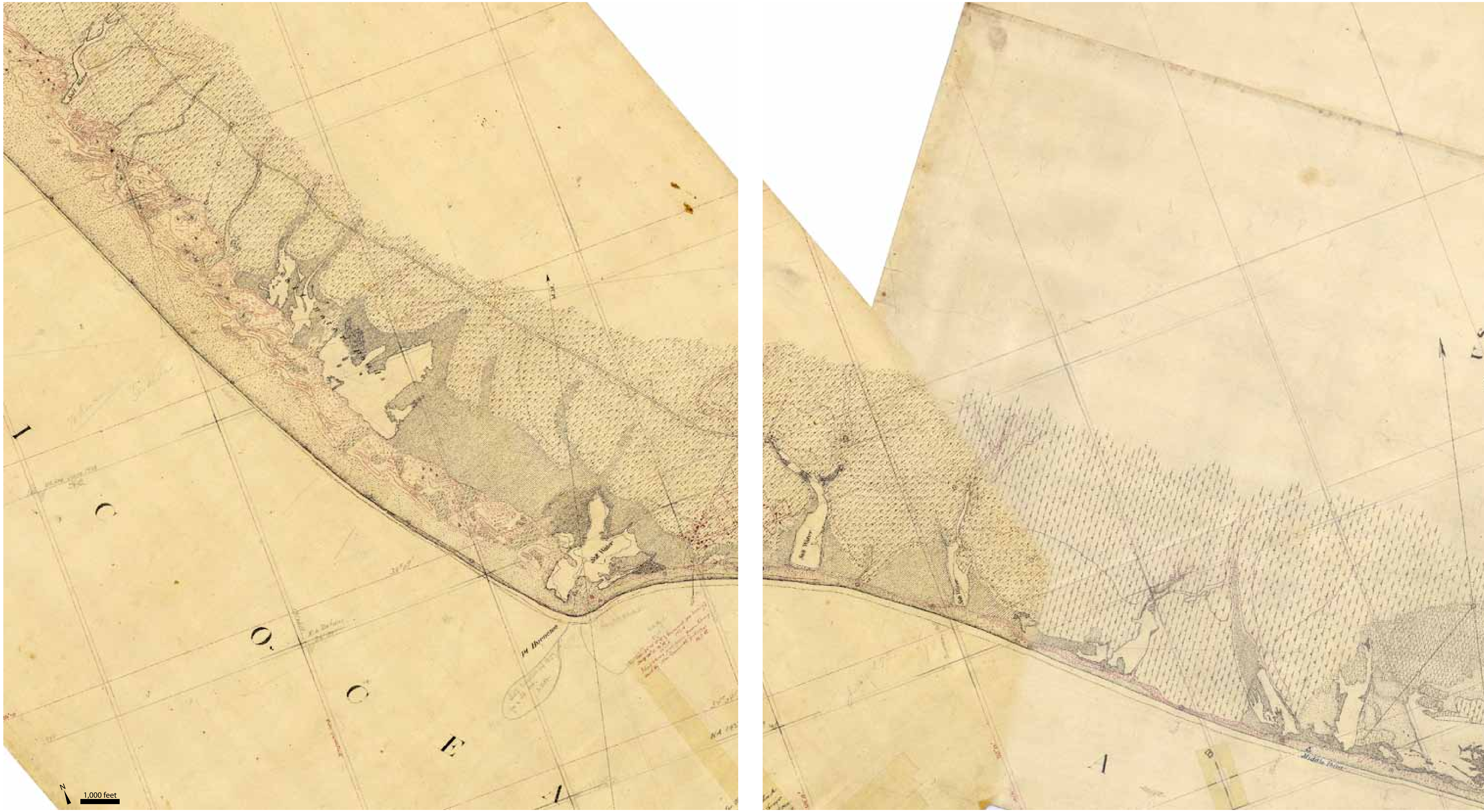


Fig. 6.16. The earliest detailed surveys of the Ventura shoreline, completed in 1855 and 1857, show the coastal wetlands with impressive precision. (Johnson 1855b and Johnson 1857, courtesy of the National Oceanographic and Atmospheric Administration)

> …we drive along in full view of several islands and observe the sand bar that waves have thrown up, that prevents the water from coming in where it formerly held sway thereby leaving a marsh and beach and many enclosed lakes and streams in and upon which are all kinds of denizens of the deep, fowls and some animals. We note three flamingoes, many water-snipe, pelicans in great numbers and ducks in flocks and pairs; and many familiar birds in these ponds are shovel-bills (resemble shovels and dig in sand)…There was an oyster bed at the point but it has been destroyed by waves and sand. (Wallace Weston Brown, in Brown 1981)

By far the most detailed depiction of the suite of coastal lagoons is provided by a set of USCS T-sheets produced in the summers of 1855 and 1857, the maps upon which the bulk of our own historical habitat mapping is based (Johnson 1855b,c and Johnson 1857; fig. 6.16; see Grossinger 2011 for more discussion of these sources). These early surveys depict the lagoons as a series of open water/salt flat/marsh complexes separated from the ocean by sand dunes, which range from 300 to 3,300 feet wide and with high points consistently above 60 feet in elevation northwest of Hueneme. None of the lagoons are shown with a tidal outlet, and the lagoons' square-end shapes and the presence of the wide, vegetated barrier dunes suggests that these systems opened relatively infrequently. These systems, though not identical, could generally be considered perched and/or dune-dammed (Jacobs et al. 2010).

This depiction of the lagoons—as a series of small systems with an infrequent tidal connection—is supported by supplementary sources, which confirm the persistence of these features throughout the 19th century. An early resident testified in 1869 that the two lagoons at Hueneme had been present as long as he had known the area, "as early as 1837 or before that time" (Gonzales 1869). Subsequent independent depictions of the lagoons are consistent with the T-sheet, matching the general location and extent of each feature, though these maps generally did not map salt marsh and fail to distinguish between salt flat and open water (Bard 1870a,b; Reed ca. 1871; Stow 1877; Schuyler 1900; Holmes and Mesmer 1901b; USGS 1904). None of these maps show any of the lagoons with a tidal connection. Narrative descriptions also support the largely non-tidal aspect of the lagoons. It was stated that the two lagoons at Point Hueneme "are some distance from and do not communicate with the sea" (Smith 1871), while the lagoons north of Point Hueneme "have no daily communication with the ocean, but on occasions of storms the waves sometimes wash over from the sea into said

LAGOONS AND DUNES

A broad barrier beach-dune system stretched from the Santa Clara River mouth to Mugu Lagoon, separating the numerous lagoon-salt marsh complexes from the ocean (fig. 6.17). The early T-sheets capture the complex Aeolian topography with characteristic detail, with solid and dashed (intermediate) red contour lines indicating 20 foot contour intervals. The mapping indicates that the dunes were broader and taller north of Hueneme, with the highest points consistently above 60 feet. Sand dune width ranges from 300 - 3,300 feet. This dune topography was described by another observer as a "continuous, high sandy beach or sea wall," where "hills and sand ridges—some of them being 60 to 75 feet high, lying parallel with the beach line—widen out and occupy a space of from half to three fourths of a mile" (Reed 1871).

Vegetation varied with position on the dune structure, with different species characterizing the foredune, middle, and inner/backdune zones. These patterns are described by Cooper (1967), who described vegetation on the dunes near Hueneme: saltbush (*Atriplex leucophylla*) and verbena (*Abronia* spp.) on the foredune, herbaceous cover and salt grass (mapped as alkali meadow) and "extensive thickets of the usual species of willow" on the middle zone, and shrubs on the innermost dunes. Many of these patterns are also reflected on the T-sheet, in particular the middle dune zone patterns of large patches of grass in dune depressions and occasional willow trees and groves. Dune species recorded near Mandalay Beach in 1930s specimen records include yellow bush lupine (*Lupinus arboreus*), beach evening-primrose (*Camissonia cheiranthifolia* ssp. *suffruticosa*), and pink and red sand verbena (*Abronia umbellata* and *A. maritima*), among many other species (Fosberg 1931a,b; Wolf 1931; fig. 6.18). Dunes in the Pierpont Bay region were recorded to have seacliff buckwheat (*Eriogonum parvifolium var. parvifolium*; Craig 1927).

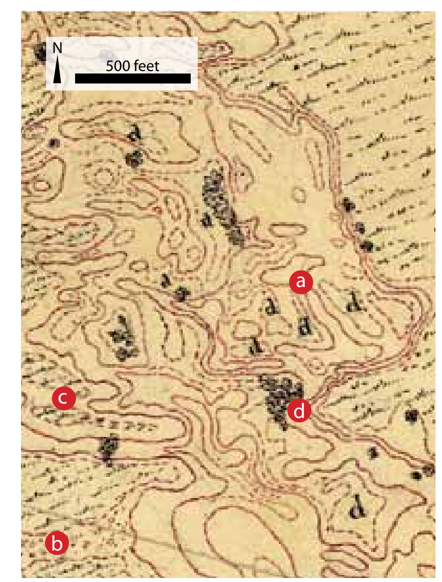


Fig. 6.17. Dune topography and vegetation near McGrath Lake, 1855 (left). Surveyors indicated a depression in the dunes with the letter "d" a, while the small red circles are thought to indicate dune tussocks b (Grossinger et al. 2011). The grassy symbol in some of the dune depressions (far left of image) is alkaline grassland c. A few willows are shown on higher portions of the dunes d. This detail is from the dunes north of West Fifth Street. (Johnson 1855/t-576, courtesy of the National Oceanic and Atmospheric Administration)

Fig. 6.18. "Hueneme Point from east," 1913 (right). Linguist and ethnographer John P. Harrington took Chumash elder Fernando Librado on a series of field trips around Ventura County, documenting significant places and place names. Librado, who would have been in his 70s at the time of this photo, is shown standing in the dunes at Point Hueneme. Some dune vegetation can be seen, including red sand verbena (*Abronia maritima*) and likely shrubby beach primrose (*Camissonia cheiranthifolia* ssp. *suffruticosa*; Baye, pers. comm.). This is consistent with Cooper (1967), who noted that verbena was characteristic of the "hillocks" of the foredunes near Hueneme. (Harrington 1913c, courtesy of the Smithsonian Institution)

salt ponds" (Rodriguez 1871b). Of the two lagoons at Point Hueneme, one resident wrote:

> Neither of these waters are connected with the sea, but both of them are disconnected from the beach by sand hills. It is possible that during the high Spring tides the water may swash over the sand hills in front of the Salinas, as there is very little vegetation growing on the sand hills in front of the said 'Salinas'—but deponent has never witnessed such over swash, though he has been along the coast here at this point very frequently and at all seasons of the year… (Bard 1871)

…there are no esteros, lagunas, or salt ponds other than the Estero Grande [Mugu Lagoon] that have outlets to the sea…

—STOW 1871

Lagoons north of Point Hueneme were blocked from the tides by substantial sand dunes which would have almost never been breached by the ocean, while lagoons south of Point Hueneme, bordered by much smaller dunes, may have experienced more frequent dune overwash.

Though the series of lagoonal systems was composed of at least four distinct complexes, early observers often referred to them as one large, continuous backdune feature (with a few notable exceptions—see below). Early references to "a strip of swampy land full of sloughs, and lagunas…from a half to three quarter of a mile in width" or "sloughs and marsh lands back of the sand hills" extending from the Santa Clara River to Mugu Lagoon illustrate this point (Thompson 1867, Haydock 1971). This is consistent with the habitat patterns represented on the T-sheet, on which lagoons are connected by extensive tidal marsh and seasonally inundated alkali meadow. This entire wetland area would have been flooded for much of the winter, creating one large marsh extending, in some years, all the way to Mugu Lagoon. In the summer, large portions of the shallow lagoons dried up, creating extensive salt flats.

These fluctuations in the quantity of open water throughout the year present a challenge in mapping these systems, particularly the lagoon (open water) and salt flat components. Lagoons and salt flats are similar geomorphic features at different points of the hydrologic spectrum: substantial components of many coastal lagoons dried out during the summer, while many salt flats were flooded during the winter, making the distinction between an open water lagoon and a salt flat somewhat arbitrary. This is reflected in historical sources as well; a few features mapped as ponds or lagoons in one source are mapped as a salt flat in another. Luckily, many of these nuances were captured by early maps and accounts which specified the degree of inundation of various lagoons at different times of year. Olivas (1861) stated that between two of the lagoons north of Hueneme, "all the space between the two lakes at certain seasons of the year is covered with water—at other times it is dry between these." At the south end of the lagoon series, another resident noted that the lagoons only connected with Mugu Lagoon "in years where there is much rain, when they may discharge their surplus waters in the said estero" (Rodriguez 1871a).

I know the two ponds [lagoons at Hueneme]—they are well known, at times there is dry land between them—they are close together.

—ANTONIO MARIA OLIVERA 1857

During the summer the region would have looked very different, with many of the seasonal ponds and even shallower lagoons drying up partially

or completely. Ornithologist James G. Cooper spent two "uncommonly dry" summers in the region in 1872-1873, and noted that at that time he "could ride a horse through almost any part" of the coastal marshes, "the exceptions being some salt lagoons encrusted with the white crystals, and unfit for nests, besides being almost deserted by all the birds, those seen being only a few small Waders and Sparrows" (Cooper 1887). Another party inspecting the lagoons during the dry season as part of a land dispute in 1871 only found water in three of the lagoons: the two at Hueneme Point and another small lagoon to the east (Reed 1871). Reed further stated that "I judge the water in these lagunas to be about on a level with high tide; the ordinary tides rising only about four feet, and spring tides about five feet, on this coast…In the summer, they contain very little water—the evaporation being almost equal to the seepage through the sand hills from the sea." (It should be noted that seepage from the ocean may have been unlikely prior to groundwater extraction on the Oxnard Plain; Swift pers. comm.)

These general observations are corroborated by annotations on an early map, which identifies some lagoons as "salt ponds" and another as "dry pond" (Bard 1870a; fig. 6.19). Remarkably, the T-sheet also has annotations describing summer conditions, written in exceptionally faint pencil within some of the lagoons and seasonal ponds. A few (for example, two seasonal ponds south of modern-day Channel Island Boulevard) are labeled "dry," another portion of one as "salt land" (perhaps marking an exposed portion of the lagoon), while others are labeled "salt water."

Despite outward similarity—each lagoon is consistently described as "salty" by 19th century observers—such variations in hydrology and topography across different lagoon complexes created variations in salinity between and within systems. Water sources for these lagoons were a mix of saline input (from sea spray and possibly from infrequent dune overwash and seepage) and fresh water input (from precipitation, runoff, and springs). Evidence indicates that some of these lagoons were fed by freshwater springs, and therefore would have maintained fresh-brackish-saline gradients and salinity stratification with depth (Parsons 2004, ESA PWA et al. 2011). Conversely, other lagoons had extremely small watersheds and no defined

Fig. 6.19. Coastal lagoons near Point Hueneme, 1870. Four lagoons between Point Hueneme (at left) and Mugu Lagoon (western edge visible as "mud flat" at right). Though we mapped each feature as a non-tidal lagoon, note the labels on the lagoons—meaningfully, each of the four lagoons is labeled slightly differently. The Salinas was so known because of its use as a collection site for salt in the 19th century, suggesting substantial hypersaline and salt flat components. Similarly, the "dry pond," though it would not have dried out completely every year, may have been shallower than adjacent lagoons. The "Laguna Hueneme" was well known for its freshwater inputs. The "salt pond" was found at the mouth of what is known today as the Oxnard Industrial Drain at Ormond Beach. Despite outward similarity, this map suggests substantial variation in hydrology and habitats across systems. (Bard 1870b, courtesy of The Bancroft Library, UC Berkeley)

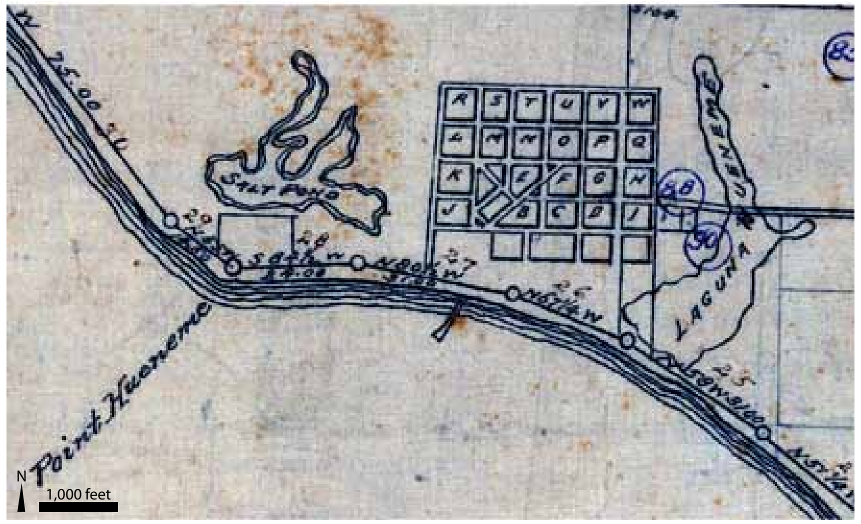


Fig. 6.20. Lagoons near Hueneme, 1877. Two well recognized lagoons were found on either side of the town of Hueneme (shown in its nascent form here). The "salt pond," to the west of town, was known as the Salinas. To the east was spring-fed Laguna Hueneme. (Stow 1877, courtesy of the Museum of Ventura County)

surface channel for freshwater input, and as a result maintained saline or hypersaline conditions. Different systems would have included different components, ranging from perennial freshwater zones in the upper portions of spring-fed lagoon/slough complexes to hypersaline salt lagoons, salt flats, and seasonal pannes.

An extreme example of this variability is found in the two ponds formerly near Hueneme (fig. 6.20). Both lagoons were well known in the 19th century, with names preserved in the historical record. To the west of Hueneme, at the current site of the port of Hueneme, was a salt water lagoon called Sitiptip by the Chumash (Harrington 1913e) and La Buena Salina or the Salinas by Spanish-speaking residents (Harrington 1986a). The Salina was so called because of its use as a gathering place for salt, implying that substantial portions of the lagoon were shallow enough to dry out during the summer for salt harvesting (fig. 6.21). This lagoon was described as the place were early residents would gather salt, and which was "well known to and is designated by the older inhabitants as the place where a certain Dr. Poli, several years ago was accustomed to collect salt and to ship the same to San Francisco" (Bard 1869, Bard 1871). This is reflected in our mapping from the T-sheet, where the ratio of salt flat to open water is 1.4.

The laguna, or lake, at Hueneme, is shown on the diseño near Point Hueneme, and also on the U.S. Coast Survey map, and the small 'salinas,' or salt ponds, further inland. Between the laguna and salt ponds, at Hueneme, and the sea, is a wide barrier of high land, 'staying the sea,'…

—Fernald & Richards and Green 1871

To the east of Hueneme, another lagoon covered approximately 35 acres. Unlike the Salina to the west, this lagoon had a very low ratio of salt flat to open water, only 0.14. It was popularly known as Laguna Hueneme (and to the Chumash as Sislomow; Harrington 1913e). The use of the term *laguna* (lake) here is notable, and unique to this lagoon. It may refer to a greater water depth, the relative lack of salt flats, or to a difference in salinity from the salt ponds surrounding it. It was quite renowned, and was included in the language of the 1846 sale of the San Buenaventura Mission as a primary landmark: "the *Laguna Hueneme*, *Palo Alto* [a large sycamore tree on the Oxnard Plain], the cultivated fields of Santa Paula, [and] the Mission Cañon [Ventura River valley]" (Weber 1978).

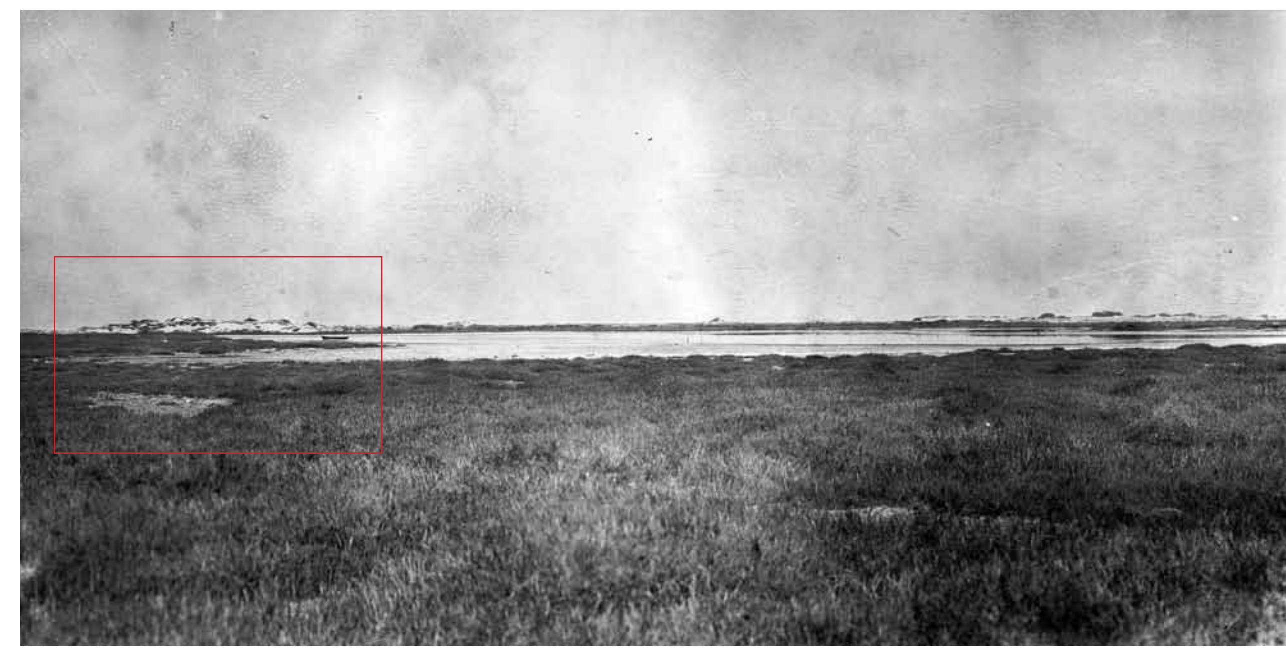


Fig. 6.21. The Salinas, 1913. These two images provide two different views of the Salinas lagoon, formerly located where the port is now. The view is generally southwest; high dunes (top and middle) and the Point Hueneme lighthouse (top; built in 1874) can be seen in the background. In the foreground, extensive salt marsh (mainly pickleweed, probably with some salt grass component and visible pannes) stretches toward the lake. A small boat (detail; at left) can be seen on the lagoon in both pictures, indicating some depth. (Harrington 1913b,d; courtesy of the Smithsonian Institution)

WHAT IS AN ESTUARY?

The abundance of information preserved in the historical record about these coastal lagoons, in particular about the Salinas and Laguna Hueneme, is in large part thanks to an early land dispute. The resulting court case centered on the wedge of land on the Oxnard Plain between two interpretations of the eastern boundary position for the Río de Santa Clara o la Colonia Rancho. The case largely hinged on the use of the word *estero* in the original property description (translated variously as a salt marsh, tidal creek, or estuary), where the boundary was described as hitting the coastline "between two *esteros*." But what, exactly, was an estero? And to what feature in Ventura County did the term refer? The grant's owners contended that the term referred to the two sloughs or arms feeding into Mugu Lagoon, and that *estero* should be translated as "estuary," and argued that the term must refer to a water body with a tidal connection. The settlers, however, interpreted the term to refer to Laguna Hueneme and the Salinas, arguing that Mugu Lagoon was an *estuario* (estuary), while *estero* was a broader term that referred to the salt lake and marsh complexes along the coast and was unrelated to the tides. (The settlers' interpretation would have opened up a wedge of land between Point Hueneme and Mugu Lagoon for settlement.) Ultimately, the dispute was resolved in favor of the land owners, and the boundary line was run to Mugu Lagoon.

Fig. 6.22. "Duck shoot near Hueneme," ca. 1889. This image shows a portion of Laguna Hueneme in the late 19th century. The lagoon is surrounded by tule (likely *Scirpus [Schoenoplectus] californicus*). What is likely sago pondweed (*Potamogeton pectinatus/ Stuckenia pectinata*) can be seen in the foreground (Collins pers. comm.). This photograph, also included as a lithograph in an 1889 article in *Overland Monthly and Out West* magazine on traveling in Ventura County, matches the description included in that article well: "spears of purple reeds [likely tule], with flocks of wild duck plowing luminous furrows across its steel-gray floor" (Eames 1889). (Brewster ca. 1889, courtesy of the Museum of Ventura County)

The most notable aspect of Laguna Hueneme, however, was its freshwater input from springs on the Oxnard Plain. Though this characteristic was not unique to the laguna (it has also been documented for the lagoon immediately to the east; Parsons 2004), it is extremely well documented in this case. Early residents testified that the laguna was "fed by springs of fresh water" (Bard 1871). This characteristic of Laguna Hueneme is a product of its status as a former mouth of the Santa Clara River, relatively recently occupied and still the recipient of substantial freshwater flows (see page 71). Though Laguna Hueneme itself is long gone, this is still the case today: the Hueneme Drain/Bubbling Springs Drain, a man-made channel which occupies the location of the former slough which fed into the lagoon, has perennial flow today as a result of springs (HDR Engineering 2009).

We stopped our horses on a rustic bridge that we might better view the Laguna, winding sinuously among its spears of purple reeds, with flocks of wild duck plowing luminous furrows across its steel-gray floor.

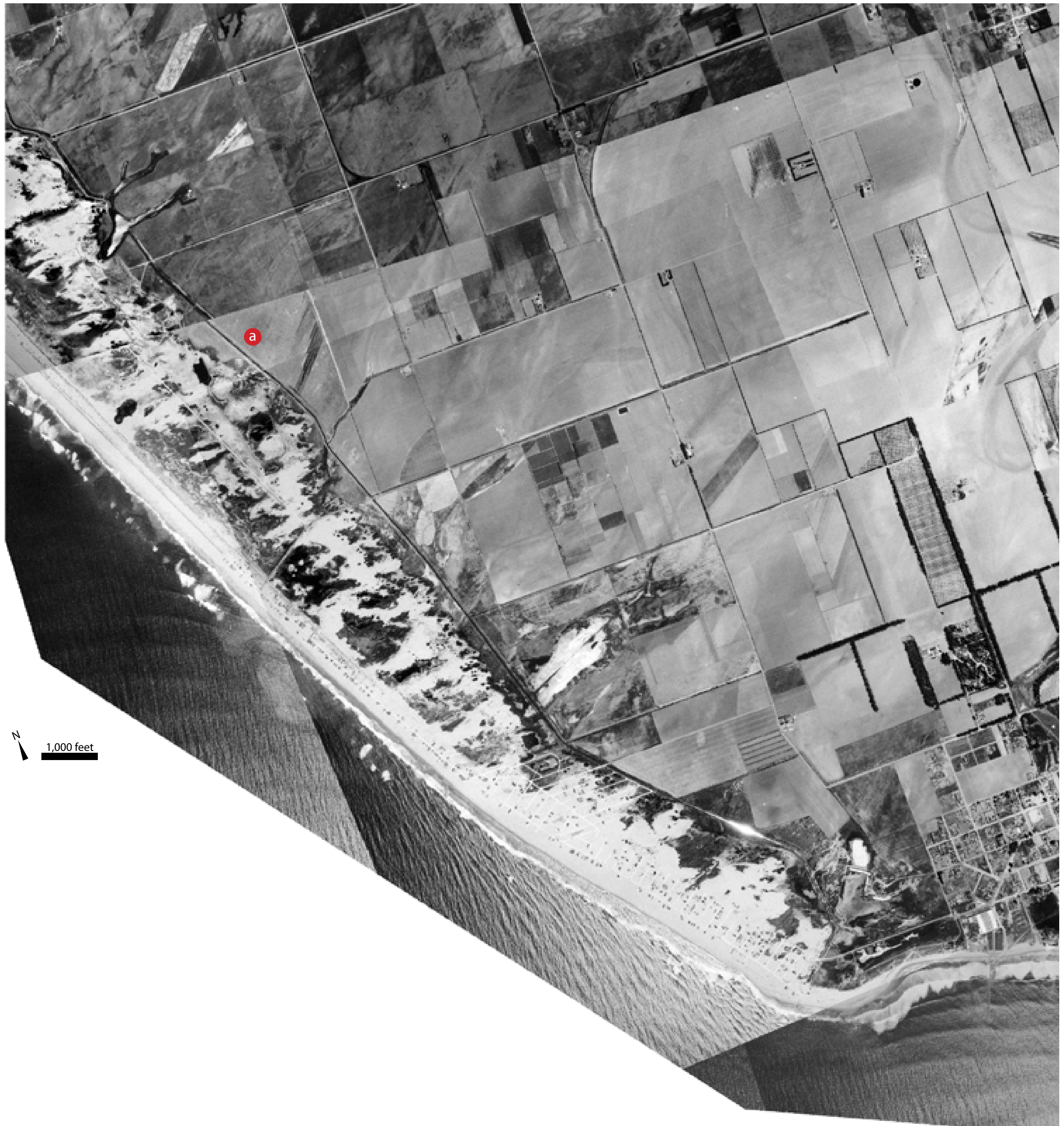
—Eames 1889

Despite this, the laguna was still considered to be a "salty" lagoon, labeled "salt water" on the T-sheet and described as salty in court testimony: "though the Hueneme is fed by fresh water springs" (Johnson 1855b, Reed 1871). It is likely that portions of the laguna (for example, closest to the shore) were saline, while other portions further upslope were brackish. An early image of a portion of the laguna shows abundant tule fringing the water (fig. 6.22).

Fragments of the Laguna Hueneme complex have persisted to the present day in the form of Moranda Park/Bard's Bubbling Spring. Though the lagoon looks largely intact in the 1938 aerial imagery, it was drained shortly thereafter, apparently filled with sediment from the dredging of the harbor at the site of the Salina lagoon (Moranda 1999, Maulhardt 2005). Currently, though the lagoon has been completely drained and filled, the slough that fed it still runs to the ocean in the same location. This is also true of the formerly spring-fed lagoon to its east, at Ormond Beach.

Most traces of the other lagoon complexes have been completely obliterated over the past 100 years (figs. 6.23 and 6.24). Much of this change had already happened by the early 1930s, by which time a five mile long drainage ditch, stretching from south of the Santa Clara River all the way to its outlet at Hueneme and bisecting the former locations of many of the coastal lagoons, had been constructed to drain the area.

Many lagoons became salt flats or marshes, tidal marshes became alkali meadows, and alkali meadows were in large part flushed and cultivated. Historical aerial imagery from 1927 and 1938 hint at this transformation, showing a long canal bisecting dry flats and clearly salt-affected land where 1850s surveyors mapped lagoons. The USCS T-sheet resurvey from winter 1933 captures the lagoons' disappearance even more explicitly (Kelsh 1933b and Kelsh 1934; fig. 6.25). Precise annotations describe former lagoon locations as "former salt pond (now drained)" in the Mandalay Beach area, "ponds formerly shown now drained" near Channel Islands harbor, and "pond, apparently drying up" at the south end of Ormond Beach. Other lagoons are shown with a combination marsh/lagoon symbol. The obvious exception is the spring-fed Laguna Hueneme, shown with substantial water



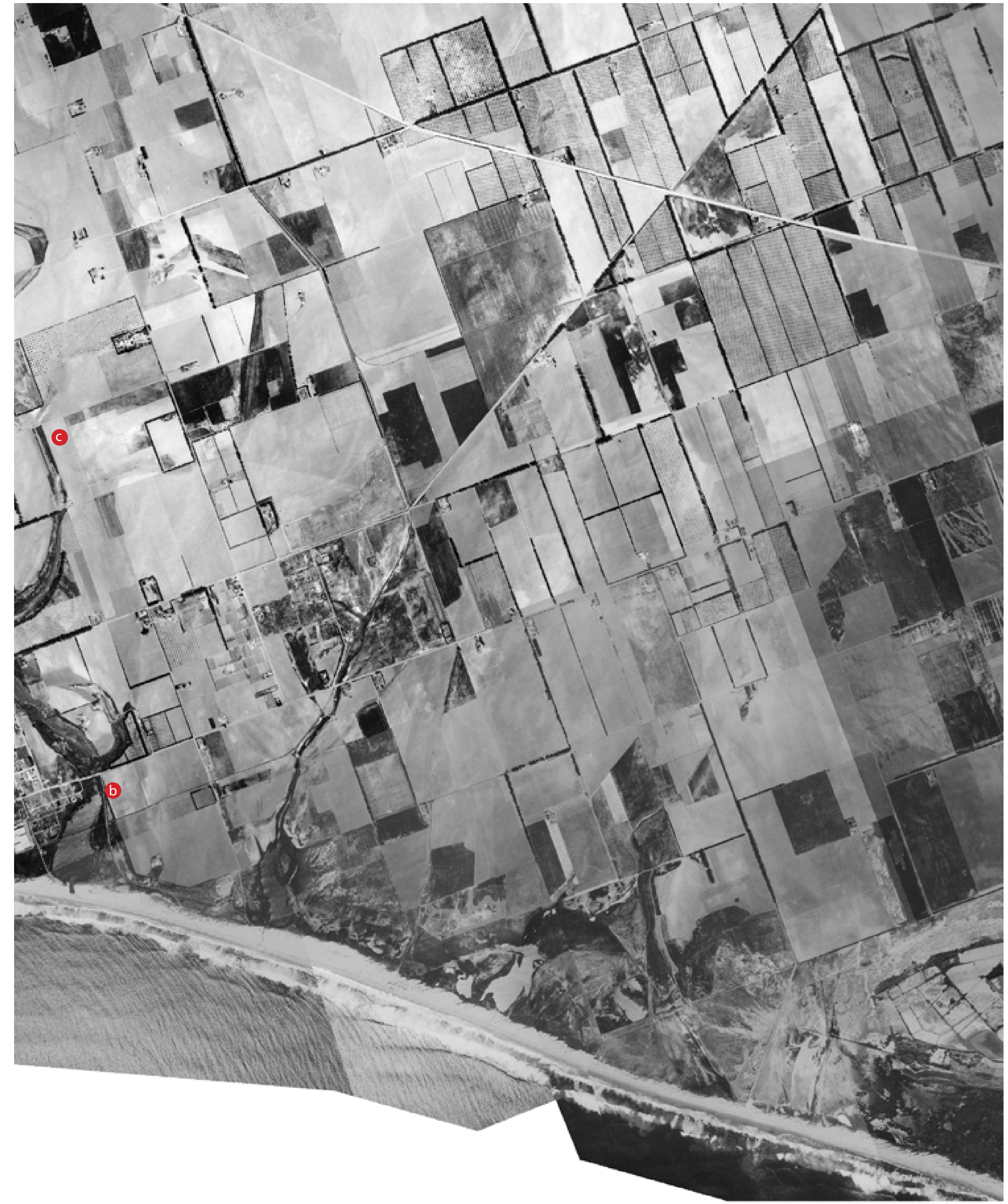


Fig. 6.23. Oxnard Plain shoreline,1927/1938. Traces of most of the 19th century lagoon complexes are still visible at the time these photos were taken in the 1920s and 1930s, though it is clear that many are in the process of being drained by the long canal seen at left a. A few lagoons, such as Laguna Hueneme b and the adjacent lagoon to the east, still appear to be filled with water. Traces of the former Santa Clara River channel are clearly visible at c, feeding into Laguna Hueneme. (Fairchild Aerial Surveys 1927, courtesy of Whittier College, USDA 1938, courtesy of Ventura County)

Fig. 6.24. Oxnard Plain shoreline, 2005. By 2005, most traces of the former lagoon complexes have been erased. A few markers remain, such as sloughs near Ormond Beach that used to empty into lagoons (portions of which have been repurposed as the Oxnard Industrial Drain and the Hueneme Drain). A lagoon similar to former features has formed to the east of Laguna Hueneme at Ormond Beach. (USDA 2005)

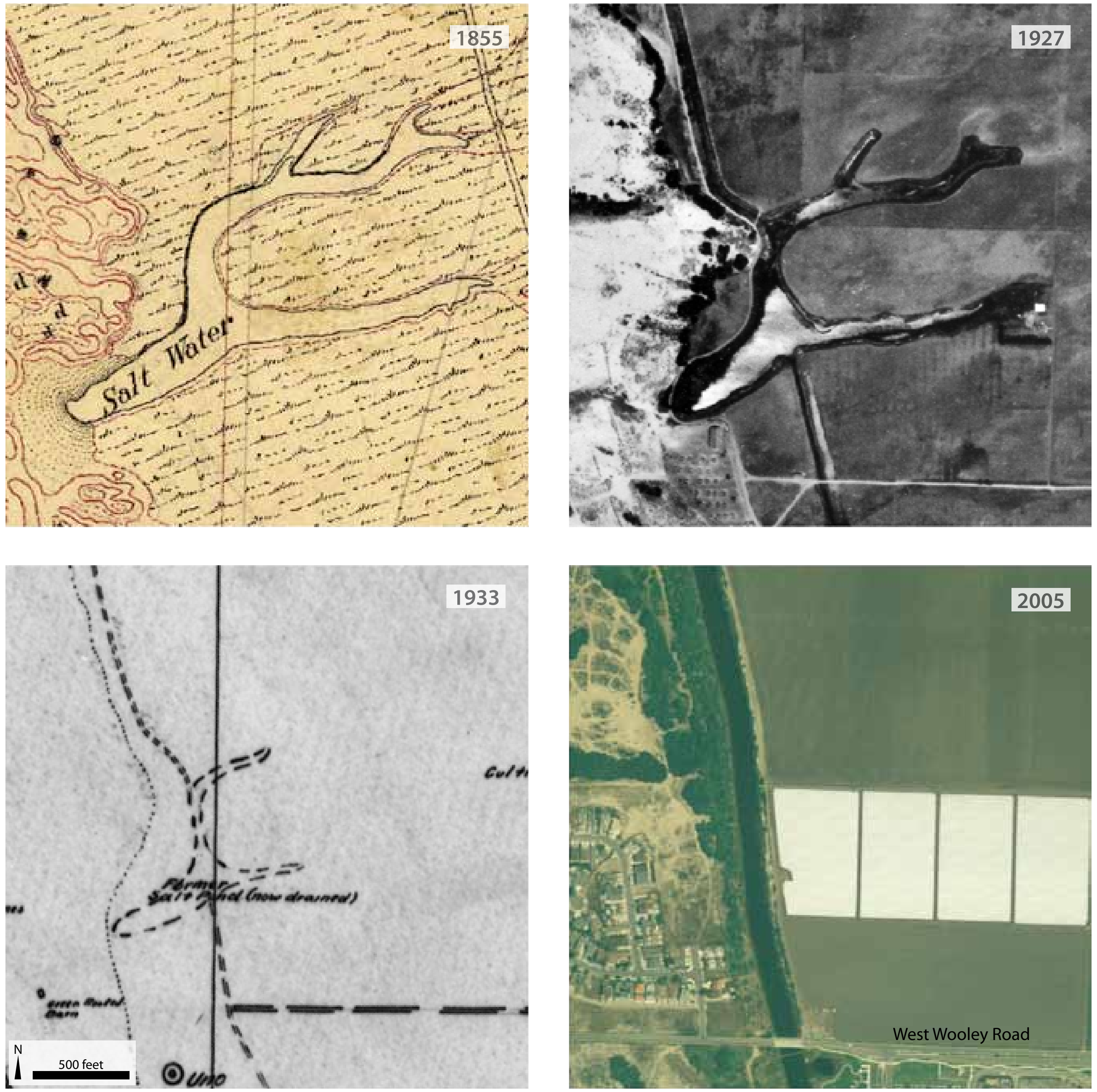


Fig. 6.25. In 1855, a small (14 acre) coastal lagoon was recorded by the U.S. Coast Survey, at what is now the end of West Wooley Road at Mandalay Bay (top left). Nearly 80 years later, in the descriptive report accompanying the T-sheet resurvey, the cartographers note that a drainage ditch (visible here on the aerials; top right) "has drained the salt pond shown on the former work… although the general shape as a dry hole is still apparent" (bottom left; Kelsh and Green 1934c). By 2005 all traces of the lagoon have been erased: only the drainage ditch remains (bottom right). (Johnson 1855b, courtesy of the National Oceanic and Atmospheric Administration; Fairchild Aerial Surveys 1927, courtesy of Whittier College; Kelsh 1933b; courtesy of IMC; USDA 2005)

in the aerial imagery and apparently intact on the resurvey. The two lagoons on either side of it, the Salinas and another spring fed lagoon to the east (at Ormond Beach), are shown with what appears to be both open water and marsh components.

Changes are also documented in the surrounding former salt marsh and high marsh transition zone, labeled as "dried up marsh," "meadow" or "marshy meadow," and "dry salt meadow." In a few portions of the former salt marsh (and in much of the former alkali meadow) the resurvey identifies "cultivated field." In the descriptive report accompanying the T-sheet resurvey, the surveyors describe this transition:

> East of this town [Hueneme] the country has remained in an undeveloped state except for the fact that farming has increased and developed this area for truck farming. As a result small swamps and sloughs have been filled in, and the farm land pushed out towards the coast, in turn tending to dry up the small ponds lying behind the sand dunes along the coast… From Hueneme west the beach area has been developed into a series (continuous) of summer resorts…Behind this ridge [of sand dunes] a long drainage ditch parallels the coast, draining into the sea just west of the Hueneme Lighthouse. This has completely eliminated the ponds previously shown, and the whole area has been developed into farming country. (Kelsh and Green 1934b)

Mugu Lagoon

Mugu Lagoon, known historically as the Estero Grande or Mugu Laguna, was one of the largest coastal wetland systems in Southern California, covering about 2,550 acres in the mid-1850s. (An additional 1,110 acres of high marsh transition zone formed an ecotone between Mugu Lagoon and the alkali meadows of the Oxnard Plain.) The lagoon occurs in a structural basin formed by the folding and faulting of marine sediments. The lagoon itself is trapped in an embayment behind prograding beach spits (Warme 1971, Jacobs et al. 2010).

The lagoon/marsh complex was the site of a broad range of coastal wetland habitats, many of which are still present today due to Mugu Lagoon's relative protection within the Point Mugu Naval Station. The complex contains the largest coastal wetland remnant in southern California today (Orme 2005).

A number of researchers have studied the history of cultural and physical change at Mugu Lagoon at length (e.g., Warme 1971, Steffen 1982, Onuf 1987, Swanson 1994, USACE 2003). An exhaustive search of the available historical record yielded little additional detail on early ecological patterns and processes at Mugu Lagoon, understandable given the region's extensive salt marshes and subsequent lack of intensive early development. As a result, we focus here on discussion and interpretation of the 1857 T-sheet (the most detailed early picture of the area), bringing to bear supplementary sources to describe the patterns of historical habitat distribution in the area.

October 26. At noon we made a little tea and were eating it when suddenly the wind blew a spark into a bunch of green tule, which was in a blaze in a minute, the flames spreading with great rapidity… Fortunately an estero prevented its spreading far and by night we had it subdued.

—Bowers 1879, in Benson 1997; at Point Mugu

Fig. 6.26. Habitats of Mugu Lagoon, early 1800s. The historical habitat mosaic surrounding Mugu Lagoon included substantial amounts of subtidal habitat, tidal flat, tidal marsh, tidal channels, marsh pannes, salt flat, vegetated former dune strands, and high marsh-alkali meadow transitional zones.

Coastal and Estuarine Habitats

- Ocean
- Beach
- Dune
- Tidal Lagoon (mostly open?)
- Tidal Flat
- Tidal Marsh
- Salt Flat/Seasonal Pond/Marsh Panne
- High Marsh Transition Zone

Palustrine and Terrestrial Habitat

- Alkali Meadow
- Alkali Meadow/Flat
- Grassland/Coastal Sage Scrub

Hydrology

- Intermittent or Ephemeral
- Perennial
- Distributary

This map is now available in greater resolution than previously (Grossinger et al. 2011).

The historical habitat mosaic at Mugu Lagoon included substantial amounts of subtidal habitat, tidal flat, tidal marsh, tidal channels, salt pannes/ seasonal ponds, salt flat/playa, vegetated former dune strands, and high marsh-alkali meadow transitional zones (fig. 6.26). Most of these features are shown in detail in the 1857 US Coast Survey T-sheet (Johnson 1857; fig. 6.27). The predominant habitat type at this time was tidal marsh (58%), with the remainder of the area distributed among subtidal water (14%), tidal flat (12%), salt flat/marsh panne (10%), and open water ponds (5%).

Mugu Lagoon included a relatively large subtidal area compared to most other Southern California estuaries (Grossinger et al. 2011). Historical maps also show evidence of extensive tidal channel networks as well as former beach ridges reflecting former shoreline positions (Thompson 1994). Historical botanical records support the prevalence of tidal marsh in the first half of the 20th century, with specimen localities described as "salt marsh on shore of lagoon," "dry salt marsh," "border of salt marsh," and "mudflats around tidal lagoon" (Fosberg 1931c,d; Hoffmann 1932a; Nobs and Smith 1948). Salt marsh vegetation captured in early (pre-1950)

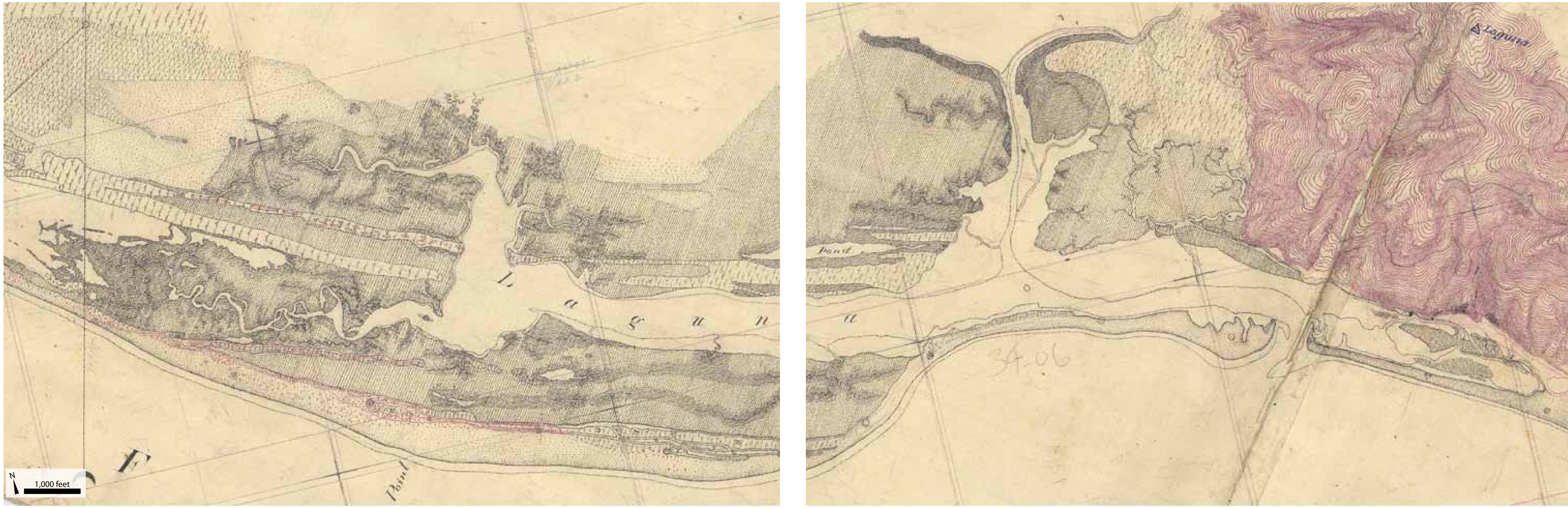


Fig. 6.27. Mugu Lagoon, 1857. (Johnson 1857, courtesy of the National Oceanic and Atmospheric Administration)

We soon came to miles of marked surface, overflown by salt water in the winter and spring season, when the tides and winds are highest. At such times they are the shallow extension of the western branches of the Estero Grande—the now bare surface being then covered with water…

—REED 1871, DESCRIBING THE SALT FLATS OF WESTERN MUGU LAGOON

records includes Virginia glasswort (*Salicornia virginica*), Parish's glasswort (*Salicornia subterminale*), marsh jaumea (*Jaumea carnosa*), and marsh rosemary (*Limonium californicum*) (Howell 1927; Fosberg 1931c,d; Purer 1935). The T-sheet resurvey of 1932 described the salt marsh south of the western arm of the lagoon as "low coarse eel grass" (Kelsh 1933b).

Supplementary sources help confirm habitat interpretations on the T-sheet. In particular, Thomas Bard's 1870 map of Mugu Lagoon is another highly detailed mid 19th-century depiction of coastal wetlands, and provides independent confirmation (after the 1861-2 flood) of many of the features shown on the T-sheet 15 years earlier. For example, Bard (1870a) confirms stippled areas shown on the T-sheet at the marsh margin as unvegetated salt flats, and refers to the salt grass area and neighboring salt flats as "mudflats," generally confirming their alkali playa characteristics. An early soils map helps confirm the extent of salt marsh depicted on the T-sheet (Nelson et al. 1917).

These sources also provide details not represented on the T-sheet, particularly at the upland edge of Mugu Lagoon (since the early T-sheet does not consistently map the full inland extent of tidal marsh). The full extent is indicated by these additional sources (6.28; see also fig. 6.2). The zone of strong alkali influence shown on the 1917 soils map provides a continuous boundary for the inland extent of tidally-influenced habitats across the entire lagoon complex, while the Bard map provides clues to the nature of the habitat at the upland edge of the marsh. The map shows a number of areas of "Juncal" or "Juncal Grande" on the upland edge of the marsh, a now-rare ecotone between tidal marsh and the adjacent lowlands of the Oxnard Plain that we mapped as high marsh transition zone. These depictions presumably represent large stands of Juncus, likely spiny rush (*Juncus acutus*), which was collected extensively in the area by native peoples for basketry (Timbrook 2007). *Juncus acutus* var. *leopoldii* was collected at the site in the 1950s and 1960s (Raven and Thompson 1959) and is reported today (USACE 2003). The presence of these large stands of rush indicates substantial brackish tidal marsh zones, both at the eastern margin towards the Calleguas Creek drainage and elsewhere in the marsh. These habitats appear to have been greatly reduced today. This modification to Mugu Lagoon may have significant habitat implications. For example, the rare light-footed clapper rail (*Rallus longirostris levipes*) is found to nest at Mugu Lagoon primarily in the spiny rush stands (USACE 2003).

The T-sheet indicates the presence of this high marsh ecotone in a few places, using a subtle variation in symbology at the northwest edge of Mugu Lagoon to show the broad transitional area between the tidal marsh and adjacent alkali meadow (Johnson 1857). The surveyor fortunately provided a clue for the interpretation of this symbol, annotating the margin with the words “line of salt grass” in faint handwritten pencil. We interpret this annotation as the distinction between the high marsh ecotone (which would have presumably had a high concentration of saltgrass (*Distichlis spicata*)), and the adjacent alkali meadow, which may have been a matrix of salt-tolerant and other grassland species.

Despite the detail these sources provide, the full former inland extent of the Mugu complex is unknown, and there is some indication that it once extended substantially further inland. Dr. William Livingston, who grew up in the Hueneme area in the 1870s and 1880s, recalled in a 1929 interview that Mugu Lagoon had shrunk considerably over his decades living on the plain:

> Dr. Livingston also tells me that in his time Mugu Lagoon has filled up to a very great extent. Originally it was a large body of water and the probabilities are that it extended in the sixteenth century to the foot of the hills where the principal town was located. Indeed, it is possible that at that time it was open ocean at that point, the lagoon not having formed. Dr. Livingston states that one time the Santa Clara River emptied into the ocean in this neighborhood, the old channel being still plainly visible. (Wagner 1929, in King 2005)

This remark is corroborated by a member of an outing to Point Mugu in March 1902, who stated that “there are indications that the marsh extended further inland, and it is claimed that small steamers and boats used to come up to the now tidewater mark” (Wallace Weston Brown, in Brown 1981).

It is possible that these accounts capture early sedimentation and deposition on the marsh plain as a result of the construction of a channel connecting Calleguas Creek to Mugu Lagoon, reducing tidal extent. The initial date of channelization has been widely stated as 1884 (e.g., Steffen 1982, Onuf 1987, Swanson 1994, USACE 2000); while this is possible, the origin of the assertion is unclear and we found no direct evidence to support it. Regardless of the precise timing, however, it is clear that Calleguas Creek did not maintain a defined connection to Mugu Lagoon prior to channelization efforts, which would have likely been initiated sometime during the late 19th or early 20th century (see page 169). If this is the case, shrinking of Mugu Lagoon could have been a result of increased sedimentation from the Calleguas watershed after channelization, as sediments previously deposited on the Oxnard Plain during floods were transported instead to Mugu Lagoon and the ocean. This process is confirmed by sediment transport calculations, which estimate a ten-fold increase in sedimentation rates over geologic levels as a result of the channelization of Calleguas Creek (Warme 1971, Steffen 1982, Capelli and Cave 1983).

Another possibility is that the former extent of Mugu Lagoon before Mission times is not captured fully by the 1857 T-sheet survey and other early sources described above. There is no way to verify this with the available historical data, though early General Land Office survey notes –slightly predating the T-sheet—suggest that this might have been the case (fig. 6.28). Notes from two surveyors in 1853-4 indicate tidal influence above our mapped zone of tidal marsh and high marsh transition

Fig. 6.28. Historical extent of tidal influence at Point Mugu, early 1800s. The Mugu Lagoon wetland complex, including high marsh transition zone areas, extended quite far inland in the 19th century compared to its current extent. Early surveyor’s notes hint that the tidal zone may have extended even further inland, as shown by the excerpts above. Excerpts along the survey line refer to a line segment rather than an individual point. (USDA 2009)

zone. Washington (1853) described a mile-long transect "almost entirely overflowed by tide from the Pacific Ocean" crossing the western slough entering Mugu Lagoon, from 500 to 1,600 feet north of our mapped extent of tidal influence. He also noted "mostly rich low prairie…is overflowed by tide water" for nearly a mile west of modern Calleguas Creek, an area mapped by Bard (1870a,b) as "juncal" and largely interpreted in our mapping as high marsh transition zone, and noted "over flow from tide" more than 1,600 feet north of this mapped edge of high marsh transition zone. Hancock (1854) also noted "tide wash" extending 1,200 feet above the mapped edge of the high marsh transition zone above the western arm of the lagoon, differentiating between "tide wash" to the south and "salt weed" (presumably alkali meadow) to the north. We did not consider these points sufficient evidence to extend our mapping, since it is also possible that these areas were non-tidal, salt-affected lands (e.g., alkali meadows and flats) of the lowland Oxnard Plain. These accounts may also reflect flooding induced by perched conditions created by periodic or partial inlet closure (Jacobs pers. comm.).

Despite these changes, Mugu Lagoon has shown significant resilience over time. By the time of the T-sheet resurvey of November-December 1932, though most of the non-tidal lagoons to the north had been (or were in the process of being) drained, the subtidal and salt marsh components of Mugu Lagoon looked largely similar to the 1857 condition: so much so that the 1933 surveyors called the coastal complex "practically unchanged… even the small sloughs in the swamp area were found as shown" (Kelsh and Green 1934a). The major exception was the migration of the lagoon inlet, which had shifted almost 3,000 feet west during the intervening 76 years.

As might be expected, evidence of closure states for Mugu Lagoon indicate that the nature of the lagoon's connection to the ocean was complex, dynamic, and variable. The cyclical migration and closure of Mugu Lagoon's inlet in the 20th century has been well documented. Sources indicate repeated closure of the inlet and migration in response to onshore and longshore wave action balanced with hydraulic forces from the lagoon and the Calleguas Creek watershed (Bascom 1954). The general location of the mouth is governed by the presence of Mugu Canyon offshore, but its location moves from the northwest to southeast over time in response to longshore movement of sand. When the mouth gets to the southeastern portion of this range it is more susceptible to complete closure from the berms built during winter storms (Bascom 1954). The lagoon then breaks through again at the canyon head and repeats the process. In the mid-20th century, this process was documented to occur up to twice a year (Bascom 1954). This closure pattern was also documented by Warme (1971), who noted that "at present the lagoon mouth is naturally sealed off about every six months to one year" before being immediately dredged open.

Many of the above observations date from after significant modifications to the lagoon complex such as road building, diking, dredging, and the construction of a channel between Mugu Lagoon and Calleguas Creek. These activities would have impacted lagoon processes, reducing tidal prism, restricting tidal access, and altering sediment availability, distribution, and freshwater inputs. As a result, the relationship of these later observations to 18th and 19th century lagoon closure dynamics is uncertain and has been intensively debated. While Warme (1971) stated that Mugu Lagoon experienced a similar cycle of closure and mouth migration prior to the major modifications of the 20th century, Onuf (1987) asserted that even prior to channelization the lagoon's tidal prism "would have been sufficient to keep the mouth open at all times."

Nineteenth century sources accentuate the relatively open character of the lagoon complex. Historical maps consistently show the lagoon with an open inlet, suggesting a direct connection to the ocean (e.g., Johnson 1857, Bard 1870b, Reed ca. 1871, Stow 1877, USGS 1904, Petit 1919). Early descriptions of the lagoon also emphasize its communication with the ocean, in contrast to the other lagoon complexes along the coast: "there are no esteros, lagunas, or salt ponds other than the Estero Grande [Mugu Lagoon] that have outlets to the sea" (Stow 1871). No 19th century source was found that described inlet closure. These data suggest that on the spectrum of Southern California estuaries, Mugu Lagoon likely had a greater degree of tidal connection than neighboring, smaller systems.

However, comparison of the early maps listed above also clearly shows changes in mouth position and width over time. One early surveyor described perceived changes in the nature of the outlet in the mid-19th century, noting that Mugu Lagoon's "outlet to the sea, which is now only 25.00 chains or a little more than ¼ mile wide" had shrunk substantially: "old residents informed me that its width had lessened one half, within the period of their knowledge of it" (Reed 1871). It is not clear whether these data represent cyclical mouth migration and periodic closure as described in the 20th century or change through time in the lagoon's closure dynamics.

Southern California lagoons existed in a range of closure states, and were connected to or closed off from the ocean at different times. Understanding of and terminology to describe these systems is currently in development, as advanced by Jacobs et al. (2010). Unfortunately, the historical record itself is insufficient at this time to resolve degree of closure or the former frequency, timing, and duration of closure patterns. It seems clear from 19th century data that Mugu Lagoon was at least periodically tidally influenced. It is possible that the size of the open water area may have created a sufficiently large tidal prism to maintain connectivity with the ocean for extended periods of time (Onuf 1987, Coats et al. 1989). Nevertheless, it is important to note that though these data emphasize the lagoon's connection to the ocean, they do not preclude occasional or regular cycles of closure, or closure in the subtidal/intertidal by a bar (Jacobs et al. 2010). Further archival and field-based research at Mugu and other sites may provide additional insight into the nature of these early lagoon dynamics.

SUMMARY OF FINDINGS

The following points represent some of the significant findings from our research on the Ventura County shoreline. Along with an understanding of modern conditions, these findings can support scientists and managers working to identify restoration opportunities in these coastal systems.

1. **A diversity of coastal systems characterized the Ventura shoreline,** each with differing habitat patterns and hydrologic dynamics. The overall habitat distribution is well documented, though available historical sources only begin to indicate the range of coastal processes that created these patterns, from Mugu Lagoon to the backbarrier lagoons, dunes, salt flats, and tidal marshes of the Oxnard Plain.

2. **Coastal wetland habitats covered about 4,300 acres,** accounting for a large proportion of former Ventura County wetlands. Differences in freshwater input, extent of vegetative cover, and closure regime led to varying support functions for native fish and wildlife.

3. **Three distinct types of coastal estuarine systems characterized the Ventura County shoreline**: the freshwater-brackish, intermittently or seasonally closed estuaries of the Ventura and Santa Clara rivers; the non-tidal lagoon complexes marking former Santa Clara River mouths; and the large, more tidally-influenced wetland system at Mugu.

4. **The Ventura and Santa Clara River estuaries were periodically open to the Pacific Ocean**. Regular, seasonal cycles of closure were documented for the Santa Clara River mouth. The Ventura River mouth closed only occasionally (less frequently than the Santa Clara River), reflecting its greater historical volume of summer flow in the lowest reach, steeper channel gradient near the mouth, and lesser wave exposure.

5. **The estuaries of both rivers also shared similar habitat mosaics.** Both rivers had fairly compressed estuaries, with the relatively limited saline and brackish wetland habitat near their mouths bordered by extensive freshwater habitats, most notably the willow-cottonwood forest and wetland documented at both mouths.

6. **McGrath Lake is a regionally significant feature,** unique because of its persistence over the past centuries and its freshwater character. Though the lake has persisted, its location has shifted substantially since the mid-1850s; only a small portion of its current area overlaps with its historical extent.

7. **An extensive suite of marsh, salt flats/pannes, and lagoons stretched from south of the Santa Clara River to the western edge of Mugu Lagoon.** Prior to drainage and agricultural expansion, these systems were a significant component of the Ventura County shoreline. They exhibited a range of habitat patterns based on variable salinity gradients and hydrologic inputs, from the spring-fed brackish Laguna Hueneme to the hypersaline Salinas near Point Hueneme.

8. **Mugu Lagoon was the largest wetland complex in Ventura County, and the site of a broad range of coastal wetland habitats,** including salt and brackish marshes, large salt flats, and extensive tidal channel networks. Dominant habitat cover was tidal marsh. There is some indication that the complex formerly extended substantially further inland than currently recognized. Its acreage has been dramatically reduced.

9. **Salt flats and high marsh transition zone were major components of Mugu Lagoon.** These transitional, high elevation habitats were particularly characteristic of the semi-arid climatic setting (Ferren et al. 2007), and have been disproportionately lost from this system. These features likely provided breeding habitat for shorebirds such as least tern and snowy plover (as small present-day remnants still do), as well as an inland migration zone for tidal marsh transgression in response to naturally rising sea level in the past.

Management Implications

- **The preponderance of closed conditions in most lagoons along the Oxnard Plain suggests strategies for habitat rehabilitation in these areas.** Efforts to restore coastal lagoon functions in these areas, for example at Ormond Beach, should consider these historical dynamics in restoration design. Current physical conditions at these sites (e.g., barrier dunes, small watersheds) may not reliably support open marine conditions without regular maintenance, but could potentially provide support functions for a range of native species. Restoration activities could also enhance the ecological functions of existing features. For example, the lagoon at Ormond Beach, though formed at a different location than historical features, currently exhibits similar closure dynamics. Sustaining and augmenting the geomorphic and ecological functions of this feature is an important restoration consideration.

- **Coastal lagoon complexes with high salinity levels and extensive surrounding salt marsh and salt flat were a significant component of the historical Ventura County shoreline.** These complexes, which occurred in areas with extremely small watersheds and limited freshwater input, may be under-represented in Southern California today.

- **Conversely, brackish-freshwater conditions maintained in some coastal complexes may be considered a significant component of coastal habitat restoration strategy.** While most coastal habitats historically exhibited high salinity levels, a few places maintained fresh-brackish conditions. In particular, the Santa Clara and Ventura river mouths and spring-fed lagoons such as Laguna Hueneme were less saline than surrounding systems. Maintenance of contemporary freshwater sources should be considered to restore or maintain such environments, with adequate consideration of water quality concerns.

- **Re-establishing transitional habitats at Mugu Lagoon is an important component of habitat restoration, and may be of regional significance.** Mugu Lagoon is recognized as the biggest coastal wetland complex in Southern California, yet it has lost much of its habitat area, particularly on its landward edge. High marsh ecotone, a transitional habitat between tidal marsh and alkali meadow, was a significant component of Mugu Lagoon and accounted for much of the region's wetland area. Re-establishing portions of this ecotone may be an important component of the lagoon's future persistence and resilience, and could provide room for inland migration in response to sea level rise. This is one of the few places where this is possible in Southern California.

- **Consideration should be given to potential brackish marsh areas within Mugu Lagoon.** Rush stands documented at the northern edge of the complex may have been important historically for light-footed clapper rail, as they are today. Expansion of this habitat may be an important part of species recovery and enhancement plans.

Fig. 6.29. San Jon Road at Highway 101, looking west. Areas of the Pierpont lowland are still susceptible to flooding, as shown in this December 2008 photograph.

RECOMMENDED FUTURE RESEARCH

This study documents historical landscape patterns of the Santa Clara and Ventura river valleys, the Oxnard Plain, and the Ventura County shoreline prior to major Euro-American modification. In particular, it focuses on former habitat distribution, riverine character and processes, and riparian ecology in each of these areas. However, there are a number of additional research directions that would enrich our understanding of the historical landscape and enhance our ability to apply these findings to current local management.

Additional geographic areas of interest

This research focused on the Ventura County portion of the Santa Clara River and valley, with limited investigation on upper (Los Angeles County) river reaches. Additional data on the upper river undoubtedly exists in Los Angeles County archives not visited during the course of this project, such as the Santa Clarita Valley Historical Society, the Los Angeles Public Library, the Braun Research Library, the Los Angeles County Surveyor's Office, and the Los Angeles County Assessor's Office. A more detailed understanding of this portion of the river, in conjunction with other studies (e.g., Stillwater Sciences 2011), would provide insight into the historical hydrogeomorphic processes and riparian patterns across the entire river.

The study area also excluded a few adjacent areas of possible interest. These include the Ojai Valley east of the Ventura River, and the Santa Rosa Valley and Conejo Valley/Thousand Oaks area east of the Oxnard Plain. In addition, while the lowest reaches of major tributaries to the Santa Clara River were included within the study area, they were not the focus of our research. Subsequent data collection and analysis efforts could reveal more details on the historical dynamics of these systems, in particular Santa Paula, Sespe, and Piru creeks.

Future research directions

Though this study covers many aspects of the Ventura County historical landscape, it is not comprehensive. A number of additional topics merit further research, and would contribute to a better understanding of ecological and hydrogeomorphic pattern, process, and function in the region. While we performed limited analysis of historical botanical and ornithological records, the voluminous available data merit more substantial analysis. In addition, we did not explore historical faunal records. A detailed analysis of these wildlife records by regional experts may support interpretation of historical habitats and linkages with species support functions, which is for the most part not covered in this report. This is particularly true for native fisheries use of Ventura County streams.

Future research into processes and dynamics that shaped the historical ecological landscape would further develop our understanding of former conditions. For example, more in-depth investigations of the history of invasive species introduction (such as *Arundo donax*), fire ecology, historical grazing impacts, and Chumash land management would provide important context for interpreting historical conditions.

In addition, future research may further elucidate historical trends and characteristics outlined here. Interviews with long-time county residents would deepen our understanding of local environmental change and persistence. Scientific studies using geoarchaeology, coring, remote sensing, and other techniques could also add additional detail to this picture of early conditions. More extensive field-based assessment of the findings outlined here would also be useful.

Application of report findings

The research presented in this report provides the foundation for supporting local and regional environmental management with detailed historical data. However, the historical record alone is insufficient to apply these findings on the ground. This research must be integrated with contemporary assessments of physical and biological conditions to develop practical, place-specific conservation strategies for use by local organizations. For example, the management implications explored here for floodplain and riparian restoration need to undergo feasibility analysis before application to particular sites. Partnerships between local residents, managers, and scientists is a crucial component of determining how and where to apply these data.

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