HISTORICAL ECOLOGY AND LANDSCAPE CHANGE of the SAN GABRIEL RIVER AND FLOODPLAIN

SCCWRP Technical Report #499

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PREFACE: A WORD ABOUT HISTORICAL ECOLOGY

A historical landscape perspective is important not for sentimental or idealistic reasons, but because it helps us understand the contemporary landscape, factors that influence its nature and structure, and its future potential. The goal of historical ecology is neither to recreate the past nor to directly design the future. Rather, the goal is to document and understand historical reference points and the factors that influence change, including land use, climate, and natural events, such as floods and fires. Historical analysis helps us to recognize the controlling factors affecting local habitats and how they have changed or stayed the same. Researching the past through restoration is not practical or desirable in all places or instances. The past does not inherently represent what is appropriate for the contemporary or future landscape. However, it does help identify restoration and management options in terms of potential location and design.

Historical ecology also illuminates potential constraints for consideration in restoration planning by providing a better understanding of how the ecosystem has functioned over time, and how it has adapted and responded to changes in the landscape. Areas of susceptibility and resiliency can be better understood through an examination of the past. In this way, historical ecology provides a valuable template for restoration and conservation planning by providing insight into the appropriate location and distribution of habitats and plant communities with respect to inherent landscape constraints. It also provides insight into where our greatest losses have occurred in terms of geography and specific habitat types. Landscapes have long been modified to meet the needs of people, and it is reasonable to assume that this will continue into the future. Based on our decisions, the landscapes of the future will be very different from today's landscapes. Understanding the past helps us understand how the present has evolved and the roles human and natural history have played in shaping the present landscape. It helps us identify where sustainable natural processes still persist and how to support them. It provides a basis for making informed decisions to maintain and improve the health of the local landscape.

EXECUTIVE SUMMARY

Southern California is undergoing a wetland renaissance. Vast resources are being devoted to watershed management, resource protection, and wetland restoration. Historical wetland losses are often cited as a motivation for prioritizing ambitious wetland restoration and management activities. However, analysis of historical conditions is often underutilized in the planning process. Historical ecology can be a valuable tool to help understand the mechanisms of past decline, provide templates for future restoration, and provide context for making decisions about allocation of scarce resources.

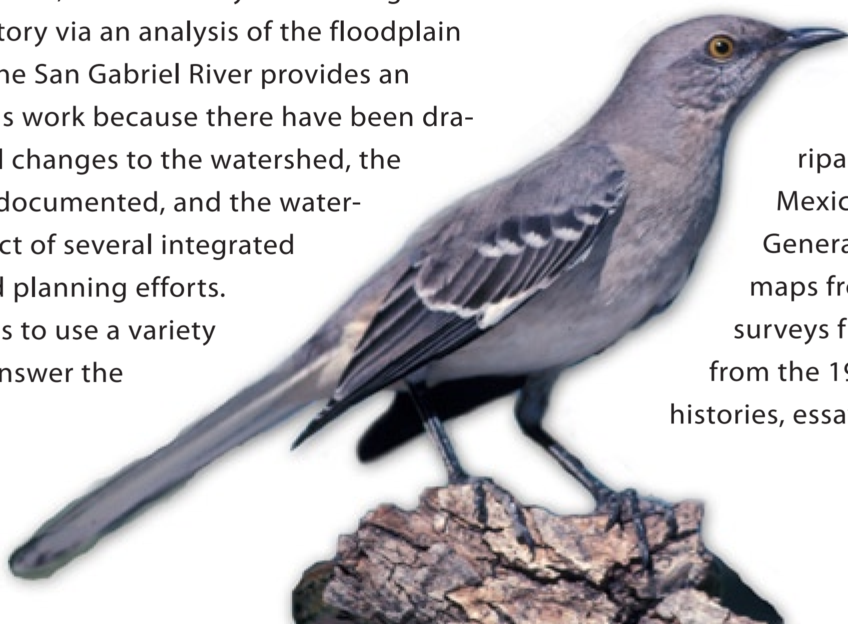
This project begins to build the framework for understanding the historical extent and function of southern California wetland and riparian resources, and how they have changed through recent human history via an analysis of the floodplain of the San Gabriel River. The San Gabriel River provides an excellent laboratory for this work because there have been dramatic physical and cultural changes to the watershed, the social history is fairly well documented, and the watershed is currently the subject of several integrated resource management and planning efforts. The goal of this project was to use a variety of historical resources to answer the following questions:

1. What was the historical acreage and distribution of wetland and riparian habitat in the watershed?

2. What was the historical extent and composition of the floodplain?

3. What was the general composition and spatial distribution of riparian vegetation community types and species?

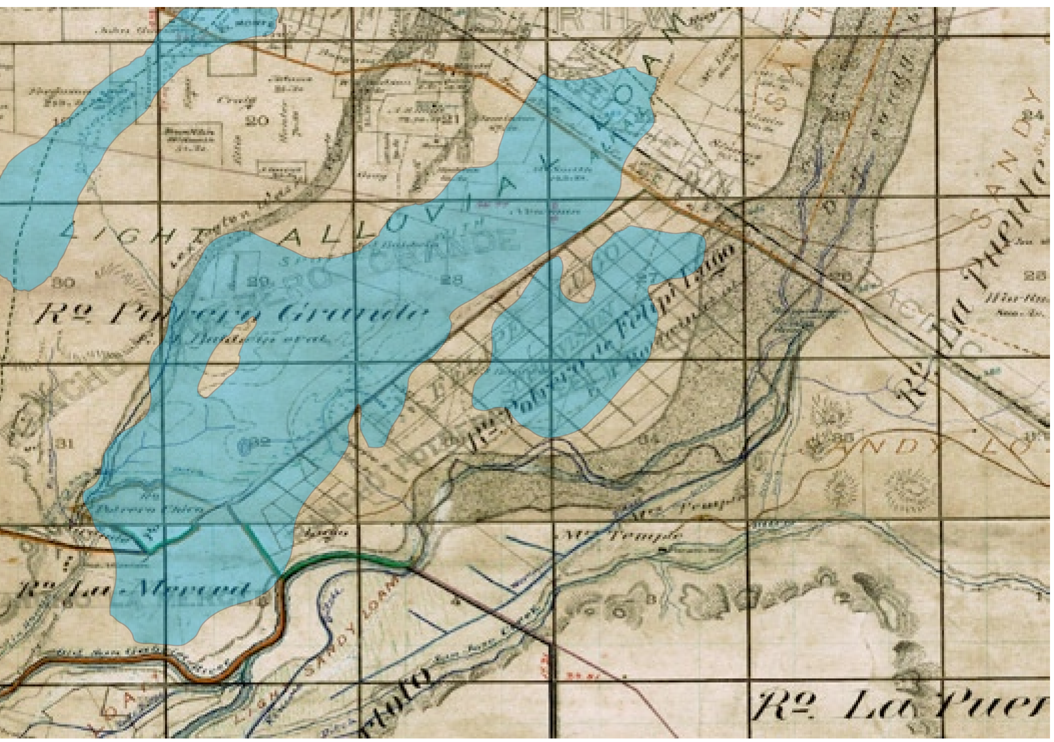
4. To what extent has the wetland and riparian habitat changed over time and what factors have been associated with these changes?



Numerous data sources were used to gain insight into the historical wetland and riparian habitats. Primary data sources included Mexican land grant sketches (diseños) and US General Land Office maps from the 1850's, irrigation maps from the 1880's, topographic maps and soil surveys from the early 1900's, and aerial photographs from the 1920's. Secondary data sources included oral histories, essays, ground photographs, and field notes.

Data sources were digitized, georeferenced, and overlaid in GIS to produce historical wetland polygons. Polygons were attributed for data sources, classified using the US Fish and Wildlife Service National Wetland Inventory (NWI) system to facilitate comparison with contemporary conditions, and assigned a confidence rating based on the certainty in the primary data sources. The concordance between multiple data sources allowed us to draw conclusions based on the collective "weight of evidence" that supported inferences about historical condition (**FIGURE ES-1**). The resulting maps were analyzed for historical extent and distribution of wetlands and riparian habitat and compared to contemporary wetland maps to assess wetland losses. Finally, historical herbaria records and bird observations were used to confirm the results of the GIS analysis and to provide insight into the composition of historical wetland plant communities.

FIGURE ES-1. Example of multiple data sources being used to infer location and extent of historical wetlands. Figure illustrates overlay of location of wetland soils (blue) on irrigation map circa 1884, along with oral description of the area from the late 19th Century.



The period of investigation for this study was characterized by higher than average rainfall and streamflow resulting from multi-decadal climatic cycles that produced wetter than average weather patterns between 1750 and 1905. The frequency and magnitude of extreme runoff events, combined with the lack of human intervention (in the form of ground water extraction, flood control, dams, or diversions) resulted in a highly dynamic river system that supported extensive wetland complexes interspersed among the upland floodplain habitats. Throughout the early 19th century (and likely during

"About 1 mile westerly of El Monte and below…there was hundreds of acres of swamp ground tullie beds and standing water year round…"
(Regan 1914 : 359)

FIGURE ES-2.

Historical & Current Alignment of the

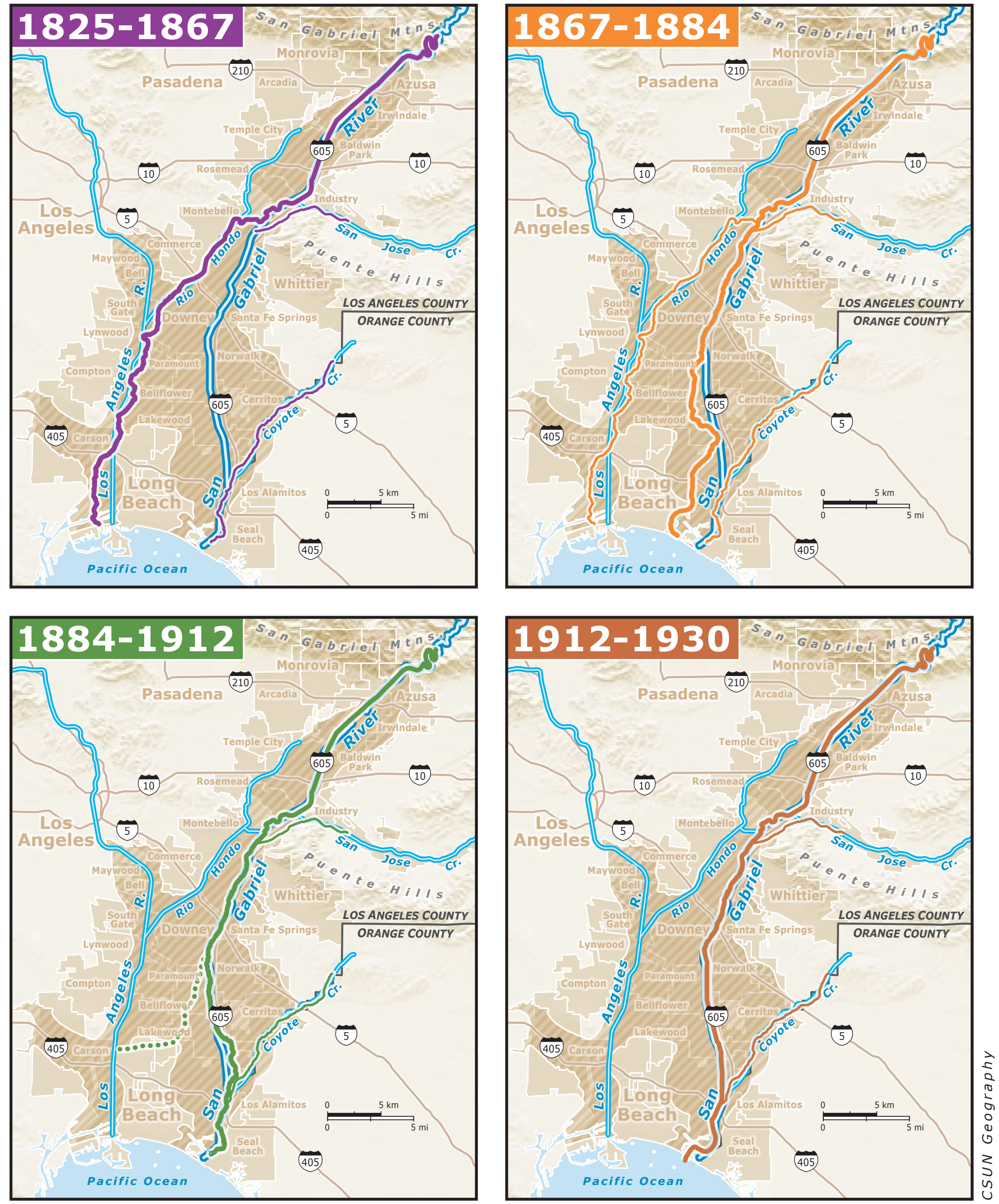
San Gabriel River

California State University, Northridge
Environmental Geography Lab

Legend

Period

- 1825-1867
- 1867-1884
- 1884-1912
- 1886
- 1912-Early 1930's
- Current Extent
- Land Subject to Inundation Prior to Flood Control



earlier periods), the path of the San Gabriel River oscillated between functioning as a tributary to the Los Angeles River and assumed one of several distinct flow paths to the ocean (**FIGURE ES-2**). Following a series of large floods during the 1860's, the river assumed a course similar to its contemporary alignment. Therefore, we chose the circa 1870 period as the focus of our investigation.

Despite the dynamic nature of the San Gabriel River floodplain, a review of maps and written oral histories suggest a consistent and identifiable pattern of floodplain structure (**FIGURE ES-3**). The upper floodplain area (below the base of the foothills) was a broad alluvial fan with highly braided channels, alternating bars, islands, and inset benches. As the river flowed toward the Whittier Narrows area it encountered fault zones and subsurface impervious layers that forced ground water to the surface. Consequently, this area supported a mosaic of riparian and wetland habitats, including willow woodlands, wet meadows, perennial freshwater wetlands, streams, and significant riparian area. Below Whittier Narrows, the river meandered dramatically across the valley floor; at times the San Gabriel and Los Angeles River floodplains were indistinguishable (**FIGURE ES-4**). Riparian areas along this reach of the river appear to have been well defined in the more permanent sections of the river. However, because this area was prone to inundation during flood years, areas adjacent to the floodplain most likely represented a complex matrix of wetlands, riparian habitat, and uplands that varied on an interannual basis depending

FIGURE ES-3. Historical wetlands of the San Gabriel River.

on climatic patterns. As the river approached the San Gabriel/ Los Angeles River estuary, seasonal inundation caused by the narrow estuary inlet and a series of barrier beaches supported a broad expanse of alkali meadow wetlands at the transition zone between the floodplain and the estuary.

Development of the San Gabriel River watershed has resulted in extensive wetland losses. Palustrine wetlands have been particularly impacted, with most of the perennial and intermittent ponds and marshes no longer present. Of particular note is the loss of the vast alkali meadows, which were once the most common type of wetland in the lower watershed, but are now totally absent from the landscape. Channelization and other flood control measures have resulted in conversion of the meandering and braided channel systems to linear flood control conduits. Similarly, the complex of seasonal floodplain wetlands has been almost entirely lost.

Despite the dramatic wetland losses, several opportunities exist for wetland restoration. Remnant wetlands and/or wetland signatures exist at locations such as Whittier Narrows (**FIGURE ES-5**), along the base of the foothills of the San Gabriel mountains, in the upper floodplain, and at a several locations in the Long Beach area.

Knowledge of landscape positions and wetland types that previously existed can help guide decisions regarding future restoration of these areas. Furthermore, the reconstructed plant

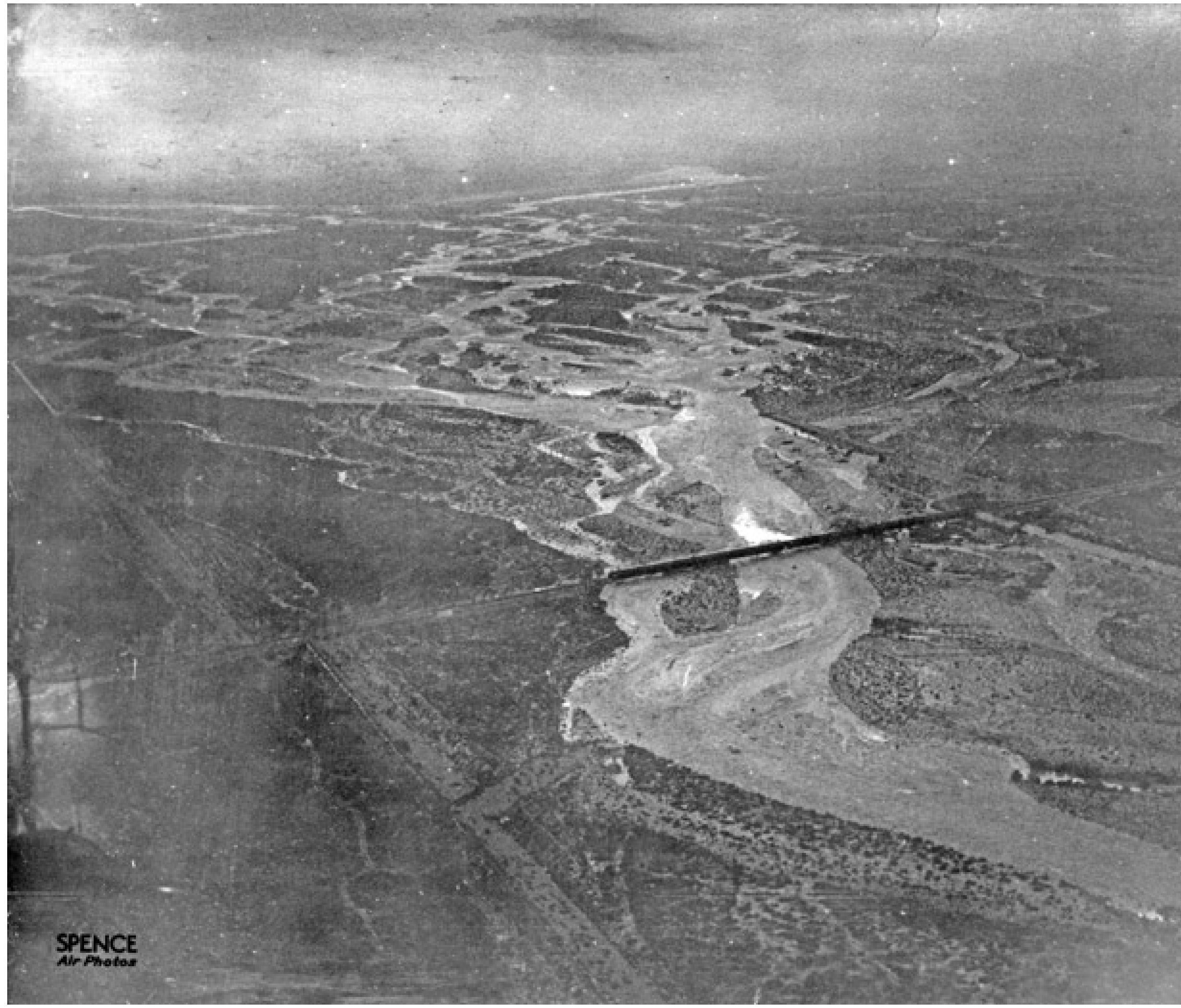


Photo courtesy of the Benjamin and Gladys Thomas Air Photo Archives, UCLA Department of Geography

FIGURE ES-4. Consolidation of braided channels at lower end of San Gabriel Wash, February 1927. Spence Air Photo E-1092. (Photo courtesy of the Benjamin and Gladys Thomas Air Photo Archives, UCLA Department of Geography)

community compositions generated by this study can provide templates for restoration planning. However, caution must be taken in the use of historical information. Restoration of wetland plant communities to their former historical configuration may not be possible for several reasons, including irreversible alteration of hydrology or soils. Thus historical analysis must be used to inform, but not replace the tools commonly used in watershed restoration science.

The framework for data collection, integration, analysis, and compilation developed through this project provides a common approach and template for more inclusive regional efforts to understand overall historical wetland and riparian nature and distribution in southern California. Future efforts can build on the foundation provided by this project by expanding the analysis to include additional data sources in other watersheds.

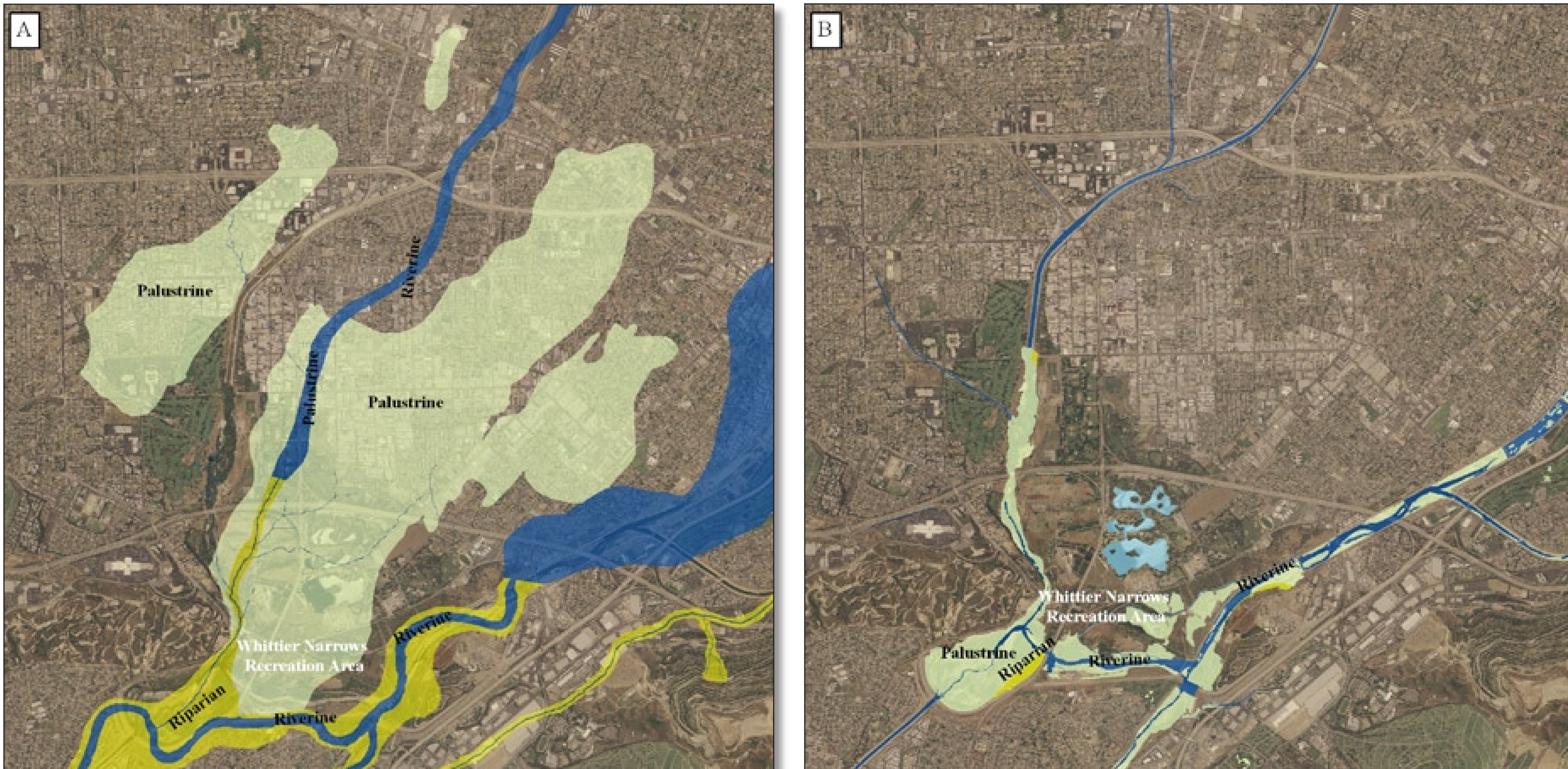


FIGURE ES-5. **Comparison of wetlands at Whittier Narrows circa 1870 (A) and today (B).**

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Additional information on historical ecology in southern California, along with digital products associated with this project can be obtained at:
www.csun.edu/centerforgeographicstudies/historical_ecology.html

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- *Appendix C* – Transcripts of Oral Histories Compiled by J.W. Reagan (1914)
- Extended project bibliography
- List of contacts and information sources
- Selected digital images, files, and data (subject to release permissions)

Website: *www.csun.edu/centerforgeographicstudies/historical_ecology.html*

1

INTRODUCTION

Southern California's wetlands and riparian ecosystems are among the most diverse and productive habitats on the Pacific coast (Warner and Hendrix 1985, USDOI 1994). However, European influence and modern development have considerably changed the southern California landscape and dramatically altered the extent, distribution, and nature of these ecosystems. It is estimated that approximately 80 to 90% of California's historical wetlands had been lost and 90 to 95% of southern California's riparian ecosystem had been destroyed or severely degraded by 1989 (Tiner 1984, Dahl and Johnson 1991, USDOI 1994).

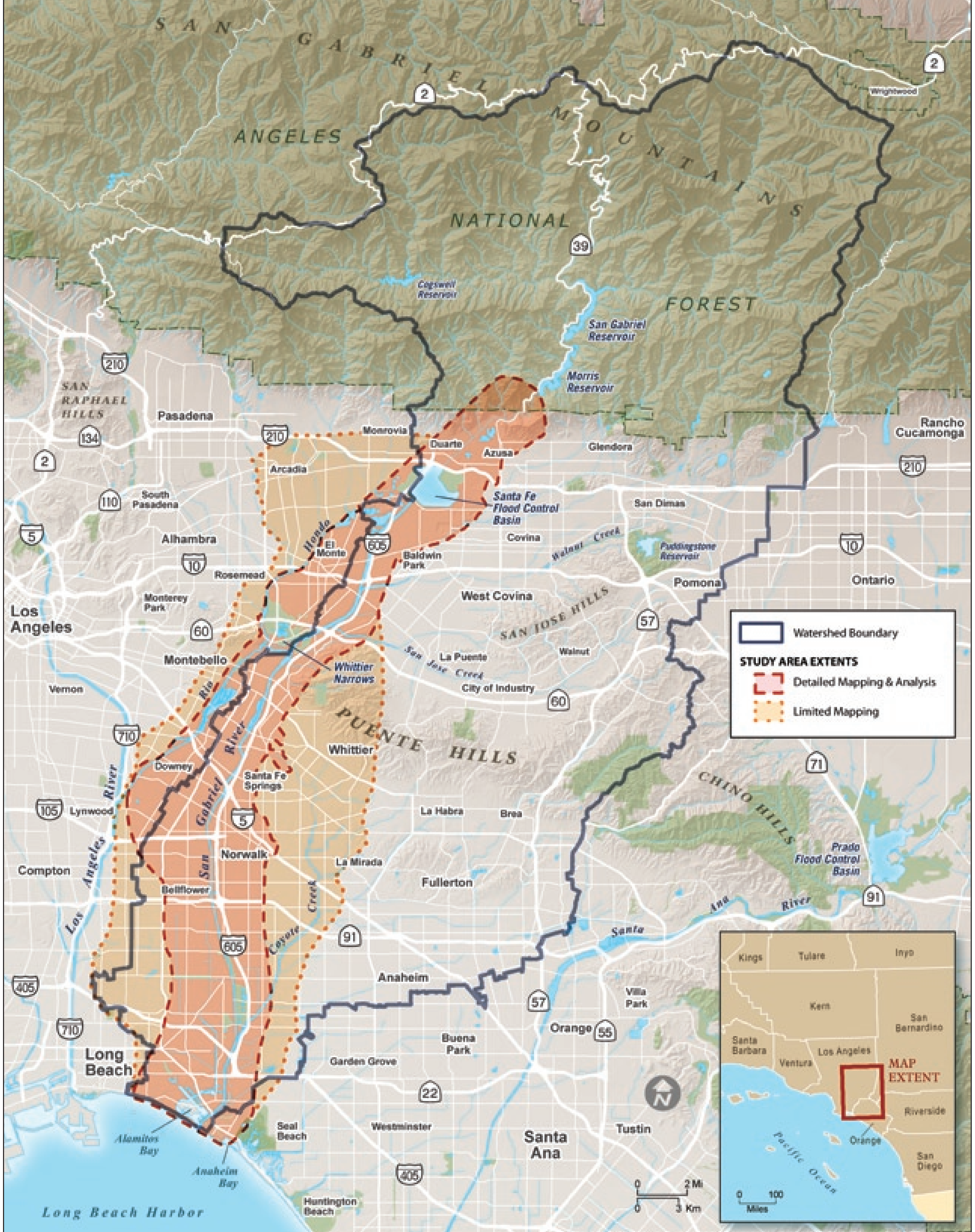
In more recent history, vast resources have been devoted to restoring and managing coastal wetlands in southern California through a variety of public and private programs. For example, the southern California Wetlands Recovery Project (WRP) has expended over $100 million since 1998 on wetland acquisition and restoration (see *www.scwrp.org*). Other State and Federal agencies, local watershed groups, and non-profits also continue to expend resources on restoration and management activities related to their respective organizational goals. Increasingly, watershed management is being used as an organizing principle for wetland and riparian preservation and restoration, examples include: the Corps of Engineers Special Area Management Plans (SAMPs) and the numerous Integrated Regional Water Management Plans (IRWMPs) being funded by the California Department of Water Resources.

Optimally, wetland and riparian habitat preservation and restoration should be guided by a comprehensive understanding of the structure and function of the ecosystem in its natural state; this understanding should serve as a reference for restoration planning and performance monitoring. Unfortunately, much of our understanding of these systems is derived from systems already highly modified by human activities. As a result, it can be difficult to identify appropriate reference conditions or models for restoration and to distinguish natural processes from anthropogenic effects. Historical information can provide a key explanatory variable for understanding present-day conditions at a project site (or larger region), and ways in which anthropogenic activities have affected landscape structure and function over time. Historical documents can not only help us determine how various cultural management regimes have affected landscape structure and function, but can also help identify changes in natural, ecological, and physical processes over a long-term period. As such, historical information can help guide decisions about wetland and riparian restoration.

Historical data has been used successfully in the San Francisco Bay area to inform a diverse range of restoration and planning projects, becoming a key component of stream and wetland restoration, endangered species recovery, watershed management, and regional ecological planning (Goals Project 1999, Grossinger and Askevold 2005). This approach has also begun to be extended to the central California coast, especially at Elkhorn Slough (Van Dyke and Wasson 2005). Unfortunately, in southern California there has been limited effort to conduct a regional analysis of historic wetland condition. The work that has been done has focused on historical analysis of individual sites, driven by program-specific objectives. Consequently, differences in approach, data sources, and assumptions between individual sites have precluded a regional assessment of historic conditions, and therefore prevented a regional evaluation of condition and restoration needs. Failure to consider a regional perspective may result in a gradual shift in the distribution of wetland types and a homogenization of wetlands across respective regions. Such "type conversion" has been observed in watersheds throughout southern California (Allen and Feddema 1996, Stein and Ambrose 1998, Sudol and Ambrose 2002).

This project begins to build the framework for understanding the historical extent and function of southern California wetland and riparian resources, and how they have changed through recent human history through an analysis of the San Gabriel watershed. This watershed provides an excellent laboratory for this work for several reasons. First, there have been dramatic cultural changes to the watershed. The floodplains of the Los Angeles and San Gabriel Rivers have long been a center of activity for native cultures that relied on these resources for many aspects of their daily life. Similar attributes drew early Spanish and American settlers, who dramatically altered the landscape to support ranching, agriculture and eventually cities, to the region. Because of this immigration, the recent human history of the region is fairly well documented, although information tends to be scattered among a range of institutions and could benefit from consolidation in one location.

Second, the natural watershed processes have been dramatically altered. The San Gabriel River receives drainage from an 1865-km^2 (720-square mile) area of eastern Los Angeles County; its headwaters originate in National Forest lands in the San Gabriel mountains (**FIGURE 1.1**). The watershed consists of extensive areas of undisturbed riparian and woodland habitats in its upper reaches. Because of its position along the coast and the associated orographic effects, the upper San Gabriel watershed is one of the wettest locations in southern California. The long-term average annual rainfall at Opids Camp, in the upper San Gabriel watershed, is 96 cm (37.8 inches), almost three times the average for the greater Los Angeles area (NOAA Western Regional Climate Center - *http://www.wrcc.dri.edu/index.html*). The combination of extreme topography, rainfall, and the erosive nature of the granitic geology of the upper San Gabriel watershed results in some of the highest sediment yields in southern California, with massive amounts of sediment and debris being discharged following large rain events. Consequently, a series of four dams has been constructed in



the upper watershed to control flow and sediment from this area. Downstream of the dams there are a series of large spreading grounds that take advantage of deep alluvial deposits at the base of the San Gabriel mountains for groundwater recharge. The combination of the dams and spreading grounds has dramatically altered the hydrology and geomorphology of the lower watershed. Furthermore, the lower portion of the San Gabriel River flows through a concrete-lined channel in a heavily urbanized portion of Los Angeles County before discharging into the ocean in the highly modified port area of the City of Long Beach (LARWQCB 2000).

Third, the San Gabriel watershed is currently the subject of several integrated resource management and planning efforts. Several State and local conservancies are in various states of planning for restoration activities ranging from the upper watershed through the estuary. Analysis of the watershed's historical ecology will provide valuable information on baseline conditions and historical changes that can be used by managers to inform

FIGURE 1.1. San Gabriel River watershed showing the project study area.

restoration and planning decisions. Furthermore, the framework for data collection, integration, analysis, and compilation developed through this project will provide a common approach and template for more comprehensive regional efforts to understand overall historical wetland and riparian nature and distribution.

The specific goal of this project is to develop key information for successful wetland and riparian habitat recovery of the San Gabriel watershed through analysis of historical conditions of the lower river and floodplain. We address questions on the distribution and character of wetland and riparian habitat prior to sustained anthropogenic activities, including:

1. What was the acreage and distribution of wetland and riparian habitat in the watershed from 1830 to 1930?

2. What was the historical extent and composition of the floodplain from 1830 to 1930?

3. What was the general composition and spatial distribution of riparian vegetation community types and species?

4. To what extent has the wetland and riparian habitat changed during historical times and what factors have been associated with these changes?

2 HISTORIC ECOLOGY TIMELINE OF THE SAN GABRIEL RIVER WATERSHED

2.1 OVERVIEW

In this section, we survey interactions between people and the San Gabriel River watershed over the past several centuries to establish a cultural and historical context for river assessment. This review summarizes key historical events and periods that were influential in the evolution of the San Gabriel River from a more natural form to its contemporary condition.

The San Gabriel River watershed has undergone significant environmental change since European contact. A modern Angeleno sent back in time on a riparian field trip would not recognize the path of the river as it was at the time of contact between the early Spanish explorers and the indigenous native population. Our contemporary observer, familiar with today's San Gabriel River — a concrete channel with its final outlet at Alamitos Bay, would find arroyos, swamps, seasonal marshes, and alkali meadows between present-day Whittier and Long Beach. Until 1867, the San Gabriel River ran in a westward direction at Whittier, where it met with its sister river, the Los Angeles River, and emptied into San Pedro Bay. For our time-traveling Angeleno, much of what is today the teeming metropolis of Los Angeles hardly resembles el Pueblo de Nuestra Señora la Reina de Los Angeles as it was when established by a group of Mexican settlers and their indigenous servants in 1781.

This timeline follows the dynamic, unpredictable, and often perilous river over a period of nearly two centuries. Its aim is to present snapshots of the San Gabriel River and the metropolis that grew up in its watershed, highlighting water as a paradoxically crucial and volatile resource in southern California. The San Gabriel River and the two other major rivers in its system — the Los Angeles River and the Santa Ana River — irrigated crops and provided drinking water for Spanish pioneers and their American conquerors, but also posed a constant threat to settlements and human lives during periods of heavy precipitation. In addition to highlighting the cycle of drought and flood, this timeline aims to render a portrait of the change over time wrought on the river and its watershed by pressures of land use, population growth, and urbanization. Taking a page from environmental historian Richard White, it is imperative to investigate the relationship between humans and the river as part of the same natural world, and to underscore the effects of the river on humans and their communities, economy, politics, planning, and infrastructure (White, 1991).

2.2 CONTACT AND SPANISH COLONIZATION

We have no record of the first European foray into California, a 1542 ocean expedition led by Juan Rodríguez Cabrillo, a seeker of a mythical Northwest Passage that purportedly connected the Pacific and Atlantic Oceans. The Spanish in fact paid little attention at all to their northern territories until exaggerated reports of Russian activity in northern Alta California prompted the viceroy to send another expedition to occupy the port at Monterey. There the expedition founded a presidio for defense against Russian incursions. Captain Gaspar de Portolá, the governor of Baja California, led the expedition. With him was a prolific young Franciscan, Juan Crespí, a confidant and close friend of Fray Junipero Serra, who recorded the expedition's journey in detail unmatched by any other of the period (Gumprecht 1999). In his field draft of his journal entry for July 31st, 1769, Crespí recorded that after camping for the night on the shore of the San Gabriel River (which he had initially dubbed the San Miguel Archangel) he took notice of the abundant natural resources in the area:

> From horseback, I plucked more than four dozen [roses] that came into my hands. The grapevines are countless in number, some of them with very large clusters. We twice came to woods so dense that it was necessary for the soldiers to clear a way through the various sorts of band many other types of tall weeds, such that it is a vastly pleasant sight to see. There are vast numbers of antelope on this level; some twelve of them have been seen close by. Tracks of very large animals are seen, and droppings are found like those of cattle. Yesterday the soldiers on duty with the mounts saw far off something like a mule, which they said might have been an elk; whether elk or buffalo there is no telling for sure. They say that in the mountain range running along on the north, there are a great many bears. (Crespi 2001)

As the group traveled that day, they came across Lexington Wash, near present-day El Monte (Bolton 1927). Reminded of the natural beauties of his native Spain, Crespí was so enamored with the area that he recommended the general area as a potential site for the fourth of California's missions. Serra and Pedro Fáges, a soldier turned military governor of Baja and Alta California, followed Crespí's suggestion, and with three potential rivers to provide sustenance and irrigation, ordered the mission constructed on the west bank of the Santa Ana River. They sent an expedition led by Frays Pedro Benito Cambón and Josef Angel Fernández de la Somera to carry out the plan.

When the Franciscans came across the Santa Ana River, however, they did not find the area to their liking, and continued on to the San Gabriel Valley, where they founded the Mission San Gabriel Arcángel in what is now the city of Montebello on September 8th, 1771 (Quinn 1973, Temple 1979). Biologist Paula Schiffman has indicated that the serendipitous similarity between the Spanish and Californian climate led to the easy application of Spanish agricultural modes and ultimately contributed to the success of self-sustaining missionary establishments in frontier California (Schiffman 2005). Schiffman (2005) and others have pointed to the more pernicious effects of missionization on native flora, noting that the introduction and expansion of hoofed ungulates (cattle and sheep) wiped out a wealth of indigenous plants. The issue was only worsened with pressures from the introduction of European plant forms, particularly wild oats (Hackel 1998, Preston 1998).

The Gabrieleño Indians – named by the friars for the mission they established in their midst – belonged to the larger Shoshonean-speaking tribes of the American Southwest. Hugo Reid, a Scottish trader who settled in Los Angeles and married a local indigenous woman in the early nineteenth century, recorded that the Gabrieleños had no name for themselves prior to that given to them by the friars. Prior to contact, these hunter-gatherers inhabited much of present-day Los Angeles, Orange, and San Bernardino Counties. Though Europeans did not make such interpretations upon contact, the Gabrieleños (like other Native Americans) understood and manipulated the land to their advantage (McCawley 1996, Gumprecht 1999, Anderson 2005).

While their lifestyle relied on mobility, water sources played a central role in the Gabrieleños' choice of settlements, which were concentrated around year-round springs and rivers that provided an ample food and water supply. They also understood the danger that rivers and streams posed to their settlements and located their villages at safe distances accordingly. Anthropologists suggest that they may well have been one of the most technologically advanced groups in the state, credited with creating extensive trade networks and developing portable mortars and pestles for grinding plant matter, primarily acorns - their central food source. They also partook of the watercress (*Rorippa* spp.), sage (*Salvia* spp.), wild celery (*Apiastrum angustifolium*), clover (*Trifolium* spp.), and several types of wild berries (e.g., *Ribes* spp., *Rubus* spp.); and hunted a wealth of animals, including: deer, antelope, skunk, lizards, frogs, and rodents. They used tule (*Schoenoplectus* and *Scirpus* species) from the wetlands to construct huts and canoes (Gumprecht, 1999; Bean and Smith, 1975; Kroeber, 1925). Anthropologist Mark Raab has indicated that the Gabrieleño people were "largely obliterated by disease and oppression before their relationship with the environment could be studied" (Raab 2005).

During his 1772 expedition into California, Governor Fáges remarked in his diary that the mission was "situated on a hill down the slopes of which flow numerous streams of water, in which the Río de San Miguel [the San Gabriel River] has its origin. There are at this place many willows, poplars, blackberry and grape vines, and roses of Castile" (Preistly 1937). Despite his rather positive assessment of the mission, this first settlement – known as the "Old Mission" or "Mission Vieja" – suffered hardships during frequent flooding of the river (King, 1990). In May of 1775, the mission was subsequently moved five miles closer to the San Gabriel mountains, to a site in the present-day city of San Gabriel, where the lands were developed over a period of fifty years, with much of the necessary manual labor performed by indigenous converts. Though the padres left the original mission intact for several years after the relocation, the only remnant of this initial structure that remains today is a marker near the Rio Hondo at the intersection of San Gabriel Boulevard and Lincoln Avenue, in Montebello (Geiger1979).

Early visitors to the new mission spoke about the region's natural resources in glowing terms. In 1774, Fray Pedro Font (a Franciscan) and Juan Bautista de Anza Bezerra Nieto (a Spanish soldier) headed a two-year expedition through Alta California. In early January 1776, Font recorded that, "In the creek celery and other plants which look like lettuce, and some roots like parsnips, grow naturally; and nearby there are many turnips, which from a little seed which was scattered took possession of the land. And near the site of the old mission, which is distant from this new one about a league to the south, there is growing great abundance of watercress, of which I ate liberally" (Bolton 1937). With constant threat of less-than-adequate rainfall, the missions struggled to remain self-sustaining units and often exerted unprecedented pressures on the food supplies of local indigenous people.

Although uncommon in the mission era, Spanish authorities did grant parcels of land to a few individuals. Fáges also granted huge tracts of land to soldiers who had accompanied him on his first California expedition. In 1784, he granted Manuel Nieto a 300,000-acre tract between the San Gabriel River (presently the Rio Hondo) and the Santa Ana River. The land encompassed the present day cities of Long Beach, Lakewood, Norwalk, Downey, Pico Rivera, and Santa Fe Springs. Fáges' grant made Nieto the richest man in California at his death in 1804 (Quinn 1973).

In order to provide crops, supplies, and defense for the nearby missions, Spanish authorities approved a plan for the establishment of an agricultural village, or pueblo, on the Río de Porciúncula, better known as the Los Angeles River, on September 4, 1781, by a group of forty-four Spanish colonists. Though the specific reason that Felipe de Neve, the first civilian governor of California, chose to locate the pueblo of Los Angeles on the Los Angeles River rather than the San Gabriel or Santa Ana is unknown, one geographer noted:

> It is clear that the location he selected better fit the needs of the settlement than any other site in Southern California. Both the Santa Ana and San Gabriel Rivers posed greater flood risks in their uncontrolled states than did the Los Angeles River, since they spread over wide areas and as soon as they left the mountains. Much of the water they carried, moreover, sank immediately underground and therefore would not have been available for irrigation using the primitive diversion methods relied upon at the time. (Gumprecht 1999).

Each family was given a house with four fields for crops that were set up in a pattern common to Spanish colonies. The twelve lots faced into the pueblo's plaza, whose corners faced each of the cardinal points of the compass. Covering only twenty-eight square miles, the houses each had twelve fields for cultivation, all irrigated through crude zanjas, or ditches, which diverted water from the river. Knowing the feast-or-famine rainfall characteristic of the Mediterranean climate, the colonists constructed a dam out of sand and willow poles, two miles upstream from the settlement (Gumprecht 1999).

2.3 MEXICAN ERA 1821–1848

The Mexican Revolution began as a series of chaotic and disorganized revolts during the early nineteenth century, and culminated in the colony's independence from the Spanish metropole in 1821. This event signaled the beginning of a series of major shifts in land use in southern California. In response to claims from frustrated Californio elites that the mission clergy were exploiting Indian labor and monopolizing land, the infant Mexican government declared the missions and secularized their land in 1833, encouraging individuals to petition the government for parcels of land. In the following decade, in spite of the efforts of liberal Mexicans to distribute a fair share of former mission land among the Indians who had long labored on its soil, Californio families received the disproportionate share of land grants from the Mexican government in parcels ranging from below one hundred acres to over one million acres. With the severe weakening of ecclesiastic authority, mission Indians either moved inland to reside among still autonomous Indian groups, or stayed on the Californio estates and ranchos to serve as laborers and ranch hands. These grants were made official with relatively informal diseño maps, which marked property with physical boundary markers such as boulders, trees, and creeks (White 1991, Fogelson 1967, Kropp 2006).

Isolated from major trade routes and dependent on natives to supply the lion's share of the requisite labor, the ranchos, like the missions before them, were relatively self-sufficient units. Historian Robert Fogelson argues that, provided with ample Indian labor, ranchero life required little of the rancheros themselves: "the herds could forage through the hills unsupervised; and thus freed from more mundane matters, the rancheros could live – or so they thought – in the style of Spanish grandees." Despite the difficulties of reaching California, a few American and British merchant seamen did manage to get to Los Angeles. When opportunities arose, the rancheros bartered tallow and hide for goods such as coffee, liquor, silk, cutlery, shoes, and jewelry that were unavailable in California. The self-sufficiency of the ranchos, however, ultimately retarded the growth of Los Angeles; there were scant opportunities for manufacturers, artisans, or other professionals to ply their trades. The isolation of the ranchero economy left them highly vulnerable to unscrupulous Anglo creditors and banks under American rule (Fogelson 1967).

The inhabitants of southern California during this era put little pressure on the San Gabriel River. Lacking an advanced system of irrigation and uninterested in intensive agriculture, early

Angelenos seldom disturbed the river. According Juan José Warner, one of Los Angeles' earliest historians, the area's rivers made themselves known to area residents during this period:

> In 1825, the rivers of this county were so swollen that their bed, their banks, and the adjoining lands were greatly changed. At the date of the settlement of Los Angeles City, a large portion of the country, from the central part of the city to the tidewater of the sea, through and over which the Los Angeles River now finds its way to the ocean, was largely covered with a forest, interspersed with tracts of marsh. From that time until 1825, it was seldom, if in any year, that the river discharged, even during the rainy season, its waters to the sea. Instead of having a river way to the sea, the waters spread over the country, filling the depressions in the surface, and forming lakes, ponds, and marshes. The river water, if any, that reached the ocean, drained off from the land at so many places and in such small volume, that no channel existed until the flood of 1825, which by cutting a river-way to tide water drained the marshland and caused the forests to disappear.... The flood of 1832 so changed the drainage in the neighborhood of Compton and the northeastern portion of the San Pedro Ranch that a number of lakes and ponds, covering a large area of the latter ranch, lying north and northwesterly of Wilmington, which to that date had been permanent, became dry a few years later. (Warner et al. 1876)

Though there are no accounts of destruction of life or property, the power of the rivers to shape and reshape the natural environment must have been abundantly clear to early Angelenos.

2.4 AMERICAN CONQUEST

Only twenty-seven years after Mexico wrestled free from the grip of the Spanish metropole, the denouement of the Mexican-American War saw the San Gabriel River shift political dominions, from Mexico to the United States. Though at the outbreak of the war the Californios were involved in their own military bid for independence from the Mexican government, they mounted an effective resistance to the aggression of the United States. During the war, American forces led by Robert F. Stockton and Stephen Watts Kearney routed José Mariá Flores' men along the banks of the river at the Battle of Rio San Gabriel. The American victory effectively ended the resistance of Californios to American rule. When the dust had settled and the 1848 treaty of Guadalupe-Hidalgo had been signed, Mexico ceded California, along with half of its northern territories, to the United States for fifteen million dollars (Crawford 1999).

The ambiguous Mexican system of land grants proved the downfall of the Californios in the American era. The government forced the rancheros to comply with mandates to pay taxes on their property and pay their Indian servants wages. The formerly self-sufficient ranchos would now be required to participate in an unfamiliar economy; they were forced to produce the requisite capital to meet the new demands imposed upon them. In 1851, Congress added to the rancheros' dilemma when it promulgated the California Land Act, which established a land commission to adjudicate between legitimate and fraudulent land claims in the union's newest state. The commission demanded proof of land ownership, which was made difficult by the often-ambiguous boundaries demarcated in the diseño maps. Unacquainted with the American judicial system, the rancheros were forced to hire lawyers, which required still further capital. As a result, many were forced to sell all or part of their land. Those who held on were faced with squatters who claimed ownership of their land (Clay and Troesken 2005, Fogelson 1967).

Other factors impacted changes in land use patterns in the San Gabriel River watershed. John Marshall's discovery of gold at Sutter's Mill, in 1848, heralded the California Gold Rush. Though mostly affecting the northern part of the state, California's population jumped from about 14,000, in 1848, to 223,856 only four years later (White 1991). The effects of the Gold Rush were felt in southern California as well. The inrush of population created huge demands for meat, and the price of cattle skyrocketed. The rancheros drove their herds up to the Sacramento Valley, where they sold off their cattle at a handsome profit. In addition, a decade after the discovery of gold in northern California, a minor rush followed a discovery of the precious mineral in the San Gabriel Valley. Stuart O'Melveny, a sportsman whose family lived, worked, and fished along the shores of the San Gabriel River for generations, recalled in 1955 that, similar to many other migrants who came to California in the 1850s, they were pulled by factors of the region including hopes of quick riches (O'Melveny 1955).

Unwise to the newly implemented and highly unstable American system of capitalist relations, the Californios were profligate with the profits they had reaped from the brief seller's market in cattle. They spent lavishly on luxury goods and lost a great deal of their earnings in gambling houses and saloons. Unfortunately, for the southern California cattle industry, the tremendous windfalls of gold rush profits would soon end when Texas and Missouri ranchers arrived with better cattle, glutting the market and occluding the cash flow of the free-spending Californios (Fogelson 1967, Kropp 2006).

2.5 FROM CATTLE RANCH TO CITRUS FIELD

The depression in the cattle market bankrupted most of the rancheros. By the end of the 1850s, after years of being unable to meet tax obligations and loan payments, most of the Californios who had been owners of tremendous parcels of land and enormous herds of cattle ten yearsearlier found themselves landless and poor. Most of their foreclosed-upon land was brokered to American investors privately or at public auctions. These Americans, hoping the cattle economy would once again shift in favor of its suppliers, borrowed heavily from San Francisco and Los Angeles capitalists to improve their stock and equipment and mortgaged their landholdings as collateral. These investors badly miscalculated the volatility of the Los Angeles precipitation (Fogelson 1967, Pitt 1966).

In late 1861, it began to rain. By late January of the following year, the Los Angeles Star reported that the San Gabriel River had "forged a new channel from the east side of El Monte to the west side of the same place. Much damage was done to ranches, houses, etc." J.D. Durffy, a resident of El Monte, one of the earliest populated cities along the river, recalled that the floods turned Lexington Wash into a river channe,: "The water broke over El Monte, and went down what was known as Lexington Wash. At that time Lexington Wash did not have the semblance of a river bed there; [it] was a large swale above El Monte, and thick with willows and brush." Several residents of towns in the river's floodplain recalled that the river's waters spread for miles. Despite the severity of the flooding, resident E.H Dalton remembered, "There was no damage done unless a few head of stock got drowned – there was nothing to damage" (Reagan 1915). Changes in historical channel location are illustrated in Section 4.

The looming aspect of the relationship between humans and the San Gabriel River has been control of its torrential potential. In a climate marked by either extreme drought or torrential rains, control of the destructive tendencies of the river has been a central concern for Los Angeles residents. Jared Orsi's recent work on flood control in Los Angeles carefully documents how the destructive capabilities of the river are much more than simply a product of heavy rainfall, but rather an outcome of contingent natural and human events (Orsi 2004).

The sparseness of the early Los Angeles population meant that the region's human element avoided the worst of southern California rivers' wrath. In the later decades of the nineteenth century, however, as the number of people in southern California began to grow, the destructive potential of the rivers became readily apparent.

After the rains stopped, there was no further significant precipitation for almost two years. As the grass dried up, cattle starved to death, and the American ranchers, as the Mexicans before them, went broke and were foreclosed upon. The land went to unpaid banks and brokerage firms. The creditors, however, realized the impracticability of utilizing the land for cattle and decided to use the land instead for large-scale agribusiness, specializing in non-perishable items like wheat and specialty fruits (particularly grapes and citrus) that could only be grown in places such as southern California. They also subdivided the land for small family farms as migration picked up after the Civil War (Fogelson 1967, Isenberg 2004). The growth of citrus fruits in Los Angeles heralded a major shift in the use of the region's rivers; not only was native riparian vegetation removed to make way for farmland and orchards, river waters were also diverted and manipulated to provide the lifeblood for intensive crop production (Zierer 1934)[1].

Towards the end of 1867, the rains began to fall again in earnest, and another flood was on. That year witnessed the

1 William McClung has recently pointed out that the orange tree served as an enduring cultural symbol for Southern California for the nineteenth century, only to be supplanted by the palm tree in the twentieth in his *Landscapes of Desire: Anglo Mythologies of Los Angeles* (Berkeley, CA: University of California Press, 2000)

most violent and dramatic change in the river since Europeans had begun to occupy southern California; a break in a logjam in the canyon above Whittier Narrows sent a rush of water with such velocity that it changed the course of the river. In a 1915 interveiw, W.R. Dodson of El Monte recounted a story told to him by a friend who had witnessed the event. According to the interveiwer:

> He says that a man by the name of Henry Roberts, now dead, told him that in the '67 flood that he had lived down below the narrows, and the water very nearly stopped running, and it had been raining hard, and he took his gun and went up to the hills by the narrows to see what had stopped the water, and the water was blocked by logs and drift, and he says some 25 to 50 feet high, and backed up three or four miles, and he says when it went out made a noise loud enough to be heard two or three miles, and broke logs four or five foot thick, and he claims that was what caused the New River to go off from the San Gabriel channel….Mr. Dodson says that after the 1867 flood he hauled wood from one place below the Narrows for about two years. There was a patch of ground about two acres in size and from 6 to 20 feet deep with logs and that had come from the jam at the Narrows, and that there were lots of logs as large as five feet in diameter that had been broken as if they were matches. He found a dead grizzly bear out in the center of the pile of logs after he had been hauling logs from the pile quite awhile. The skeleton of the bear and hide was all there, and he said it looked as if it had been caught in the flood, and tried to save himself by riding the drift wood. (Reagan 1915)

The wood brought down from the canyon proved a boon to other area residents as well – many recalled that the event provided fuel and building material for years afterward (Reagan 1915).

Prior to the flood, the San Gabriel River flowed in a southwest direction and met with the Los Angeles River near Cerritos and emptied into San Pedro Bay. According to J.D. Durffy, "It broke out a little above old Temple place and continued south instead of making the turn over toward the point of hills just below Old Mission settlement" eventually emptying into Alamitos Bay. According to one account, the channel followed an old irrigation ditch, and early maps suggest it followed an existing arroyo. According to a 1913 Flood Control report for the Los Angeles County Board of Supervisors, the water "broke South through a small draw." After the channel shifted course, the amount of water in the Old River (now the Rio Hondo) declined by a large margin. A.B.P. Patten, a longtime resident of Downey, recalled that only one-tenth of the water in the San Gabriel's new channel made it all the way down to Alamitos Bay; instead, it spread all over the country and "made lots of sloughs and swampy ground" near the towns of Bellflower, Clearwater, and Hynes. One resident described how these wetlands did not last for long, however. With the expansion of commercial agriculture, "People began to sink wells for irrigation purposes and this began to lower the water plane and then the marshes began to disappear" (Warner et al. 1876, Reagan 1915, Olmsted 1913).

2.6 THE COMING OF THE OCTOPUS AND THE BOOM THAT FOLLOWED

In 1872, Los Angeles elites convinced railroad magnate Collis Huntington to extend the main trunk of his Southern Pacific line to Los Angeles; the tycoon agreed, with the caveat that Los Angeles taxpayers provide a $610,000 subsidy to its construction. Despite initial hostility among the public towards the railroads, by November the business community had convinced the populace that the line was requisite for the future prosperity of their city, and the measure was approved. Four years later, Los Angeles had its link to the transatlantic line. This trunk connected Los Angeles to the Central Pacific's transcontinental line at San Francisco, effectively plugging the city into national markets. At the urging of the business community, the city got its second railroad, the Santa Fe, which opened a bevy of eastern markets for California oranges and lemons with its completion in 1886. Construction of a web of local feeder railroads sprang up all over Los Angeles, plugging local producers in to markets across the continent (Fogelson 1967, Gumprecht 1999).

While the coming of the railroad served as a new mechanism to move oranges, lemons, and limes to distant markets, it had additional consequences for the river. Railroad companies built bridges over the rivers that created blockages for debris flows during floods. The construction of these structures and the running of heavy machinery over river waters undoubtedly had ecological consequences as well. In tandem with tremendous booster efforts of the Los Angeles Chamber of Commerce, the Merchants and Manufacturer's Association, and the Los Angeles Times to attract both tourism and industrial investment, the increased ease of mobility offered by the railroads saw the population of Los Angeles begin to swell with working and middle-class Anglo immigrants from the Midwest, and to a lesser extent, from the East Coast[2]. Between 1890 and 1930, a period of growth at the end of which Los Angeles was ranked the nation's fifth largest city, the number of Los Angeles' inhabitants grew from 50,000 to 1.2 million. In the same period, Los Angeles County's population grew from 101,000 to 2.2 million (**FIGURE 2.1**; Fogelson 1967). O'Melveny recalled that before the railroads, "The San Gabriel Valley was in many respects a plain with a few ranches here and there." Afterwards, "these ranches were subdivided, farms sold, and town sites laid out. In the immediate vicinity of the San Gabriel Canyon the town sites of Azusa, Covina, Duarte, and Monrovia were established and flourished" (O'Melveny 1955).

The conversion of ranches and farms to residential areas created new demands for water. For example, the private sector company that supplied water to homes in the greater

2 For examples of this type of booster literature, see Charles Frederick Holder, *Southern California: Its Climate, Trails, Mountains, Canyons, Watering Places, Fruits, Flowers, and Game. A Guidebook*. (Los Angeles, CA: Times-Mirror Publishing, 1888); J.W. Hanson *The American Italy: The Scenic Wonderland of Perfect climate, Golden sunshine, Ever-Blooming Flowers and Always-Ripening Fruits, Southern California* (Chicago IL: W.B. Conkey, 1896); Ward Brothers *The Land of Sunshine, Fruit and Flowers* (Columbus, Ward, c.1898) all in HRBC

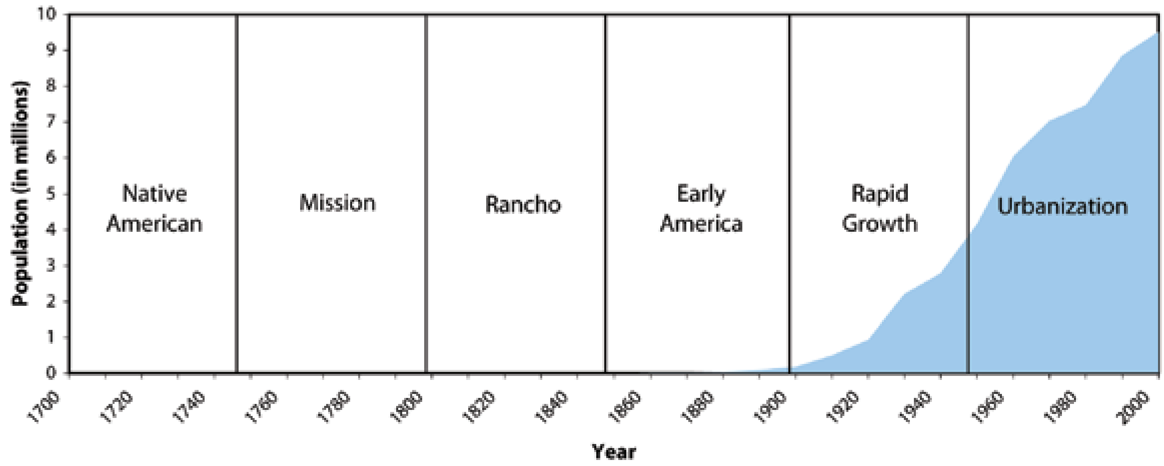
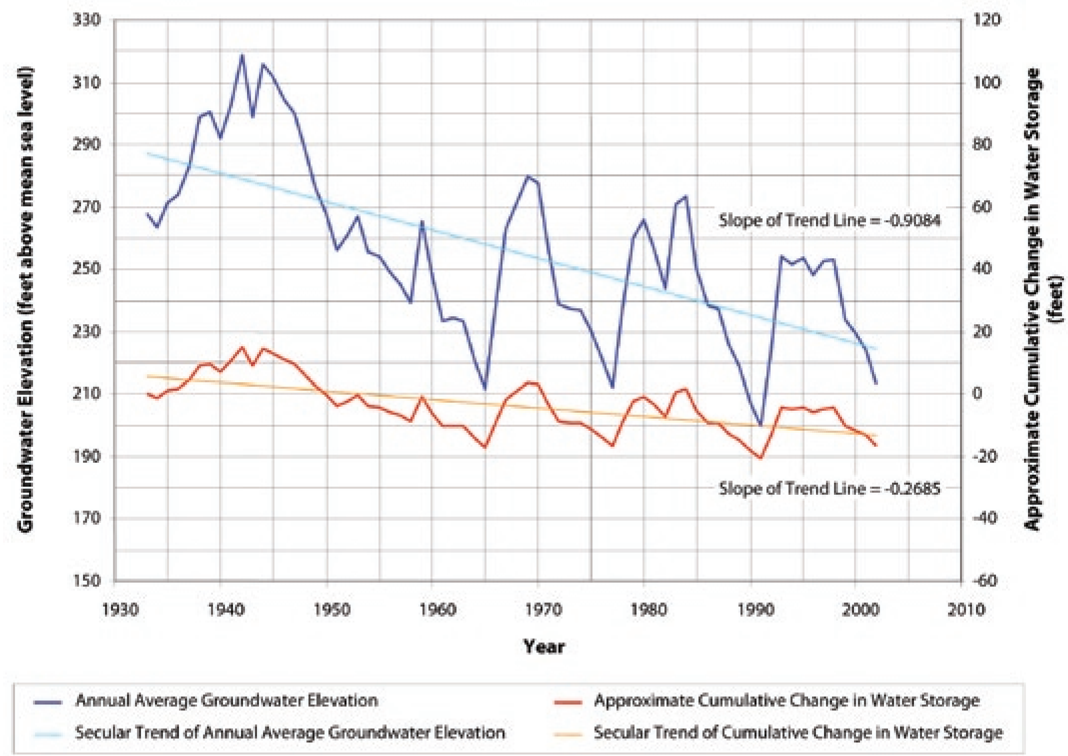


FIGURE 2.1. Population growth in Los Angeles according to the decennial census.

Los Angeles area reported a five-fold increase in the number of customers between 1883 and 1892 (Gumprecht 1999). To meet the increasing demand, water purveyors began intercepting and storing surface runoff and extracting ground water with infiltration fields and pumps. By the early 1900s, ground water extraction had lowered the water table of the San Gabriel and Los Angeles Rivers to the point where streamside vegetation could no longer survive and reaches that had typically flowed year round began to dry up (**FIGURE 2.2**). The progressive lowering of the water table increased dramatically after 1930 with the invention of turbine pumps. This trend has continued through to contemporary times, greatly affecting the ability of the river and flood-plain to support riparian and wetland habitat.

FIGURE 2.2. Annual average ground water elevation and change in cumulative water storage over time in the lower San Gabriel River basin. Figure from McMillan and Vincent 2003.



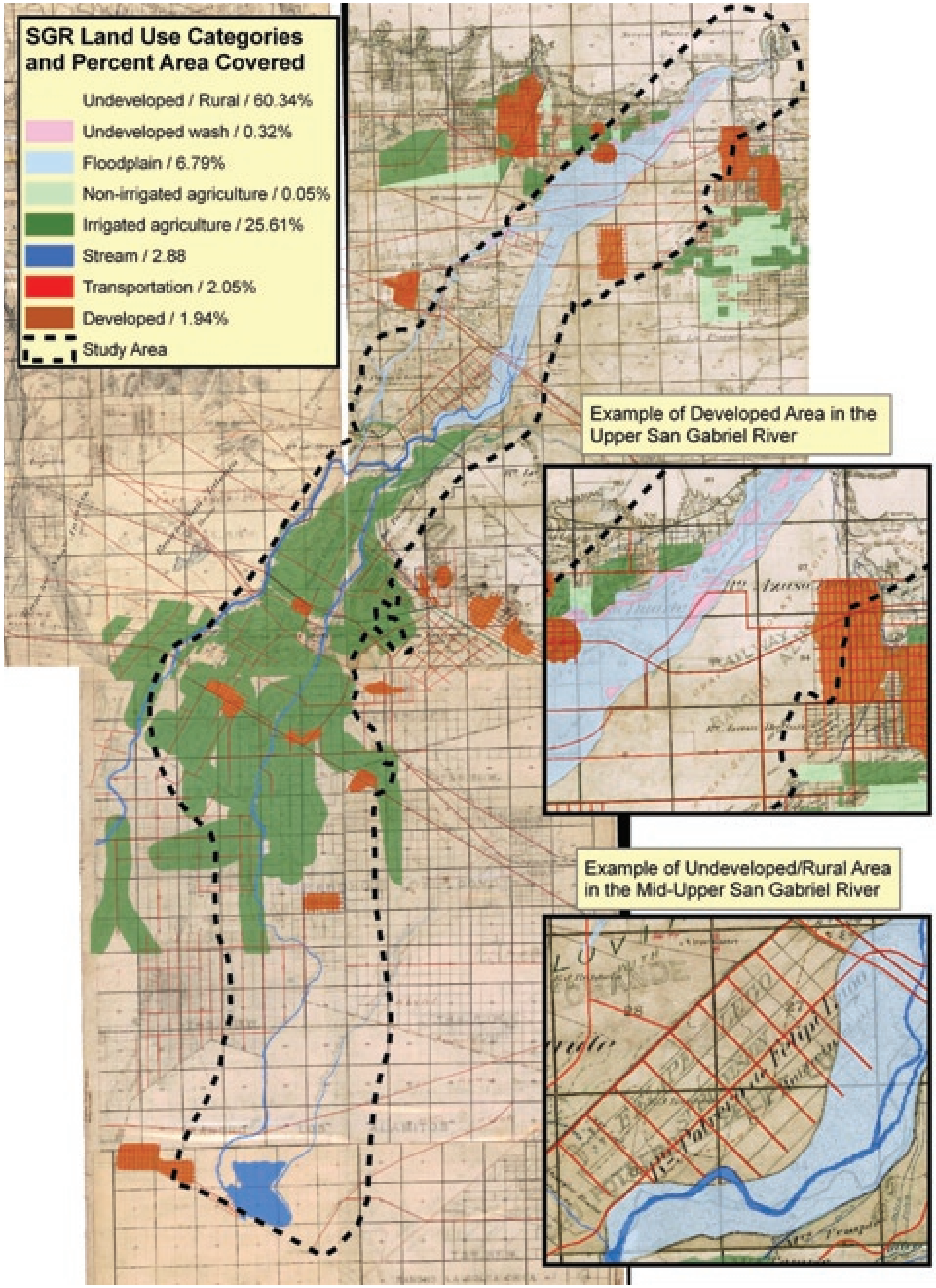


FIGURE 2.3. Land use within San Gabriel River study area in the late 1880s.

In early 1884, as the Southern California population began to grow in earnest, the skies above Los Angeles opened again (**FIGURE 2.3**). Residents along the Los Angeles River got the worst of it. One area resident described how "the water broke through the levees and over the lowlands and where the Santa Fe Station now is the water was about three feet deep. All of this water flowed westwardly into Alameda Street. Some forty-one houses were washed away in the lowlands near First Street and below. In those days the streets ended at the river. The people built their houses on the sand and when the floods came lost them." Residents along the San Gabriel also felt the impacts of the storm. "Before 1884," W.C. Sproul of Norwalk reminisced, "the New River was running through Belleflower [sic.], where the schoolhouse stands, but in the 1884 flood it changed to the east a short distance." Mr. Walter P. Temple of El Monte remembered, "In that year the San Gabriel River changed its course somewhat in that it cut across the Rio Hondo just below the Whittier narrows" (Reagan 1915). On February 6th, the Los Angeles Express reported that the New River had flooded Downey. By the 19th, the paper reported even more startling news: "The Cerritos country and the New River country are all under water. The New River has changed its channel, which it cut in 1867, and is running through two channels at present….There is a grand stream 15 miles in length, composed of Old and New San Gabriel Rivers, and the Los Angeles." As the storm waters finally began to recede in March, the paper reported that the New River washed away 350 acres of cornfields at a cost of $21,000 (*Los Angeles Express* 2/6/1884, 2/19/1884, 3/14/1884).

Floods came again in 1889 and 1891. Recalling the former, Thomas Gregory of Long Beach lamented, "These rivers, the Los Angeles, and the San Gabriel have been all over the valley. It is a new river with them every time a big flood comes. The San Gabriel River shifts from one side of the valley to the other. Wherever the flood waters go they carry sand and silt, and as the grade of the river changes, the waters drop their deposits as the current loses its velocity. The velocity, just the same, is no small matter, as around Bellflower the floods brought down logs, trees, etc. and it would have kept anyone moving pretty lively to have kept up with them" (Reagan 1915). In February 1891, the Los Angeles Times reported that "the country about Downey looked like a raging sea…the new San Gabriel jumped its banks, and joining Old River, swept everything before it." Some reports from El Monte intimated that at the height of the downpour, the new San Gabriel was 1,200 feet wide (*Los Angeles Times* 2/25/1891; 2/26/1891).

Los Angeles County enjoyed a period free of major flooding between 1891 and 1914 (**FIGURE 2.4**). This era also saw the most intense influx of new residents, many of whom settled in subdivisions constructed in the San Gabriel River's floodplain. The practice of laying down concrete and asphalt for the expanding metropolis made runoff problems more concentrated during severe rainstorms (Reagan 1917). Thus, a downpour in 1914, smaller than those of the 19th Century, caused significantly more property destruction and loss of life than earlier floods, and spawned a public outcry for flood control engineering (Orsi 2004).

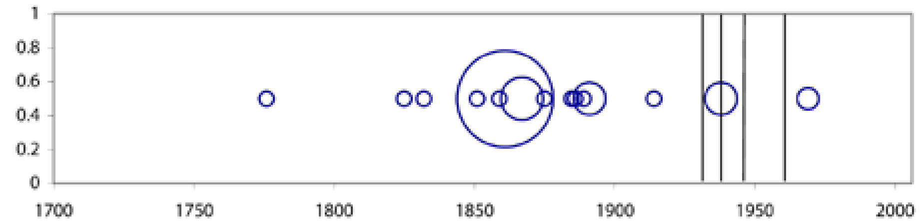


FIGURE 2.4. Major flood events on the San Gabriel River, 1700–2006. Circles indicate documented flood events, with diameter of circle proportional to size of event. The four horizontal lines indicate construction of the Morris and Cogswell dams (1934), San Gabriel Dam (1939), Santa Fe Dam (1947) and Whittier Narrows dam (1957).

Other human factors made the flood potential of the San Gabriel River problematic. The completion of the Los Angeles Harbor, in 1907, and the opening of the Panama Canal, in 1914, solidified Los Angeles' status as a major west coast metropolis. The port served as a major point of entry for Asian commodities, and the shortcut through the Isthmus of Panama slashed transit times for both goods and people from Atlantic ports. The harbor doubles as the outlet for both the Los Angeles and San Gabriel Rivers, but with the relative climatic calm during the years of its planning and construction, the impacts of streamside activity were overlooked. In reality, flooding was a major concern; heavy rainfalls could result in huge deposits of silt that the newly built breakwater would then prevent from flowing into the ocean (Orsi 2004).

The flood of 1914, the first major flood in Los Angeles in over twenty years, became serious in the early hours of February 18th, with rain falling at a rate of more than an inch an hour. The flow of debris down the rivers caused a buildup of silt in the harbor, impeding the pathway of incoming and outgoing ships and bringing Los Angeles commerce to a virtual standstill

(*Los Angeles Times* 2/19/1914; 2/22/1914). With the destruction wrought by the flood on a much larger public than previously affected by Los Angeles' episodic flooding, an outcry for a centralized authority over riparian threats to life and property arose. What ensued was massive infighting and financial mismanagement that gave rise to twenty years of new bureaucracy, engineering panels, a takeover of flood planning by the County (the State refused funding), and very little success translating potential flood management proposals into built reality[3].

One of the four-member Los Angeles County Board of Engineers hired in the aftermath of the 1914 flood, James W. Reagan, proved to be a maverick. The other four flood control members relied solely on empirical methods, taking soil samples, measuring the flow of the rivers, and carefully recording and analyzing their data. Reagan opted instead for a more unorthodox method, driving thousands of miles around Los Angeles to interview longtime residents. The result was an extensive six-hundred-page oral history of Los Angeles rivers. Reagan refused to sign off on the rest of the Board's 1915 final report to the County Board of Supervisors, and filed his report separately. The County Board of Supervisors, however, were not as irked as his fellow engineers at his methods and promoted him head of county flood control. The report filed by the majority of the Board of Engineers realized the dangers posed by the increasing metropolitanization of Los Angeles on its rivers. The effects of population growth concomitantly increased the destructive potential of local rivers. After witnessing such effects during the 1914 flood, the engineers warned that "the growth of cities and towns, with their great areas of roofs and paved streets, by the extension of paved highways and improved watercourses, and by the return water from increasing irrigation, the run-off resulting from any given rainfall is steadily increasing, and will change moderate floods of the past into serious floods of the future" (Olmsted et al. 1915).

The inefficiency and corruption of County flood planning was baldly exposed during the 1920s San Gabriel Dam fiasco. A pet project of Reagan's since the 1910s, the Forks Project Dam aimed to solve Los Angeles' two main water-related problems: flood control and drought relief. In 1924, Los Angeles voters approved funding for the enormous project, set to be a 425 ft-tall dam in San Gabriel Canyon at Twin Forks (the meeting point of the river's two branches). The planning behind the project was inherently flawed, and when construction finally began in 1929, "the west abutment of the dam site caved in, and five hundred thousand cubic yards of mountainside slumped into the canyon" (Orsi 2004). An investigation by the State revealed widespread corruption among city officials and the private contractors they had hired. According to Orsi, "The contractors had what was known as a front-balanced contract,

3 Much of the resulting literature contains maps, graphs, and suggestions for flood control. See especially Los Angeles County, Calif. Board of Engineers. Olmsted, Frank H., Engineer in Charge. *Report on San Gabriel River Control* (1913); J.W. Reagan *Los Angeles County Flood Control District* (filed w/ Board of Supervisors 1/2/1917); Frank Olmsted, H. Hawgood (chair), J.B. Lippincott, Charles Leeds, *Report of the Board of Engineers Flood Control to the Board of Supervisors Los Angeles County California* (1915); J.W. Reagan, *Tentative Report to the Board of Supervisors of the Los Angeles County Flood Control District* (1924); California Department of Public Works (CDPW); Division of Water Rights. *San Gabriel Investigation: Analysis and Conclusions*, by Harold Conkling. Bulletin Nos. 5, 6, and 7, Reports of the Division of Water Rights. Sacramento: California Printing Office, 1927 (bulletin No.5) 1929 (bulletin Nos. 6 & 7) all in HRBC.

meaning they had organized their bid in such way as to earn the bulk of their profit early in the construction process" (Orsi 2004)[4]. Disillusioned and impoverished by the Great Depression, County residents showed little interest in pursuing any further flood control in the early 1930s.

All of this changed when New Deal relief programs infused massive amounts of federal money into Los Angeles river engineering, and Los Angeles County flood engineers teamed up with the US Army Corps of Engineers (USACE). Three dams (the Morris, Cogswell, and a scaled-down version of the San Gabriel) were constructed to hold reservoirs in the mountains in the 1930s. Two other dam projects, the Santa Fe (completed 1946) and the Whittier Narrows (completed 1957) were then constructed further down the watershed. Another major flood control mechanism came into vogue by happenstance when a 1933 debris flood was efficiently caught by a former gravel mining operation in Haines Valley's Verdugo Wash, sparking the idea for the debris basin. Most dramatically, however, new mechanized paving developed in the 1950s made the paving of the Los Angeles and San Gabriel riverbeds feasible, and the USACE and County officials saw to it that nearly all of the downstream areas of both the Los Angeles and San Gabriel Rivers were remade in concrete (**FIGURE 2.5**). As this transformation of natural riparian habitats suggests, the technocratic approach to flood control in southern California has had a range of effects, both planned and unanticipated, as fluvial processes have continued to assert themselves.

Recollections of the river prior to major engineering programs indicate the existence of an abundance and diversity of riparian vegetation, but offer little in the way of precise location or extent.

Photo courtesy of the Benjamin and Gladys Thomas Air Photo Archives, UCLA Department of Geography

FIGURE 2.5. Levees being constructed along the Los Angeles River near Cerritos in 1932. Photograph E-3848 from Spence Air Photo collection.

4 Primary source information on the failed dam project located in the John D. Galloway papers and Andrae Nordskog papers at the Water Resources Center Archives at UC Berkeley.

Beginning in the 1960s, the environmental movement posed the first serious challenge to the technocratic approaches to river management. Twenty years of activism by the environmental community influenced Los Angeles County's Master Plan for the San Gabriel River, which claims to provide "a shared, comprehensive vision of the river corridor, from the mountains to the ocean. It integrates the multiple goals of enhancing habitat, recreation and open space, while maintaining and enhancing flood protection, water supply and water quality." The non-profit San Gabriel Mountains Regional Conservancy aims "to promote the preservation of land and/or buildings for historic, educational, ecological, recreational, or open space opportunities." Projects such as these, along with the state's San Gabriel and Lower Los Angeles Rivers and Mountains Conservancy, reinterpret the river as part and parcel of the Southern California environment, not simply a system in need of manipulation and control. Efforts are also underway to uncover the lost aesthetic appeal of the rivers in their natural state, prior to their casting in cement. Though these steps have been preliminary, they stand as important portents for ecological restoration and natural renewal.

2.7 SUMMARY OF KEY HISTORIC EVENTS

- **1769** - Crespi's first passage through the valley on the Portola expedition. (Crespi recommends it as a mission site)
- **1771** - Mission San Gabriel is founded in present-day Montebello
- **1775** – The San Gabriel River destroys the mission and its fields (t is moved to its present site twenty miles upriver)
- **1781** – The pueblo of Los Angeles is founded with a total population of 44 people
- **1821** – Mexico declares independence from Spain
- **1833** – The Mexican government secularizes the California missions and divides their massive landholdings (though intended to benefit Indians, the huge tracts of lands were parceled out to a small number of Californio elites)
- **1847** – The last armed battle of the Mexican-American War is fought across the banks of the Rio Hondo
- **1848** – The Treaty of Guadalupe-Hidalgo officially ends the Mexican-American War and California becomes a territory of the United States
- **1849** – Cattle production in the San Gabriel Valley skyrockets in response to demands of Gold Rush in northern California
- **1861/1862** – Major flooding occurs
- **1862/1864** – Severe droughts wipe out most of the rancheros' cattle – (unable to meet the payments of their creditors, their lands go to banks who sell it to white settlers and much of the land is converted from pasture land for cattle to agriculture, primarily citrus, grain, and viticulture)

- **1867/1868** – A logjam on the San Gabriel River above the Whittier Narrows breaks and cuts a new channel from its westward course to a southbound course into Alamitos Bay
- **1876** – The Southern Pacific Railroad completes construction on a trunk line through Los Angeles
- **1880** – The census reveals that the populations of the city and county of Los Angeles have doubled during the past decade
- **1884** – Major flooding occurs and the construction of the Santa Fe Railroad begins
- **1886** – The Santa Fe Railroad comes to Los Angeles: a rate war between the Southern Pacific and Santa Fe Railroads ensues, the population of Los Angeles booms, and Land syndicates begin to buy agricultural land and subdivide it into satellite town sites for Los Angeles as the first generation American landowners begin to die off
- **1889** – Major flooding occurs
- **1890** – The census reveals 350% growth in the population of the city of Los Angeles in the past decade and a 204% growth rate for the population of Los Angeles County
- **1891/1892** – Major flooding enlarges the connection between the San Gabriel River and Lexington Wash
- **1907** – The Los Angeles River in San Pedro is dredged, opening the port to major cargo vessels
- **1914** – Major flooding occurs and a County Board of Engineers is formed to try to manage the rivers during floods. (one of the Board's engineers, J.W. Reagan, compiles a list of oral histories of longtime county residents)
- **1929** – After a hillside cave-in incident occurred during construction of a 425-ft dam/reservoir, the San Gabriel Dam, at Twin Forks in San Gabriel Canyon, massive corruption in municipal government is uncovered and the project shuts down (Twin Forks Fiasco)
- **1934** – The Morris Dam and the Cogswell Dam are built
- **1938** – Major flooding occurs (most flood projects installed to this point fail)
- **Late 1930s to1950s** – Massive influxes of federal money and the coordination of USACE, most of the Los Angeles, San Gabriel, and Santa Ana Rivers are paved, along with their primary tributaries
- **1939** – The San Gabriel Dam #2 is built
- **1957** – The Whittier Narrows Dam is completed

2.8 CONTEXT OF LONG-TERM CLIMATE CHANGE

The historical descriptions of the San Gabriel River indicate periods of drought and deluge of a greater intensity than experienced in recent memory. The great floods of the late 1800s were larger than anything experienced since and their

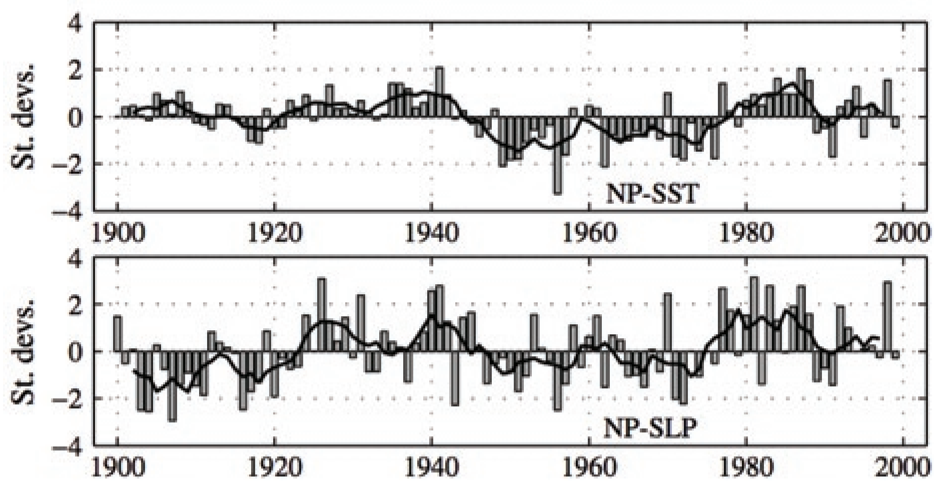


FIGURE 2.6. Sea surface temperature (SST) and sea level pressure (SLP) anomalies in the Pacific Ocean 1900 to 2000. The warm phase of the PDO is indicated by values above the mean (i.e., portion of the bar or line above zero). A five-year running mean (dark line) shows periods of extended warm or cool dominance. Figure from Mantua and Hare (2002).

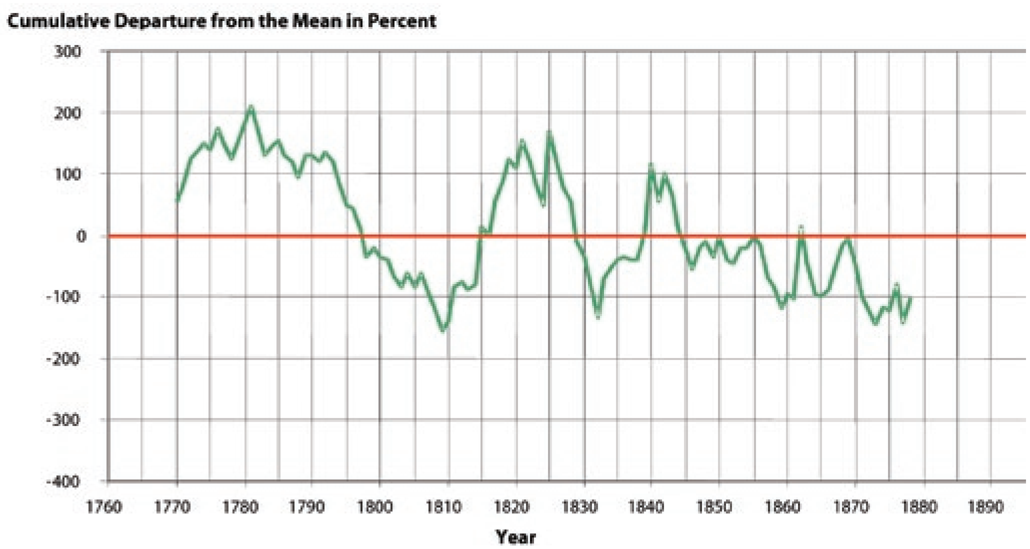


FIGURE 2.7. Annual rainfall in Los Angeles 1769 to 1878 expressed as cumulative departure (i.e., deviation) from the long-term mean of 38.4 cm (15.12 inches). Data from Lynch (1931).

magnitude has certainly faded from the collective memory of the public. Southern California rainfall patterns are governed by two major climate cycles. The El Niño/Southern Oscillation (ENSO) is characterized by a geographic shift of sea surface temperature in the Pacific Ocean and associated with increased frequency and accumulation of rainfall in southern California. ENSO periodicity is on the order of one to two years and affects annual rainfall patterns. The Pacific Decadal Oscillation (PDO) modulates ENSO over multi-decadal cycles and causes longer-term fluctuations between wet and dry phases in western North America (**FIGURE 2.6**; Douglas et al. 1982, Mantua and Hare 2002). During the warm phase, a flurry of strong ENSO events may occur (Goddard and Graham 1997), leading to stronger than normal streamflow and sediment movement in rivers in the southwestern United States (Ely et al. 1994, Inman and Jenkins 1999). The cool phase of the PDO cycle is dominated by a drier climate and less streamflow in southern California. The rainfall history for Los Angeles shows this pattern of drier and wetter periods, with major ENSO events occurring in 1876-77, 1891, 1925-26, 1982-82, and 1997-98; consequently, the extreme variability of rainfall from year to year is particularly important to the structure of the San Gabriel River (**FIGURE 2.7**). This variability and its affect on stream flow were instrumental in supporting the dynamic wetland complexes characteristic of the San Gabriel River watershed (*see sections 4 and 5 of this report*).

The period of investigation for this study was characterized by a generally warmer than usual PDO cycle, which was associated with higher than average rainfall and streamflow. Biondi et al. (2001) used six tree ring sites located in southern California to reconstruct climate records between 1610 and 1995 (**FIGURE 2.8**). Their analysis showed wetter than average weather patterns between 1750 and 1905. Lynch (1931) analyzed long-term rainfall and runoff records in southern Californa and noted signifant rain events between 1849-53, 1859-62, 1866-68, and 1873-76 (**FIGURE 2.7**). Similarly, Bradley (1976) concluded that 1861-1875 was an extraordinary wet period, followed by drought conditions between 1905 and 1950. The somewhat unprecedented series of ENSO events during this period shaped the physical structure of the San Gabriel River and the associated human response. Contemporary comparisons should be cognizant of these longer-term climatic cycles and the differences between historical and contemporary climate.

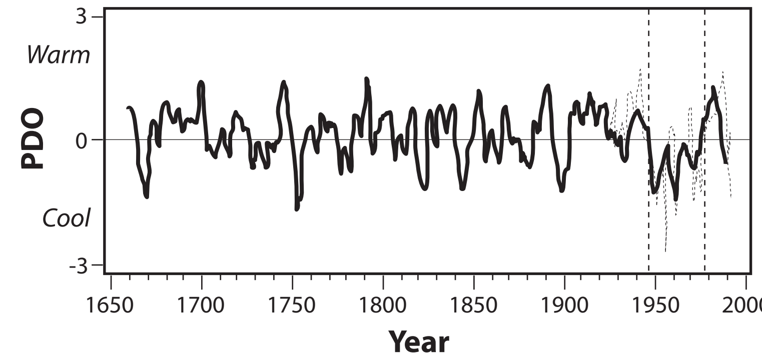


FIGURE 2.8. Pacific Decadal Oscillation (PDO) between 1610 and 1995 in southern California. Note warm PDO (positive oscillation) between 1780 and 1910. Vertical dashed lines indicate major reversals in 1947 and 1977. The cooler PDO during this period was characterized by lower than average rainfall. Figure from Biondi et al.(2001).

3 METHODS / APPROACH

Unlike contemporary habitat analysis, historical ecology relies on interpretation of numerous information sources that were not necessarily compiled to meet the objectives of our particular analysis. As such, conclusions must be developed from multiple data sources that collectively provide a "weight of evidence" that supports inferences about historical condition. Our baseline methodology was structured from previous historical wetlands and watershed mapping projects conducted by the San Francisco Estuary Institute (Pearce and Grossinger 2004, Grossinger et al. 2006). This approach relied heavily on the use of Geographic Information Systems (GIS) as a method to map, interpret, and catalog our data. As such, this section will provide specific details on the use of GIS. Core GIS functionality allows us to spatially reference and overlay scanned maps, photography, etc., as well as develop databases that integrate spatial and non-spatial (textual) information under one umbrella. This contributed significantly to our ability to interpret changes in the landscape over time and to place specific wetlands within a historical context. The process used to create historical maps and habitat profiles consisted of the following general steps:

1. Compile primary data sources on historical condition, including: maps, soil and geologic surveys, and aerial photography. Sources were considered 'primary' if they were collected using a structured procedure that allowed for general quality control at the time they were produced.

2. Use primary data sources to refine study area and to prioritize locations and time periods for additional analysis.

3. Compile secondary data sources that expand or clarify primary sources. Secondary sources include personal and written accounts, ground-level photographs, and floral and faunal records.

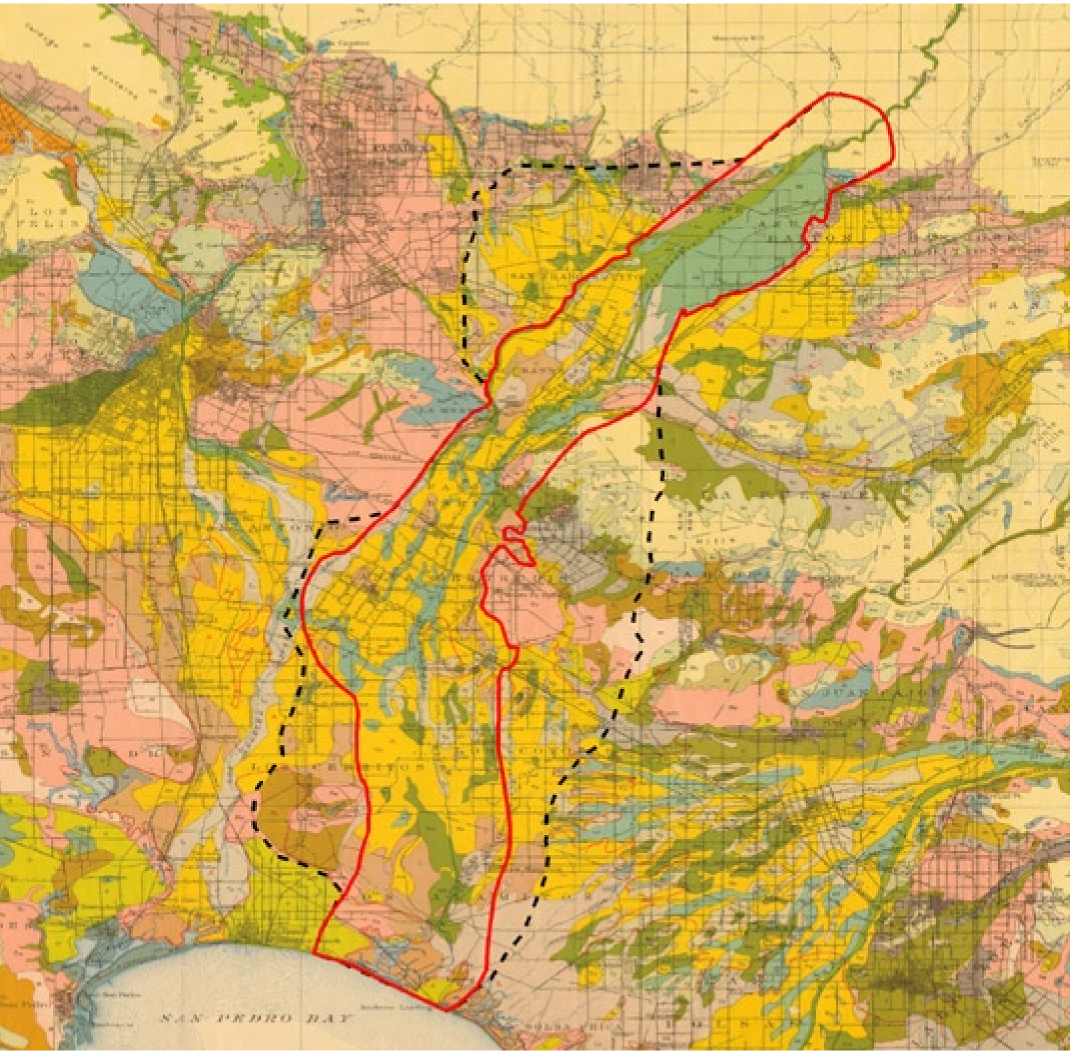


FIGURE 3.1. USDA soil survey map with an overlay of the study area boundary (solid red line). The dotted line depicts wetland areas that were mapped outside of the study area.

4. Digitize and georeference acceptable data sources.

5. Overlay all suitable data sources to create an initial set of historical wetland polygons.

6. Classify inferred historical wetland polygons using a system that is compatible with the contemporary National Wetlands Inventory (NWI) mapping system. This allows comparison of historical and current wetland extent and distribution.

7. Assign confidence levels to the wetland polygons based on estimated accuracy and concordance of available data sources.

8. Produce summary maps and tables of historical wetlands.

9. Characterize historical plant communities for representative wetland type.

Each of these steps will be discussed in detail within this section and results presented throughout the report in relevant sections.

3.1 STUDY AREA

Analysis of historical conditions focused on the San Gabriel River floodplain (circa 1870) from the base of the San Gabriel foothills (near present day Azusa) to the boundary with the historic San Gabriel/Los Angeles River estuary (**FIGURE 3.1**). The lower San Gabriel River valley was naturally a relatively low gradient broad alluvial floodplain with few obvious features that demarcated the floodplain limits. Closer to the ocean, the San Gabriel River floodplain was contiguous with the floodplain of the Los Angeles River during many years, and the Santa Ana River following periodic extreme flood events. Consequently, we focused on soils designated as having a high potential for wetlands (Dunn et al. 1921) and geomorphic context (alluvial fan associated with the San Gabriel River) to delineate the study area boundary. The boundary between the lower San Gabriel and Los Angeles River floodplains was estimated based on approximate topographic differences; however, this boundary was somewhat arbitrary. For completeness, some contiguous features that extended beyond our designated project boundary were mapped. Expansion of our study to encompass the Los Angeles River floodplain would ultimately provide a more comprehensive assessment of historical conditions for this portion of the southern California coast.

3.2 HISTORICAL DATA SOURCES, COLLECTION, AND COMPILATION

Primary data sources were identified by censusing a wide range of local institutions that compile or house historical data (**TABLE 3.1**). The acquisition of sources that had been created for a variety of purposes and from different time periods provide a more reliable and accurate understanding of the study area's historical conditions (Grossinger 2001, Grossinger and Askevold 2005). While a discussion of the voluminous sources collected is beyond the scope of this report, the following sections provide a brief summary of the principal sources used to evaluate historical conditions during this project. For a full list of historical sources and the collection locations, please refer to the reference section of this report.

TABLE 3.1. Institutional Sources for Historical Data

UCLA Spence & Fairchild Collection
USDA Archives
Heritage Park
UCSB/Alexandria Digital Library Project
David Rumsey Collection
Bancroft Library
NRCS
Pio Pico State Historic Park
Huntington Library
Bancroft Library
Bureau of Land Management
NOAA
Sante Fe Springs Public Library
Los Angeles Public Library
Los Alamitos Public Library

3.2.1 Primary Data Sources

Mexican Land Grant Sketches (Diseños). When the United States took possession of California and other Mexican lands in 1848, it was bound by the Treaty of Guadalupe Hidalgo to honor the legitimate land claims of Mexican citizens residing in those captured territories. American officials collected the records of the Spanish and Mexican governments. Those records, most of which were transferred to the U. S. Surveyor General's Office in San Francisco, included land deeds, sketch-maps (diseño), and various other documents. Influential Spanish-Mexicans submitted claims and acquired large land grants from the Mexican government. At this time, drawings were created by untrained surveyors to represent desired land and boundaries, which were primarily identified by distinctive landscape features such as wetlands, rivers, creeks and woodlands (**FIGURE 3.2**).

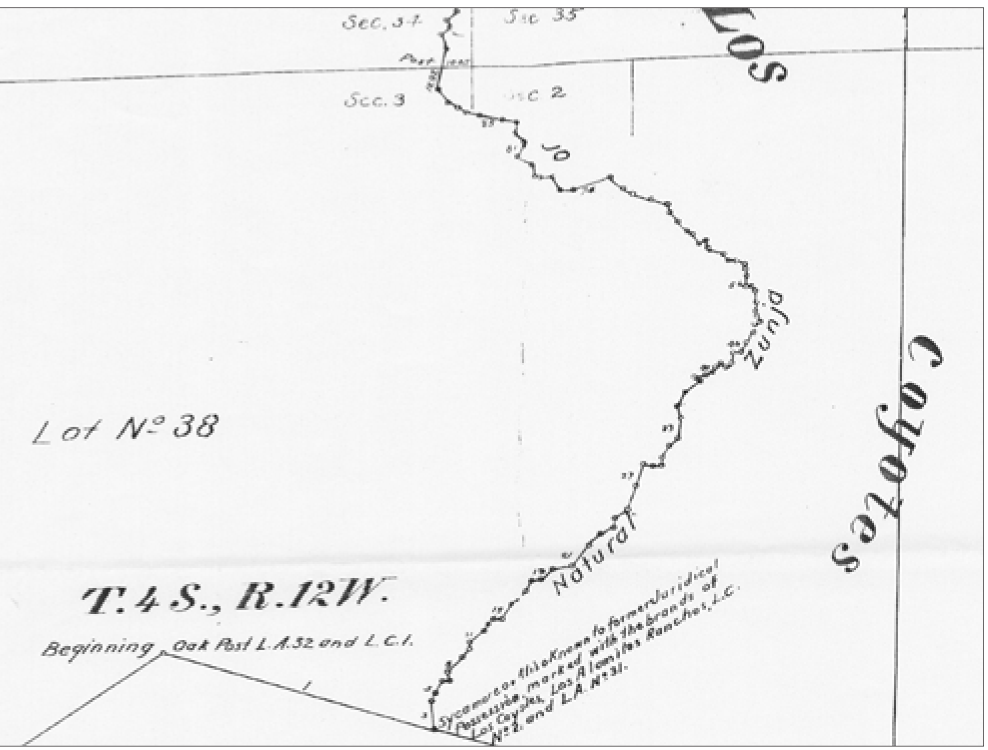


FIGURE 3.2. Example of diseño map for Santa Gertrudes. Notice stippled area between the two rivers (Los Angeles River and present day Rio Hondo) indicating a wetland complex. In the upper right corner the dark spot is a "laguna" (left). Map courtesy of the Bancroft Library.

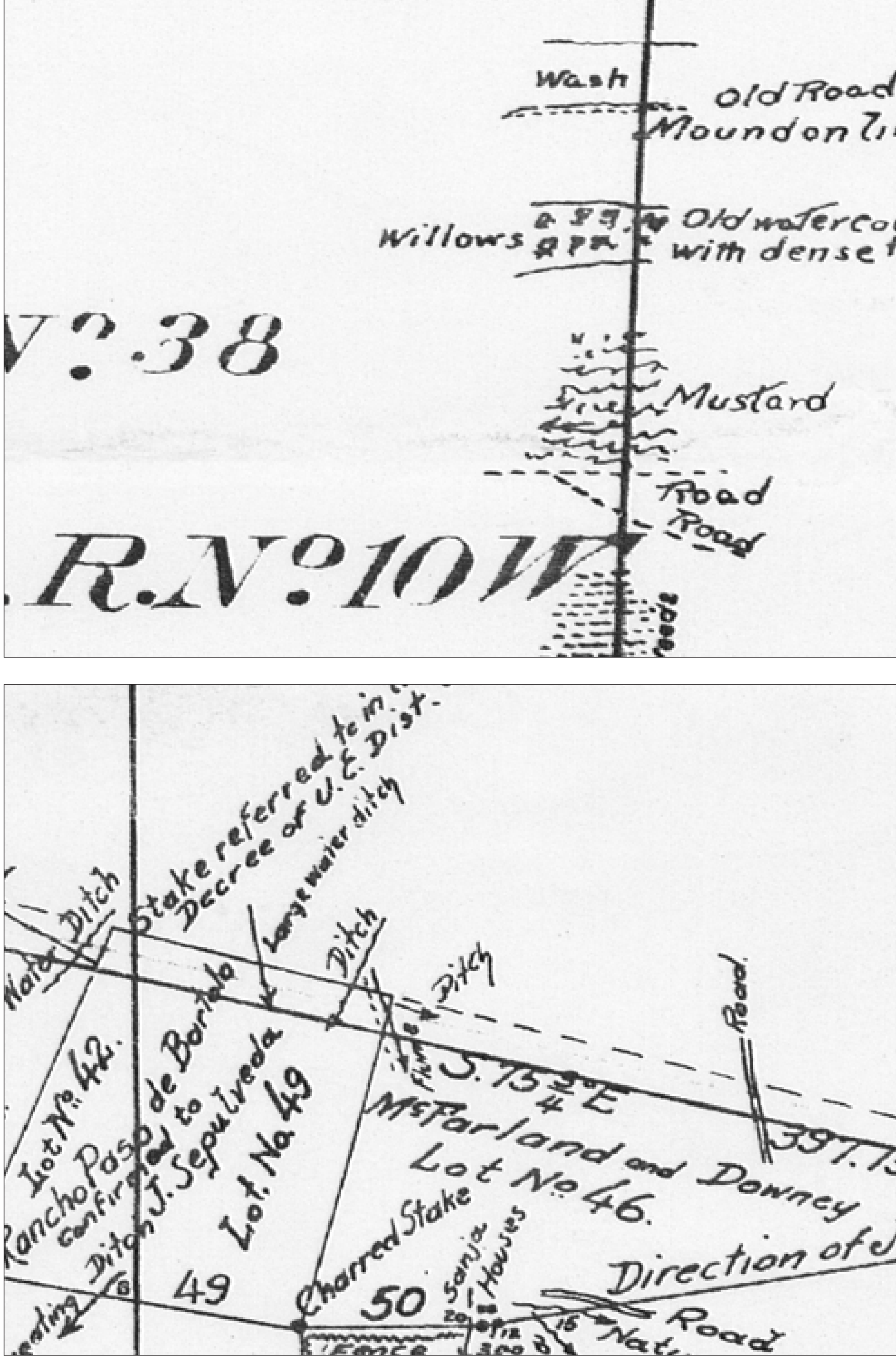
FIGURE 3.3. Example of a General Land Office map showing the location of a natural creek or zunja (bottom left). Map courtesy of the Bureau of Land Management.

These diseño maps are the oldest detailed maps of water features in California. Fortunately, the boundaries of the ranchos often followed water courses and note valuable surface water features. As such, they proved to be a useful tool for delineating historically significant wetlands. The Mexican Land Grant-based Ranchos in the study area included (from North to South): Azusa, San Francisquito, La Puente, Potrero Grande, Paso De Bartolo, San Antonio, Pasa De Bartolo, Santa Gertrudes, Los Cerritos, Los Coyotes, and Los Alamitos.

General Land Office (GLO) Surveys. The General Land Office, established in 1812 within the Department of Treasury, carried out federal surveys of public land throughout the United States. A rectangular township system that consisted of six-mile squares divided into thirty-six square mile sections was established as the format for the survey endeavor (Whitney and DeCant 2001). In California, the township system was broken in some areas by the existing Mexican Land Grant boundaries. The grant boundaries were based on landscape features, rather a grid system.

The surveys attempted to follow the original grant boundaries, in addition to the sectional boundaries, noting the natural and anthropological phenomena, such as creeks (**FIGURE 3.3**), oak

FIGURE 3.4. **Example of General Land Office Map showing a thicket of willows (right) and roads and irrigation ditches (bottom right). Map courtesy of the Bureau of Land Management.**



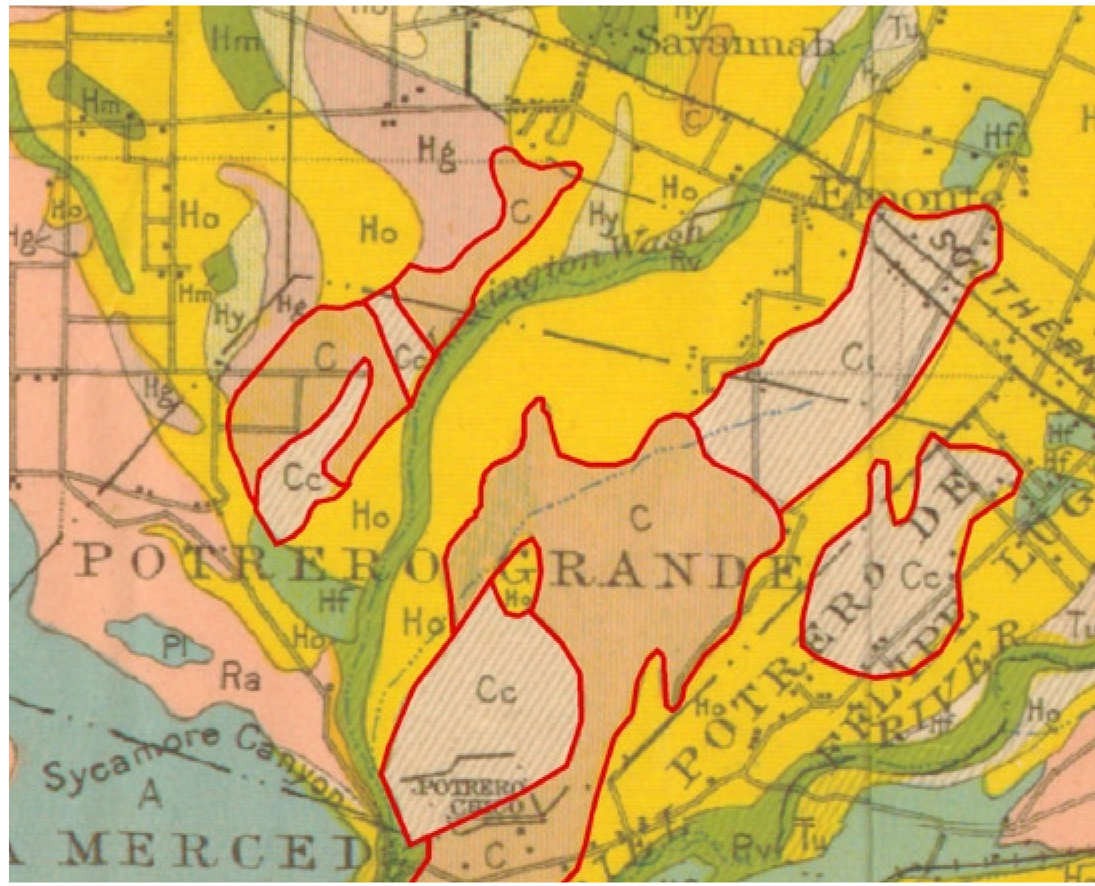
and willow groves, and roads and irrigation ditches (**FIGURE 3.4**) found along these lines. Perhaps the most useful aspect of this survey data were the field notes which state precise locations of markers along the survey boundary. These markers were often natural features such as trees or bends in the river that can be used to help substantiate the location of historical aquatic resources.

W.H. Hall Irrigation Engineering (Draft) Maps and Report. William Hammond Hall's Irrigation Report was published in 1888. The report was accompanied by an unpublished draft map series that was produced during the years of research leading up to the date of report completion. Hall was California's first State Engineer. His work is well respected for its detail and quality (State of California Department of Water Resources website). The draft maps were of immense value to the wetlands identification effort for this project. The Hall (1886) draft maps use a number of standard mapping symbols and textual annotations of water resources present in the study area such as springs and seep, creeks and reservoirs, marshes or ciénegas, and natural depressions (**FIGURE 3.5**). Hall (1886) also provides evidence of the dynamic nature of the San Gabriel River by documenting the old and new course of the river channel at that time.

USDA Reconnaissance Soil Survey and Report. The Reconnaissance Soil Survey and Report of the Central and Southern Area, California was authorized by the US Department of

FIGURE 3.5. Sample inset map from Hall (1886) showing the location of reservoirs, springs, and "line of moist land" (left). Map courtesy of the Huntington Library.

FIGURE 3.6. Inset map from the Dunn et al. (1917) soil survey. This map was published with the textual document Dunn et al. (1921) soils report. Areas marked with a C and outlined in red represent Chino soils (bottom). Map courtesy of California State University, Northridge.



Agriculture (USDA). The soil survey was carried out in 1917 and the report was published in 1921. For the project study area, the soils survey report was of particular use in identifying the hydric and well-drained soils, and alkali features across the landscape. We were able to obtain a copy of the soil survey report from the Natural Resources Conservation Service (NRCS) Lancaster Office and a copy of the accompanying map from the California State University, Northridge Map Library. The soil survey map proved to be an important initial data source for the identification of historical wetlands (**FIGURE 3.6**).

United States Geological Survey Topographic Maps. The United States Geological Survey (USGS) was established in

1879 and began its topographic atlas of the United States in 1882. California State University, Northridge (CSUN) houses a collection of the earliest of these maps within southern California. The oldest map for our study area was dated 1893 and covers a major portion of the study area. While these maps were produced at a much smaller scale than local sources such as Hall (1886), the advantage of these maps is the attention to detail with regard to water resources and use of a standardized mapping convention. Water resources are colored blue and perennial wetlands are drawn on the map using standardized blue tufts along horizontal lines. These maps not only provide a basis for identification of historical wetlands, but their consistency with contemporary maps facilitated comparisons across multiple time periods. In addition, the high quality condition of the maps from the CSUN Map Library allowed these maps to be easily georeferenced.

Aerial Photography. The 1928 aerial photographs used in this project were originally created and maintained by Fairchild Aerial Surveys, Inc. (Casanova 2004). One set of the 1928 photographs now resides at the Los Angeles County Department of Public Works (LACDWP). The aerial photos were available for the full study area and proved to be a valuable source in accessing ecological change and evaluating land use change. The photos, when analyzed in comparison with earlier historical map documents, exhibited numerous landscape changes brought about by natural disturbances and human modification. An example of the landscape transformation can be seen in the 1928 aerial photographs of the San Gabriel River channel and the evidence of a previous channel on cultivated land seen approximately three quarters of a mile to the west (**FIGURE 3.7**). In addition, the photos provided a unique perspective on the complexity of the upper San Gabriel River flood plain and the extent of riparian corridors during this period.

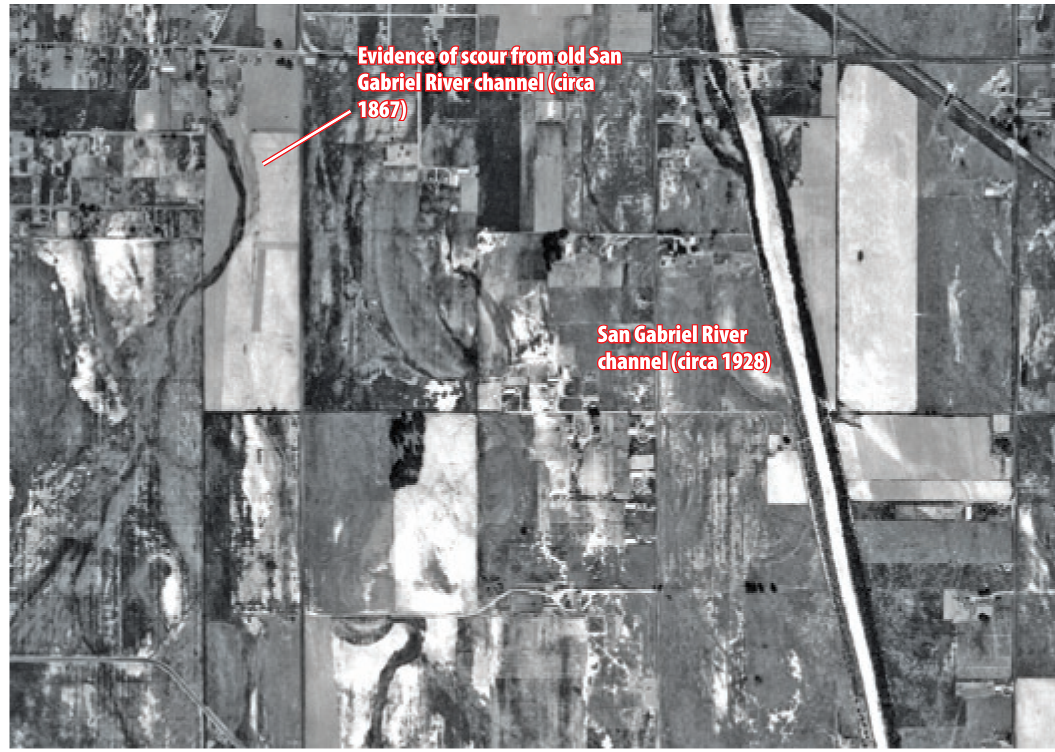


FIGURE 3.7. Aerial photograph showing the channelized San Gabriel River in 1928, as well as evidence of a previous channel. The photograph also provided further collateral data on the size of the southern San Gabriel River flood plain.

To acquire historical images of the vegetation along the San Gabriel River we searched the Ben and Gladys Thomas Air Photo Archive at the University of California, Los Angeles (UCLA) Department of Geography. This archive houses the

Spence and Fairchild collections of oblique aerial photographs. All pre-1935 photographs were visually searched for areas that included portions of the San Gabriel River.

3.2.2 Secondary Data Sources

Primary data sources were supplemented by a general survey of key historical and geographical analyses of Los Angeles area rivers. Jared Orsi' *Hazardous Metropolis* (2004) and Blake Gumprecht's *Los Angeles River* (1999) both offered critical starting points for general information on flooding, land use, and political developments in Los Angeles' history, in addition to highlighting how the regional river network has affected the choices of city planners, political figures, and area boosters. Several essay collections also came to be of great use, in particular *Land of Sunshine* (2005), edited by Greg Hise and William Deverell, and *Contested Eden* (1998), edited by Ramón Gutiérrez and Richard J. Orsi. Each collection contains essays on indigenous peoples, development, and historical environmental conditions. Most information on land use prior to European contact comes from these and other secondary accounts.

Additional supporting information was found in local histories, such as Charles Russell Quinn's *History of Downey* (1973), and accounts more than a century old, such as Juan José Warner, Joseph Pomeroy Widney, and Benjamin Hayes' *Historical Sketch of Los Angeles County* (1876) provided invaluable microhistories of local events.

The most important secondary resource for the timeline was a collection of oral histories of floods as told by residents interviewed by maverick flood engineer James W. Reagan and his assistants in 1915. This 600-page document contains the testimony of long-time residents about the impacts of the river on an increasingly large human population. The report contains some contradictory information and some accounts based on little more than hearsay, so many accounts contained in the document required a process of cross-checking information to ensure the veracity of certain stories. In spite of these methodological obstacles, Reagan's report provided the most specific and crucial evidentiary information on the nature of the San Gabriel River during the latter half of the 19th century, including accounts of the extent and duration of inundation, and major shifts in the course of the river associated with large storms. These accounts were cross-referenced against information obtained from the primary data sources to enhance our understanding of the dynamism of the river during this period of extreme climatic and social change.

3.3 DATA COMPILATION AND CONSTRUCTION OF THE HISTORICAL INFORMATION DATABASE

The collected historical data sets were generalized into two broad categories, non-spatial and spatial, and cataloged using Endnote® software. Because our historical data sets represent many rare or obscure sources, standardized citation formats were not always available. Instead, we used a citation and database format developed by the San Francisco Estuary Institute for use in historical ecology (Grossinger et al. 2006). This Endnote® database is available to the public as part of the final products of this project.

ArcGIS 9.0 was used to collect, catalog, and analyze the spatial elements of the study area. Georeferencing of historical maps and the 1928 aerial photographs allowed us to overlay and compare historical layers and contemporary data sets, such as recent aerial photography and wetland maps. Georeferenced maps were also used to locate geographically referenced textual information gathered from surveyor notes, early explorers' journals, travelers' accounts, and newspaper articles.

Prior to initiating wetlands mapping, we created an ArcGIS 9.0 geospatial database for storage of newly created data sets. A geodatabase is the native format for spatial data in ArcGIS 9.0 and represents both spatial and associated attribute data. There are various types of geographic datasets that can be stored in a geodatabase, including feature classes, attribute tables, raster datasets, and many others. For this project we created feature classes for both the regional and local wetlands mapping. Associated with each feature class is a table that holds its associated attribute data. A detailed description of the format for these data is outlined in subsequent sections. Our final geodatabase (both spatial and associated attribute data) is available to the public as part of the final products of this project.

3.4 DATA INTEGRATION AND WETLAND MAPPING

Integration of the collected information into a map of historical wetland extent consisted of a ten-step process whereby numerous data sources were overlaid and compared to produce wetland polygons (**FIGURE 3.8**). These polygons were identi-

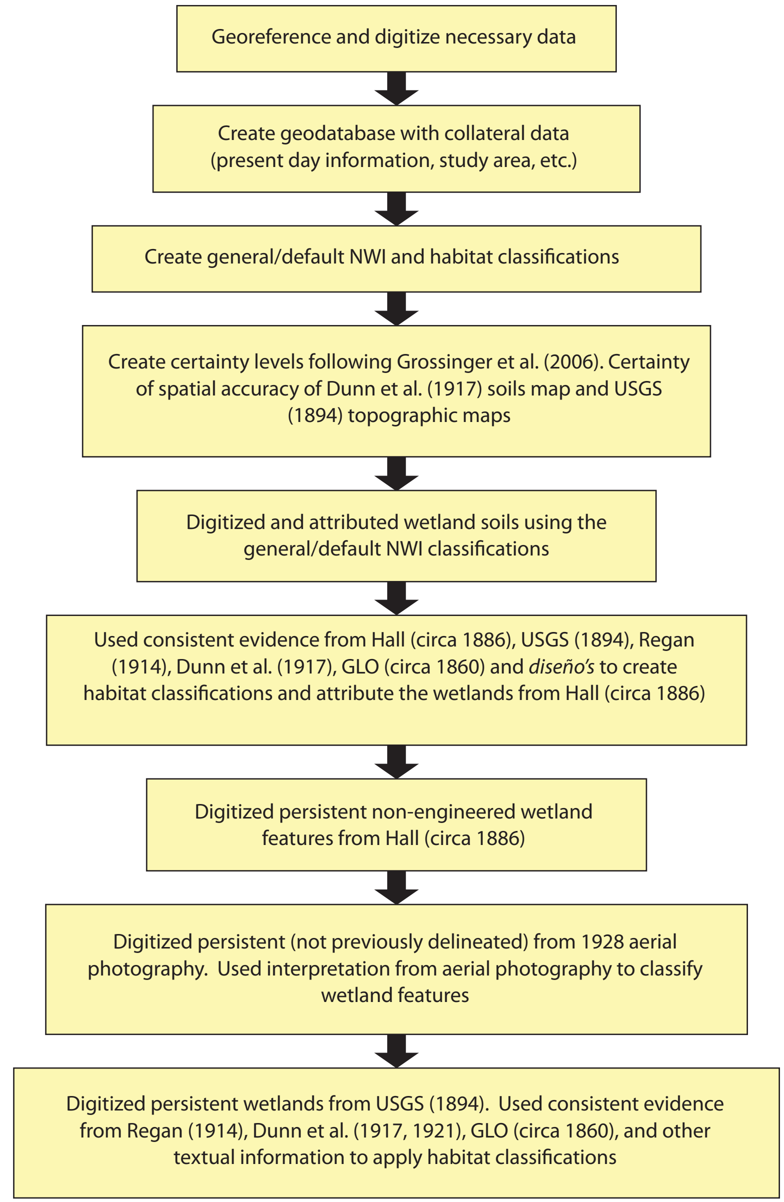


FIGURE 3.8. **Historical Wetlands Data Integration and Mapping Flowchart**

fied and classified based on concordance of evidence from multiple sources. The approach to mapping and assignment of confidence measures to the wetland polygons is summarized in the following sections.

Mapping within the study area boundary proved to be difficult as wetland complexes often crossed or were located just outside the boundary. As a result, in cases where an adjacent wetland was obvious on a map source and yet it was slightly outside of the study area, we still chose to map it. However, because we did not have the detailed source data for places outside of the study area many of these wetlands were classified with a lower confidence rating (*see detailed discussion of confidence estimates below*). In examining these areas outside the study area, it is important to keep in mind that comprehensive surveys of historical wetlands were conducted only within the study area.

3.4.1 Target Time Period

The southern California landscape has historically been dynamic across both spatial and temporal scales, particularly with regard to water features (Gumprecht 1999). This dynamism complicates historical wetlands mapping, but is not prohibitive given the voluminous historical data sets we obtained, a defined study area boundary, and a defined target time period. In light of this dynamism, we mapped features that tended to persist over several centuries or more, such as stream channels, topographically controlled wetlands, and the larger floodplains associated with the San Gabriel River. These features are controlled by geomorphic and climatic processes that have been relatively stable in the western United States for the past several hundred years (Meko et al. 2001).

A wide variety of source materials from 1769 to the 1940's were used to document prevailing conditions prior to significant Euro-American modification. While recognizing natural inter-annual and decadal variation, we attempted to use these data to map average conditions in the decades surrounding initial Euro-American occupation, circa 1769–1880. We found that palustrine, depressional wetlands were typically relatively stable, documented by multiple sources during this time period (e.g., Hall 1886, Dunn et al. 1917, Gannett and Goode 1893). For the fluvial and riparian features of the San Gabriel River channel, which was more dynamic, we targeted the post-1867, pre-1884 alignment. This time period represents the most recent shift of the San Gabriel River channel to an independent alignment with a distinct outlet (as opposed to an alignment as a tributary to the Los Angeles River; *see Section 4.1*). This alignment also conforms to the earlier Arroyo San Gabriel and likely represents a path that the San Gabriel River took at various times over the last several centuries.

3.4.2 Mapping Approach And Conventions

Paper maps, photos, and sketches were scanned for high-resolution digital copies. The maps, photos, and sketches were analyzed for potential usefulness in a GIS as a georeferenced data layer. The sources that were determined to be most suitable for georeferencing were the GLO survey maps, USGS topographic maps, US Coast Survey navigation maps, Dunn et al. soil survey map, aerial photographs, and the Mendenhall and Hall irrigation maps. These data sources were used in combination to draw overall conclusions about the location and type of historical wetlands.

The soil survey from Dunn et al. (1921) served as the baseline guide for mapping wetland features. Riverwash and other floodplain alluvial soils were used to help indentify the likely extent of persistent stream channels and their associated floodplains. In addition, the Hanford and Chino soil series stood out as important indicators of potential wetland areas. The Hanford series was described by Dunn et al. (1921) as follows: "The soils are well drained but parts are subject to overflow or a high water table, and the accumulation of alkali." The lower lying, poorly drained areas of Hanford Fine Sandy Loams and Hanford Loams appeared to have wetland character, including injurious quantities of alkali salts with high water table and places with "a growth of willow, salt grasses, and other moisture loving alkali resistant plants." Using the Hall maps in combination with the soil survey (circa 1886), we were able to identify areas with alkali soils. These areas occurred in the southern section of the study area, adjacent to the estuary. When collateral data supported the potential for wetland features, these areas were mapped as either perennial freshwater wetland or seasonal wetland.

The Chino series was described by Dunn et al. (1921) as containing "much lime, which has accumulated as the result of restricted drainage, the drainage as a whole, being poorly developed. Accumulations of akali also are common in many places." In addition to the Dunn et al. (1917) georectified soil map, we also obtained a NRCS (1965) soil survey in a geospatial data layer. When comparing the 1965 geospatial data layer to the Dunn et al. (1917) map, it was apparent several of the Chino soils (high likelihood of wetlands) were grouped together. Consequently, the 1965 data provided less information than the 1917 data. Likewise, the 1965 polygons did not line up with other features on the landscape suggesting poor georeferencing of the data. To limit spatial errors and provide more detail, we mapped all potential wetland soils polygons from the Dunn et al. (1917) map.

Within our study area, three Chino soils were identified as having the potential for supporting wetlands:

- **Loam, Mucky Phase** – Dunn et al. (1921) describe Chino loam, mucky phase soils as having "a high water table and poor drainage. In addition, this soil type occupies depressed areas in swampy flats kept more or less wet by springs and seepage water.
- **Clay Loams and Clays** – Dunn et al. (1921) indicates that these soils are typically saturated and characterized by " high water table, lying only a few feet below the surface…parts are wet and marshy and contain accumulations of alkali." A general description by Dunn et al. (1921) also states that "parts of the areas consist of shallow, basin like depressions of sluggish drainage, and supporting swamp vegetetation."

- **Loams** – Dunn et al. (1921) describe Chino loams as soils occupying "the flatter margines of recent alluvial fans, and shallow depressions of restricted drainage… Some tracts occupy swampy or permanently wet depressions, where a high water table, usually within 6 feet of the surface, generally exists."

Theses soil types were digitized and copied into the historical wetland geodatabase. Each was given an NWI wetland classification and a habitat classification (**TABLE 3.2**).

TABLE 3.2. General wetland classification for Chino soil series

Soil Type	NWI Classification	Default Habitat Classification*
Loams, Mucky Phase	PEMB to E/H (saturated to permanently flooded	Perennial freshwater wetlands
Clay Loams and Clays	PEMC to B (seasonally flooded or saturated	Wet meadow, seasonal wet meadow
Loams	PEMA to H (temporarily flooded to permanently flooded)	Perennial freshwater wetlands

* As mapping progressed, some of these classifications were refined with collateral data. Therefore, not all wetland polygons created directly from soils retained this default habitat classification.

Each of the wetland features indicated in Table 3.2 was given a hydrogeomorphic classification of either D3SW1 (Depression, Alluvial Fan, Swale, Diffuse Topographic Low) or D2SW1 (Depression, Topographic Plain, Swale, Diffuse Topographic Low) depending upon their geomorphic setting (*see Table 3.4*). The habitat classification of these soil polygons was then checked with the written text and other maps. Habitat classification of these features changed to scrub shrub (SS) or forested (FO) when other given evidence indicated the necessity for change. Likewise, a wetter water regime was used if collateral evidence suggested a wetland was more than temporarily flooded for the Chino Clay Loams and Clays, and the Chino Loams.

Following the initial analysis of historical soils, all natural persistent wetland features on the Hall (1886) irrigation maps were digitized and overlaid onto the probable wetland soils polygons. Streams were mapped by drawing a line following the stream meander and buffering it by 2.5 meters to create a stream polygon. In cases where the floodplain extended beyond 2.5 meters, we created a polygon following the boundary of the natural boundary of the floodplain as depicted on the map. Locations of persistent wetland features were verified by overlaying digitized GLO maps, diseño maps, and aerial photographs. The GIS synthesis of selected historical data layers was used to create a composite map representing the historic landscape (Grossinger et al. 2006).

For the southern section of the study area, comparison with the 1890's USGS topographic maps suggested that a great deal of detail was omitted from the Hall (1886) map with regard to wetland features. Consequently, natural wetland features on both the Hall (1886) and USGS topographic maps were digitized. Habitat classification assignments were based on the wetland depiction on the map and other collateral data.

The final phase of mapping used two approaches to create a zone of potential floodplain riparian vegetation. First, we reviewed the 1928 aerial photos. In places where riparian areas were evident, we measured the average distance from the active channel and floodprone area. From this effort, it appeared that riparian areas were all within 200 meters of the floodprone area. Consequently, we buffered the active channels from the Whittier Narrows area south to the Alamitos Bay by 200 meters. We classified this area as having a high potential for riparian habitat.

While the buffering technique likely captured the more stable riparian areas, we also believed there was riparian development throughout the lower floodplain as evidenced by the GLO maps. It is clear that the river periodically changed course and meandered across the floodplain. It is likely that riparian areas underwent cycles of inundation and drying on both intra and inter annual time scales, particularly along the southern San Gabriel River floodplain. Following large flood events and changes in river course, depressional wetlands likely persisted on the floodplain for periods of weeks to months. These transient riparian areas were not well documented on either primary or secondary data sources; consequently, we lacked evidence for a systematic approach for mapping riparian across the broader floodplain. Therefore, we used potential wetland soils and geomorphology (coastal plain) to create a zone of "potential wetland/upland matrix," keeping in mind that our confidence ratings for this area must be lower than for many of our wetland habitats. We proposed this larger, hypothetical area as a hypothesis for which further analysis of the Lower Los Angeles River watershed may provide additional insight.

3.4.3 Classification Of Historic Wetland Polygons

Wetland polygons were attributed and classified based on features and notes on the GLO, diseno, and irrigation maps, and using collateral information, such as the Reagan (1915) oral histories and ground level photographs. Each polygon was attributed with a general habitat description and classified using the US Fish and Wildlife Service NWI system to map contemporary wetlands and riparian areas in southern California. This system uses the standard classification developed by Cowardin et al. (1979), but adds a set of modifiers based on the Corps of Engineers hydrogeomorphic (HGM) classification system (Brinson 1993). The NWI classifications are defined by plants, soils and frequency of flooding. The Cowardin classification hierarchy consists of systems (Marine, Estuarine, Riverine, Lacustrine and Palustrine), subsystems (includes deepwater habitats), and more detailed classes, subclasses and dominance types (**TABLE 3.3**).

The HGM modifiers build upon the Cowardin classification system and provide more specificity about landscape setting and likely hydrogeomorphic function of wetlands in California (**TABLE 3.4**).

In some instances, we were not able to be as detailed as contemporary mapping with the NWI classification due to a lack of information about a specific wetland, particularly with regard to water regime or specific habitat type (i.e., scrub-shrub or emergent vegetation). However, most wetlands were assessed down to the class level of the NWI classification. Additional technical specifications about attribution and classification can

TABLE 3.3. Definitions of the wetland systems under the Cowardin classification system (Cowardin et al. 1979)

System	Definition
Marine	The Marine system consists of the open ocean overlying the continental shelf and its associated high-energy coastline. Marine habitats are exposed to the waves and currents of the open ocean and the water regimes are determined primarily by the ebb and flow of oceanic tides. Salinities exceed 30 ‰, with little or no dilution except outside the mouths of estuaries.
Estuarine	The Estuarine system consists of deepwater tidal habitats and adjacent tidal wetlands that are usually semi enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The salinity may be periodically increased above that of the open ocean by evaporation
Riverine	The Riverine system includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts in excess of 0.5 ‰. A channel is "an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water" (Langbein and Iseri 1960:5).
Lacustrine	The Lacustrine system includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage; and (3) total area exceeds 8 ha (20 acres).
Palustrine	The Palustrine system includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ‰. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 ha (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than 2 m at low water; and (4) salinity due to ocean-derived salts less than 0.5 ‰.

be found in the metadata associated with the final geodatabase distributed with this report.

3.4.4 Confidence Estimations Of Historical Wetland Polygons

The source data layers used to create the historical wetland polygons offered varying levels of confidence for different features. In order to estimate certainty in the results of the historical analysis, we attributed each wetland or riparian polygon with a confidence level, based on a system developed by Grossinger et al. (2006). This system is being applied consistently in historical watershed analyses in the Bay Area and coastal California to provide comparable data sets. Certainty levels were assessed for each feature at the time of digitization based upon the strength of source information, variation between different sources, and an overall estimate of potential error. Confidence level estimates were assigned based on estimated accuracy of the size, shape, and location of each polygon given the data sources used to generate it. Definitions of each confidence level for each category are shown in **TABLE 3.5**.

3.5 DEVELOPMENT OF 1880S LAND USE MAP

To describe the historical land use in the study area, we used Hall's 1880s irrigation map. Six general, yet distinct, land use categories were interpreted and digitized from a combination of the 1880's draft irrigation map and/or final irrigation map of the San Gabriel River study area. These categories are listed below with their descriptions.

TABLE 3.4. Hydrogeomorphic (HGM) modifiers for mapping of California wetlands (Brinson 1993)

HGM Category	Level I (Landscape Geomorphic Context)	Level I Modifier	Level II (Local Geomorphic Context)	Level II Modifier
Fluvial (F)	Coastal Terrace (1) Topographic Plain (2) Alluvial Fan (3) Canyon (4) Valley (5) Montane (6) Foothill (7) Delta (8)	Slope > 4% (a) Slope 2% to 4% (b) Slope < 2% (c) Artificial (d)	In- Channel (IC) Bank (BK) Flood Plain (FP) Other (OT) Insufficient Information (IN)	Indistinct topographic low (1) Distinct topographic low (2)
Depressions (D)	Coastal Terrace (1) Topographic Plain (2) Alluvial Fan (3) Canyon (4) Valley (5) Montane (6) Foothill (7) Drainage Divide (9) Dunes (0)	Volcanic (a) Aeolian (b) Tectonic (c) Colluvial (d) Glacial (e) Artificial (f)	Fault Sag (FS) Caldera (CL) Rift (RF) Ravine (RV) Cone (CN) Inter-dune pannes and ponds (PP) Rock Pools (RP) Synclines (SN) Slump (SL) Swale (SW) Impoundment (IM) Scarp (SC) Structural basins> 500 acres (SB) Hillside Slump (HS) Landslide Slump (LS) Cirque (CQ) Kettle/pothole (KP) Other (OT) Insufficient Information (IN)	Diffuse Topographic Low (1) Discrete Topographic Low (2)
Seeps and Springs (S)	Coastal Terrace (1) Topographic Plain (2) Alluvial Fan (3) Canyon (4) Valley (5) Montane (6) Foothill (7) Drainage Divide (9) Dunes (0)	Slopes (a) Flats (b) Pools (c)	Alluvial Fan Toe (AF) Hillslope/Dune Toe (HT) Fault Trace (FT) Geologic Contact (GC) Landslide toe (LT) Scarp (SC) Other (OT) Insufficient Information (IN)	
Lake & Reservoir Shores and Beds (L)	Coastal Terrace (1) Topographic Plain (2) Alluvial Fan (3) Canyon (4) Valley (5) Montane (6) Foothill (7)	Volcanic (a) Glacial (b) Structural (c) Colluvial (d) Artificial (e)	Caldera (CL) Rift (RF) Cone (CN) Synclines (SN) Impoundment (IM) Structural basins> 500 acres (SB) Cirque (CQ) Other (OT) Insufficient Information (IN)	Flow through (1) Terminal (2) Headwater (3) Playa (4) Other (5) Insufficient Information (6)
Tidal (T)	Embayment (1) Lagoon (2) Channel Reach (3) Channel Mouth (4) Coves (5) Artificial (6) Exposed Shoreline/Headland (7)	High-Gradient Estuarine (parallel drainage systems) (a) Low-Gradient Estuarine (vegetated flats with dendritic drainage systems) (b) Marine (c)	Shores (SH) Flats (FL) Channels (CH) Bottom/Bed (BB) Benches (BN) Ridges (RD) Islet (IS) Beaches (BC) Other (OT) Insufficient Information (IN)	

TABLE 3.5. Confidence levels for historical landscape synthesis (based on Grossinger et al. 2006)

Certainty Level	Interpretation	Size	Location
Extra High (Location Only) "Definite"	—	—	Expected maximum horizontal displacement < 15 meters.
High "Definite"	Feature definitely representative of coniditions circa 1870.	Accurate source material that probably closely follows actual shape; estimated to be correct to within 10% of actual area.	Expected maximum horizontal displacement < 50 meters.
Medium "Probable"	Feature probably representative of conditions circa 1870.	Less accurate source material that probably generally follows actual shape; estimated to be correct to within 50% of actual area.	Expected maximum horizontal displacement < 150 meters.
Low "Possible"	Feature possibly representative of conditions circa 1870.	Not necessarily representative of actual shape/size.	Expected maximum horizontal displacement < 500 meters.
Extra Low (Location Only) "Possible"	—	—	Expected maximum horizontal displacement < 2500 meters.

AGRICULTURE

- **Irrigated Agriculture** - This category pertains to areas on the final irrigation maps where sections of land were categorized as "Lands Irrigated." There was not a final irrigation map for the lower San Gabriel River area; therefore, the linear features of canals and ditches were digitized from the draft irrigation map and buffered with 500 meters to capture the full extent of the floodplains. A test area was performed on the final irrigation map to determine the appropriate buffer distance.
- **Non-Irrigated Agricultural Land** - This category pertains to areas on the final irrigation maps where sections of land were categorized as "Lands for which water is held."

TRANSPORTATION / POPULATION DENSITY

Transportation networks generally signify a level of urban development. Therefore, railroads and roads were digitized from the three draft irrigation maps. Once the transportation features were digitized, the "linedensity" function was performed in ArcInfo grid. This function calculates the density of lines in a circular neighborhood (user-defined 250 meter radius; 162,254 m^2) around each output grid cell. Two types of population density, rural/undeveloped land and city center, were generated from this analysis.

- **Roads** – Linear features that have road symbols and written labels were digitized from the three draft irrigation maps. According to the street designations and standards of the City of Los Angeles, the standard width of a collector street is 64 feet (19.5072 meter). A 9.7536-meter buffer was placed around the road features to develop the roads coverage.

- **Railroads** – Linear features that have railroad symbols and written labels were digitized from the three draft irrigation maps. The standard railroad track width is 56.5 inches (1.4 meter); however that is below the minimum mapping unit of this project. The road buffer of 9.7536-meter was used to buffer the railroad features as well.
- **Rural/Undeveloped Land** – Area does not contain any transportation network or "sparse" network. Density value between 0 - 0.00252 m/m^2.
- **City Center** – Area contains "close" network of transportation. Density value between 0.00252 - 0.0159 m/m^2.

WATER

- **Perennial Streams** – This category includes the Old San Gabriel River, New San Gabriel River, Lexington Wash, Coyote Creek, and San Jose Creek on the final irrigation maps. Some streams contain area (polygon features) while smaller streams are line features. A 6-meter buffer was placed around the streamlines to convert them into polygon features so that all streams can be represented on the land use map.

FLOODPLAINS

- This category includes the San Gabriel River bed and its islands on the draft irrigation maps.

Once the geographic features were digitized, they were converted into raster coverages in order to clean the coverage and to make sure that not more than one feature occupied the same location. A hierarchy was incorporated (Transportation Network, Population Density, Irrigated Agriculture, Non-irrigated Agriculture, Streams, Floodplain) to assist in the cleaning and the generation of general statistics (i.e., percent area covered) for the land use coverage.

3.6 RECONSTRUCTION OF HISTORICAL FLORISTIC CHARACTER AND AVIAN COMMUNITIES

To provide additional insight into historical wetlands, we characterized the general floristic composition of representative wetland types using available herbaria records. The initial data for this effort was obtained via the electronic data portal at the Jepson Flora Project's online interchange (*http://ucjeps.berkeley.edu/interchange.html*). We searched for all specimens that included a series of place names in the "locality" field. These place names included current and historic names of all places that could be identified along the coastal plain of the San Gabriel River from Asuza to Long Beach. All results were limited to Los Angeles County. To facilitate the acquisition and retention of the results of multiple queries, we customized a software program to conduct the searches automatically and save the results to a tab-delimited database file.

We furthermore reviewed the two classic floras of Los Angeles (Abrams 1904, 1911; Davidson and Moxley 1923). Based on these sources, we created a list of potential species by either place name or habitat description. All plant species that might have been found in riparian zones of the San Gabriel River were recorded based on their known habitat and any unequivocal specimen localities along the river. The following place name categories were used: Azusa/Duarte, Irwindale, Baldwin Park El Monte, South El Monte/Bassett, Whittier, Pico Rivera, Santa Fe Springs, Downy/Norwalk, Bellflower, Artesia/Cerritos, Los Alamitos, and Long Beach. As part of the research into the general history of the San Gabriel River, we transcribed any text from primary data sources that included reference to vegetation. These sources included primarily original documents located at the Huntington Library.

Bird communities for each subset of the study area were established by submitting location key words to the ORNIS database (*www.ornisnet.org)*. This Internet-accessible database contains over five million records from musuems around the world, including many institutions in California. Results of the queries, which used the same place names as the botanical record search, were assembled to create lists of birds that, at least historically, had been found within the study region.

OVERALL STRUCTURE OF THE HISTORICAL SAN GABRIEL FLOODPLAIN

The San Gabriel River Valley is a broad, gently sloping valley running from the base of the San Gabriel mountains to the Pacific Ocean. Bounded on the north by the rugged San Gabriel mountains, on the southeast by the San Jose and Puente Hills, and on the southeast by the Montebello hills, this valley represents a contemporary and multifarious urban landscape (**FIGURE 4.1**). However, historically this was a naturally dynamic landscape dominated by the unpredictable flow of water from the San Gabriel River.

The San Gabriel River was the dominant feature of the landscape as it meandered over the valley floor, maintaining a wide zone of influence along its 51-km (32-mile) course across the valley to the mouth of Alamitos Bay and into the Pacific Ocean. The river represented an extremely dynamic system changing its course on an almost decadal basis in response to significant rain events prior to the onset of flood control practices. These extreme flood events were interspersed among extended periods of drought (e.g., 1851-55 and 1876-1880), during which wetlands and riparian areas proliferated. Upon subsequent flood events, these dense vegetated areas facilitated dramatic channel migration and adjustment across the floodplain.

The San Gabriel Valley, like many larger coastal plains in southern California, was mostly filled with stream deposited material derived from the San Gabriel mountains. The valley consists of numerous coalescing alluvial fans emerging from the mountain canyons and forming a continuous alluvial plain (Dunn et al. 1917, Mendenhall 1908). The San Gabriel watershed is noteworthy because it lacks a substantial storage basin before it emerges onto the coastal plain. As such, the river likely experienced greater variability in baseflows and a greater range of sediment-transporting events than other southern California rivers. This dynamism would have greatly affected the character of the river and associated wetlands and riparian areas downstream of the mountain front.

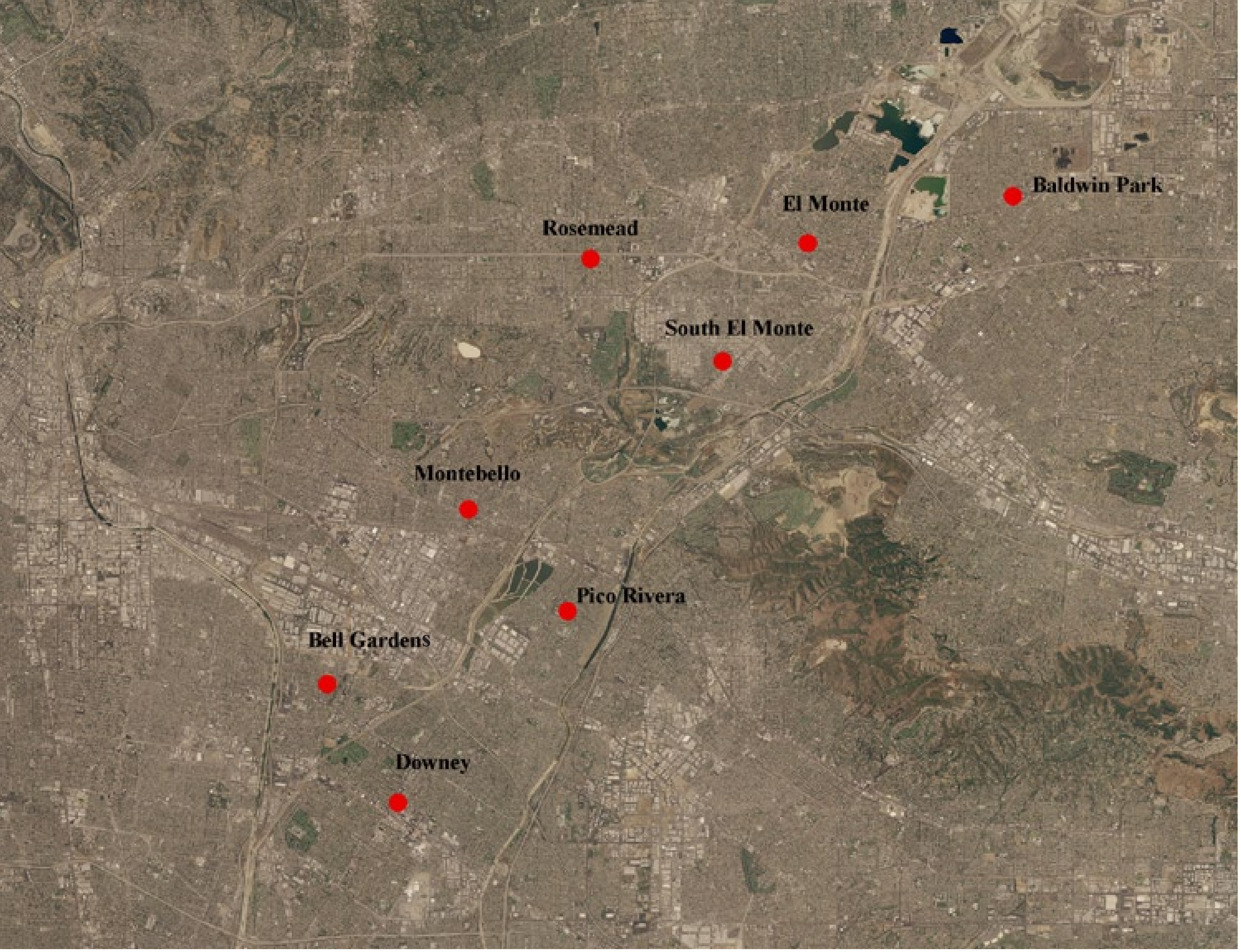


FIGURE 4.1. Portion of the historical ecology study area showing present day urban conditions. Aerial photography courtesy of NAIP (2005).

In the mountainous region, the streams, historically and presently, have had many tributaries and are usually deeply entrenched in V-shaped canyons of steep gradients. When these tributaries reached the valley floor, the slopes of the stream beds diminished, the velocity of water flow slowed, and deposition of immense quantities of sand, boulders, gravel, and silt began (Dunn et al. 1917, Mendenall 1908, Gumprecht 1999). This pattern of deposition resulted in the unique character of wetlands throughout the valley region. As the coastal plain and inland valleys became covered with a thick layer of alluvial deposits, a large amount of the runoff during the rainy season sank into the ground, recharging the San Gabriel Valley Basin (Mendenhall 1908). The result was a relatively shallow aquifer in much of the lower floodplain, with the depth of ground water decreasing as the valley neared the coast.

Below the mountains and foothills, the valley was dominated by a network of shallow stream channels flowing through deep alluvial deposits. During major flood events stream flow would routinely overflow the channels and spread across the floodplain forming braided channels across the alluvial

FIGURE 4.2. **Extensive flooding along Coyote Creek in March 1938. Spence Air Photo E-8467.**

Photo courtesy of the Benjamin and Gladys Thomas Air Photo Archives, UCLA Department of Geography

fan. Theses systems were highly dynamic with the flow alternating between several established courses following major storms. Faulting and a natural impermeable layer in the Whittier Narrows area forced shallow groundwater to the surface. From this point to the Pacific Ocean, 32 km (20 miles) south, the floodplain was characterized by a diverse array of wetland habitats along the river banks, in valley depressions, and adjacent to the estuarine systems of the lower San Gabriel Valley.

The landscape with regard to wetlands in the San Gabriel Valley was both spatially and temporally dynamic. During major flood events, accounts suggest the entire southern region of the valley became covered with water (**FIGURE 4.2**). As stated by a resident during the 1867-8 flood:

> *"The whole lower country [of the San Gabriel Valley] was more or less under water…there has been water all over that country that is not mesa ground."* (Bixby: Reagan 1915)

Apparently, a complex of depressional and riverine wetlands would persist in the lower floodplain for an extended duration (up to several years) following large floods. These systems likely evolved in cyclical patterns over multi-decadal times-cales, with a given location supporting channels, basins, alkali flats, levees, or dunes at any given time based on recent hy-drologic events. We speculate that some floodplain wetlands would, over time, dry and/or be grazed and convert to a scrub dominated system, until the next flood recharged the aquifer and allowed the wetland and riparian habitat to recolonize the floodplain. However, we believe that some wetlands persisted from year to year, supported by either regular overbank flow or shallow subsurface water. This pattern and cycle persisted until modern flood control efforts confined the San Gabriel River and diverted tributaries to concrete channels. As a consequence, the dynamic and diverse wetland ecosystems of the San Gabriel Valley have not been recognized and are often poorly understood.

Finally, it is important to recognize the critical role of fire in shaping the historical landscape. It has been well documented that accidental and intentional fires dramatically affected the vegetation of southern California prior to Euro-American settlement (Keeley 2002). Storms following moderate to severe burns undoubtedly mobilized large volumes of sediment, which likely contributed to some of the documented changes to the San Gabriel River during the 19th Century. Unfor-tunately, fire frequency records prior to the late 1800s, are limited, thus precluding a systematic evaluation of the effect of fire. Nevertheless, we acknowledge fire's important role in the dynamism of the historical floodplain.

4.1 HISTORIC ALIGNMENTS OF THE SAN GABRIEL RIVER

Prior to 1870, the San Gabriel River was a dynamic system that changed unpredictably, creating a volatile combination of periods with little to no flow and periods of massive flooding (Hall 1886, Reagan 1915). However, it was not just variability in precipitation that created this dynamic fluvial system. The geology of the valley floor created a landscape where surface water was spatially heterogeneous. As the coastal plain and inland valleys became covered with a thick layer of porous alluvial deposits, much of the runoff during the rainy season sank into the ground and collected in the underground basin. Only during major storms did stream channels have significant flows. Most of the year, streams flowed both above and below ground, disappearing and reappearing at several locations between the mountains and the sea (Hall 1886). Because the valley's rivers and streams seldom flowed above ground, they were shallow and poorly developed. During major flood events, they were incapable of containing the large quantities of water resulting in massive flood events.

The geology of the San Gabriel mountains likewise contributed to the dynamics of the historic floodplain conditions. The San Gabriel mountains are among the most rugged in southern California, with elevation ranging from 610 m (2,000 ft) to well over 3,048 m (10,000 feet; Dunn et al. 1917). The rugged terrain encourages erosion during rainfall events, which results in boulders, gravel, and other debris being washed out of the basin. Historically, larger debris was deposited at the base of the mountains, but smaller particles such as clays, silts, coarse gravel, and sands spread far along the valley floor creating its porous soils (Dunn et al. 1917). The already shallow stream and river beds would quickly fill up until they overflowed. On occasion, debris jams and/or extreme flows would cause the course of a river or stream to change entirely (Hall 1886).

Between 1825 (the earliest available maps) and 1912, the San Gabriel River had at least four major alignments (**FIGURE 4.3**). Between 1825 and the 1861-1867 period, the San Gabriel River was a tributary to the Los Angeles River. After flowing across the alluvial fan immediately below the San Gabriel foothills, the river flowed southwest following the approximate course of the current Rio Hondo River, until joining the Los Angeles River near the contemporary Whittier Narrows area. During the flood of 1861-62, facilitated by dense willow growth in the channel, a portion of the flow from the San Gabriel River migrated eastward. During the storms of 1867-68, in which nearly 127 cm (50 inches) of rain fell over a 30 to 40-day period, the majority of flow migrated east and was referred to as the "New River". The New River appears to have followed the earlier Arroyo San Gabriel, as illustrated with distinctive meanders in early diseños. The Arroyo San Gabriel may have been a former or overflow channel, as primary flow moved back and forth between the Los Angeles and San Gabriel alignments.

Between 1867 and 1884, flow in the San Gabriel River was split between the "Old River", which was tributary to the Los Angeles River and the New River. In 1884, one of the largest floods recorded inundated the Los Angeles Basin:

> The Santa Ana River broke over into Coyote Creek and the flood waters came into Alamitos Bay. In fact, the waters of the Los Angeles, Rio Hondo, San Gabriel, Coyote Creek and Santa Ana rivers were all joined in one vast sheet of water. The country was impassable for several weeks. (Clark: Reagan 1915)

Following this storm, the New River conveyed all the San Gabriel River flow into Alamitos Bay without joining the Los Angeles River. The New River changed course several times between 1884 and 1912, including the formation of a connection to the Los Angeles River via a secondary channel in the lower floodplain, in 1886. Beginning in 1912, a series of levees and other flood control measures, combined with aggressive ground water extraction, resulted in a more "stable" alignment of the San Gabriel River, approximating its contemporary course.

The dynamic quality of the San Gabriel River Valley made characterization of the floodplain in this project particularly difficult. The focus of this study is the wetland and riparian condition circa 1868, when the San Gabriel River assumed an independent course into Alamitos Bay (i.e., was not tributary to the Los Angeles River). However, as noted earlier, it is important to recognize that the river likely flowed along this independent course at some point prior to 1867. Reagan's (1915) oral histories of the area document several instances in which residents of the valley suggested that prior to 1867 water might have flowed in its post-1867 extent:

FIGURE 4.3.

Historical & Current Alignment of the

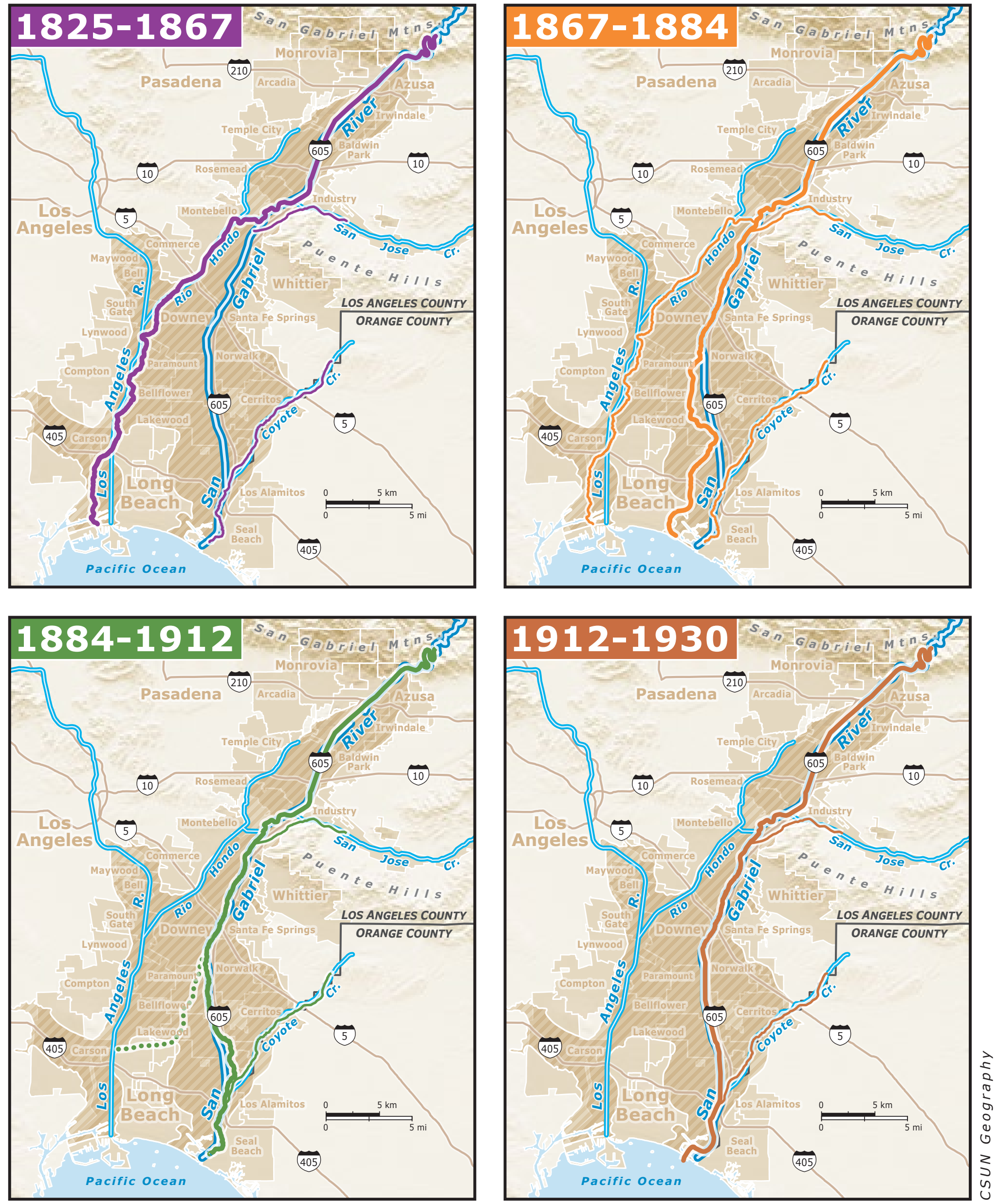
San Gabriel River

California State University, Northridge
Environmental Geography Lab

Legend

Period

- 1825-1867
- 1867-1884
- 1884-1912
- 1886
- 1912-Early 1930's
- Current Extent
- Land Subject to Inundation Prior to Flood Control



> There is no doubt in my mind that the river had run on the New River side of the Valley before 1867 as evidenced by the sand ridges and formation of the country, which show that very plainly. (King: Reagan 1915)

Likewise, in reviewing mid-1800 cartographic sources, we found evidence of some floodplain development in early diseños and GLO maps of the study area for the post-1867 floodplain course. The lower reach of the river was labeled the Arroyo San Gabriel prior to 1867 and was also called "La Puente Creek", "San Jose Creek" (GLO Maps); after 1867, this reach became known as the San Gabriel River.

5

WETLAND AND RIPARIAN HABITATS OF THE HISTORIC SAN GABRIEL FLOODPLAIN

Despite the dynamic nature of the San Gabriel River floodplain, a review of maps and written oral histories suggest a consistent and identifiable pattern of floodplain structure. Based on this evidence, we were able to delineate four distinct floodplain regions (**FIGURE 5.1**) within the study area:

- the Upper San Gabriel River Floodplain
- the Whittier Narrows Area
- Southern San Gabriel River Floodplain
- and the Tidal Fringe Area

"The San Gabriel River was the best trout stream in Southern California and I have taken good trout from it in the Whittier Narrows long after it left the mountains and commenced to traverse the coastal plain." *(S. O'Melveny 1955)*

"In early days all the lands above our place here up to El Monte were low and swampy. There was a very heavy growth of willows, tullies [sic.], and balckberry [sic.] vines over all. It was almost impossible for water to have washed anything or to have had much velocity. When the big rains came the water drained off slowly and did practically no damage."
(Temple: Reagan 1915:533)

FIGURE 5.1. Historical wetlands of the San Gabriel River (left)

CSUN Geography

5.1 UPPER SAN GABRIEL RIVER FLOOD PLAIN

The Upper San Gabriel River Floodplain represents a 19-km (12-mile) stretch of the floodplain starting at the base of the San Gabriel mountains and extending southward to just north of the Whittier Narrows (**FIGURE 5.2**). The floodplain in this area was not well developed, and can best be described as a broad alluvial fan with highly braided channels, alternating bars, islands, and inset benches (**FIGURE 5.3**). Because of its porous nature, this reach had little or no surface water most of the year, although it probably had substantial subsurface flow. The upper region was further divided into two distinct subsections, the Braided Upper Reach and the Narrower Dry Sandy Bed, based on distinct changes in the width and habitat of the floodplain within this drier part of the river as indicated on the Hall (1886) draft irrigation map (**FIGURE 5.4**).

FIGURE 5.2. Historical wetlands of the San Gabriel River upper floodplain area.

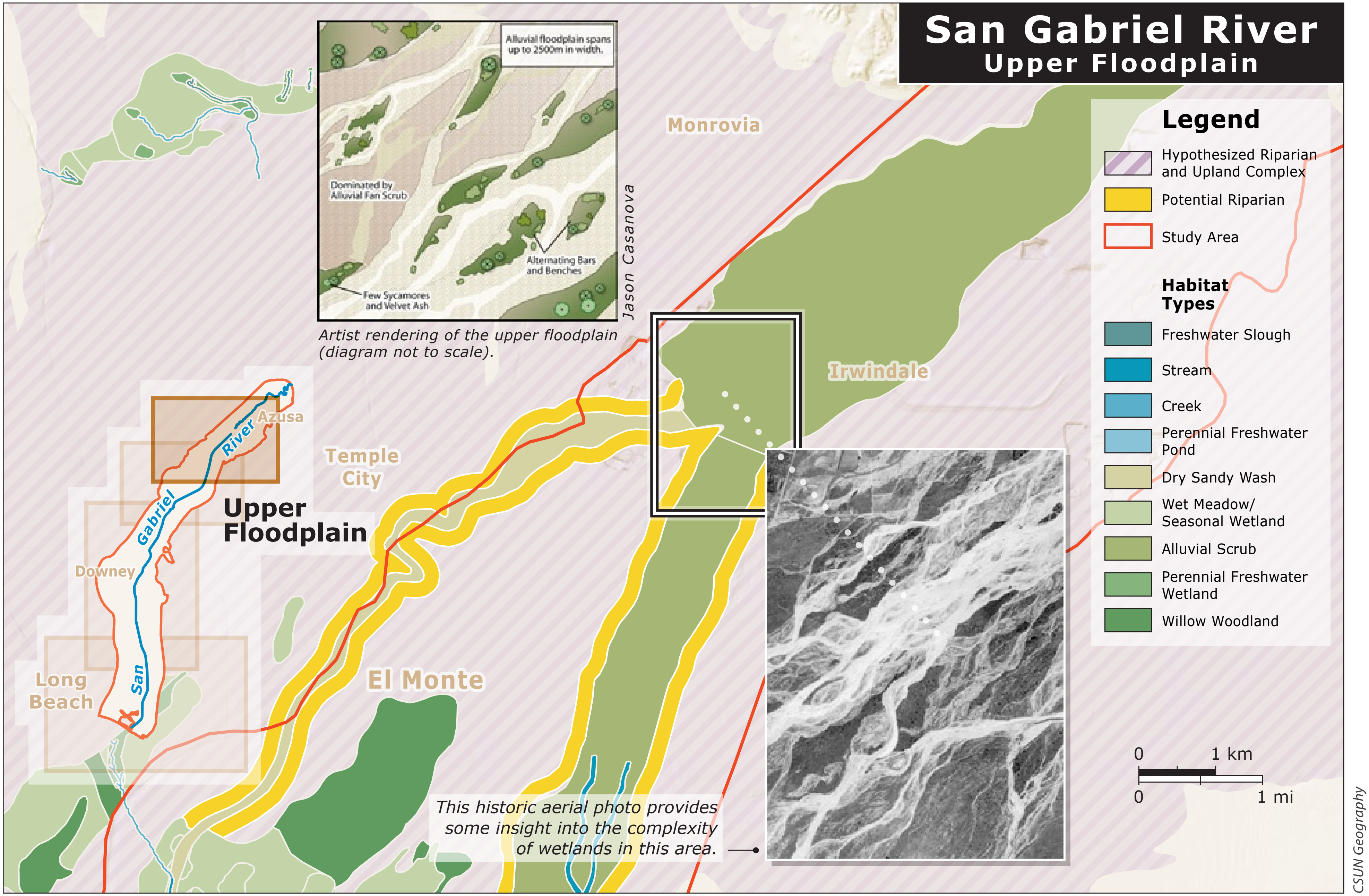


Photo courtesy of the Benjamin and Gladys Thomas Air Photo Archives, UCLA Department of Geography

FIGURE 5.3. **1927 Aerial photograph of San Gabriel Wash showing braided stream morphology. Spence Air Photo E-1118.**

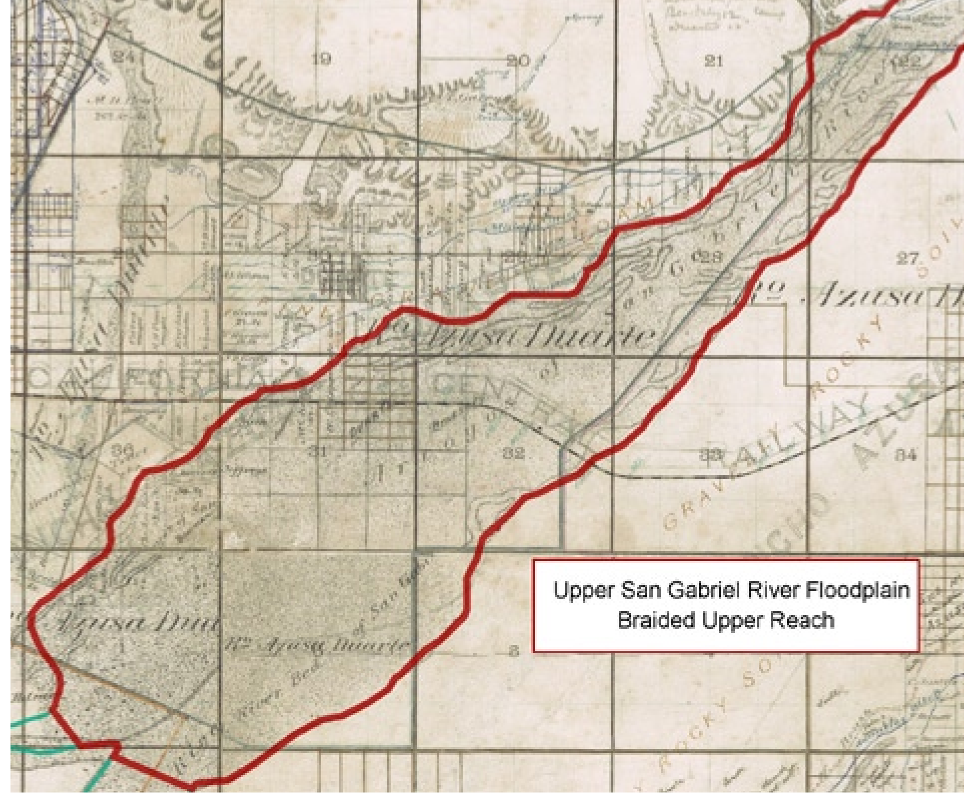


FIGURE 5.4. **Hall's 1886 map of the upper San Gabriel River floodplain (braided upper reach). Stippled texture used on map indicates a dry and likely braided system. Map courtesy of the Huntington Library.**

The braided upper reach begins at the mouth of the San Gabriel Canyon and ends at the mouth of the Lexington Wash. The 2,500-meter (8,200-foot) wide floodplain within this reach was poorly defined. The soils of this reach were particularly porous, resulting in seasonal surface flow from the river infiltrating to the groundwater basin upon emergence from the canyon. This upper reach was consistently denoted as the "San Gabriel Wash" on USGS topographic maps (Gannett and Goode 1893) and on the Dunn et al. (1917) soil survey. However, the most detailed evidence for the distinction of this reach was found on the Hall map (1886) which labels this reach as "dry sandy bed of San Gabriel River" and uses a stippled map texture associated with the traditional pattern for unvegetated gravel/sands.

The plant community in this area was a mosaic of alluvial fan scrub and riparian scrub (*Appendix A*). Historical plant communities have been well documented by Smith (1980) in his description of a study site within the Sante Fe Dam area. The floristic community was comprised of primarily drought tolerant species typically found on alluvial fans, along with some more mesically adapted species. Sycamores and velvet ash occurred occasionally, but the overall vegetation was scrub, not forest. California juniper was found within this habitat, extending somewhat out onto the plain (Smith 1980). The bird species from Asuza and Duarte reflected the scrub-dominated character of the vegetation, as shown in **TABLE 5.1**.

SPECIES	HABITAT
Scrub and Grassland Associated	
Black-chinned sparrow	Arid brushlands
Black-tailed gnatcatcher (5)	Semiarid or desert scrub
Blue-gray gnatcatcher (2)	Broad range of wooded habitats from shrublands to mature forest
Bushtit (2)	Large variety of habitats, ranging from forested mountains to arid brush
Cactus wren	Scrublandscrubland, desert
California gnatcatcher (4)	Variety of arid-scrub vegetation types
Common poorwill (2)	Sagebrush and shadscale flats
Fox sparrow	Thick tangles of brush
Loggerhead shrike	Open country with short vegetation
Rufous-crowned sparrow (3)	Semiarid grassy shrublands
Sage sparrow	Semiopen habitats with evenly spaced shrubs
Wren-tit (2)	Cismontane scrub
Riparian Associated	
American goldfinch (3)	Flood plains characteristic of early successional growth
Audubon's warbler (10)	Winters in open areas
Bullock's oriole	Riparian and oak woodlands
California thrasher	Chaparral
Cassin's vireo	Coniferous, mixed-coniferous/deciduous, and deciduous forests
Golden-crowned sparrow (2)	Wintering in dense riparian thickets of willow and cottonwood
Hermit thrush (6)	Broad spectrum of forested and edge habitat
Hooded oriole	Riparian areas with scattered trees
House wren	Edges of deciduous forests and in open woodlands
Least Bell's vireo (2)	Dense, low, shrubby vegetation, generally early successional stages in riparian areas
Orange-crowned warbler (3)	Stream-side thickets and woodland groves
Violet-green swallow	Open deciduous, coniferous, and mixed woodlands
Warbling vireo	Cottonwood/poplar (*Populus* spp.)-dominated riparian forests
Wilson's warbler	Variety of mesic shrub habitats
Generalists and Transient	
Brown towhee (5)	Wide array of upland and riparian habitats
Hammond's flycatcher	Transient
House finch (2)	Variety of undisturbed habitats
MacGillivray's Warbler (2)	Transient
Northern Mockingbird	Second growth habitat
Olive-sided flycatcher (2)	Coniferous forests
Pacific-slope flycatcher	Transient

TABLE 5.1. Historic bird communities of the upper floodplain as documented by museum specimens. All specimen locality information was identifyied as Azusa or Duarte. Number of specimens in parentheses. Historic bird communities were referenced against contemporary habitat summaries from the *Birds of North America* (Gill and Poole, eds., multiple years).

The bird records suggest that sufficient areas of scrubby willow vegetation were also present to support such riparian obligates as the Least Bell's Vireo, but the preponderance of historic bird records from Azusa are of scrub and open riparian specialists. According to these records, wrentits and thrashers are primarily found in shrubland, but also in shrubby riparian growth; similarly, American goldfinch is typically found in willows but not in mixed forests (Zembal 1989).

Interpretation of bird records from Azusa is somewhat difficult because the locality information does not always specify whether birds were obtained from the wash, up the in the canyon, or in the foothills. Vegetation within the canyon presumably contained more typically riparian vegetation. The records of species such as common poorwill strongly indicate the scrub nature of the habitat. This species in particular is strongly associated with open environment of alluvial fan scrub.

Below this zone of alluvial fan scrub the narrower dry sandy bed of the Upper San Gabriel Floodplain begins at the Lexington Wash and terminates at the southern border of the La Puente Rancho (or northern border of Paso de Bartolo) just north of the Whittier Nar-

FIGURE 5.5. **Upper San Gabriel River Floodplain (Narrower Dry Sandy Bed). Stippled texture used on map indicates a dry system with a distinct channel in the floodplain. This reach of the floodplain is also evidenced by the "reappearance of water in the river" designated on Hall (1886). Map courtesy of the Huntington Library (below).**

FIGURE 5.6. **Consolidation of braided channels at lower end of San Gabriel Wash, February 1927. Spence Air Photo E-1092 (above).**

rows. Hall (1886) designated this area with a clearly defined channel, suggesting more surface flow throughout the year (**FIGURE 5.5**). This area includes a location on the San Gabriel River where Hall (1886) designates the reappearance of water within the floodplain, which suggests this area may have been flooded with ground water throughout various portions of the year unlike the highly braided upper reach of the floodplain.

Riparian areas were more clearly defined within the narrower dry sandy bed reach of the river as designated on Hall (1886) and in the 1927 aerial photography (**FIGURE 5.6**). It appears the riparian areas were well developed along the banks of the floodplain and likely were dominated by more riparian species than upland species.

5.2 WHITTIER NARROWS AREA

The lower end of the San Gabriel Wash runoff began to consolidate into distinct channels and collect above the Whittier Narrows (**FIGURE 5.7**). The historic irrigation maps show that the water table was close to the surface, and thatsurface water was maintained sometimes year round. The Whittier Narrows area was a well-defined narrow channel when compared to the upper San Gabriel River floodplain. Surficial geology is extremely important in the Whittier Narrows area. A combination of the convergence of three thrust faults (the Elysian Park, Puente Hills, and Whittier faults) combined with shallow restrictive subsurface layers associated with the Whittier Narrows pluton force ground water to the surface, allowing this area to be dominated by a series of perennial wetlands. This region of the floodplain, begining just north of Whittier Narrows, was designated on Hall (1886) as a narrow channel with no stippling (**FIGURE 5.8**). The northern section of this area was likely to have the same plant community as the narrower, dry sandy bed reach of the upper floodplain. However, as the channel approached the Whittier Narrows area southward, the area likely transitioned to a mosaic of riparian and wetland habitats. According to Hall (1886), "Willow woodlands, wet meadows, perennial freshwater wetlands, streams, floodplain, and significant riparian area were all part of the wetland complex expanding from Whittier Narrows northward."

This area was unique, in large part, due to its high water table and year round saturated soils and would have been characterized by freshwater marsh and lacustrine habitats, and dense riparian willow forests with blackberries, gooseberries, grapes, and other shrubs. The historic accounts of this area, which include the towns of El Monte, South El Monte, Bassett, and Whittier, describe a "jungle." A specimen of *Rubes divaricatum* var. *parishii* (now *R. ursinus*) collected along Lexington Wash on July 7, 1933 was described as being "with *Rubus* in *Populus-Salix* (cottonwood-willow) jungle" (UCR70822; **FIGURE 5.9**). Oral histories describe the area as follows:

> *Up above El Monte there was a large swale which was full of elder bushes and brush, that lead from up toward the canyon and over toward Savannah or about 1 mile Westerly of El Monte, and below El Monte and down toward Old Mission settlement there was hundreds of acres of swamp ground tullie [sic.] beds and standing water the year around. (King: Reagan 1915)*

> *[Lexington Wash] It was a draw in 1862 and was filled with willows and elder bushes so thick you could hardly get through it on horseback. (Guess: Reagan 1915)*

> *[There] was a large swale above El Monte, and thick with willows and brush. (Durffy: Reagan 1915)*

> *The country below El Monte was swampy and low and covered with willow, lots of springs and lakes of water and there was where Mission Creek got its water from, and was a live, clear stream of water, not very wide but fairly deep. (Forman: Reagan 1915)*

FIGURE 5.7. Historical wetlands of the San Gabriel River Whittier Narrows area.

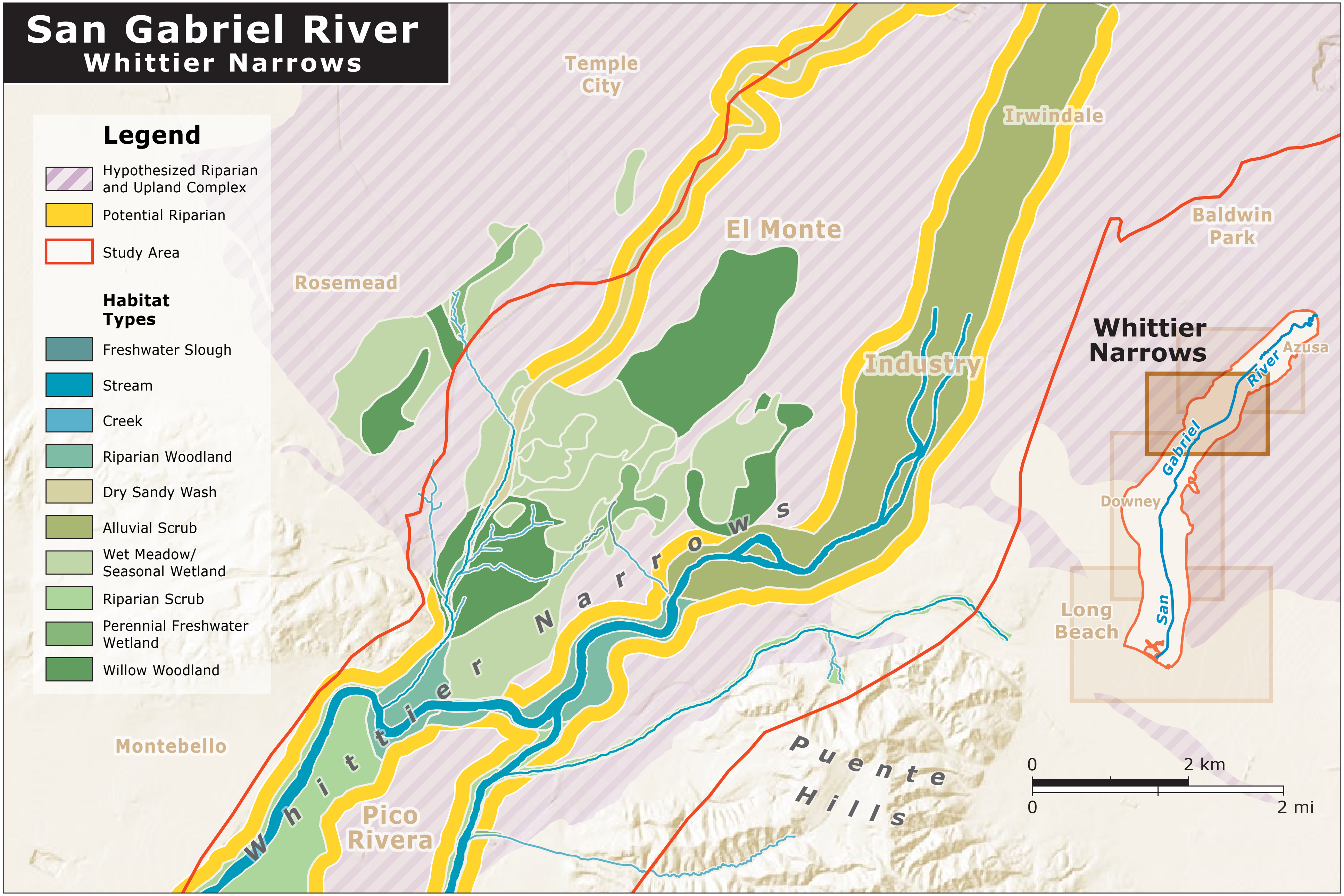


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FIGURE 5.8. **Example of the Whittier Narrows floodplain (Hall 1886). The floodplain designation transitioning from a stippled pattern to a smooth pattern indicates a larger gradient of water flowing throughout the year. Map courtesy of the Huntington Library (above).**

The San Gabriel River was the best trout stream in Southern California and I have taken good trout from it in the Whittier Narrows long after it left the mountains and commenced to traverse the coastal plain. (S. O'Melveny 1955)

There were hundreds of acres of swamp grounds below El Monte where stood the year around knee deep. (Thurman: Reagan 1915)

Down near the Old Mission the water would come to the surface and this is where the stock got their water. The cattle would graze up in the valley and about every other day would go down for water; it was too far for them to go everyday. This drainage from the swamps above formed what is called Rio Hondo. (Rowland: Reagan 1915).

FIGURE 5.9. **Remnant willow forest along the Rio Hondo in 1941. Fairchild Photograph O-8052 (below).**

Photo courtesy of the Benjamin and Gladys Thomas Air Photo Archives, UCLA Department of Geography

There used to be willow trees in the marshy land here in the valley 3 feet or more in diameter. These, of course, have now all disappeared. (Manzanares: Reagan 1915)

In early days all the lands above our place here up to El Monte were low and swampy. There was a very heavy growth of willows, tullies [sic.], and balckberry [sic.] vines over all. It was almost impossible for water to have washed anything or to have had much velocity. When the big rains came the water drained off slowly and did practically no damage. (Temple: Reagan 1915)

These descriptions were confirmed by plant specimen records (*see Appendix A*). The stretch from El Monte to Whittier Narrows is comprised of far more specimen records of obligate wetland species than either above or below this area. These records include many sedges, rushes, ferns, and a full complement of woody riparian species. The historic bird community in this section of the river reflected this dense, forested, and wet habitat (**TABLE 5.2**).

TABLE 5.2. Historic bird communities of the Whittier Narrows as documented by museum specimens. Number of specimens in parentheses. Habitat summaries from the *Birds of North America* (Gill and Poole, eds., multiple years).

SPECIES	HABITAT
Scrub and Grassland Associated	
Blue-gray gnatcatcher	Broad range of wooded habitats from shrublands to mature forest
Lark sparrow (2)	Ecotones between grassland or shrub and forested habitat
Lazuli bunting (2)	Wide variety of brushy habitats
Lesser goldfinch (2)	Oak foothills, riparian woods, brushy areas
Loggerhead shrike (2)	Open country with short vegetation
Say's phoebe	Open, lowland habitat, grassy bluffs, fields, scrub, and agricultural areas
Riparian Associated	
Bullock's oriole	Riparian woodlands with large cottonwoods, sycamores, and willows
Downy woodpecker	Lowland riparian woodland
Hermit thrush	Wintering, broad spectrum of forested and edge habitat
House wren	Edges of deciduous forests and in open woodlands
Hutton's vireo	Evergreen forests and woodlands with moderate to dense crown closure and understory
Least Bell's vireo	Dense, low, shrubby vegetation, generally early successional stages in riparian areas
Mallard	Ephemeral, seasonal, and semipermanent ponds and marshes
Mountain bluebird	Prairie-forest ecotones with groves of trees, short grasses, and few shrubs
Northern flicker	Forest edge and open woodlands, esp. cottonwoods in riparian woodlands
Northern pintail	Wide variety of shallow inland freshwater and intertidal habitats
Red-winged blackbird (3)	Variety of wetland and upland habitats
Ruby crowned kinglet	Winters in broad range of habitats, including coniferous and deciduous forests, floodplain forests, willow shrubs (*Salix* ssp.)
Screech owl	Riparian habitats
Varied thrush (2)	Winter/migrant dark forest, with wet, mossy, almost completely shaded floor
Wilson's warbler (2)	Variety of mesic shrub habitats
Yellow-billed cuckoo	Woodland with clearings and low, dense, scrubby vegetation; often associated with watercourses
Yellow-breasted chat	Riparian and shrubby habitats
Yellowthroat (3)	Thick vegetation in wide range of habitats
Generalists and Transient	
American crow	Wide range of habitats
Barn owl	Wide range of habitats
Brewer's blackbird (2)	Wide range of habitats
Gray flycatcher	Migrant
Western scrub jay	Scrub and other habitats including riparian

The birds indicate the presence of scrubby willow habitat for the Least Bell's Vireo and Yellow-Breasted Chat (Zembal 1989). Furthermore, there were likely large, old gallery forests of willow, because only old forests have sufficient snags for cavity nesters such as house wrens (Zembal 1989); the Manzanares description of 0.9-meter (3-foot) diameter willow trees reiterates the existence of these more persistent habitats in this area. The presence of downy woodpeckers is also indicative of gallery willow stands, at least based on surveys in Orange County (Zembal 1989). Similarly, the presence of marsh wrens, which nest over emergent wetland vegetation is indicative of open water and emergent marsh habitat (Swarth 1917). Mallard and northern pintail further document the presence of open water habitats.

5.3 SOUTHERN SAN GABRIEL RIVER FLOODPLAIN

Just beyond the Whittier Narrows area, the San Gabriel River again flowed over a more permeable surface, resulting in an increase in subsurface flow and decrease in the duration and extent of surface flow. The floodplain in this area meandered dramatically across the valley floor during major flood events and was indistinguishable from the Los Angeles River floodplain (**FIGURE 5.10**). As such, this highly dynamic riverine system changed its spatial extent on a fairly regular basis (Hall 1886). Riparian areas along this reach of the river appear to have been well defined, based on the 1928 aerial photography and oral histories, in the more permanent sections of the river (**FIGURE 5.11**). However, because this area was prone to inundation during flood years, areas adjacent to the floodplain most likely represented a complex of riparian and upland plant communities (Dunn et al. 1917, Reagan 1915, Hall 1886). By 1928, vast areas of the southern floodplain had been converted to agriculture, and the riparian zone was restricted to a relatively narrow area (**FIGURE 5.12**). However, following extreme flood events, much of this agricultural was inundated as the flow engaged the historical floodplain. Given the spatial and temporal dynamism of the southern floodplain, we have included a zone of "riparian/upland complex" (indicated by the hatched pattern) on the map for this area. This area likely supported a range of wetland types in cyclical patterns based on recent flood events and associated sediment deposition.

Based on historical soil surveys, maps, and written accounts, it is highly plausible that the southern San Gabriel floodplain was a complex matrix of wetlands, riparian habitat, and uplands that varied on an interannual basis depending on climatic patterns. Following large storm events, the combined 15-km (9-mile) wide San Gabriel and Los Angeles River floodplain likely supported freshwater marshes, vernal pools, alkali meadows, and riparian scrub communities interspersed among a matrix of upland scrub-shrub plant communities. During intervening dry years, the floodplain gradually reverted to more xeric habitats, and the extent of wetlands diminished. However, following the next flood event, the floodplain was inundated, the shallow aquifer was recharged, and the complex of wetlands recolonized the floodplain. Because the 19th century was substantially wetter than the current climate (with a large flood event occurring every 6–7 years; *see Section 2.8*), this cycle was likely maintained until the early 20th century.

FIGURE 5.10. Historical wetlands of the San Gabriel River southern floodplain area.

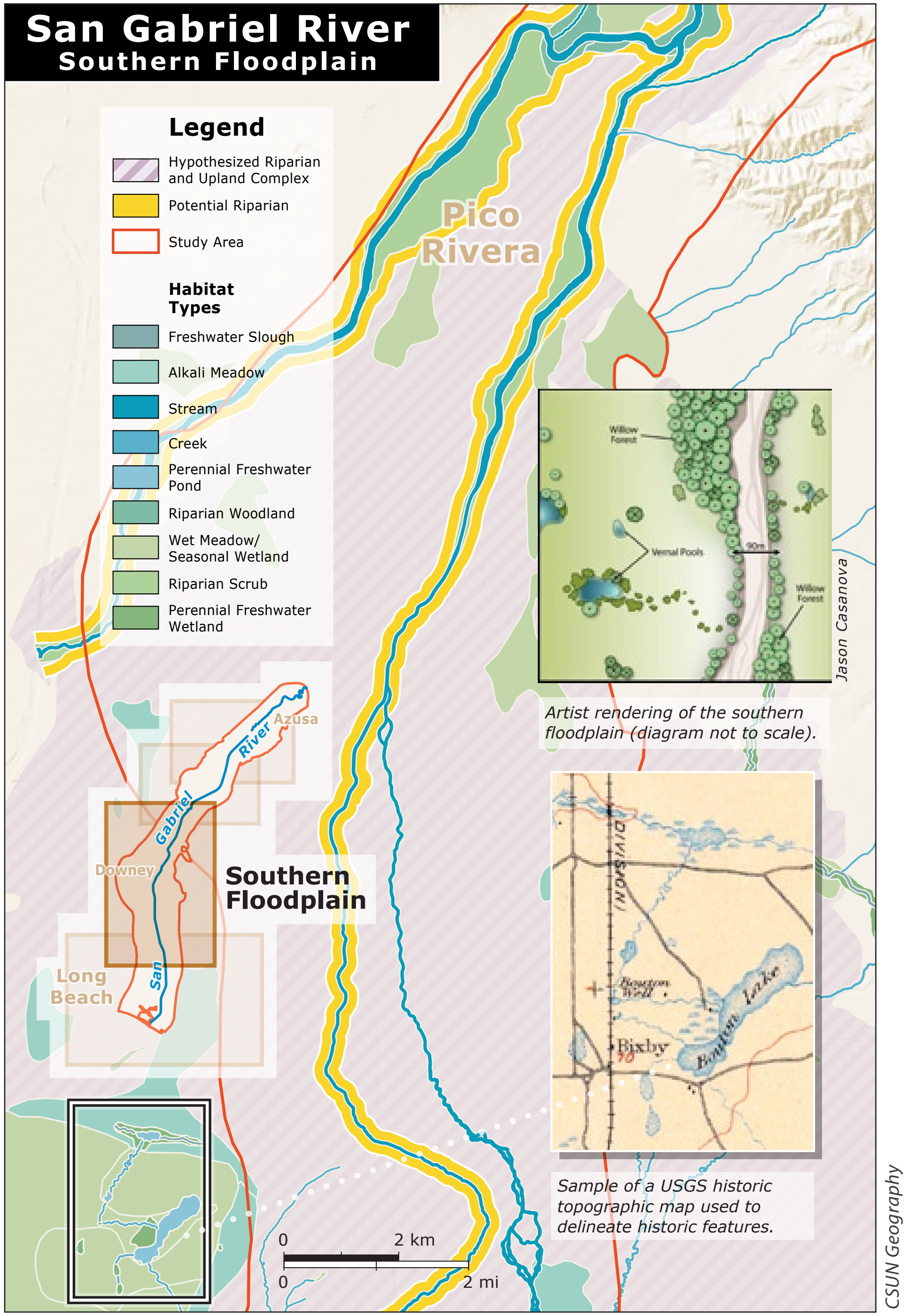


FIGURE 5.11. Aerial photographs just south of Whittier Narrows (A) and Hall's map (B)(1886) at the same location. Photograph courtesy of LACDPW and map courtesy of the Huntington Library.

Photo courtesy of the Benjamin and Gladys Thomas Air Photo Archives, UCLA Department of Geography

FIGURE 5.12. **San Gabriel River looking north, March 1928. By this time, agricultural development had displaced much of the native vegetation. Spence Air Photo E-1950.**

The historical condition of the vegetation in the reaches of the southern San Gabriel River floodplain is somewhat difficult to describe. The land use history, combined with the dynamism of the river itself, has resulted in somewhat inconsistent descriptions of the native vegetation. Indeed, this variability was very likely natural.

The first complication was that the current course of the river channel was only assumed in the late 1800s. Oral accounts indicate that the river could change course rapidly, and at flood stage could spread widely across large regions. This provided nutrients and sediment to the landscape and produced prime farmland. It is likely that willow forests dominated these large bottomlands, with occasional sycamores on higher ground. Interspersed within these forests could have been sloughs and swamps.

Historic accounts describe predominantly willows and sycamores to the exclusion of other species.

> *In early days the valley was covered with willows, larch, sycamore, etc. Later only willows in patches, until they were finally cleaned out almost entirely by the settlers. (Cruz: Reagan 1915)*

> *He says in 1867, when he first came to Compton you could see only two trees in the whole valley, one of them is still standing (the landmark) on the north line of the Rancho San Pedro, both trees were sycamores. (Morton: Reagan 1915)*

These descriptions are particularly evident in accounts of bird species from this reach.

> *On May 10, 1910, I found this nest while exploring a very thick growth of willows along an old flood channel of the San Gabriel River, about two miles southwest of Artesia, California. The flood channel had about two feet of stagnant water in it, and the willow trees on either bank leaned out over the water. (Robertson 1933)*

[The bird was found] in the willows along the channel of the San Gabriel River, about one mile west of Artesia. (Robertson 1926)

There is some hint that willows only dominated after large flood events; however, land use complicates interpretation of this possibility.

There were very few trees in the lower country in the early times but the whole country was covered with mustard about seven feet high and as thick as the hair on a dog's back and there were just trails leading through it. (Guess: Reagan 1915)

This and other passages in the Reagan's oral histories suggest that the large willow forests resulted only after the flood of 1867. While this seems to be a reasonable interpretation, previous floods would have created a similar regeneration niche for willows in the past, and the absence of willows would have been a function of land use, not biophysical constraints.

A cross-section of the San Gabriel River in Pico Rivera, from the 1915 Board of Engineers report, describes a wide-open channel with willows extending two hundred feet back from the banks on either side of the channel. The elevations clearly show that the surrounding landscape was lower than the channel. The channel itself would have been dry in the summer, while the surrounding landscape might have been willow-dominated. The plant records from this reach (Pico Rivera, Downey, Norwalk, Artesia and Cerritos) are far fewer than those available for the upper floodplain. The reasons for this could be many, including: sparse populations, distance from collector's residences (especially in the early days), and potentially a lack of botanical interest.

The evidence for swamps and sloughs is clear in the historical descriptions.

The channel it cut in 1867 did not carry one-tenth of the water that went down to Alamitos Bay, that it spread all over the country and made lots of sloughs and swampy ground down near where Bellflower, Clearwater and Hynes now is. Says that he has caught fish in the sloughs and the people used to shoot ducks over in that section. (Patten: Reagan 1915)

In the early days of his time, all of Watts and Willows were swamps, sloughs, and tullies [sic.], and where the black soil in Watts is was a tullie [sic.] a peat bed. He says some people used to cut and dry that soil and burn it. It afterwards dried out and they burned it off and cultivated it. (Reagan 1915)

Characteristic plants of these swamps and sloughs were not found in the available herbarium records. The reference to "larch" is probably a misidentification of an exotic tamarisk species (*Tamarix* spp.). Larch would have been familiar to migrants from the eastern portions of the continent and its characteristics best match tamarisk.

The avian specimen records are consistent with the presence of dense and mature willow forests, at least by the early 1900s (**TABLE 5.3**). House wren, yellow-billed cuckoo, downy woodpecker, willow flycatcher, and yellow-breasted chat all indicate willow forests of varying stature. Swamps and sloughs are indicated by the records of black-crowned night-heron, green heron, and red-winged blackbird. Black-necked stilt would have been found in the open, sandy channel of the river and tributaries.

TABLE 5.3. Historic bird communities of the southern floodplain as documented by museum specimens. Number of specimens in parentheses. Habitat summaries from the *Birds of North America* (Gill and Poole, eds., multiple years).

American goldfinch	Cerritos, Downey (4)	Flood plains characteristic of early successional growth
Barn owl	Cerritos (2)	Wide range of habitats
Black-crowned night-heron	Pico Rivera	Varied wetlands
Black-headed grosbeak	Downey (2)	Cottonwood (*Populus*)/willow (*Salix*) groves and other riparian habitats
Black-necked stilt	Pico Rivera (2)	Shallow inland wetlands
Bullock's oriole	Cerritos	Riparian woodlands with large cottonwoods, sycamores, and willows
California cuckoo	Pico Rivera	Woodland with clearings and low, dense, scrubby vegetation; often associated with watercourses
California quail	Cerritos	Chaparral, desert chaparral, and coastal sage scrub
Cassin's kingbird	Cerritos	Forests
Downy woodpecker	Pico Rivera (2), Cerritos (3)	Lowland riparian woodland
Green heron	Pico Rivera (3)	Swampy thickets near water
Hairy woodpecker	Pico Rivera, Cerritos	Mature woodlands
House wren	Cerritos	Edges of deciduous forests and in open woodlands
Northern harrier	Cerritos	Riparian woodland and open uplands
Pacific-slope flycatcher	Cerritos	Transient
Red-winged blackbird	Downey, Artesia, Cerritos (2)	Variety of wetland and upland habitats
Screech owl	Cerritos	Riparian habitats
Song sparrow	Downey, Artesia	Wide range of forest, shrub, and riparian habitats, but near fresh water
Spotted towhee	Downey	Dense, broadleaf shrubby growth
Tree swallow	Cerritos (2)	Open areas, usually near water, including fields, marshes, shorelines, and wooded swamps with standing dead trees that provide sites for cavities
Tricolored blackbird	Cerritos (9)	Most in freshwater marshes dominated by cattails or bulrushes; also willows, blackberries, thistles, and nettles
White-crowned sparrow	Artesia	Dense shrubs plus open areas to forage
Willow flycatcher	Cerritos (2)	"strikingly restricted to thickets of willows"
Yellow-breasted chat	Downey, Cerritos	Riparian and shrubby habitats
Yellow-billed cuckoo	Pico Rivera, Artesia (Gaines and Laymon 1984; Jay 1911)	Woodland with clearings and low, dense, scrubby vegetation; often associated with watercourses

The lowest portion of the coastal plain of the San Gabriel River intergrades into the estuary at Alamitos Bay in Long Beach. The historical vegetation of this area included extensive willow forests, marshes and sloughs, and alkali meadows. Evidence for these communities begins in the narrative accounts, including Jay's (1911) description of a bird's nest found in a forty-acre dense grove of willows near Wilmington below.

> *In the lower part of Los Angeles County, within a few miles of the ocean, are numerous swampy places and river bottoms, which are surrounded by willow timber. Although much of this has been cut away of late years, there still remain some groves here and there, either uncut or second growth, and in these groves we found the Cuckoo at home. (Jay 1911)*

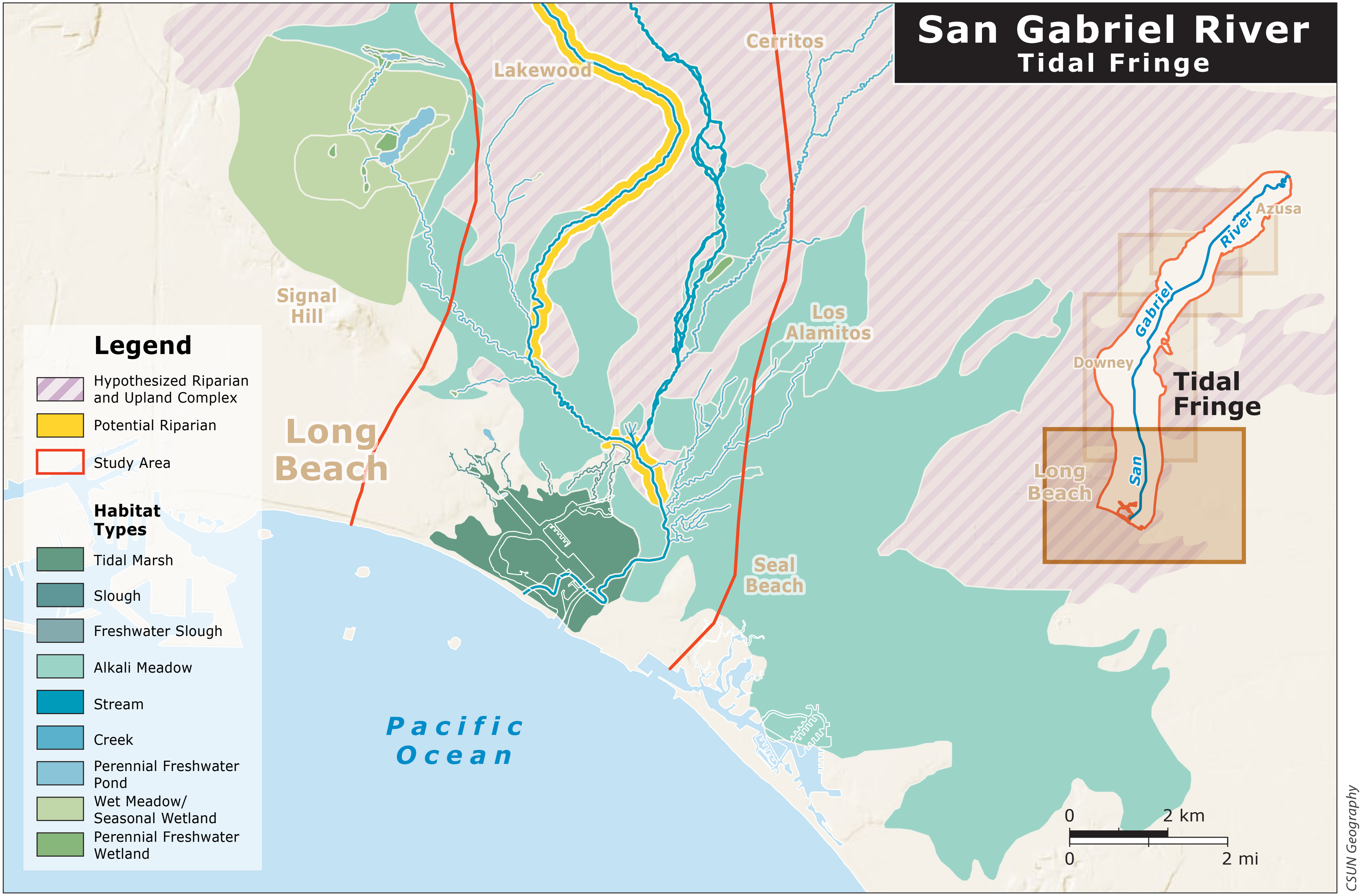
> *These forests [south and west of the city] were in all probability thickets or copse of willow, larch, and cottonwood similar to those found in the low ground near the mouth of the Santa Ana River and in the swampy lands of the San Gabriel River thirty years ago. (Robertson 1933)*

Interestingly, this description suggests the presence of cottonwood in the lower coastal plain, but its presence was not confirmed with herbarium records. As to the extent of the thick growth, Jotham Bixby, owner of Bixby ranch in what is now northern Long Beach, recalled, "Below this point [Los Cerritos and Dominguez] it was all a mass of willows and marsh" (Reagan 1915). Bixby goes on to describe this land as having been used for grazing and the native willows having been grazed down. During the dry years of 1862-1866, grazing cleared out even the marshy areas. After the 1868 flood, willows "sprang up all over the valley, up around Compton, Watts, Huntington Park, etc." (Reagan 1915). This account supports the conclusion that the lower watershed historically had extensive willow forests that were removed during the Rancho era.

5.4 TIDAL FRINGE

The boundary between the southern San Gabriel River floodplain and the San Gabriel/Los Angeles River estuary was a dynamic zone that changed on both annual and interannual cycles. Like many estuaries along the southern California coastline, the San Gabriel/Los Angeles River estuary was connected to the ocean through a narrow inlet(s). A series of low sand dunes, sand spits, and barrier beaches created systems that were alternately impounded and open to the ocean, referred to by 19th century observers as lagoons, bays, esteros, sloughs, lakes, and river mouths (Engstrom 2006). Following storms, these areas could be impounded for several kilometers upstream. Vast alkali flats produced by the combination of routine inundation with seawater followed by evaporative drying and persistent shallow ground water surrounded the estuarine/tidal wetlands (**FIGURE 5.13**). This tidal fringe area supported expansive alkali meadow wetlands that are no longer present on the contemporary landscape.

FIGURE 5.13. Historical wetlands of the San Gabriel River tidal fringe area.



Descriptions of alkali meadows in this area are found in both the narrative accounts and in the locality information from herbarium records:

> *In the earlier years, part of the land lying east of Los Alamitos ranch was white in spots, when the alkali lay in cakes on the ground. After the flood these places were covered from a few inches to four feet deep with silt. The land would then grow anything. (Thornburg: Reagan 1915)*

Davidson and Moxley report the distribution of Nuttall's alkali grass (*Puccinellia nuttalliana*) as "subalkaline flats at Santa Ana, Alamitos, and Hynes" (Davidson and Moxley 1923). Spreading alkaliweed is evident in "alkaline soil" in Long Beach. Salt marsh bird's-beak, a hemiparisitic plant, was collected a in northern Long Beach "in alkaline pasture" that was clearly not part of the Long Beach estuary. The only habitats described for the species are coastal salt marsh and alkaline flats (Hickman 1993); previously, the coastal subspecies found in Long Beach and Alamitos had been thought to be found only in salt marshes. These specimen records extend the generally accepted habitat preferences for the subspecies and conclusively indicate presence of an alkaline substrate.

The region contains other indicators of dense alkaline soil, including occurrences of Parry's tarweed, which is generally found in vernal pools or salt marsh edges. Other alkali tolerant species from this area include yellowray goldfields and spreading alkaliweed. These alkaline meadows may have developed as a result of the emergence and drying of vernal pools and marshes. When large floods occurred and deposited sediment on top of the alkaline soil, a typical floodplain flora (including willows) could develop again (**FIGURE 5.14**). This pattern probably occurred repeatedly as alkaline flats developed during drier climatic periods and were covered over with fresh silt during flood events.

Photo courtesy of the Benjamin and Gladys Thomas Air Photo Archives, UCLA Department of Geography

FIGURE 5.14. Looking north from Long Beach across the San Gabriel River and surrounding plain in 1921. Spence Air Photo 4013.

HISTORICAL PLANT COMMUNITY EXTENT AND DISTRIBUTION

It is difficult to appreciate the botanical diversity of the historical vegetation communities along the San Gabriel River system because they have been severely modified by urban development, flood management infrastructure, and agriculture. Those native sites that remain are isolated and degraded by invasive plants. Simply by loss of area alone, the native floristic diversity of the coastal plain portion of the San Gabriel River watershed is impoverished.

A reconstruction of the historical vegetation communities in the highly urbanized coastal plain can provide important guidance for restoration planning along the San Gabriel River. Such reconstructions both identify the proportions of various communities within the landscape and illustrate the diversity of plant species that were once found. Although current restoration efforts may not be able to replicate communities exactly where they were once found because of the dramatic alteration of the hydrological system, the historic vegetation description can serve as guidance for the choice of species to include in restoration projects.

Herbarium records have been somewhat under-utilized in historical ecology. They are not mentioned at all in the leading text in the field (Egan and Howell 2001). Despite certainly being used for development of local projects and guidelines, few examples have been published that tap this unique historical datasource (Mattoni and Longcore 1997, Reihmer 1939, SFEI 1999). Herbarium records, when properly prepared (Ross 1996), contain ample geographic information to link specimens with locations, particularly in with respect to co-occurring species. Other types of historical records, however, rarely contain this level of detail and interpretation requires more subjective judgment. Herbarium specimens in southern California can be found from the 1880s onward.

Comparison of herbarium records to aerial photographs and historical accounts of the study area indicate that the San Gabriel River floodplain historically supported a diverse array of wetland and riparian plant communities. We estimate that the study area supported about (19,000 ha) (47,000 acres) of wetland and riparian areas. These communities represented

	Alkali Meadow/ Tidal Fringe	Tidal Marsh	Willow Woodland (Depressional)	Wet Meadow (Seasonal)	Perennial Freshwater Wetland	Perennial Freshwater Pond	Alluvial Scrub Shrub	Dry Sandy Wash	Riparian Woodland/ Scrub	Riparian Scrub Shrub	Freshwater Seeps and Springs	Streams	Tidal Slough
Upper Floodplain			P		P		D	P	P		P	P	
Whittier Narrows			D	D	P				D		P	P	
Southern Floodplain	P		P	P	P	P		P	P	D	P	D	
Tidal Fringe	D	D		P	P						P	P	D
Total (acres)	23,137	1,874	1,474	9,420	891	144	5,665	535	461	1,846	251	1,370	13
Total (ha)	9,363	758	596	3,812	361	58	2,293	216	186	747	101	554	5

TABLE 6.1. Approximate distribution of habitats in various regions of the San Gabriel River floodplain circa 1880. Approximately 19,000 ha (47,000 acres) of wetland and riparian areas are estimated to have occurred in the study area. P= Present, D= Dominant.

the diverse moisture gradients and dynamism of the floodplain. Most regions of the San Gabriel River floodplain contained a complex of different wetland types, although certain types predominated in certain floodplain regions (**TABLE 6.1**). The sections below provide a description of the predominant wetland and riparian plant communities that comprised the historical San Gabriel floodplain. As previously stated, limitations of historic data (e.g., lower spatial resolution, inability to ground-truth) do not allow full application of contemporary habitat classification methods. However, for comparison, we attempted to relate the historic plant communities identified by this project to contemporary classification systems (**TABLE 6.2**).

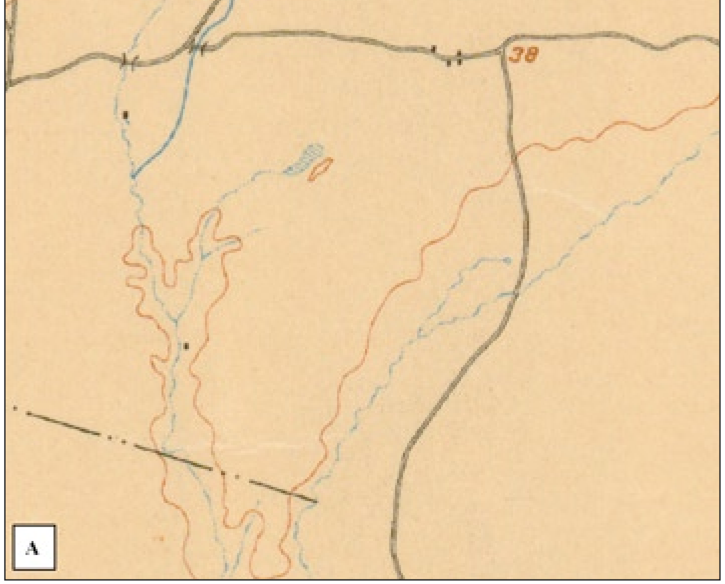
6.1 RIPARIAN (IN RIVER) HABITATS

Riparian habitats were the most difficult historical features to map. Permanent wetland features are likely to be documented on multiple maps and their presence supported by oral histories. However, because riparian areas are transitional between upland and wetland they were not well documented on maps or in other collateral data sources. Given the dynamic nature of the river, it is likely that riparian areas developed periodically only to be inundated with flood waters, and then dry over a period of years. Furthermore, riparian areas likely existed as a complex with other wetlands and upland habitats, making them less well documented. As described in the methods section, we used soils and geomorphology to identify zones where riparian habitat likely existed, keeping in mind that our confidence ratings for these areas must be lower than many of our wetland habitats. We estimated a larger proportion of the floodplain area to represent a complex of riparian and upland communities that changed every couple of years based on precipitation and the flow of water across the valley. These areas represent an idealized distribution of riparian habitat based on the fragmentary evidence available. Further research on the Los Angeles River and other similar systems would help to clarify this designation.

In addition to vegetated riparian areas, we also attempted to document other fluvial features within the floodplain, such as smaller tributary streams and creeks. Streams were delineated

TABLE 6.2. Habitat classification system for historic wetlands and comparison to contemporary classification systems.

Classification for Historical Habitat	Wetland Classification and Water Regime (Cowardin 1979)	Hydrogeomorphic Classification
Tidal Fringe\Alkali Meadow	Palustrine emergent saline wetland. Temporarily flooded, seasonally to permanently saturated.	Depressional (Topographic Plain or Alluvial Fan)
Tidal Marsh		
Willow Woodland	Palustrine forested wetland. Temporarily flooded, permanently saturated.	Depressional (Topographic Plain or Alluvial Fan)
Wet Meadow (Seasonal Wetland)	Palustrine emergent or scrub shrub wetland.	Depressional (Topographic Plain or Alluvial Fan) Seeps and Springs (Topographic Plain or Alluvial Fan)
Perennial Freshwater Wetland	Temporarily flooded, seasonally to permanently saturated	Depressional (Topographic Plain or Alluvial Fan)
Perennial Freshwater Pond	Palustrine persistent emergent or scrub shrub freshwater/saline wetland. Temporarily to seasonally flooded, pernanently saturated.	Seeps and Springs (Topographic Plain, Alluvial Fan, or Foothill)
Alluvial Scrub Shrub\Upper San Gabriel River Flood Plain	Palustrine permanently flooded wetland.	Fluvial (Topographic Plain, Alluvial Fan, Foothill)
Dry Wash\Upper San Gabriel River Flood Plain	Braided unvegetated channel, riparian scrub shrub, gravel beds, islands and bars	Fluvial (Topographic Plain, Alluvial Fan, Foothill)
Riparian Woodland\Whittier Narrows Flood Plain	Narrower than the Highly Braided Upper Reach, dry sandy bed	Fluvial (Topographic Plain, Alluvial Fan, Foothill)
Riparian Scrub Shrub\Southern San Gabriel River Flood Plain	Characterized by presence of perennial water within a larger dry flood plain surrounding chanel	Fluvial (Topographic Plain, Alluvial Fan, Foothill)
Dry Wash\Not associated with Upper San Gabriel River Flood Plain	Narrow perennial chanel without much flood creek within the study area.	Fluvial (Topographic Plain, Alluvial Fan, Foothill)
Freshwater Seeps and Springs	Riverine systems (fed by groundwater) or Palustrine Systems fed by groundwater.	
Creeks	Temporarily flooded wetlands confined to a chanel. See notes for further description.	Fluvial (Topographic Plain, Alluvial Fan, Foothill)
Freshwater Slough	Streams that are distinct within a freshwater meadow.	Fluvial (Topographic Plain, Alluvial Fan, Foothill)
Streams	Seasonally flooded wetlands confined to a chanel. See notes for further description.	Fluvial (Topographic Plain, Alluvial Fan, Foothill)



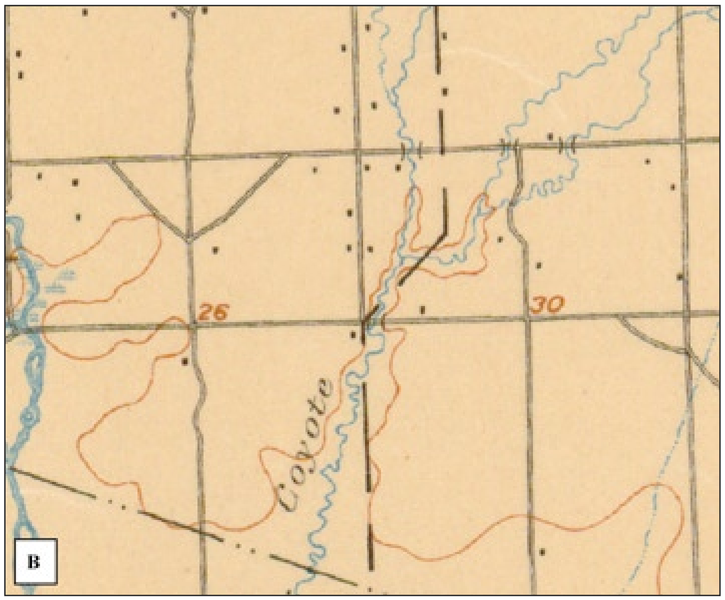


FIGURE 6.1. Creeks (A) and streams (B) along the San Gabriel River. Dotted lines were classified as creeks (ephemeral or intermittent streams) and solid lines were classified as streams (permanent or nearly permanent). Maps courtesy of California State University, Northridge.

on USGS topographic maps (late 1890's) as a solid blue, which indicate a more wet and permanent water regime than a dotted blue line (**FIGURE 6.1**). Dotted blue lines on the USGS topographic maps were delineated as "creeks" and most likely represent ephemeral or intermittent streams that ran only during wet years.

6.2 WILLOW WOODLANDS (DEPRESSIONAL)

Willow woodlands are forested, nontidal wetlands in the valley that were dominated by a combination of willow trees (*Salix* spp.), sycamore (*Planatus racemosa*), and mule fat (*Baccharis salicifolia*) (Schiffman 2005). These areas differ from riparian areas in the presence of a wetter water regime. A total of nine unique willow woodlands were mapped within the study area representing a total of 3.1% of the wetland area mapped. Virtually all of these woodlands were mapped in or near the Whittier Narrows area where the high water table saturated the soils and created a large and diverse wetland complex.

Evidence for willow woodlands were delineated initially from the historical soils map and classified into the drier NWI palustrine categories typically associated with willow woodlands or seasonal meadows. These delineations were then refined using secondary evidence from written accounts and classified either as seasonal wet meadow or willow woodlands. For example, several polygons in the El Monte area were delineated as the drier palustrine category. Secondary evidence was then used to locate and re-classify these areas. An example of this secondary evidence can be demonstrated via Thurston (Reagan

1915), who states there was a "large swale above El Monte thick with willows and brush" and King (Reagan 1915) states that the El Monte area was located north of the "willow groves". When speaking of the area south of El Monte, S. D. Thurman stated, "the water came down out of the canyon and split up into several channels above the Monte and ran through the brush and willows and spread all over the country and sank into the ground and stood on the ground" (Reagan 1915). Another useful secondary written account states of this area, "It was a draw in 1862 and was filled with willows and elder bushes so thick you could hardly get through it on horseback, and was very shallow." (Guess: Reagan 1915), providing further supporting evidence of willow woodlands in this area.

6.3 WET MEADOW/SEASONAL WETLAND

Wet meadows, which covered broad areas around Whittier Narrows and on the southern floodplain, are characterized by poorly drained soils, moist to saturated conditions with standing water present for brief or moderate duration (Grossinger et al. 2006). They support grasses and a significant but non-dominant proportion of facultative or obligate wetland species, especially sedges and rushes. Ratliff (1988) states that in California, valley and foothill grasslands can potentially provide wet meadow conditions, but that these sites "dry rapidly" and are dominated by annual grasses and forbs.

To create a map of wetland meadows for our target time period, we used the 1917 soil survey by Dunn et al. (1917) with further refinements and calibration from a number of other data sources. The primary areas delineated as wetland meadows were Chino clay loams and clays as cited in Dunn et al. (1917). These soils were considered slightly drier than other soils in the Chino series and most reflective of seasonal wetlands or meadows. We also used the line of moist land from Hall (1886) as a convenient secondary form of confirmation. This line was often larger than the Chino soils delineation. However, the soil maps represent a later time period when ground water may have been lower than at the time of the Hall (1886) mapping. Likewise, Hall seemed to have a special interest in water features because his report was focused on irrigation and may have paid particular attention to moisture demarcations.

The presence of wet meadows was confirmed with secondary data sources. Dunn et al. (1917) state in their reports that the Chino clay loams and clays were found in "shallow, basin like depressions" with "unfavorable drainage conditions" (Dunn et al. 1917). In addition to the Chino clay loams and clays, we also examined the Ramona clay loam series. As stated by Dunn et al. (1917), "Only in some of the low depressed areas, where water accumulates and stands during the wet season, is drainage very poor. Some alkali exists in these areas. Notable instances of this kind are seen in parts of the areas lying north of Long Beach." This information was used to make the distinction between wet meadows and alkali meadows in the area north of Long Beach.

Within the study area we mapped a total of 46 wet meadows representing approximately 3,812 ha (9,420 acres) or 20% of the total wetland area within our study area (*see Table 6.1*). These wet meadows were the dominant wetland south of the Whittier Narrows and dotted the valley landscape in scattered depressions. During winter months water accumulated within these depressions saturating the soils and creating the unique seasonal wetland conditions. These wetlands likely dried and contracted spatially during the summer months, although some may have stayed saturated throughout the year if fed by a high water table (depending on the amount of rainfall during the previous year(s)). Dominant plant species likely varied across these wetlands based on water regime; drier meadows may have been dominated by various species of grasses such as ryegrass (*Elymus* spp.), while wetter sites may have had more wetland species.

6.4 PERENNIAL FRESHWATER WETLAND

While wetland meadows were flooded or saturated seasonally during the year, perennial freshwater wetlands were saturated or permanently flooded throughout the year. Evidence for perennial freshwater wetlands was found in a variety sources. From historical soils map, we digitized and classified all polygons in the Chino loam mucky phase series as perennial freshwater wetlands. These locations were then refined based on information from other historical maps. Similar to lagunas, in which water was permanent, these features were included on a variety of maps and within textual documentation. The Spanish word "cienaga", meaning swamp or marsh (especially one formed by springs), was used on the early *diseños* maps (Hall 1886), and the early USGS topographic maps. In addition, these historic maps also used the standard symbol of blue tufts with horizontal lines (**FIGURE 6.2**) to designate these features.

Perennial freshwater wetlands were found along permanent sources of water such as springs, seeps, and lagunas throughout the study area. We mapped 39 unique perennial freshwater wetlands representing 361 ha (891 acres) or 2% of the total wetland area mapped. This wetter water regime supported unique vegetation associated with bulrush (*Scirpus* spp.) and other wetland plant species.

6.5 PERENNIAL FRESHWATER POND: LAGUNA

Persistent fresh surface waters were relatively rare in the San Gabriel Valley, making this a valuable resource to early ranchers. As a result, historical documents reliably recorded the few, important water bodies that persisted throughout the year. According to Grossinger et al. (2006), Spanish, Mexican, and early American accounts and maps use the term laguna for these permanently flooded, unvegetated wetlands. These features are too small to be considered lakes (greater than 8 ha (20 acres)) within the NWI classification, so we chose to use the term pond to identify these unique wetlands.

Perennial freshwater ponds were identified in Hall (1886) and early USGS topographic maps that designated areas with permanent water as lakes (**FIGURE 6.3**). The historical USGS topographic maps also identified depressions with blue concentric rings, which is conventional documentation for ponds on these historical maps. Within our study area we mapped a total of

FIGURE 6.2. Examples of a cienaga (Hall 1886; A) and horizontal tufts on historic topographic map (Gannett and Goode 1893; B). Maps courtesy of the Huntington Library and California State University, Northridge.

FIGURE 6.3. Example of perennial freshwater pond (laguna) from historical topographic map (Gannett and Goode 1893). Map courtesy of California State University, Northridge.

five unique perennial freshwater ponds representing a total land area of 58 ha (144 acres). Many of these ponds were located on the southern floodplain between the Los Angeles and San Gabriel Rivers, just north of Long Beach where depressional wetlands dominated the landscape. Small creeks and streams (along with seasonal ground water input) fed these ponds as they meandered across the valley floor.

6.6 ALKALI MEADOW

Saltgrass (*Distichlis* spp.) dominated alkali meadows at the landward edge of the tidal marsh at Alamitos Bay and extended well beyond regular tidal influence, creating a broad ecotone. A total of 26 unique meadows were identified in this area representing 9,363 ha (23,137 acres) or 49% of the wetlands within the study area. Defining the transitional boundary between alkali meadow and upland\riparian areas can be difficult. However, for this project we found a number of indicators on the historic soils map (Dunn et al. 1917, Hall 1886). Dunn et al. (1917) states that north of Long Beach was an area with “a growth of willow, salt, grasses, and moisture loving or alkali resistant plants.” A red line is also marked on the Dunn et al. (1917) soils map indicating soils with an alkali component.

The alkali meadows were characterized by native grasses, wetland plants, and an array of rare plants associated with vernal pools and alkali flats. Soil conditions resulted in agriculture known to be resistant to alkali soils, such as sugar beets and corn, and in some instances the alkali conditions precluded agriculture entirely (Dunn et al. 1917, Eckmann 1915). Botanical evidence suggests that these alkali meadows may have expanded and contracted over time, being larger than the extent mapped within the study area during certain periods.

6.7 FRESHWATER SLOUGHS, SEEPS, AND SPRINGS

Springs, areas where ground water provides the primary source of surface water, were identified often in the foothill regions on Hall (1886). Within our study area, springs often terminated in larger perennial freshwater wetlands that provided their dominant source of water. These features were mapped as springs or fresh water sloughs. However, there were springs outside of our study area in the Puente foothills and along the south side of the San Gabriel mountains that did not terminate in perennial freshwater wetlands. Springs such as these were likely an important source of water for Native Americans and ranchers living the foothill regions. As indicated by Hall (1886), springs were often the proposed locations for small reservoirs to contain the unique year round water supply (**FIGURE 6.4**).

FIGURE 6.4. Example of a freshwater slough. Line marked in red was delineated as a freshwater slough. Map courtesy of the Huntington Library.

7 COMPARISON OF HISTORIC AND CONTEMPORARY WETLAND DISTRIBUTION

> ***"The whole lower country [of the San Gabriel Valley] was more or less under water…there has been water all over that country that is not mesa ground."***
> *(Bixby: Reagan 1914)*

> ***"The Santa Ana River broke over into Coyote Creek and the flood waters came into Alamitos Bay. In fact, the waters of the Los Angeles, Rio Hondo, San Gabriel, Coyote Creek and Santa Ana rivers were all joined in one vast sheet of water. The country was impassable for several weeks..."***
> *(Clark: Reagan 1914)*

7.1 HISTORICAL WETLAND EXTENT AND COMPOSITION

Historical analysis of the lower San Gabriel River floodplain resulted in an estimate of 19,000 ha (47,000 acres) of wetlands and riparian habitat (**TABLE 7.1**). Two depressional wetland types and one riverine wetland type dominated the historic wetland distribution (**FIGURE 7.1**). The most common historical wetlands were the expansive alkali meadows found along the tidal fringe area of the lower floodplain and the wet meadows of the Whittier Narrows area. The most common riverine system consisted of the alluvial scrub shrub of the upper floodplain. The distribution of historical wetlands by HGM class shows a similar pattern, with over 11,000 ha of depressional wetlands in the tidal fringe being the predominant wetland type. In the upper floodplain, the estimated 2,200 ha of fluvial wetlands were most common wetland type (**TABLE 7.2**). Of particular note are the approximate 100 ha of slope/seep/spring wetlands, most of which have been extirpated from the contemporary landscape (*see Section 7.2*).

Habitat Classification	No. Unique Wetlands	General Area	
		Acres	Hectares
Alkali Meadow	33	23,137	9,363
Tidal Marsh	2	1,874	758
Willow Woodland	9	1,474	596
Wet Meadow	50	9,420	3,812
Perennial Freshwater Wetland	42	891	361
Perennial Freshwater Pond	6	144	58
Alluvial Scrub Shrub	4	5,665	2,293
Dry Sandy Wash	2	535	216
Riparian Woodland	9	461	186
Riparian Scrub Shrub	10	1,846	747
Creeks	38	191	77
Freshwater Slough	18	72	29
Streams	9	1,370	554
TOTALS	232	47,079	19,052

TABLE 7.1. Extent of historical wetlands in the San Gabriel River floodplain. Area mapped and number of polygons is a rough estimate of historical features.

The southern floodplain supported the broadest diversity of wetland types, supporting willow woodlands, wet meadow, perennial freshwater wetland, perennial freshwater ponds, dry sandy washes, and riparian scrub (*see Table 6.1*). As discussed in *Section 5*, the southern floodplain was extremely dynamic and likely consisted of a mosaic of riparian habitat, wetlands, and uplands in varying proportions depending on the specific year, the time of year and the amount of rainfall the previous winter. We estimate that the southern floodplain may have supported an additional 200 to 1000 ha of wetlands at various times, depending on assumptions about the extent and complexity of this wetland/upland mosaic (**TABLE 7.3**).

There are several important considerations to keep in mind when interpreting estimates of historical wetland extent. First, our estimates are confined to the boundaries of the study area (*as shown in Figure 3.1*) and immediately adjacent areas (contiguous wetland polygons that extended beyond the study

FIGURE 7.1. Distribution of historical wetland types in various portions of the San Gabriel River floodplain. Note that approximately 9,300 ha of alkali meadow existed in the tidal fringe area; the plot has been truncated to facilitate presentation.

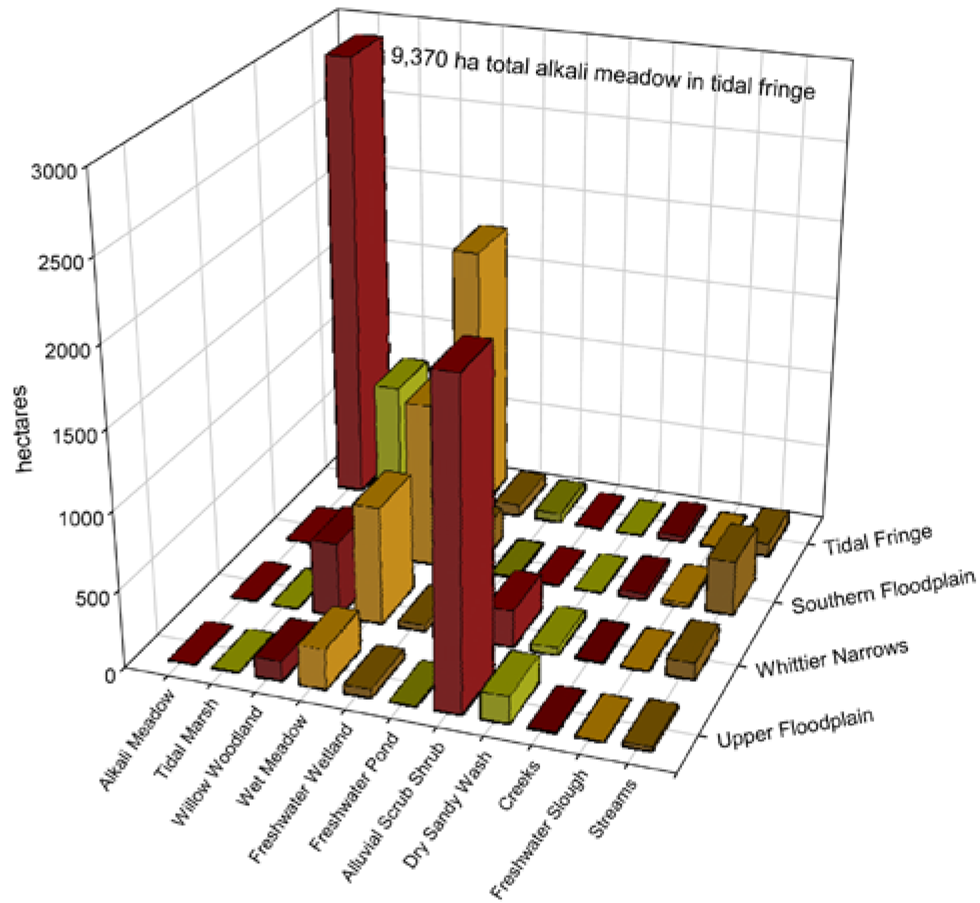


TABLE 7.2. Distribution of historical wetlands by HGM class.

Region	Area by HGM Class (hectares)		
	Fluvial	Depressions	Seeps/Springs/Slopes
TIdal Fringe	94	11,012	34
Southern Floodplain	333	1,523	59
Whittier Narrows	377	1,269	5
Upper Floodplain	2,242	422	3

TABLE 7.3. Potential additional wetland area that may have occurred as part of a wetland/upland complex based on assumed percent of total area comprised of wetlands. The wetland/upland complex likely did not extend into the tidal fringe area, hence it is not included in this table.

Region	Total Area		Assumed Percent Wetland		
	hectares	acres	2%	5%	10%
Upper Floodplain	4,772	11,783	95	239	477
Whittier Narrows	488	1,206	10	24	49
Southern Floodplain	11,025	27,222	221	551	1,103
		Total hectares	326	814	1,629
		Total acres	804	2,011	4,021

area boundaries were included in our analysis). Undoubtedly, additional wetlands occurred in tributary watersheds, such as Coyote and San Jose Creeks, and in the floodplain of the Rio Hondo and Los Angeles Rivers, which were immediately adjacent and contiguous with our study area. Second, estimates of historical area include inherent uncertainty. Third, our analysis was based on a specific point in time (circa 1870). As previously discussed, the San Gabriel valley was extremely dynamic with wetland extent and distribution varying over decadal and annual timescales. Any estimate of confidence must be viewed in light of this dynamism.

As discussed is *Section 3*, we estimated confidence in the historical analysis based on three factors: interpretation of data sources, wetland location, and wetland size (*see Section 3.4.4*). Overall confidence in data interpretation was relatively high, with 71% of polygons have a high level of confidence, and only 3% of polygons exhibiting a low level of confidence. However, confidence in the size of wetland polygons (and hence the overall acreage) was lower, with 77% of polygons exhibiting medium level of confidence and 11% of polygons exhibiting a low level of confidence.

As stated above, the extent of wetland type was not uniform, with total area per wetland type varying from 9,300 ha for alkali meadow to 6 ha for tidal slough (*see Table 6.1*). To account for this variation on overall confidence estimates, we calculated a weighted average of overall confidence. This analysis showed that we had high or medium confidence in our interpretation of 94% of the wetland area (i.e., we are fairly confident in their presence). In contrast, we have low confidence in the size estimates for 50% of the wetland area (i.e., there is moderate to high uncertainty in the actual extent of historical wetlands; **FIGURE 7.2**). However, because one wetland type, alkali meadow, accounted for 50% of the total estimated historical wetland area, it dominated our overall confidence estimates. To account for this, we estimated confidence levels excluding the alkali meadow areas. This analysis improved the certainty

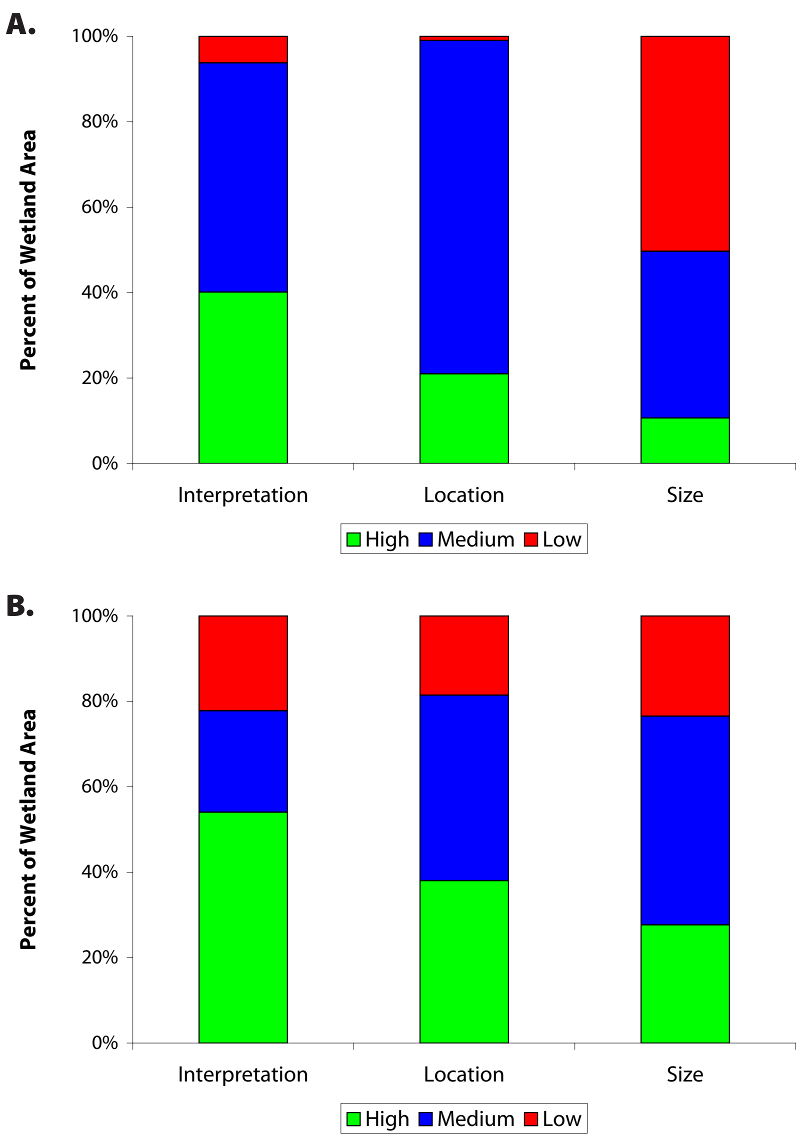


FIGURE 7.2. Overall confidence estimates based on percent of total wetland area for all wetland types (A) and excluding alkali meadow (B).

in our estimates of wetland extent to 77% of wetland area exhibiting high or medium confidence levels.

Finally, we estimated overall confidence, based on interpretation, location, and size for each wetland type. This analysis showed that overall confidence was high or medium for greater than 80% of historical wetlands (**FIGURE 7.3**). The greatest overall uncertainty was for alkali meadow and wet meadow habitats. This may be reflective of their extent as these were the most prevalent wetland types, and the diffuse nature of these systems. Stream systems and perennial wetlands and ponds generally exhibited the highest confidence; this is likely reflective of their stable nature on the landscape, and hence higher likelihood of accurate and repetitive documentation over time. These confidence estimates cannot be converted to statistical measures of certainty; however, they illustrate the relative certainty in estimates of historical wetlands and help bound the potential error associated with these estimates.

7.2 RELATIONSHIP OF HISTORICAL AND CONTEMPORARY MAPPING

Development of historical wetland maps provides an opportunity for comparison to present day wetland maps of the study area. However, there are several differences between historical and contemporary wetland maps that complicate this comparison. Perhaps the most important difference between these two datasets is the scale of the maps. Contemporary maps are created with color infra-red aerial photography taken at a 1-m resolution. This imagery allows for fine scale mapping and the delineation of features not visible on historical maps. Historical

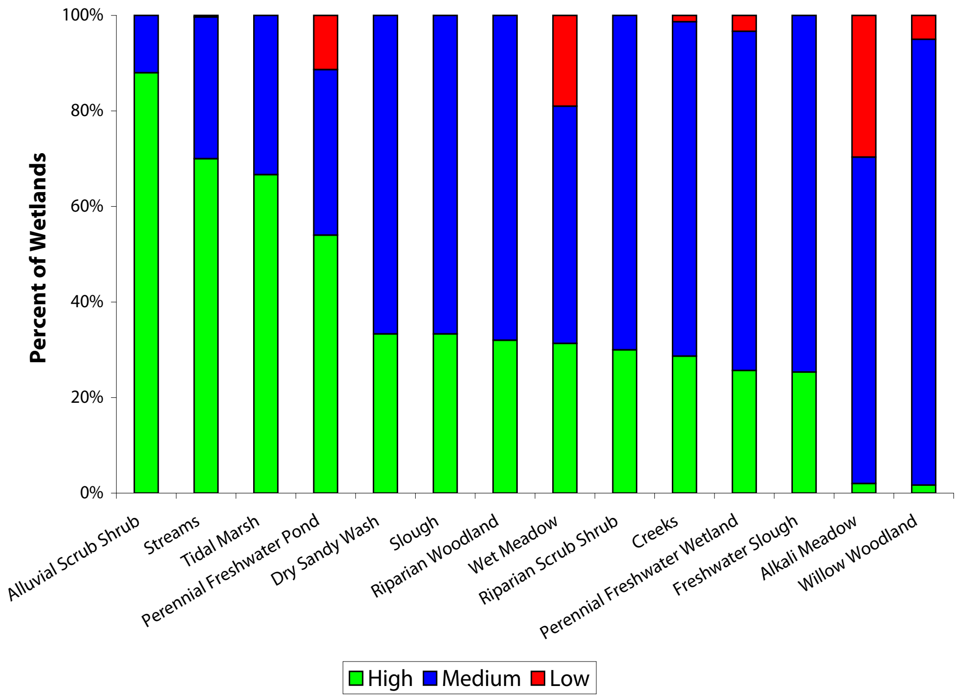


FIGURE 7.3. **Overall confidence in historical wetlands, by wetland type.**

maps often only include wetland features that were large and obvious on the landscape and neglected smaller, intermittent wetlands. Consequently, contemporary maps in some places may contain significantly more detailed information about the landscape than historical maps.

The second key difference between historical and contemporary maps is the comprehensiveness of the mapping efforts. Contemporary wetland maps use modern technology, such as infra-red aerial photography, to comprehensively elucidate landscape features. This makes identification and detailed mapping of wetlands easier and more accurate. Obviously, the same level of technology was not available for the historical wetlands mapping source material. Rather, mapping was restricted to areas that were readily accessible and areas of commercial, social, or political importance were of particular interest to the surveyor.

Finally, it is important to keep in mind that present day wetlands still exist in the field, available for us to survey as part of the mapping process. When a spectral signature or elevation gradient is hard to discern on source imagery, technicians can go out in the field to validate the data source. Obviously, with historical data this is not the case. Photographs taken after the target time period are occasionally available and can be useful for validation purposes. However, site specific visual information is rarely available. As a consequence, we are less certain about our classifications with historical wetland maps than contemporary wetland maps. Nevertheless, many of the source material discussed in the preceding sections are surprisingly accurate and allow for a general depiction of wetlands across the historical landscape.

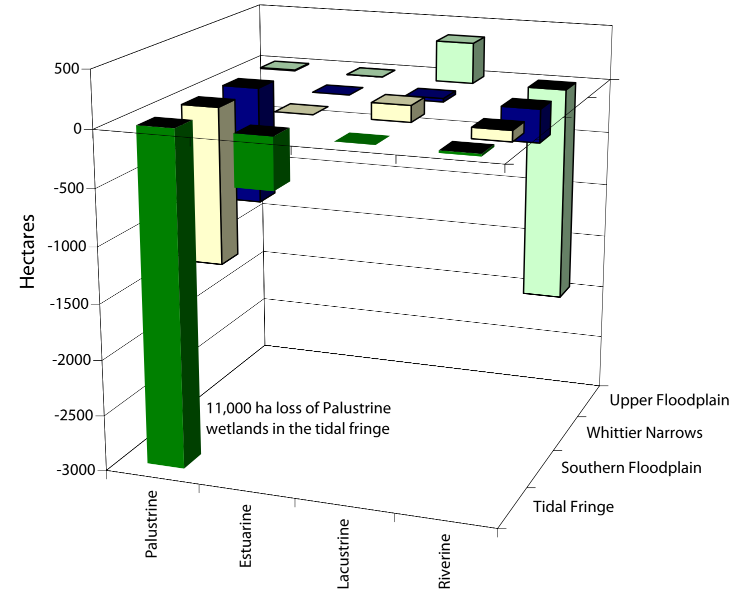
Despite these differences, a comparison between historical and contemporary wetland maps is still a worthwhile endeavor. Contemporary data can be merged at the Cowardin system level (Cowardin et al. 1979) for a baseline comparison to historical data. Likewise, a qualitative comparison of maps allows for the identification of dominant historical habitat types that are now missing and perhaps alludes to reasons that they are missing. It also allows for a general analysis of changes to the pattern and distribution of wetlands. However, caution is advised when making a specific quantitative comparison; such analyses should always be accompanied by a disclaimer indicating the differences between historical and contemporary mapping efforts.

7.2.1 Analysis of Changes from Historical Wetland Extent and Distribution

Because of the discrepancies between historical and contemporary data discussed above, we focused our analysis on semi-quantitative descriptions of relative change. Not surprisingly, there has been a fairly dramatic loss of wetlands since the circa 1870 period of our historical analysis. The study area currently supports approximately 2,500 ha of wetlands, compared to approximately 19,000 ha historically. However, the losses have not been evenly distributed across the study area. The greatest losses have been to palustrine wetlands in the tidal fringe and riverine wetlands of the upper floodplain (**FIGURE 7.4** and **FIGURE 7.5**, **TABLE 7.4**).

Overall, palustrine wetlands have experienced the greatest loss of any wetland category, with approximately 94% reduction in area. This wetland class represents all nontidal wetlands dominated by trees, shrubs, persistent emergent vegetation, emergent mosses, or lichens (Cowardin et al. 1979). The palustrine system includes seasonal and perennial wetlands, alkali meadows, and small ponds. Within our study area, these wetlands were most likely supported by a combination of shallow ground water and surface flow associated with precipitation. The most dramatic loss within this wetland

FIGURE 7.4. Wetland loss (or gain) by class (Cowardin et al. 1979) and portion of the study area. Note that approximately 11,000 ha of palustrine wetlands have been lost from the tidal fringe; the plot has been truncated to facilitate presentation.



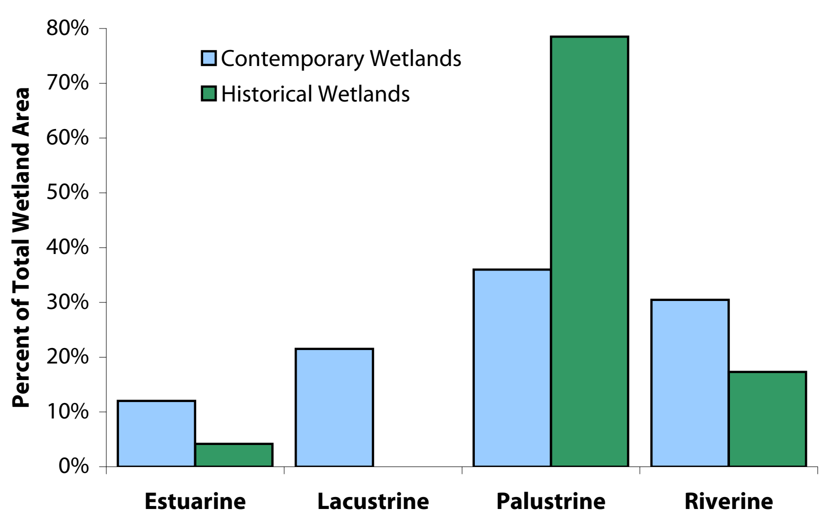
class is the vast expanses of alkali meadow that dominated the southern floodplain and tidal fringe areas. As discussed above, these wetlands were once the most expansive type in the lower watershed, yet today, they are totally absent from the landscape. Another palustrine wetland type heavily impacted was the series of seeps and springs along the foothills of the San Gabriel mountains. Historic maps often document chains of small slope and seep wetlands supported by ground water that surfaced along the topographic transition zone between the foothills and the valley. Although readily observable on the maps, most of these features were either outside of our study area or too small to accurately map. Consequently, they

TABLE 7.4. **Percent change in wetland area by class (Cowardin et al. 1979) and portion of the study area. Note that Lacustrine wetlands were absent from the historic landscape, so figures presented are the contemporary area (ha) vs. percent change.**

Region	Palustrine	Estuarine	Lacustrine	Riverine
Tidal Fringe	-99%	-60%	0%	-20%
Southern Floodplain	-93%	0%	144*	-24%
Whittier Narrows	-83%	0%	30*	-76%
Upper Floodplain	2%	0%	369*	-87%

* = area (ha) present in the contemporary landscape - Lacustrine wetlands were not historically present; therefore, percentage change was not calculated

FIGURE 7.5. **Percentage of wetland area within the study area comprised of each wetland type (Cowardin class) under current and historical conditions. Data from National Wetlands Inventory and California State University, Northridge.**



are underrepresented in our historical inventory. Nevertheless, these wetlands have been largely eliminated, except in remote areas in the upper San Gabriel watershed.

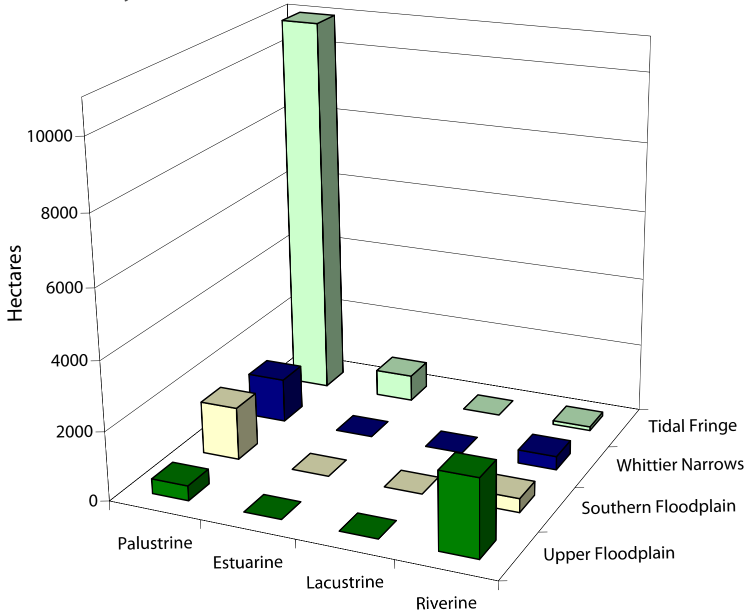
Riverine systems have also undergone extensive loss and modification since the 1870s. Approximately 75% of the historical riverine area has been lost, with the greatest proportional losses occurring in the upper floodplain and Whittier Narrows areas. Although there has been proportionately less loss in the southern floodplain, the most dramatic change has been the conversion of the broad alluvial floodplains of the upper watershed and the meandering streams of the southern floodplain to flood control channels. Historically, the valley floor was covered with small intermittent streams carrying water from the foothill areas or places with a shallow water table out to the ocean. These streams likely ran at their highest during the rainy season and became dry stream beds during the summer. The dynamism of the San Gabriel River during major flood events contributed to a large surface flows that overtopped the active channel banks and engaged the broad flat floodplain areas. We estimate that the floodplains of the San Gabriel River periodically supported a complex mosaic of depressional wetlands, tributaries, and secondary channels interspersed among an upland matrix. These areas may have amounted to hundreds to thousands of hectares of intermittent wetlands (*see Table 7.3*). Today, the alluvial aquifer has been largely dewatered, and its access to the floodplain has been eliminated by a series of damns, diversions and channels.

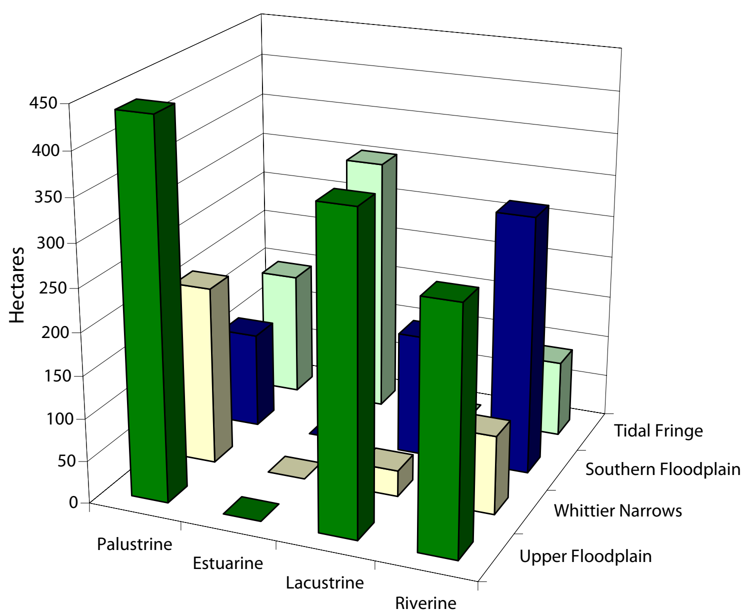
The decline in aerial extent of the estuarine wetlands is not as dramatic as for the palustrine or riverine systems. This may, in large part, be due to confinement of the estuarine systems to a coastline with water supply coming from the ocean as opposed to being disbursed throughout a larger area where water is supplied via precipitation or ground water. However, it is also important to note that although they still exist, the contemporary estuarine systems within the study area have been largely converted to commercial ports and harbors that lack the functional complexity of historical tidal wetlands (**FIGURE 7.6**).

The addition of lacustrine wetlands is indicative of the effect of humans within the study area (**FIGURE 7.7**). A wetland that is permanently covered with water, lacking vegetation, and larger than 8 ha in size is classified as lacustrine in contemporary mapping. Virtually, all present day lacustrine systems within the study area were created by humans for the purpose of either containing water during periods of high flow or spreading ground for ground water recharge. Other current day lacustrine systems within the study area are either in parks (serving a recreational purpose) or gravel pits. Historically, there was little evidence of lacustrine systems. This may be due to the shallow topography of the study area and dynamic flow of the San Gabriel River across the valley floor. The addition of lacustrine wetlands to the contemporary landscape is illustrative of the wetland type-conversion (from riverine and palustrine to lacustrine) that commonly occurs as an area developes.

FIGURE 7.6. Maps showing a comparison of historical (A) and contemporary (B) estuarine wetlands. Aerial photography courtesy of the National Agricultural Imagery Program (NAIP) Survey.

FIGURE 7.7. Distribution of wetland types (Cowardin) by portion of the study area under historical (A) and contemporary (B) conditions. Note the different scales of the y-axes.





7.2.2 Sample Comparison of Historical and Contemporary Wetlands

FIGURE 7.8 shows a comparison of historical and contemporary wetland conditions within the upper floodplain region of our study area. The figures were taken at the base of the San Gabriel mountains where the San Gabriel River now runs into the Santa Fe Dam. Historically this region was dominated by alluvial fan scrub shrub. Today, there is minor evidence of this scrub shrub habitat within the Santa Fe Dam. The river at this point has been channelized, and the historical alluvial fan is no longer evident. Virtually all of the contemporary wetlands within this area have been altered, as indicated by the relatively large amount of palustrine and lacustrine wetlands that were not present historically, including a recreational pond at the Santa Fe Dam Recreational area and a series of gravel pits that have been filled with water.

The Whittier Narrows region historically supported large areas of diverse wetlands, owing to its relatively unique geomorphic setting. Today, the Whittier Narrows Recreation Area still supports remnant wetlands. However, the extent and complexity of these wetlands have been reduced, and the area is managed by the presence of a dam and channelization of the San Gabriel River. Notably, because the area is public open space and historically supported wetlands, it would be a good candidate for future wetland restoration and/or creation planning efforts. FIGURE 7.9 shows a comparison of historical and contemporary wetlands in the Whittier Narrows area.

FIGURE 7.8. Maps showing a comparison of historical (A) and contemporary (B) wetlands in the upper San Gabriel River floodplain region. Aerial photography courtesy of the National Agricultural Imagery Program (NAIP) Survey.

FIGURE 7.9. Comparison of historical (A) and contemporary (B) wetlands in the Whittier Narrows region. Aerial photography courtesy of the National Agricultural Imagery Program (NAIP) Survey.

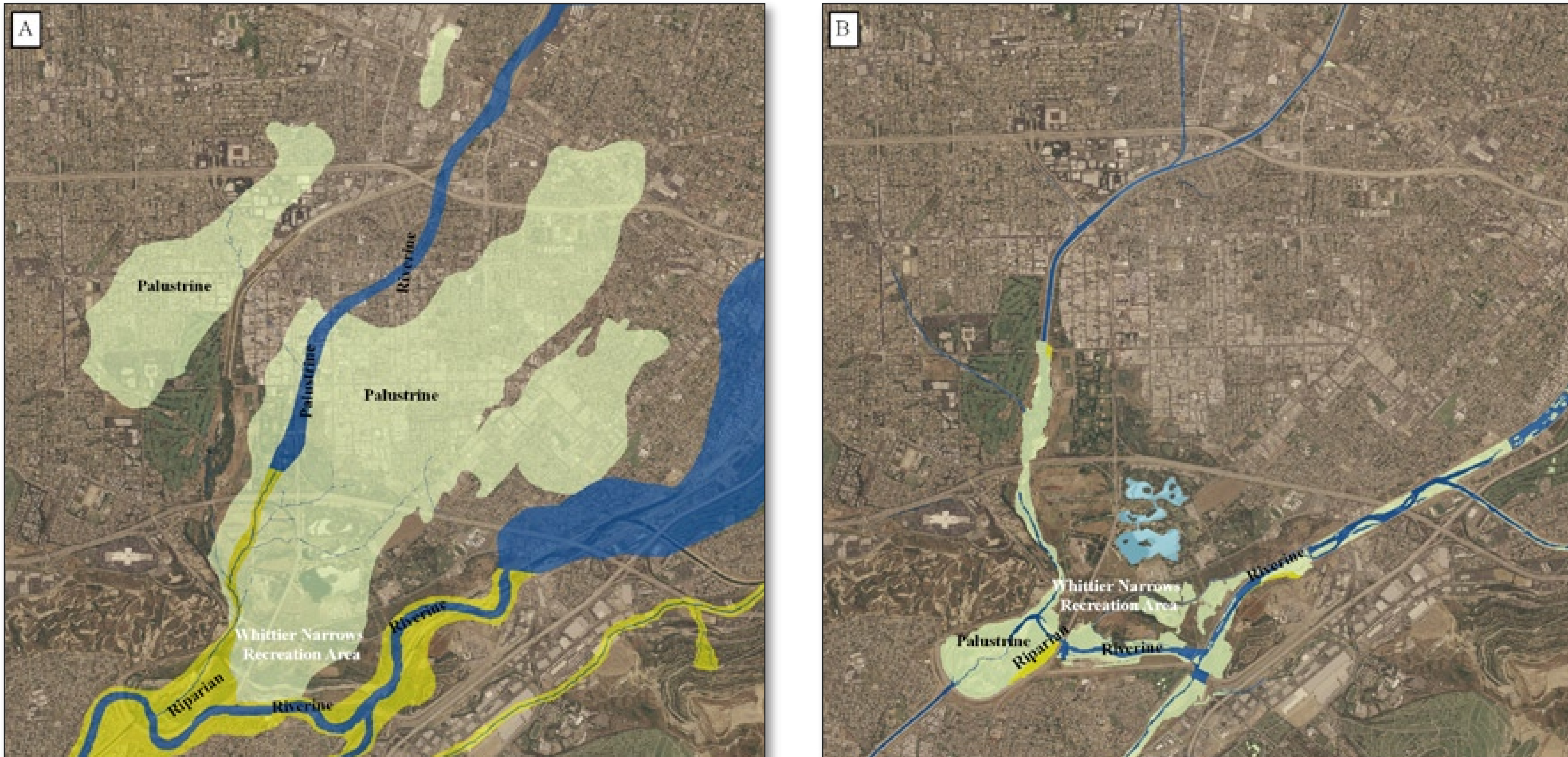


FIGURE 7.10. **Historical perennial pond in the southern San Gabriel floodplain (A) and its current manifestation as a golf course pond (B). Aerial photography courtesy of the National Agricultural Imagery Program (NAIP) Survey.**

The southern San Gabriel River floodplain was historically dominated by a series perennial and seasonal wetlands. Today, this area has been entirely converted to urban land uses. However, in some instances remanent wetlands still exist in the form of ponds at recreational facilities and golf courses (**FIGURE 7.10**). Although they are smaller and their functionality has been decreased, these recreational facilities and golf courses are reminders of the historical landscape and opportunities for future restoration.

8

CONCLUSIONS AND A LOOK AT THE FUTURE

Analysis of the historical San Gabriel River floodplain provides a glimpse of the impressive dynamism that was likely characteristic of many of southern California's coastal rivers and streams. The river migrated across tens of kilometers of floodplain alternatively joining with the Los Angeles River and assuming a distinct course to the ocean. This dynamism facilitated the formation and support of complex expanses of channels, ponds, sloughs, marshes, and flats that alternated between wet and dry cycles. The combination of uncontrolled runoff and sediment delivery and broad shallow aquifers supported expanses of alkali meadows, freshwater wetlands and riparian woodlands that are no longer present on the landscape.

Although impressive, it is important to not overstate the river's dynamics. While the channel made a major shift in 1867, the "New River" appears to have followed the route of an existing arroyo (Arroyo San Gabriel), which may have been a former overflow channel. The earliest description we have (ca. 1769) suggest the pre-1867 pattern had been generally stable for a century. Despite major, roughly decadal floods the New River did stay in place for quite some time, prior to artificial confinement. It is likely that the frequency and magnitude of major channel changes fluctuated with climatic cycles. However, the historical accounts clearly suggest a system that was much "wetter" than contemporary conditions or traditional views of Los Angeles as a desert.

While we did not conduct assessment of present-day restoration potential, initial investigations suggest that historical landscape maps can be used to identify historical wetland areas with significant, often unrecognized, potential for restoration and enhancement. Possibilities that could be explored include:

- **Whittier Narrows** – historically, faulting and the shallow impervious layers in this area forced ground water to the surface supporting vast expanses of perennial wetlands and riparian areas. Remnants of these systems persist today, suggesting that restoration efforts could expand the wetland extent and complexity in this area.
- **Long Beach golf course area** – the current golf course pond appears to be in the same location as a historical laguna on the southern floodplain. The persistence of this feature over the past 150 years suggest that conditions may be conducive to further restoration or enhancement.
- **Several signatures of historical wetlands** – dispersed on the landscape in both the upper floodplain and southern floodplain areas are numerous small, moist areas that are likely the signatures of historical marshes or floodplain depressions. There may be opportunity to recreate these features and reconnect them with adjacent undeveloped open space to restore fragments of the historical wetland/upland mosaic.
- **Seeps along the foothills** – numerous canyons exiting the San Gabriel mountains still contain active seeps and springs that could be enhanced to support additional wetlands.

Despite these opportunities, it is important to understand how the results of this work can be used in regional planning and restoration of habitats in the San Gabriel River watershed and lower Los Angeles River basins. The goal of this study was to document and understand historical reference points and the factors that influence change, including land use, climate, and natural events, such as floods and fires. The aim was to develop information, which is sufficiently detailed to inform local environmental planning and management efforts, such as habitat restoration, flood control, endangered species recovery, erosion control, and natural reserve prioritization and design. This analysis helps provide planners with a valuable template for restoration and conservation planning by providing the several types of information, including:

- An analysis of the how the ecosystem has functioned over time, including controlling factors affecting local habitats and how they have adapted and responded to changes in the landscape.
- Insight into the appropriate location and distribution of habitats and plant communities.
- Information on where the greatest losses have occurred, both geographically, and in terms of specific habitat types.

- Suggestions as restoration possibilities in light of current-day landscape constraints.
- Identification of locally-calibrated restoration and management options, in terms of potential location which may still support appropriate native habitats.

Recreating past conditions through restoration is not practical or desirable in all places or instances, especially in the San Gabriel River watershed where urban infrastructure poses severe limitation on future restoration work. In particular, the restoration of riparian plant communities to their former historical configuration may not be possible for several reasons, including the lack of appropriate hydrology and soils. Thus historical analysis must be used to inform, but not replace the tools commonly used in watershed restoration science.

The limited possible temporal scope of our analysis illustrates the rapidity with which systemic change occurred in southern California. Less than 150 years transpired between Crespi's initial accounts of the "natural" form of the San Gabriel River and its demise due to channelization, ground water extraction, and floodplain development. For this relatively brief 150-year period we have approximately 75 years of information to gain insight into the form and function of a highly dynamic and episodic system, which changes in response to multidecadal climatic patterns.

This brief window of opportunity suggests that the structure and methodology for assessing historical landscape conditions developed through this study be expanded to other watersheds in order to provide sufficient detail and understanding to support environmental planning and restoration efforts in Southern California. Future efforts can build on the foundation provided by this project by including additional data sources, such as:

- **Mexican Land-Grant Testimony.** While we used maps and sketches associated with the Mexican land grants, there is an additional, potentially invaluable body of specific narrative landscape description contained in the court transcripts of the land cases following the acquisition of California by the US. These can provide highly detailed descriptions of streams and wetlands prior to 1850 (e.g., Grossinger et al. 2006). This is particularly likely because San Gabriel River served as a Rancho boundary.
- **General Land Office Survey Notes.** These can provide detailed information about features encountered on survey lines in the 1850s through 1870s. While we acquired and used some of these data, they remain a strong potential source of additional information.
- **Archaeological Data.** A major potential source of information that we did not incorporate involves information from the field of archaeology. For example, the location of shellmounds and other archaeological sites tends to be associated with wetland or fluvial features and can help establish their long-term persistence (i.e., an archaeological site with several thou-

sand year history along a river reach would suggest a high degree of channel stability). The floral and faunal contents of shellmounds can also be extremely illuminating with regard to indigenous fish and wildlife species.

- **Mission Records.** Some of the outstanding questions in the project relate to conditions during the first half of the 19th century, when there is some evidence for extensive wetlands associated with terminal rivers. Investigating early sources associated with the explorations, missions, and pueblos could extend our detailed understanding back half a century, when conditions may have been very different, increasing our understanding of the natural variability of the system.

Continued investigation of the past will provide valuable insight into the possibilities of our future not only by providing design templates, but also by helping to spur our imagination of an alternative future landscape.

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Additional references and information sources can be found at:
www.csun.edu/centerforgeographicstudies/historical_ecology.html

- **Appendix A** - Distribution of Plant Species on the San Gabriel Floodplain
- **Appendix B** - Historic Plant Compendium for San Gabriel Watershed
- **Appendix C** – Transcripts of Oral Histories Compiled by J.W. Reagan (1914)

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