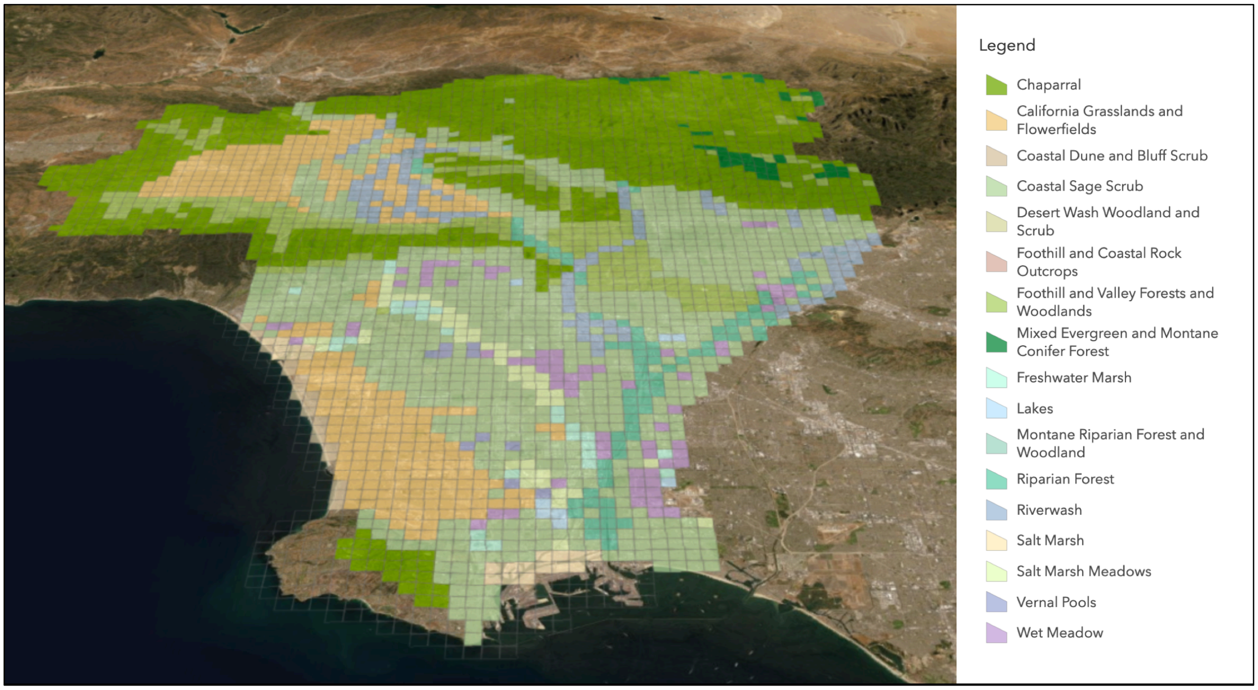
Historical Ecology of the Los Angeles River Watershed and Environs

Infrastructure for a Comprehensive Analysis



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Executive Summary

As the Los Angeles metropolis continues to grow in the 21st century, so has public and governmental support for sustainable development. Open space is increasingly valued for its social, historical, and ecological values, and the practice of environmental restoration and management of remnant open spaces has expanded. Major ecological rejuvenation efforts are proposed or underway throughout the region, but these sustainable development and landscape restoration projects urgently need reliable, evidence-based knowledge about the underlying natural ecology. What natural vegetation would historically have thrived in different areas of the metropolis? Which animals fed on that vegetation and who were the predators? Where were the ever-shifting rivers, tributaries, creeks, and the springs? What time periods of the region's past should be used for models of restored landscapes?

While detailed, neighborhood-scale projects have described the historical ecology of some portions of the region, a general study of the entire Los Angeles River and Watershed has been lacking. In this two-year research project funded by the John Randolph Haynes and Dora Haynes Foundation, we developed the foundation for a uniform, evidence-based understanding of the historical natural habitats of the Los Angeles River and Watershed—and of the Los Angeles Basin generally. Due to the great size of this area: approximately 1,988 square miles (3,200 km^2), we set the goal of establishing a durable, public-use knowledgebase for this area at a medium, 1-kilometer scale, so that a growing body of researchers can pursue the next phase of the project: to build detailed neighborhood-level studies at the scale of 100 meters or less.

The primary results of this project are:

1) The first-ever public-use geo-historical database of map layers, data, historical images, and textual records that covers the entire Los Angeles River and Watershed, which can be used and augmented collaboratively by a growing body of researchers. It combines all known historical maps and sources, plus newly discovered sources, as layers and geo-located objects in a common geographic reference grid, so that researchers and the general public can view all currently known sources pertaining to any location in the Los Angeles Basin.

2) The first comprehensive chronological framework for understanding the different historical eras and sub-periods of the very ancient past of the Los Angeles region. This chronological framework, built from Indigenous and modern scientific knowledge, makes it possible to specify the ecological dynamics pertaining to any given historical date, beginning about 2.5 million years ago and continuing through more than 9,000 years of human civilization.

3) An initial assessment at the 1-km scale of the potential natural vegetation (PNV) of all areas of the Los Angeles Basin, classified by "macrogroup" designations of landscape types, such chaparral, grasslands and flowerfields, foothill and valley forests and

woodlands, riparian forest, salt marsh, alkali meadow, wet meadow, and freshwater marsh for the entire 3,200 km^2 (1,988 sq. mi.) area of the Los Angeles Basin.

4) A new assessment of the extent of habitat loss across the Los Angeles Basin due to urbanization over the last two centuries. Within the present-day extent of the Los Angeles River Watershed, most vegetation groups have experienced at least some urban development in all 1-km^2 blocks where they occurred historically. For California chaparral, 69% of the blocks have some urban development, 85% for foothill and valley forests and woodlands, 98% for riverwash, 99% for coastal sage scrub. No single 1-km^2 block persists without some urban development within it for California grasslands and flowerfields, riparian forest, wet meadow, salt marsh meadow, freshwater marsh, lakes, and vernal pools.

This report, and further updates and data from the project, can be found in digital form at the website: https://lalandscapehistory.org.

Chapter 1 Introduction

1.1 Background and Purpose of Historical Ecology

As the population of the Los Angeles Basin grows and open space is increasingly valued for its social, historical, and ecological values, the practice of environmental restoration and management of remnant open spaces has expanded. Major ecological rejuvenation efforts are proposed or underway throughout the region, including along the Los Angeles River through the City of Los Angeles, at the Ballona Wetlands, in the Baldwin Hills, and the Lower Los Angeles River as it passes through Bell, Cudahy, Downey, and other cities on its way to the sea. The efforts already underway represent a substantial investment of public and private funds.

The goal of Los Angeles, as with any great metropolis, should be sustainability, which requires intensive knowledge of the surrounding and underlying natural ecology. What was the natural vegetation that would historically have thrived in different areas of the metropolis? Which animals fed on that vegetation and who were the predators? Where were the ever-shifting rivers, tributaries, creeks, and the springs?

Sustainable development and landscape restoration projects urgently need to know answers to such questions as these: What is the natural extent of native oaks in the Los Angeles Basin? Were they found in the Baldwin Hills or Palos Verdes Peninsula historically? What was the relative distribution of grasslands, forblands (dominated by annual wildflowers), and scrublands across the broad valleys of the basin? How widely did the Los Angeles River flood during the pre-channelization period, and what associated habitats such as alkali meadow were associated with that dynamism? What was the extent of perennial freshwater ponds in the foothills and plains?

Because of development patterns that have transformed much of the landscape of the Los Angeles Basin, examples of the pre-urban natural ecosystem are difficult if not impossible to see, except in the many surviving habitats in the mountains and deserts surrounding the metropolis. As a result, the public is left with misconceptions about the natural landscape on which they live. Memory has been lost of the hazardous power of natural water features, along with memory of the original extent of riparian flows through canyons, across floodplains, collected in wetlands, and returned to the sea in estuaries.

We are at a turning point in public investment in the Los Angeles River. We are also at a point of major public investment in the green infrastructure of natural open spaces. It is more important than ever for today's projects and proposals to be informed by an accurate, deeply informed knowledge of what "green" means in the Los Angeles Basin. What is "natural" in a place that has been continuously inhabited for at least 9,000 years, and urbanized for more than a century? All current efforts to restore greenspace and sustainable development in the Los Angeles Basin should stand on a relatively uniform geographical knowledgebase about the environmental history of the Los Angeles River and watershed, with a high degree of spatial resolution—down to the neighborhood scale.

Currently, there is no map that details the historical extent and location of the Los Angeles River at a high spatial resolution, none that shows the extent of flooding as reflected in historical textual records, nor one that documents the natural conditions of the vegetation and faunal habitats of its watershed. ***A reliable, uniform, evidence-based understanding of the historical natural habitats of the Los Angeles River and watershed—and of the Los Angeles Basin generally—is currently lacking.***

Thankfully, we have a foundation for understanding that knowledgebase. Historians and geographers have written several important books about the Los Angeles River. Blake Gumprecht, "*The Los Angeles River: Its Life, Death, and Possible Rebirth*" (1999); Jared Orsi, "*Hazardous Metropolis: Flooding and Urban Ecology in Los Angeles*" (2004); William Deverell and Tom Sitton, "*Water and Los Angeles: A Tale of Three Rivers, 1900–1941*" (2016), among others, provide invaluable foundation for understanding the history and urbanization of the LA River system, including the epochal "hardening" of the river for flood control purposes by the US Army's Corps of Engineers in the 1930s. These books also help us to understand the historical record of land use and human observation that are needed to reconstruct the river's historical ecology. These books are primarily textual, after all, and their authors have not attempted a detailed survey at close, neighborhood-level scale across the entire river and watershed system.

A reasonably uniform geographic survey of the historical floral and faunal habitats at the micro-scale (neighborhoods, city blocks) would be of incalculable value for 21st-century efforts toward sustainability and preservation, especially due to the major efforts underway to restore the Los Angeles River as a natural river course for environmental and recreational purposes. Urbanization of the LA region has obliterated most natural habitats over the hundreds of square miles on the flatlands surrounding the LA River, but even more hundreds of square miles of natural habitats remain viable, in the hillsides, remaining wetlands, and mountains. Indeed, the many still-wild intact ecosystems in the uplands and mountains provide invaluable knowledge about the historic conditions of comparable habitats in now-urbanized areas. There is an urgent need to understand how existing habitats functioned before the 20th century.

1.2 Existing historical ecology resources for Los Angeles River watershed and environs

Within the Los Angeles Basin, an early study of historical ecology was Mattoni and Longcore (1997), a description of the Los Angeles Coastal Prairie, an undulating region of vernal pools and wildflower fields that was once found from the Ballona Bluffs southward to the Palos Verdes Peninsula (Figure 1-1). The unique vegetation of this region, which was dominated not by grasses but by annual wildflower species remains only in a few scattered locations, yet the knowledge of its presence led to the conservation and management of both rare species and those remnant locations, such as the Madrona Marsh in Torrance.

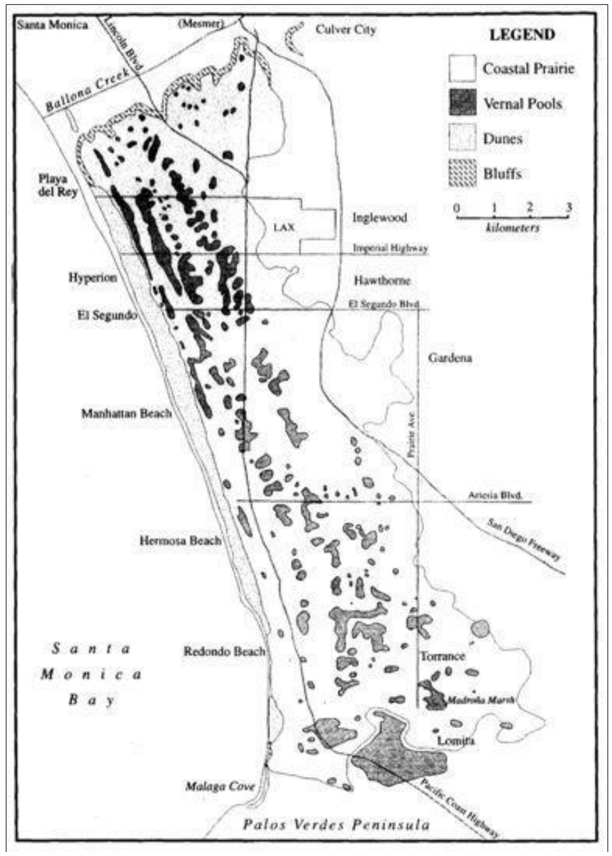


Figure 1-1. Map of the Los Angeles Coastal Prairie and Vernal Pools (Mattoni and Longcore 1997).

Dark et al. (2011) investigated the wetland habitats of the Ballona Creek watershed, documenting the extent and character of the coastal brackish and salt marshes, as well as large inland wetlands, wet meadows, streams and springs (Figure 1-2). The Ballona Creek study compiled records from historical archives in the form of textual documents, natural history specimen records, photographs, and maps to produce a depiction of the natural landscape near the end of the 1800s, at a point in time certainly influenced by thousands of years of human occupation by Native Americans and hundreds of years of European colonization, but still with hydrological and ecological processes more or less intact.

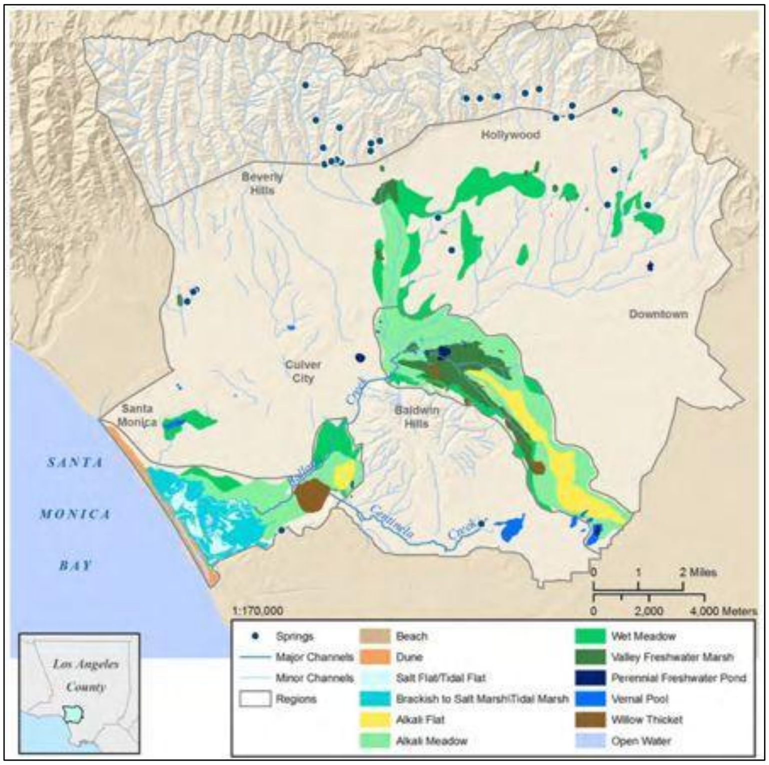


Figure 1-2. The historical wetland habitats of the Ballona Creek Watershed (Dark et al. 2011).

The results of this study provide a basis for rational discussion of the restoration options available for the Ballona Wetlands, as well as showing locations and potentials for enhancement and weaving of streams and habitats into the dense urban fabric of the western portion of Los Angeles, from Hollywood to the ocean. It does not, however, include descriptions of upland vegetation.

As part of a planning effort for the Elysian Valley of the Los Angeles River, Longcore (2016) compiled and interpreted maps, photographs, and archival sources to describe the nature of the Los Angeles River and its floodplain and terraces between the confluence with the Arroyo Seco and the entry of the river to the San Fernando Valley. The resulting map shows how the river channel once meandered and cut back on itself in places, yet was remarkably stable in other places in response to other historical hydraulic features (Figure 1-3).

Yet this stretch in Elysian Valley is the only portion of the Los Angeles River and watershed for which there is a detailed reconstruction of the historical ecology upon which to draw to inspire and inform potential restoration and ecological management proposals or to educate the public about the rich landscape history of the site at the neighborhood scale.

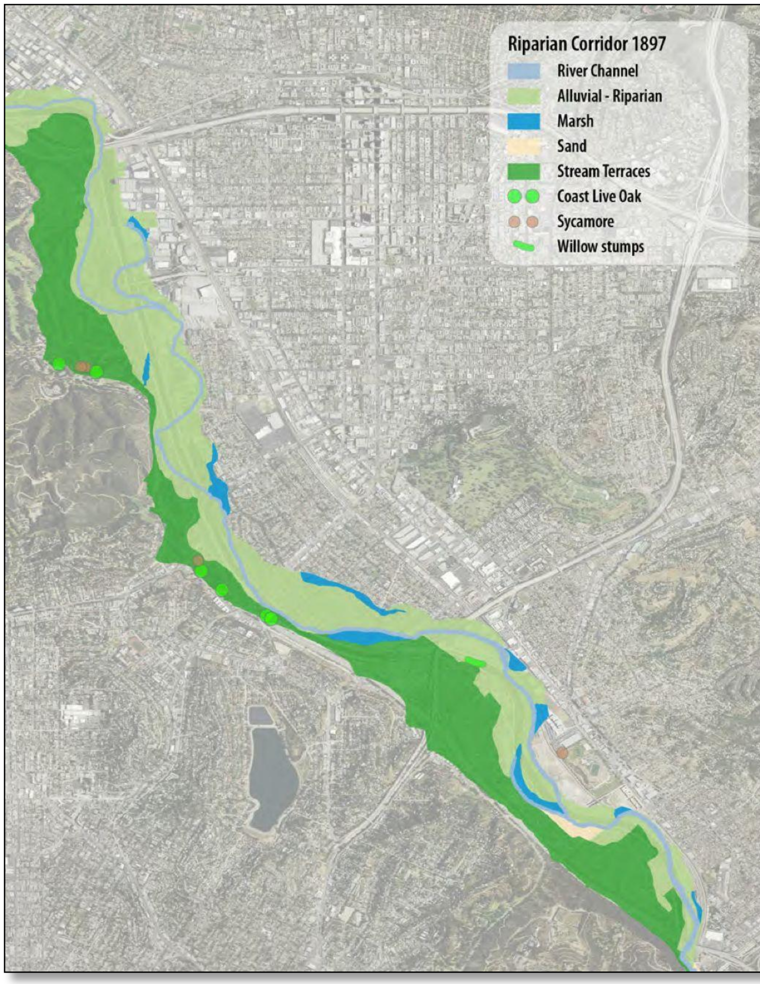


Figure 1-3. Habitats historically associated with the Los Angeles River through the Elysian Valley (Longcore 2016).

Other major historical ecology efforts in southern California have described the Tijuana River Valley (Safran et al. 2017), the many lagoons of northern San Diego County (Beller et al. 2014), and the Ventura River, Santa Clara River, and Oxnard Plain (Beller et al. 2011).

The San Gabriel River and floodplain was studied by an interdisciplinary team in the 2000s, resulting in a map of historical habitats, detailed historical descriptions, and description of the implications for restoration and management (Figure 1-4; Stein et al. 2007, Stein et al. 2010). The interrelationships between the San Gabriel River, Rio Hondo, and lower Los Angeles River were mapped and described, yet the Los Angeles River as a whole remains a blank spot on the historical habitats map.

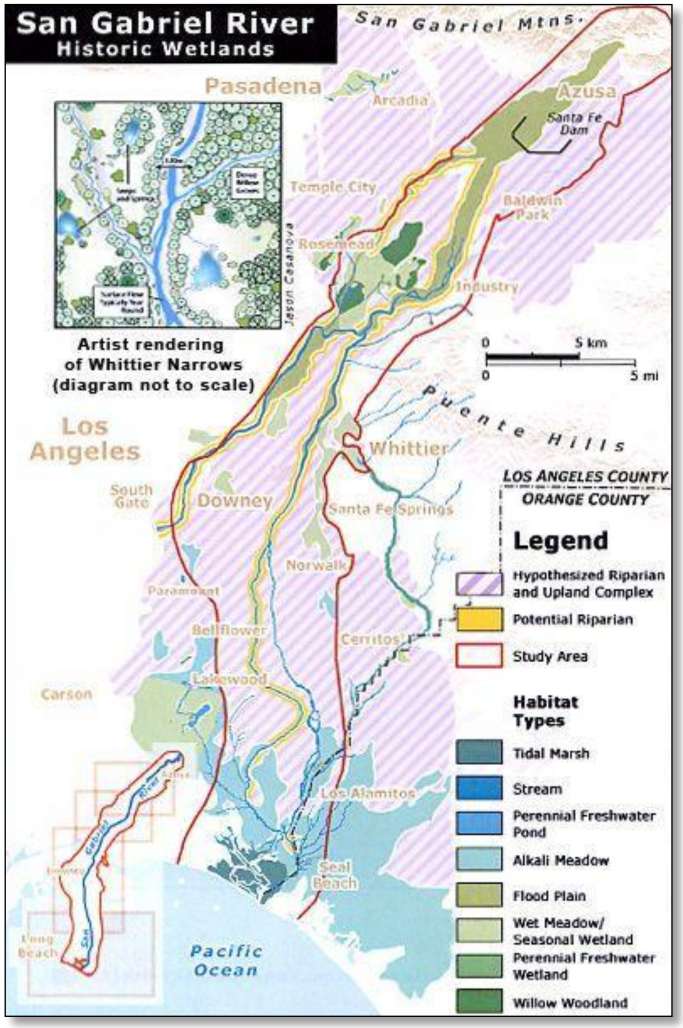


Figure 1-4. Historical wetlands of the San Gabriel River through the San Gabriel Valley and Coastal Plain (Stein et al. 2007).

In this context, it is somewhat remarkable that a detailed historical ecology effort has not yet been mounted for the Los Angeles River. With the exception of the Los Angeles Coastal Prairie (Mattoni and Longcore 1997), these efforts have predominantly focused on wetlands and riparian vegetation, with less attention to upland habitat types such as oak woodlands, chaparral, grasslands, and coastal sage scrub. Gumprecht (1999) provided maps that documented many features of the Los Angeles River and its floodplain, but did not provide the results at a sufficiently high spatial resolution to inform local restoration and management efforts.

1.3 Project Objectives

To fill this knowledge gap and management need, we set out to gather information and create a framework that would be the basis of a detailed historical ecology study of the Los Angeles River watershed and environs. Toward that goal we pursued four objectives:

1. To discover and geolocate historical information in archives that had not previously been widely available to researchers.
2. To develop, test, and share an online mapping tool and associated spatial database to support sharing and analyzing historical information in many formats (maps, text, photographs).
3. To synthesize and describe the historical periods leading up to the modern era; and
4. To develop a map of the historical ecology of the Los Angeles River watershed and environs in the form of the potential natural vegetation at a 1-km square resolution.

The geographic scope of the project is the Los Angeles River watershed, with a focus on the Los Angeles River. We also include information from the Ballona Creek Watershed and the coastal watersheds along the coast to the south. Because this area encompasses ~3,200 km^2, it is a medium-scale project: seeking to compile information to understand the broad patterns of the landscape. Although we seek to connect historical information to locations as accurately as possible, the geographic scope of the work precludes detailed work at the scale of meters. To establish the knowledge infrastructure for a comprehensive coverage of the entire Los Angeles Basin at the neighborhood scale, we established, in this two-year project, a comprehensive coverage at a 1-km resolution. Neighborhood-level work at the scale of meters will be the focus of future phases of the project.

Chapter 2 Approach and Methods

2.1 Establishing the "Historical Ecology" Framework and Chronology

To conduct the necessary archival research to estimate the "historical ecology" of the Los Angeles River and watershed, we needed first to develop a framework within which the term "historical" could be deployed with precision and specificity, and within which the sense of "ecology" can be compared across different time periods. How far back in time does "historical" begin and end? What justifies the choices of dates and time periods to cut up the past into coherent eras? "Historical" needs to be unpacked along two major dimensions: "natural" and "human," and the powerful interaction between the two need to be understood before any chronology is possible. Likewise for the term "ecology." Given that humans have densely occupied the Los Angeles region and exploited its natural resources for thousands of years, the term "ecology" must, for all practical purposes, always include a very large component of human contributions. Because the First Peoples of Los Angeles began their settlement of the Channel Islands and then the mainland beginning about 9,000 years ago, that long past needs to be understood as "historical," but must also be parsed into more meaningful and useful time periods.

Even more daunting is the pre-human past of the Los Angeles region. Because the goal of this study is to establish a reliable account of the "potential natural vegetation" (PNV), it is tempting to simply say: "natural" would be the ecology that operated prior to human settlement and manipulation. As if getting an accurate picture of the ecology 9,000 years ago was not hard enough, that date would not even serve to identify an undisturbed "natural" state of the landscape. Prior to the first (Clovis culture) arrival of human beings about 13,000 years ago, the Pleistocene megafauna—giant herbivores (mammoths, mastodonts, giant sloths) and their also-giant carnivorous predators (American lions, short-faced bears, and saber-toothed cats)—powerfully shaped their environments through massive vegetal consumption, stomping, and soil disruption. It would be pointless, therefore, to look at the pre-human landscape for insights about a current landscape that lacks megafauna. Rather, the influences of both the megafauna and period of human occupation inform understanding of the landscape and the species remaining on it today, or with the potential to be restored given the landscape's natural history.

For Angelenos to have a reliable portrait of the historical ecology of their region, cities and neighborhoods, the vastness of the past needs to be brought under control by developing a commonly accepted understanding of its meaningful periods and dynamics. We hope that this study will begin to provide a lasting basis for such an accepted general chronology: one that is based on solid evidence now, and can be adjusted in future years as knowledge becomes more refined.

Fortunately, Southern California's natural and human past has been studied systematically for well over a century. That body of "Western" scientific knowledge comes after the indigenous knowledge remembered by the living descendants of its First Peoples: the Chumash, the

Tongva, and their many neighbors: the Cahuilla, Serrano, Payomkawichum, Tataviam, and others. Establishing a coherent chronology for the historical-ecological eras—and the dynamics shaping those eras—is not a matter of new research, but of synthesizing the body of knowledge that we already have.

The following are the main bodies of knowledge we have synthesized for the Los Angeles region:

1) Geologic and climate history;
2) Ecological and environmental sciences;
3) Human archeology, anthropology, paleolinguistics, and paleogenetics;
4) Indigenous oral memory and eyewitness testimony;
5) Euro-American historical eyewitness accounts during their conquest of the region; and
6) Contemporary research into ecological dynamics and relict landscapes (native plant and animal communities where non-native invasive species have not become dominant).

This wide array of knowledge types (represented in the Primary and Secondary Sources section at the end of this report) is certainly daunting in its scope, encompassing many disciplines and reams of published scholarship. We did not set out to synthesize it completely, but rather, we set out to synthesize it sufficiently to establish the *framework* for a chronology that will provide the scaffolding for the future, ongoing integration of interdisciplinary and intercultural knowledge about the different past eras and periods of the region's long and varied historical ecology.

2.2 Archival Research

The key task for archival research revolved around "mining the unmined," to search for archival data sources that either have not been studied closely, or not have not yet been digitized (so that they can be analyzed in relation to other sources more effectively).

Our team was familiar with published works on the Los Angeles River. We know of the primary sources used in those published secondary sources, many of which are readily available today, and began with those well-known sources, before recruiting new ones. Additionally, historical ecology research projects for other areas had used certain types of sources that had not yet been exploited for the Los Angeles River. Therefore, the first phase of our research was a search for "historical gems" or the "needle in the haystack" types of sources that could help identify natural landscape features or habitats within the watershed, or gain insight into the Los Angeles River as it was before heavy urbanization at the end of the 19th century. Our approach in the archives pinpointed certain selection criteria such as locations or infrastructure near the LA River, hydrological or geological sources, and any other types of materials that could help in understanding the ecology of the river and its watershed.

Mining unmined archives meant visiting various collections, including the LA City Archives (Piper Technical Center); the Water Resources Collections and Archive (WRCA) at UC Riverside;

the Western Foundation of Vertebrate Zoology; and the Seaver Center for Western Historical Research at the Natural History Museum in Los Angeles. For nearly all of the archival collections/materials consulted, we used a camera to photograph manuscript files, maps, city or county reports. We also downloaded and geo-rectified scanned archival maps and reports, either available through a digital archive or sent from the archive directly to us.

Some examples of the types of sources we found and incorporated into our study include surveyor field books, diaries, archival maps, correspondence, flood control reports, river flow studies, city and county ordinances, and bird nest cards and egg records.

Table 2-1. Archives visited.

C. Erwin Piper Technical Center (City of Los Angeles Archives)
California Institute of Technology
The Huntington Library
Long Beach Historical Society
Long Beach Public Library
Natural History Museum of Los Angeles County; Seaver Center for Western Historical Research
Water Resources Collections and Archive (WRCA), University of California, Riverside
University of Southern California (USC) Libraries
The Western Foundation of Vertebrate Zoology (WFVZ)

2.3 Geodatabase Development

We defined the study area as the Los Angeles River watershed, plus the Ballona Creek watershed and all other coastal watersheds southward to the San Gabriel River watershed. These boundaries were defined by contemporary drainage and topography as reported in the National Hydrography Dataset (NHD). We extracted a 1-km grid from the Military Grid Reference System that covered all of the area of interest plus a minimum of one grid cell outside every watershed of interest and used this as the framework for data integration.

Spatial data were managed using GIS (geographical information science/system) software tools from Esri's suite: ArcGIS Pro, ArcMap, and ArcGIS Online. As a primary base layer for geolocating and georeferencing historical data, we used a mosaic of large-scale (1:24,000) 1920s USGS topographic map quadrangles for Los Angeles County that had been developed by Itatsu and Ethington (2006). This layer was published as a GIS feature service in ArcGIS Online and shared within a defined user group of project participants. Earlier (1894–1904) USGS maps at smaller scale (1:62,500) were incorporated from the online USGS Historical Topographic Map Explorer (USGS, Esri 2019). We added additional historical maps that were previously georeferenced or georeferenced as part of the project to the group so that these reference sources were available to different team members as research aids and to inform interpretation.

We created an "Archival Data Capture" GIS feature service, editable by all project participants, to contain geographic locations associated with historical information (e.g., field notes, sketch maps, photographs) represented as polygons and points. Geodatabase feature attributes were developed and refined to capture details about specific resources (e.g., the name of the archive and collection; author; the item, source type and year; event year and month; keywords; notes), and the service was enabled to accept multiple photographs of archival data as image attachments to each record. The feature service was also added as a layer to an archival data capture map in ArcGIS Online. Any team member could then use desktop or cloud-based Esri software tools to create a polygon or point to delineate the spatial extent of a historical resource and save the associated information to ArcGIS Online, with all information archived in a single database. Separate editable feature services with appropriate attribute fields were developed for other new information layers we created (e.g., explorers' landscape descriptions, potential natural vegetation) and for collateral data sources (e.g., locations of indigenous villages, herbaria records, natural history observations).

2.4 Georeferencing New Sources

As part of our goal of unlocking new information from historical documents and placing them on maps for spatial integration, we georeferenced and geolocated archival materials and text. These fell into two broad categories: an extensive effort to identify locations described in the diaries of Spanish explorers to link these historical texts to landscape features, and geolocating and georeferencing maps, sketches, and texts from archives.

2.4.1 Parsing of Spanish explorer diaries

Every account of the pre-European conquest California environment depends, ironically, on the observations recorded by the Spanish conquerors themselves. Native Americans' accounts of their environment are invaluable, but the European observers registered their wonder at distinctive features which were considered normal and therefore unremarkable to indigenous observers and attempted a catalog or survey that can be used in conjunction with other sources to visualize specific landscapes. These accounts begin with the diaries of the seaborne visit by Juan Rodriguez Cabrillo in 1542, but the Spanish neglected California for over two centuries after that. Detailed accounts begin with the journals of Father Juan Crespí, the priest and diarist of the Portolá–Serra Expedition to found Spanish California in 1769. Scores of other accounts followed, and scholars have been mining these accounts for generations. Because the expedition diarists were required to keep detailed daily accounts of the natural resources available at all points along their routes up the coast seeking locations for missions, forts, and towns, these diaries provide a valuable snapshot of how the environment appeared to European eyes at "first contact."

The remarkably rich Crespí diary has never been fully exploited, however. Scholars and environmental scientists have long quoted apt passages to support claims about flora, fauna, and cultural practices of the indigenous, but Crespí's observations have never been systematically mapped to reconstruct as precisely as possible the locations of each specific observation. We were greatly aided in constructing such a map by the new edition and translation of Crespí's original diary, published by Alan Brown in 2001. Brown rediscovered Crespí's lengthy field diary in a Mexico City archive and took pains to reconstruct the locations of each campsite along the expedition's route from the Yuma Crossing of the Colorado River, through the Los Angeles Basin, the Central Coast, to the San Francisco Bay and back from 1769–1770.

We created a new map of information about the natural environment in the Crespí diary by parsing its contents into discrete spatial units. The "campsites" geolocated by Brown are only one reference point in the journals. Typical entries were evidently written at the end of a day, so they constitute Crespí's narrative of a journey from one campsite to another, and therefore contain many more locations than campsites. The spatial structure of the narrative is complex. In his daily diaries, Crespí mixes observations made by himself about his immediate surroundings, with observations made about landscapes observed from a distance, and with observations made by scouts and reported to him at camp or along the trail.

We therefore divided up each day's diary entry into separate locations. "Location 1" often referred to the "campsite" from which the day's journey began, at times including the first few leagues that the Expedition traversed. "Location 2" could then refer to the crux of the day's travels and where they would end up; or it could describe a stop they made along the way, or a landscape observed in the distance; and so on for Locations 3, 4, etc. An example could be taken from the day the Expedition stops at the Los Angeles River, 2 August 1769, or Porciúncula Day. "Location 2" describes their arrival at the LA River and some of the flora observed there. "Location 3" refers to the valley seen from a distance. "Location 4" describes the La Brea Tar Pits, where the Captain and scouts saw "volcanoes of pitch coming out of the ground like springs of water," coming from "about half a league or more from this spot, where we made camp, to the west…"

Another task of parsing through Crespí's diary entries revolved around separating descriptions into different categories, including "landscape feature," "flora," and "fauna." We also highlighted "Environs," or places Crespí described in the distance that could be associated with its present-day location. For each location, any description of landscape features, flora or fauna was inserted into a table with these distinct categories, and each entry included both Spanish and English text, using Brown's (2001) translations. We also incorporated the full text of Crespí's diary entry for each day, in both Spanish and English, with each location highlighted throughout. Some examples of landscape features — the broadest and most cited category — include "a very wide-reaching, spacious valley of very level dark friable soil"; "a great deal of running water in a north to northeastward direction through gaps in many mountain ranges at this same plain"; and "a village of some ten grass houses, where they had a good-sized stream of water nearby." Flora and fauna categories include descriptions of specific plant, tree, or animal species.

A table containing these categorical divisions and how we parsed through them can be found in the Results section. We also parsed and geolocated descriptions from the diary of Captain

Pedro Fages from the Portolá–Serra Expedition. Fages wrote recollections of the days they spent along the way, and his entries were much shorter and less detailed than those of Crespí.

Each text-based "location" extracted from the diaries was then geolocated and represented by a separate data point on the map. Initial geographic coordinates were derived from Brown's (2001) geolocated "campsites." We collaboratively edited point locations using the descriptions of landscape features from the diaries, natural history records, environmental data, various types of maps, and expert knowledge.

2.4.2 Georeferencing and geolocating primary sources

For new primary sources, we used any available and reliable information to locate them on topographic base maps. For the purposes of this study, we describe *georeferencing* as the process of taking a digital copy of a map and associating it with a physical location, aligning it spatially within a GIS. Identifiable landmarks on the map are linked to places on historical topo base maps or contemporary data points, and the image is stretched, if necessary, to capture the true geographical extent as accurately as possible. Georeferencing requires interpretation of historical source material and is best supported by high-resolution scanned images of detailed maps with recognizable features that can be associated with collateral data. For maps we georeferenced, we used ArcGIS Pro and ArcMap georeferencing tools and shared the image services to our ArcGIS Online group.

For *geolocation*, we used the archival data capture feature service in the ArcGIS Online map to create polygons that defined the area to which information pertained. For archival texts, photographs, and sketch maps, we digitized a free-hand polygon that bounded the extent of the geography covered by the item. Archival maps that were excessively creased or folded within collection envelopes or without enough detail were geolocated rather than georeferenced. Within the geodatabase, the polygon geometry is associated with a spreadsheet of information about the item, including a description, the archive from which it was obtained, dates, and links to images of the items. All of this information was stored within the ArcGIS Online database.

2.5 Synthesis of Historical Ecology of Los Angeles River Watershed at 1-km Scale

As an initial synthesis of the data amassed as part of this project, we developed a map of the historical ecology at the 1-km scale. Because our goal was to understand the processes present on the landscape, we did not attempt to describe the vegetation exactly as it might have been in the late nineteenth century, but rather used information from that time period and later to describe the "potential natural vegetation" at that time. The concept of potential natural vegetation (PNV) was developed in the early twentieth century to envision what species a landscape would support in the absence of human disturbance. It is described as "The vegetation that would develop in a particular ecological zone or environment, assuming the conditions of flora and fauna to be natural, if the action of man on the vegetation mantle stopped and in the absence of substantial alteration in present climatic conditions" (Tüxen

1956, translated in Gallizia Vuerich et al. 2001). For landscapes such as the Los Angeles Basin, understanding potential natural vegetation provides a reference point to understand the distribution and effects of the long period of human occupation, and guideposts to understand the processes that shape the landscape and could be incorporated into future ecological restoration and management. To develop PNV, we consider the influence that the megafauna must have had on vegetation, but given their irrevocable absence, predict the vegetation patterns without them, and without the regular burning of the Indigenous Era. Neither of these factors remains on the landscape and cannot be incorporated into future land management. The patterns of environmental conditions made by the landscape itself, however, can be consulted as guideposts to interpret remnant features and to guide efforts to sustain the remaining native biodiversity. We therefore developed a map of PNV, using the 1-km grid established for the project, to describe the broad patterns and processes shaping the landscape and its ecological function. Because we expect this map to be refined, we consider it a "working draft" as a hypothesis to be tested and amended as research in the region advances.

To inform this map, we compiled an extensive set of historical data in the form of maps, texts, and geolocated records of natural history observations. These data included, for example:

- Topographical Map of Los Angeles River (1897. City of Los Angeles Bureau of Engineering, Compton and Dockweiler.);
- Detail Irrigation Map, Los Angeles Sheet and Santa Monica Sheet (1888. California State Engineering Department, Hall.);
- Soil Map. California. Los Angeles Sheet (1903, 1916, and 1917. USDA Bureau of Soils, University of California, and USGS.);
- USGS topographic surveys (1896–1904, 1:62,500 scale, 1923–1935, 1:24,000 scale; and a composite of 1:24,000 maps from the 1920s, Itatsu and Ethington 2006);
- Georeferenced localities of oak and walnut tree species recorded through 1930 from the Jepson Online Interchange for California Floristics;
- Many sketch maps digitized and georeferenced from the late 1800s and early 1900s;
- Orthogonal aerial photographs from the 1920s compiled by the UC Santa Barbara library; and
- Georeferenced texts describing natural landscape features extracted from diaries from Spanish expeditions in the 1700s.

In addition, we consulted high-resolution maps of contemporary annual precipitation, slope, elevation, and aspect as available through Esri's Living Atlas.

With all these layers available and easily visualized in ArcGIS Pro, we assigned each cell in the grid to a vegetation macrogroup. We used macrogroups to remain compliant with national vegetation mapping standards and because finer-scale inferences about potential vegetation across the region would be difficult without extensive environmental niche modeling (see Longcore et al. 2018). Macrogroup classification considers regional topographic differences and provides an ideal starting point to understand landscape processes in shaping vegetation patterns.

Table 2-2. Vegetation Macrogroups of the Los Angeles River Watershed and Environs.

California Chaparral
California Grasslands and Flowerfields
Coastal Dune and Bluff Scrub
Coastal Sage Scrub
Desert Wash Woodland and Scrub
Foothill and Valley Forests and Woodlands (include Oak and Walnut woodlands)
Mixed Evergreen and Montane Conifer Forest
Montane Riparian Forest and Woodland
Riparian Forest
Riverwash
Freshwater Marsh
Lakes
Salt Marsh
Salt Marsh Meadows (including Alkali Meadow not influenced by seawater)
Vernal Pools
Wet Meadow

For each 1-km^2 grid cell we used a 50% rule to assign it to a macrogroup, except for isolated water features in an upland matrix we assigned the water feature at 40% to illustrate distribution of such features. For areas of the study area for which historical ecology studies had already been completed (Mattoni and Longcore 1997, Stein et al. 2007, Dark et al. 2011, Longcore 2016) or where current vegetation is relatively undisturbed (Keeler-Wolf and Evens 2006), we used those studies and converted to macrogroups using the 50% rule. The available macrogroups for classification were stretched in their meaning in some instances. We used "Salt Marsh Meadows" as the macrogroup for Alkali Meadows (see Stein et al. 2010, Dark et al. 2010), even though alkali meadows develop in areas not associated with salt marshes.

2.6 Data Sharing and Outreach

Sharing data from the project requires a multi-level approach. For working on the project, we used an internal ArcGIS Online group so that team members could access, map, and edit spatial data associated with the project, but by default no information was shared outside the group. As additional permissions are obtained from archives, we will move content from the project into ArcGIS Online groups that are accessible to the public, or if required by the archives, only to researchers who will be provided login credentials to access the data compilation.

By serving all of the data as feature layers in ArcGIS Online it will be available for any user with appropriate permissions to add the information to their own map. Serving the data this way allows us to update the underlying data as new information becomes available and to ensure that the appropriate metadata and acknowledgements necessary for archival sources are served to the user with the data itself. We have and can maintain different sharing permissions (e.g., view only, download) for resources obtained from different archives in this manner.

As the project progressed, we responded to data requests in this manner, by sharing map feature layers to interested parties as part of building a shared research infrastructure for the project. Other shared layers were incorporated within online map viewers. We developed ArcGIS Online web map applications that incorporate various GIS feature layers to allow users to visualize various datasets together in a spatial context; for example, overlaying transparent potential natural vegetation grids on archival data polygons and explorer journal waypoints, with historical topo map base maps. We tested many configurations for web map “pop-ups” that display when users “click” on map locations, allowing access to attribute information, image attachments, or hyperlinks to compiled archival data resources associated with individual map features. Cloud-based GIS, ArcGIS Online, and the expression language used for pop-ups and visualization have evolved over the life of the project; adjustments for new data-sharing permissions will incorporate relevant updates.

Chapter 3 Four Eras in the Historical Ecology of the Los Angeles River Watershed in Natural and Human Time: From the Pleistocene to the Present

The ecological past of the Los Angeles River and Watershed is extremely deep, but it divides coherently into four historical-ecological *eras*, each with sub-*periods* marking important shifts within each major ecological era. Each era is a *regime* of faunal-landscape interactions bounded and punctuated by climate change events.

1) Pleistocene-Megafaunal (2.6 mya to 9,000 BP)
    A) Early to Mid- Pleistocene (2.5 mya to 1 mya)
    B) Rancholabrean (1 mya to 30,000 BP)
    C) Late Pleistocene Mediterranean Transition (30,000–15,000 BP)
    D) Catastrophic Extinction Event (15,000–10,000 BP)
2) Indigenous (9,000 BP to 1769)
    A) Early Period, about 9,000 BP until about 2,500 BP
    B) Middle Period, about 2500 BP to 1150 CE (600 BCE to 1150 CE)
    C) Transitional Period ("Time of Troubles"), 1150–1300
    D) Late Period, 1300 CE to 1769
3) Euro-American Conquest (1770s–1870s)
    A) The Spanish Conquest, 1769–1821
    B) The Mexican-American Rancho and Viticulture Economy, 1821–1860s
4) Urban-Industrial-Global (1870s-Present)
    A) Rise of Citriculture, Agriculture, Industrialization, and Urbanization, 1870s-1940
    B) The Military-Industrial Metropolis, 1940s–1990s
    C) Globalization, Climate Change, and the Rebirth of Sustainability, 1990s–Present

We begin marking ecological eras in the Pleistocene (2.6 Mya to 13,000 years before present), because most of the flora and fauna that are common and endemic to the region evolved during the Pleistocene, and adapted to the South Coast Bioregion's unique characteristics as it went through many glacial and interglacial cycles and eventually transitioned into a Mediterranean-type climate. The biota of the South Coast Bioregion descend from the Pleistocene Epoch, so today's potential natural vegetation is derived from both the Pleistocene (2.6 mya to 13,000 years ago, and the Holocene/Anthropocene (13,000–present), but not the preceding Pliocene (5.4–2.6 million years ago), when global temperatures were much higher, the Los Angeles region was actually undersea.

The native flora and fauna of the Los Angeles region today are of Pleistocene ancestry, which survived the last extinction event. Understanding how the landscape evolved during the Mediterranean Pleistocene is of paramount importance for understanding the potential natural vegetation today. Following the mass extinction event of circa 13,000–10,000 years ago, in which the landscape-shaping megafauna passed from the scene, three eras of human occupation, exploitation, and landscape-shaping followed. The Indigenous Landscape was that shaped by the intensive management of plant and animal species by the Chumash, Tongva, and their neighbors. It was suddenly disrupted by the Euro-American conquest and massive introduction of non-native species during the period 1770s–1870s, causing "type conversions" in the landscape and mass death and cultural collapse among the indigenous population. That era, characterized by a rapidly developing agricultural and pastoral economy dependent upon vast herds of grazing livestock, was replaced by an urban-industrial ecological era, which we date from the arrival of the first transcontinental rail link in 1870. The entirety of the four eras are represented in Figure 3-1.

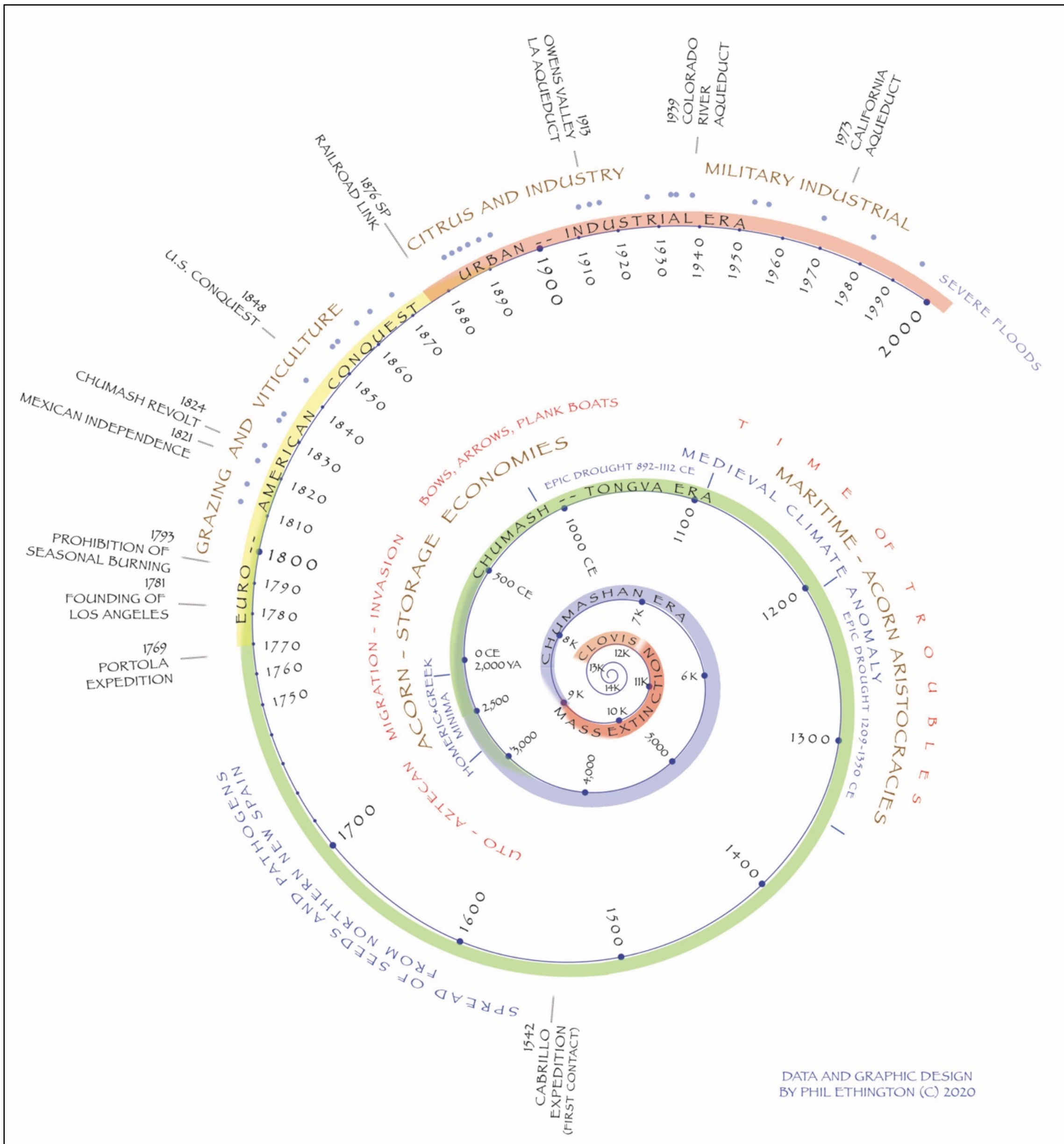


Figure 3-1. Historical Ecological Eras of the Los Angeles River within the South Coast Bioregion

3.1 The Geologic and Evolutionary Formation of the South Coast Bioregion

Southern California is an "island on the land" within an island of biodiversity: the California Floristic Province, one Earth's top-25 "biodiversity hotspots" (Figure 3-2; Myers et al. 1999).

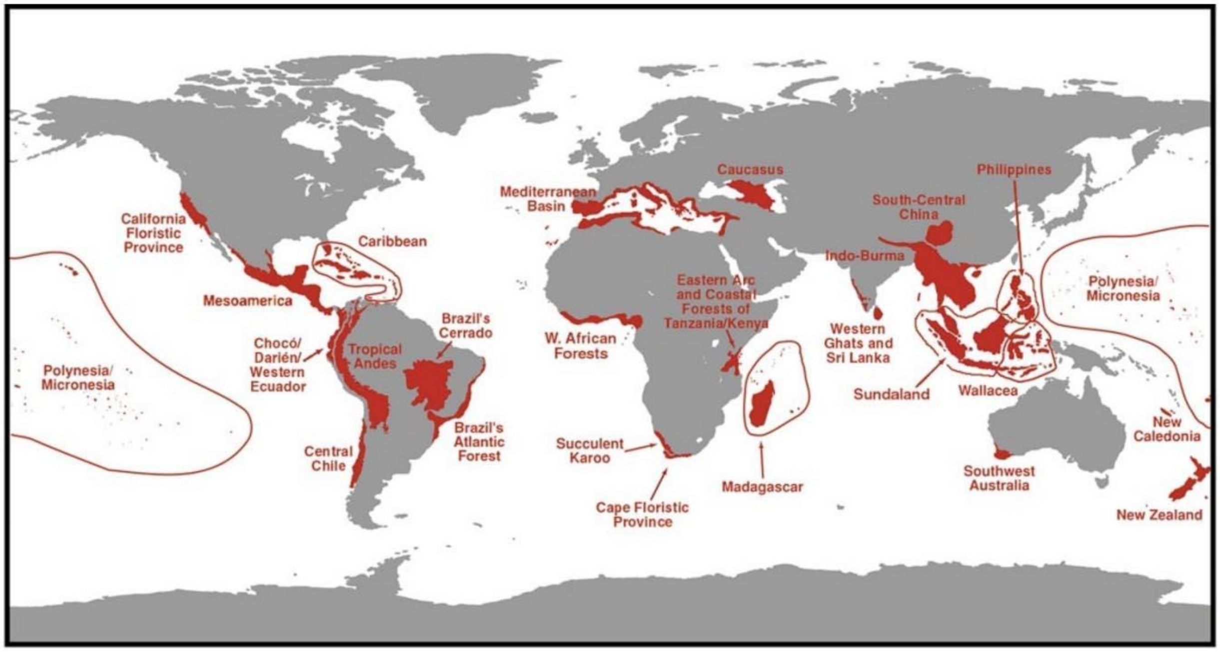


Figure 3-2. The California Floristic Province within the top 25 Global Biodiversity Hotspots. "As many as 44% of all species of vascular plants and 35% of all species in four vertebrate groups are confined to 25 hotspots comprising only 1.4% of the land surface of the Earth." Map and quotation from (from Myers et al. 1999: 853).

Walled-off from the rest of North America by Sierra Nevada Mountains, the California Floristic Province is home to thousands of endemic plant and animal species: those native and geographically restricted to it. Calsbeek et al. (2003) have shown through genetic analysis that the evolutionary rise of California's endemic species coincided with the formation of the Sierra Nevada beginning 20 million years ago. Within this highly endemic province, the South Coast Bioregion is isolated once again by the Transverse Ranges, which isolated Southern California from the rest of the region, forming another regional ancestral lineage: "Most animal taxa had an obvious genetic split that separated northern and southern populations about the Transverse Ranges." Even marine species are subdivided north and south of Point Concepcion, where the Santa Ynez Range pierces the sea and forms a ninety-degree turn in the Pacific coastline (see Figure 3-3) and anchors the northern boundary of the California Bight (Calsbeek et al. 2003: 1023).

Figure 3-3. The Transverse Ranges and Major Watersheds of the California Bight

Southern California is a product of the Transverse Ranges, which run about 275 miles east to west from Point Arguello to the Mojave Desert, at about 50 miles in width, with peaks exceeding 10,000 feet. It is the only major mountain chain in California to run east-west. During the late Miocene, from about 17 to 8 million years ago, a snag in the slippage between the Pacific and North American tectonic plates along the San Andreas Fault rotated this segment of the Coast Ranges 90 degrees. This rotation also deformed the coastline to shape the California Bight, creating mostly south-facing beaches along the coastline from Pt. Concepcion to San Diego. The Channel Islands are the semi-submerged extension of the Transverse Ranges, forming the Santa Barbara Channel that lies between islands and mainland comprises a distinct marine ecosystem, with lee-side kelp forests nourished by upwelling cold currents from underwater canyons (Hall 2007; Keeley 2006).

By Earth's chronology, the steep rocky ridges of the Transverse Ranges are very young and still growing. The five major Transverse Ranges are: the Santa Ynez; Santa Monica; Castaic or Liebre; San Gabriel, and San Bernardino. Lying between these ridges are its watersheds and drainages. From northwest to southeast, these are: the Santa Ynez, Ventura, Santa Clara, Calleguas, Los Angeles, San Gabriel, and Santa Ana watersheds.

The Los Angeles River and watershed lies at the very center of this region and shares every one of its sub-regional ecological zones, from saltwater estuaries to coastal shrublands, chaparral scrub, oak savannas, prairie flowerfields, and montane coniferous forests. Taxa and plant associations endemic to and typical of this entire region are as likely to thrive in the Los Angeles River watershed as anywhere else in the space bounded by the Transverse Ranges, the Peninsular Range, and the south- south-westerly facing beaches of the Pacific Ocean. In other words, ecological knowledge about the South Coast Bioregion as a whole provides the widest set of species that constitute the potential natural vegetation of the Los Angeles River's

Watershed and those adjacent and often overlapping with it (Santa Clara, Calleguas, Coastal, and San Gabriel).

3.2 Era 1: The Pleistocene-Megafaunal Era, 2.6 Mya to 13,000 Before Present

By about 1 million years ago, very large mammals—the largest known land mammals—began to stalk the bioregion. The name given to these fantastic beasts is "Rancholabrean," after Rancho La Brea, the La Brea Tar pits that constitute one of the world's richest Pleistocene records. These were the creatures who ruled the region until a sudden climate shift to colder temperatures known as the Younger Dryas, between 12,800 to 11,700 years ago, and the simultaneous invasion of humans.

We subdivide the first ecological era of the Los Angeles region into four ecological periods: A) Early to Mid- Pleistocene; B) Rancholabrean (1 mya to 30,000 BP); C) Late Pleistocene Mediterranean Transition (30–15,000 BP); D) Catastrophic Extinction Event (15,000–10,000 BP).

A) Early to Mid- Pleistocene (2.6 mya to 1 mya)

The entire Pleistocene of Southern California was punctuated by long glacial periods in which sea levels dropped and the geographic ranges of vegetation macrogroups such as grasslands, woodlands, and wetland plant communities, expanded and contracted according to suitability. Ice sheets extended from the polar to the mid-latitude regions, and a series of "ice ages" or glaciations typically lasted about 100,000 years, with interglacial warming lasting only about 10–15,000 years. Sea levels rose and fell significantly during each of these cycles, fluctuating by more than 100 vertical meters: extending or contracting the coastline horizontally by as much as 30–50 km along the California Bight. The distributions of plants also changed dramatically: "During maximum glaciations, elevational ranges of plants were 600–1,200 below present" (Schierenbeck 2014: 58) During glacial maxima, Southern California saw "the widespread distribution of *Hesperocyparis macrocarpa* (Monterey cypress), *Pinus muricata* (Bishop pine), and *P. radiata* (Monterey pine) in a climate in that region more similar to present-day Monterey" (Schierenbeck 2014: 59; Axelrod and Govean 1996). Oaks and other hardwoods were not dominant but survived in refugia until the interglacial periods allowed them to expand again relative to the softwood pines.

B) Rancholabrean (1 mya to 30,000 BP)

The long-term average abundance of Southern California supported immense biomass and extraordinary biodiversity during the Pleistocene. Evolutionary pressures of competition for this abundance led to the emergence of the "Rancholabrean" megafauna about 1 million years ago. The apex herbivore of the Pleistocene was the 10,000 kg (22,000 lbs) Columbian mammoth (*Mammuthus columbi*), which consumed an estimated 250 kg (500 lbs) of vegetation per day. Lesser herbivores were also gigantic: The Giant ground sloth *Paramylodon*, weighing 1,000 kg (2,200 lbs) could reach 10 feet to consume tree foliage, small branches, nuts and fruits (Stock and Harris 2001; Gill, et al. 2009).

Equally giant were the predators. At the apex of predation was the Short-Faced Bear (*Arctodus simus*), the largest mammalian carnivore yet discovered, as large as 1,000 kg (2,200 lbs, or one metric ton). *A. simus*, 2 m (6 ft) tall at the shoulder, stood 3 m (12 ft) on its hind legs, and could slash with its 6-inch claws as high as 5 m (15 ft). The behavior and specialization of this extinct bear has long been debated. A long-popular portrayal has been that *A. simus* was a long-legged fast-running super-predator with bone-crunching jaws and a primary diet of meat (Neiburger, 2006). A recent review and comparative analysis by Figueirido, et al. (2010) casts doubt on the most extravagant claims, however, indicating that it had much more in common with modern ursids. Even so, they confirm the enormous size and potential ferocity of *A. simus*: "a colossal omnivorous bear whose diet probably varied according to resource availability" (2010: 262). In this, it resembled the apex predator that survived the megafaunal extinction event, the modern grizzly. With numerous specimens estimated at 1,000 kg (2,200 lbs), *Arctodus simus* was as much as four times the size of today's grizzly bear: *Ursus arctos horribilis*, which reaches a mere 180–360 kg (400–790 lbs) (McLellan and Reiner 1992). The next-largest Pleistocene predator, the American Lion (*Panthera leo atrox*), weighed as much as 523 kg (1,153 lbs) and was far larger than today's African Lion (McLellan and Reiner 1992: 89–91).

Ample evidence "suggests that large Rancholabrean herbivores were very abundant and thus must have had dramatic and pervasive effects on vegetation and flora" (Edwards 2007: 49).

> Big herbivores have big effects on plants. Beyond the direct impacts of herbivory on the physiology, form and growth of individual plants, herbivores shape plant communities in many ways: by reducing vegetation density and creating gaps; facilitating species coexistence; dispersing seeds; suppressing sensitive species; reducing fire potential by preventing accumulation of dry plant tissue; and accelerating nutrient recycling via urine (Johnson, 2009: 2509).

Massive herbivores grazed, browsed, and trampled the landscape. Mammoths and mastodonts, like their living relatives the elephants, were migratory herd animals, impacting thousands of square kilometers of landscape and shaping local geomorphology and biodiversity substantially (Haynes 2012). Not only the largest herbivores, but the Pleistocene fauna also included grazers (pre-modern horse), grazer/browsers (mammoths, camels, elk, bison, and oxen), and browsers (mastodon, ground sloths, tapir, peccary, deer, and pronghorn) (Edwards 1992).

But the presence of such fearsome predators made the impact of herbivores on the landscape even greater. The hooves of a thousand bison (*Bison antiquus*), of elk (*Cervus canadensis nannodes*), and of pronghorns (*Antilocapra americana*), harried by swift predators such as the short-faced bear (*Arctodus simus*) or the American lion (*Panthera leo atrox)*, would have had a massive trampling impact on the grazing lands, while the mowing effect of so many hungry herbivores would have kept the plains open and ready for a maximum yield of fresh herbs and grasses each spring rainy season. "It is likely that such impacts by Rancholabrean megafauna helped to maintain large areas of grassland even during glacial periods when cooler, more mesic conditions favored forest" (Edwards 2007: 52; Johnson 2009).

C) Late Pleistocene Mediterranean Transition (30–15,000 BP)

As the cooler, wetter mesic conditions of the Pleistocene were succeeded by the warmer, drier conditions of the Holocene, the region became more fully Mediterranean. As Edwards (2007: 48) observes, "a climatically induced type conversion from lush Pleistocene grasslands to arid Holocene landscapes dominated by native annuals had already diminished megafaunal populations." Evidence indicates that "Megafaunal populations collapsed from 14,800 to 13,700 years ago, well before the final extinctions" associated with the arrival of Clovis Humans (Gill, et al. 2009: 1100).

D) Human Invasion and Catastrophic Extinction Event (15,000–10,000 BP).

The end of the Southern California Pleistocene arrived with a possible extraterrestrial impact event circa 12,800 and the sudden, "Impact Winter" cooling event called the Younger Dryas 12,800 to 11,700 years ago (Walbach et al. 2018a, 2018b; Gill et al. 2009; Burney and Flannery 2005).

Encountering "capital accumulation" in the form of biomass, the first Humans in the bioregion, the Clovis culture, hunted the megafauna with devastating impact. Already diminished in scope and stressed by the rise of a fully Mediterranean climate, the final extinction of the Rancholabrean megafauna is attributed to the hunters of the Clovis people who arrived during this period of climate change. They pushed to extinction not only the giant herbivores but the giant cats, lions, and bears that fed on them (Sandom et al. 2014). This was the first major ecological collapse for the region.

Of the approximately 60 North American megafaunal species that disappeared, most were herbivores (Barnowsky et al. 2016: 856), so the "loss of keystone megaherbivores may thus have altered ecosystem structure and function, by the release of palatable hardwoods from herbivory pressure and by fuel accumulation" (Gill et al. 2009: 1100). The release of the megaherbivore pressure on hardwoods coincided with the retreat of the pine forests typical of the Last Glacial Maximum, and the expansion of favorable habitats for the *Quercus* (oak) and *Juglans* (walnut) genera into the coastal valleys, canyons, and riparian terraces that typify the fully Mediterranean landscapes of the Southern California Holocene (Davis, Baldocci, and Tyler 2016; Axelrod 1983).

3.3 Era 2: The Indigenous Landscape (9,000 BP to 1769 CE)

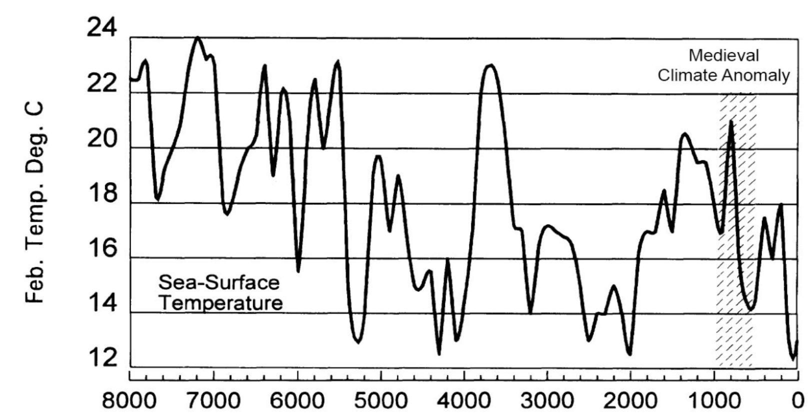
The second era is divided into four periods.

A) Early Period, about 9,000 BP to about 2,500 BP
B) Middle Period, about 2500 BP to 1150 CE (600 BCE to 1150 CE)
C) Transitional Period ("Time of Troubles"), 1150 to 1300 CE
D) Late Period, 1300 to 1769

The Indigenous era began not long after Southern California's Mediterranean climate of cool wet winters and hot dry summers had become fully developed. Mediterranean-type environments, occurring between latitudes 23 and 45 north and south of the equator, on the western sides of continents, are rare bioregions that comprise only a small portion of the Earth's ecological zones: the eponymous Mediterranean Basin itself; coastal California; coastal Chile; portions of South Africa; and portions of Australia. They are typified by evergreen and drought deciduous, drought- and fire-adapted vegetation, dense shrublands, flowerfields and grasslands, woodlands, and coniferous montane forests. Each Mediterranean climate zone is unique with endemic taxa, but plants from each zone tend to thrive in all other Mediterranean environments.

Three basic characteristics of the South Coast Bioregion have remained constant since the end of the Pleistocene: 1) Mediterranean climate; 2) Long-term abundance; 3) High climatic variability. These features have evolutionarily encouraged genera and species that are adapted to the extremes of drought, fire and flood.

Species native and endemic to the South Coast Bioregion are drought-, fire- and flood adapted, survivors of the severity of its otherwise generous climate (Schiffman 2005, 2007). The extremes of drought and flood to which species have adapted are apparent in long time-series of paleoclimatic data. In recent millennia there have been "epic droughts" lasting one and two centuries. Sea Surface Temperature (SST) of the Santa Barbara Channel has fluctuated substantially over the last 8,000 years (Figure 3-4).



Sea Surface Temperatures in the Santa Barbara Channel, 8,000 Years BP to the Present

From L. Mark Raab and Daniel O. Larson, 1997, "Medieval Climatic Anomaly and Punctuated Cultural Evolution in Coastal Southern California." American Antiquity,. 62: 2 (April), pp. 319-336, data drawn from Pisias, N. G. 1978 "Paleoceanography of the Santa Barbara Basin during the Last 8000 Years." Quaternary Research 10:366-384.

Figure 3-4. Sea Surface Temperatures in the Santa Barbara Channel since 8,000 BP.

Floods, droughts and fires follow one another in irregular oscillations. During the great flood during the winter of 1861–18622, when 50 inches of rain fell in just one month, “the Los Angeles, San Gabriel, and Santa Ana Rivers merged, emptying into the ocean as an 18-mile wide river” (quoted in Vellanoweth and Grenda 2002: 70). And yet the years 1863–1865 suffered a severe drought, killing almost 100,000 cattle and hundreds of thousands of grape vines, fruit trees, and other crops. (Engstrom 1996; Orsi 2004: 3, 12; Gumprecht 2001: 145). The bleached white bones from this die-off littered the landscape for years to come. Similar die-offs, of the vast herds of bison, elk, and pronghorn, would have occurred many times during the Pleistocene and Holocene. Herd die-offs were brutal, but they nourished the soil, conserving nutrients for later generations.

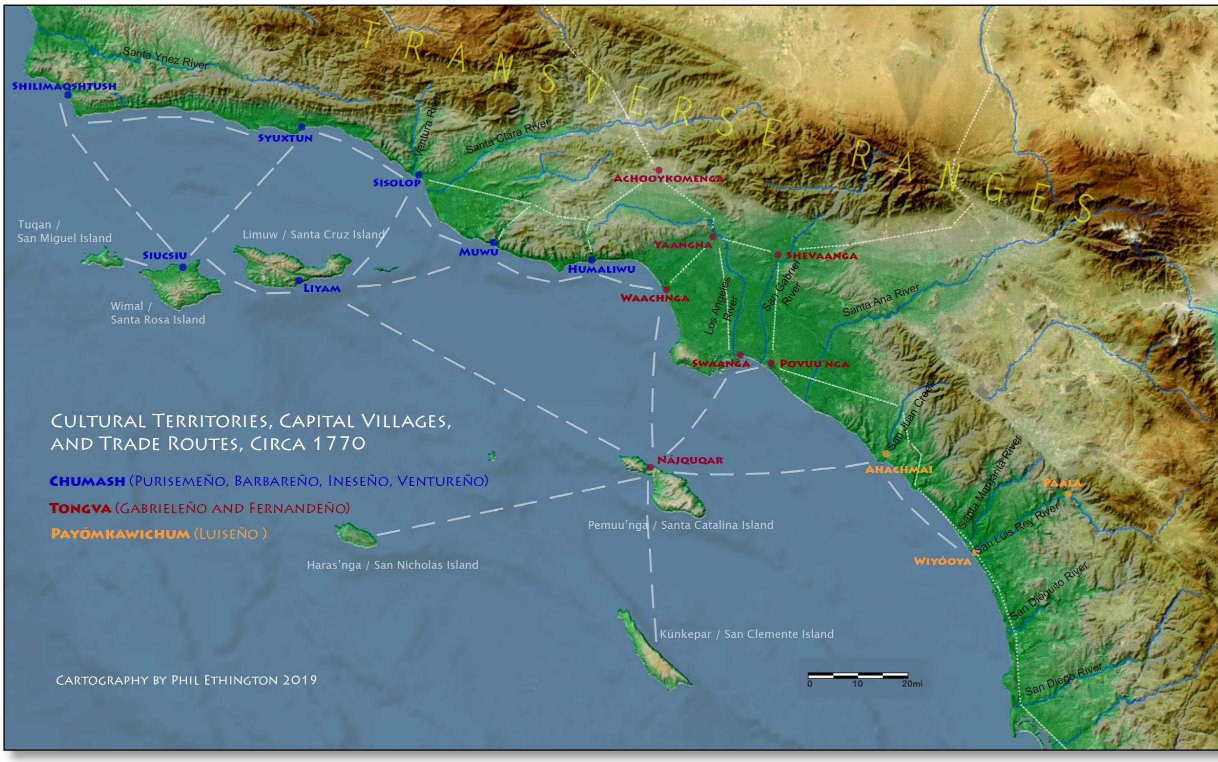


Figure 3-5. The Ancient Civilizations of the South Coast Bioregion

After the mass extinction event that struck the megafauna circa 11,500–9,000 years ago, long after the departure of the nomadic Clovis hunters, a new people arrived by sea whom we call the “Chumashans.” No living culture understands Southern California better than the Chumashans, whose language is the oldest of all California tongues. The Chumash first settled on Limuw (Santa Cruz Island) inhabiting and cultivating the Southern California region for more than 8,000 years. Chumashan cosmology begins with a picture of overall abundance punctuated randomly by drought, famine, and death.

According to the Chumash, above the underworld, called *cʔoyinasup*, and the mortal world called *ʔitiasup*, there is a third, supernatural world of the sky, called *ʔalapay*, where *Sloʔw*, the

Eagle, rules as chief, assisted by *Xiliw*, the Hawk. Each year, two gods of the sky, Sun and Šnilemun (Coyote), gather in a special place to play a game of chance for the fate of this world:

> Sun stakes all kinds of harvest products—acorns, deer, islay, chia, ducks, and geese—and when Šnilemun is the winner he cannot wait for the stakes to be distributed, but pulls open the door so that everything falls down into this world. And we humans are involved in that game, for when Sun wins he receives his pay in human lives (Blackburn, 1975, pp 91–2).

The long rule of the Chumashans over the region had an enormous impact on the landscape, which cannot easily be summarized. Our account condenses the most commonly accepted claims and findings across a vast body of indigenous and scholarly sources. It is a chronological-developmental framework developed principally by Ethington (2010; forthcoming), one of this study's co-authors. Here we emphasize the principal components of the indigenous cultures and political economies that had a shaping role in the composition of the landscape: its plant and animal concentrations and distributions, its alliances and associations.

Because our goal in outlining the major era and sub-periods of Southern California's ecological history is to outline the contours and predominant characteristics of the historical landscapes of the Los Angeles River region for each of the four broad historical periods that we have identified, our account of the Indigenous period, circa 9,000 BP to 1769 CE, emphasizes those themes, and refrains from delving into other aspects of the wide, deep and rich history of the ancient and diverse cultures who have occupied this landscape. Three principal components of this ecological era stand out:

1. The uniformity of the ecological-economic practices among all Human cultures of the South Coast Bioregion: Grouped as Chumash, Uto-Aztecan (Takic branch: including the Tongva, the Tataviam, the Kitanemuk, Serrano, and Cahuilla), and Payomkawichim (also called Luiseno, who are linguistically Uto-Aztecan but ancestrally Hokan).
2. The rise of densely settled, intensely sedentary acorn-centered storage and trading societies circa 2,500 years before present, which prioritized the management of oak woodland landscapes and intensified resource production in open grasslands and flowerfields.
3. The impact of anthropogenic fire on the landscape: through seasonal burning and firewood fuel consumption.

3.3.1 The Maritime-Terrestrial Civilizations of the South Coast Bioregion, c. 9,000 BP to 1769 CE

For thousands of years, Chumash, Uto-Aztecan, and Hokan-Yuman peoples controlled the core resources of the Southern California Bight (Point Conception to San Diego), centered on the Santa Barbara Channel: its fisheries, land and sea trade routes, river valleys, estuaries, wetlands, montane pine and foothill-riparian oak forests, oak savannas, and wildflower prairies.

At the core of this region, on the Santa Barbara Channel and the Los Angeles Basin, wealthy aristocracies with great social power ruled dense coastal populations. North of the Santa Monica Mountains lie the ancient Chumash homelands, where capital villages like Syuxtun (present-day Santa Barbara) with populations greater than 1,000 population sat atop an urban hierarchy ruled by great chiefs (Paquot) and lesser chiefs (Quot), and a permanent, hereditary aristocracy (Gamble 2008; Arnold 1992, 1996; Raab and Jones 2004).

With a total population of about 20,000 at the time of European arrival, the Chumash were the most populous and urbanized of all indigenous Californians. They settled the Channel Islands almost ten thousand years ago and, from linguistic and genetic evidence, are most probably the oldest population in Southern California (Codding and Jones 2013). The Daisy Cave (SMI-261) site on San Miguel Island dates between 9,000 and 9,600 years ago, "making it one of the oldest archaeological sites currently known in California (Byrd and Raab 2007: 219), and at one of the five bluff-top sites above the Ballona Creek wetlands, (LAN-64) is "one of the oldest sites along the California Bight," with radiocarbon dates as early as 8,200 years ago (Ciolek-Torello, et al. 2013: 16). The age differentials in Chumashan sites on the Channel Islands and those of the mainland strongly indicate a seaborne arrival, and a possible colonization of the mainland once population pressures overtaxed the resources of those islands.

By the time of the European conquest, the Chumashans had settled the islands and mainland river drainages for so long that their original language had separated into at least six separate tongues, as different as French, Spanish, and Italian are today. These tongues came to be known by reference to the Spanish missions that were established for each separate group, in recognition of those differences and the density of population: Obispeño (for the Mission San Luis Obispo); Cuyama (for the Cuyama valley, which does not have a mission); Purisimeño (for the La Purisima mission); Barbareño (For Mission Santa Barbara); Ineseño (for the Mission Santa Ynez); Ventureño; and Cruzeño (for the ancient home island of Santa Cruz, which does not have a mission). It takes at least 1,000 years of relative isolation for languages to separate, so we can infer a very deep history of occupation by Chumashans in these separate valleys. The environmental implications of their extreme sedentarism are discussed below (Beeler and Klar 1977).

Sometime after 5,500 years of Chumashan rule of the Santa Barbara Channel and its coastal plains, approximately 3,500 to 2,500 years ago, the ancestors of the people who call themselves Tongva today (whom the Spanish called Gabrielino) arrived in a slow-motion Uto-Aztecan migration-invasion from the high passes of the Tehachapi and San Gabriel Mountains southward to the Los Angeles Basin and further southward to the occupy the Southern Channel Islands: Santa Catalina, San Clemente, and San Nicholas.

These newcomers were members of the great northern and western Uto-Aztecan migration out of Northern Mexico, whose members include the Hopi and the Shoshone. By the time this stream reached California, they had formed the Takic linguistic family and formed a new homeland somewhere near the southern tip of the Central Valley. The mode of their migration and displacement—or incorporation—of the Chumashan people who formerly controlled the

Los Angeles Basin is a matter of great and long-running controversy (Sutton 2009; Johnson and Lorenz 2006; Johnson et al. 2012). It may be significant that their migration lies within chronological range of the Homeric and Greek climate anomalies, which may have put stress on the mountain and desert resource base, driving the Takic people to the richer lands of coastal Southern California (which would have been known to them from the trade goods that flowed into the interiors)

Two aspects of this ethnic succession are of immediate relevance to this study of the historical ecology of the Indigenous era. First, the speakers of the Uto-Aztecan language family, settling in separate valleys and watersheds, became isolated from one another long enough to evolve at least six different languages by the time of the European conquest in the 18th century. From north to south, these are the Kawiisu; the Kitanemuk; the Serrano; the Tataviam; the Tongva (Fernandeño and Gabrieliño, after the two missions of San Fernando Rey de España (1797, and the Mision San Gabriel Archangel, founded 1771); the Payomkawichim (Luiseño and Juaneño, after the two missions planted in its territory: Mission San Luis Rey and Mission San Juan Capistrano).

The second outstanding fact about the Uto-Aztecan migration-conquest by the ancestors of the Tongva is that the formerly desert-and mountain-based Uto-Aztecan people adopted the economy and lifeways of the resident Chumashans. By the time the Europeans first observed them, the Tongva were equally rulers of the sea and land, sharing their maritime mastery of ocean-going plank boats with the Chumash. In short, the Uto-Aztecan invaders acculturated themselves to the economic lifeways of the Chumash (McCawley 2002; Gamble, 2015).

As of the Spanish Portolá expedition of conquest in 1769, which provides the first detailed historical descriptions, the Tongva people of Uto-Aztecan descent plied the Santa Barbara Channel fisheries, cultivated, harvested, hunted, and fished the same resources, with the same techniques, as the Chumashans had done for all the generations before they arrived.

We observe a highly complex relationship is evident between the Tongva and their southern neighbors, the Luiseño, who call themselves Payómkawichum, and whose territory centers on the San Luis Rey River in present-day Orange County. The Payómkawichum speak an Uto-Aztecan language, related to Tongva to the same degree as Spanish and French are related. But remarkably, people of this identity do not share very much genetic ancestry with the Tongva: their donated DNA samples support, instead, a Hokan or Yuman ancestry, common with the people to their south and west: the Kumayaay (Ipai-Tipai, called by the Spanish “Diegeños”), and the Quechan (or Yuma) (Quechan: Kwtsaan) whose territory marks the southern end of the South Coast Bioregion at the Colorado River (Johnson and Lorenz 2006; Johnson et al. 2012).

The Payómkawichum, while not a seafaring people, shared the same terrestrial mode of production with the Tongva and the Chumash to the north. From all early European records, the ecological landscapes of these three people were nearly identical. The Spanish in their 1769, 1774, and later expeditions noted a marked change toward greater verdancy as they traveled northward, beginning with the San Luis Rey River, where they left behind the more arid Kumeyaay and Yuman territories to the south (the San Diego - Colorado River region).

For these reasons, it is possible to speak of a single Chumashan-Uto-Aztecan-Hokan indigenous mode of production, which would have put a uniform pressure on the landscape across the entire South Coast Bioregion centered on the Los Angeles River. Evidence from any of these societies will provide strong evidence of practices among any of the others within the region. Each used prescribed burning techniques on land in a seed- and acorn- centered economy, and, for the Chumash and Tongva, a full suite of maritime production, control of open-ocean transportation and sea lanes.

The indigenous people of this region, from each of the cultures named here, have been demonstrating and explaining to Euro-Americans for several centuries now, how they exploited those landscapes: how they made boats, nets, spears, fish hooks, and plank boats; how they harvested the seeds of the annual flowerfields, the fruits of the shrubs, and the acorns and walnuts of the woodlands. They have told their own stories of hunting bear, deer, elk, pronghorn, and rabbits; how they used thousands of species of plants for food, medicine, tools, weapons, cooking and serving utensils. Indigenous testimony about these practices continues to this day, as with a recent survey of tribal councils (Northwest Economic Associates and King, 2004). The anthropologist John P. Harrington (1884–1961) recorded extensive testimony from Chumash speakers such as Maria Solares 1842–1922), Luisa Ygnacio (1835?–1922), and Fernando Librado (1839–1915) These and others gave priceless accounts of the practices they could recall from the mid-19th century.

Drawing heavily on John P. Harrington's specimen collection and archival notes, Jan Timbrook (2007) has published an extraordinarily meticulous compendia called *Chumash Ethnobotany: Plant Knowledge Among the Chumash People of Southern California*. M. Kat Anderson (2005), Kent G. Lightfoot and Otis Parrish (2009) have published extensive guides to the full suite of Native Californian landscape management and resource use, covering practices of the people throughout the South Coast Bioregion. For foods, medicines and tools, hundreds of species were used by thousands of generations, each passing along its knowledge. Chia (*Salvia columbaria*) and Red maids (*Calandrinia ciliata*) were important and highly valued sources of nutrition, measured and traded in a standard unit of a women's basketry hat (Timbrook 2007: 46, 188–189). From shrubs the indigenous harvested a wide range of fruits and nuts: Toyon (*Heteromeles arbutifolia*), California juniper (*Juniperus californicus*) and Holly-leaved cherry (*Prunus ilicifolia*) (2007: 91, 108, 151). From trees, the Coast live oak *Q. agrifolia* were relied upon the most for the all-important acorns throughout the Los Angeles Basin, but also Valley oak (*Q. lobata*) and, in more montane zones, the Black oak (*Q. kelloggii*). For medicines, Yerba Santa (*Eriodictyon crassifolium*), and Verbena (*Verbena lasiostachys*) (2007: 83, 223–4). For arrow shafts, Carrizo (*Leymus condensatus)* and Scrub oak (*Q. beberidfolia)* (2007:111, 162–3), for sweeping brooms, Deerweed (*Acmispon glaber*) (2007: 117). These are just a handful of examples. Each was known for thousands of years by Chumash and Uto-Aztecan names, of course. Verbena was called *shikhwapsh 'i'ashk'a'* in Barbareño Chumash, and *s'uwmo' 'oyoso* in Inezeño Chumash. Carrizo, a Spanish name for Giant Wild Rye, was *shtemelel* in Barbareño

Chumash, *shakh* in Cruzeño, Inezeño, and Ventureño Chumash, and *tqmimu'* in Obispeño Chumash (Timbrook 2007: 111, 223–4).

In geographic terms, the center of this regional economy and cultural sphere was somewhere between the Chumashan capital village of Liyam on Limuw (Santa Cruz Island), and at the Tongva's capital village of Yaangna on the Los Angeles River--what became Downtown Los Angeles. To the South, the Luiseño San Luis Rey River villages from Wiyóoya to Páala, marked the southern extent of this coastal-montane regional complex.

The deep similarities and interconnections between these three peoples are important for the purposes of reconstructing the human and natural history of the Los Angeles Basin. The unity of its mode of production and resource base allows us to infer from surviving evidence from all three cultures, to characterize landscapes in the Los Angeles Basin. This unity is fortunate, because the Chumash and Payómkawichum cultures are better documented in the historical record than the Tongva. The Spanish were quick to extinguish indigenous cultures and economic practices and were more efficient and more rapid in wiping-out records and memories of Tongva culture than they were in destroying Chumashan and Payómkawichum culture. Secondly, the massive urbanization of the Los Angeles Basin has more completely obliterated both the archeological record and the living ecology in the Tongva territories. Santa Barbara and the coastal plain of Orange County have today retained large non-urbanized areas, even many old-growth oak riparian woodlands and oak savannas, from which we can draw more evidence of the overall civilizational complex that unified the Chumshan-Uto Aztecan-Hokan region.

3.3.2 Resource Intensification and the Rise of Acorn Aristocracies after 2,500 BP

As should be expected, the indigenous societies of Southern California underwent numerous changes over the course of their many generations of occupancy of the bioregion. Research over the last several decades has increasingly confirmed and reinforced the chronologies established by King (1990), Arnold (1992), and Raab and Larson (1997), which divide pre-conquest Southern California cultures into four broad time periods, adapted slightly by our own refinements:

1. Early Period, from the earliest date of about 9,000 BP until about 2,600 BP
2. Middle Period, from about 2500 BP to 1150 CE (600 BCE to 1150 CE)
3. Transitional Period, 1150–1300
4. Late Period, 1300 CE to 1769

While these developments and their particulars have been the subject of lively debates, we wish to draw only the largest generalizations from them, regarding the likely impact of these societies on the Los Angeles regional landscapes.

1. Early Period: 9,000 BP until about 2,600 BP

During this long period of initial sedentary occupation of Southern California, the Chumash controlled most of the Southern California Bight, perfecting marine pelagic fishing and marine mammal hunting techniques, expanding their villages from the Channel Islands into the mainland. In the Los Angeles Basin, they practiced seasonal field burning and for their vegetal staple they relied mainly on the seeds of the annual flowers such as Chia (*Salvia columbariae*), grasses and bulbs on fruits and nuts of shrubs. They hunted rabbits, deer, and other small game on the land, and marine mammals on the islands. Large millingstones are the signature artifact from this period across the region, leading to the long-applied archeological designation "Millingstone" for these cultures.

2. Middle Period: (2,500 BP/600 BCE to 1150 CE): The Rise of Acorn-Storage Societies

The transition to Acorn-centered storage economies after 2,500 BP is the single most defining event in the historical ecology of the Indigenous period of the Los Angeles region. It led to a dependence on oak woodlands and savannas and an extreme spatial sedentarism in which each specific tract of land, separated usually by watershed ridges, was held in hereditary possession of families for many generations. The clear implication of this extreme sedentarism is that landscape management was practiced intensively. Annual prescribed burning was the signature management practice but pruning, weeding, seed broadcasting, and other forms of resource intensification were practiced in order to extract the maximum from all plant and animal resources in rigidly confined territories. At the center of this landscape husbandry was the careful tending of the acorn-bearing oaks, especially Coast live oak (*Quercus agrifolia*), Valley oak (*Q. lobata*), Black oak (*Q. kelloggli*), Canyon live oak (*Q. chrysolepis)*; and Scrub oak (*Q. berberidifolia*). The most prized of these were very large and very old specimens (Fagan 2003: 127–146).

The decision to begin harvesting and processing acorns was very significant because they require labor-intensive processing prior to consumption. Storing them in granaries required the construction of durable above-ground structures, and a consequent concentration of wealth and power as these granaries were treasuries for each village-state (Basgall 2004).

What seems to have spurred these societies to begin the labor-intensive commitment to acorns as their central staple, were the stressful climatic years of the Homeric - Greek Minima. Populations on the mainland would have reached carrying capacity by the time of the extended climate anomaly between 800–260 BCE, which then put an urgent premium on resource intensification. As the research of Arnold and Raab and coworkers has shown, climate fluctuations in Sea Surface Temperatures (SST) has different effects on fisheries than on land: thus, the Chumash and Tongva enjoyed diversified economies that buffered them against the impacts of the droughts of the solar minima. On land, the leading strategy for resource intensification was to exploit the abundant acorns of the oak genus, *Quercus*.

Fagan (2003: 131) estimates that at the time of Spanish contact, 300,000 native Californians were harvesting more than 60,000 tons of acorns per year. A great body of anthropological and archeological research has been published for more than 100 years, on the importance of acorn economies to most Native Californians. The broad consensus today is that indigenous Californians turned to rely on acorns as their central terrestrial staple only after thousands of years of avoiding them, because the labor costs of processing acorns were far higher than those of gathering annual seeds such as Chia (*Salvia columbariae*) in the flowerfields that typified the open plain and prairie lands. With highly acidic tannin content, the acorn meats must be leached for hours in running water before they are edible and safe to eat. This, in turn, made nearby year-round sources of water in rivers and springs a necessity. Like 200–500-year-old oak trees, year-round flowing segments and perennial springs are fixed assets, reinforcing geographic sedentarism and precluding nomadism.

From about 2,500 years ago, oak trees became the terrestrial centerpiece of the indigenous resource base, which also continued to include very large quantities of annual forb seeds, fruits and nuts, and a rich harvest of marine resources circulated by the Chumash and Tongva seafarers. The harvesting, storing, and processing of acorns was a complex process, however, requiring the organizing of labor and political-economic authority. From this period onward, mortars and pestles appear in the archeological record, used to crack the acorn shells and pulpify the acorn meats. Millingstones (*metates* and *manos*) had formerly been sufficient to grind the annual seeds. Also appearing from this period onward are many fixed location "bedrock mortars" in rocky outcrops, where villages literally inscribed their new economy into the landscape.

Oak trees are notoriously variable in their yields, both from year-to-year and from tree-to-tree. According to McCarthy (1993: 216), "most species sometimes produce heavy crops but with great tree-to-tree and place to place variability." Some individual trees "never produce a single acorn," writes McCarthy," but "bumper crops reveal the range of potential productivity." At the high end, "500–600 lbs [of acorns] per tree have been reported for *Q. garryana* (Smith 1929: 160), while comparable amounts have been noted for *Q lobata* ... and *Q. kelloggi*" (McCarthy 1993: 216).

The reliability of oaks for consistent annual acorn production, therefore, required the control of entire groves, which belonged to a single village and managed collectively under the direction of the Paquot/Quot of the Chumash and the Tomyaar of the Tongva, who ruled a highly proprietary society. Sparkman, the linguist and ethnologist who lived among the Payomkawichim/Luiseño near Paala, noted that "Each band seems to have guarded its allotted territory with the greatest jealousy, and more quarrels are said to have arisen over trespassing than from all other causes combined. When questioned as to when or how the land was divided and subdivided, the Indians say they cannot tell, that their fathers told them that it always had been thus" (1908: 190).

"Luiseño geographical names are very numerous indeed," Sparkman learned from his fluent informants from the Paala and Palomar area: "[E]very small tract with any distinguishing feature being named. Sometimes there will be a name for a large tract of country, and then other names for small portions of such a tract. This is not, however, the rule. Usually each small tract has its name, without any general name for the larger area" (Sparkman 1908: 190).

Southern California had reached its population limits (using the technologies available) centuries earlier. Every critical resource in every canyon or ravine had long ago come under familial or village possession. "Each village area contained many named places associated with food products, raw materials, or sacred beings," write Bean and Shipak (1978: 551) of the Payomkawichim/Luiseño: "Each place was owned by an individual, a family, the chief, or by the group collectively. Trails, temporary campsites, hunting sites, areas for rabbit or deer drives, quarry sites, and areas for ceremonial use and gaming are examples of places owned by the community as a whole."

Villages co-existed with their oak tree properties in a variety of configurations. Some villages controlled oak stands far from their permanent lowland village and maintained temporary camps and processing stations the oak stands during harvesting season. Bedrock mortar grinding stations can be found today near oak stands at higher elevations. These were owned by specific families. Far more advantageous, however, was to control oak stands at the same site at the primary village.

Evidence from the accounts of the Spanish conquerors beginning in 1769 make it very clear that many principal and secondary villages of the Tongva in the Los Angeles Basin were located in or near woodland and savanna groves of oak. Key examples are discussed below.

The village-state of Yaangna, today's Downtown Los Angeles, was situated within "great forests of oak" as described by Pedro Fages (1734–1794), the second governor of Alta California (1770–1774), who was again the fifth governor in 1782–1794. In 1774, by which time he had resided in and traversed the Southern California region for more than four years, Fages made the following description of the entire area we now know as Downtown LA and East Los Angeles:

> One [Castilian] league [2.6 miles] to the westward from the mission [the Old San Gabriel Mission, at Whittier Narrows] there are great forests of oak from which a supply of acorns is obtained. A great many Indians live there, hidden in their villages (1919: 497; Chardon 1980: 150).

From Fages' reference point at the original location of the Mission San Gabriel, we estimate these "great forests of oak" to have characterized the terraces and tablelands of East LA, later called "City Terrace," "Lincoln Heights," and "Boston Heights" (later "Boyle Heights"). By his use of the plural ("forests," and "villages"), he seems to be describing several terraces and several villages. It is also clear from his description that the villages were sited within ("hidden within") the oak groves which provided ample shade and also territorial protection.

Yaangna, situated on the Glendale Narrows where the Los Angeles River (called Rio Porciúncula by the Spanish) runs above ground all year round, was most likely the capital village among the oak-grove villages. The others, mapped in Figure 3-6, would have been, from west to east:

Maawnga (on the western, or right bank of the LA River); Yaangna (straddling the right and left (east) banks of the LA River; Ochuunga (approximately Boyle Heights), and possibly others whose names and locations have been lost.

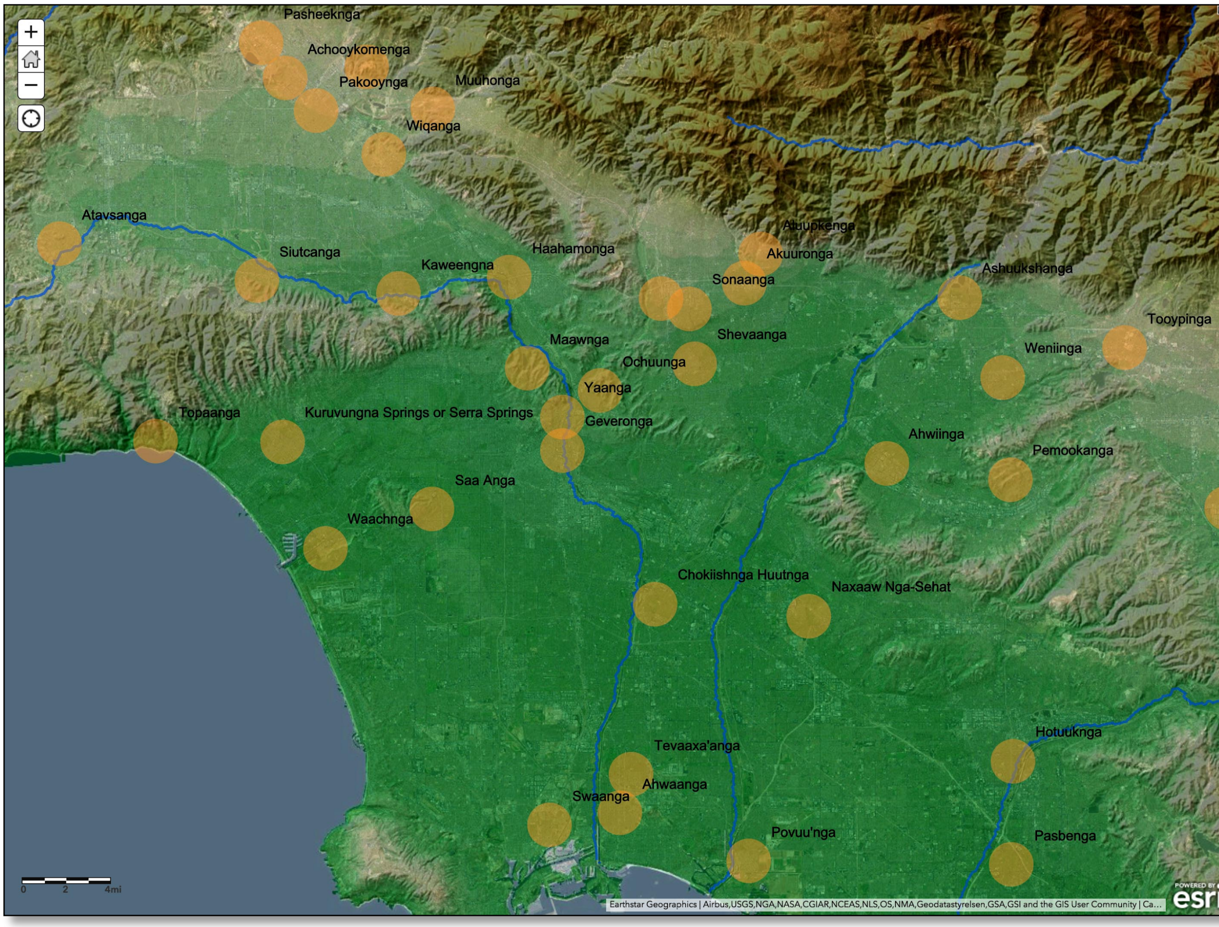


Figure 3-6. Tongva Villages of the Los Angeles Basin, circa 1769.

Numerous descriptions of the villages along the southern fringe of the San Fernando Valley, along the course of the Los Angeles River at the northern base of the Santa Monica Mountains, make it clear that those villages were also situated within their respective proprietary oak woodlands. In Figure 3-6 those were, from west to east: Atavsanga (roughly Canoga Park); Siutcanga (Encino); and Kaweengna (Cahuenga Pass and Studio City)

Tongva Villages described in early Spanish accounts as situated among oak groves also include the religious capital of Povu'ungna, on the terraces above Long Beach at Bixby Knolls today. Archaeological research at all of these sites confirms their great age, which is not surprising given that the social culture was organized around the long-lived oak forests in which they were situated.

3. Periods 3 and 4: Transitional Period/Time of Troubles, and Late Period 1150 to 1769 CE

We call the period from about 1000 CE to 1400 CE (coinciding with the Transitional period and the Medieval Climate Anomaly) the *Time of Troubles*. Evidence abounds of terrible droughts, famines, and a prolonged period of violence. Over the same period, the Chumash and the Tongva, who controlled the Santa Barbara Channel and the most fertile lands within Southern California, became more socially stratified, with concentrations of wealth and power in the hands of a few aristocratic families, from whose ranks hereditary chieftains and shaman were drawn. The owners of ocean-going plank boats, to Chumash *tomol* and the Tongva *ti'at* monopolized the fisheries and trade routes, formed a guild that regulated this trade (Arnold 1992; Gamble 2005, 2008, 2015; Raab and Larson 1997; Raab and Jones 2004; Raab 2005).

This second great historical transformation in the indigenous societies of the South Coast Bioregion took place during this long unstable period of epic droughts and the Medieval Climate Anomaly from 892 to 1350 of the Common Era. Over the course of the Middle Period (circa 600 BCE to 1150 CE) the South Coast Bioregion, under the pressure of population limits and recurrent scarcity, became even more micro-territorial, with the acquisition of the bow and arrow and the rise of chieftaincies. These sedentary storage societies etched families and clans into the canyons, valleys, bluffs, and estuaries. Families, clans, tribelets, and chiefdoms controlled specific oak stands, wildflower prairies, riverscapes, wetland marshes, fishing grounds, sea lanes, transportation routes.

Through their extreme proprietary sedentarism, and their central exploitation of the long-lived oaks, we can be certain that the social institutions put the highest priority on management of the forests and the fields in ways that maximized their yields. That involved pruning, culling, clearing, and above all, burning, which was the central landscape practice of the Indigenous landscape (Blackburn and Anderson 1993; Anderson 1999, 2005).

When the Spanish captain Juan Rodriguez Cabrillo briefly reconnoitered the Los Angeles Basin and the Channel Islands in 1542, he reported very large villages ruled by powerful chieftains. The same situation was reported when the Spanish finally returned to stay in 1769 and through the early decades of conquest. We have every reason to believe that the Acorn Aristocracies that emerged from the Time of Troubles circa 1400 remained in place in a more or less stable state for almost four centuries before the Spanish conquest beginning in 1769.

During these centuries prior to European arrival and the third great ecological era of the region, the historical ecology would have remained relatively stable, under consistent landscape management by fire, pruning, and other forms of tending. The indigenous undoubtedly valued and tended their oak groves, seasonally burned the grass and flowerfields to keep them open and productive, and combined the bounties of these harvests with extensive fisheries of the Santa Barbara Channel and the estuarial wetlands at river outflow. Because this type of landscape was developed around 2,500 years ago, it is about as close as we might ever imagine to the "original" landscape of the Los Angeles Basin prior to urbanization.

3.3.3 The Impact of Anthropogenic Fire on the Indigenous Landscape

An enormous body of indigenous knowledge, historical observation, and research has established beyond doubt that the indigenous landscape of the Southern California Bioregion, like that of the entire California Floristic Province, was shaped and managed by seasonal burning. In the practice known as "fire broadcasting" and "prescribed burning" Chumashans and Uto-Aztecans intentionally ignited low-intensity fires after the summer-fall harvest of the annual wildflower seeds. This practice replenished the soil nutrients, triggered fire-adapted germinations, and maximized herbaceous ground cover annually (Blackburn and Anderson 1993; Sugihara, et al. 2006).

Growing at lower elevations on the mountain and foothill fringes of the lower riparian systems, oak forests and oak savannahs were greatly favored by fire broadcasting, which kept the areas around the oaks open to sunlight, optimizing acorn yields. Low-intensity fires at the herbaceous level would not have threatened the canopies of mature oaks. The oak savanna in Figure 3-7 showing this resistance to fire was in the territory of the Tongva village of Siutcanga, on the fringe of the Santa Monica Mountains, along the Los Angeles River course. It most likely had survived many such fires during the Indigenous ecological era.

The low-intensity prescribed grassland fires did threaten saplings and younger oaks, but in doing so favored the older, high acorn-yielding oaks. Coast live oaks (*Q. agrifolia*) reach maturity by about 50 years, and commonly live up to 200 years. Valley Oaks (*Q. lobata*) live to 500 years. A well-managed stand of acorn-bearing oaks would have been treated like an orchard, with mature trees yielding value for many generations.

Figure 3-7. Oak Savanna, Santa Monica Mountain Foothills Untouched by Grassland Fire (undated, before 1960). Uncredited photograph in Aschmann (1959: 40, Fig 8). Caption reads: "Oak parkland or savanna on the north side of the Santa Monica Mountains. The grass on the hill had been burned minutes before the picture was taken. Note that the mature trees were scarcely affected by the burning."

Pyro-management of the landscape has been observed to achieve at least two major goals: 1) flowerfield and grassland area maximization, and 2) type conversion, from shrubland and chaparral associations to herbaceous layer associations. As Keeley (2006) explains, the practice "that likely had the greatest impact was burning shrublands for type conversion to herb-dominated associations." The archeological record indicates the "sudden emergence of charcoal deposits and replacement of woody elements by herbaceous taxa around 5,000 yr B.P.

in Coastal Southern California" (Keely 2006: 358, citing Davis 1992). If previous generations had already type-converted a landscape to herbaceous groundcover, subsequent seasonal burnings likely only reinforced the boundaries with shrub- and woodland landscapes at upper elevations, and riparian- wetland associations at lower elevations.

Lightfoot and Parrish (2009: 125–126) present a more elaborate model, called "pyrodiversity management," in which Southern California Indians "employed a regional rotation system of prescribed burns to promote and exploit a diverse range of plant and animal species for food, as well as for medicines, baskets, building materials, ceremonial regalia, and so on." Besides fire broadcasting, techniques "include pruning, coppicing, weeding, digging, and removing debris from around plants" (Lightfoot and Parrish 2009: 125). While all of these techniques shaped the ecology of the indigenous landscape, the central factor was fire broadcasting, which, they argue, was carried-out in a high-frequency, small-area rotational system of 1- to 10-year fire-return intervals. This practice "would have produced fine-grained vegetation patterns composed of many small stands of plants whose age structure varied from one stand to the next. By employing such rotational cycles," they write, Native people would have ensured that different stages of succession were continually unfolding in distinctive patches of grassland, scrubland, oak woodland, and mixed conifer forests across local regions" (Lightfoot and Parrish 2009: 101).

Given the wide diversity of landscapes occupied by hundreds of indigenous villages, we can assume a wide variation on the Lightfoot-Parrish model of pyrodiversity management. Eyewitness accounts by European explorers and colonizers from 1769 through the early 19th century report more simply on the widespread burning of large areas. As the Portolá Expedition first encountered and described the upper watershed of the Los Angeles River in the San Fernando Valley on the 5th of August 1769, diarist Father Juan Crespí reported:

> This is a large valley that must be not less than six [Castilian] leagues in length from east to west; its width from north to south is not under three leaguers; all of it very good, very grass-grown solid, though most of it had been burnt off; many patches however had not been, where the grass still showed (Brown 2001: 353; Chardon 1980: 150).

Whether this was an observation of very selective burning as in the Lightfoot-Parrish model, or evidence of a more indiscriminate approach, Crespí makes it clear that "most of" the San Fernando Valley, which he estimates at six [Castilian] leagues (15.6 miles) by three Spanish leagues (7.8 miles) had been intentionally burnt.

By the time of the second major expedition to establish settlements throughout California in 1774–1776, led by Fernando Rivera y Moncada, the practice of seasonal burning was widely observed. Commandant Rivera reported with great frustration that on the entire road between Mission San Gabriel in Tongva territory and San Buenaventura in Chumash territory, that the natives:

> [B]urn the fields as soon as they gather up the seeds, and that [burning] is universal, although on some occasions it happens that it can be greater or less, according to the winds or calm (quoted in Timbrook, Johnson and Earle 1993: 127).

This account, "like Crespí's, stresses the fact that vegetation burning was deliberate, widespread, and affected large areas. He also indicates that fires were not necessarily controlled, and therefore could have spread from grassland or savanna into shrublands in the foothills and mountains" (Timbrook et al. 1993: 127).

As the Spanish rapidly imposed an entirely different political economy of grazing livestock and planting orchards and vineyards, the massive seasonal practice of grassland burning by the indigenous population had to be forcibly suppressed, beginning with a decree by Governor Jose Joaquinde Arrillaga in 1793:

> With attention to the widespread damage which results to the public from the burning of fields, customary up to now among both Christian and Gentile Indians in this country, whose childishness has been unduly tolerated...I see myself required to have the foresight to prohibit for the future...all kinds of burning, not only in the vicinity of towns, but even at the most remote distances…(quoted in Timbrook et al. 1993, pp 130–131).

The Early Spanish accounts make it clear that either by intention or by accident, annual prescribed burning would have resulted often in type conversion, at the expense mainly of up-slope shrubland communities of manzanita, ceanothus and chamise chaparral associations, and at the expense of saplings around forest and woodland edges. Also affected and reduced in scope would have been coastal sage scrub.

Prescribed burnings must have had an enormous impact on a wide range of consumable plant and animal resources. Maximizing grasslands and flowerfields also maximized the small herbivores and their predators: from snakes to owls to hawks, eagles, and grizzly bears. Larger more productive grasslands/forblands would also have boosted the grazing herds of elk and pronghorn. The lengthened perimeters of the grassland- shrubland and woodland edges would have attracted the browsing deer, and with these large herbivores, the mountain lions (*Puma concolor*) who specialized in hunting them. And seasonal burning doubled as a rabbit-drive, with fencing, nets, enclosures, and snares that were constructed before the prairie fires were set.

As Father Juan Crespí first encountered the Los Angeles Basin, he reported exactly what one would expect from the resource-magnifying effect of the Tongva landscape management:

> There are a great many antelope at all of these rivers, and very large hares the latter especially here at this spot

and

> Here we have seen a great many ring-necked turtle-doves and a great many thrushes, and a great many quail are heard calling. There are packs of coyotes and wolves at all these spots.

Arriving at the Los Angeles River and the oak-grove village of Yaangna on 2 August 1679, Juan Crespí recorded:

> A very lush pleasing spot in every respect. There are great amounts of brambles, a great deal of grapevines, and a great many rose bushes having very good-sized roses, to southward there is a great extent of soil, all very green, so that really it can be said to be a most beautiful garden.

How the suppression of indigenous prescribed seasonal burning changed the fire regime of the region during the next ecological era (Era 3: Euro-American Conquest, 1769–1870s) is a topic briefly addressed in Section 3.4.

3.3.4 The Impact of Firewood Fuel Consumption

In addition to their profound shaping effect of annual or period prescribed burning, the gathering of firewood fuels for cooking, domestic heating, and sweat-lodges, would have had a significant impact on the areas surrounding population centers, with effects much like those of prescribed burning.

The Los Angeles River drainages were inhabited by about 5,000 Tongva distributed across about 50 villages, which ranged from about 50 to about 400 individuals in size. Keeping the home fires burning for the modest-sized villages of the Tongva (100–300 individuals), or the much larger Chumash villages (over 1,000 individuals), would have required large quantities of fuel per year. Using the lower end of the estimates from field research, we estimate that a modest Tongva village of just 20 households would require 200 kilograms (441 lbs) of wood per day, or 80 tons of firewood per year. A much larger Chumash village of 1,000 individuals would require over 400 tons of wood per year.[1]

Where did all this wood come from? Such daily consumption requirements would have depleted nearby sources long ago, and evidence confirms that firewood was gathered from forests far from villages. At the coastal Chumash village of Muwu (present day Point Mugu), visitors to ceremonies brought firewood because the hosts had none locally (King 1993:280). Ethnographic accounts from the Pacific Coast indicate that many villages depended on firewood

[1] As an index and point of reference, we can begin with evidence from another environment, in contemporary times, studied with exacting techniques. S.J. Vermeulen et al. (1996:479) report that "Households in part of Gokwe Communal Area, a rural Zimbabwean study area in which wood is considered plentiful, use a mean 4.8 tons per household per year (t hh-1 yr-1) of wood for fuel, comprising 4.0 t to meet day-to-day requirements and 0.8 t for special occasions and beer brewing." That rate of consumption would equal about 26 lbs, or about 10 kilos, of firewood per day per household, which accords well with a 1949 estimate by S.F. Cook that "a family in the Teotlalpan of central Mexico burns I0 kilos or 20.2 pounds of wood per day." E.W. Gifford (1916) gave a much higher estimate for an archeological site on the San Francisco Bay, which he reports "used 83 pounds of wood per day per family or 1,250 pounds per day for the village." (Gifford 1916: 12 cited in Heizer 1963: 191).

that was carried from forests, in some places miles away. Jewitt and Thompson, the English captives among the Nootka [on Vancouver Island], were forced to "perform the laborious task of cutting and collecting fuel, which we had to bring on our shoulders from nearly three miles distance, as it consisted wholly of dry trees, all of which, near the village, had been consumed" (Jewitt 1820:14, quoted in Heizer 1963: 192).

Tongva villages harbored oak and walnut woodlands for acorn production, and most villages lay far from the dense coniferous forest of the San Gabriel Mountains. By contrast, woody, oily chaparral scrub would have been a very abundant and renewable fire field resource. Chester King (1993) confirmed this hypothesis by analyzing the charcoal at a site in Ventura County, finding predominance of four genera of chaparral plants: Chamise, or Greasewood, (*Adenostoma fasciculatum*); Big-pod Ceanothus (*Ceanothus megacarpus)*; Sugar Bush (*Rhus ovata*); and Manzanitas (*Arctostaphylos* spp.) Each of these are common today in Southern California's chaparral communities.

3.4 Era 3: European-American Conquest Landscape, 1770s–1870s

Following their permanent arrival in July of 1769, Spanish colonizers rapidly transformed the overall ecology of the South Coast Bioregion. The very epicenter of that rapid impact was the Los Angeles and San Gabriel River drainages. Within a few decades, thousands of years of ecological history was put to a sudden and violent end, as the Spanish introduced grazing, European crops, irrigation, and the decimation of the oak woodlands for building materials. By the end of Spanish rule in 1821, the Spanish had decimated the Chumashan-Uto-Aztecan-Hokan civilization complex, with mass displacement of village populations, epidemiological depopulation, disruption of native resources, and institutionalized mistreatment of the indigenous peoples by both soldiers and father-priests who oversaw large gangs of coerced labor on high-productivity haciendas called "missions." These were engines of destruction where death rates out-paced birth rates and the seemingly indifferent Franciscan priests buried their new flock in mass unmarked graves.

The indigenous landscape of the second long ecological era of 8,500 BP to 1769 ended abruptly by the first decades of the 19th century because it was a complex political economy that shaped the land, and the Spanish were very efficient at dismantling that political economy. The central role of the oak trees, the seasonal burning, the pruning and tending of thousands of plant species for thousands of purposes, was lost within a generation.

What replaced it was not, however, fully coherent nor uniformly distributed across the South Coast Bioregion, nor even across the Los Angeles River and watershed. The newly dominant Euro-American political economy arose in the form of the mission haciendas, the most important and productive of which was that at San Gabriel. By 1813, as many as 1,000 indigenous "neophytes" lived and worked at Misión San Gabriel Arcángel (Figure 3-8).

In that year, the converted Chumashans, Uto-Aztecans, and Hokans (all displaced and mixed together) at the Mission San Gabriel by that time herded 17,433 cattle, 2,938 horses, 6,548 sheep. They cultivated 163,578 grape vines and 2,333 fruit trees, and manufactured nearly everything used by Spanish colonials: cloth, leather, wagons, candles, wine, and they built the Mission buildings themselves. “The mission herd reached 42,350, primarily cattle (25,000) and sheep (15,000) at its peak in 1829.” Mission agriculture and manufacture at the missions was essential to the colonizing conquest in large part because the Quechan (Yuma) people closed the land route from Sonora and Baja California at the Colorado River in 1781 and kept it closed for the next 50 years (Jackson and Castillo 1995: 113–132).

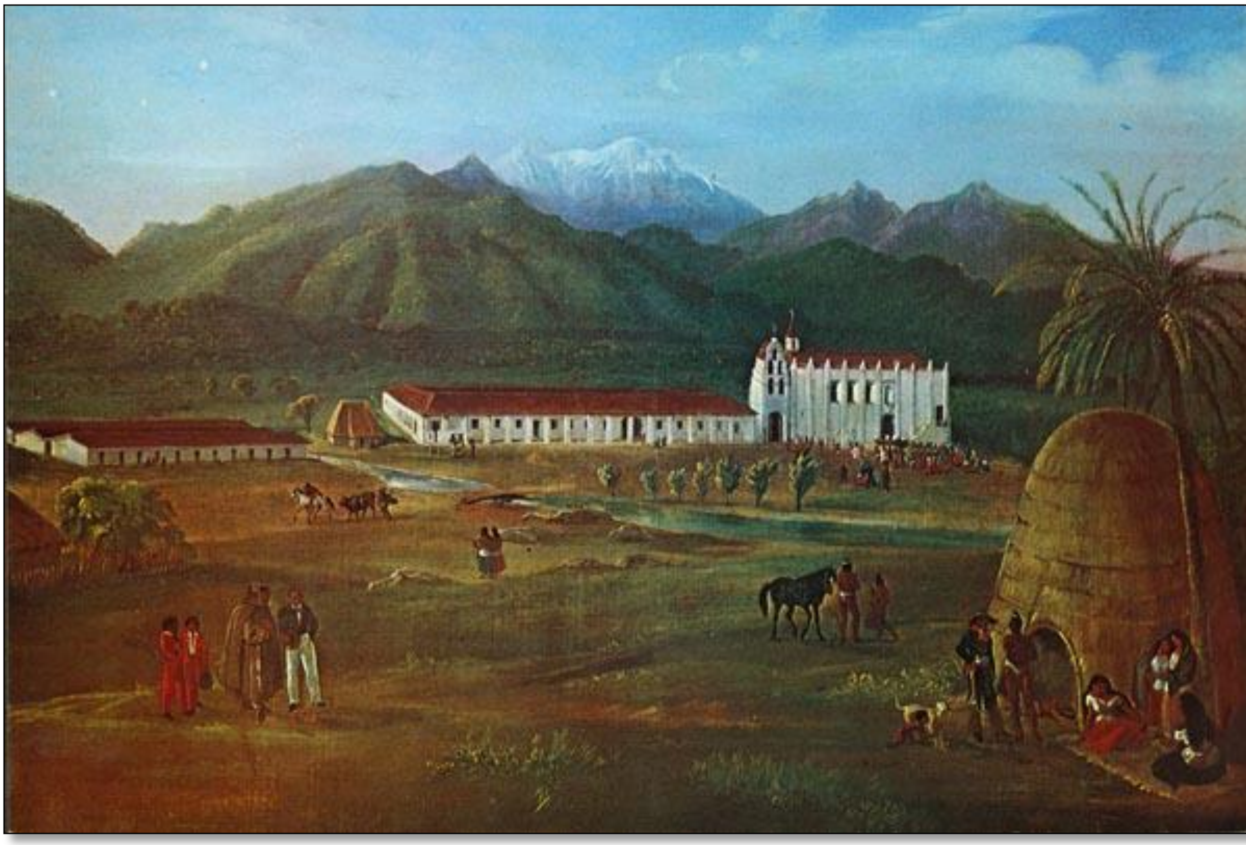


Figure 3-8. Misión San Gabriel Arcángel (1771). Painting by Ferdinand Deppe, 1828. California Historical Society Collection, USC.

Displacement and disruption to an ever-expanding acreage of the Southern California landscape was the major theme of the third ecological period, which we date from 1769 to the beginnings of railroad-centered industries in the 1870s. This period needs to be further subdivided, however, into two overlapping phases:

A) The Spanish Conquest: 1769–1821
B) The Mexican-American Rancho and Viticulture Economy, 1821–1860s

The arrival of the Spanish immediately brought invasive species and led to both floral and faunal type conversions across much of the Los Angeles Basin. The flower fields of the Indigenous Landscape were heavily, but not completely, displaced by invasive grasses. Relict native grassland landscapes survived for long periods, even into the early 20th century, when the Stanford botanist LeRoy Abrams cataloged native and naturalized plants in the Los Angeles vicinity (Abrams 1917). His list of native species overlaps with 60% of the species found in today's major relict landscapes in the Carrizo Plain and Santa Barbara County (Schiffman 2005: 45–6).

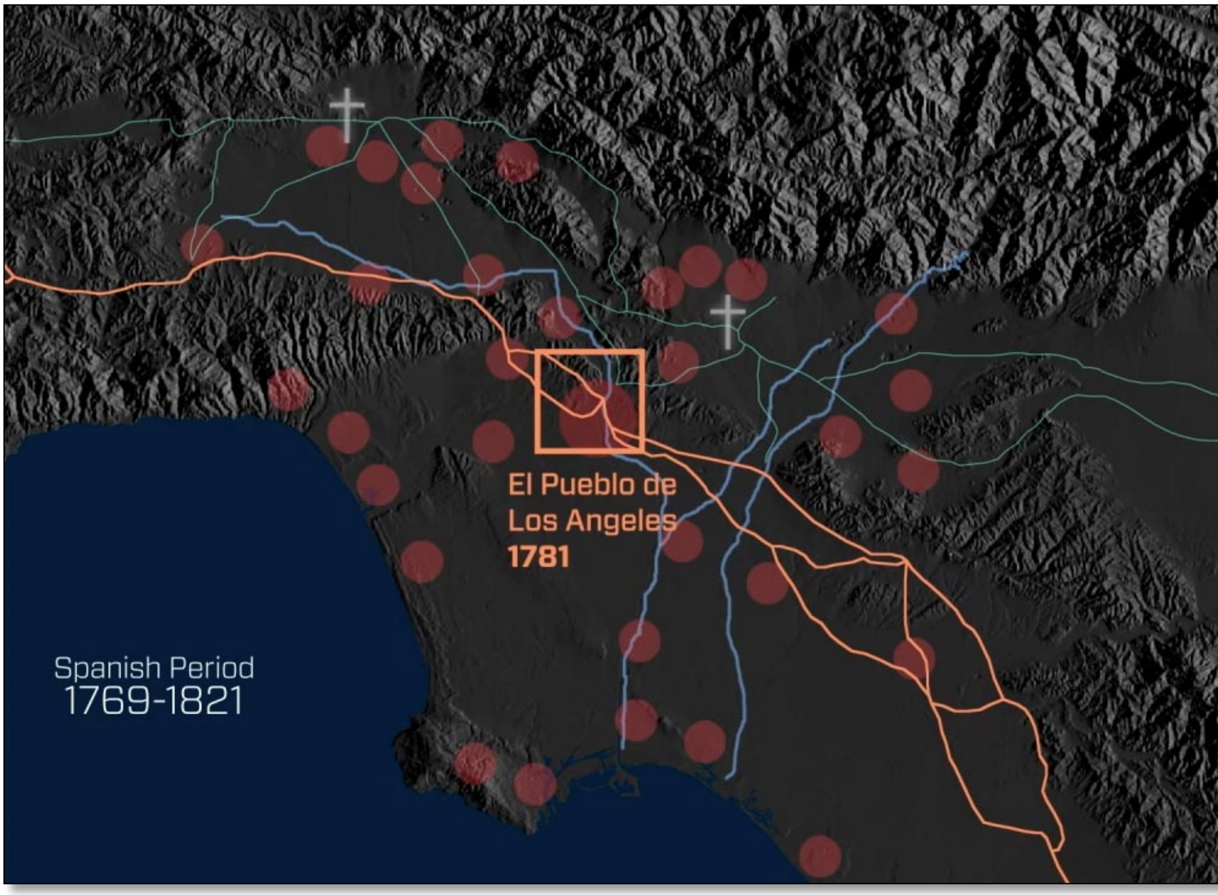


Figure 3-9. The Los Angeles Basin During the Spanish Period.

The most dramatic impact was the introduction of non-native annual grasses such as wild oats (*Aventa barbata* and *A. fatua*) and red brome (*Bromus madritensis*). Also introduced were yellow mustards (*Brassica nigra*, *Hirschfeldia incana*), and filaree (*Erodium cicutarium*). These are ruderal species, the first to colonize disturbed lands. And as we have seen, during the Indigenous Landscape, the Los Angeles region prairies were always already disturbed by intensive investment by ground-dwelling herbivores such as pocket gophers, ground squirrels, and the grizzly bears who roto-tilled the land looking for them (Schiffman 2005). Many invasive species had already spread from Northern New Spanish colonies long before the Portolá–Serra expedition of 1769. "Because they originated in the Mediterranean region," Schiffman (2005) observes: "not only where the invaders pre-adapted to Southern California's Mediterranean-type climate, they were also adapted to the effects of livestock grazing and other environmental changes introduced by the Spanish." They "simply had Mediterranean evolutionary histories that included prolonged exposure to agricultural soil cultivation." In short, the rapid introduction of ploughed fields and livestock grazing favored the European Mediterranean grasses over the native wildflowers.

The vast wildflower-dominant prairie plains of the San Fernando Valley, portions of the Los Angeles Basin south of the Santa Monica Mountains, and the San Gabriel Valley, were converted within a few decades to brome-dominant grasslands. And these landscapes began to carry a very heavy load of ungulates: cattle, sheep, horses, and pigs. The sizes of the herds were as vast as the landscape itself: in 1860, 30,000 to 50,000 head of cattle grazed in the ex-Mission San Fernando lands of the San Fernando Valley, an area of approximately 250 square miles. By that time, the rancho economy of the Mexican and early American period had taken hold: large tracts had been granted to the Spanish and Mexican colonizers, and the lands of the missions were also carved-up, to graze more than one hundred thousand of cattle in the lands adjoining the Los Angeles River.

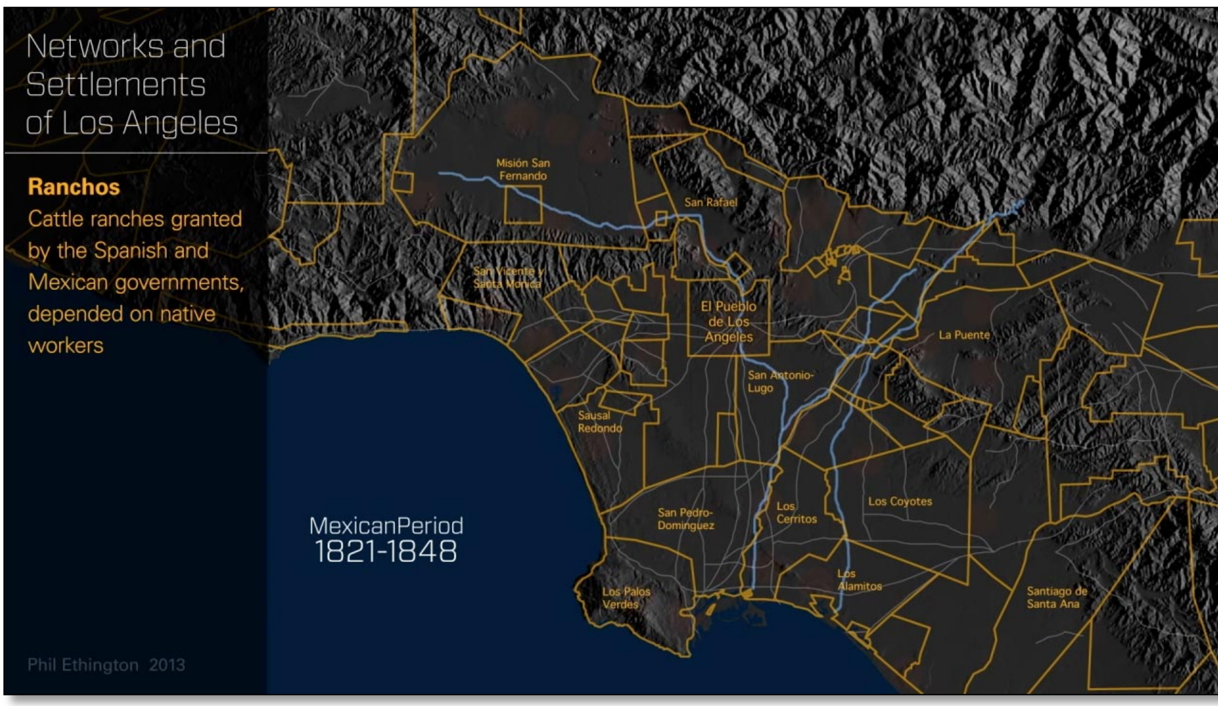


Figure 3-10. Ranchos of the Los Angeles Basin during the Mexican Period (1821–1848)

The pastoral grazing economy continued after the US conquest of California beginning in 1848, but faltered within two decades, when it became clear that the instability of the region's climate and hydrology were not suited to the requirements of very large grazing herds.

While the prairies of the Los Angeles Basin can support such biomass, it remains a violent and unstable climate. Several events converged in the 1870s to end the cattle-grazing political economy of the Conquest era, and launch the urban-industrial era. During the mid-1860s, Southern California suffered flood and drought in biblical proportions. First, the "Great Flood" of 1861–2, dropped 50 inches of rain in one month. "The Los Angeles, San Gabriel, and Santa

Ana Rivers merged, emptying into the ocean as an 18-mile wide river." And yet the years 1863–1865 suffered a severe drought, killing almost 100,000 cattle and hundreds of thousands of grape vines, fruit trees, and other crops. The bleached white bones from this die-off littered the landscape for years to come. Next came the two-year drought of 1862–1864, in which rainfall fell below 10 inches for the year, one third of the average. A great cattle die-off resulted. The rancho cattle population fell from 100,000 head to about 12,000 (Orsi 2004: 3, 12; Gumprecht 2001: 145).

Apart from the central role of livestock grazing, the other most distinctive feature of the pastoral political economy of the third (1769–1870s) ecological era, was the rise of orchards and winemaking. The Mission San Gabriel introduced Aqua Tibia, a sweet Valencia-type orange, in a six-acre grove of 400 trees in 1804, but widespread cultivation of oranges did not occur until the 1870s, after the Euro-American Conquest ecological era (Zierer 1934). Instead, wine, table, and raisin grapes became an increasingly widespread crop, first at the missions. Mission San Gabriel had 163,578 grape vines and 2,333 fruit trees in 1813, but much of this was destroyed during the secularization of the missions in the 1830s, and the commercial exploitation of vine and tree fruits shifted to secular entrepreneurs (Monroy 1990: 117–162).

During the Mexican (1821–1848) and American (1848–on) periods, a veritable wine industry arose under the leadership of the French immigrant Jean-Luis Vignes, known as "Don Luis del Aliso" (1780–1862). Vignes, whose name literally means "vines" in French, came from a wine-growing family in Girone, near Bordeaux, and used his family networks to import French vines Cabernet franc and Sauvignon blanc. He arrived in Los Angeles in 1831 and started an extensive vineyard in a large tract of land south of the Pueblo along the Los Angeles River, calling it Rancho Aliso, after the large California sycamore on the property, near today's Aliso St. By 1847 El Aliso Vineyards cultivated 40,000 vines. By 1850, 20 percent of the Los Angeles population was French: they brought the skills needed for winemaking as vintners and coopers. Together in that year, they cultivated 400,000 vines, producing 57,355 gallons. Just seven years later, Los Angeles was producing 250,000 gallons of wine and 945,000 pounds of grapes shipped from Los Angeles, mostly to San Francisco. In 1861, Vignes and his sons shipped their first wines to New York City. By 1870, 6,000,000 (six *million*) grapevines were growing in and around Los Angeles. (Gumprecht 1999: 48–53). Most of this extensive acreage was located in the immediate river terraces along the eastern bank Los Angeles River, with vineyards stretching about three miles southward from the Plaza at the center of the settlement.

The fantastic growth of the Los Angeles wine sector is today only a curiosity of the fickle Los Angeles past, however. When transcontinental railroads arrived in the 1870s, the vineyards were rapidly uprooted to make way for urban development south of Downtown. Today, the vineyards of Don Aliso Vignes lie beneath the concrete and asphalt hardscape of the city's nearly treeless commercial, industrial, and warehouse district.

The Euro-American Conquest period of 1769–1870s reconfigured and re-shaped the landscape not only by type conversion to agricultural flora and fauna, but also by deforestation. The acorn-centered political economy of the Indigenous Landscape, at least since about 2,500 years ago, valued the mighty oak trees above all other terrestrial resources. Villages owned and protected large tracts of oak woodlands for countless generations. With the collapse of the indigenous civilization the oak groves took on entirely different value, within the Euro-American political economy. Like the giant sequoia, the endemic oaks of the California Floristic Province are record-holders of age and size. The valley oak (*Quercus lobata*) is the largest and longest-living oak species on earth. The coast live oak, which dominated most of the oak woodlands of the Los Angeles Basin, also reaches enormous size, with 3-meter trunk circumferences common. The Europeans looked at these ancient woodlands and saw not acorns but lumber. To build their missions, adobe homes, horse-carts, and wagon wheels, the Spanish, Mexicans, and Americans put these oak stands to the axe—beginning with the "great forests of oak" between Mission San Gabriel and Pueblo of Los Angeles.

By the end of the Euro-American conquest period, most of the oak woodlands near the town of Los Angeles had been removed, to make room for both cultivation and urban construction. Also removed were the large oak stands in the open areas of the southern San Fernando Valley, which Pedro Fages called "Valle de los Encinos," memorialized today in the neighborhood name "Encino." Much of this San Fernando Valley woodland and savannah may have survived through the era of intensive grazing that ended in the 1870s, but the rise of the Lankershim wheat ranch during the last decades of the 19th century assured its doom. Relict stands of this old forest survived on the lower north-facing slopes of the Santa Monica Mountains, recorded in surveys of the 19th century, and several oak species continue to thrive in the canyons and protected areas of the Santa Monica Mountains today, cherished again as shade trees and as terrestrial reefs supporting wildlife in their capacious crowns.

3.5 Era 4: The Urban-Industrial Era: 1870s-Present

We date the boundaries between each of the ecological eras based on sudden shifts in the political economy of the region, which caused rapid shifts in land use and plant community distributions. The last shift of this type took place in the 1870s, when the ranching economy was abandoned by largely Anglo-American landowners, in favor of commercial crop farming (led by wheat) and citrus orchards. Simultaneously, transcontinental railroads arrived to spur the rapid urban and industrial growth of Los Angeles from a town to a city by the 1920s, and then to a global metropolis by the middle of the 20th century. The Urban-Industrial Era subdivides into three periods.

A) Rise of Citriculture, Agriculture, Industrialization, and Urbanization: 1870s–1940
B) The Military-Industrial Metropolis: 1940s–1990s
C) Globalization, Climate Change, and the Rebirth of Sustainability, 1990s–Present

The first of these periods, which saw a dramatic increase in industry, population, and urbanization of the landscape, was nevertheless very unevenly distributed across the Los Angeles Basin, leaving relict landscapes relatively unimpacted.

A) Rise of Citriculture, Agriculture, Industrialization, and Urbanization: 1870s–1940

The most transformative development of the 1870s was the arrival in downtown Los Angeles of the Southern Pacific Railroad in 1876, followed by the Atchison, Topeka & Santa Fe Railway (AT&SF)—or simply, the Santa Fe—in 1881. The railroads opened a continental market for the growing city's goods, led to a rapid population growth and urban development at the core of the Los Angeles Basin, and spurred the development of the massive citrus industry, especially after the introduction of refrigerated railroad cars in 1887.

Four fruits became the basis of the Southern California citrus industry: The navel orange, introduced to Riverside from Brazil in 1873; the Valencia orange, introduced in 1876 from the Azores; the Lisbon lemon, introduced in 1874 from Australia and a Eureka variety developed from Sicilian seed in 1877. The Marsh seedless grapefruit joined the crop from Florida in 1890 (Zierer 1934: 55). After proving the success of these fruits by the end of the 19th century, large cooperatives were formed and industrial-type processing facilities were introduced.

It would be hard to exaggerate the rapid growth in land-area covered, and enormous volume of citrus grown in the Los Angeles Basin by 1935. Writing in that year, economic geographer Clifford Zierer reported that in the Los Angeles Basin alone,

> Approximately 170,000 acres [680 km^2] of land are planted to citrus fruits in the area (1/2 Valencias, 1/3 navels, 1/7 lemons, and the remainder grapefruit and miscellaneous varieties). No other horticultural industry of equal importance in the United States is so compactly situated [geographically] and no fruit district is more intensively cultivated or more productive of wealth (Zierer 1934).

The California citrus industry as a whole grossed $130 million dollars per year in the mid-1930s, or about 3.3 *billion* in 2020 US dollars. Of this, approximately 78 % of the oranges (11 million boxes), 60 % of the lemons (3 million boxes), and an unknown proportion of the grapefruits, were grown in Los Angeles (1935: 56–7). The map of citrus coverage in Figure 3-11 indicates how much of the 170,000 acres (680 km^2) of citrus lay within the Los Angeles River watershed itself. Especially extensive was the citrus district on the plain between the lower drainages of the Los Angeles River and the San Gabriel River, centered on the present-day city of Downey (incorporated 1956).

In the first two decades of the 20th century, the citrus growers formed large collectives and adopted an industrial model of production, with large mechanized packing factories.

> Shipping the 849.2 million boxes of citrus produced between 1914 and 1939 required more than 1.8 million railroad car loads. In 1939 alone, 51.4 million boxes of citrus left California in more than 111,000 railroad cars. At fifty cars per train, at least six trains loaded exclusively with citrus made their way out of southern California every single day (Toby and Wetherell 1995: 13).

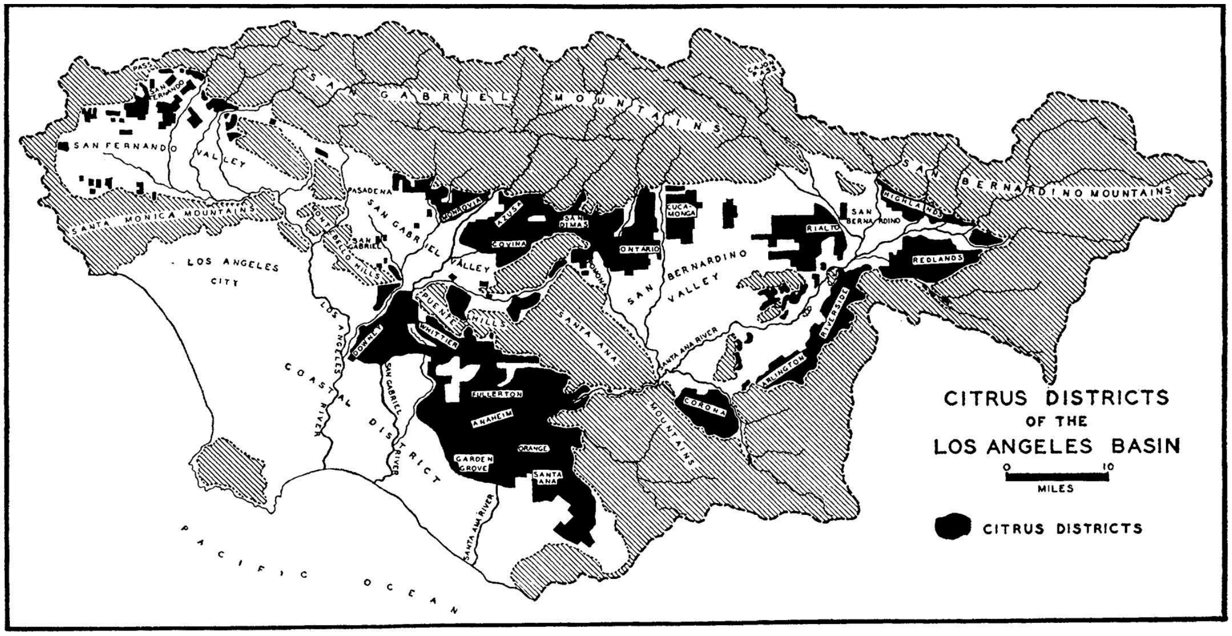


Figure 3-11. Citrus Districts of Southern California, 1934 (Zierer 1934).

The citrus industry was certainly a central driver of urbanization in Southern California at the turn of the last century. It not only provided a seductive global image for the region, drawing hundreds of thousands of new settlers. But it also brought capital and infrastructural improvements that made possible the rise of new industries at the leading edge of technology that became central to the region by the 1920s, especially motion picture and aircraft production. Fueling all industries and the spread of the automobile across the region as a favored form of transport, was the regional oil industry. Each of these industries also attracted newcomers, who fed another major new sector: residential home-building.

Under the pressure of these overlapping developments, thousands of acres were converted to urban centers and residential subdivisions. The population of the City of Los Angeles shot up from 11,000 in 1880 to 50,000 in 1890, and more than doubled from 577,000 in 1920 to 1,238,000 in 1930.

These two early booms bear special attention because the urbanization process was so transformative and also so incomplete and uneven at the same time. By 1915, urbanization was so advanced that traffic jams were common in downtown LA and a new social institution, the Automobile Club of Southern California (ACSC, the national headquarters of AAA) was formed to promote hard surface road construction and the improvement of traffic safety, and support for auto tourism. For auto tourists, the ACSC began an extensive cartography enterprise, and today houses one of the most important collections of historical maps of the metropolis. The generalized ACSC regional map of 1915 is very revealing of the way the LA Basin was still a patchwork of urban nodes and large open spaces, both entirely undeveloped and cultivated by citrus and other crops (Figure 3-12).

An urban development boom took place during the 1920s, involving the minting of new municipalities and a gargantuan rate of home building. With the growth of the population of the City of Los Angeles from about 500,000 in 1920 to 1.2 million population in 1930 (and the growth of the County from 900,000 to 2.2 million in the same decade), much land cover was not only changed radically to houses, office buildings, factories, streets, and storm drains. The built fabric of this process, including the hardscaping of streets, sidewalks, and parking lots, withdrew the land from any kind of ground cover. But the interstitial spaces of the growth of the "artificial landscape" was vast, at several scales: Backyards and hill-slopes behind neighborhoods remained green, while large parks, such as Griffith Park, remained devoid of concrete, and the large open areas between the new subdivisions harbored large areas of both relict ("wild") and cultivated acreages.

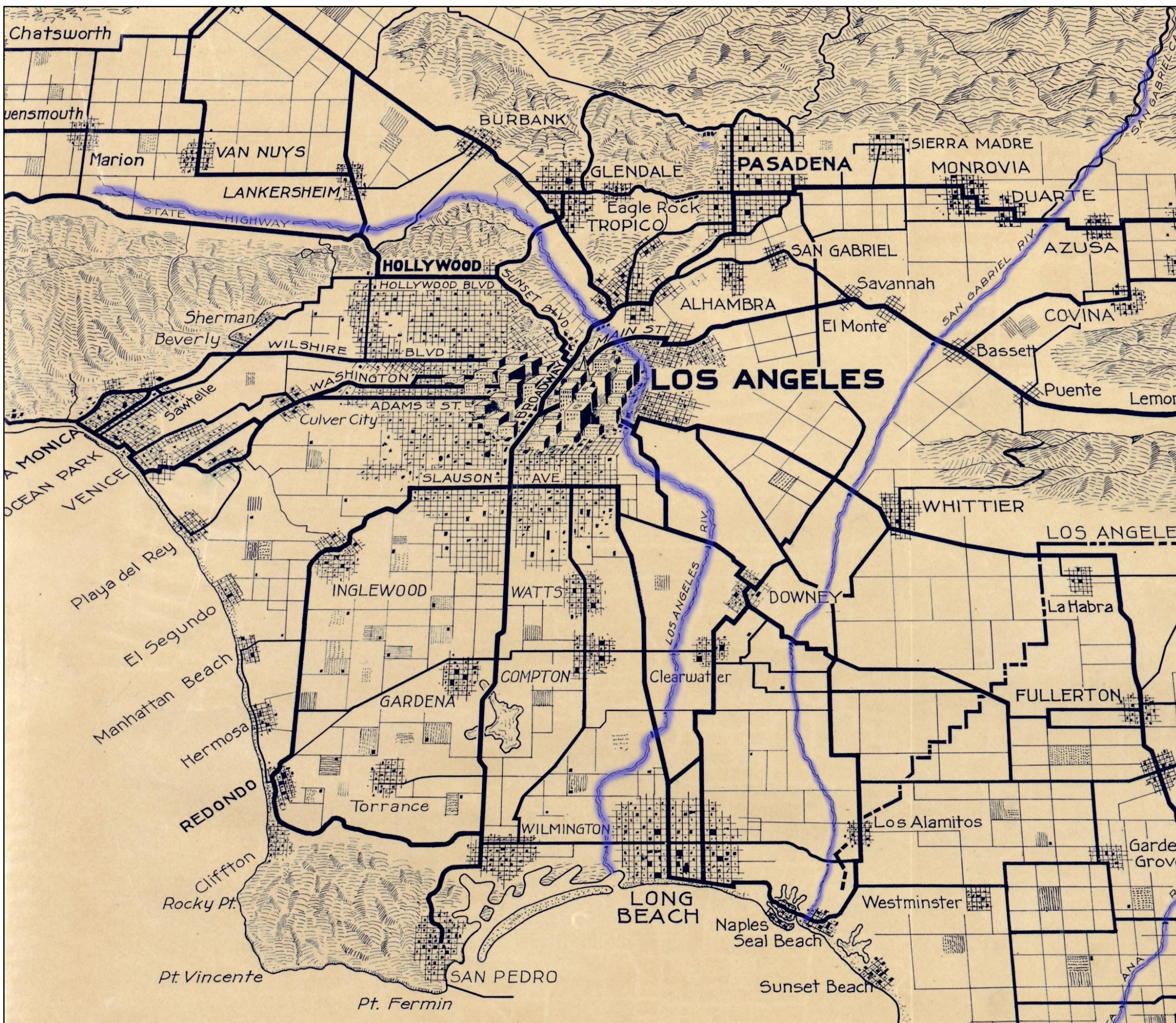


Figure 3-12. Uneven Urbanization: The Auto Club of Southern California Map of 1915. (Detail, rivers added). Source: Library of Congress. https://www.loc.gov/resource/g4364l.ct001803/

The extent of the surviving relict landscapes during the 1920s can be observed in detail in many sources that we have mined in this study, and in more that still remain to be mined. One of the most valuable is a special series of 119 topographical quadrangles produced by the US Geological Survey (USGS) in collaboration with the County of Los Angeles, using aerial photography.

Figure 3-13. North Hollywood, Studio City, Cahuenga Pass, Griffith Park, Burbank, Glendale and the LA River, 1928 and 2020. Incomplete urbanization during the 1920s is evident in the area along the Los Angeles River as it flowed past the newly established Universal City movie studios. The natural Toluca

Lake and its surrounding landforms were still entirely undeveloped in 1925. The lake still exists but is inaccessible to the public. It is owned and maintained by surrounding property owners of the Lake Property Owners Association. The Los Angeles River still followed its own natural course in the 1925 USGS map, before it was channelized with reinforced concrete by the Army Corps of Engineers in the 1930s, giving it the straightened course followed in the 2020 aerial image.

Also transformative during the Urban-Industrial Landscape was the damming, channelization, and diversion of the Los Angeles River, and the importation of water via major aqueducts: The Owens Valley-Los Angeles Aqueduct, completed in 1913, the Colorado River Aqueduct, completed in 1939, and the California Aqueduct, completed in 1973. Together these aqueducts brought millions of acre-feet of water to Los Angeles, dwarfing the native supply from the Los Angeles watershed, and made possible the growth of Los Angeles to the rank of "mega-city," with more than 15 million people within 60 miles of Downtown Los Angeles by the end of the 20th century.

Former riparian habitats along the course of the Los Angeles River were extensively degraded by the concrete channelization and diversion of its waters, but the formerly vast river-wash, riparian terraces, and plains surrounding the river's course were simultaneously paved-over for warehouse, factory, and residential developments, hardscaping almost the entire lower course of the Los Angeles and San Gabriel watersheds, from downtown Los Angeles to the outflow in the twin harbors of San Pedro-Long Beach.

3.5.1 Global Gardening: The Explosion of an Exotic Urban Woodland from 1870s Present

While the citrus industry rose and fell by the late 1960s, the vegetal ground cover in the form of yards and gardens became a wonderland of exotic flora during the Urban-Industrial ecological era. One of the world's largest gardening industries took root in the region by the beginning of the 20th century and became central to the regional culture of the metropolis. Again, the ancient fecundity of the Los Angeles alluvial plains supported abundance, so long as the imported water continued to flow. As numerous historians and commentators have recounted, the exotic orchards and year-round gardening became key selling-points in the commercial promotion of the region's real estate. As Douglas Sackman explains:

> From the 1870s to the second decade of the twentieth century, the environs of Los Angeles and its people became consumed with gardening. Gardening became a source of livelihood and pride. Southern Californians grew fruit trees, and they grew ornamental trees. Their identity, and economy, became fixed to plants. This was the land of the golden orange, a place where rose parades could be held in January. Each bustling enclave—Pasadena and Ontario, Pomona and Anaheim—vied for the title of the garden spot of earth (Sackman 2005: 247).

Immigrants from around the globe, led largely by Japanese nursery operators and gardeners, brought their familiarity and expertise with global flora to the watersheds and irrigation districts of the Los Angeles Basin, as Pierette Hondagneu-Sotelo (2014) has shown. Schiffman uses a simple name to this new landscape type, which we embrace: "Urban Woodlands." Indeed, in many neighborhoods, dense woodlands composed almost entirely of non-native trees, cover areas once typified by hillside chaparral or prairie grasslands. This new urban woodland is, however, a hybrid one, as Schiffman explains, supporting a very unnatural mix of exotic flora ranging from Brazilian silk floss tree (*Chorisia speciosa*) to the Asian Ginkgo biloba and the ubiquitous Australian genera *Eucalyptus* and many others. Feral flocks of green parrots compete to control territory alongside North American crows.

3.6 Observations Regarding Influence on Ecology

From this review of the historical context of the landscape of the Los Angeles Basin, a few things become evident. Any interpretation of the "natural" landscape has to be made with recognition of the influence of human occupation and the megafauna before that, along with climatic change. We can only draw general conclusions about the nature and spatial distribution of the effects of the trampling, grazing, and browsing of the megafauna, and about the consequences of indigenous management on vegetation distributions. As we think about what the patterns of natural vegetation would have been historically, we can advance some reasoned hypotheses about these effects.

During the megafaunal era, from the end of the Pleistocene to c. 9,000 years BP, the emerging Mediterranean landscapes would have been influenced by that megafauna. There were large riparian zones, with chaparral and coastal sage scrub (documented by Wake and Roeder 2017), but also a larger preponderance of grasslands and flowerfields. The megafauna, through a combination of grazing and browsing, would have maintained grasslands while putting pressure on woodlands and scrublands, just as the large fauna of tropical grasslands do today. During the indigenous era from 9,000 BP to 1769, the influences of burning to promote annual plant growth, collecting firewood, and tending oak trees is likely to have expanded grasslands and flowerfields at the expense of coastal sage scrub. Firewood harvesting and burning in oak and walnut woodlands would have created (type-converted) or maintained more open areas for annual forbs within chaparral and woodland environments. During the Euro-American Conquest Era, those flowerfields were transformed to annual grasslands and the extent of shrublands, especially coastal sage scrub, was dramatically diminished in favor of open range. Woodlands were under severe pressure and almost certainly reduced in extent, as the disappearance of the oak woodlands in the Downtown and East Los Angeles area attests. During the Urban-Industrial Era, the grasslands and scrublands were equally decimated to make way for citriculture, agriculture and then increasingly massive urban development. The riparian zones were lost to urban development as well, as channelization expanded as the period progressed. Forests overall increased, but in the form of urban forests of introduced species.

In some areas native trees persisted and expanded if the urban form allowed it, such as the slow, unaided reclamation of the northern portions of the UCLA campus by coast live oaks (*Q. agrifolia*). It has also seen the introduction of plant species from around the world, supported by water imported from outside the watershed to create wholly new landscapes. But underneath all of this change, the landscape and its soils, slope, aspect, and elevation still create conditions that would support different plant communities and their associated biodiversity should they be allowed once again to function. Because those native communities, more in tune with the land and requiring fewer external inputs, would be more sustainable, it is worthwhile peeling back the layers of disruption to imagine what they might be (i.e., the potential natural vegetation). The patterns and processes inherent in the landscape itself can inform plans for more ecologically aware and sustainable management.

Across this historical review, we assert that it is *not* fruitful to choose a baseline date or era during which the historical ecology of the Los Angeles region can be reconstructed. The great periodic dynamism of the region's ecological distributions, shown throughout this section, makes such a project unattainable. Instead, we hope to have established a framework for thinking about the entire period from the Pleistocene to the present as sharing a common suite of vegetal communities, all capable of recurring depending on the circumstances. This concept of "potential natural vegetation," cuts across the dramatic differences between the ecological regimes of each of the four eras and the sub-periods within them.

Chapter 4 Archival Research and Infrastructure for Spatial Analysis

In this chapter, we describe the new archival information on the historical ecology of the Los Angeles River watershed that we located and its integration into a digital spatial data management system to provide an infrastructure for analysis.

4.1 From the Archives to GIS

Most new archival sources in terms of maps and text were concentrated in the area along the Los Angeles River from south of present-day downtown, northward into the upper reaches of the river in the San Fernando Valley. The information gathered from archives is listed in the bibliography and appendices.

The most fruitful archival collection was the Solano-Reeve Papers, 1849 – c.1910, found at the Huntington Library. The collection is named for Alfred Solano and Sidney B. Reeve, both surveyors in Los Angeles during the late 19th – early 20th centuries. Most of the collection's materials come from George Hansen, a civil engineer and surveyor who would serve as the Los Angeles County Surveyor from 1864 to 1869, and multiple terms as Los Angeles City Surveyor. Hansen came to California in 1850 to seek gold but began work as a surveyor in Los Angeles in 1853 after an unsuccessful attempt at prospecting. Hansen left his records to Alfred Solano, whom he taught surveying and mentored. Solano became a civil engineer, eventually becoming Hansen's full partner and sole heir. Solano later became a partner of Sidney B. Reeve, with an office in Los Angeles. The collection's contents come from the material that Reeve's widow and Solano gathered from the Los Angeles office.

The Solano-Reeve collection is arranged by alphabetical business files, field books and diaries, and flat and rolled maps. Many maps of ranchos or diseños have been scanned and made available as digital copies on the Huntington Library website. The surveyor field books in the archive were especially useful for our research approach. While Hansen's field books take up the majority of the collection, we also examined and geolocated sketch maps and documents from surveys conducted by other early Los Angeles surveyors such as Frank Lecouvreur, who served as Los Angeles City Surveyor from 1868–1869, Adolphus Waldemar, and William P. Moore, who worked closely with Hansen in the city surveyor office for almost 20 years and also served as County Surveyor and City Street Superintendent. Other diaries and surveys from Moore are found in the William Moore Papers, also at the Huntington Library.

An example of survey field notes or maps from the collections that we examined and geolocated or georeferenced were those from George Hansen's 1864 Ranchos Cahuenga y Providencia survey along the Los Angeles River. The survey notes include multiple large, clear maps that proved extremely useful. One map from 2 May 1864 depicts lands on each side of the Los Angeles River, and includes descriptions of the river's course and bends, including the large bend near the starting point of Rancho Providencia. Another detailed map from 23 May 1864 is a survey plat of a portion of the river north of present-day Griffith Park that contains

Hansen's field notes on the map, including a description of the river's course, distances, and several points of intersection.

A large preliminary sketch map without written descriptions illustrates the geomorphic setting and extent of Rancho Providencia: adjacent to the Verdugo Mountains foothills, crossed by three large riverwash channels extending southward across the eastern San Fernando Valley that join the Los Angeles River near Cahuenga Pass at the northern edge of the Santa Monica Mountains. Collectively, Tujunga Wash channels capture flashy seasonal runoff from the largest Los Angeles River subwatershed, with its headwaters in the western San Gabriel Mountains. Historical maps of this region document shifting stream locations across a broad alluvial plain. The Providencia sketch map contains Public Land Survey township sections 9–10, 15–16, and 21–23, which align with corresponding survey data on Hansen's completed Cahuenga "S-R Map 111" obtained from the Huntington Library Solano-Reeve collection digital archive. Both maps are shown georeferenced and overlaid on an 1898 USGS topographic map (Figure 4-1).

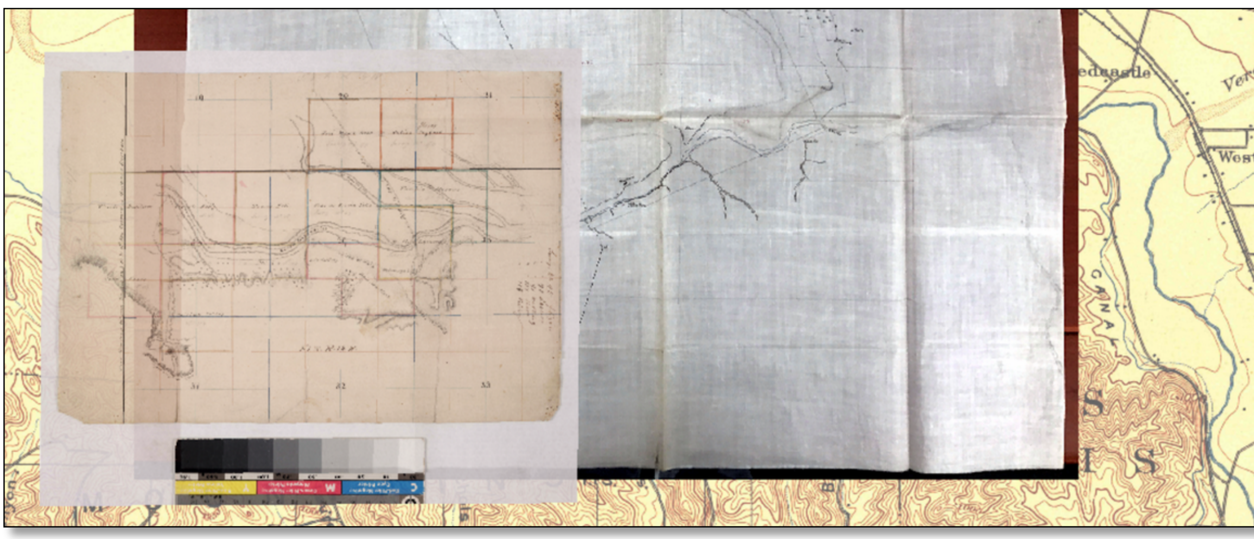


Figure 4-1. Two of Hansen's survey maps from the Solano-Reeve collection, georeferenced and overlaid on an 1898 USGS topographic map: Ranchos Cahuenga (completed map, at left) and Providencia (sketch map, at right), located along the Los Angeles River as it flows eastward along the northern flank of the Santa Monica Mountains before turning south towards Elysian Valley and Los Angeles.

Maps and field notes were geolocated individually or collectively on the ArcGIS Online archival data capture map by drawing or digitizing polygons to delineate approximate spatial footprints for survey locations. Comprehensive attributes and metadata associated with archival data sources were entered in the online feature service geodatabase when polygons were digitized. Photographs of archival data items were uploaded to the geodatabase as image attachments. Once added to a map, information from the GIS feature service layer attributes can be accessed and displayed using map pop-up windows configured and formatted in various ways.

For the Ranchos Cahuenga y Providencia survey, the largest polygon encompassed the entire survey area, including the Cahuenga map, sketch map of Rancho Providencia and surrounding area, and areas surveyed along the river to the east, with smaller polygons drawn for specific components from the archive. In this example (Figure 4-2), the larger screenshot shows all polygons, with an inset at the right showing the pop-up window that appears when clicking inside the largest polygon (shown highlighted). In this pop-up configuration, the user can scroll between polygons and data points nested within larger polygons. Other map symbols correspond to the campsites of the Portolá Expedition and indigenous (Tongva) villages.

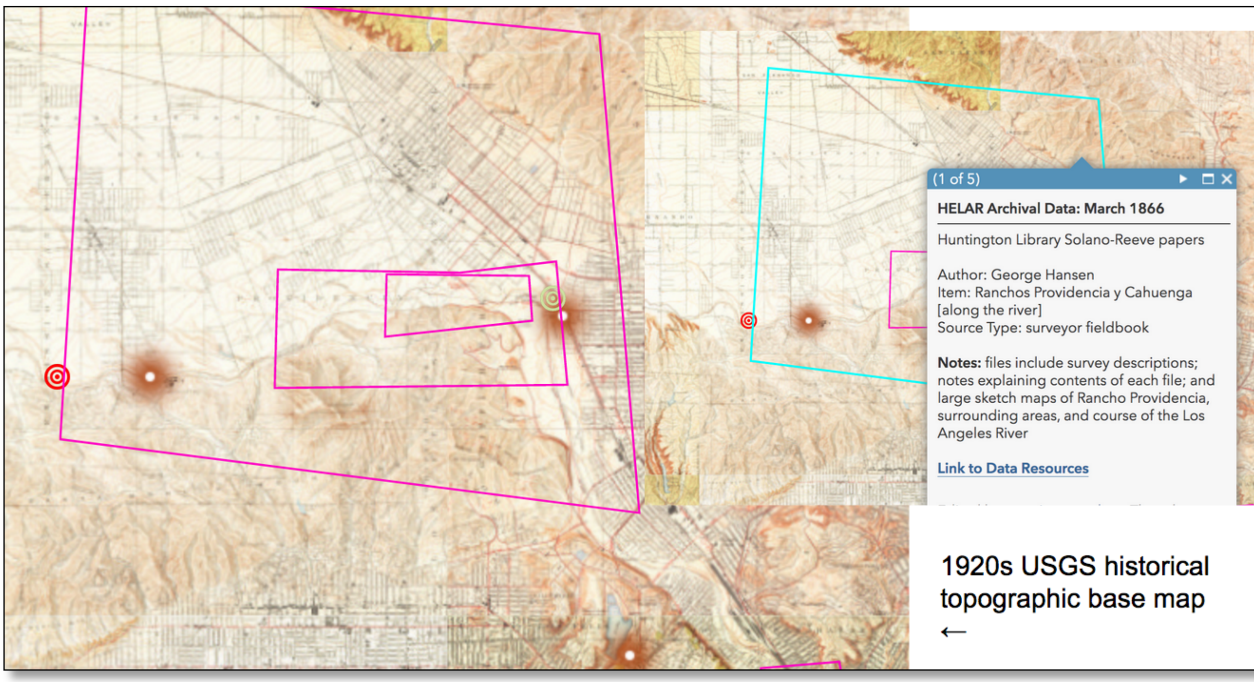


Figure 4-2. Examples of the geolocation process, data capture, and data visualization in ArcGIS Online for Hansen's Rancho Providencia y Cahuenga survey. The larger screenshot shows three data footprints (pink polygons) drawn on the 1920s topo map mosaic base map. In the inset at the right, the pop-up window that appears when the larger polygon is clicked (highlighted in blue) describes the archival material.

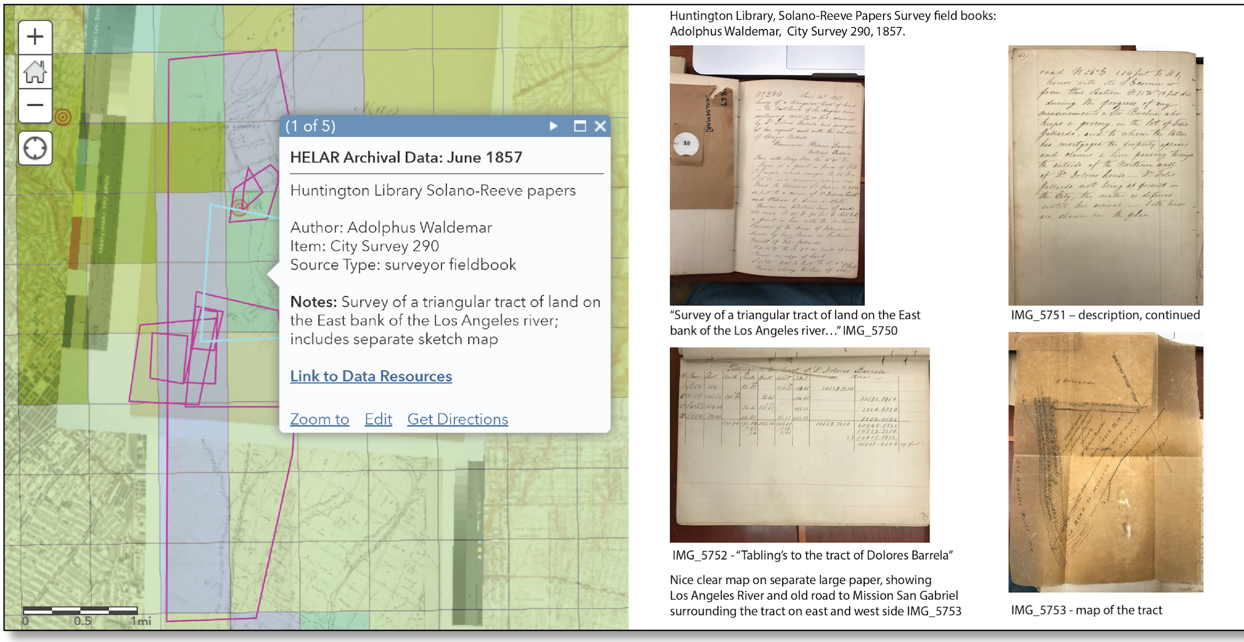


Figure 4-3. Data visualization example for Adolphus Waldemar's 1857 City Survey 290, conducted for a tract along the bank of the Los Angeles River east of downtown Los Angeles.

A second example is a data visualization for Adolphus Waldemar's 1857 City Survey 290, conducted along the bank of the Los Angeles River (Figure 4-3). At the left, several types of data layers in this online map include transparent potential vegetation grids, archival survey data polygons, georeferenced maps, and historic topo maps. This pop-up window configuration accesses archived field book data (blue-highlighted polygon represents data footprint) that includes metadata, descriptive notes, and a "Link to Data Resources." At right, the hyperlink accesses a page of images with brief descriptions about archival data items; clicking on the image thumbnails accesses higher-resolution images on our server, and could potentially link back to high-resolution scans from the original archival source, with data-sharing permissions.

A third example uses 1-km^2 grid cells for selection (Figure 4-4). The map pop-up is formatted to display hypothesized potential natural vegetation and archival data associated with the polygons intersected by the selected 1-km$_2$ grid cell. Information displayed indicates that the potential natural vegetation is Riparian Forest and includes the MGRS grid-cell reference and brief information for several archival datasets, including George Hansen's 1856 Survey 13, conducted for the Clement Michel tract along the east bank of the Los Angeles River. Clicking on the "Link to Data Resources" similarly accesses thumbnail images shown at the right that link to high-resolution images of sketch maps and notes from field books for users with data-sharing permissions.

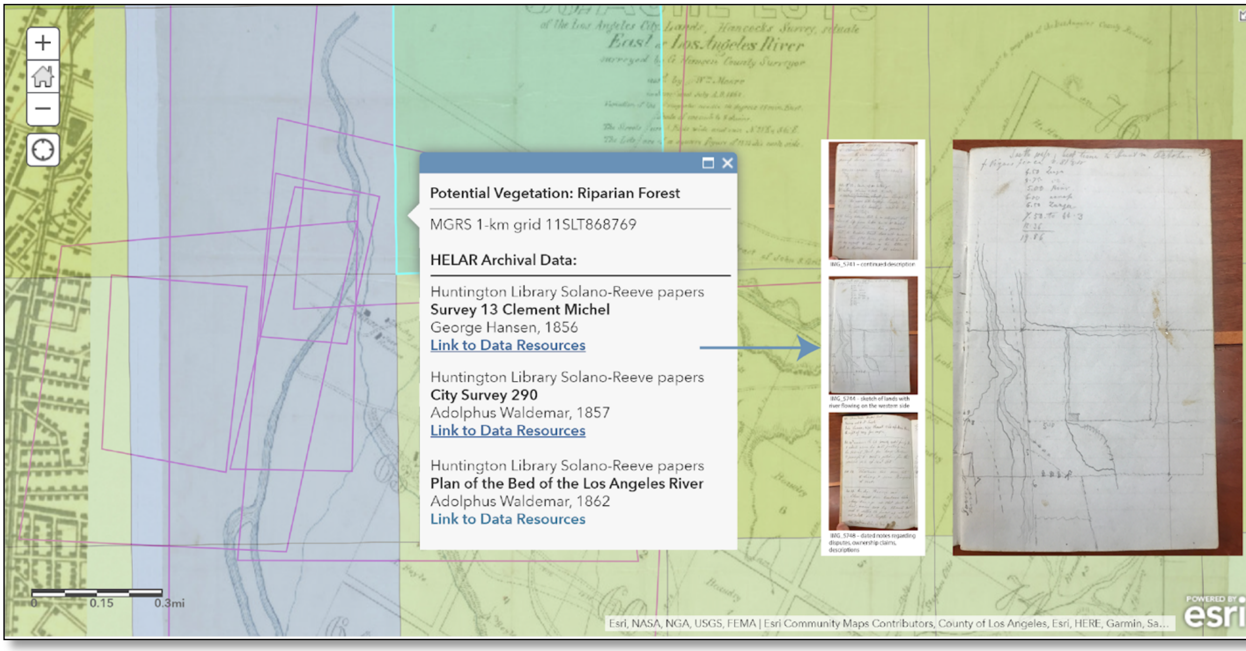


Figure 4-4. Data visualization example using 1-km² grid cells for selection. The map pop-up displays hypothesized potential natural vegetation (riparian forest), the MGRS grid cell reference, and archival data associated with the polygons intersected by the selected grid cell. Clicking the "Link to Data Resources" for the first entry, George Hansen's 1856 Survey 13 conducted for the Clement Michel tract, accesses the thumbnail images shown at the right, which also link to high-resolution images like the sketch map shown at the far right.

We georeferenced additional maps for our study area which had been scanned and made available as digital copies on the Huntington Library website and added them as map image services to our online database. Other relevant scanned images to georeference were identified and are included in the appendix. Sketch maps we found within surveyor field books were often folded or creased and would benefit from pre-processing before being scanned for georeferencing. An example (Figure 4-5) illustrates two stages of the georeferencing process for M. Kelleher's 1875 "Map showing the locations of the Old Zanja Madre, Ditches, Vineyards and Old Town, etc." In the original image, Rio Porciúncula (Los Angeles River) crosses the page from lower left to right. A river island is visible and extensive tracts of willows are mapped along the river. Irrigation ditches, gardens and vineyards lie between the river and the streets and buildings of early Los Angeles, built next to the mountains shown by contour lines across the top of the map. At right, the georeferenced map is semi-transparent to show its new spatial alignment with an 1894 USGS topo map; Los Angeles River flows south from the top left to the bottom of the map.

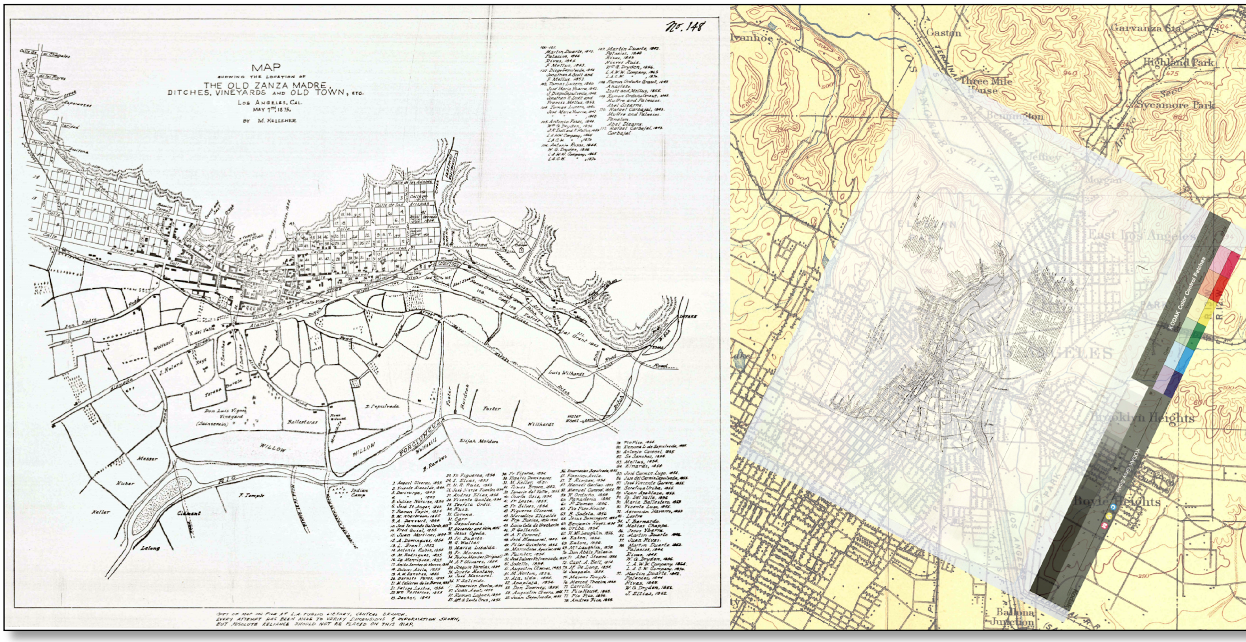


Figure 4-5. Example of georeferencing for M. Kelleher's 1875 "Map showing the locations of the Old Zanja Madre, Ditches, Vineyards and Old Town, etc." At left, original image: Rio Porciúncula (Los Angeles River) crosses the page from left to right, with a river island at lower left and extensive tracts of willows along the river; irrigation ditches, gardens and vineyards lie between the river and the streets and buildings of the old town, built next to the mountains shown by contour lines across the top of the map. At right, the georeferenced map is semi-transparent to show its new spatial alignment with an 1894 USGS topo map; the Los Angeles River flows southward from the top left to the bottom of the map.

4.2 Georeferencing and Geolocating New Sources

4.2.1 Spanish Expedition Journals

The location information and associated natural history information from Crespí's journals were parsed into a table (Figure 4-6) and then mapped. For the Crespí journal, we geolocated not only the campsites of the Expedition, which we largely know, but certain indigenous villages and "environs," or locations that the group or Crespí encountered and described along their route. We geolocated the different environmental features cited within each location, and formatted pop-up windows to display original and translated text from Crespí or Fages along with date and toponym.

The expedition waypoints were coded to provide full text of the local observations when the symbol is clicked inside the ArcGIS Online environment (Figure 4-7). The expedition waypoint map pop-ups were coded to provide full text in English and Spanish of the local observations of the environment when the symbol was clicked inside the ArcGIS Online map. Two examples below from the Crespí diaries (Figure 4-8) are from two different sites visited on 2 August 1769. At Location 2, Rio Porciúncula, the Los Angeles River near the Arroyo Seco, Crespí described a "good-sized full-flowing river with very good water, pure and fresh, flowing through another very pleasant green valley lying westward," as well as another "river bed about seven yards wide [that] flows from north-northwest, from the mountains." At Location 4, "they came upon volcanoes of pitch" at the La Brea Tar Pits. An example from Fages (Figure 4-9) includes his description of the environment encountered during the expedition's travel to their campsite along the San Gabriel River, where they stayed for multiple days before travelling to the Los Angeles River on 2 August 1769.

DATE	Expedition	TOPONYM_DIARY	TOPONYM_TODAY	ENVIRONS	LANDSCAPE FEATURE	FLORA	FAUNA	FULL TEXT
1769-07-28	Portolá	Rio de los Temblores	Santa Ana River, Placentia		*[Location 1]:* [los explorad	*[Location 2]:* Está	*[Location 2]:* Han	*[Location 1]:* A las Se conoce que est Del otro lado del rí
1769-07-29	Portolá	Santa Maria	S base of Punete Hills		*[Location 1]:* famoso, gran	*[Location 2]:* Esta		*[Location 1]:* A las Andaríamos dos h // *[Location 1]:* We In this little march
1769-07-30	Portolá	Rio La Puente... San Migu	San Gabriel River, La Puente		*[Location 1]:* también se v	*[Location 2]:* unas		Bajamos la loma y (Día 30 julio obcer *[Location 1]:* We w
1769-07-31	Portolá	Rio La Puente...San Migu	San Gabriel River, La Puente	LA River	*[Location 1]:* sanjita de ag	*[Location 1]:* tantí	*[Location 1]:* Ai e	*[Location 1]:* Salim *[Location 3]:* En do *[Location 1]:* Anoc
1769-08-01	Portolá	Rio La Puente...San Migu	San Gabriel River, La Puente	LA River	*[Location 2]:* que en las fa		*[Location 1]:* dos	*[Location 1]:* Oy dí *[Location 1]:* Mr. C
1769-08-02	Portolá	Rio Porciuncula, volcanos	LA River, La Brea Tar Pits		*[Location 1]:* a una sierrec	*[Location 2]:* [arro	*[Location 2]:* En	*[Location 1]:* Día 2 Llegados a este an *[Location 4]:* Como

Figure 4-6. Snapshot of the geodatabase table based on data parsed from Crespí's journal.

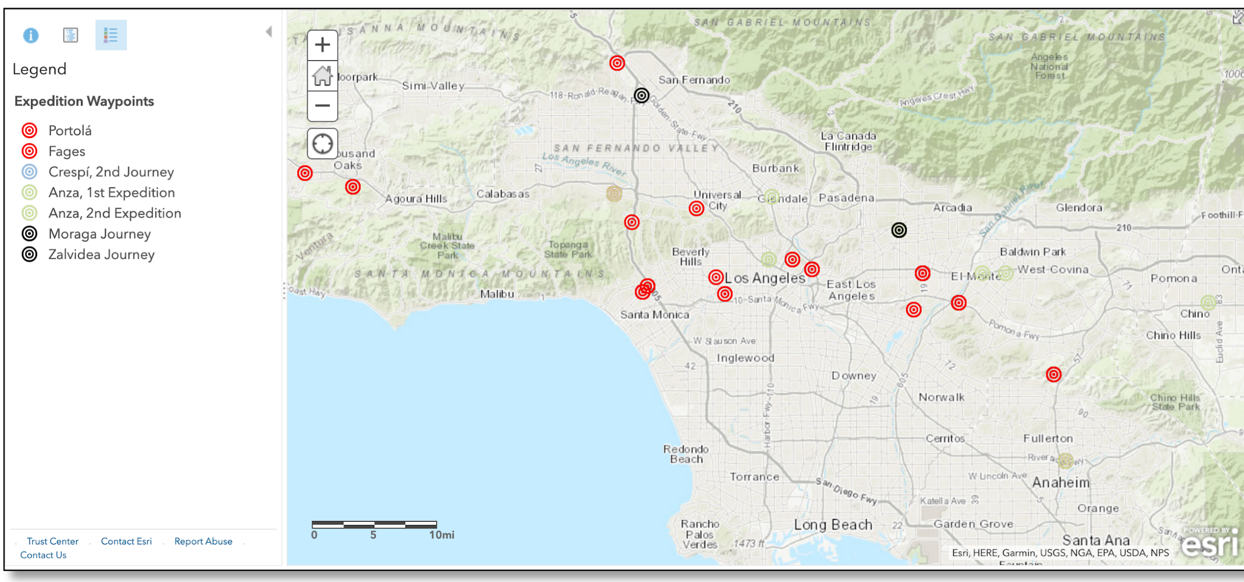


Figure 4-7. Waypoints from Spanish expeditions through the Los Angeles Basin in the 1700s, marking each location associated with a description of the environment.

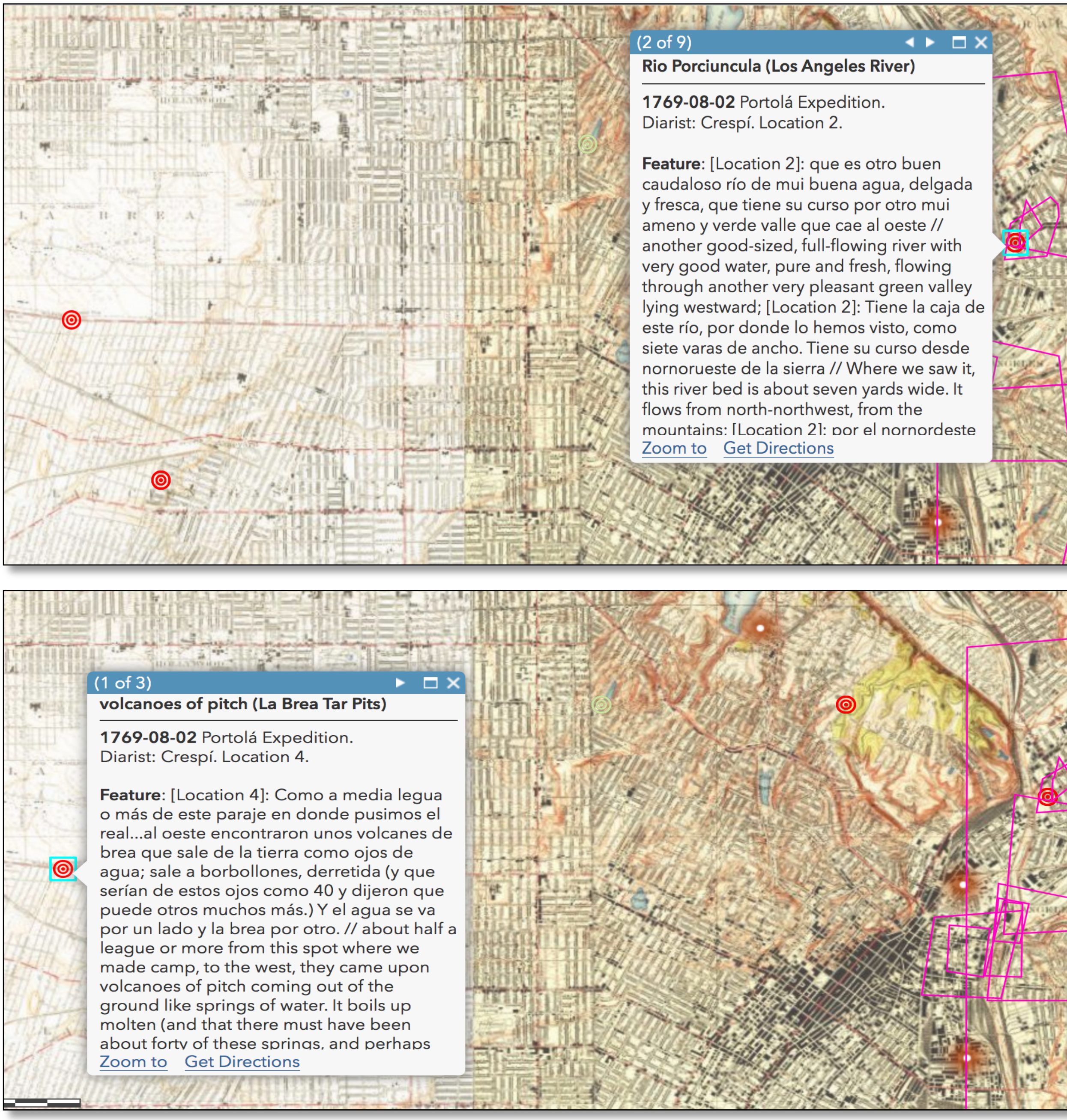


Figure 4-8. Screenshots of two different locations described in the Crespí diaries (both from 2 August 1769) with pop-up windows associating text with observation locations.

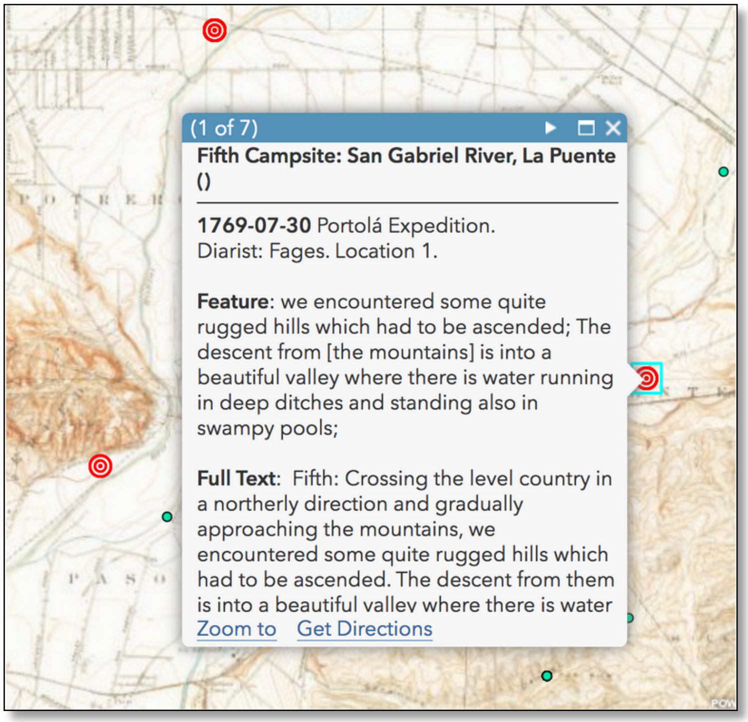


Figure 4-9. Example of pop-up window with Pedro Fages' descriptions from the expedition's campsite near the San Gabriel River, where they stayed for multiple days (including 30 July) before arriving at the Los Angeles River on 2 August 1769.

4.2.2 Natural History Records

For the primary sources from the Western Foundation of Vertebrate Zoology (WFVZ), we narrowed the data down to bird nest and egg records from Los Angeles County, which the Foundation sent us with an extensive list of collections and collectors. We geolocated these, and restricted them to observations prior to 1930, which left us with 5,318 records, with 3,917 within the final potential natural vegetation grid. We created a GIS feature service and added them to our map. The user could then click any one of the points on the map (represented by green dots) which would include information such as the bird species, location of the nest or eggs, the name of the collector, and year the specimen was found (Figure 4-10).

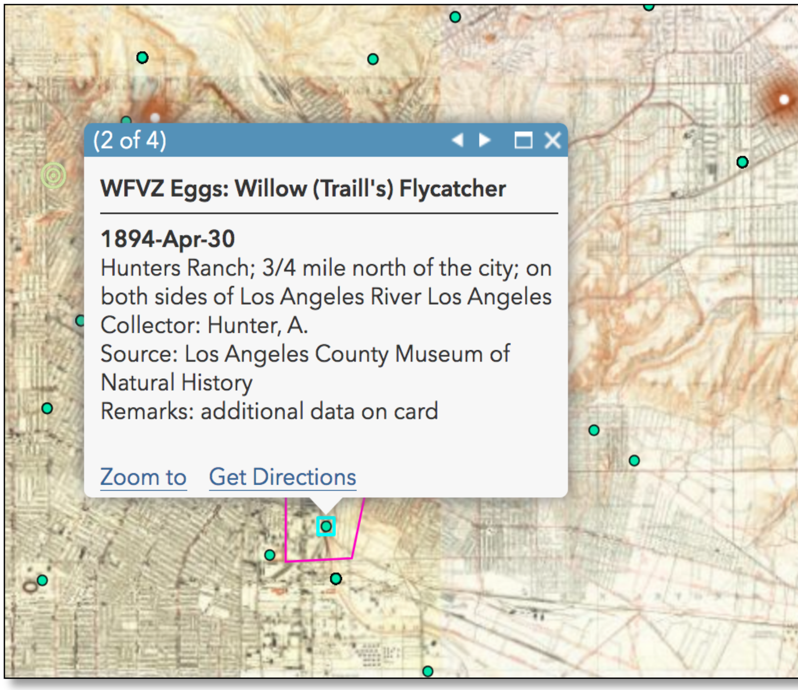


Figure 4-10. Example of a geolocated egg record, and its data available to the user.

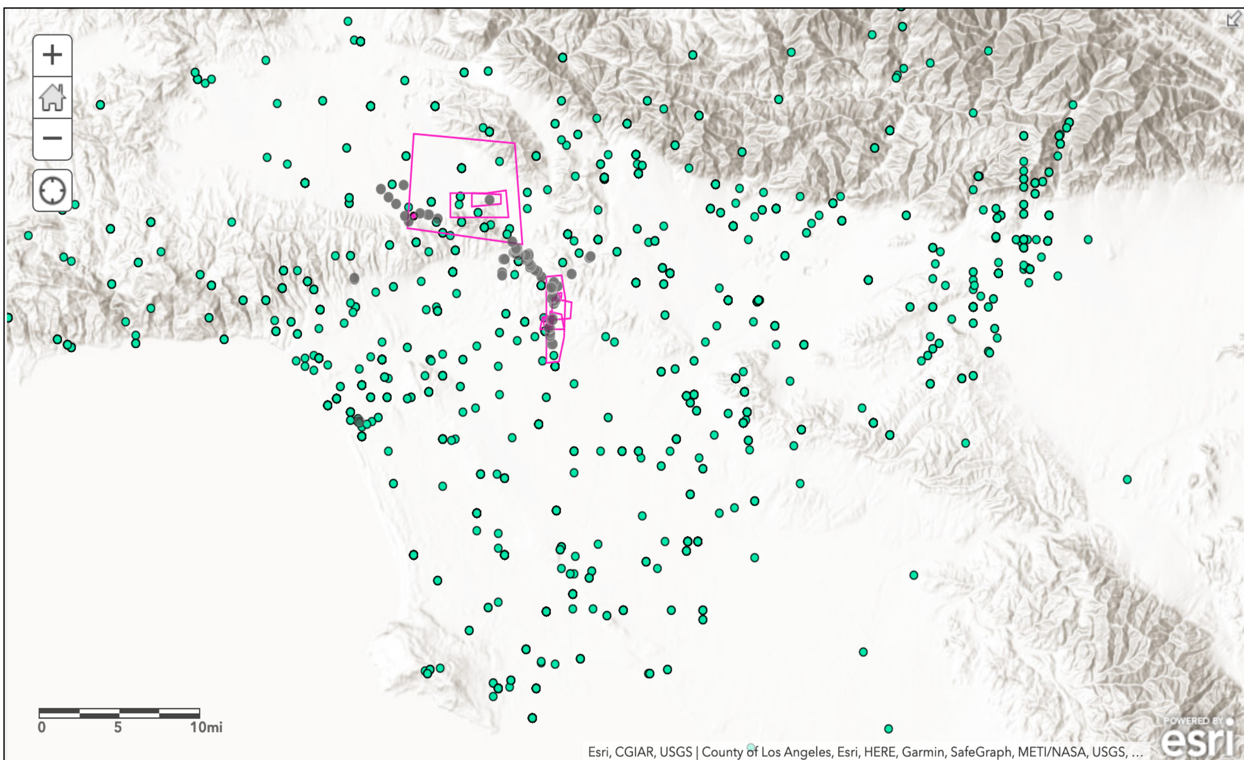


Figure 4-11. Map of geolocated reference items from archives, including notes, sketches, and text (polygons), historical photographs (gray points), and bird nest records (green points).

In addition to the bird nest and egg records that identify the locations of particular habitat types associated with a given species, other natural history observations were reviewed and mapped to help inform decisions about potential vegetation. To help delineate the extent of oak and walnut woodlands, oak (*Quercus agrifolia*, *Q. berberidifolia*, *Q. dumosa*, *Q. lobata*) and California black walnut (*Juglans californica*) observations from Los Angeles County were obtained from the Jepson Online Interchange for California Floristics. We geolocated the data points, excluded locations with questionable accuracy, and created GIS feature services for both. In the area within 5 km of the final vegetation grid, we kept 366 records for oaks, dating from 1882, and 158 for walnuts, dating from 1860. These are mapped below (Figure 4-12) along with the WFVZ bird nest and egg records that fall within the same grid extent.

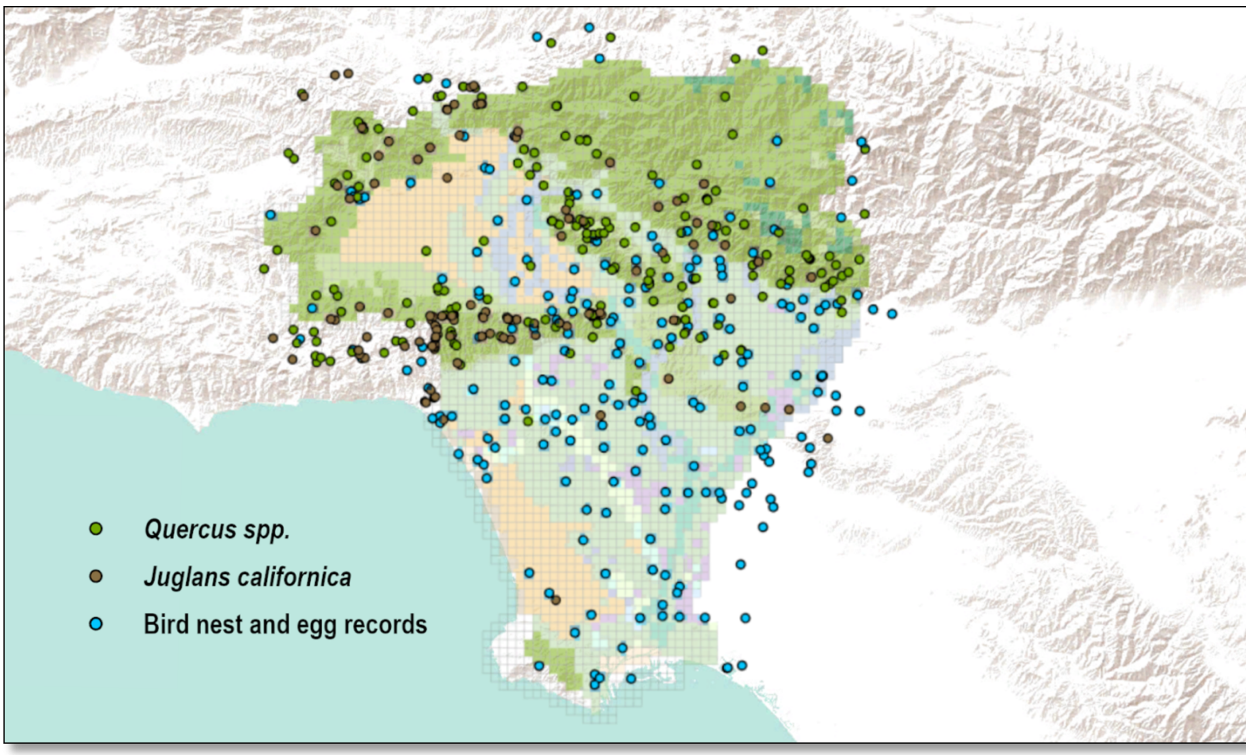


Figure 4-12. Map of natural history data used to help inform the classification by potential natural vegetation of 1-km² grid cells. Oak and walnut tree observations and bird nest and egg records are shown that fall within 5 km of the study area grid.

4.2.3 Historical Photographs of Bridges

Historical photographs we included were primarily taken near bridges along the Los Angeles River in the 1920s, with a few earlier images, and others that document extensive 1938 floods. The geographic extent of the collection is mapped below (Figure 4-13) as purple dots that follow the river, with the USDA Soil Map from 1917 as a base map. The map pop-ups are formatted as shown, with a hyperlink to the photograph.

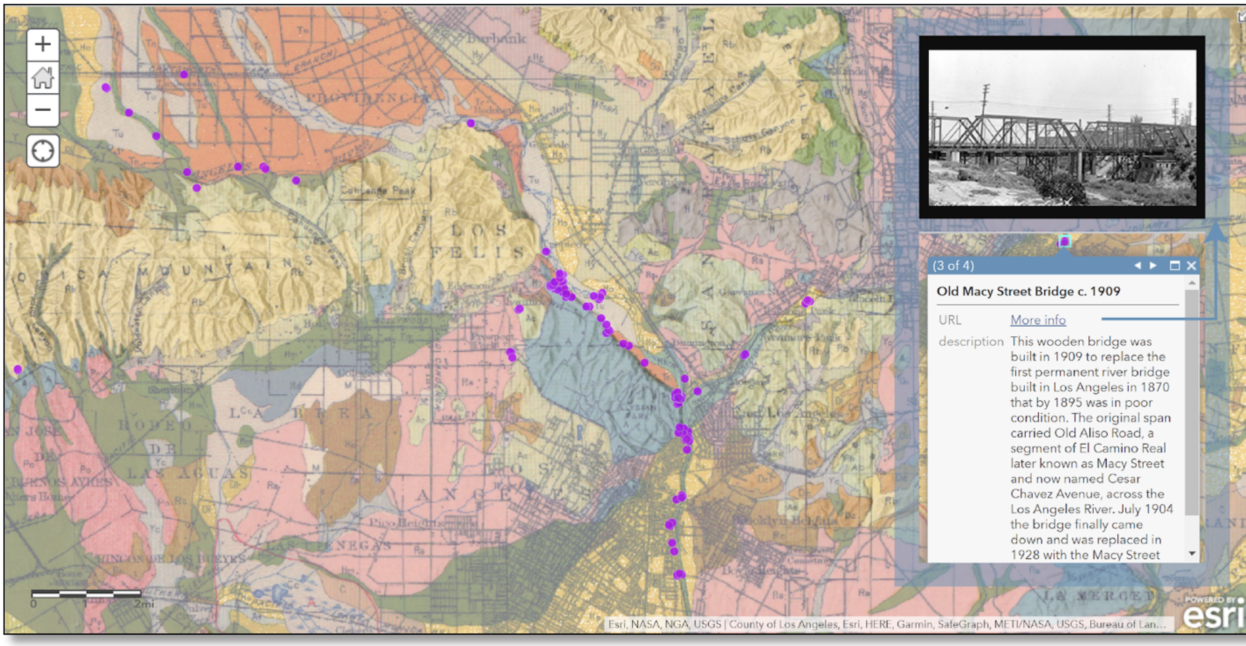


Figure 4-13. Map of historical bridge photograph locations (purple dots), shown with the USDA 1917 Soil Map as a base map. Data visualization is illustrated by the Old Macy Street Bridge example, with the date of the photograph, a description, and a hyperlink to the photograph.

Chapter 5 Potential Natural Vegetation of Los Angeles River Watershed and Environs

We classified 3,197 1-km^2 blocks in the study area by potential natural vegetation. The most prevalent macrogroups were California Chaparral and Coastal Sage, together making up 63% of the landscape. Foothill and Valley Forests and Woodlands, which include oak and walnut woodlands made up 9% of the study area, while riverwash (seasonally dry riverbed) and riparian forest made up another 7%. Grasslands and flowerfields were 13% of the landscape, and open wet meadows and alkali meadows (categorized as Salt Marsh Meadows) constituted 4%.

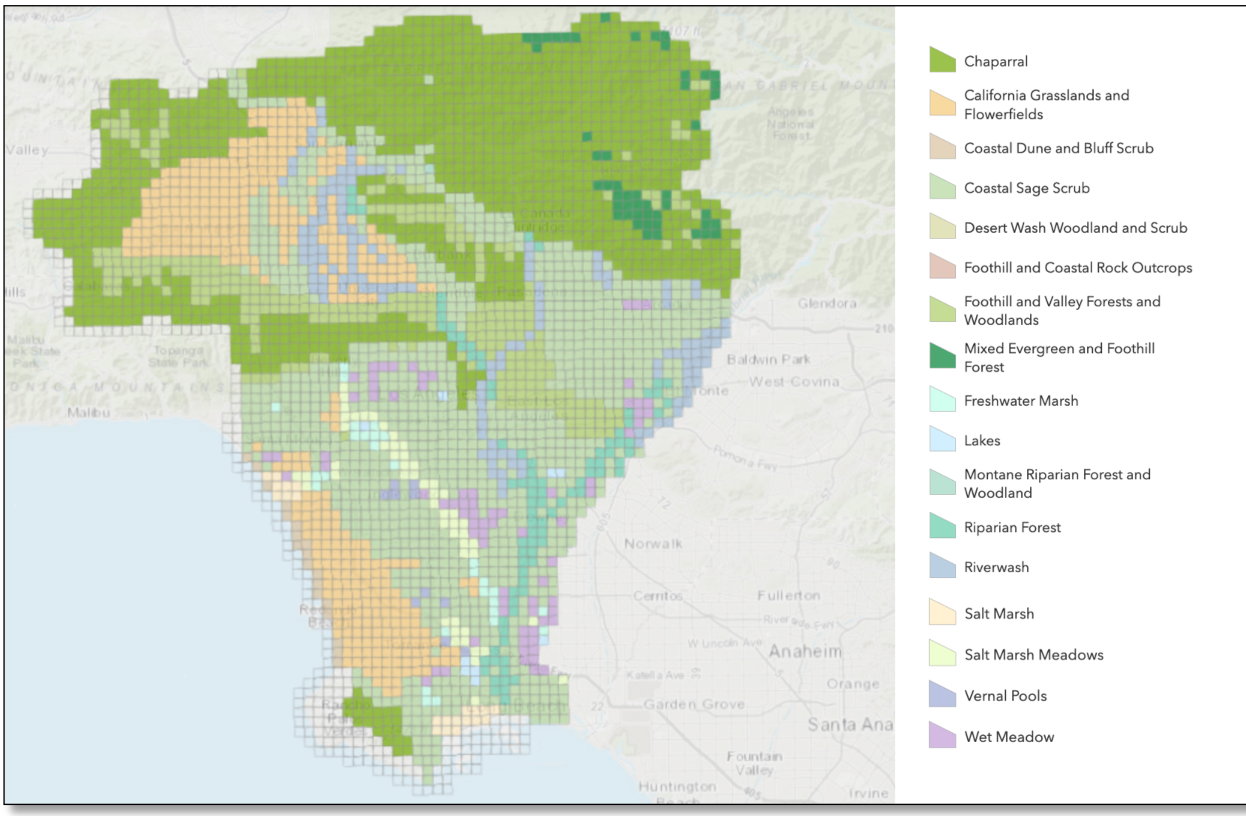


Figure 5-1. Potential natural vegetation of the Los Angeles River watershed and environs at a 1 km^2 resolution.

5.1 Functional Interpretation of Potential Natural Vegetation

The resulting map of potential natural vegetation (Figure 5-1) illustrates the geomorphological features and landscape function of the region. South facing slopes of the Santa Monica Mountains and Verdugo Hills were chaparral, while the north facing slopes supported walnut and oak forests. The Los Angeles River and larger tributaries were defined by distinct segments that included riverwash across the San Fernando Plain, riparian forest through the Elysian Valley, riverwash through and southward from downtown, the riparian forest in the lower alluvial plain. The elevated hills of the Newport-Inglewood fault ponded water at their inland base, creating a series of wet meadows and alkali meadows extending southeast to northwest until terminating at the extensive marsh inland of the Baldwin Hills. California grassland and flowerfields likely dominated the San Fernando Plain, as they did the sandy soils of the Los Angeles Coastal Prairie covering the former dune system from the Westchester Bluffs southward to the Palos Verdes Peninsula. The hills east of the Los Angeles River —Boyle Heights, Mount Washington, Elephant Hill, Ascot Hills, Rose Hills, Monterey Hills—were the "great forests of oak" described in the Fages diary, also including California black walnut trees, which also persist in these hills today. Finally, coastal scrub habitats were found throughout many of the lower slopes and plains and these might also have been burned to increase production of annual wildflowers.

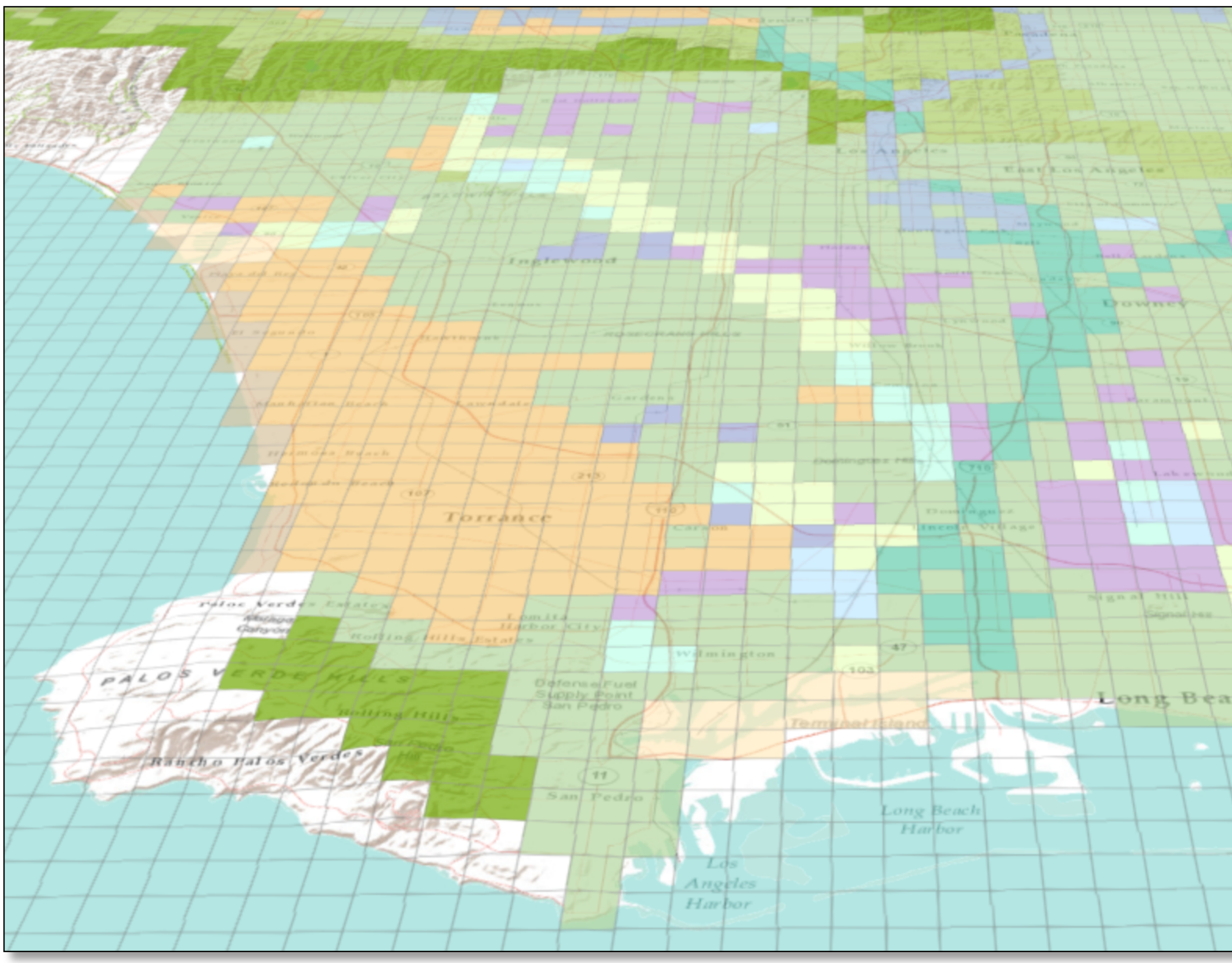


Figure 5-2. View of potential natural vegetation of lower watershed and coastal area from the south. Legend follows Figure 5-1.

PNV reflects landscape function and history. Looking at the lower Los Angeles River and Compton Creek area (Figure 5-2), one sees a set of features running northeast to southwest, starting at the coast. These are defined by soils, topography, and hydrology. Starting immediately along the coast is a line of active dunes and bluffs, where some coastal scrub vegetation persists to this day and is being restored. The next area is described as Grassland and Flowerfields at the macrogroup level. It consisted of the Los Angeles Coastal Prairie and its vernal pools (Mattoni and Longcore 1997). The extent of this habitat is defined by the extent of sandy soils left behind from a historical dune field that covered this area in recent geologic time. The vernal pools were extensive but do not show up within this area because of their size relative to the 1-km grid. The next band is coastal sage scrub, which was found on the raised land along the Newport-Inglewood Fault, which also includes the Cheviot Hills, Baldwin Hills, Dominguez Hills, Rosecrans Hills, Signal Hill, and mesas farther to the south (see Figure 5-3).

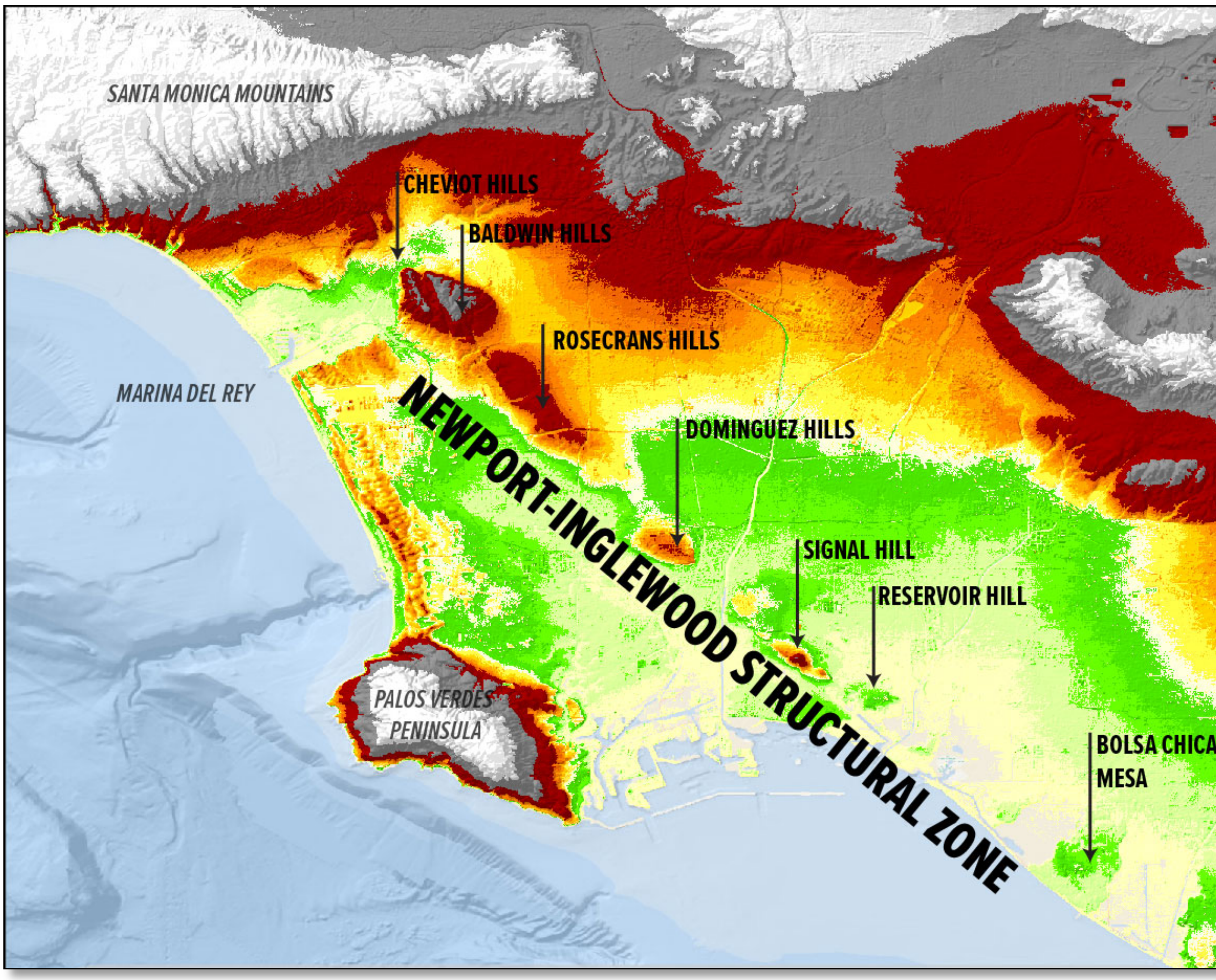


Figure 5-3. Newport-Inglewood Structural Zone (adapted from research associated with Longcore 2016)

Because of the uplift of the Newport-Inglewood structural zone, water that flows toward the ocean from the upper watershed has to find its way through any one the gaps between the hills and mesas. For some periods in deep history the Los Angeles River flowed out between the Baldwin Hills and Cheviot Hills through the Ballona Creek, marsh, and estuary. The gap between the Dominguez Hills and Signal Hills is the more recent outlet. Along the inland side of the Baldwin Hills, Rosecrans Hills, and Dominguez Hills water would accumulate before making its way to one of the gaps. This created the large freshwater marsh at the Baldwin Hills (the

Cienega; Dark et al. 2011), and freshwater marshes at the base of the Dominguez Hills. In between these two marshes, along the Rosecrans Hills, were found wet meadows and alkali meadows, depending on their inundation patterns. Alkali meadows are depressional wetlands in which salts build up through repeated inundation and drying cycles.

Continuing inland, a second band of coastal sage scrub would have been found uphill from the freshwater marsh, wet meadow, and alkali meadow complex, and continued until the riparian forest of the lower Los Angeles River was reached. The line of riparian trees associated with the river is described in the early Spanish accounts, “A great deal of trees are visible upon the beds of both, large sycamores, willows, a great many cottonwoods, very large live oaks, and they say they saw güéribo trees farther down,” (2 August 1769, Crespí) and persisted through to be visible in the earliest aerial photographs.

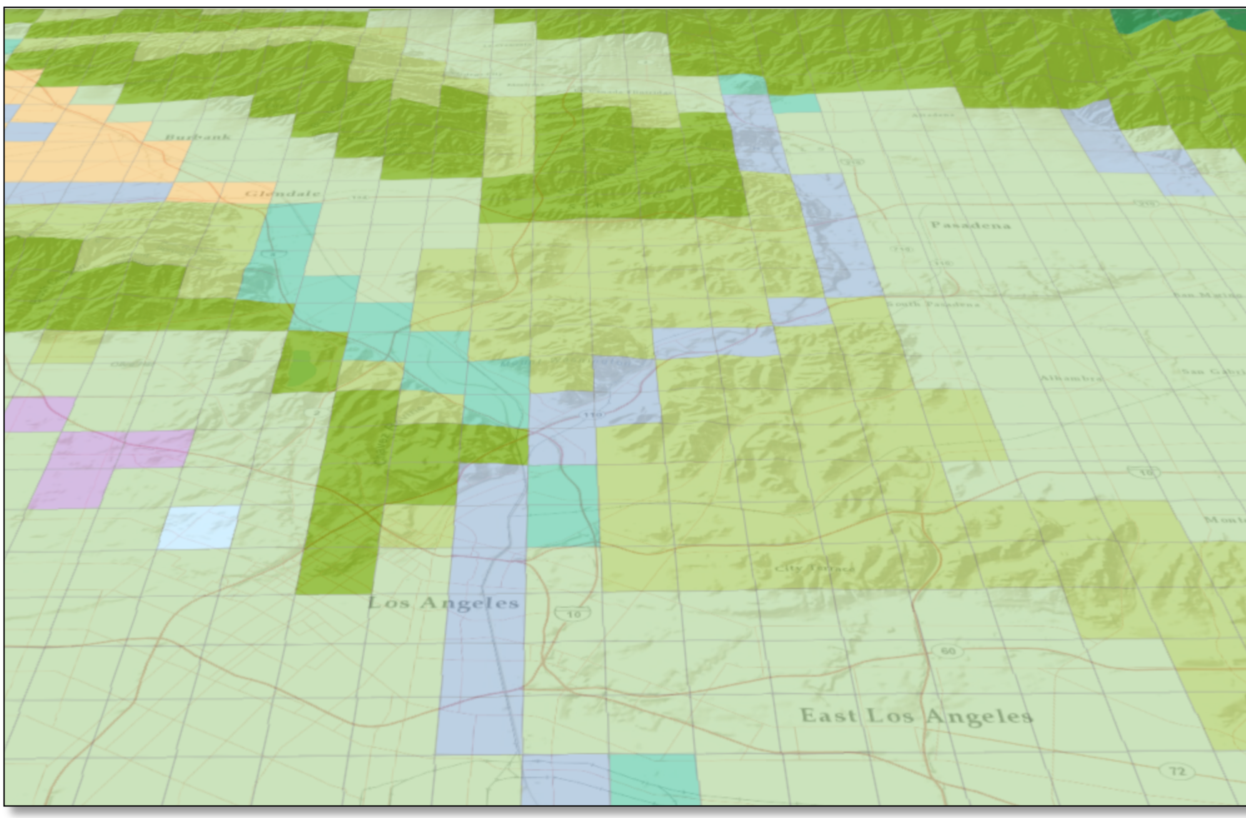


Figure 5-4. View of potential natural vegetation in the vicinity of downtown Los Angeles northward, including the Arroyo Seco and Elysian Valley. Legend follows Figure 5-1.

The vegetation along the Los Angeles River appears to have been a mix of types, depending on the gradient and hydrology. We have mapped riparian forest for most of the lower reaches, matching the conclusions drawn about the San Gabriel River (Stein et al. 2007). In other areas, based on clues from the soils maps, we map riverwash, which differs in being treeless with patchy vegetation that is frequently scoured by winter storms. We map riverwash as the dominant vegetation of the Arroyo Seco and the Los Angeles River past downtown and East Los Angeles (Figure 5-4). Farther south, as the slope flattened out, we map riparian forest to the upper limits of the coastal estuary. We also map riparian forest through the Elysian Valley where it was documented to exist on terraces above the sinuous channel (Longcore et al. 2016).

Wetland vegetation in the Ballona Creek Watershed was generalized from the maps produced by Dark et al. (2010). The Ballona Wetlands were coded as Salt Marsh, even though they are properly mapped as seasonal brackish to salt marsh. Areas of wet meadow and alkali meadow were found upstream from the wetlands, mirroring the pattern found along the Newport-Inglewood fault farther inland. The presence of flat clay soils outside the wetland zone near Ballona Wetlands was mapped as grassland because scrub species are susceptible to root rot during wet years in flat clay soils such as these.

For the Santa Monica Mountains, the hills of East Los Angeles, and the Verdugo Hills, we used historical plant observation records, fine-scale rainfall estimates, textual accounts, and remnant vegetation to conclude that they mostly shared a common pattern. The lower foothills near the coast supported oak and walnut woodlands (Foothill and Valley Forest and Woodland) then transitioned to chaparral with elevation and slope. Canyons would have supported oak and walnut woodlands as well but do not show up at the 1 km scale. The north slopes of these ranges, because of the decreased solar insolation, would have supported oak and walnut woodlands. In the case of the Santa Monica Mountains, this woodland extended down to the valley floor, thinning out into a savanna with two oak species (Coast Live Oak and Valley Oak).

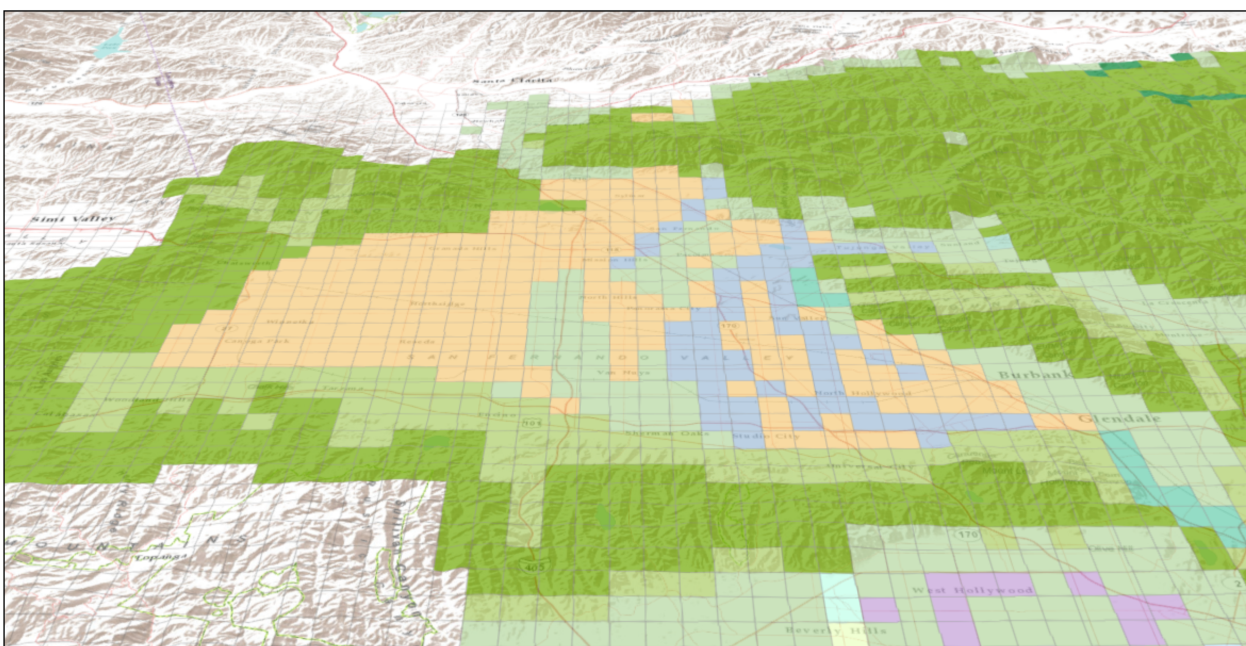


Figure 5-5. Potential natural vegetation of the Santa Monica Mountains and San Fernando Plain. Legend follows Figure 3 25.

We concluded that most of the San Fernando Plain was grassland and flowerfields, based on the rainfall and soils, with some areas of loamier soils supporting sage scrub. The large washes that transect the plain north to south are familiar features that are visible in the early topographic maps and were assigned to the riverwash category as sparsely vegetated, seasonally scoured drainage features. Although some riparian forest would have been found at the base of the Santa Monica Mountains as the Los Angeles River flowed to the east toward the Elysian Valley, it was not extensive enough to show up at a 1 km scale. The Foothill and Valley Forests and Woodlands (predominantly oak and walnut woodlands) on the north slope of the Santa Monica Mountains extended down to the southern edge of the valley and into it as a savanna reaching out onto the plain.

The vegetation types in the upper watershed of Tujunga Wash are largely similar today to the historical condition and were extrapolated to the 1 km scale.

Our map of potential natural vegetation is a hypothesis, based on the information currently available and our interpretation of it. We propose that it be amended as more detailed information becomes available and with quantitative approaches such as we used for the potential natural vegetation of Catalina Island (Longcore et al. 2018) can be applied to a reconstructed historical topography of the region. Potential natural vegetation is itself a "provisionally useful fiction" (Jackson 2013), in that it is describing landscape conditions that do not exist. It is, however, useful in highlighting the types of habitats most lost to urban development and to help interpret the units (ecotopes) of the modern landscape.

5.2 Loss of Historical Vegetation Types to Urbanization

To illustrate the relative proportion of different habitat types degraded and lost through urbanization, we focused on a subset of the study area, the current Los Angeles River Watershed. We then intersected the potential natural vegetation with the current extent of the "urban" land use as mapped by the CALVEG dataset (U.S. Forest Service, Pacific Southwest Region, 2009) to see how many 1-km blocks of each vegetation type survive with no incursion from urbanization. Mixed Evergreen and Foothill Forest has been spared through its location in the Angeles National Forest, as has some of California Chaparral. But California chaparral has urban land uses in 69% of the 1-km^2 blocks that make up its historical extent, Foothill and Valley Forests and Woodlands in 85%, and the remainder of vegetation types have been impacted at least some in 98–100% of the 1-km^2 blocks that we mapped (Table 5-1).

Table 5-1. Vegetation Macrogroups of the Los Angeles River Watershed and Environs and percent of 1-km blocks affected by urbanization.

Vegetation Macrogroup	km^2 dominant in whole study area	km2 dominant in current LA river watershed	km^2 at least partially urbanized in current LA river watershed
California Chaparral	1121	954	297 (-69%)
Coastal Sage Scrub	898	553	546 (-99%)
Foothill and Valley Forests and Woodlands	279	258	219 (-85%)
California Grasslands and Flowerfields	400	240	240 (-100%)
Riverwash	142	133	130 (-98%)
Riparian Forest	91	86	86 (-100%)
Wet Meadow	100	47	47 (-100%)
Mixed Evergreen and Foothill Forest	50	39	1 (-3%)
Salt Marsh Meadows (inc. Alkali Meadow)	52	16	16 (-100%)
Freshwater Marsh	28	9	9 (-100%)
Lakes	9	2	2 (-100%)
Vernal Pools	10	1	1 (-100%)
Salt Marsh	21	0	0
Coastal Dune and Bluff Scrub	19	0	0
Montane Riparian Forest and Woodland	1	0	0

Chapter 6 Coordination with Stakeholders, Outreach, and Research Directions

6.1 Coordination with Stakeholders

During the course of the project we identified agencies that were actively planning for the future of the Los Angeles River, including the Los Angeles County Department of Public Works, the City of Los Angeles, the Mountains Recreation and Conservation Authority, and the San Gabriel and Lower Los Angeles Rivers and Mountains Conservancy. We shared our work plan with the County team developing the new Master Plan for the Los Angeles River early in the project and received positive feedback about the usefulness of the proposed products and synthesis to implementation of the plan. Presentations of the usefulness of historical ecology were also made at other agencies.

In Spring 2020, we convened a workshop of participants from key agencies with a stake in restoration and ecological conservation in the Los Angeles River watershed. We presented a summary of the research and had extensive discussions about the products and their delivery to interested stakeholders. A video of that meeting, held online for public health reasons, is available at: https://drive.google.com/file/d/18GFQWmRTg6BQxBod2LUYJn8GpgNmigFf/view .

At the request of the Los Angeles Department of Sanitation and the Environment, we shared our draft map of the potential natural vegetation of the Los Angeles River watershed and environs for inclusion in a report associated with their 2020 biodiversity initiative report as a Los Angeles Urban Biodiversity Case Study and included in the atlas characterizing the "ecotopes" of Los Angeles.

Outreach associated with the project, including the agency stakeholder workshop, confirmed the value of a robust and nuanced understanding of environmental history to current culture and planning. We shared specific research results as they were requested. For example, we provided the location of zanjas through downtown Los Angeles from a recently georeferenced map to an artist working on a project to interpret those features. We also researched and shared details on the location of a small creek running into the Los Angeles River in the Elysian Valley with a landscape architect working on a project there. Following our workshop, participants had ideas and suggestions to move the work forward, and highlighted connections to other ongoing planning and analysis efforts, such as a study of the current flows of the Los Angeles River currently underway.

The uses of the work fall into several categories: as a baseline for further, shared research about the history of the region, as a reference for environmental scientists addressing contemporary issues (e.g., flooding, restoration), as background for landscape architects, architects, and designers creating new spaces that can or might reflect natural processes and ecosystem function, and as a record for public education about the functioning of the landscape before its engineered transformation through urbanization.

In assembling and analyzing the information presented here, it was obvious that many, many different stories, from different perspectives could be told about the history of this place. We have focused on two: the cultural history and the underlying function of the landscape. The tools we have developed, however, can be used to tell many different stories, of peoples, places, and the land beyond our initial syntheses. It is for this reason that we envisioned the project from the start as a framework for further analysis. Open data and transparent workflows have transformed scientific research in the past five years. Doing so has ensured that science is more replicable and has facilitated breakthroughs as multiple datasets are combined in new ways to find patterns. Our effort extends an open data ideal to environmental history, with the conviction that by sharing our results and database we will promote more cooperative research as well as allow many different narratives to be built from the results.

6.2 Outreach

A central goal of this project has been to assemble an online geohistorical database of known and newly discovered data layers as the "infrastructure" for the next phases of the project, which will involve more investigators who draw on those layers and also augment them with additional layers and increasingly fine resolution and detail. The "comprehensive" endpoint for an ongoing collaborative research program will be to have readily available for any neighborhood-sized (100 meter resolution and less) local area, sufficient historical ecological information to estimate the potential natural vegetation, in the form of plant associations and alliances, faunal and avifaunal associations, for that particular neighborhood. While the present study does not attempt to make estimates of potential natural vegetation at a resolution finer than 1 kilometer, the geohistorical database that we have assembled in online form is the infrastructure necessary to launch an increasingly larger collaboration and take the study to finer degrees of resolution.

The collaborative geohistorical database is now available for any collaborating investigators, who may work on any part of the study area. Because we included in this database a large volume of scanned archival records, such as maps, manuscripts, and photographs that are held by diverse archives, each with their own intellectual property concerns, this geohistorical database will remain restricted to researchers and is not for fully public access. The software platform that serves the data, ESRI's ArcGIS Online, is also not suitable for a general public, requiring some expert knowledge to operate. This database is established for long-term durability on the servers of the Spatial Sciences institute at USC. With this Final Report in its PDF and website (https://lalandscapehistory.org/) formats, we have now fulfilled the goal stated in our proposal "publish a preliminary analysis at 1-km resolution and release the entire geo-database in open-access via ArcGIS Online, so that the public and a wider set of researchers can access the digitized analog sources, analyze and augment local areas with greater detail, and realize a complete portrait of the Los Angeles Basin's historical ecology down to each canyon, creek, and wetland."

We also have a goal of offering the general public access to the various layers in the geohistorical database, to allow people to explore the historical ecology of the entire metropolis, and to explore their own neighborhoods and districts. This platform will take a much more public-friendly form, will be read-only, and will only publish archival sources for which permissions have been obtained from the archives contributing them, such as the Huntington Library. With this Final Report, we will now approach those archives to gain permission to publish their records in some form (perhaps lower resolution, or a sub-set), for the public to view. We plan to release this all-public access web application by the end of July 2020, along with a press release announcing our main findings and informing the public about the beginning of this longer-term collaborative effort going forward.

6.3 Further Research

Further research is needed to support conservation and restoration planning and to enhance understanding of the cultural history of the Los Angeles River, and the Los Angeles Basin more generally. Our work thus far has extended the resources available to understand our landscape history, extracted and compiled new data, situated landscape interpretation within a 9,000-year context of human settlement, and interpreted the processes that govern the nature and distribution of vegetation at a coarse (1-km) scale. Designers, ecologists, and public educators, however, need greater integration at a higher spatial resolution to do their jobs effectively. We have identified a series of next steps that would be the focus of further research.

First, we used composite imagery of the earliest USGS topographic maps as a base for our investigation. Those maps are, however, only currently available as images and for the features on them to be used and analyzed on other maps those features need to be digitized and extracted into standalone GIS layers. For example, all of the bounds of streams and rivers would need to be digitized by technicians tracing the lines for each feature type. The topographic information also needs to be extracted so that we can create spatially explicit hydrological models that describe the pre-channelization dynamics of the Los Angeles River. Currently available models of the topography include all the channelization, grading, and landform manipulation of the past eighty years. To address questions currently being posed by local agencies, such as defining the pre-channelization flows of the Los Angeles River, historical, pre-urbanization geographic information is needed.

For example, members of our research group are currently completing a project where historical elevations and landscape features were digitized from an 1800s topographic map of San Clemente Island. After extracting all of the topographic lines, streams, bluffs, coastline, and high and low elevations, we created a digital elevation model that could be used in landscape modelling. Figure 6-1 shows a "hillshade" representation of the DEM with the original map draped over the top. We have subsequently been able to use the DEM to model erosion and the changing distribution of plant communities in response to landscape change (Longcore, MacDonald, and Wilson, unpublished data). Similar analysis could be done at the scale of the Los Angeles Basin.

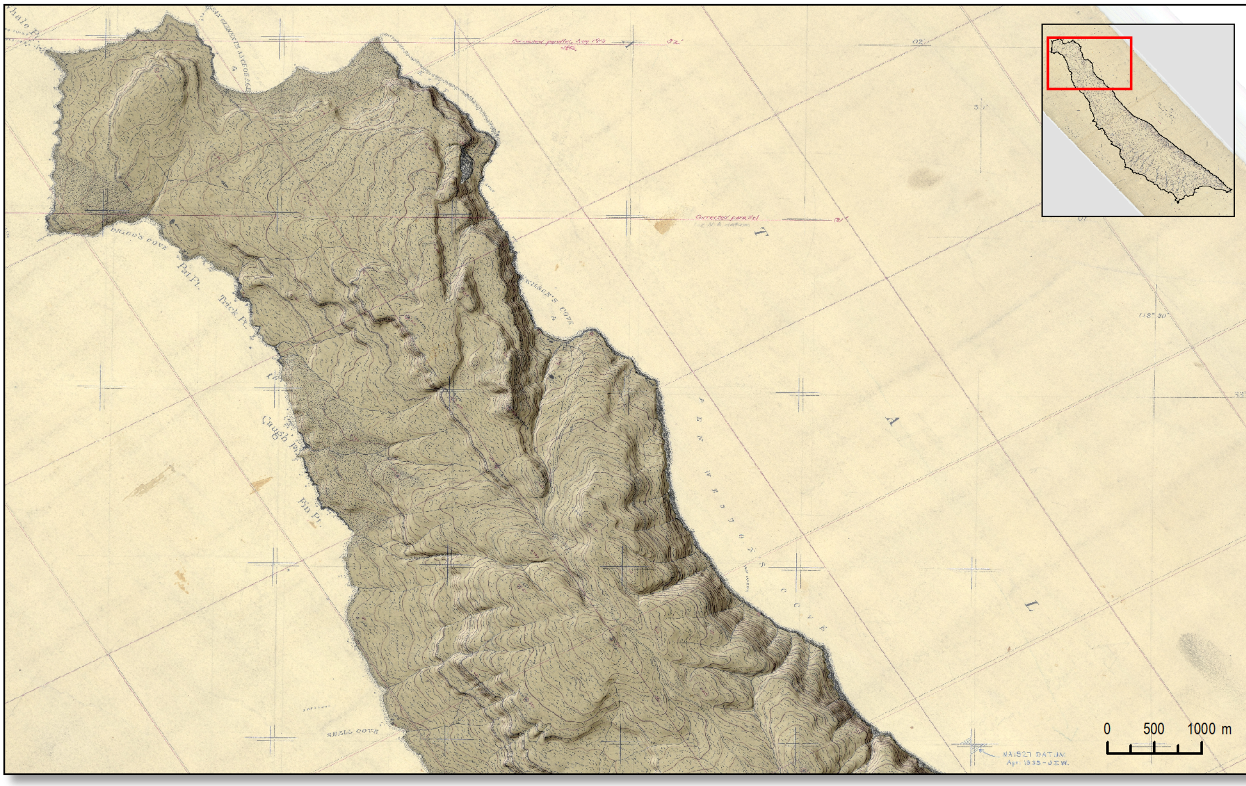


Figure 6-1. Shaded relief of 1879 San Clemente Island produced from a digital elevation model extracted from topographic lines in the underlying map (Longcore, MacDonald, and Wilson, unpublished data).

Digitizing features from topographic maps would also be a key step toward refining the potential vegetation map below our 1-km resolution.

Second, an incredibly useful archive of aerial photographs from the 1920s and 1930s is available for the Los Angeles River Basin. The photographs are all geolocated with a point indicating the location of roughly the center of each (see Figure 6-2). To increase the resolution of our historical maps for planning and education, we need to georeference a seamless mosaic of these images to cover the entire extent of the region. This would be a manual process, where identifiable points on the photographs are lined up with current-day landmarks and the images are projected to fit over the current landscape precisely. Such a resource would make the development of fine-scale maps of ecological history exponentially easier and would give people a significant, new perspective on their environment. As an example, the landscape architecture team that is advising the current update to the County of Los Angeles's Los Angeles River Master Plan put together a mosaic of images along the Los Angeles River and compared them to present day (Figure 6-3; https://drive.google.com/file/d/1UswHH6-rn9ExwzJYfJSTfHJeNfp38FUQ/view; Source: OLIN).

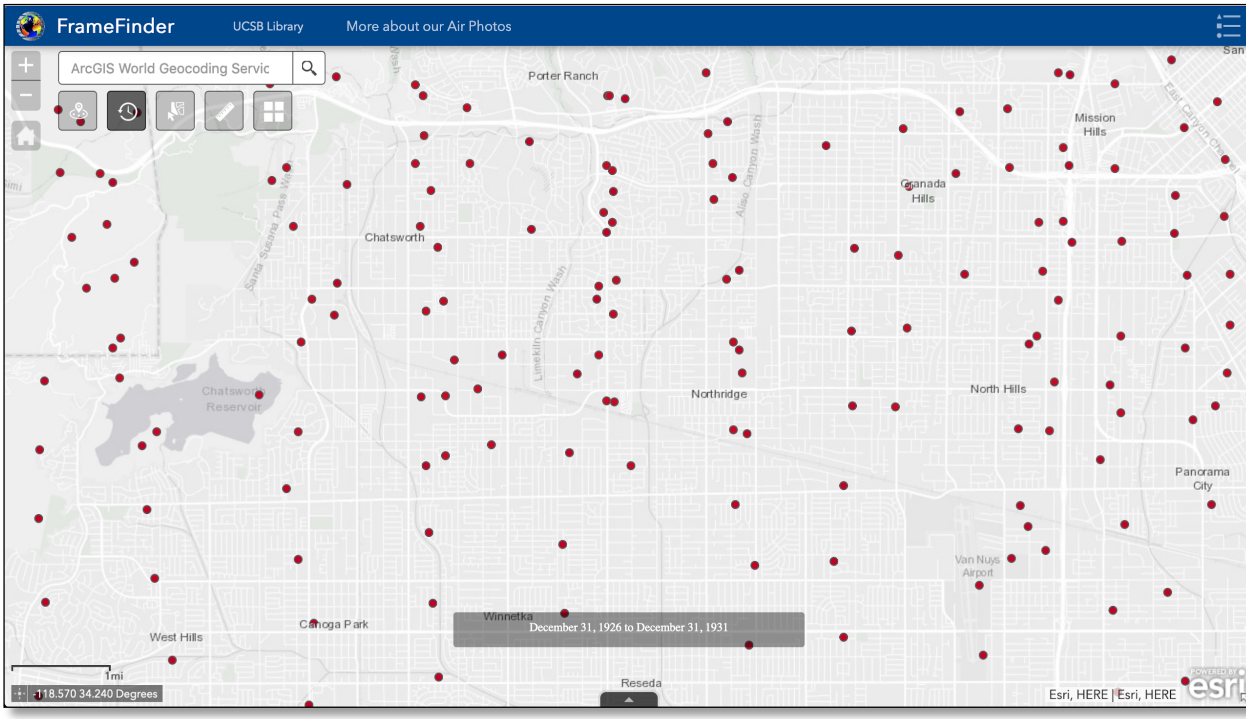


Figure 6-2. Location of orthogonal aerial photographs taken between 1927 and 1931 in the San Fernando Valley, as archived at the UC Santa Barbara library.

Figure 6-3. Screen still from OLIN's comparison of historical and current aerial photography in the several hundred meters on either side of the Los Angeles River.

Third, the breadth and accuracy of the natural history records for the region should be expanded and improved. We noted that the accuracy of many records currently georeferenced was coarse and through the research we became aware of additional repositories where specimens were collected but have never been indexed to shared databases. Considerable opportunity remains to enhance the understanding of biodiversity across this landscape and to tie it both to cultural history and current restoration efforts.

Fourth, once the historical topography and hydrography has been extracted through digitizing topographic maps, more quantitative tools should be used to define the habitat conditions associated with major vegetation types as a means to better resolve the potential natural vegetation map. This would be important from a restoration and management perspective because it could provide insights on where to plant certain species in the restoration process and where to look for currently rare species such as California black walnut (*Juglans californica*).

Fifth, future work should continue to be built on a principle of shared data and collaboration. Through the course of the project we have found interest from different sectors who can and are willing to contribute to a shared understanding of our regional environmental history. Different researchers have special skills and capacity to contribute to either distinct geographic areas or specific technical questions. For example, OLIN shared its Los Angeles River mosaic after participating in our workshop. By committing to shared data and credit, we can together build a body of knowledge and resources to support these varied interests, ranging from academic historians to public works officials to the general public looking for insights on their neighborhoods within this region.

Chapter 7 Sources

7.1 Primary Sources

7.1.1 Maps

- Topographical Map of Los Angeles River. City of Los Angeles Bureau of Engineering, C.S. Compton and J.H. Dockweiler, City Engineers. Surveyed in 1896–97. Scale 200 Feet to 1 Inch. Sheets 1-2-3-4. 1897.
- Detail Irrigation Map, Los Angeles Sheet and Santa Monica Sheet. California State Engineering Department, Wm. Ham. Hall, State Engineer. Irrigation Data 1888. Scale 1 ½ Inches to One Mile. 1888.
- Soil Map. California. Los Angeles Sheet. US Department of Agriculture Bureau of Soils, USGS base map. 1903. USDA Bureau of Soils and University of California Agricultural Experiment Station, USGS base map. 1916 and 1917. Scale 1:62,500.
- USGS topographic surveys composite mosaic of 1920s Los Angeles County 1:24,000 scale quadrangle maps. Itatsu and Ethington. 2006.
- USGS topographic surveys, 1:62,500 scale. Calabasas (1903); Downey (1899); Pasadena (1900); Redondo (1896); Rock Creek (1903); San Fernando (1900); San Pedro (1896); Santa Monica (1898); Santa Susana (1903); Tujunga (1900).
- USGS topographic surveys, 1:24,000 scale.
- Plan de la Ciudad de Los Angeles. E.O.C. Ord. Scale 10 Inches to the Mile. 1849. Reproduced by the Historical Society of Southern California.
- Solano-Reeve Collection, Huntington Digital Library. Map 111: Ranchos Providencia y Cahuenga: parcels along Los Angeles River. G. Hansen. 1854.
- Solano-Reeve Collection, Huntington Digital Library. Map 313: Tract of Land. containing 11 1/4 acres; occupied & claimed by Don Manuel Romero. G. Hansen. 1855.
- Solano-Reeve Collection, Huntington Digital Library. Map 314: Survey of M. Romero Tract (George Hansen and Alfred Solano, 1875)
- Solano-Reeve Collection, Huntington Digital Library. Map 319: Los Angeles: Subdivision, land between west bank of Los Angeles River and road to Arroyo Seco. Undated.
- Solano-Reeve Collection, Huntington Digital Library. Map 325: Los Angeles: Map of the Millseat of Messrs Mellus Scott and Stearns. G. Hansen. 1856.
- Solano-Reeve Collection, Huntington Digital Library. Map 374 (1-2): Map of the 35-Acre Lots of the Los Angeles City Lands. East of Los Angeles River. G. Hansen and W. Moore. 1868.
- Solano-Reeve Collection, Huntington Digital Library. Map 394: Proposed prolongation of Aliso Street through the property of F. P. F. Temple Esqr. F. Lecouvreur. 1870.
- Solano-Reeve Collection, Huntington Digital Library. Map 429: Property of J.G. Downey, L. Willhart, E. Moulton, M. Ruiz, Dolores Sepulveda and Benita Peraza and Julian Chavis. F. Lecouvreur. 1874.
- Solano-Reeve Collection, Huntington Digital Library. Map 441: Map showing location of the old Zanja Madre, ditches, vineyards and Old Town, etc. M. Kelleher. 1875.

- Solano-Reeve Collection, Huntington Digital Library. Fieldbooks. G. Hansen – Survey 150, Louis Vignes, 1855. Sketch map.
- Solano-Reeve Collection, Huntington Digital Library. Fieldbooks. G. Hansen – Clement Michel tract, 1856. Sketch map.
- Solano-Reeve Collection, Huntington Digital Library. Fieldbooks. G. Hansen – Ranchos Providencia y Cahuenga along river, 1864. Sketch map.
- Solano-Reeve Collection, Huntington Digital Library. Fieldbooks. G. Hansen – bed of LA River survey, 1866. Sketch map.
- Solano-Reeve Collection, Huntington Digital Library. Fieldbooks. G. Hansen and A. Solano – Survey of Los Angeles River Bed at Macy St. Bridge, 1891. Sketch map.
- Solano-Reeve Collection, Huntington Digital Library. Fieldbooks. A. Waldemar – City survey 290, 1857. Sketch map.

- USGS Historical Topographic Map Explorer. USGS and Esri. Esri ArcGIS Online Living Atlas.
- USA Mean Rainfall. USGS and Esri. Esri ArcGIS Online Living Atlas.
- USA National Hydrography Dataset - High Resolution. Esri ArcGIS Online Living Atlas.
- World Elevation Terrain Service: Aspect Map, Slope Map. Esri ArcGIS Online Living Atlas.

- Existing Vegetation polygon feature class. GIS data for Upper Los Angeles River watershed, San Gabriel Mountains, Angeles National Forest. US Forest Service, Region 5, South Coast.
- GIS data from historical ecology studies of greater Los Angeles region watersheds, including the Los Angeles River through Elysian Valley (Longcore 2016); Ballona Creek (Dark et al. 2011); the San Gabriel River (Stein et al. 2007); the lower Santa Clara River, Ventura River, and Oxnard Plain (Beller et al. 2011); and Wetlands of the Southern California Coast (Stein et al. 2014). Additional GIS feature services and web map created for this study, USC Spatial Sciences Institute 2018.
- Los Angeles River Mile Markers and Design Reaches, LA River Master Plan Update 2018. GIS data from the County of Los Angeles Department of Public Works and Geosyntec.
- Georeferenced localities of oak and walnut tree species, Los Angeles County. Jepson Online Interchange for California Floristics.
- Georeferenced localities for bird nests and egg records, Los Angeles County. Western Museum for Vertebrate Zoology.

7.1.2 Archives

California Institute of Technology

The University only had some subdivision and city maps, plus previous theses that are searchable online that could provide some useful information; none identified yet.

C. Erwin Piper Technical Center, Los Angeles City Archives

The archive did not have much pertaining to vegetation, watershed, or ecology. It had two large survey maps, one of which is also found in the Solano-Reeve collection at the Huntington Library, and the other not useful for our research approach and methods. It also contained Los Angeles City Council meeting minutes, some searchable, but little useful information found relating to the ecology of the Los Angeles River.

The Huntington Library, San Marino, CA

- Solano-Reeve Papers, c.1849–1910

The collection is named for Alfred Solano and Sidney B. Reeve, both surveyors in Los Angeles during the late 19th – early 20th centuries. The majority of the collection's materials come from George Hansen, a civil engineer and surveyor who would serve as the Los Angeles County Surveyor from 1864 to 1869, and multiple terms as Los Angeles *City* Surveyor. The collection is arranged by alphabetical business files, field books and diaries, and flat and rolled maps, many of which are of ranchos and have been digitized onto the website of the Huntington digital library. Other surveys examined and geolocated were conducted by Los Angeles surveyors such as Frank Lecouvrer, who would serve as Los Angeles City Surveyor from 1868–1869, Adolphus Waldemar, and William P. Moore, who worked closely with Hansen in the city surveyor office for almost 20 years and also served as County Surveyor and City Street Superintendent. Several of the land surveys near the Los Angeles River were geo-located onto our ArcGis map.

- Los Angeles Assessor's Road Maps

This is a collection of maps surveyed for the Los Angeles County Assessor's Office, 1860–1897. The maps primarily focus on excavations, improvements, and expansions of roads throughout Los Angeles, San Bernardino, and Orange Counties. Most of the maps show boundary lines of the various Ranchos existent throughout these counties, and many also include houses, railroads, telegraph lines, and elements of the natural landscape such as canyons and rivers. Several maps are available for download on the Huntington's Digital Archive, two of which we identified and downloaded but have not yet geo-rectified. (See Appendix).

- 1914 Los Angeles flood control research, led by US Army Corps of Engineers and supervised by JW Reagan

This collection consists of oral histories containing the recollections of residents – many of whom lived along the banks of the Los Angeles River – concerning the multiple floods in late 19th-early 20th century Los Angeles.

- Frank Lecouvreur, Report to "the Mayor and Common Council of Los Angeles City," 20 April 1870

The report contains much information about early Los Angeles and ordinances, proposals for infrastructure, sewage, street grades, etc., but not much on ecology, flora, or the like.

The following sources were investigated and contained useful information but did not contribute directly to our research methods and approach.

- Bruce Bartag, *Río de dios: Thirteen histories of the Los Angeles River*, rare book, Red Hen Press, 2008.
- Vincent A Hoover, "Diary of Life in Los Angeles (1873–1883)," manuscripts.
- Los Angeles Superior Court Records, 1850-1910: Case Numbers 39223, 16437, 57798.

Long Beach Public Library, Long Beach Collection

- Newspaper collection, dating from c.1993–2006. The majority of the clipped articles related to different initiatives to clean up the river, divert it, restore it, etc. The author Joe Segura was a recurring presence.
- Public Works 1996 report on debris accumulation.
- Long Beach "Riverlink" proposal (2006).
- Bibliography of secondary sources; small section on the geology and ecology of the Los Angeles River (some titles cited in Appendix; most works available at the Los Angeles Public Library).

Long Beach Historical Society

- Brandon Werts, archivist; Larry Rich, Sustainability Coordinator at the Long Beach Office of Sustainability.
- Few materials dating back to the 19th century, since the city of Long Beach not officially founded until 1888 with no newspaper in existence until 1902. Newspaper collection consists mostly of hard copies (not microfilm), but little found on the LA River; cannot search online.
- City manager reports with potential information on the channelization of the river; nothing fruitful found.

Natural History Museum, Seaver Center for Western Historical Research

- Vignes Family Papers

The collection consists of only one box, which included a diary, correspondence, photos, recipes, and legal documents. Jean-Louis Vignes moved to Los Angeles from France in 1831 and lived there until his death in 1863. He bought a tract of land adjacent to the Los Angeles River (near the present location of Alameda Street and south of Aliso Street) and laid out El Aliso Vineyard. Vignes' land and vineyard adjacent to the River was surveyed by George Hansen and has been geolocated.

- William P. Moore Los Angeles Survey Books, 1854; 1864-1865

This collection consists of only one box as well, housing two field notebooks with handwritten notes consisting of Moore's surveying activities in early Los Angeles. William P. Moore (1827–1897) was City Surveyor 1857–1860, 1864–1865, 1873–1875. As City Surveyor and Superintendent of Streets, Moore is credited with standardizing, straightening and leveling to uniform grade the city sidewalks. He maintained a lifelong friendship and work partnership with fellow Los Angeles surveyor George Hansen. Although the collection did not produce much useful information, it led us to the William P. Moore collection and the Solano-Reeve collection, which contains George Hansen's surveys and field notebooks, located at the Huntington Library. These collections provided us with an abundance of rich archival sources such as surveyor diaries, field notes, reports, and sketch maps of surveys conducted.

Water Resources Collections and Archive (WRCA) at UC Riverside

- Joseph Barlow Lippincott Papers, 1882–1942

The collection contains numerous engineering and flood control project materials, but one report in particular includes photographs of the river and its surroundings as well as details about its flow, general location, and cross sections. The information could be helpful for locating the different sites on a map and its relation to the Los Angeles River and its watershed. The report and other maps were scanned and sent by the archive.

- Blake Gumprecht Papers, 1916–2007

This collection contains mostly published materials, largely pertaining to Gumprecht's book, *The Los Angeles River* and the research he conducted for the study. Examples include interviews, advertisements, published articles, as well as previously published books and other sources. As for maps, we only found copied and/or published maps, none of the maps or sketches that he personally drew for the book.

- David E. Hughes Papers, 1880-1942 (bulk 1920–1935)

Most of the materials in this collection were engineering records dealing with flood control, water diversion and the like. However, they presented very little information regarding the ecology or similar environmental features of the Los Angeles River and its watershed.

The Western Foundation of Vertebrate Zoology (WFVZ)

The archive had a small physical collection of field books and nest cards, describing eggs and bird species; we examined other materials such as correspondence and photographs, but did not find anything clearly having to do with the Los Angeles River or its ecology. In addition to the materials examined in-person, however, the staff at the foundation agreed to send us an extensive list of the nest and egg records of birds located in Los Angeles County, until the 1930s, housed in their database. This enabled us to specify based on historical and contemporary place names in the river's watershed, and identify and locate the types of bird species present within and surrounding the watershed. We then geolocated the material.

7.2 Collections Identified for Future Research:

- William Moore Papers, 1857–1891, The Huntington Library, San Marino, California.
- Historical Society of Southern California Collection -- Charles Puck Collection of Negatives and Photographs, The Huntington Library, San Marino, California.
- Matthew Keller Papers and Addenda, The Huntington Library, San Marino, California.

7.3 Secondary Sources Identified for Potential Future Research:

- Dorland, "The Los Angeles River: Its History and Ownership." The Annual Publication of the Historical Society of Southern California (1893).
- Troxell, Harold. "Hydrology of the Los Angeles Basin." California Divisions of Mines Bulletin (1954).
- Woodford, et al. "Geology of the Los Angeles Basin." California Divisions of Mines Bulletin (1954).

7.4 Itemized List of Geolocated Archival Sources

The following archival surveys taken from surveyor field books, housed in the Solano-Reeve Papers, were geolocated (through polygons) and added into our ArcGIS geodatabase:

1. George Hansen – Survey 150, Louis Vignes, 1855
   Fieldbooks: Box 1, Volume 6
2. George Hansen – 1856 (field book 13) September 26; Clement Michel
   Fieldbooks: Box 1, Volume 13
3. George Hansen – Ranchos Providencia and Cahuenga along river, May 1864
   Alphabetical Business Files (ranchos): Box 22, Folder 12
4. George Hansen – bed of LA River survey, July 1866 (field book 40)
   Fieldbooks: Box 3, Volume 40
5. George Hansen and Alfred Solano – Survey of Los Angeles River Bed at Macy St. Bridge, 30 January 1891
6. Adolphus Waldemar – City survey 290, June 16, 1857 – Dolores Barella
   Fieldbooks: Box 1, Volume 15

The following survey maps, available as scanned copies in the Huntington Library digital archive, were georeferenced and added to our ArcGIS database:

1. Map 111: Ranchos Providencia and Cahuenga: parcels along Los Angeles River (George Hansen, 1854)
2. Map 313: Tract of Land. containing 11 1/4 acres; occupied & claimed by Don Manuel Romero (George Hansen, 1855)
3. Map 314: Survey of M. Romero Tract (George Hansen and Alfred Solano, 1875)
4. Map 319: Los Angeles: Subdivision, land between west bank of Los Angeles River and road to Arroyo Seco (undated)
5. Map 325: Los Angeles : Map of the Millseat of Messrs Mellus Scott and Stearns. (George Hansen, 1856)
6. Map 374(1-2): Map of the 35-Acre Lots of the Los Angeles City Lands. East of Los Angeles River. (George Hansen and William Moore, 1868)
7. Map 394: Proposed prolongation of Aliso Street through the property of F.P.F. Temple Esqr. (Frank Lecouvreur, 1870)
8. Map 429: Property of J.G. Downey, L. Willhart, E. Moulton, M. Ruiz, Dolores Sepulveda and Benita Peraza and Julian Chavis (Frank Lecouvreur, 1874)

9. Map 441: Map showing location of the old Zanja Madre, ditches, vineyards and Old Town, etc. (M. Kelleher, 1875)

Other digital maps located but not yet georectified:

1. (s-r) Map 305: Los Angeles : Wilhardt Tract - lots between Arroyo Seco Street and Los Angeles River. (George Hansen, 1890)
2. (s-r) Map 322: Los Angeles : Tract of land of Don Julian Chaves 81.75 acres. (George Hansen, 1856)
3. (s-r) Map 323 (1-2): Los Angeles : Tract of Land. containing 19 48/100 ac.s and claimed by Cayetano Barreles. (Adolphus Waldemar, 1856)
4.
5. (s-r) Map 401: Los Angeles : parcels of John Behn, Francisco Ruiz, & Basilio Jurado. (George Hansen, 1871)
6. (s-r) Map 424(1-3): Los Angeles : Alameda Street to Los Angeles River. (undated)
7. (s-r) Rancho San Antonio : S65 - subdivision map, land between Los Angeles and Old San Gabriel rivers. (undated)
8. (LARM) Profile of the Los Angeles River Bottom at the Crossing of the Old Aliso Road. (Frank Lecouvreur, 1872)
9. (LARM) Plan of the crossings of the Los Angeles River at the Old Aliso Road and at Aliso Street. (Frank Lecouvreur, 1872)

The following materials were scanned and sent by the WRCA archive:

1. Reagan, J.W. “Map of a Portion of Los Angeles County [re: 1914 flood],” Joseph Barlow
2. Lippincott papers, LIPP, Water Resources Collections and Archives, University of California, Riverside.
3. Reagan, J.W. “Map Showing Past and Present Artesian Areas and Storage Sites in the
4. Mountains of Los Angeles County, August 1923,” Joseph Barlow Lippincott papers, LIPP, Water Resources Collections and Archives, University of California, Riverside.
5. Reagan, J.W. “Map Showing San Gabriel and Lower Los Angeles Valleys, August 1923,”
6. Joseph Barlow Lippincott papers, LIPP, Water Resources Collections and Archives, University of California, Riverside.
7. Reagan, J.W. Report outlining the “work already done and future needs of flood control and conservation with tentative estimates, maps, plans and flood pictures.” 7 February 1924.
8. Joseph Barlow Lippincott papers, LIPP, Water Resources Collections and Archives, University of California, Riverside. (Box 10, item no: 23-2)
9. “Revised notes upon flood flows of streams in Los Angeles County during February 1914,” Joseph Barlow Lippincott papers, LIPP, Water Resources Collections and Archives, University of California, Riverside.
10. “Tentative report to the Board of Supervisors of the Los Angeles County Flood Control District,” A 27-page report with photographs, describing cross sections of the river and measurements of slopes, area, channel width, discharge, etc. Joseph Barlow Lippincott papers, LIPP, Water Resources Collections and Archives, University of California, Riverside. (Box 10, item no: 23-2)

7.5 Bibliography of Secondary Sources

Part A: Geology, Tectonics, Seismicity, and Landforms

Part B: Environmental Science and Historical Ecology

Part C: Indigenous, Conquest, and Urban-Industrial Cultural Landscapes

1) Indigenous Cultures: Resource Use, and Landscape Management (8,500 YA to 1769)

2) Conquest Era and Urban-Industrial Cultures: Resource Use, and Landscape Management (1769–2020)

7.5.1 Part A: Geology, Tectonics, Seismicity, and Landforms

Biddle, Kevin. 1990. “The Los Angeles Basin: An Overview”. Pages 5–52 in Biddle, Kevin T., ed. *Active Margin Basins*. Tulsa, Oklahoma: American Association of Petroleum Geologists Memoir 52.

Bilodeau, William, Bilodeau, Sally, Gath, Eldon, Oborne, Mark, and Proctor, Richard. 2007. “Geology of Los Angeles, United States of America”. *Environmental & Engineering Geoscience*, XIII (2): 99–160.

Crouch, James, and Suppe, John. 1993. “Late Cenozoic Tectonic Evolution of the Los Angeles Basin and Inner California Borderland: A Model for Core Complex-Like Crustal Extension”. *Geological Society of America Bulletin*, 105(11): 1415–1435.

Eldridge, G. EL, and Arnold, Ralph, 1907. “The Santa Clara Valley, Puente Hills, and Los Angeles oil districts, southern California.” *U. S. Geological Survey Bulletin* 309.

Hall, Clarence A. 2007. “Chapter 16: The Western Transverse Ranges.” Pages 233–279 in *Introduction to the Geology of Southern California and Its Native Plants*. Berkeley: University of California Press.

Jahns, Richard 1973. “A Profile of Southern California Geology and Seismicity of the Los Angeles Basin”. *Pacific Section of AAPG*, 1–20.

Waring, G. A. 1915. “Springs of California.” United States Geological Survey. Water-Supply Paper 338.

Yeats, Robert S. 2004. “Tectonics of the San Gabriel Basin and surroundings, southern California”. *Geological Society of America Bulletin*, 116: 1158–1182.

Yerkes, R., McCulloch, T., Schoellhamer, J., and Vedder, J. 1965. “Geology of the Los Angeles Basin, California- An Introduction”. Geological Professional Survey Paper, A1–A55.

7.5.2 Part B: Environmental Science and Historical Ecology

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