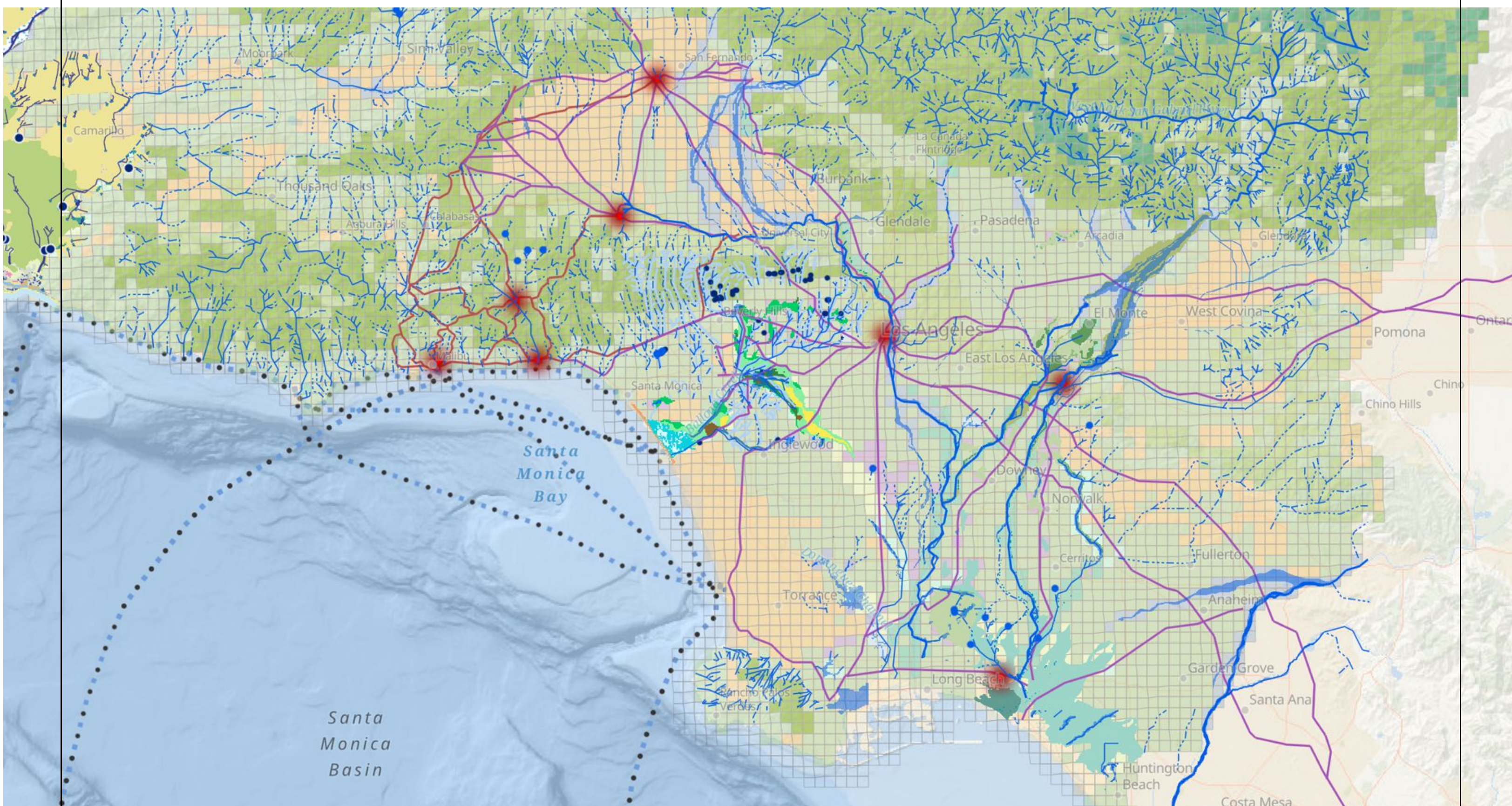
Mapping Los Angeles Landscape History: The Indigenous Landscape



Final Report to the John Randolph Haynes and Dora Haynes Foundation

October 9, 2023

Spatial Sciences Institute, University of Southern California, Los Angeles, California

Mapping Los Angeles Landscape History

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Acknowledgments

This research was supported by a grant from the John Randolph Haynes and Dora Haynes Foundation (PJE), building on previous research supported by the foundation. We appreciate productive conversations and information sharing with Yve Chavez, John McCormack, Sam Safran, Marcus Renner, and Steve Appleton.

We thank our research assistants for their substantial contributions. UCLA: Chloe Belinsky, Alondra Gallegos, Jasmine Kim, Chanaporn (New) Tohsuwanwanich. CSULB: Narasimha Pavan Appala, Kenya Creer, Prudhvi Katta, Ajendar Mamindla, Lyssa Salger, Temsupong Imsong, Anusuya Gogoi, Tribeni Devi, Deepjyoti Nath, Lalngaihsaki Fanai, Riya Buragohain, Farhazur R. Choudhury, Richa Gogoi, Palash Borah, Sweet Gazelle Lyngdoh Nongpiur, Parishmita Konwar, Roja Rai, Anjanjyoti Gogoi, Nayantika Rajbangshi, Phoebe Amerone Lyngdoh Buam, Pinku K. Marak, Neingusa-Ii Chietsii, Akumsangla I Longkumer, Korva Prashanth, Dudyala Pranay Kumar, Attanti Teja, Nakka Akshitha, Bollaram Himaja, Tejavath Anil, Theddu Arthi. CSUN: Nikolas Adler, Brandon Hoffman, Sandra Martinez, Julie Quintero.

We mourn the loss of Nat Zappia, whose significant contributions to this project and southern California history, sustainability, and Indigenous studies were cut short by his untimely death in April 2023.

Recommended Citation

Longcore, T. and P.J. Ethington, eds. 2023. *Mapping Los Angeles Landscape History: The Indigenous Landscape*. Report to the John Randolph Haynes and Dora Haynes Foundation. Spatial Sciences Institute, University of Southern California, Los Angeles.

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Executive Summary

As projects emerge to protect, restore, and enhance natural landscape in the Los Angeles region, attention turns to the historical landscape for understanding, inspiration, and context. Descriptions of the historical landscape patterns and function have led to a conclusion that this landscape and region cannot be understood without listening to the stories of Indigenous people who managed this land and thrived for thousands of years before the arrival of European settlers. In this project, our team blended geographers, historians, and biologists with representatives of three tribes — Chumash, Tataviam, and Gabrieleño (Kizh) — to undertake a collective investigation of six village areas and their natural features as they would have existed before European arrival. The resulting effort blends different approaches to understanding and describing the landscape to produce a set of parallel products that describe the six village areas in detail and provide detailed maps of the natural environment, its flora and fauna, and tools to understand its influence into the modern era for the region.

Stories about each place and its importance have been recorded by tribal representatives for humaliwo (now Malibu, with additional reference to topaŋa; Chumash), Siutcanga (Encino; Tataviam), Achoicomenga (San Fernando; Tataviam), Yaanga (downtown Los Angeles; Kizh), Shevaanga (Whittier Narrows; Kizh), and Povuu'unga (Long Beach; Kizh). Videos of these in-site discussions have been compiled to and are presented in a map-based website.

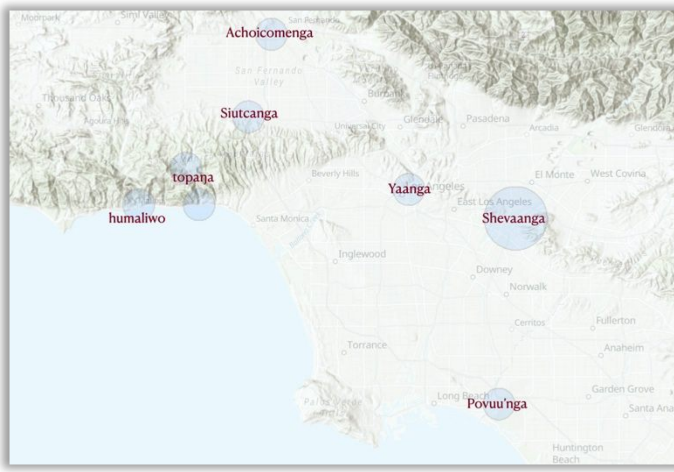


Figure 0-1. Location of focal Indigenous village areas.

Together, the team pursued many additional investigations designed to provide insights on these places and the region from different disciplinary lens and using different methodological sources and approaches. These provide complementary and standalone resources to understand the past and current landscapes of the region and were also synthesized into highly detailed three-dimensional maps of the vegetation and natural features of each village area.

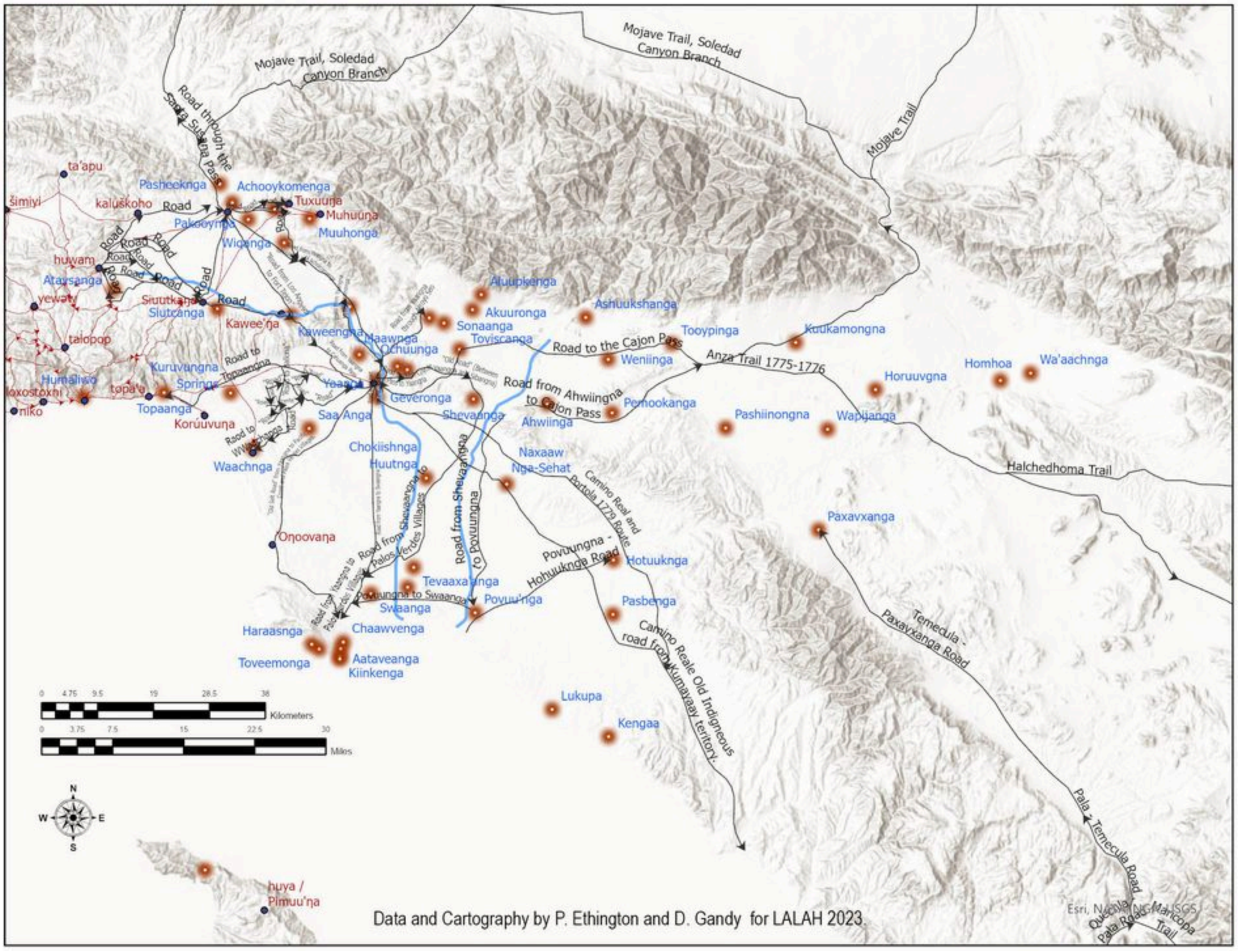


Figure 0-2. Indigenous roads and pathways within and extending from the Los Angeles Basin.

Indigenous trade networks. The pathways that linked together people and resources within the Los Angeles region and to points across the entire southwest are easily forgotten in a city crossed by freeways. Drawing on extensive archival sources, newly digitized maps, sketches, Indigenous place names and histories, and other texts, our team constructed a synthesis map of the pre-European trade and movement networks across the region.

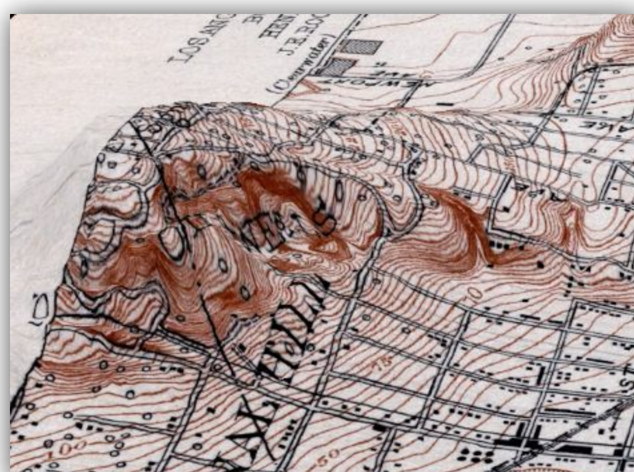


Figure 0-3. Historical topographic map draped over topography extracted from it onto a digital elevation model.

Topographic reconstruction. Topography is fundamental to understanding landscapes, but the Los Angeles region has been highly modified both for water management and to accommodate urban development and transportation infrastructure. Historical maps of topography exist but do not provide data in a form that can be used for modern models and visualizations. Our team used sophisticated image recognition tools and an international volunteer effort to extract the elevations of over fifteen million individual points located on historical topographic maps to create the first-ever historical digital elevation model of the Los Angeles Basin from Ventura County to Orange County.

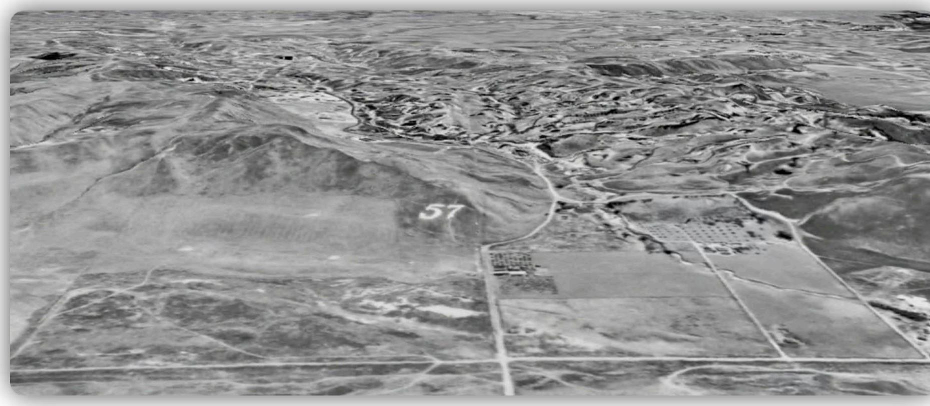


Figure 0-4. Photomosaic of 1928 aerial photographs draped over topography, looking south toward the Baldwin Hills, just east of Culver City.

Aerial photograph mosaic. Although aerial photography was started consistently in the 1920s in Los Angeles, images from that era are extremely useful in visualizing and understanding landscape features that were present before urbanization. A full-county set of images from 1928 had been previously scanned, but not oriented so they could be placed on a map and compared with contemporary features. Our team created a mosaic of these images, located them in geographic space, and linked them together into a continuous map image layer encompassing the Los Angeles Basin, Santa Monica Mountains, and into the foothills of the valleys covering 1,745 square miles.

"Blue line" streams and water bodies. Our team digitized all the rivers, lakes, streams, wetlands, ponds, and other water features on the 1900s and 1920s U.S. Geological Survey topographic maps. These lines can now be overlaid on contemporary maps to reveal the location of buried streams, filled wetlands, and water features that have persisted through time.

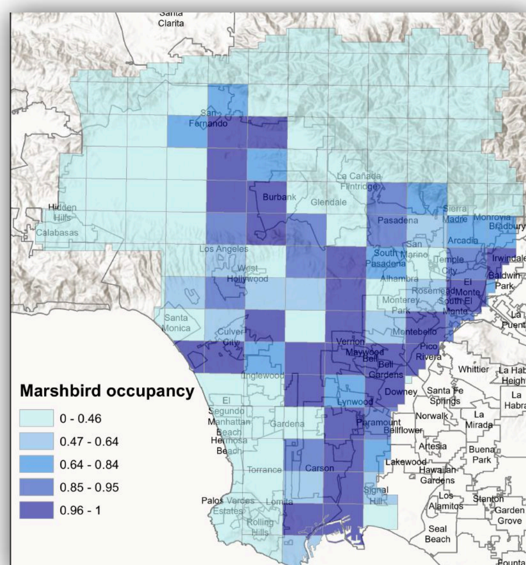


Figure 0-5. Historical marshbird presence across the Los Angeles Basin.

Historical bird distributions. The nature that would have been found across the Los Angeles region has been altered dramatically by urbanization. To understand what bird species would have been found at our focal villages and what species have declined and increased, our team used bird egg, nest, and adult specimen location records from museum collections along with our previously developed potential natural vegetation map to predict historical bird species composition. Some groups of species have declined nearly to extirpation, such as those associated with grassland, while others have been more resilient in the face of urbanization.

Oak, walnut, and elderberry habitat models. Plants that provide food resources are important to Indigenous food systems and culture. The team selected a set of such plants, including several oak species (coast live, valley, mesa, and scrub), California black walnut, and blue elderberry for our biogeographers to investigate. Using environmental data, including historical topography developed by the project in some areas, and current distributional data for these species, habitat models were developed with machine learning approaches that suggest the historical distributions of these species, even in areas where they have been eliminated today.

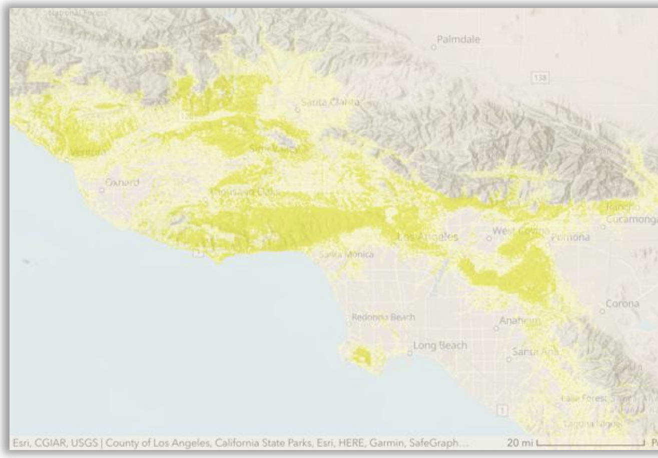


Figure 0-6. Habitat suitability map for California Black Walnut.

Potential natural vegetation. The overall vegetation types across the lansdcape were mapped at a 1-km resolution and expanded from previous work by the team. High-resolution maps for each of the focal villages were drawn from extensive documentary information, the habitat models, and Indigenous knowledge.

Remnant native plants. Notwithstanding several hundred years of urbanization, some of the plants native to the region may survive, even in highly developed neighborhoods. To investigate this possibility, surveys for spontaneous vegetation (weeds) were undertaken along sidewalks in areas that supported a range of different vegetation types historically. Some native plants persist, and those located were consistent with the mapped historical vegetation type, supporting the landscape descriptions developed for the region.

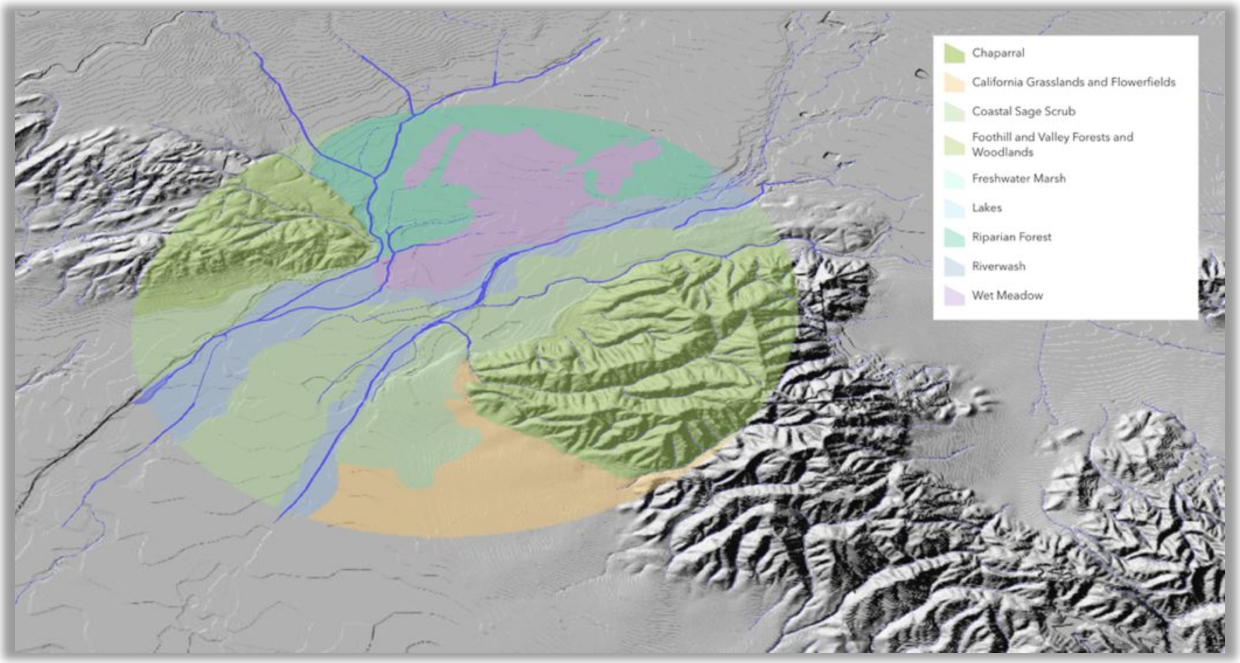


Figure 0-7. Potential natural vegetation and historical topography of the area surrounding the village of Shevaanga.

This project is unique because a commonly shared, detailed map of the historical ecology—the flora, fauna, hydrology, and landforms, that evolved within Southern California's Mediterranean climate over millennia and supported human populations for 10,000 years—has never been developed. Individually and cumulatively, the results of this research are vital resources to all regional and local planning efforts involving sustainability, preparing for climate change, habitat restoration, and seeking to live in greater harmony with the landscape.

Chapter 1 Mapping Los Angeles Landscape History: A StoryMap

This project focuses on describing the landscape of pre-European Los Angeles as inhabited and managed by the Indigenous peoples who lived here for thousands of years. As described in the next chapter, the knowledge and stories of first peoples have been shared within the context of specific places, often in the form of videos. Access to these videos and texts, as well as the maps and analyses compiled and created for this project, is found in an online, multimedia StoryMap:

https://storymaps.arcgis.com/stories/b76cab116cbe4432a629d4791249a958

StoryMaps are a browser-based platform for sharing mixed media (photographs, text, videos) alongside interactive maps that can be explored by the visitor. StoryMaps, developed as a communications tool by Esri, have emerged as a useful tool in the physical sciences, social sciences, and humanities, including previous mapping of Indigenous places and culture in the Los Angeles Basin.

The StoryMap has two sections. The first section focuses on six important Indigenous village areas for which the historical vegetation and landscape were reconstructed and mapped. These serve as the jumping off point for additional context and stories of the places from the Indigenous perspective. These locations are:

- Yaangna, present day downtown Los Angeles;
- humaliwo [lowercase intentional because the written language does not capitalize], present day Malibu Lagoon, with reference also to topaŋa (Topanga) and Topanga Lagoon;
- Siutcanga, present day Encino;
- Achoicomenga, present day San Fernando;
- Shevaanga, present day Whittier Narrows; and
- Povuu'nga, present day Long Beach.

The second half of the StoryMap provides summarized methods and interactive maps for the analyses and spatial data compilations described in this report in the chapters that follow.

Chapter 2 Indigenous Knowledge

The so-called natural ecology of Los Angeles has been shaped by direct human intervention for over 10,000 years by Native peoples, including the Chumash, Gabrieleño, Tataviam, Taaqtam, Payomkawichum peoples, and neighboring Cahuilla and Serrano peoples, who ruled and densely settled the mainland and the islands of the Santa Barbara Channel. For this reason, we call the entire period before the 18th-century Spanish conquest the "Indigenous Landscape." It is the specific, local manifestations of this Indigenous Landscape that we seek to reconstruct for select portions of the Los Angeles Basin at the neighborhood scale. The Indigenous peoples of Los Angeles never formally ceded their territory, still live within it, and have a special authority to provide knowledge of its ecology, which for countless generations they shaped, through fire management, cultivation, tending, pruning, and managing its oak trees, flowerfields, scrublands, wetlands, estuaries, and the fisheries of the Santa Barbara Channel and Santa Monica Bay.

Indigenous knowledge of places may incorporate knowledge of local ecology, or traditional ecological knowledge related to the natural world, including geography, geology, watersheds, and wildlife. Since Native life ways were inseparable from the natural world, that intimate relationship defines their worldview, their culture, their cosmology, their spirituality, and, especially in this instance, informs their narratives about place. This type of knowledge is often referred to as traditional ecological knowledge. Confirmation of traditional ecological knowledge has in recent decades been offered by western science, although Native peoples do not need science to affirm their knowledge. Thousands of years of knowledge garnered from lived experience, including especially a world view that supports care for the natural world as a sacred obligation, provide Native peoples ways of living that attain balance and harmony with nature.

Narratives regarding people and place are organized at selected key village locations as determined by each tribal representative. Rather than applying a common framework across sites, the culture bearers allowed the site and the knowledge about the site to determine what narratives to share. This approach is consistent with the idea that "wisdom sits in places" (Keith Basso, *Wisdom Sits in Places*, 1996), a common theme in Native cultures generally. In this way, the stories generated by each culture bearer are site reactive—the site determines the story to be shared. Knowledge of place is supplemented, when possible, with relevant contemporary research.

It is important to remember that the stories told by Native people are not just stories for information and entertainment. Place names and their accompanying narratives derive from a world view, cosmology, and spirituality foreign to non-tribal members. Many places have sacred significance, which cannot often be conveyed in the story map platform. That said, culture bearers have shared what is appropriate for them to share with non-members and have permission to do so from their respective tribes. In the context of the project, it was important then to have the culture bearers retain full rights to the Indigenous knowledge each shared—Indigenous cultural knowledge cannot be owned.

The Indigenous Knowledge Group consists of culture bearers from the three main tribal groups in the selected area: Matthew Vestuto (Chumash), Chair of the Barbareño/Ventureño Band of Mission Indians; Jesus Alvarez (Tataviam), Senator of the Fernandeño Tataviam Band of Mission Indians); and Matthew Teutimez, Tribal Biologist of the Kizh Nation: Gabrieleño Band of Mission Indians. Culture bearers brought to the project their knowledge of tribal culture and history, and especially their knowledge of place names. For logistical reasons, the number of culture bearers was limited, although the project may expand in the future. The culture bearers's contributions were supported with the assistance of Jonathan Cordero (Indigenous Knowledge Group Co-Coordinator), Natale Zappia Indigenous Knowledge Group Co-Coordinator), Philip J. Ethington (Principal Investigator), and Devlin Gandy (Consultant).

Chapter 3 Topographic Reconstruction from Historical Digital Elevation Models

Suzanne Perlitsh, Abhinov Dutta, and Scott Winslow

Contributors: Narasimha Pavan Appala, Kenya Creer, Prudhvi Katta, Ajendar Mamindla, Lyssa Salger, and students from Accelcraft Institute of Geoinformatics and Telangana University

Introduction

Elevation is arguably one of the most important spatial datasets for understanding landscapes. Terrain position and elevation determine the incoming solar radiation and drive hydrologic flow which in turn impacts the type of vegetation that develops on a landscape. How Indigenous peoples interacted with a landscape is very much tied to terrain and terrain attributes.

Models of the historical terrain can be derived by extracting elevation data from historical topographic maps. Historical topographic maps are available dating back to the early 1900s. Associated terrain representation would provide an understanding of the landscape before significant urbanization and facilitate prediction of the historical landscape.

The U.S. Geological Survey provides historical scanned topographic maps referenced to real world coordinates (georeferenced) *for the purposes of visualization*. These historical topographic maps do not provide meaningful underlying data for use in geospatial analyses. Like a digital photograph, pixel grid cells in these images contain values which generate the colors we see on the computer screen and in the printed maps, however these values do not correlate to meaningful values that can be used for spatial analyses (e.g., elevation values associated with contour lines). To create a terrain model, elevation data associated with contour lines must be extracted and attributed with the associated elevation value.

Extracting meaningful information from these historical maps poses a specific set of analytical challenges (Khontanzad and Zink 2003, Chiang et al. 2013) and required us to develop and implement a systematic approach to generate and process the historical elevation data. A methodology was developed to extract and separate the contour lines from high resolution scanned topographic maps using techniques typically used to extract information from satellite imagery. Underlying co-located elevation data were then assigned to these lines. The lines were then converted to points for interpolation, where known elevations are recorded in grid cells, and unknown elevations are estimated from the surrounding data. The resulting digital elevation model (DEM) provides a seamless visualization of the bare earth landscape as it might have been, based on the underlying historical map data.

We developed a methodology to extract elevation and other topographic features from historical topographic maps. The effort included development and implementation of a consistent approach to data extraction, creation of training procedures for others to perform the work, outreach to students to contribute to the work via crowdsourcing approaches and implementation of quality assurance and control methods on the data contributed.

This work contributes to the field of historical cartography, applying cutting edge innovations that are transferable to other types of scanned imagery. It joins other efforts for Southern California (e.g., Beattie 2014, Longcore et al. 2020) and complements previous work to automate extraction of text and other features from scanned maps (James et al. 2012, Chiang and Knoblock 2014). Being able to obtain useable data effectively and efficiently from historical maps is essential to understanding, for example, questions of land use change and changes in political boundaries (Martínez-Casanovas et al. 2004, Wheaton et al. 2009, James et al. 2012) representing the terrain *before significant urbanization* occurred in the region is important because elevation represents how historic populations may have experienced the landscape.

Methods

Study Area and Data Sources

<u>USGS 1:24,000 Quadrangle Maps</u>: The research team agreed on the use of 1:24,000 scale topographic maps from the USGS historical map collection as the base reference maps for this study. These quadrangle maps provide the most consistent coverage over the study area and associated estimated locations of the focal villages. The production dates for these maps range from 1925 to 1940 (Table 3-1). To assist in visualizing the study area a mosaic of the sixty-two (62) quadrangles covering the study area was produced (Figure 3-1).

<u>High Resolution Scanned Topographic Maps</u>: The USGS-provided images were too coarse and could not be used for the feature extracting methodology. High resolution (1200 dpi) scanned quadrangles were obtained for the study area from CSU Northridge Center for Geospatial Science & Technology. Each of these images were georeferenced to real-world coordinates.

<u>Shuttle Radar Topography Mission</u>: Some areas in the study area are very complex topographically. These areas on the landscape have likely not been as significantly altered as other parts of the study area. We used elevation data derived from the 2000 Shuttle Radar Topography Mission (SRTM) to “fill in” the elevation values in these areas of highly complex terrain.

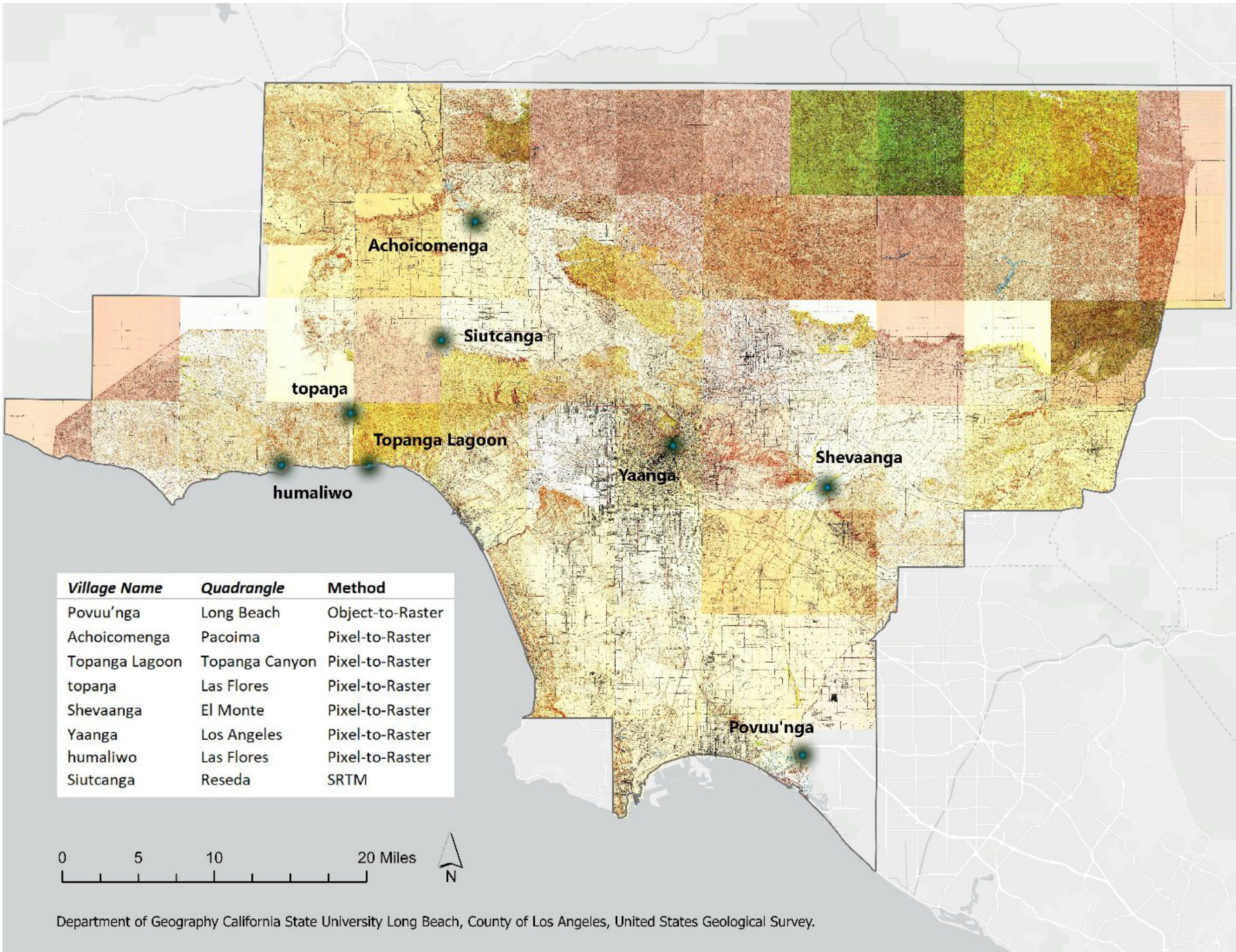


Figure 3-1. Study Area – Mosaic of 62 historical quadrangles with Indigenous villages.

The methodology we developed includes four general steps (Figure 3-2):

(1) Georeference high resolution scanned quadrangle maps.

(2) Process images to extract features; two methods were developed and applied.

(3) Assign elevation attributes to extracted features.

(4) Interpolate digital elevation models.

Table 3-1. Quadrangles in the study area and year mapped.

Quadrangle Name	*Quadrangle Year*	*Quadrangle Name*	*Quadrangle Year*
Alder Creek	*1941*	Long Beach	1925
Alhambra	1926	Los Alamitos	1935
Altadena	1928	Los Angeles	1928
Arroyo Sequit	*1932*	Mt Baden Powell	*1940*
Artesia	1925	Mt Gleason	*1942*
Azusa	1939	Mt Lowe	*1939*
Bell	1925	Mt Wilson	*1939*
Burbank	1926	Newhall	*1933*
Camp Baldy	*1940*	Pacoima	1927
Camp Bonita	*1940*	Pico	*1940*
Camp Rincon	*1940*	Puente	1927
Chatsworth	1927	Reseda	*1928*
Chileno Canyon	*1942*	Russell Valley	1932
Claremont	1928	Sawtelle	1925
Clearwater	1925	Seal Beach	1935
Compton	1924	Seminole	*1932*
Covina	1927	Sierra Madre	1928
Crystal Lake	*1941*	Solstice Canyon	1932
Dry Canyon	1928	Sunland	1926
Dume Point	1932	Swarthout	*1941*
El Monte	1926	Sylmar	1935
Evey Canyon	1940	Topanga Canyon	1928
Glendale	1928	Torrance	1924
Glendora	1927	Trail Canyon	*1940*
Hollywood	1926	Van Nuys	1926
Inglewood	1924	Venice	1924
La Crescenta	*1928*	Waterman Mtn	*1948*
La Habra	1927	Watts	1924
La Verne	*1940*	Whittier	1925
Las Flores	1932	Wilmington	1925
Little Tujunga	*1939*	Zelzah	1928
Quadrangles highlighted in blue indicate quads where SRTM data were used.			

Figure 3-2. Flowchart of methodology.

Projection and Georeferencing

The high-resolution scanned images (1200 dpi) of the quadrangles obtained from CSUN were geo-reference to the pre-determined spatial reference system used for this project - the projected coordinate system NAD 1927 Zone 11 (WKID - 26711). An image-to-image georeferencing technique was applied using the georeferenced quadrangle maps from USC as the base reference dataset. To ensure accurate alignment of the scanned images, a comprehensive set of more than

24 control points were strategically selected across the maps to serve as reference features. These control points were carefully chosen based on their visibility and distinctiveness in both the scanned maps and the georeferenced quadrangle maps. By precisely matching the control points between the two sets of maps, the georeferencing process achieved a high level of accuracy.

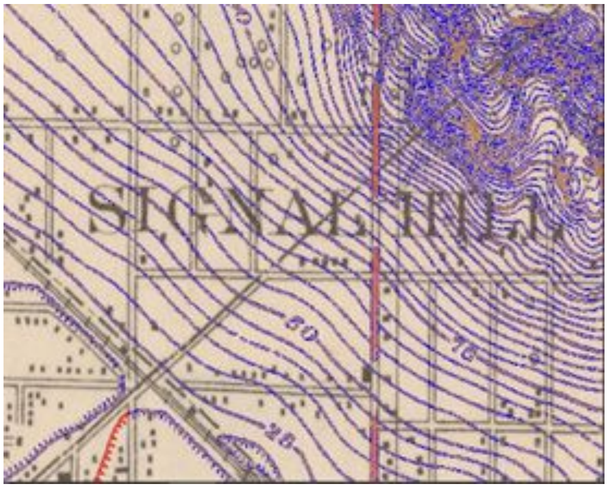
Image Processing

Our team developed two digital image processing approaches to extract features from the high-resolution scans — an object-to-raster approach and a pixel-to-raster approach.

Point-Feature Extraction — Object-to-Raster Approach

An object-based image classification was conducted on five of the high-resolution topographic quadrangles. A detailed 'ruleset' was developed to extract features using eCognition software. This object-based classification involved segmenting the high-resolution image into individual 'objects' based on their spectral and spatial properties (Figure 3-3). The multi-threshold segmentation algorithm was employed, which simultaneously generated and classified objects. This algorithm partitioned the image into objects and assigned classifications based on a single layer pixel value (Niu and Li 2019).

To improve the accuracy of the results, a subsequent step involved conducting a multi-resolution segmentation to refine misclassified objects. The multi-resolution segmentation progressively merged neighboring pixels until a predefined homogeneity criterion, known as the scale parameter (SP), was satisfied. The user had the flexibility to adjust the SP, thereby controlling the size, number, and homogeneity of the image objects generated from the segmentation process. Additionally, the user could incorporate other user-defined parameters, such as shape, compactness, and the influence of image bands, to further customize the image objects (Figure 3-3).

a. 

b. 

Figure 3-3. Object-to-Raster OBIA process. a. Initial image segmentation where all features including text and lines are extracted and classified so that just contour lines can be identified. b. Features represented as points corresponding only to the contour lines are extracted.

To train the random forest classifier, manual collection of training samples was performed, encompassing both contour and non-contour features. Subsequently, a supervised classification algorithm was applied to obtain more precise contour lines. Following this, the contour lines underwent re-segmentation using the chessboard segmentation algorithm to export them as a point feature class. The chessboard segmentation algorithm effectively identified and separated different objects within the image based on their unique characteristics and spatial arrangement, without considering spectral information. After additional refinement processes, the resulting objects were exported as a point feature class and seamlessly integrated into ArcGIS Pro. Utilizing a lassoing technique within ArcGIS Pro, point features were carefully selected for each contour line, and elevation values were added using the field calculator. Lastly, to incorporate additional information about the quadrangles, a standardized schema consisting of the quad name, village name, analyst name, contour type and the source of contours, was added to the feature class. These preparations effectively prepared the data for subsequent interpolation processes.

Point-Feature Extraction — Pixel-to-Raster Approach

Despite the successful extraction of point features using the object-to-raster approach, a significant challenge arose when attributing elevation values to these points. The distribution of points across the quadrangles lacked any discernible pattern, making it difficult for an analyst to select them collectively and assign height values. This difficulty was particularly pronounced in densely contoured areas, where identifying points along individual contour lines proved arduous. Consequently, concerns regarding the accuracy of the extraction method were raised. To address this challenge, our team devised another novel approach, referred to here as pixel-to-raster, aimed at extracting polylines instead of point features from the topographic maps. These polylines effectively represented the contour lines, simplifying the process of identifying and associating contour values with each line (Figure 3-4).

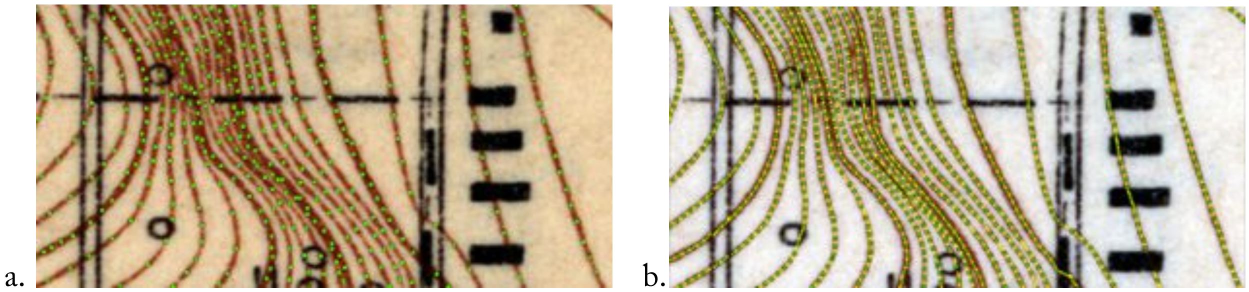


Figure 3-4. Comparison of feature extraction methods. a. Points extracted using object-to-raster. b. Continuous contour lines extracted along with the point.

The pixel-to-raster method not only exhibited greater accuracy but also offered time-saving benefits, enabling us to complete a higher number of quadrangles within the given time. The method involved a pixel-based supervised classification to extract continuous contour lines from the high-resolution scanned topographic quadrangles.

Pixel-based image classification entails the classification of individual pixels in an image into predefined categories based on their similar spectral characteristics (Casals-Carrasco et al. 2000). Two classes were established for the training samples: contours and non-contours. The contour class was assigned a standardized value of '0' and was represented by the red color of the contour lines on the high-resolution topographic quadrangles. Conversely, all other colors visible on the map were assigned to the non-contour class with a value of '1' (Figure 3-5). The support vector machine (SVM) classifier, known for providing superior classification results compared to other recognized procedures (Satya Varma et al. 2016), was trained using the collected training samples. The supervised classification algorithm was then employed to generate the classified raster (Figure 3-6).

Once the raster was classified, the ArcScan geoprocessing tool was used to convert the pixels to vector polylines. These polylines were subsequently merged into single contour lines, to which elevation values were assigned. Subsequently, the 'generate points along line geoprocessing tool' was applied to create evenly spaced point features at regular 5-meter intervals. Lastly, the standard schema was incorporated into the attribute table of the point features, ensuring consistency in the data.

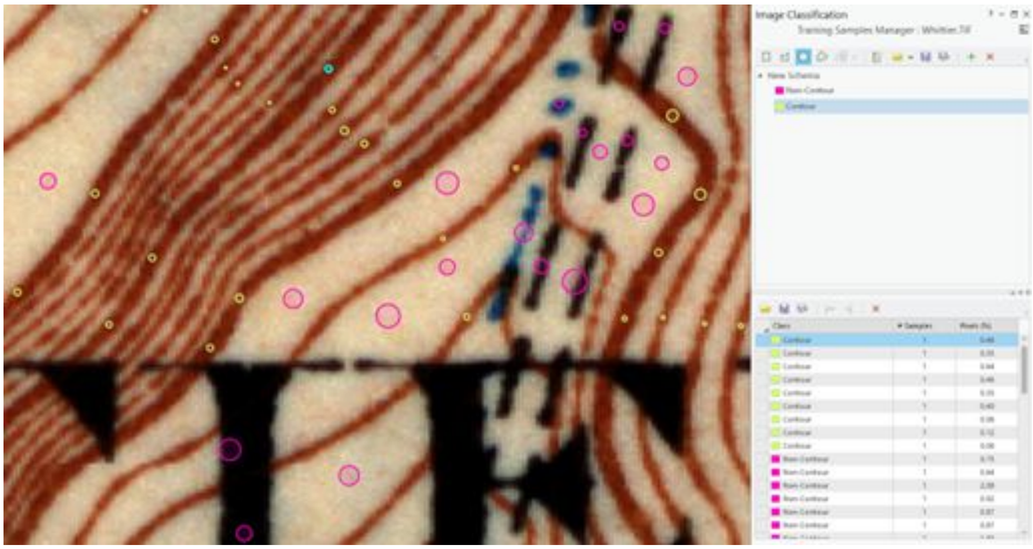


Figure 3-5. Training sample collection for the supervised classification.

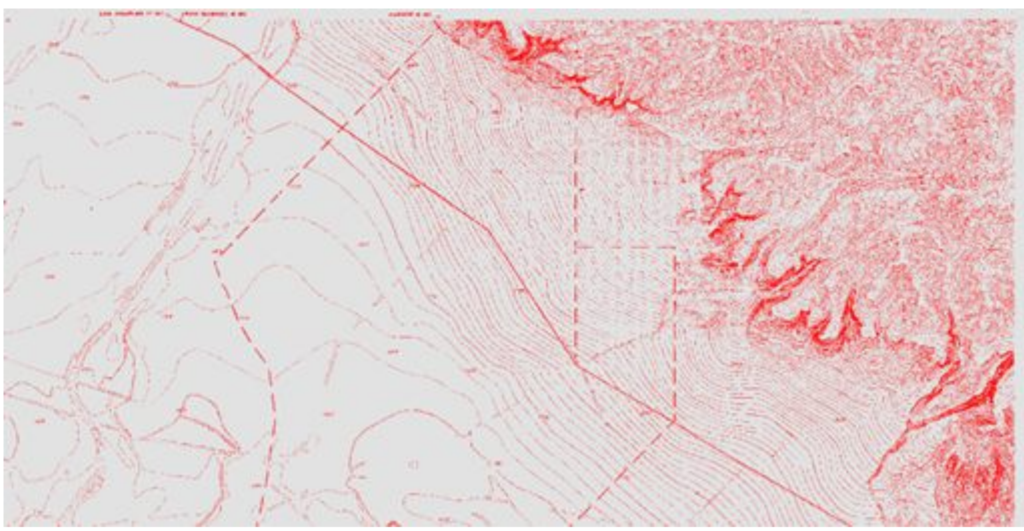


Figure 3-6. Classified raster showing contours in red and non-contours in grey.

Volunteer Work and Student Crowdsourcing

The most time-intensive task in this project involved cleaning misclassified polylines data. To assist with this process, a group of 25 undergraduate GIS students from Accelcraft Institute of Geoinformatics and Telangana University in India were selected as volunteers. Our graduate students working on this project—Mr. Abhinov Dutta (Accelcraft Institute of Geoinformatics) and Mr. Ajendar Mamindla (Telangana University)—are alumni from these institutions and built this relationship for the purposes of the research.

Twenty-five students from these institutions participated in this project, each contributing 80–300 hours processing data for 31 quadrangles representing 3,300 hours combined (Table 3-2). The student volunteers processed 925,567 polylines which resulted in 14,382,634 attributed points over these 31 quadrangles.

This collaborative approach allowed us to successfully complete the processing of many more quadrangles than originally anticipated within the designated timeframe.

Table 3-2. Effort Required for Assigning Elevation Values to Extracted Polylines

Volunteer	***Quad Names***	***Hours***	***Total Polylines***
Temsupong Imsong	Evey Canyon, Las Flores, Glendale	300	110,676
Anusuya Gogoi	Chatsworth, Dume Point	200	59,050
Tribeni Devi	Los Alamitos, Topanga Canyon	170	29,741
Deepjyoti Nath	Vannuys, Altadena	240	94,650
Lalngaihsaki Fanai	Dry Canyon, Topanga Canyon	190	52,236
Riya Buragohain	Claremont	70	12,999
Farhazur R. Choudhury	Sierra Madre	80	19,745
Richa Gogoi	Alhambra	100	37,800
Palash Borah	Torrance	80	23,900
Sweet Gazelle Lyngdoh Nongpiur	Sunland	80	22,800
Parishmita Konwar	La Habra	80	23,700
Roja Rai	Sylmar	80	23,800
Anjanjyoti Gogoi	Sylmar	80	19,970
Nayantika Rajbangshi	Hollywood	100	33,000
Phoebe Amerone Lyngdoh Buam	Azusa	160	53,400
Pinku K. Marak	Hollywood	80	18,500
Neingusa-Ii Chietsii	Zelzah	300	103,550
Akumsangla I Longkumer	Dume Point	80	18,670
Korva Prashanth	Los Angeles	160	54,373
Dudyala Pranay Kumar	Puente	100	27,882
Attanti Teja	Sawtelle	240	86,864
Nakka Akshitha	Glendora	80	27,340
Bollaram Himaja	Venice	80	23,700
Tejavath Anil	Pacoima	80	21,612
Theddu Arthi	Covina	100	29,159

The CSULB team georeferenced the high-resolution scanned quadrangles, classified them, and then vectorized them to extract the polylines. The extracted data was sent to the volunteers to perform the data cleaning and attributing step. Their primary responsibilities included deleting misclassified contour lines, merging split contour lines into a single line, and attributing elevation values to each contour line. Our team closely monitored their progress weekly, diligently tracking the number of polylines cleaned.

On average, it required approximately 80 hours to clean a quadrangle with 30,000 or fewer polylines. Quadrangles with denser contouring required more hours. Once the cleaning process was completed, our team conducted a thorough quality check to ensure accuracy before granting final acceptance. Any errors or mistakes identified during the quality check were promptly sent back for correction.

Shuttle Radar Topography Mission Data

Portions of the study area contain very complex topography and are in mountainous regions. Processing data in these areas using the methods described above was not feasible given the intricate and time-intensive nature of extracting contour lines in these densely contoured regions. We compared contour lines from the early historical quadrangle maps with more recent topographic maps from 1999 in these areas. For areas that remained mostly unchanged, we substituted existing digital elevation data. Digital elevation models from NASA's 2000 Shuttle Radar Topography Mission were selected as these were the oldest available continuous digital dataset for the study area.

We generated 250,000 random points (using the "generate random points" tool in ArcGIS) and used these to extract co-located elevation data values from the SRTM raster (using the "extract values to points" tool) to append the elevation values from the raster to the corresponding point features (Figure 3-7). We converted the elevation values from meters to feet. The standard schema was applied to these points to match the point files generated using the other methods and to prepare them for interpolation.

SRTM data were used to represent historical elevation in twenty-one (21) of the study area quadrangles. Additionally, elevation data in parts of seven (7) quadrangles where data were extracted using the pixel-to-raster approach were supplemented by data from SRTM (Table 3-1).

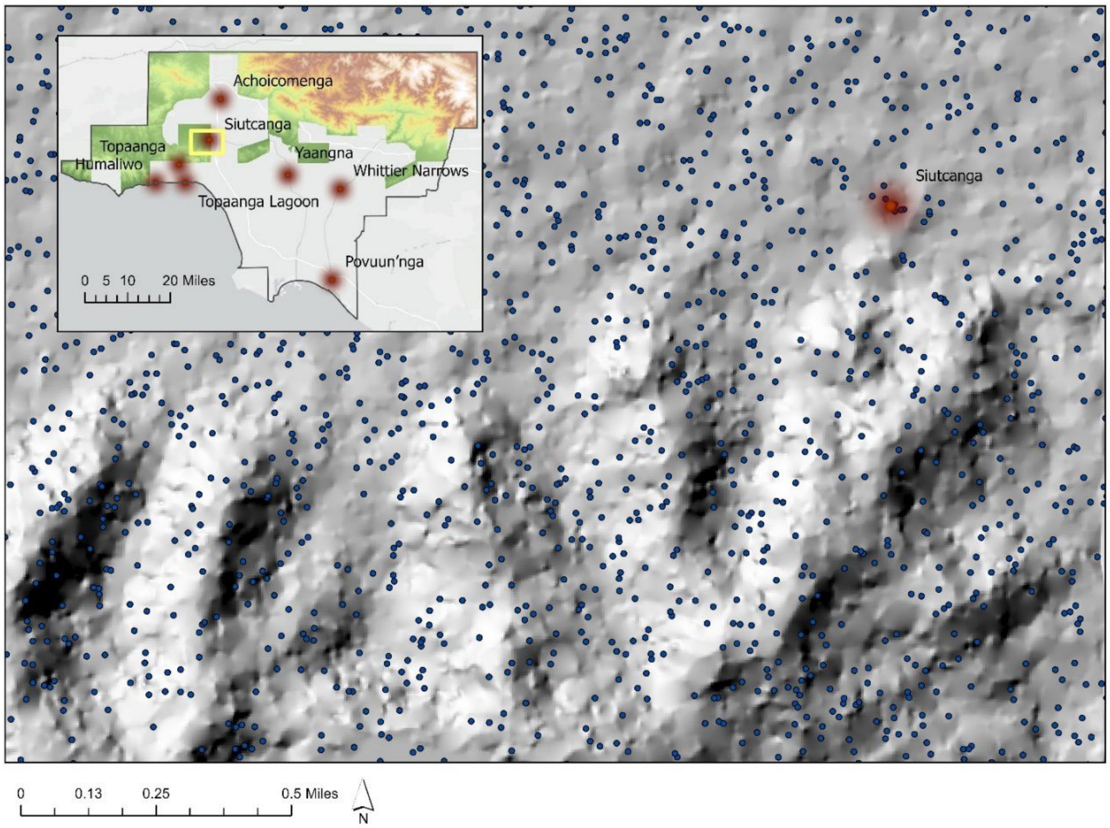


Figure 3-7. Example of random elevation points selected from the SRTM DEM for use in interpolating.

Interpolation and Merging of Rasters

Points generated from each of the methods were merged, and the inverse distance weighted (IDW) interpolation technique was applied to generate a combined digital elevation model representing the historical topography in the study area.

Results

Deliverables include:

- Mosaic of historical quadrangles for use in visualization (Figure 3-1),
- DEM for the study area using input data combined from the three methods described (Figure 3-9).

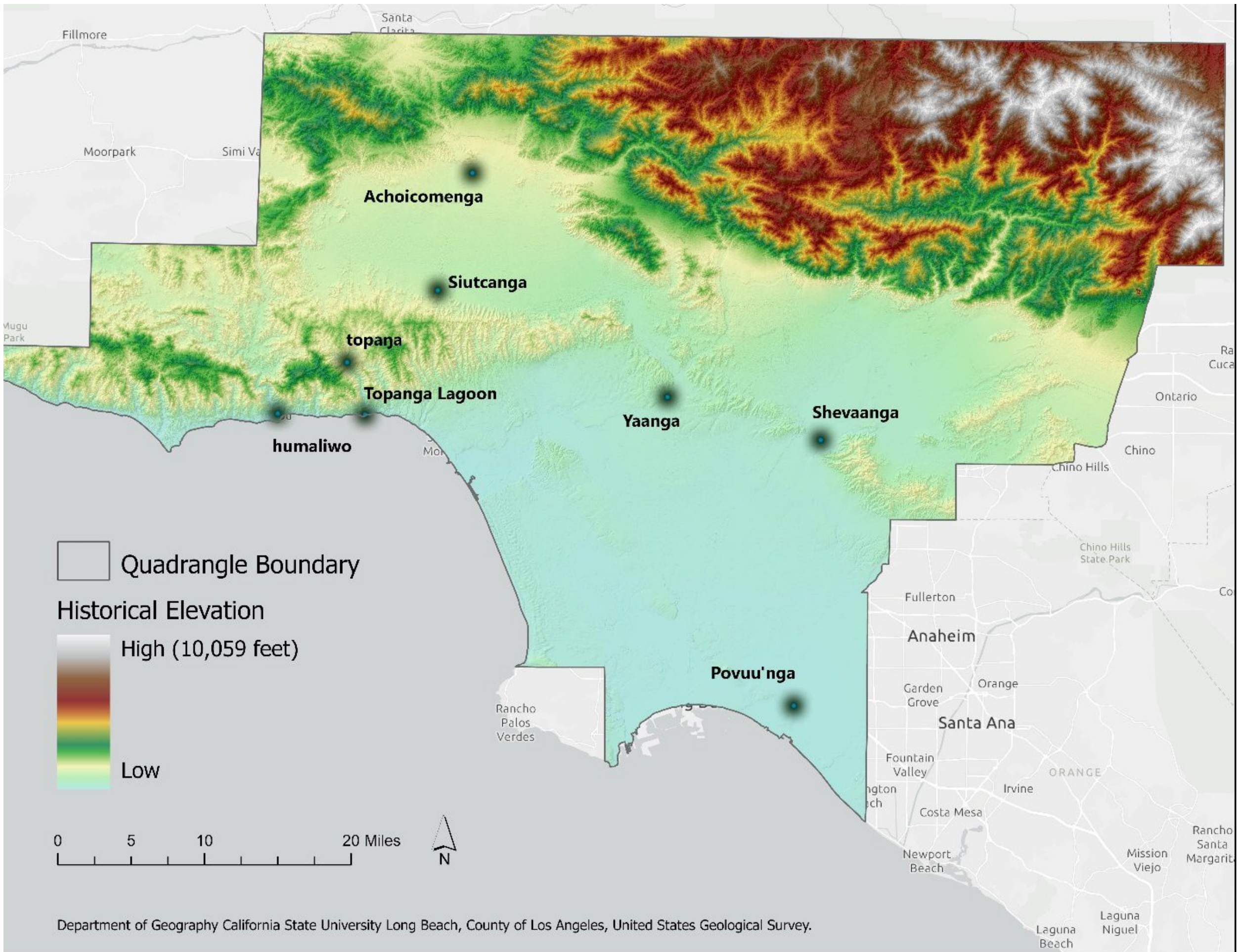


Figure 3-8. Historical Digital Elevation Model.

The Object-to-Raster approach generated 398,233 historical elevation points from 6 quadrangles (Table 3-3, Figure 3-9).

Table 3-3. Object-to-Raster Point Extraction Results

Quadrangle Name	# Points
Artesia	22,528
Bell	46,044
Clearwater	49,033
Long Beach	39,538
Whittier	156,490
Wilmington	84,600
Total Points (6 quadrangles)	*398,233*

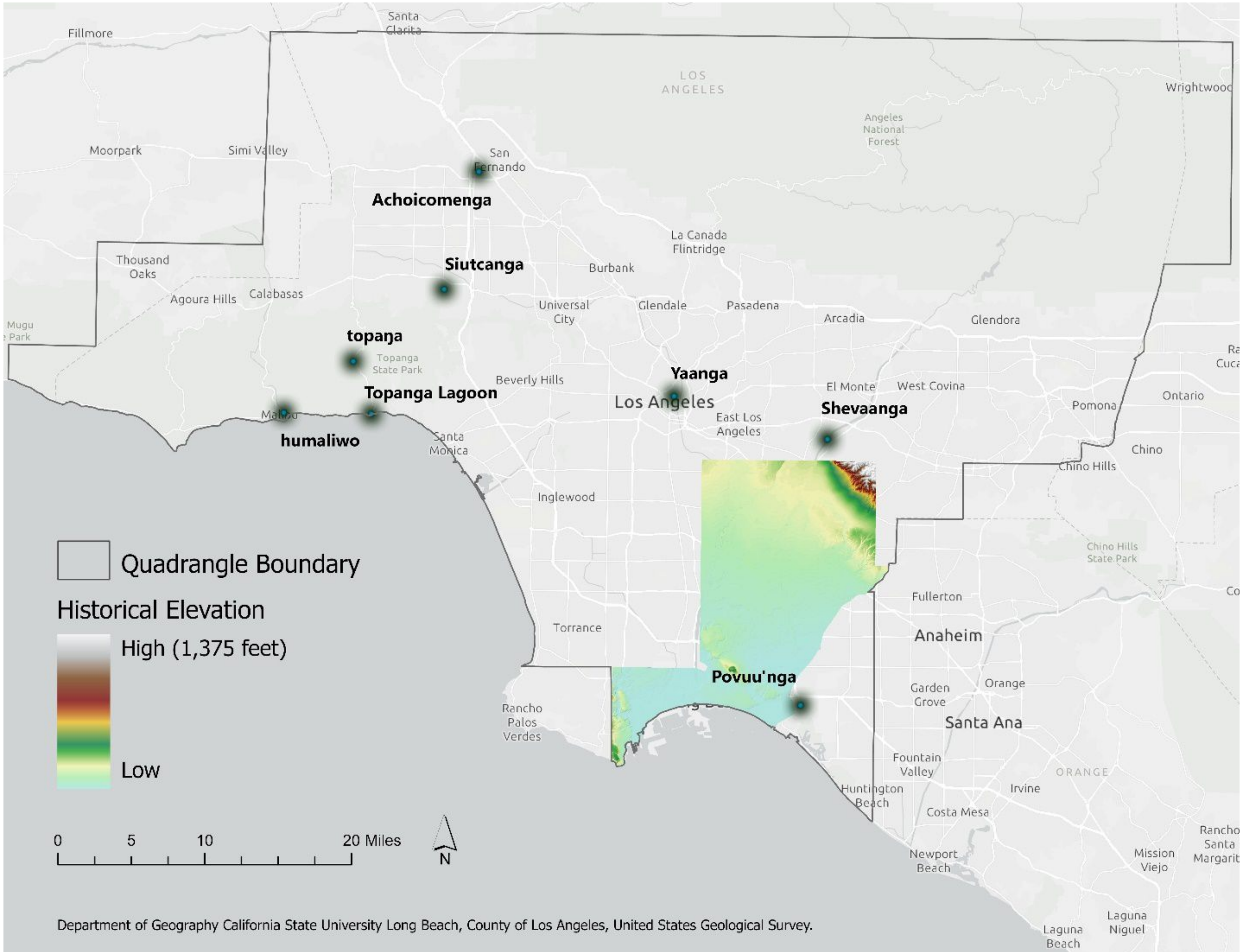


Figure 3-9. Object-to-Raster DEM.

The Pixel-to-Raster approach generated 16,634,453 historical elevation points from thirty-three (33) quadrangles (Table 3-4, Figure 3-10).

Table 3-4. Pixel-to-Raster Point Extraction Results

Quadrangle Name	# Points	Quadrangle Name	# Points
Alhambra	664,142	Las Flores	869,540
*Altadena	458,000	Los Alamitos	54,000
Azusa	593,774	Los Angeles	380,707
*Burbank	214,466	Pacoima	650,158
Chatsworth	251,968	Puente	321,833
Claremont	296,841	Sawtelle	791,420
Compton	230,000	Seal Beach	84,000
*Covina	765,214	Sierra Madre	460,566
*Dry Canyon	237,000	**Sunland*	*541,484*
Dume Point	1,450,000	Sylmar	1,640,552
El Monte	4,40,000	Topanga Canyon	1,305,831

Evey Canyon	251,179	Torrance	518,889
**Glendale*	*222,714*	Van Nuys	609,479
**Glendora*	*308,000*	Venice	688,500
Hollywood	334,000	Watts	115,267
Inglewood	416,800	Zelzah	341,938
La Habra	566,191		
		Total Points	***16,634,453***

** These quadrangles were supplemented with data extracted from SRTM in locations with high complexity.*

Figure 3-10. Pixel-to-Raster DEM.

SRTM data were used to supplement elevation data in seven of the quadrangles where the majority of the data were extracted using the Pixel-to-Raster approach. Elevation data from 1,000,000 randomly selected points over twenty-one (21) quadrangles were extracted from SRTM data in areas of complex terrain (refer to Table 3-1, Figure 3-11).

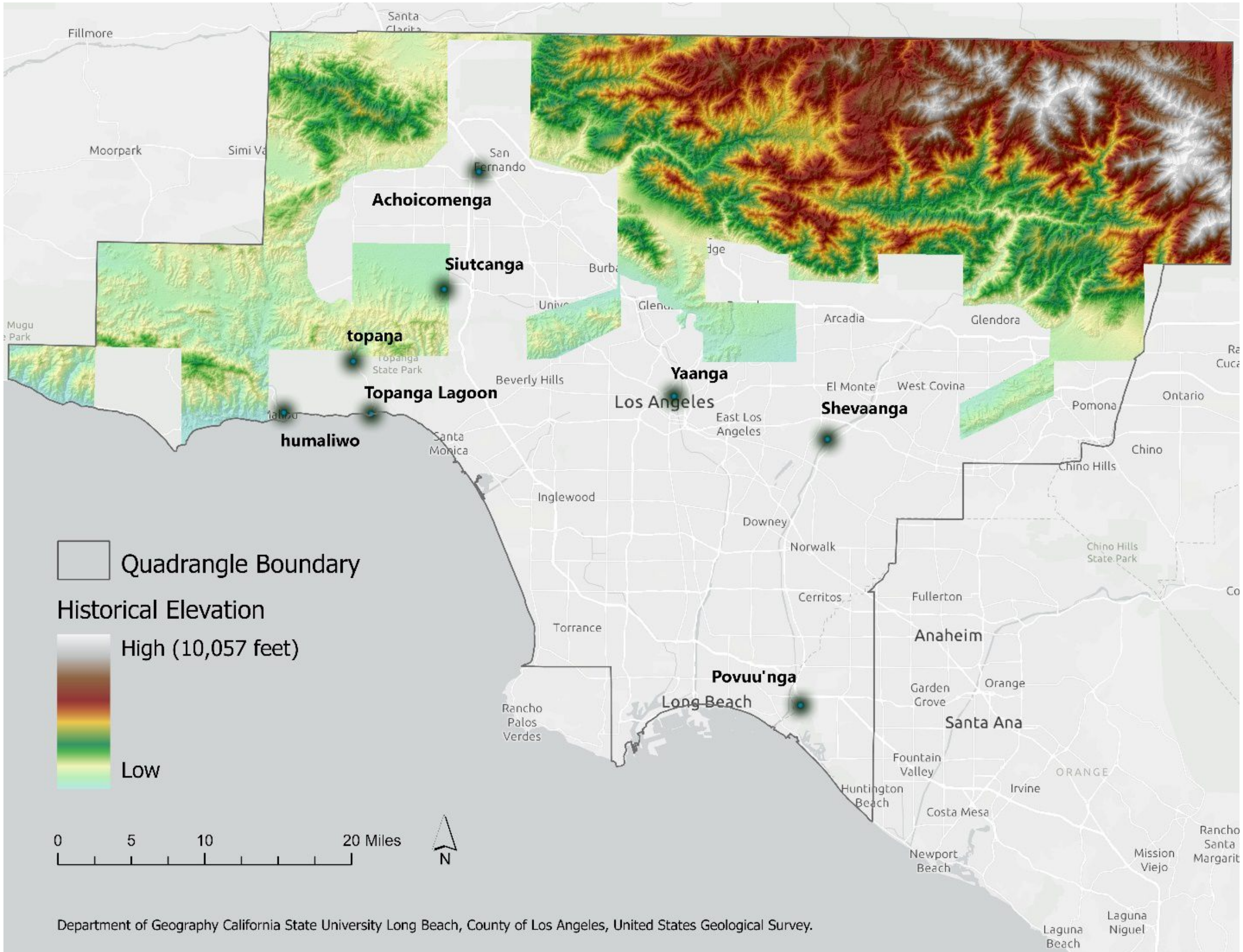


Figure 3-11. SRTM DEM.

Discussion

This effort produced the first-ever of its kind historical digital elevation model (DEM) of the Los Angeles region. DEM production in the United States began in the 1990s. Digital representations of pre-1990 topography do not exist. This project provided the opportunity to develop a methodology to derive meaningful data from some of the earliest historical maps in the region. The quadrangle maps used to derive this surface are from the 1920s–1940s and, as such the landscape they represent was already quite developed. However, these are the earliest data available from which to base such a representation.

Digital elevation models are one of the most important datasets for understanding a landscape. The resulting product provides a baseline for ongoing analysis of the historical Los Angeles landscape. Examples of such investigations include comprehensive identification of areas that have undergone significant change across the region. The DEM can be used to derive slope, and the direction of slope (aspect) which informs how vegetation and soils may form on a landscape.

The DEM serves as a base dataset for calculating pathways between villages that may have been used. The DEM can be used to generate watersheds to understand village placement in relation to 'natural' preferential flow pathways and how water might have traveled across the landscape before significant channelization. The historical DEM will provide a rich dataset for ongoing exploration of the landscape and provides a mechanism for further understanding of Indigenous peoples' relationship to it.

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Chapter 4 Photographic Time Machine for the Los Angeles Basin

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Introduction

Systematic aerial photography began in the 1920s, using technology developed during the First World War. Because of the massive urban and suburban development of Southern California during that decade, air photo companies produced many "flights" of images, which have been retained in archives ever since. These photos (produced in a string of overlapping images along a flight path at a steady altitude) are priceless records of the actual groundcover and landforms at very high resolution. Studying the nature of landscape features, such as the breadth of the washes that flowed southward across the San Fernando Valley or the extent of the floodplain of the lower Los Angeles River, are aided immensely by a seamless mosaic of digitized historical aerial images of those actual landscapes that is linked to and can be layered over existing imagery and data. For example, this mosaic can be "draped" over topographic maps in a three-dimensional representation, creating a time machine for the type of visualizations one can produce in Google Earth for contemporary data. It will complement the historical Digital Elevation Model (DEM) that was produced by this study (see Chapter 3). 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. Such mosaics are indispensable when interpreting historical maps and features and are unparalleled for developing outreach materials for the public and supporting synthesis efforts.

The CSUN team acquired and processed over a thousand historical aerial images from the 1920s to create a seamless mosaic that covers the entire Los Angeles Basin.

Methods

Data Acquisition and Processing

Data Acquisition

1,387 historical aerial photos from 1928 were downloaded from the UC Santa Barbara Aerial Photography Library.

Color Correction

These individual photos were then color corrected using Adobe Photoshop to allow researchers to easily identify landmarks and create a more seamless historical imagery mosaic. Due to the age and condition of many individual photos, color correction efforts could only address certain issues and artifacts in the imagery. For example, darkening an area on an image might make it better match the rest of the image, but may result in obscuring specific features in the image so they can no longer be identified. Therefore, special care was taken to carefully assess and review each image to determine the best next steps. Additionally, images were cropped to remove extraneous borders so that they would seamlessly blend in with adjacent images during the mosaic process.

Figure 4-1. Color correction and cropping example.

Photomerge Process

During this process we merged individual images to create mosaics of images that cover a larger area. This process resulted in mosaics for the six indigenous village areas in the LALAH study area.

Figure 4-2. Photomerging example showing a mosaic of image with the Ballona Lagoon and wetlands, Ballona Bluffs, El Segundo Dunes and the future site of the Los Angeles International Airport.

Georeferencing

Following the photomerge process, each village mosaic was *georeferenced* to accurately align the imagery so it can be overlaid with other layers of information in the same area. To do this, the team selected historical 1:24000 topographic maps as the source of accurate location data (Figure 4-3). The U.S. Geological Survey (USGS) has already georeferenced the historical topographic maps and for this project we have taken the 1920s 1:24000 maps as the "gold standard" upon which all other layers are built. We know at the outset that the maps do not match current locations exactly, but they are internally consistent across the study area.

Figure 4-3. Example of georeferenced aerial photograph on the U.S. Geological Survey map used as the gold standard for the study.

Final Mosaic

The final step in the process was to produce a final full mosaic of the entire study area from all village mosaics.

Results

The overall process took approximately 12 months with 4 research assistants working part-time on the effort. The final mosaicked image covered an area of **1,745 square miles** (Figure 4-4). It has been converted to an image layer feature and served to ArcGIS Online where it can be explored by users.

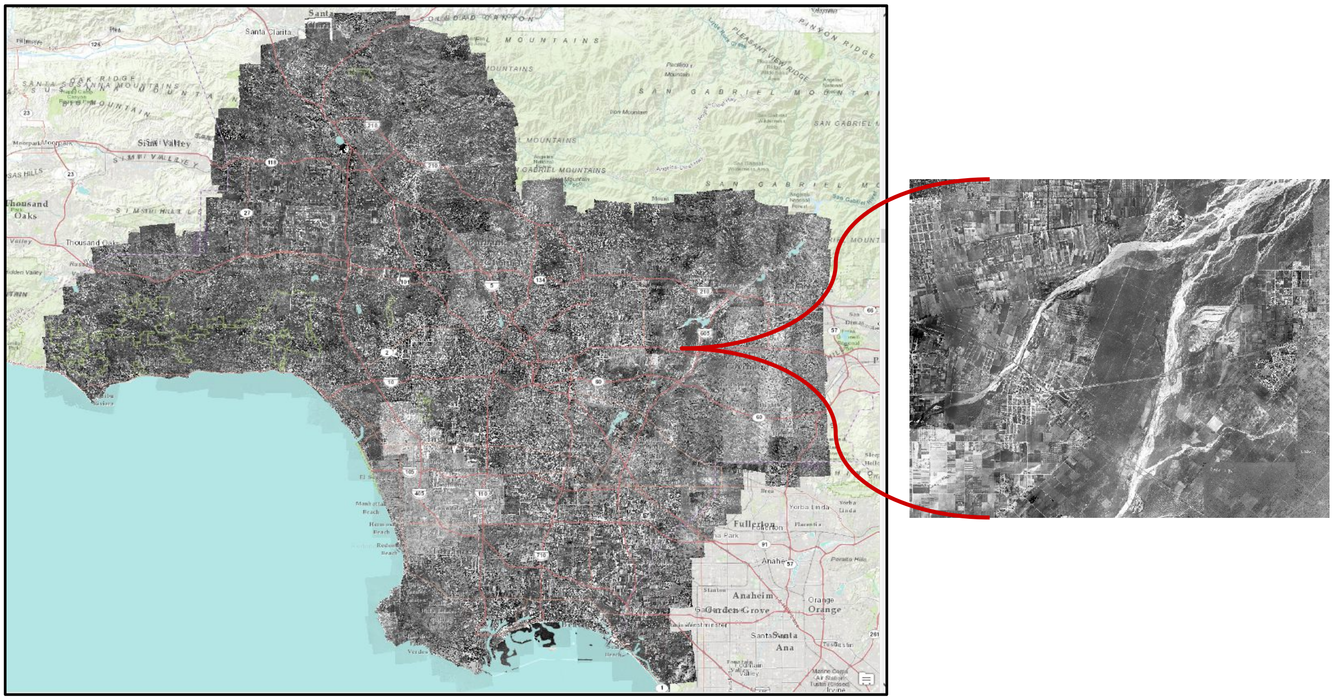


Figure 4-4. Final mosaic image and enlargement of the San Gabriel River above the Whittier Narrows.

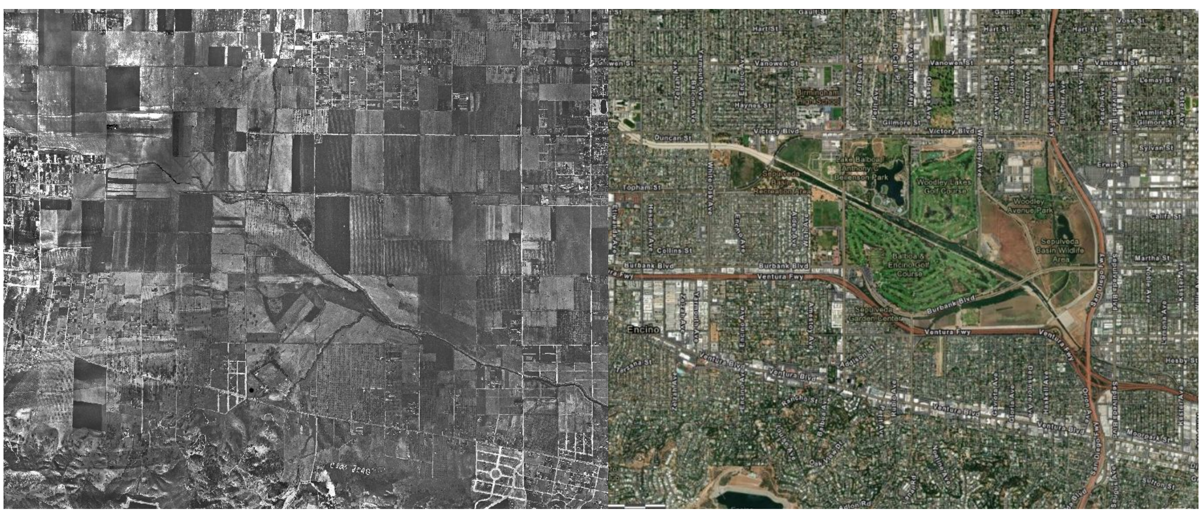
Discussion

Historical imagery of the Los Angeles Basin provides a solid indication of what the landscape looked like prior to the impact of Europeans. Due to the low resolution and artifacts found in the historical images, the level of detail that can be observed is limited. Regardless, the overall value of the dataset, especially when combined with other datasets (e.g., historical topography) produced by this project, is substantial. Even by 1928, most of the LA Basin had already been modified significantly in some form or another. The imagery does offer a glimpse of the (semi)original state of specific landscape features such as waterways, and also illustrates the degree of massive urbanization and development in the area since 1928.

In much of what is now considered central Los Angeles, urbanization had already overshadowed the area by 1928, so little of the natural landscape is visible (Figure 4-5). In the San Fernando Valley near Siutcanga, agriculture dominated the landscape, but you can see the beginnings of residential and some commercial development beginning to inch in (Figure 4-6). Fortunately, many waterways and waterbodies had not been channelized or modified yet, so the historical floodplain extent and natural channel behavior and braiding patterns are readily apparent (Figure 4-7).

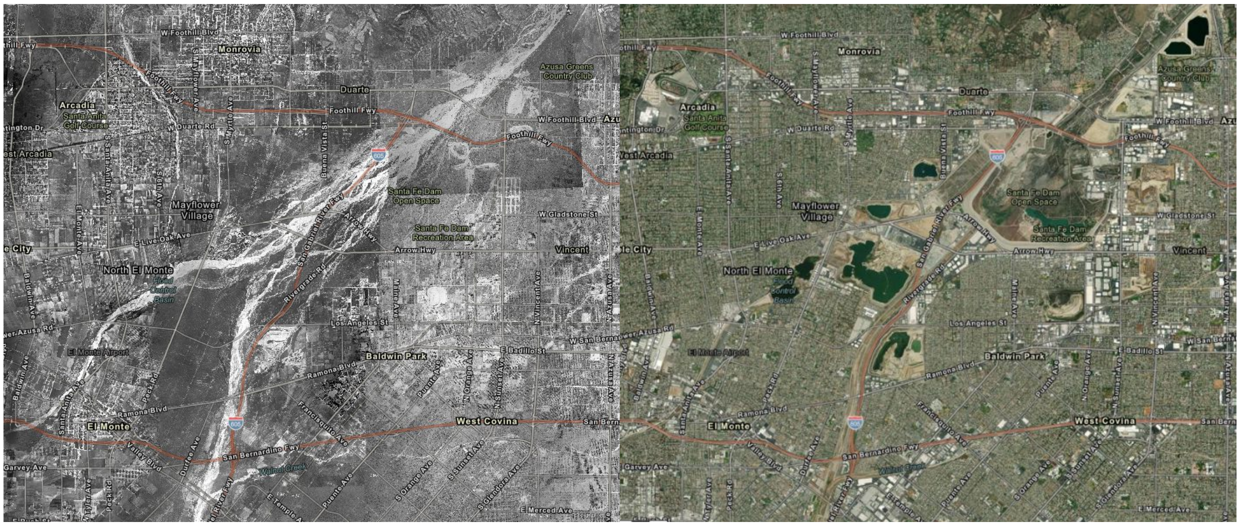
1928 Imagery Contemporary Imagery

Figure 4-5. Comparison of 1928 and current imagery for central Los Angeles – Yaanga.



1928 Imagery Contemporary Imagery

Figure 4-6. Comparison of 1928 and current imagery for the San Fernando Valley - Siutcanga (Encino).



1928 Imagery Contemporary Imagery

Figure 4-7. Comparison of 1928 and current imagery for the San Gabriel River – North of the El Monte.

Chapter 5 Wetland Features from Historical Topographic Maps in the Los Angeles Region

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Introduction

The development of Los Angeles, like many other cities, has been effective at erasing the natural water features that traversed the landscape. Rivers have been channelized, creeks and streams buried, springs diverted into storm drains, and wetlands and ponds integrated into "water features" in parks and golf courses. These features become lost to memory and their presence invisible except to academics, enthusiasts, and other enterprising readers of the landscape (see https://lacreekfreak.wordpress.com/).

Some of the only extensive, if not perfect, records of the water features of the landscape, which cover the entire region, are the topographic maps produced by the U.S. Geological Survey in the late 1800s and early 1900s. The 1890s maps were created at 1:62,500 scale, which was sufficient to see the major wetland features and understand the large-scale dynamics in the region (Figure 5-1). These were followed by the 1:24,000 scale maps produced generally in the 1920s and later, which contained additional detail, but also reflected the greater urbanization that had already occurred at that point.

Some of the well-known depictions of the historical course of the Los Angeles River and associated features were almost certainly drafted from the USGS topographic maps, such as Blake Gumprecht's map (Figure 5-1) in his influential book on the Los Angeles River (Gumprecht 1999). Our previous historical ecology investigations in the region have similarly used the 1920s topographic maps as a foundational source, especially for streams and wetlands, including studies of the Ballona Watershed (Dark et al. 2011), San Gabriel River (Stein et al. 2007, Stein et al. 2010), and Elysian Valley of the Los Angeles River (Longcore 2016). These topographic maps are also available to the general public through a single-purpose web viewer, in which the map images are overlaid on contemporary maps (USGS Historical Topographic Map Explorer, https://livingatlas.arcgis.com/topoexplorer/).

The available versions of the USGS topographic maps, however, are images only and do not include underlying data that is useful in a Geographic Information System (GIS). Chapter 3 of this report involved extracting topographic data from these maps, while in this chapter address the digitizing of wetland features so that they can be mapped and analyzed with other layers of spatial data in GIS.

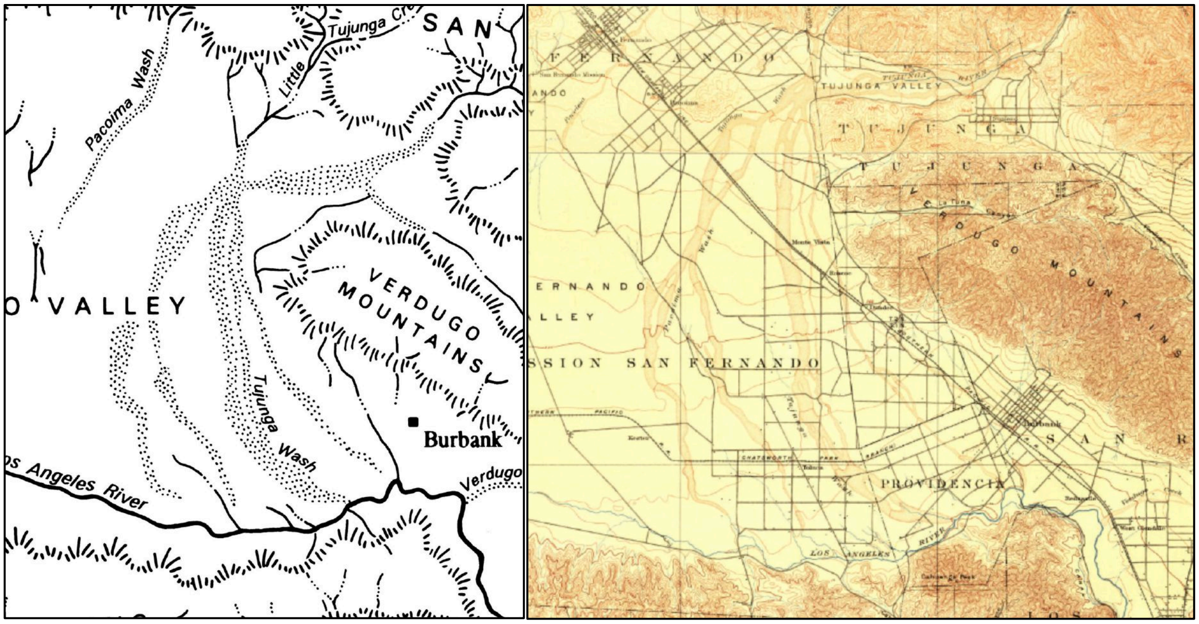


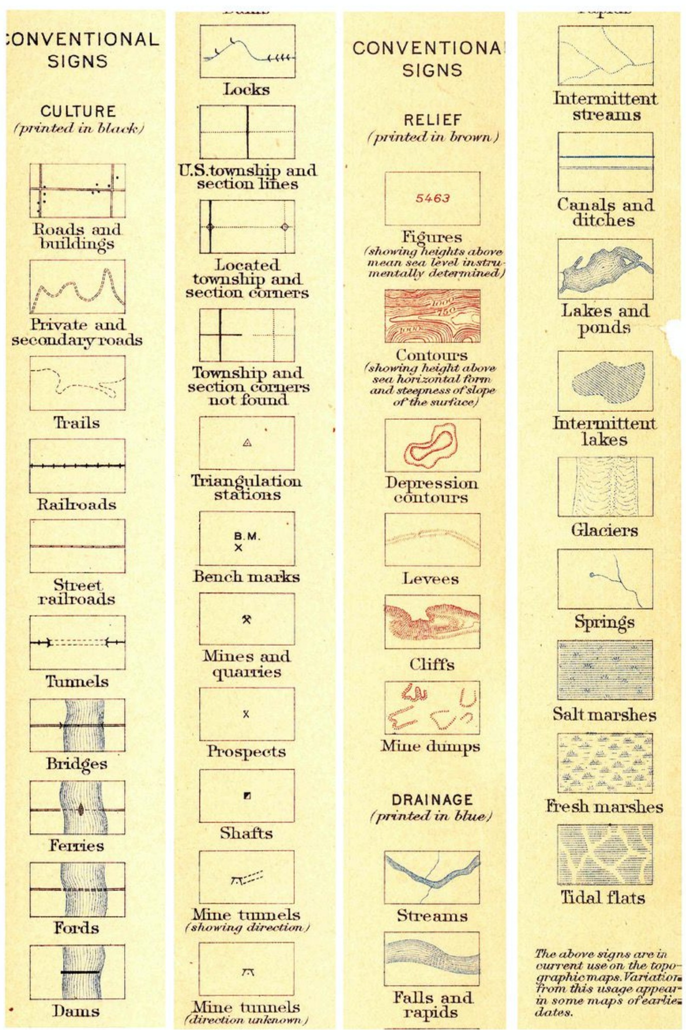
Figure 5-1. Detail of map of the Los Angeles River (Gumprecht 1999) and surroundings, compared with the 1894 Los Angeles and 1900 San Fernando USGS topographic maps at 1:62500.

The USGS has already georeferenced the historical topographic maps and for this project we have taken the 1920s 1:24000 maps as the "gold standard" upon which all other layers are built. We know at the outset that the maps do not match current locations exactly, but they are internally consistent across the study area. All investigations using historical maps used the 1920s USGS topographic maps as the base, including reconstruction of topography, the historical aerial photograph mosaic, and indigenous road network, in addition to the "blue line" water features in this chapter.

Our approach was to digitize and attribute the features by hand, notwithstanding technology available to use image interpretation software to extract features automatically (Khontanzad and Zink 2003). Even the most modern techniques to extract data automatically from these maps still require manual processing (see Chapter 3). Previous experience indicated the same (Longcore et al. 2020), so we opted to simply digitize and attribute the blue lines by hand using heads-up digitizing (Mendes 1995).

Methods

The USGS quadrangles were downloaded and imported into GIS using the georectification already done by the USGS. The historical legend for attributes on these maps (Figure 5-2) was provided to those digitizing. Each map was digitized into a new shapefile in either QGIS or ArcGIS Pro. Point, line, and polygon features were digitized separately with a goal of digitizing at 1:9000 or larger scale. All wetland and water associated features were digitized and the feature name stored as an attribute associated with each point, line, or polygon. These features on the maps included: streams (including falls and rapids), intermittent streams, canals and ditches, lakes and ponds, intermittent lakes, springs, salt marshes, fresh marshes, and tidal flats. Because of the availability of more detailed maps for coastal salt marshes and tidal flats (Grossinger et al. 2011), those features were not digitized. High elevation areas that have experienced little urbanization were also not digitized in the more recent maps. The shapefiles were then combined into a single layer for the study area.



U.S.G.S. Topo Legends

Figure 5-2. Legend for features depicted on USGS topographic maps in the early 1900s.

Results

Sixty-one maps were digitized, while some quadrangles in the study area in the mountains were not because of the limited topographic alterations (Alder Creek, Camp Baldy, Camp Bonita, Camp Rincon, Chileno Canyon, mountainous portions of La Crescenta, Mt. Wilson, Mount Gleason). The Wilmington quadrangle was not digitized because the Coast Survey maps (T-Sheets) are a more detailed source for this location. Maps covered the years 1924–1941 in the 1:24000 series, being the first created at this resolution, while the 1:625000 maps ranged from 1896–1921.

Table 5-1. USGS topographic maps for which blue line water features were digitized.

Quad	Scale	Date	Digitizing Resolution	GIS Specialist
Las Bolsas	1:62500	1896	1:9,000	New
Redondo	1:62500	1896	1:9,000	New
San Pedro Hills	1:62500	1896	1:9,000 (lines), 1:2,359 (polygons)	Jasmine
Downey	1:62500	1899	1:9,000	Jasmine
Fernando	1:62500	1900	1:18,000	Alondra
Pasadena	1:62500	1900	1:9,000	Alondra
Tujunga	1:62500	1900	1:9,000	Alondra
Anaheim	1:62500	1901	1:18,000	Alondra
Santa Ana	1:62500	1901	1:9,000	Alondra
Santa Monica	1:62500	1902	1:9,000	Alondra
Calabasas	1:62500	1903	1:9,000	Chloe
Santa Susana	1:62500	1903	1:9,000	Alondra
Pomona	1:62500	1904	1:9,000	Alondra
Piru	1:62500	1921	1:9,000	Alondra
Triunfo Pass	1:62500	1921	1:9,000	Alondra
Compton	1:24000	1924	1:9,000	Jasmine
Inglewood	1:24000	1924	1:9,000 (lines), 1:2,000 (polygons)	New
Venice	1:24000	1924	Varies; noted one-by-one in the attribute tables	New
Watts	1:24000	1924	1:9,000 (lines), 1:2,500-4,000 (polygons)	New
Artesia	1:24000	1925	1:9,000	Alondra
Bell	1:24000	1925	1:9,000	Alondra
Clearwater	1:24000	1925	1:9,000	Alondra
Long Beach	1:24000	1925	1:9,000	Alondra
Sawtelle	1:24000	1925	1:9,000	New
Whittier	1:24000	1925	1:9,000	Alondra
Alhambra	1:24000	1926	1:9,000, 1:5,760 (lines), 1:3,686 (polygons)	Jasmine
Burbank	1:24000	1926	1:9,000	Chloe
El Monte	1:24000	1926	1:9,000	Alondra

Hollywood	1:24000	1926	1:9,000 (lines), 1:2,000 (polygons)	New
Sunland	1:24000	1926	1:9,000	New
Van Nuys	1:24000	1926	1:9,000	Chloe
Chatsworth	1:24000	1927	1:9,000	New
Covina	1:24000	1927	1:9,000 (lines), 1:3,686 (polygons)	Jasmine
Glendora	1:24000	1927	1:9,000 (lines), 1:2,000/5,000 (polygons)	New
La Habra	1:24000	1927	1:5,760	Alondra
Pacoima	1:24000	1927	Varies; noted in the attribute tables	New
Puente	1:24000	1927	1:9,000	Alondra
Altadena	1:24000	1928	1:9,000	Alondra
Azusa	1:24000	1928	1:9,000 (lines), 1:4,000 (polygons)	Jasmine
Claremont	1:24000	1928	1:9,000	Alondra
Dry Canyon	1:24000	1928	1:9.000	New
Glendale	1:24000	1928	1:9,000	Alondra
La Brea	1:24000	1928	1:9,000 (lines), 1:2,359 (polygons)	Jasmine
La Crescenta	1:24000	1928	1:9,000 (lines), 1:2,560 (polygons)	Jasmine
Los Angeles	1:24000	1928	1:9,000	Chloe
Reseda	1:24000	1928	1:9,000	Chloe
San Pedro	1:24000	1928	1:9,000	Alondra
Sierra Madre	1:24000	1928	1:9,000, 1:5,760 (lines), 1:2,560 (polygons)	Jasmine
Topanga Canyon	1:24000	1928	1:9,000	New
Torrance	1:24000	1928	1:9,000	Alondra
Zelzah	1:24000	1928	1:9,000	Chloe
Arroyo Sequit	1:24000	1932	1:9,000	Alondra
Dume Point	1:24000	1932	1:9,000	Alondra
Las Flores	1:24000	1932	At least 1:9,000, with larger scale for polygons	New
Russell Valley	1:24000	1932	1:9,000	New
Seminole	1:24000	1932	1:9,000	New
Solstice Canyon	1:24000	1932	1:9,000	Alondra
Newhall	1:24000	1933	1:6,000	Chloe
Sylmar	1:24000	1935	1:5,000	Chloe
Little Tujunga	1:24000	1939	1:5,000 (lines), 1:9,000 (polygons)	Alondra
Mt. Lowe	1:24000	1939	1:9,000 (lines), 1:2,000 (polygons)	New
Evey Canyon	1:24000	1940	1:9,000 (lines), 1:2,000 (polygons)	New
La Verne	1:24000	1940	1:9,000 (points), 1:5,760 (lines), 1:5,760-1,510 (polygons)	Jasmine
Mt. Baden-Powell	1:24000	1940	1:9,000 (lines), 1:5,760 (polygons)	Jasmine
Pico	1:24000	1940	1:9,000	Alondra
Rock Creek	1:24000	1940	1:9,000	Alondra
Trail Canyon	1:24000	1940	1:9,000	Alondra

Alder Creek	1:24000	1941	1:9,000	Jasmine
Crystal Lake	1:24000	1941	1:9,000	Alondra
Mount Waterman	1:24000	1941	1:3,686 (lines), 1:5,760 (polygons),	Jasmine
Swartout	1:24000	1941	1:9,000 (lines), 1:3,000 (polygons)	New

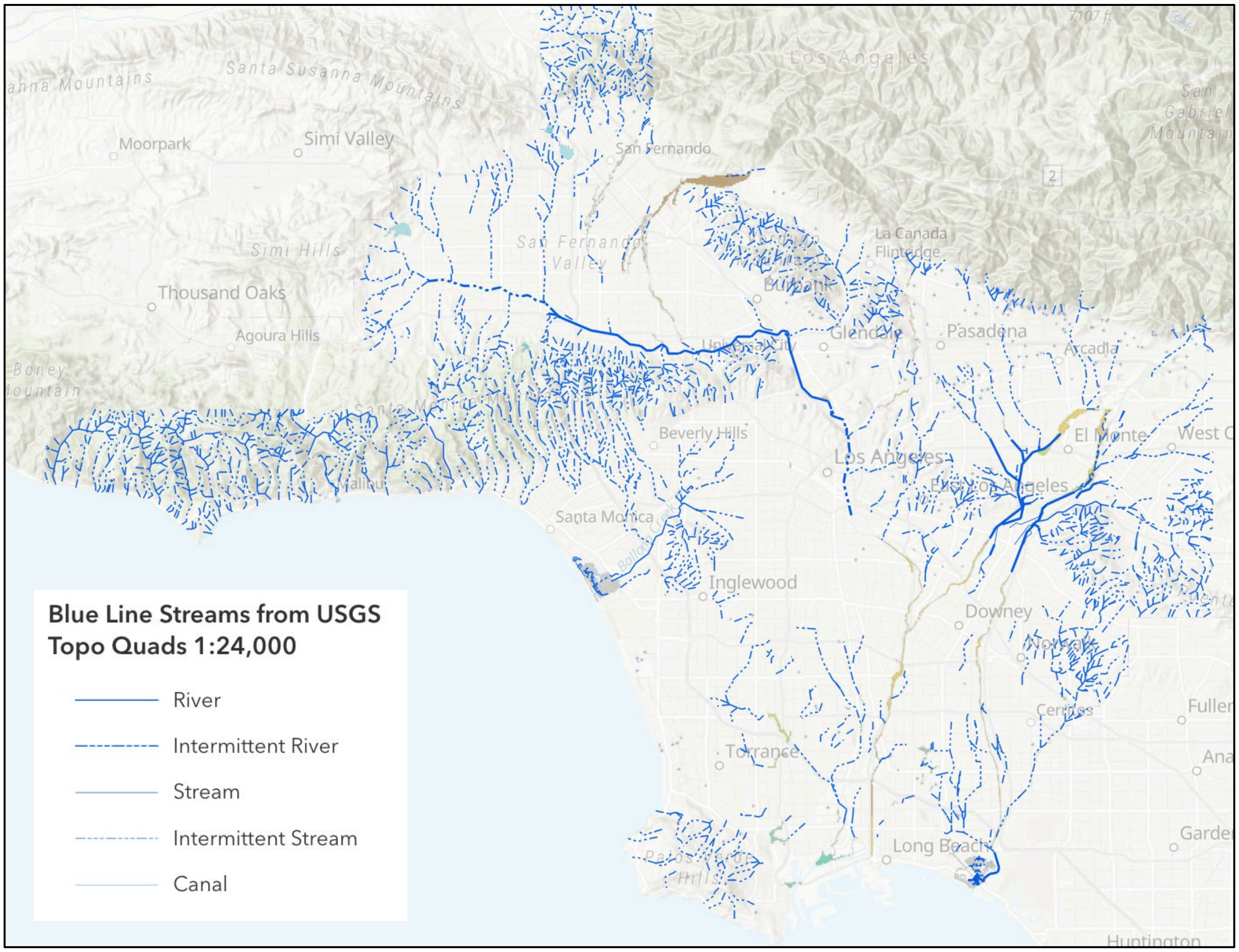


Figure 5-3. Water features digitized from historical 1:24,000 USGS topographic maps.

The features were merged together and mapped for both the 1:24,000 series (Figure 5-3) and the 1:62,500 series (Figure 5-4).

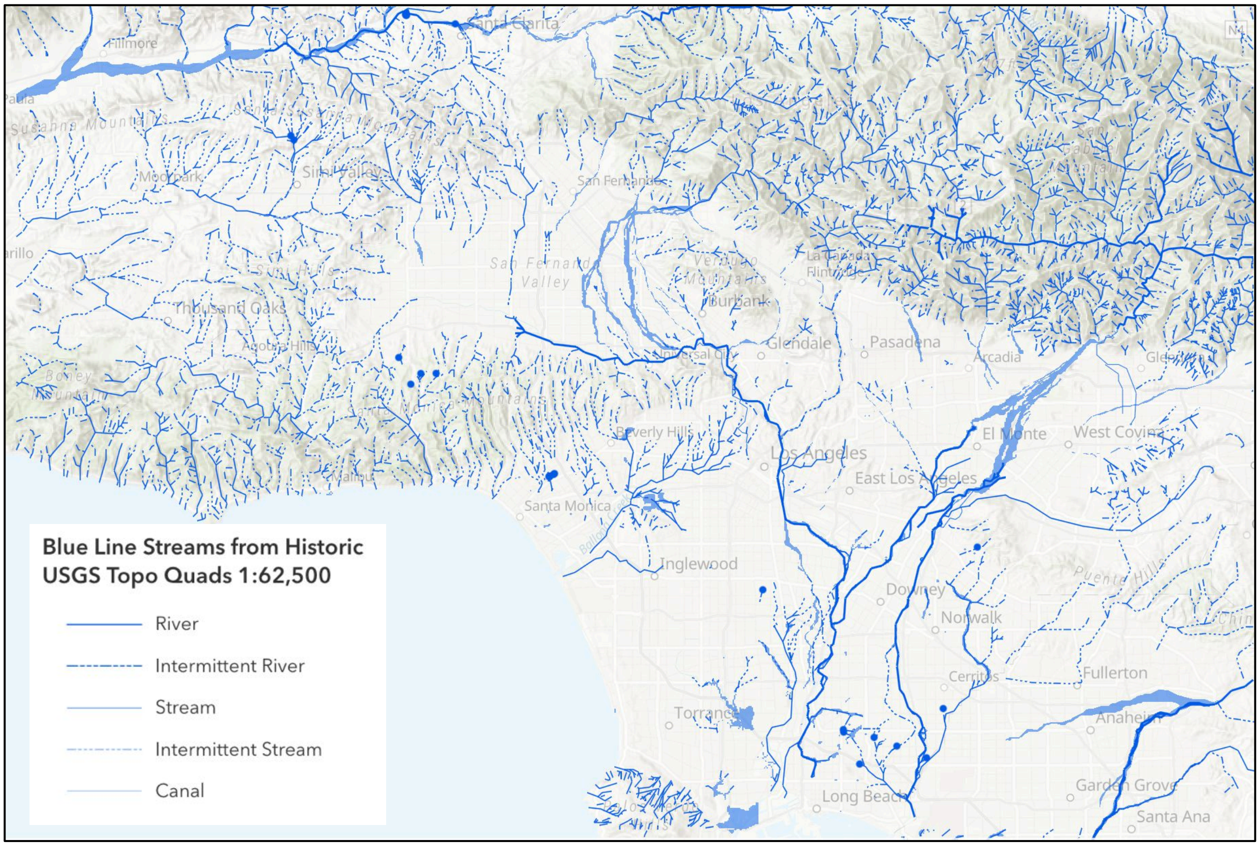


Figure 5-4. Water features digitized from historical 1:62,500 USGS topographic maps.

Discussion

The full array of wetland features from the early topographic maps can make an effective addition to representations of the historical ecology of the region. Despite being the source for graphic depictions of the Los Angeles River and other contemporary maps, these wetland features had not previously been digitized in a systematic manner and made available for use. The features can now be used to communicate more effectively with the public about landscape history by being overlain on contemporary maps and aerial imagery, showing in detail where creeks are hidden under the urban landscape and where other wetland features have been incorporated into the current landscape.

We elected to digitize the wetland features to coincide with the USGS georectification of the 1920s 1:24,000 series topographic maps. Although this georectification is the best available, it does not exactly match contemporary maps or imagery, so adjustments would need to be made to precisely locate these features on current maps. The offset, however, is modest and this newly digitized feature set is adequate to enhance understanding of the distribution of water-associated features in a region where they have been all but erased, both from the contemporary landscape and from the collective memory of its current residents. The 1:62,500 series provides additional information on the historical water features although it has an offset from the 1:24,000 series and contemporary maps. Nevertheless, for visualizing the scale and detail of the hydrology of the Los Angeles before widespread channelization and urbanization, the data are extraordinarily useful.

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Chapter 6 Indigenous Road Networks of the Los Angeles Region

Philip J. Ethington, Devlin Gandy, Matthew Teutimez, and Andy Salas

Introduction

Our goal was to develop a reliable map of the ancient roads that linked the pre-Hispanic settlement sites of the Southern California, using available cultural resources–principally historic maps produced during the post-conquest era, oral memory provided by Indigenous tradition, inferences based on the verifiable location of ancient Indigenous villages, and comparison with the results of the unpublished Least-Cost Paths computational analysis produced previously for the Chumash territories by Gandy, and by MacDonald, Wilson, and Longcore.

The purpose of this project is to provide improved knowledge and to fill a particularly glaring void in the historical geography of Southern California, which has been inhabited for at least ten millennia, during which countless generations traversed the region and undoubtedly inscribed pathways that linked their settlements and provided links to the territories beyond the region. While a great deal is known about the location of hundreds of Indigenous villages throughout the region, practically nothing has ever been published about the geographic linkages between them. The many published maps of village and archaeological sites, presented simply as labeled points on the landscape, leaves the unfortunate and illogical implication that villages were somehow isolated from one another, autonomous, or autochthonous (self-reliant) despite generations of archeological and cultural evidence to the contrary, which documents the rich material and cultural communications within and beyond the region.

A relatively precise knowledge of the location of the ancient road network is integral to understanding the ecological-cultural (eco-cultural) history of the Los Angeles regional landscape, because these paths were inscribed by the Indigenous managers of that landscape, and so, were integral to its overall function. Knowledge of these ancient roadways is also valuable for interpreting the development of the region during the period following the conquest and colonization of the region beginning in 1769. Indeed, it is clear from both the historical record and our cartography that the post-1769 regional road network was built directly upon many of these ancient roadways, which demonstrates a very strong continuity in the cultural history of the region. Indeed, it is easy to demonstrate the many of the most modern of contemporary roadways, the freeways, were built on top of these very ancient roadways.

Overall, we hope that the production of this new regional map of ancient roads will help the general public to appreciate the deep historical past of the region, cities, and neighborhoods in which they live and the roads on which they travel, as a continuum owing to the Indigenous founders of the region. We hope this map will help researchers in many fields to better understand the historical geography of the region that they study. The benefit to specialists is not limited to purely academic study, but also has an important bearing on current decisions regarding land use. As an example, it can help to demonstrate that the protection of Native American cultural sites should not be limited to the narrowly defined areas focused on archaeological sites presumed to be areas of settlement but also along the roadways that connected ancient Indigenous settlement sites. Numerous cultural features such as artifacts from trade and burial sites would logically have been located along the paths between villages.

Methods

Sources for Los Angeles Basin, San Fernando Valley, San Gabriel and San Bernardino Valley, and Long-Distance Roads to Lower Colorado River, and Greater Southwest

Evidence of the location of ancient roads during pre-Hispanic times is rare but not inaccessible. The first written records of roads are the journal accounts of the Spanish from their earliest land exploration of the densely settled region. Father Juan Crespi penned the first of these for California in 1769-70, recording in his daily journal a great many clues as to the path he took. Throughout the Crespi narrative, it is either explicitly stated or implied that the Portolá Expedition followed well-beaten roads, which could accommodate hundreds of horses and pack mules. This is hardly surprising. Accounts of the 16th-century Spanish conquest of Central Mexico confirm that the conquistadors followed the major roads already in use by the Indigenous of each region. Carl Sauer's (1932) research on the road network of Northwest Mexico makes this case very clear, concluding that those roads were rapidly renamed "Royal Roads" or Caminos Reales and became the central network of roads for New Spain (Sauer 1932).

In his report of 1775, Don Pedro Fages, second in command under Gaspar de Portolá in the 1769-70 expedition, recounted the initially peaceful support and guidance given to the Spanish by each of the tribal groups on their two hundred league journey northward to the San Francisco Bay.

> "The Indians came voluntarily to nearly every place where our men camped…presented us fish, hare, nuts, pine-nuts, acorns, and other seeds prepared after their fashion. Our men made themselves understood by signs, **and they in like manner indicated to us the road, and other matters concerning which we required information for our guidance on the march.** It was never necessary for us to use our weapons for any purpose save to obtain some game, which was generally bears" (Fages 1919).

This initial amity was very short-lived, of course. Once the Indigenous realized that the Spanish had come to take their lands, armed resistance replaced this initial peaceful welcome and by the time he wrote his report in 1775, Fages warned that it was very dangerous to travel anywhere along these same roads without armed escorts. But the point is that the Spanish depended entirely on the Indigenous road network to accomplish their conquest, and kept using the same roads for generations to come.

We can therefore reasonably assume that at least the principal roads that were in constant use by the time that the first maps were produced would represent Indigenous roads. Southern California is ringed by steep mountains and crisscrossed by lesser ranges, which permit only a limited number of routes. Travel between villages that had become permanent centuries or possibly thousands of years earlier certainly inscribed their routes into the landscape.

Maps from the Spanish Archives: Archivo General de Indias (AGI)

The Spanish made very few maps showing roads within Southern California during their period of colonization. Numerous references to these roads survive in various documents. Father Francisco Palou, for example, describes the founding of the Pueblo of Los Angeles in 1781 "on the road to the channel", meaning the road that reached the Santa Barbara channel by way of the Cahuenga Pass, the southern edge of the San Fernando Valley, the through the Simi Hills. This did indeed become the "Camino Real" and was almost certainly, following the logic above, a very ancient trail (Palóu 1926).

Two Spanish maps in particular were extremely useful in locating the longer-distance roads connecting the Southern California region with the Greater Southwest, and southward across the Colorado River into Sonora and Baja California, drawn in the years 1777 and 1778. Two Franciscan priests were helping Juan Bautista de Anza to establish a land route to California. It is from these reports that the names of the long-distance trails have been derived, based on the Indigenous groups who controlled the territories through which they ran in the early Spanish colonization period. These roads most certainly pre-dated the Spanish by hundreds, if not thousands, of years.

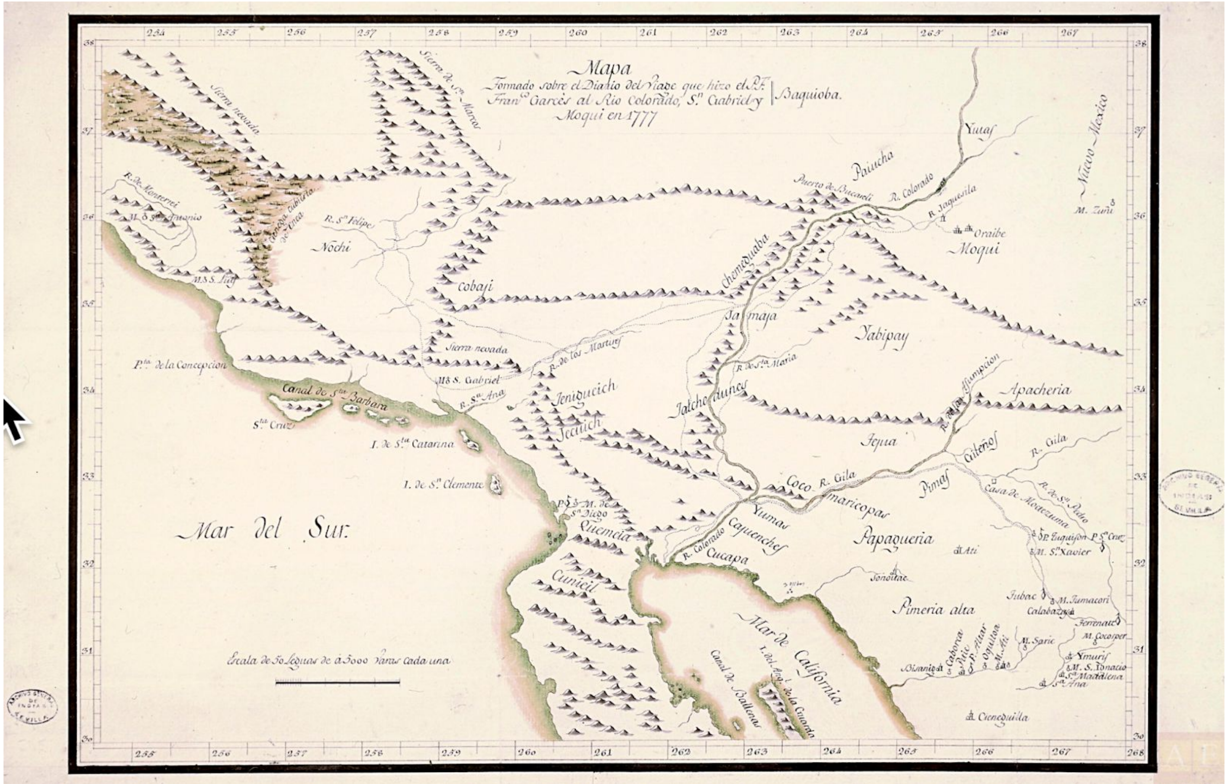

Figure 6-1. "Mapa Formado sobre el Diario del Viage que hizo el P[adre] F[ray] Fran[cis]co Garcés al Río Colorado, S[a]n Gabriel y Moqui en 1777"
http://pares.mcu.es:80/ParesBusquedas20/catalogo/description/21490 Metadata: "El mapa se formó como complemento al Diario de fray Francisco Garcés del viaje que hizo junto con fray Pedro Font hasta la junta de los ríos Colorado y Gila, y provincia del Moqui, escrito en Tubutama, el 3 de enero de 1777. Comprende desde el 1 de octubre de 1775 al 17 de septiembre de 1776. Incluye reflexiones sobre nuevas misiones, descubrimientos hechos anteriormente, las naciones indias de la zona, presidios que serían necesarios, posibles caminos para la comunicación"

Figure 6-2. Map of 1778 showing The Mojave Trail (Traced in Blue) from Southern California to the Hopi and Zuñi Settlements, drawn from reports by Coronel D[o]n Ant[oni]o Crespo y de los P.P. Misioneros Fr[ray] Pedro Font y Fr[ay] Francisco Garcé. "Plano que conti[en]e las Provincias de Sonora, Pimerías, Papaguería, Apachería, Rios Gila y Colorado y tierras descubiert[a]s hasta el Puerto de S[a]n Fran[cis]co en la California Septentrional y jasta el Pueblo de Oraybe en la Provincia de el Moqui, con arreglo á los diarios de el Coronel D[o]n Ant[oni]o Crespo y de los P.P. Misioneros Fr[ray] Pedro Font y Fr[ay] Francisco Garcés de q[uie]n, los viajes desde la nación Jabajaba en el Río Colorado hasta la misión de S[a]n Gabriel, a las Naciones que están al Norte de esta Misión, su regreso á los Jamajabas y camino que hizo al Moqui, están señalados con lineas de puntos: con cuia señal se manifiesta también la línea de Presidios de esta frontera" 2 August 1778. Archivo General de Indias. ES.41091.AGI//MP-MEXICO,349

Diseño Maps

The earliest archival maps showing the road network of the region begin to appear only near the end of the Mexican period (1821–1848). These were made to record the legal titles to the rancho land grants that eventually carved-up the region. It is from this period that the cartographic trail begins. Two types of maps can be used to reconstruct the earliest maps: "Diseños," or hand-drawn pictorial maps, and plat maps, which were based on rigorous surveys using modern survey techniques.

Diseño maps date from the Mexican period and early U.S. period (beginning 1848). They were very approximate, often draw in perspective, and served mainly to record the boundary markers and major features of the rancho. They were first drawn to accompany a petition to the Mexican governor for the grant of the land, initially in reward for military service, and later in an apparent land-grab by leading families with connections to the governors. Very few of these Diseño maps show roads, however, unless those roads somehow helped to fix the landmarks that defined the rancho. A representative example of one that does show roads is shown here, for Rancho Santa Anita, which encompassed all or much of today's Arcadia, Monrovia, Sierra Madre, Pasadena and San Marino.

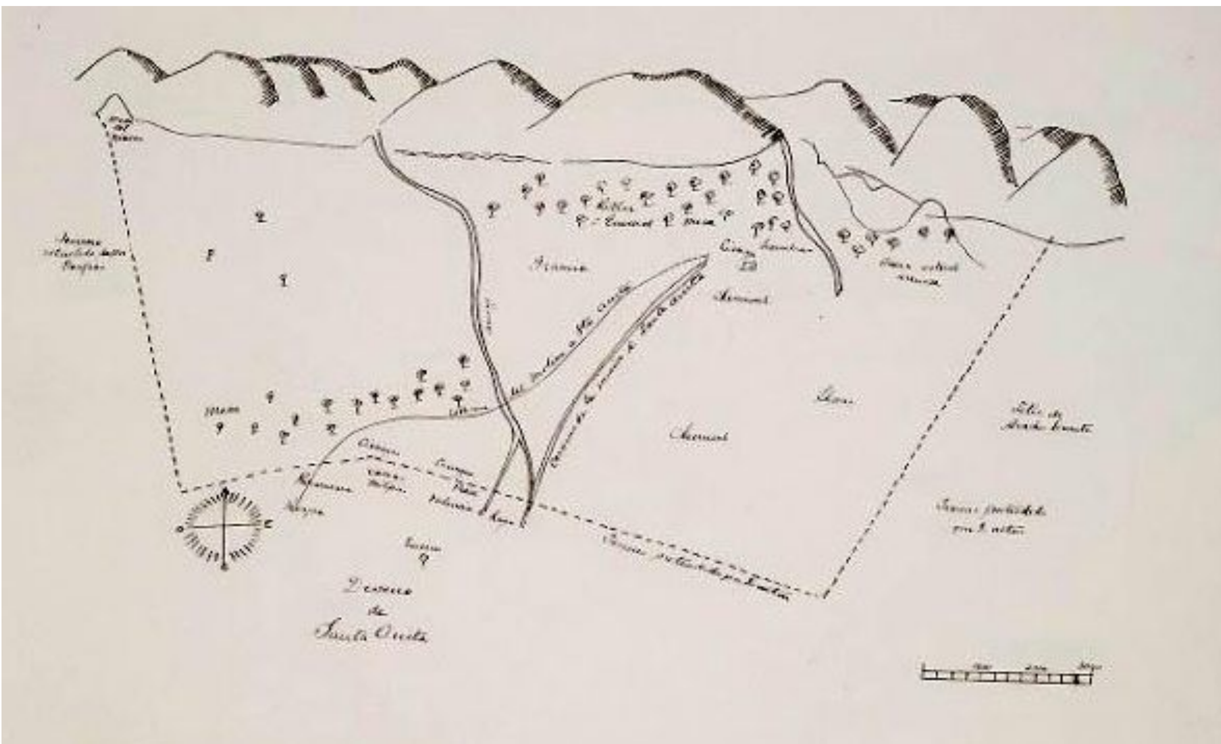

Figure 6-3. Diseño Map, Rancho Santa Anita, n.d, circa 1840s-1850s.

The main difficulty with using the Diseño maps is that they cannot be georeferenced to modern cartographic reference grids because they were drawn intuitively, without any spatial reference system. Nevertheless, they can be used to verify or indicate the presence of old roads, as in the case of the two roads in the example given here (Figure 6-3). Two roads are clearly labeled: "Camino del Molino a Sta. Anita," drawn with a single line, and "Camino de la misión a Snta Anita", drawn with two lines, indicating a wider road. The former, "Road from the Mill to Santa Anita," was most likely a post-conquest. The latter, "Road from the Mission to Santa Anita," was most probably an ancient road, running from the ancient village of *Toviscangna*, which the Spanish commandeered for the location for Misión San Gabriel in 1774, and *Sisitcanonga*, which was the heart of what became Rancho Santa Anita. That village was located next to a bountiful year-round spring which is still there, forming a lagoon at the heart of the Los Angeles County Arboretum.

Plat Maps from the Solano-Reeve Collection at the Huntington Library (1850s–1870s)

Because the Treaty of Guadalupe Hidalgo (1848) guaranteed that Mexican citizens could become U.S. citizens and retain the rights to their lands, a Land Commission was established under U.S. rule to adjudicate the rights to such lands. Decades of legal challenges pursued, and many former Mexican rancheros ultimately lost their claims to greedy Americans with superior legal representation. Nevertheless, many Californios, as the former Mexican citizens were known, did manage to retain their titles. In either case, the official result of each confirmed case of ownership included what is called a "plat map," which followed the township and range system long established across the United States in a process that had its beginnings in the Northwest Ordinance of 1787. Based in part on the Diseños that provided the initial land claim, they were drawn on the basis of physical surveys using modern cartographic methods.

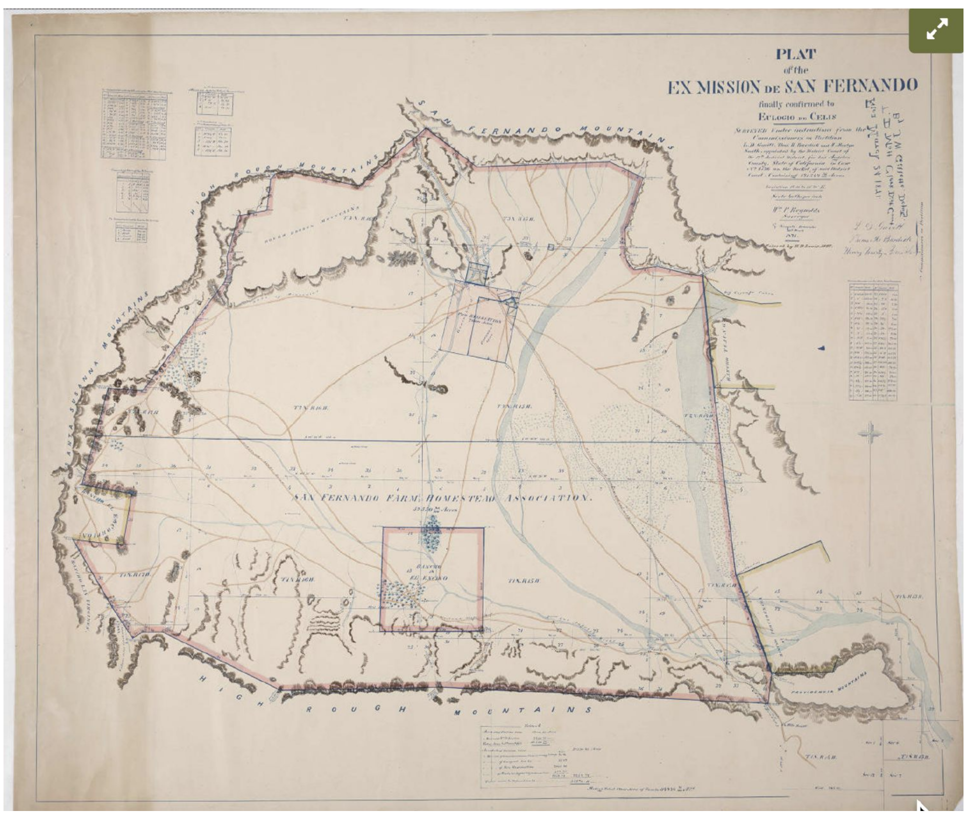

Figure 6-4. Plat Map, Ex-Misión San Fernando, 1871 "Plat of the Ex Mission de San Fernando finally confirmed to Eulogio de Celis." 1871-03-16. William P. Reynolds, cartographer. Huntington Digital Library. Solano-Reeve Collection. SR_Map_0795.
[*https://hdl.huntington.org/digital/collection/p15150coll4/id/12292/rec/3*](https://hdl.huntington.org/digital/collection/p15150coll4/id/12292/rec/3)

As with the Diseño maps, however, only a minority of the plat maps contain useful depictions of roads. Often, they only show a short segment of a road where it crosses the rancho boundary, as part of the boundary's landmark references. Thankfully, however, a significant number of the plat maps do contain extensive road depictions, and because the overall map was created using modern survey methods with township and range grids, they can be georeferenced with a high degree of accuracy to the base maps of today, and in particular, the base maps used for common reference in this study. A particularly good example of the base maps we used in this study is shown below, the 1871 map of the Ex-Mision San Fernando, which covered nearly the entire San Fernando Valley (Figure 6-4).

LA City and County Maps, Late 19th Century

Several maps produced during the 19th century, while Los Angeles County was still very sparsely settled, show old and unpaved roads. A fine example is the 1881 map of Los Angeles County by H.J. Stevenson, USGS Surveyor, published by C.L. Smith and Co, Lithographers, in Oakland California (Figure 6-5).

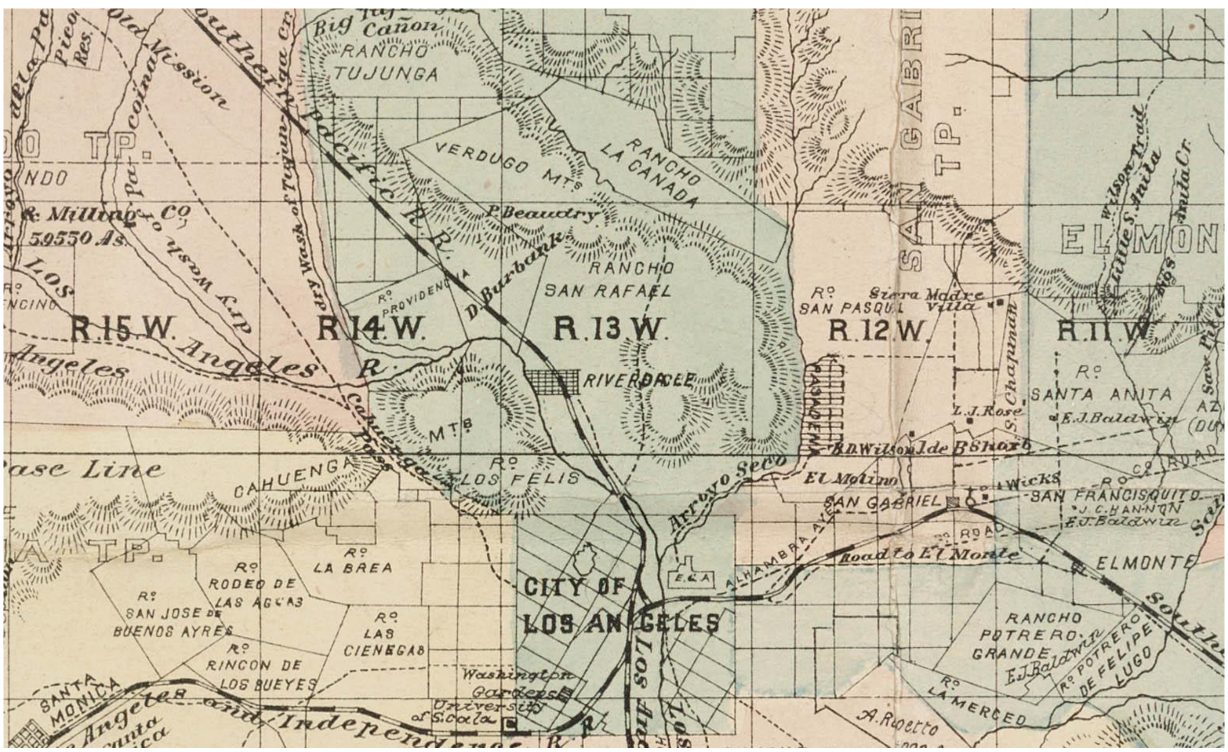

Figure 6-5. "Map of the County of Los Angeles, California, by H.J. Stephenson, U.S. Dept. Surveyor…1881." (Detail). Digital Copy from UCLA Map Library.

Figure 6-6. California. Office of State Engineer, Hall, Wm. Ham. (William Hammond). Los Angeles & San Bernardino topography. Wm. H. Hall, State Engineer, Sacramento. (circa 1880). Source: David Rumsey Map Collection, cf Vogdes p. 220, 226, 210; cf Cowen p. 260; California Water Atlas p. 22, 23. https://www.davidrumsey.com/maps3795.html BELOW: Detail showing trails emanating from downtown Los Angeles, which was built on top of Yaangna. In 1880 most of the lands on the east side of the LA river were not yet built up. Ancient roads likely survived into this year. Not all roads shown can be certainly identified as ancient, however, as Europeans have colonized the area for more than a century already.

U.S. Geological Survey Quadrangles, 1:62,500 Scale (1896-1904)

The most detailed and precisely drawn maps showing landscape features of the Los Angeles region prior to widespread urbanization are those published by the U.S. Geological Survey. The series for the Los Angeles area published from 1896-1904 at the 1:62,500 scale is particularly useful for showing older, unpaved roads (Figure 6-7).

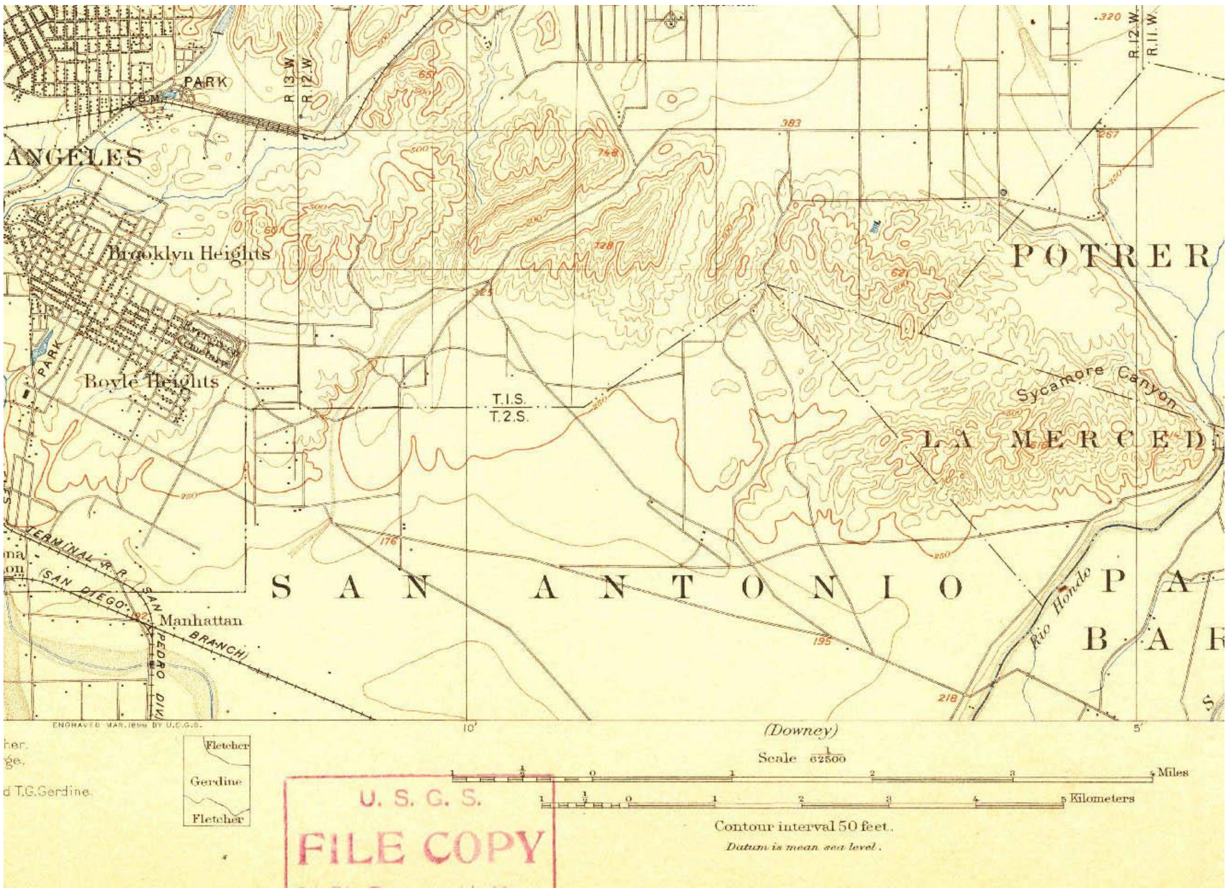

Figure 6-7. U.S. Geological Survey Quadrangle, 1:62,500 Scale "Pasadena" Sheet, "CA CA_Pasadena_298496_1900_62500" Detail.

The farther in time that maps were produced from the time of initial colonization in the 1770s, the more likely they are to show roads that were not ancient, but instead the result of development under the successive conquest regimes. For this reason, we avoided, with one exception, maps created after 1904 in our search for the oldest roads of the region.

The Kirkman-Harriman Map of 1938

One unique map from the early twentieth century has proven very useful to our project to reconstruct the ancient road network of the Los Angeles region, despite its drawbacks. Published in 1938 as "PICTORIAL and HISTORICAL MAP OF LOS ANGELES COUNTY" by Geo. W.Kirkman and Wm. R. Harriman, the map is familiar to many historians of Southern

California. An inscribed and framed copy hangs on the wall of the Los Angeles City Archives, and many other copies survive in various archives. Favorably reviewed in the journal of the Historical Society of Southern California the year it was published (Layne 1938), it depicts hundreds of historical landmarks and events, and three categories of roads across Los Angeles County: "The Camino Real," "Missoni Roads," and "Old Roads." One of the latter, running from Downtown LA to the Port of San Pedro/Long Beach, is labeled "Very Ancient Road" (Figure 6-8).

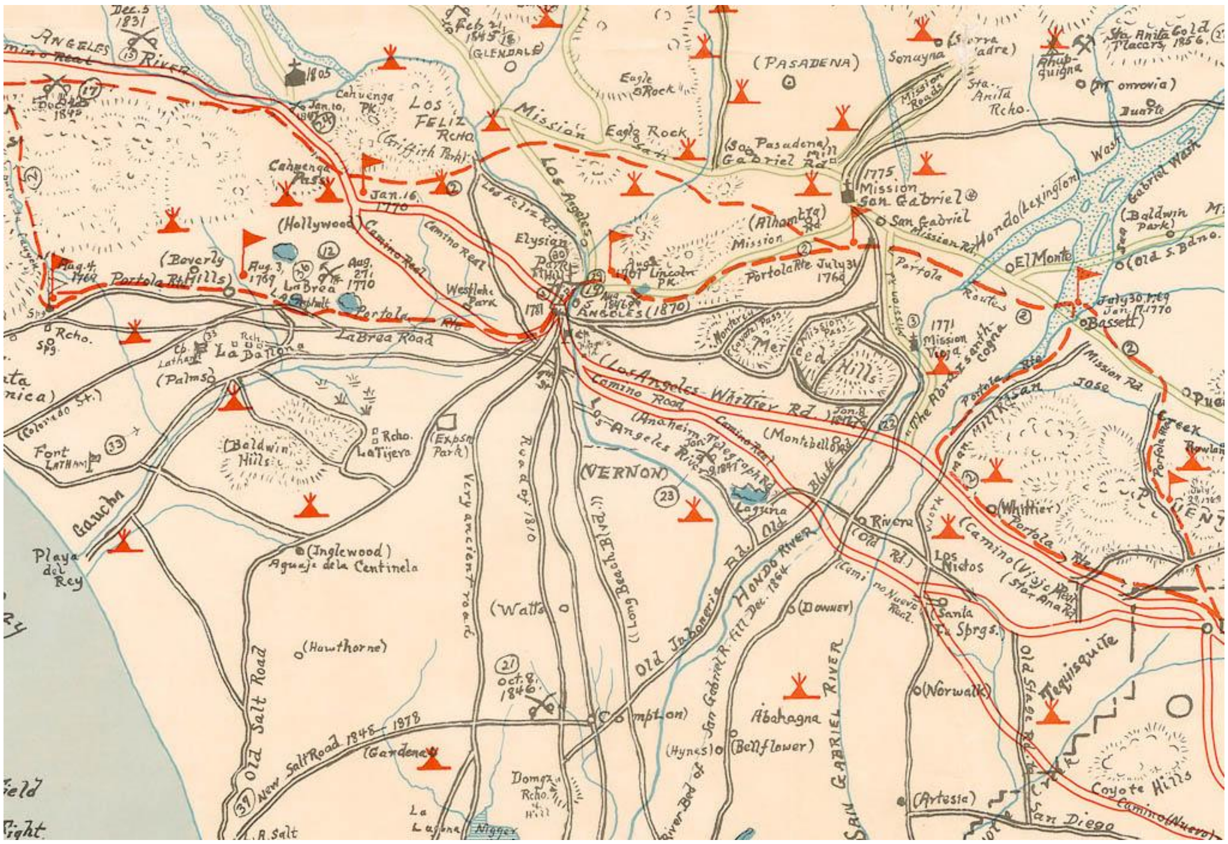

Figure 6-8. The Kirkman-Harriman Map of 1938 (Detail).

Unfortunately, the Kirkman Harriman map of 1938 is devoid of any references to the sources used in its creation, and we have been unable to locate any archive of notes or maps used by the authors to construct their fascinating map. Given the dedication for the LALAH project to establish a solid and verifiable basis of knowledge about the Los Angeles Landscape, it was tempting to ignore this map given its undocumented sources. After careful comparison of the map with all the other sources we have collected, which includes the contributions of Indigenous collaborators on this project drawing on their tribal memories, we have found it to be highly useful in many respects, and not completely without any footnotes. The inscribed copy at the Los Angeles City Archives, which was scanned for us by the late City Archivist Todd Gaydowski, reads:

> For The Map Room of the History Dept, Los Angeles Public Library. In appreciation of the many kindnesses shown me, during many years of research, by the History Librarians. George Wiserly Kirkman, Los Angeles, April 5, 1938.

It turns out that no one knows who Harriman was and it is not clear what role if any he had in creating the map. If Kirkman spent "many years" researching then available in the Map Room, he simply did not see it as necessary to publish a list of those maps as the source used when he published his final compilation in 1938.

Hoping to find the cache of maps used by Harriman there, we requested all maps held in the Map Room dating from the 19th century, but the librarians had virtually nothing. Only two microfiche maps: One of the well-known Ord Survey of 1851m, and other of a commonly available County map of 1886. Given the lavish praise of Kirkman for the resources of the Map Room, we enquired further, and were greatly helped by the current curator responsible for the map collection, Nicholas Beyelia. He conducted research into the matter, and has kindly agreed to permit us to reproduce his communication verbatim:

> The Kirkman-Harriman map is a bit of a mystery to be honest. We own three copies of the map and only one has that personalized notation. There are no notes on the back (or anywhere for that matter) to indicate sources. I hoped that searching through local newspapers might help but information was sparse. I found two articles related to the map itself. The most relevant one is taken from the LA Times Magazine from August 28, 1938. It reports the following:
>
> "After 15 years of patient research, George Kirkman produced a map of old Los Angeles County in which are set down like lines on a blueprint the old roads, trails and location of ancient Indian villages and battlefields, the sunny stretches of El Camino Real, the King's highway and many other things like those that so fascinate the imagination." Again, no mention of resources or what the information in the map was based upon. A second article simply states that "The map is the result of years of research, much of its necessarily original since this is the first map of its kind covering its area..." I found an article in a newspaper that was written by Kirkman in 1927, it was a response to something he had apparently published (an article) and it seemed to indicate that he was working on a book on the History of California. It does not appear to have been published.
>
> This is all conjecture but I do not believe that he based his map on maps that LAPL owned at any point in time. In fact, I don't believe that there is any

> pinpoint accuracy to the map. I think it's a collage of descriptions harvested from primary material that he found at Central Library (memoirs, travelogues, newspapers, etc.) and was based on "best guess" estimates. I think the personalized map was his gift to the librarians who were pulling resources for him while he was researching the book that never materialized. God only knows what happened to the manuscript as that might have an accounting of the resources he used." (Email, Nicholas Beyelia to Philip J. Ethington, 30 June 2023.)

Compilation and Analysis for Los Angeles Basin

A high-resolution digital copy of each of the source maps were georeferenced within the LALAH map geodatabase, using the 1920s USGS 1:24,000 scale map series as the base reference (Figure 6-9). Careful inspection of the source maps in relation to the terrain, to historical textual sources, and especially to the known locations of ancient Indigenous villages.

Locations of Indigenous villages for the Kizh Nation territories (primarily from Yaanga in the west to the greater San Gabriel Valley and southward to Povuu'nga, and the road networks between them) were provided or confirmed by Andy Salas, Tribal Chairman of the Kizh Nation: Gabrieleño Band of Mission Indians. Salas also provided context from tribal memory about the movements of the Kizh peoples during the pre-urban era.

From these contextual inspections of archival maps in conjunction with tribal memory, we identified what were most probably the oldest roads and traced them to create a new vector line layer representing each road segment. Every line drawn in this was given attribute data describing the road, recording any labels it was given on the source map, and recording the full source information about source map used (see map list below).

The final step used in our development of this map was to compare the results with the "Least Cost Paths" map produced using computational methods as a separate, but companion project within the LALAH study. That map was calculated to indicate routes across the landscape that would minimize effort and distance from any location to any other location, for a hypothetical pedestrian, assuming the existence of no established roads.

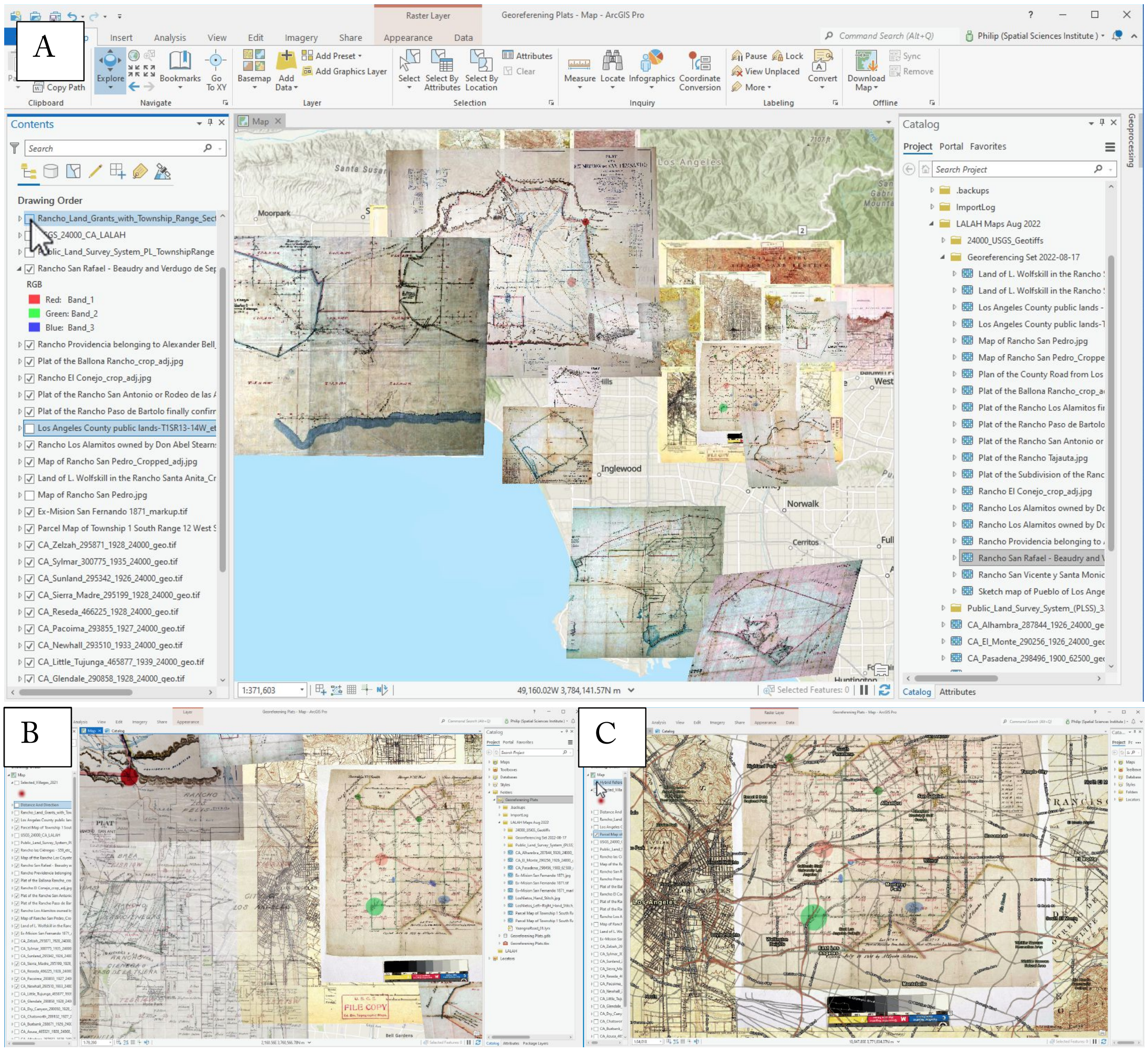

Figure 6-9. Examples of source map overlays being used to trace paths of roads identified as of ancient origin. Plat Maps from the Solano-Reeves Collection of the Huntington Library georeferenced to the LALAH geodatabase. View A: County scale. View B: Medium scale. View C: Colored polygons are areas of interest identified for spatial reference or ecological data. Plat maps not only showed old roads but bodies of water and trees.

Delineating Chumash trails

Historical background

On October 10, 1542, the conquistador Juan Rodríguez Cabrillo, sailing under the Spanish flag, made landfall at the Chumash village of muwu—christened Pueblo de las Canoas by Cabrillo—at the western terminus of the Santa Monica Mountains. The arrival of Cabrillo marked first contact between Europe and the Chumash; and perhaps unsurprisingly, at this seminal moment in history Cabrillo was focused on just one thing, trails:

> We saw on land an Indian town close to the sea with large houses like those of New Spain, and they anchored in front of a large valley on the coast. Here many fine canoes holding twelve or thirteen Indians each came to the ships, and gave news of Christians who were going about inland... Some presents were given them with which they were much pleased. They made signs that in seven days one could go to where the Spaniards were, so Juan Rodriguez decided to send on a chance two Spaniards inland with a letter to the Christians (Wagner 1929).

From the outset, European colonizers aggressively sought out Indigenous trail systems and trade networks. However, after extracting this knowledge, they actively assimilated and reshaped these paths to serve their colonial trade agendas and facilitate travel by horse, cart, and wagon .That Cabrillo would send two men on horseback, into the unknown and likely hostile interior of California, to find—and ultimately claim—the Indigenous trail systems connecting the Pacific, Southwest, and Colorado Plateau, underscores an interrelationship between movement, people, and power which was pivotal to both sustaining Native culture and advancing European colonization. As colonization, missionization, and the horrors of genocide progressed in California, Native Californian's knowledge of, access to, and utilization of their pre-colonial trails diminished, while colonial trails and trade networks grew stronger.

Three and a half centuries after Cabrillo's arrival, in August 1913, American ethnolinguist, John P. Harrington, and Mitsqanaqa'n Chumash elder, kitsepawit (Fernando Librado) undertook a place name trip by horse and buggy across the Santa Monica Mountains. Born in 1839, kitsepawit was part of the third Chumash generation born after Spanish colonization of California. Harrington (1884–1961) was at the start of a career that would ultimately become synonymous with the documentation of Native Californian cultures and languages. His tenure at the Smithsonian Institution, from 1915 through 1954, resulted in almost 700 linear feet of handwritten field notes, documents, and photographs now housed at National Anthropological Archives—a significant portion of which represents the largest written recordation of Chumashan languages and culture. This placename trip would become the first of three significant place name trips Harrington would make with Chumash elders into the Santa Monica Mountains in an effort to record Chumash spatial knowledge and histories. Indeed, much of the ethnohistoric and ethnogeographic knowledge utilized for this was recorded from Chumash elders Harrington actively sought out, including, kitsepawit (Fernando Librado), silinawit (José Juan Olivas), and Juan José Menéndez.

Harrington and kitsepawit traveled first to the village of muwu—Cabrillo's Pueblo de las Canoas, inland to ts^{h}ipuk, and then across the rugged spine of the Santa Monica Mountains to the Malibu coastline—visiting the numerous Chumash places and villages that dotted it—as they made their way to Malibu's eponym, humaliwo. It may have been there that Harrington recorded kitsepawit's description of humaliwo:

> "…for humaliwo was capital—quiet water on coast of humaliwo, and many good trails leading inland through the mountains to San Fernando and Calleguas" (Harrington Notes 3.72.867).

Trails connecting interior villages to coastal settlements are demonstrated archaeologically by the rich marine resources recovered from interior villages. At the ethnohistoric site of huwam, located approximately 15 miles north of Humaliwo, analyses of archeological deposits indicate shellfish accounted for up to 30% of the ecofactual remains recovered from excavation units (Romani 1981). Similarly, considerable quantities of shellfish are documented at other ethnohistoric inland sites like ta'lopop, tsʰipuk, ts'apwə, Suitcanga, and Momoonga. This pattern is also evident at numerous rock art sites in the area, including LAn-717/H (Edberg 1982, King 2011).

Figure 6-10. The site of the village of humaliwo (image center, above pier) circa 1906. Photo: Bob Plunkett, Ernest Marquez Photograph Collection of the Huntington Library; Photo Restoration: Devlin Gandy.

During a subsequent placename trip with silinawit (José Juan Olivas) in 1916, silinawit told Harrington he had once taken the old trail from the village huwam, at the mouth of modern-day Bell Canyon, to humaliwo. The pair climbed a nearby knoll, where Harrington illustrated the landscape that silinawit described, and photographically documented scene (Figure 6-11). Regrettably, no notes pertaining to silinawit's hike to humaliwo have been identified in the National Anthropological Archives.

In fact, it appears neither Harrington, nor any other ethnographer, recorded a detailed account from a Chumash person of the pre-colonial trail systems to, from, and around humaliwo. Instead, scant mission period documents are our sole reference point. In 1771, as the Portola expedition returned to San Gabriel, the expedition was guided through the heart of the Western Santa Monica Mountains, along the Malibu Creek watershed, by Chumash guides from the village of tsʰipuk:

> January 15th. We set out early in the morning from this grand spot of the village, stream, and large hollow of tsʰipuk, being followed or led through these mountains by two or three villagers belonging to this spot, on a southeastward course. We came into a small hollow in the quite high, gullied, and cliffy mountains… At about four leagues we came down it upon the aforesaid course. At the foot of the mountains we came upon a small stream with a great deal of willow, sycamore, and live-oak trees… Beyond this, we came into the large San Fernando Valley, and on going another three leagues through the valley here, we came to the good-sized pool of hot water on the south side of this valley… [at the village of Siutcanga]."

Though the account is brief, details provided by Crespi indicate that Chumash trails in the Santa Monica Mountains utilized both the edges of wide valley floors as well ridgelines to traverse the dramatic and rugged topography of the Santa Monica Mountains. It is worth mentioning that at this point in the expedition, the expedition team numbered over 50 individuals on horseback. That they quickly made it through such rugged country suggests a well-maintained pre-colonial trail system. This pattern of movement is not all too different from the modern trail systems utilized by hundreds of thousands of hikers annually in what has become the Santa Monica Mountains National Recreation Area.

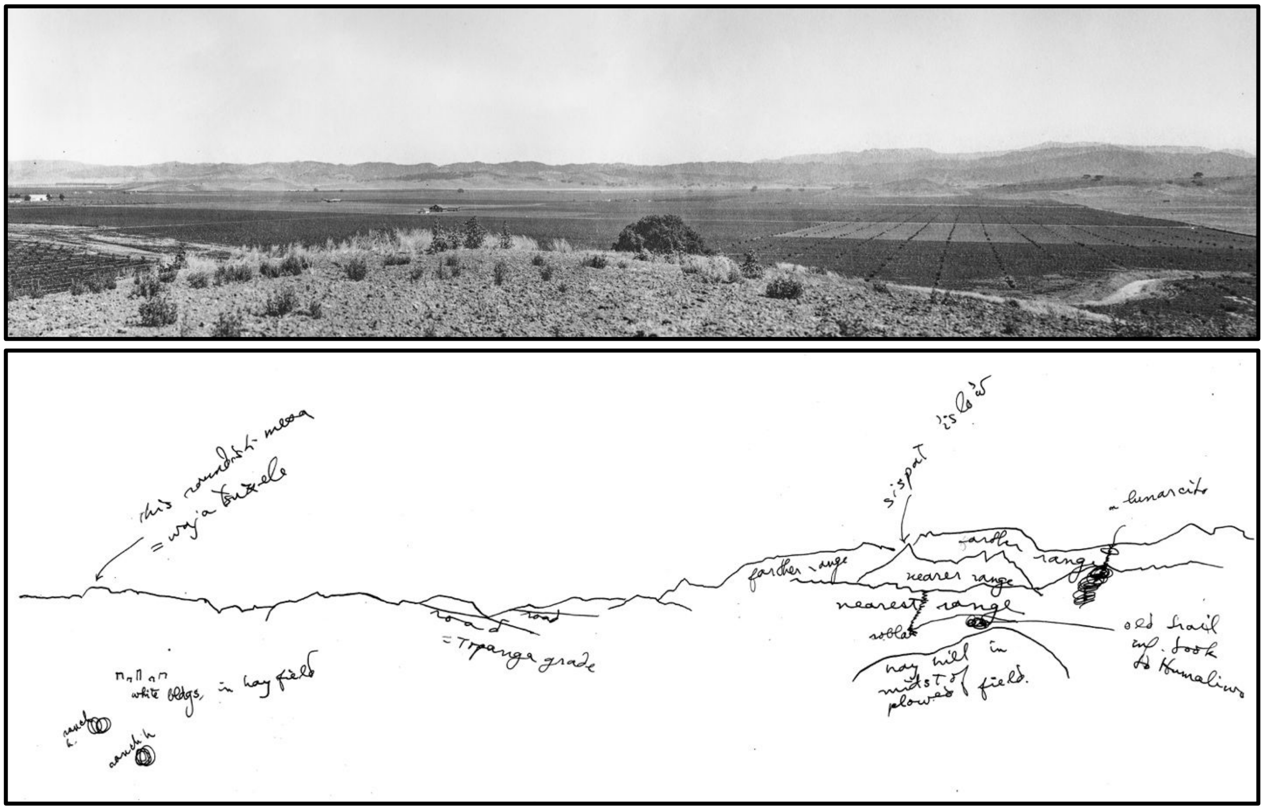

Figure 6-11. Above: Composite panorama of the Santa Monica Mountains taken from within the vicinity of huwam. Below: Field sketch by John P. Harrington documenting ethnogeographic details provided by silinawit (José Juan Olivas). Note on lower right reads: "Old trail inf[ormant] took to Humaliwo" (Harrington Notes 3.98.634-5; John Peabody Harrington photographs from California, Composite of #91-31229, 91-31230; NMAI Archive Center, Smithsonian Institution).

GIS modeling

Geographic Information Systems (GIS) based methods of inquiry, such as cost-path and viewshed, are often criticized within the archaeological community for oversimplifying complex human-environment interactions. Ontological gaps, phenological ambiguity, and disembodied experience of landscapes and the deterministic nature of these models has raised concerns from academics and Indigenous communities alike (Rundstrom 1995, Hacigüzeller 2012, Wienhold and Robinson 2017, Beimers 2022). When complemented with Indigenous traditional knowledge, historical records, archaeological insights, and firsthand on the ground experience, however, GIS holds the potential to provide a more nuanced and insightful understanding of how humans may have conceptualized, created, and interacted with past landscapes.

To model traditional trails, we (DG) began with a phenomenological approach rooted in our experiences hiking in remote sections of the Santa Monica Mountains and made the following assumptions:

1. Trails connected where people lived.
2. Movement reflects ontological postulates about spaces and the relationships.
3. Trails will correlate to the opportunities, obstacles, relationships, and use(s) provided by geology and topography.
4. Trails will correlate to the opportunities, obstacles, relationships, and use(s) provided by Native vegetation because:
    a. Some plants present obstacles to movement.
    b. Plants can provide protection from the elements.
    c. Some plants are edible and vary in processing needs and times.
    d. Some plants are better for creating tools than others.
    e. Different plants have different medicinal and spiritual use and significance.
5. Trails will have access to reliable water sources; ergo, trails will frequently interconnect reliable water sources to one another.

To test the accuracy of cost path trail reconstructions, following considerations were made:

1. Least Cost Paths should correspond strongly with archaeologically recorded site boundaries.
2. Available (albeit limited) ethnographic data suggests rock art sites were along trails, therefore some rock art sites should be proximal to/along trails.
3. Least Cost Paths should strongly correspond to ethnohistoric information regarding trail locations.

Regional hydrographic datasets were sourced from lacounty.gov and venturacounty.gov; 1/3 arc second DEMs and contour lines were obtained from the National Map Viewer. Vegetation datasets were acquired from the National Park Service (irma.nps.gov; Data Store Project 2177190). Village localities were mapped by Devlin Gandy and Mathew Vestuto based upon the notes of John P. Harrington and in consideration of pertinent academic research.

A 1/3 arc-second NED DEM, a ~10 m resolution dataset, was utilized as the base geographic layer. Slope tool was used to calculate the slope angle of each cell from the base DEM. Slope was also used to develop a cost raster for movement. Hydrographic data were initially acquired through lacounty.gov and venturacounty.gov. This compiled hydrologic dataset differed markedly from pre-colonial features due to modified water features, which could skew analysis.

To resolve this, all channelized, dammed, and anthropogenic bodies of water were expunged from the dataset and replaced by hand drawn historic water features based upon USGS topo maps prior to 1928.

To develop Least Cost Path trails, a cost raster was created through the combination of a phenomenologically cost-weighted vegetation layer (Table 6-1), reclassification and weighting of slope, and hydrologic features. Tobler's Hiking Function was used for the Vertical Factor as transcribed through Tripcevich's (2009) ToblerAway.txt obtained from http://mapaspects.org/.

Analysis of the cost raster started by giving the blank raster an overall value of 4, based on the premise that no matter where one travels to one must expend effort. After the first run, it was apparent that the least cost path was taking creeks and rivers through rugged mountainous regions. From experience in the field (DG), these routes present significant difficulties—due to rocks, brush, and water—that were lost in the granulation of data. To resolve this issue, a buffer of 100 m was created for perennial streams and it was intersected with slopes >17º —which correlated to narrow canyons where granulation would likely obscure the true difficulty of the route. Any intersections were saved as a new layer, with a 10 m buffer placed around them due to the granulation of the DEM. This layer was given a value of +5 and merged through union to the cost raster. Finally, cost paths were created between the presumed locations of each interior and coastal village. These paths showed a strong correlation for known archaeological and cultural resources, but due to the sensitive nature of these resources no further details are provided at the request of Tribal collaborators.

Table 6-1. Cost weights assigned to landscape factors.

Species	Veg_wt	Geologic Layer	Geo_wt
coastal dune/bluff scrub	1	Old alluvium, undivided	0
coastal sage scrub	1	San Pedro Formation	-2
coastal sage scrub-chaparral transition	0	Artificial fill	-1
northern mixed chaparral	-1	Eolian (dune) deposits	-2
red shank chaparral	-2	Trancas Formation, undivided	0
chamise chaparral	-3	Young marine terrace deposits	0
coastal cactus scrubs	1	Zuma Volcanics	-2
non-native grassland/herbaceous	1	Beach deposits	-1
rock outcrops (barren inland)	0	Wash deposits	0
salt marsh	0	Monterey Shale, undivided	0
valley oak	2	Sedimentary rocks of the Pacific Palisades area	1
coast live oak	2	Alluvial-fan deposits	-1
walnut	0	Modelo Formation, undivided	-2
riparian (sycamore-oak)	1	Intrusive rocks, undivided	-1
non-native conifer/hardwood	1	Young alluvium, undivided	0
coastal strand	1	Sespe Formation, undivided	2

water	0	Topanga Group, undivided	3
development	0	Vaqueros Formation, undivided	3
agricultre	1	Landslide deposits	-2
		Tuna Canyon Formation, undivided	0
		Coal Canyon Formation	2
		Llajas Formation	0
		Simi Conglomerate, undivided	-1
		Trabuco Formation	-2
		Mixed rocks	-2
		Santa Monica Slate, undivided	-2
		Granitic rocks	0
		Puente Formation, undivided	-1
		Santa Susana Formation	0
		Calabasas Formation	3
		Pico Formation	0
		Towsley Formation, undivided	0
		Chatsworth Formation	5
		Biotite-quartz diorite	-1
		Las Virgenes Formation	2
		Saugus Formation, undivided	0
		Conejo Volcanics, undivided	2

Stream/River	SR_wt	Water Sources	W_wt	Slope	Slope_wt
Perennial	2	Perennial Spring	3,2,1	< 5.01	0
Intermittent	1	Intermittent Spring	2,1	< 11.01	-1
		Pond	2	< 17.01	-2
				< 25.01	-3
				< 30.01	-4
				< 40.01	-5

Results

The results of our reconstruction are digital vector-line maps in GIS format that can be shared widely. Every road is a separate line segment with its own metadata in the attribute table that describes the source or sources used to determine the path of that line segment. A name for each road is given in the "description" field, merely to identify its route. It is entirely unknown what Indigenous people called any of these roads. We gave them descriptors like "Road from Yaanga to Swaanga." A single GIS feature layer contains the local regional roads of the Los Angeles Basin in the Uto-Aztecan areas, and also the long-distance roads leading out of the region to the

Greater Southwest. A separate GIS shapefile contains the reconstructed roads in the Chumashan territories.

Figure 6-12 shows the regional road network for the Chumashan humaliwo province and the Uto-Aztecan areas of the Los Angeles Basin. It is important to note that this map is most certainly incomplete. We only reconstructed roads for which we had reasonable archival evidence, but it is clear from the fact that some ancient village sites remain unconnected, that some roads are missing. We hope that future research can continue to build out these reconstructions.

Figure 6-12. Reconstruction of pre-Hispanic ancient road networks: humaliwo province and Takic Uto-Aztecan territories.

Figure 6-13 shows the same feature layer at a wider scale, showing the long-distance roads that connected Southern California to its trade network in the Greater Southwest and southward into what is now Mexico. The same caveat about incompleteness applies at this scale as well. Certainly, numerous smaller roads existed in this larger region, and many of these are documented in some of the published sources listed in the bibliography below. We limited our search in the larger area to the main trunk lines, and even these are subject to alternative routes and interpretations of the sources. We hope that by carefully documenting the sources used for every line segment that our work is subject to constructive revision by other researchers in the years to come.

Figure 6-13. Reconstruction of pre-Hispanic long-distance trade roads to greater Southwest.

Complete List of Source Maps Used for Identifying Ancient Indigenous Roads

Diseño Maps

Diseño Maps from UCLA Library, Online Archive of California (OAC) Diseños : maps and plans of ranchos of Southern California, mostly within Los Angeles and Orange counties
Title: Santa Anita (diseno) **Caption:** Diseno de Santa Anita **Note:** Owner(s) [as indicated on page]: **Identifier:** uclamss_170/508_470.3 **From:** Diseños : maps and plans of ranchos of Southern California, mostly within Los Angeles and Orange counties
Title: Palos Verdes, Los **Caption:** Diseno del Rancho de los Palos Verde **Note:** Owner(s) [as indicated on page]: **Identifier:** uclamss_170/508_446

From: Diseños : maps and plans of ranchos of Southern California, mostly within Los Angeles and Orange counties

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Title: Los Angeles, La Reina de
Caption: City of Los Angeles, Pueblo lands
Note: Dated: January / 11 / [18]54
Identifier: uclamss_170/508_422.1
From: Diseños : maps and plans of ranchos of Southern California, mostly within Los Angeles and Orange counties

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Title: Los Angeles, La Reina de (plano)
Caption: Plano de la Plaza de la Ciudad de los Angeles
Note: Two tracts shown, including legends indicating ownership or residency of houses in the Plaza; no date
Identifier: uclamss_170/508_422.2
From: Diseños : maps and plans of ranchos of Southern California, mostly within Los Angeles and Orange counties

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Title: San Jacinto y San Gregorio
Caption: Louis Roubideau, San Jacinto & San Gregorio
Note: Owner(s) [as indicated on page]: Louis Roubideau [i.e., Rubidoux?]; dated: Nov /1/1853
Identifier: uclamss_170/508_443
From: Diseños : maps and plans of ranchos of Southern California, mostly within Los Angeles and Orange counties

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Title: Boca de Santa Monica (sketched partial copy)
Caption: Diseno de Santa Harmonica [sic]
Note: Owner(s) [as indicated on page]:
Identifier: uclamss_170/508_445.2
From: Diseños : maps and plans of ranchos of Southern California, mostly within Los Angeles and Orange counties

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Title: San Vicente y Santa Monica (plan)
Caption: Plan de San Vicente y Santa Monica ..
Note: Owner(s) [as indicated on page]:
Identifier: uclamss_170/508_457.1
From: Diseños : maps and plans of ranchos of Southern California, mostly within Los Angeles and Orange counties

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Title: Mission San Gabriel
Caption: Mission San Gabriel
Note: Embossed seal of The Pacific Coast Abstract Bureau, Los Angeles, Cal
Owner(s) [as indicated on page]:
Identifier: uclamss_170/508_609.1
From: Diseños : maps and plans of ranchos of Southern California, mostly within Los Angeles and Orange counties

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Title: Mission San Fernando (vers. 1)

Caption: Joseph S. Alemany, Lands of Cath. Ch. (b&w) **Note:** Embossed seal of The Pacific Coast Abstract Bureau, Los Angeles, Cal Owner(s) [as indicated on page]: **Identifier:** uclamss_170/508_609.2 **From:** **Diseños : maps and plans of ranchos of Southern California, mostly within Los Angeles and Orange counties**
Title: Mission San Fernando (vers. 2) **Caption:** Mision San Fernando (b&w; some watercoloring) **Note:** Owner(s) [as indicated on page]: **Identifier:** uclamss_170/508_609.3 **From:** **Diseños : maps and plans of ranchos of Southern California, mostly within Los Angeles and Orange counties**

Plat Maps and Parcel Maps from the Solano-Reeve Collection at the Huntington Library, 1850s-1870s

Rancho las Ciénegas Sept. 1858 Rancho las Ciénegas: S59 - Plat of the Rancho la Cienega finally confirmed to Anuario sic Abila et al. 1858-09. Henry Hancock, surveyor. Huntington Digital Library. Solano-Reeve Collection. SR_Box_21(04).06. https://hdl.huntington.org/digital/collection/p15150coll4/id/12361/rec/15
Plat of the Ballona Rancho 1858 Plat of the Ballona Rancho. 1858. Henry Hancock, surveyor. Huntington Digital Library. Solano-Reeve Collection. SR_Box_25(10).03. https://hdl.huntington.org/digital/collection/p15150coll4/id/11314/rec/1
Map of Rancho San Pedro 1856 Map of Rancho San Pedro. 1856-01. George Hansen, surveyor. Huntington Digital Library. Solano-Reeve Collection. SR_Map_0190.01. https://hdl.huntington.org/digital/collection/p15150coll4/id/11535/rec/67
Map of the Rancho Los Coyotes 1857 Map of the Rancho Los Coyotes. 1857-11. Henry Hancock, surveyor. Huntington Digital Library. Solano-Reeve Collection. SR_Map_0050. https://hdl.huntington.org/digital/collection/p15150coll4/id/11371/rec/42
Plat of the Rancho San Antonio or Rodeo de las Aguas 1868 Plat of the Rancho San Antonio or Rodeo de las Aguas. 1868-07. George H. Thompson, surveyor. Huntington Digital Library. Solano-Reeve Collection. SR_Map_0132. https://hdl.huntington.org/digital/collection/p15150coll4/id/11476/rec/43

Plat of the Rancho Paso de Bartolo finally confirmed to Pio Pico Plat of the Rancho Paso de Bartolo finally confirmed to Pio Pico. undated. Henry Hancock, surveyor. Huntington Digital Library. Solano-Reeve Collection. SR_Box_22(06).05. https://hdl.huntington.org/digital/collection/p15150coll4/id/12383/rec/1
Rancho El Conejo before 1857 Rancho El Conejo. before 1857. Alt. title: Rancho El Conejo: with parts of ranchos Simi, Las Virgenes, Ex-Misión de San Fernando, el Escorpión, and Topanga Malibu Sequit [...]. Huntington Digital Library. Solano-Reeve Collection. SR_Map_0049. https://hdl.huntington.org/digital/collection/p15150coll4/id/11370/rec/5
Los Angeles County public lands: T1T2T3S R 1314W S.B.M. 1878 // Los Angeles County public lands: T. 1S. R. 13-14W., T.2S. R. 13-14W., and T.3S. R. 13-14W. S.B.M. 1878. George H. Thompson, surveyor. Huntington Digital Library. Solano-Reeve Collection. SR_Map_0769. https://hdl.huntington.org/digital/collection/p15150coll4/id/12264/rec/25
Rancho Los Alamitos owned by Don Abel Stearns 1858 Rancho Los Alamitos owned by Don Abel Stearns. 1858. Draft version of Plat of the Rancho Los Alamitos finally confirmed to A. Stearns. 1858-09. Henry Hancock, surveyor. Huntington Digital Library. Solano-Reeve Collection. SR_Map_0006. https://hdl.huntington.org/digital/collection/p15150coll4/id/11322/rec/39 Final version: https://hdl.huntington.org/digital/collection/p15150coll4/id/11301/rec/38
Land of L. Wolfskill in the Rancho Santa Anita 1871 Land of L. Wolfskill in the Rancho Santa Anita 1871-11-02. Original map, Lothar Seebold, 1869-05; copied by Alfred Solano. Huntington Digital Library. Solano-Reeve Collection. SR_Map_0243. https://hdl.huntington.org/digital/collection/p15150coll4/id/13116/rec/26
Plat of the Ex Mission de San Fernando finally confirmed to Eulogio de Celis 1871 Plat of the Ex Mission de San Fernando finally confirmed to Eulogio de Celis. 1871-03-16. William P. Reynolds, cartographer. Huntington Digital Library. Solano-Reeve Collection. SR_Map_0795. https://hdl.huntington.org/digital/collection/p15150coll4/id/12292/rec/3
Parcel map Township 1 South Range 12 West San Bernardino Meridian 1871 Parcel map Township 1 South Range 12 West San Bernardino Meridian. 1871-07-14. Solano, Alfred. Huntington Digital Library. Solano-Reeve Collection. SR_Map_0153.01 https://hdl.huntington.org/digital/collection/p15150coll4/id/13113/rec/28

LA County Maps

William Hammond Hall map of 1880 California. Office of State Engineer, Hall, Wm. Ham. (William Hammond) Los Angeles & San Bernardino topography. Wm. H. Hall, State Engineer, Sacramento. (circa 1880) Source: David Rumsey Map Collection, cf Vogdes p. 220, 226, 210; cf Cowen p. 260; California Water Atlas p. 22, 23. https://www.davidrumsey.com/maps3795.html
"Map of the County of Los Angeles, California, by H.J. Stephenson, U.S. Dept. Surveyor…1881." published by C.L. Smith and Co, Lithographers, in Oakland California. Digital copy obtained from the UCLA Map Library.
Geo. W.Kirkman and Wm. R. Harriman "PICTORIAL and HISTORICAL MAP OF LOS ANGELES COUNTY" (Los Angeles, 1938). Copy in the Los Angeles Public Library.

Maps in the Archivo General de Indias, PARES, Portal de Archivos Españoles

Formal title: "Mapa Formado sobre el Diario del Viage que hizo el P[adre] F[ray] Fran[cis]co Garcés al Río Colorado, S[a]n Gabriel y Moqui en 1777" **Reference number:** MP-MEXICO,535 [Original reference number] **Date of creation:** 1777 **Level of description:** Unidad Documental Simple_en **Reference code:** ES.41091.AGI//MP-MEXICO,535 http://pares.mcu.es:80/ParesBusquedas20/catalogo/description/21490
Formal title: "Plano que conti[en]e las Provincias de Sonora, Pimerías, Papaguería, Apachería, Rios Gila y Colorado y tierras descubiert[a]s hasta el Puerto de S[a]n Fran[cis]co en la California Septentrional y jasta el Pueblo de Oraybe en la Provincia de el Moqui, con arreglo á los diarios de el Coronel D[o]n Ant[oni]o Crespo y de los P.P. Misioneros Fr[ray] Pedro Font y Fr[ay] Francisco Garcés de q[uie]n, los viajes desde la nación Jabajaba en el Río Colorado hasta la misión de S[a]n Gabriel, a las Naciones que están al Norte de esta Misión, su regreso á los Jamajabas y camino que hizo al Moqui, están señalados con lineas de puntos: con cuia señal se manifiesta también la línea de Presidios de esta frontera" **Reference number:** MP-MEXICO,349 [Original reference number] **Date of creation:** 1778-08-02 **Level of description:** Unidad Documental Simple_en **Reference code:** ES.41091.AGI//MP-MEXICO,349 http://pares.mcu.es/ParesBusquedas20/catalogo/description/21218

Diaries and Memoirs of Spanish Colonizers: Juan Crespi (1769-70), Pedro Font (1775-6), and Pedro Fages

Of central importance to the LALAH study are the detailed eyewitness accounts of landscapes and cultures recorded by Franciscan priests Juan Crespi and Pedro Font, and by Pedro Fages, who was the second in military command of the Portolá Expedition. Crespi was the lead diarist for the Portolá Expedition of 1769-70, and Font was the official diarist for the Anza Expedition of 1775-6. These diaries have been expertly edited and published in both Spanish and English by the late Alan K. Brown. Fages remained in California as its first Spanish Governor. He published an account and memoir in 1775, which was translated and published in 1919.

Juan Crespí, Edited by Alan K. Brown, *A Description of Distant Roads: Original Journals of the First Expedition into California, 1769-1770*. San Diego, California: San Diego State University Press, 2001.

Alan K. Brown, Translator and Editor, With Anza to California, 1775–1776: The Journal of Pedro Font, O.F.M. The Arthur H. Clark Company, 2011.

Don Pedro Fages, translated by Herbert J. Priestley, "An Historical, Political, and Natural Description of California." Vol. 1. *The Catholic Historical Review*, Vol. 4, No. 4 (Jan., 1919), pp. 486–509.

Don Pedro Fages, translated by Herbert J. Priestley, "An Historical, Political, and Natural Description of California." Vol. 2. *The Catholic Historical Review*, Vol. 5, No. 1 (Apr., 1919), pp. 71–90

Bibliography of Published Works on Ancient Roads and Trails

The following is an extensive bibliography of published works that we consulted on the subject of ancient trade networks and the trails and roads that supported those networks. It covers California, Southern California, the Greater Southwest, and Mexico. The trails and roads within Southern California since ancient times were connected to other regions, north, east, and south. Our map of the ancient trails of the Los Angeles Region includes several of these longer-distance roads where it was possible to reconstruct them.

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Barr, Juliana. (2011) "Geographies of Power: Mapping Indian Borders in the "Borderlands" of the Early Southwest." *The William and Mary Quarterly*, Vol. 68, No. 1, pp. 5–46.

Bieber, Ralph P. (1925) "The Southwestern Trails to California in 1849." *The Mississippi Valley Historical Review*, Vol. 12, No. 3, pp. 342–375.

Brand, Donald (1938) "Aboriginal Trade Routes for Sea Shells in the Southwest." *Yearbook of the Association of Pacific Coast Geographers*, Vol. 1938, No. 4, pp. 3–10.

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Darling, J. Andrew. (2009) "O'odham Trails and the Archaeology of Space." In Snead, James E., Clark L. Erickson, J. Andrew Darling, eds. (2009) *Landscapes of Movement: Trails, Paths, and Roads in Anthropological Perspective*. University of Pennsylvania Press, pp. 84–105.

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Dockal, James A., and Michael S. Smith (2005) "Evidence for a Prehistoric Petroglyph Map in Central Arizona." *Kiva*, Summer, 2005, Vol. 70, No. 4, pp. 413–421.

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Chapter 7 Modeling the Historical Bird Communities of the Los Angeles Basin

Sean Lyon and Eric Wood

Introduction

Coastal Southern California was home to Indigenous peoples who thrived in the area for thousands of years before Spanish, Mexican, and American colonization (Anderson 2007). Before colonization, which began with the Spanish mission period in 1769 (Mooney and Zavaleta 2016), the region was a diverse mosaic of ecosystem types, including coastal dunes and estuaries, fast-flowing and highly seasonal rivers, extensive flower fields, and walnut (*Juglans californica*) and oak (*Quercus* spp.) woodlands (Ethington et al. 2020). The landscape was varied and structured by the variety of abiotic and biotic conditions prevalent in the coastal Southern California region (Stein et al. 2007).

The diversity of ecosystem types generated highly diverse flora and fauna (Mooney and Zavaleta 2016). Grizzly Bears (*Ursus arctos horribilis*) in the region used the woodlands, waterways, and coastal areas for resource acquisition and movement corridors (Mattson and Merrill 2002), while American Badgers (*Taxidea taxus*) were common in coastal Southern California grasslands (Quinn 2008) and the California Mule Deer (*Odocoileus hemionus californicus*) was likely abundant throughout multiple habitats (Pease et al. 2009, Fraser et al. 2019). Colonization, persecution, and intense urbanization have extirpated the Grizzly Bear from the state, restricted badgers to only a few locations in the region, and limited deer to foothill and montane areas (Mooney and Zavaleta 2016).

The loss of iconic animals that provided numerous ecological services is emblematic of greater changes to the region's ecosystems (Mooney and Zavaleta 2016). The biodiversity of the region was critical for Indigenous peoples, who strategically located villages near freshwater sources and ecosystems that produced food and fuel, e.g., oak-walnut woodlands (Anderson 2007). Further, Indigenous peoples used land management practices such as frequent burning to augment ecosystems to suit their needs, which carried over to affect the distribution of animals within a given region (Anderson 2007).

In addition to large mammals and humans that were affected by Indigenous land-management practices, a highly diverse assemblage of birds inhabited the region. Some iconic birds that were ecologically important were also culturally important to the Indigenous peoples, including the California Condor (*Gymnogyps californianus*) and the Golden Eagle (*Aquila chrysaetos*). However, we have a limited understanding of the potential historical distribution of avifauna, especially in the vicinity of village sites in the Los Angeles region. Our goal with this analysis was to model the potential historical avian community and to quantify changes following urbanization to understand which bird species have been lost from the locations of historic indigenous villages in coastal Southern California.

Methods

Our study area covered the Los Angeles Plain, the Palos Verdes Peninsula, the San Gabriel and San Fernando Valleys, the foothills and montane regions of the San Gabriel, Verdugo, and Santa Monica Mountains, and the hills throughout the region (e.g., the Puente Hills, the Baldwin Hills; see Figure 7-1).

Potential Natural Vegetation and Parcel-level Development Data

The habitat source data for this project included two components: the Potential Natural Vegetation of the Los Angeles Basin (PNV), which is a historical landcover map of the region (Ethington et al. 2020), and parcel development data (Galvin et al. 2016). We used the PNV map as a theoretical baseline of the underlying vegetative community, as this map was developed based on known plant species distributions and abiotic conditions (Ethington et al. 2020). According to Ethington et al. (2020), "Information for these preliminary macro-scale classifications was derived from various sources, including entries from early expedition journals; a suite of historical survey maps, topographic maps, and soils maps and reports; natural history observations; recent data about the physical environment (e.g., slope, aspect, rainfall, hydrology) and forest vegetation classes; and historical ecology research done in adjacent areas." The assigned historical land cover was present in at least 50% of a cell, and thus other habitats and land uses, e.g., grazing and row-crop agriculture also may have been present at the time of bird specimen collection (see below), but not reflected in the whole-cell designation. This hypothesized land cover is at a 1-km scale, and while the vegetation types and extents are not a complete representation of what was historically present at any one time, the layer offers the best historical characterization of what vegetation types and ecosystems may have been on the landscape before the development of L.A., and roughly the time when the bird specimens were collected (1889–1936, see below) (Ethington et al. 2020).

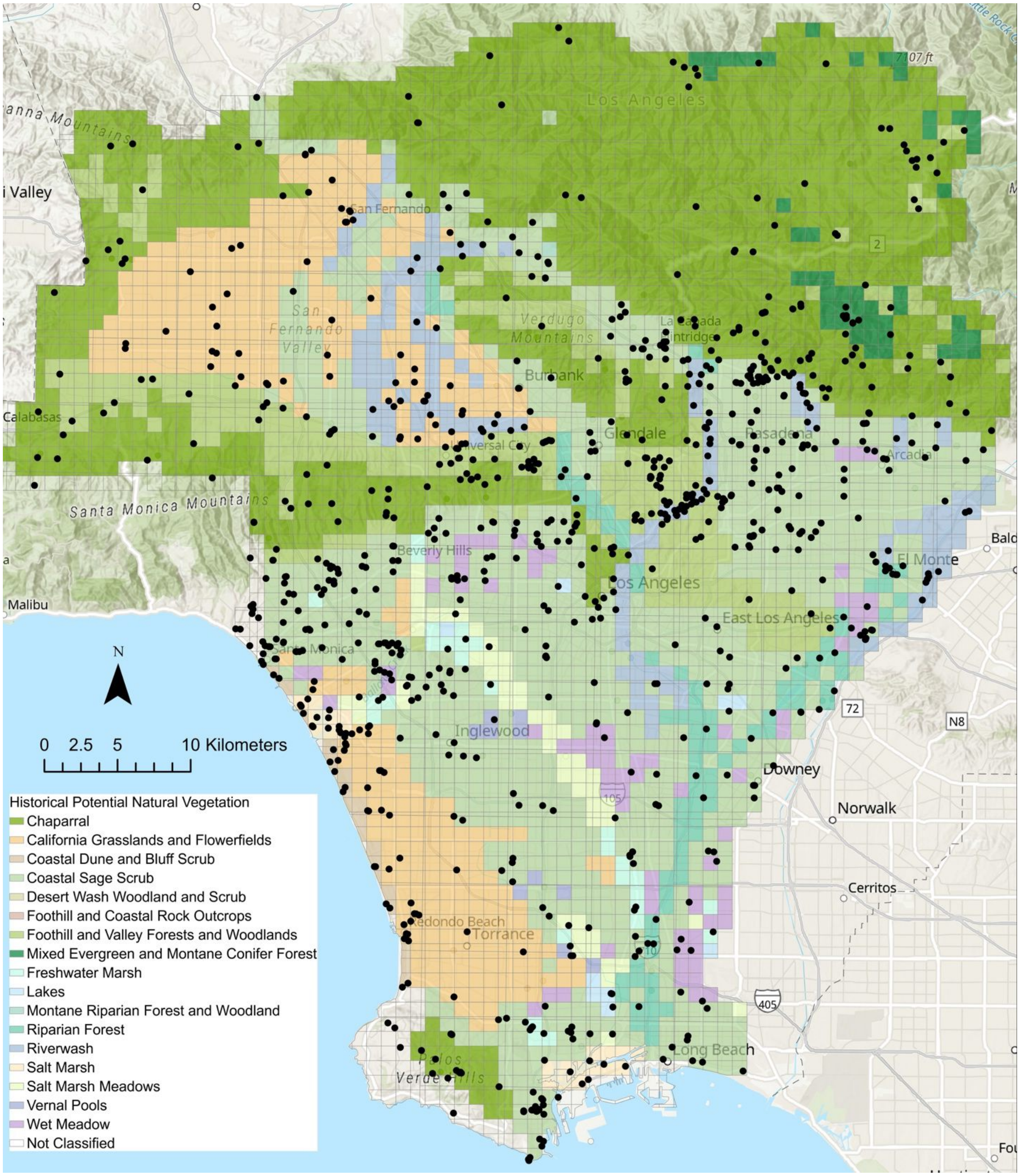

Figure 7-1. Study area in coastal Southern California denoted by the boundaries of the Potential Natural Vegetation of the Los Angeles Basin (Ethington et al. 2020). The Breeding Birds Atlas blocks are visualized as gray rectangles. The Potential Natural Vegetation cells (smaller cell size, and multiple colors) denote different vegetation types within the Los Angeles watershed. All historical bird records, indicated by black dots, were assigned to a Breeding Bird Atlas block based on their overlapping location.

Parcel data for structures built before the 1930s, which was the general period of the last bird specimens used for modeling, were extracted from the Los Angeles GeoHub (2023) and overlaid atop the PNV map. The goal of using these data was to update the PNV map to account for early urban development before the urban boom that began following the diversion of water from the eastern Sierra Nevada in 1913 (Reisner 1987). We computed the area of the parcels within the Breeding Bird Atlas cells (see below, which was our modern bird data comparison, please see below) to produce a "% cover" measure of "urban," which accounts for the early development that reshaped the landscape. Assuming that there was additional development such as roads and rail lines associated with the parcels, we considered the urban land cover as a general index to human land use. Thus, even if a 1-km grid had a small footprint (range: 0–25.6%, avg. 2.6%) of urban land cover, we assumed this reflected a potentially larger pattern of anthropogenic land use within a given cell. The combined PNV and parcel data formed our habitat predictor variables for our occupancy modeling routine (see below).

Historical Bird Specimen Records

The coastal Southern California region was an important focus for biological collections during the latter 19th century and the early 20th century. Robust collections of bird eggs and nests have been preserved in regional and national museums, and their records are now aggregated through the Global Biodiversity Information Facility (GBIF). The region is also an important center for historical ecology studies, with projects focusing on the San Gabriel River (Stein et al. 2007), Ballona Creek (Dark et al. 2011), and the Los Angeles watershed (Ethington et al. 2020).

The bird data for this project were collected by 280 people between 1889 and 1936, spanning 47 years. Field ornithologists and collectors noted species, date, and location information in field notebooks, which they transcribed into collections record books. The record books have since been digitized in collections management system software (such as EMu or Arctos) and then aggregated into GBIF. We accessed GBIF via its online portal (gbif.org, 2023) and downloaded all data that corresponded to the search criteria "Area: Los Angeles Co," "Taxonomy: Aves," "Occurrence type: Preserved Specimen," and "Date: 1870 – 2020." We removed all specimen records without GPS coordinates, and all records with a coordinate uncertainty greater than 6,000 meters, which is the approximate side length of the grid cells used in our analysis. Further, there was a substantial drop off in collections after 1936. Therefore, we removed all specimen records after 1936. Development in L.A. was in full swing during this time. Yet, there were still many natural areas where collectors were gathering nests and eggs. Thus, our approach was intended to incorporate as much data as available needed for our modeling routines. We then were able to predict distributions from the models to the historical landcover for a robust assessment of historical bird distributions (see "Historical Occupancy Modeling" below).

To further filter the specimen records to reflect the breeding bird community, we employed "safe dates" utilized by the Los Angeles Breeding Bird Atlas Project (BBA) (Allen et al. 2016). We used safe dates to remove any specimens that may have reflected non-breeding birds, e.g., spring migratory birds. Safe dates are two annual dates for each species, including a start and end date, based on published literature and field observations, within which a bird located within Los Angeles County can be safely assumed to be a breeding bird (Allen et al. 2016, Cooper et al. 2020). If any egg or nest records fell outside of the safe dates, we retained them as valid breeding records as they confirmed breeding for the given species. Our final tally of bird specimens within safe dates was 3,325 among 154 species. The bird species of our analysis had a variety of life-history traits, including specialist and generalist; arboreal and ground-dwelling; sensitive and resilient to land-cover change; and diet guilds, including granivores, insectivores, nectarivores, and carnivores; and occurred in a variety of habitat types throughout our study area (e.g., uplands and wetlands). Thus, the focal species of our analysis were suitable indicators of the potential avian community throughout the region and of the village sites.

Los Angeles Breeding Bird Atlas Count Blocks and Post-Urban Records

We accessed a similar suite of contemporary breeding bird records from the BBA, which were collected by 316 volunteer observers from 1995–1999 (Allen et al. 2016). The BBA is a systematic breeding bird survey that divided the county into atlas blocks. Atlas blocks were grouped, at a resolution of 3.75' wide by 2.5' high, with resulting side lengths of 5.8 km E-W and 4.6 km N-S, with an area of approximately 27.6 km^2 per block from which breeding bird surveys were conducted (Allen et al. 2016). A volunteer observer visited each count block at least once over the five years of the survey, systematically noting the presence of each species and the degree of breeding evidence of birds in that location. The research effort for the BBA resulted in 28,935 observations and covered all of Los Angeles County, including areas outside of the Los Angeles Basin.

The BBA data do not capture the current avifaunal conditions in L.A. They do, however, represent the most robust data on breeding birds for the region and thus are a suitable data source for examining the before-and-after effects of urbanization on the breeding bird community (Cooper et al. 2020). From the BBA data, we included only records that corresponded to a "Confirmed" breeding code and excluded records for that species associated with "Probable" or "Possible" breeding in the contemporary record (Allen et al. 2016). This enabled a direct comparison between the vouchered historical specimens and the modern observational records.

Relating Spatial Extent of Historical and Contemporary Data

The historical bird specimens data and the PNV and historical urban landcover data were the basis for the historical modeling component. To complete the before-and-after assessment, we first matched the historical bird data, the PNV and urban historical land cover datasets, and the contemporary BBA bird data. For birds, we spatially overlaid the boundaries of the BBA grids with the historical bird specimen data (Figure 7-2). The BBA atlas blocks provided a suitable framework for grouping historical bird specimen records with contemporary records because the blocks were large and thus could match potential uncertainty in specimen locations. To match the extent of the PNV and urban land cover data with that of the historical bird specimen data, we intersected the PNV and urban land cover data with the boundaries of each BBA atlas block in ArcGIS (ESRI 2021), then computed the proportion of the PNV and urban land cover types within each atlas block (Figure 7-2). Thus, the resolution of our occupancy analysis was the BBA atlas blocks. Some blocks were clipped by natural features e.g., the ocean (Figure 7-1). Nevertheless, even clipped blocks were suitable for analysis as our predictor data were proportions. We included a total of 148 BBA atlas blocks in our analysis (Figure 7-1).

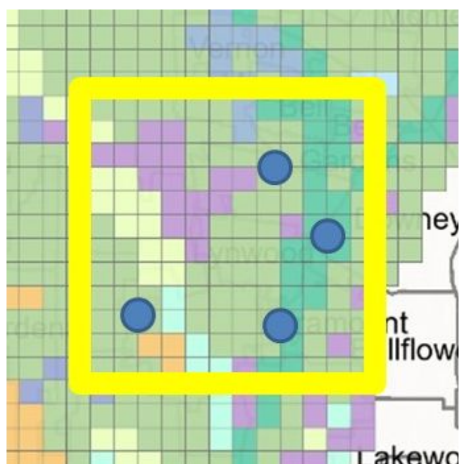

Figure 7-2. Within each BBA grid (yellow square), we aggregated all historical bird specimens from 1889–1936 for a measure of presence or absence within a cell for each of the 30 focal species; we computed the proportion of landcover from the PNV (potential natural vegetation historical landcover database) and computed the presence or absence of the contemporary bird community from the BBA for each grid.

Historical Occupancy Modeling

To recreate the historical bird occupancy in the Los Angeles Basin, we modeled the historical occupancy of 154 bird species. We fitted single-season, single-species occupancy models (MacKenzie et al. 2017), using the function *occu* in the package 'unmarked' (Fiske and Chandler 2011) in R (R Core Team 2022). Single-season models estimate two parameters: detection probability and occupancy (MacKenzie et al. 2017). The models are hierarchical in that detection probability is estimated first, which then informs the occupancy estimate (MacKenzie et al. 2017). The models rely on binomial data (0/1), and repeated visits to a site (MacKenzie et al. 2017). We grouped all specimen records (*n* = 3,325) within decades, resulting in six sampling periods: 1880-1889, 1890-1899, 1900-1909, 1910-1919, 1920-1931, and 1931-1936. Occupancy models were fitted using logistic regression with the estimates of detection and occupancy as probabilities of success (MacKenzie et al. 2017).

Occupancy models are a $Zi \sim Bernoulli(\psi i)$ process, in which Zi is the true state of occupancy of the species in the landscape, based on the occupancy probability ψ and modeled from a Bernoulli distribution (MacKenzie et al. 2017). Observations are modeled with $y_{ij} \sim Bernoulli(Z_i p_{ij})$ in which y_{ij} is the observations at site *i* and p_{ij} is the detection probability of the species (MacKenzie et al. 2017). The model uses a logit link function to estimate both p (detection probability) and ψ (occupancy) as deterministic and stochastic processes based on habitat or observer covariates (MacKenzie et al. 2017). Thus, occupancy models account for imperfect detection of the species (p) — i.e., the species is present but not detected. The detection probability is then included within the model to inform and adjust the estimate of occupancy, which can be described by various predictor variables — in our case, the PNV landcover data (MacKenzie et al. 2017). We assumed that detection probability reflected an observer visiting a grid cell (the extent of a BBA cell) and not collecting a species, though that species may be present.

To fit models, we used a three-step approach. First, we explored three models explaining detection probability: the intercept-only models, a time-varying model (distinct intercept among decadal time steps), and an effort model (the number of collection attempts within a given BBA block atlas per decadal time step). The latter model was important to account for potential uneven sampling across decades. We then used AIC to select the top fitting detection model (Burnham and Anderson 2002). Second, after determining the best-fitting detection model, we used an *a priori* approach to model ψ (occupancy) based on expected habitat associations, using the PNV vegetation types. Our *a priori* assessment was based on our knowledge, and published information, based on the habitat associations for a species (Billerman et al. 2021). Last, we modeled ψ (occupancy) as a function of urbanization landcover (parcels) for the last decade of a bird detection to understand whether there were any associations between urbanization and occupancy for a given bird species. We also fitted the intercept-only occupancy model to determine whether the PNV or urban occupancy model explained more of the likelihood than the average likelihood of the bird response variable-only model. We then used AIC to rank the intercept-only model with the PNV and urban land cover models.

We were only able to fit meaningful models for ninety-four bird species. Meaningful models were those that had a relationship between a bird response variable with a PNV or urban landcover type (e.g., p-value ≈ < 0.10), those that converged, and where detection probability was ≈ > 0.10. Based on the ninety-four best-fitting species-habitat models, we predicted the occupancy of each species across the study area. To do so, we fitted a model using the coefficient value, i.e., the slope, for the best-fitting model, with the full PNV data within each of the 148 BBA bird atlas blocks. We then graphed the predicted occupancy based on these BBA atlas-level predictions and visualized predictions in ArcGIS (ESRI 2021).

Results and Discussion

Village Site Ecological Descriptions

The village sites varied considerably in the composition of the proportion of historical land cover proportion (PNV landcover types) (Table 7-1). In general, most village sites were located near rivers, typically in uplands, and situated within areas that harbored coastal sage scrub, chaparral, woodlands, and riparian and freshwater marshes (Table 7-1). Following is a general description of five village sites. The Chumash site humaliwo (Malibu) is omitted from our analysis because we did not have the PNV of this site.

Table 7-1. The potential natural vegetation (proportional of dominant historical land cover) of five indigenous villages and their adjacent surroundings (≈ 6 km buffer of village sites).

Potential Natural Vegetation	Povuu'unga	Shevaanga	Yaanga	Siutcanga	Achoicomenga
Grasslands and Flower fields	0	0	0	0.38	0.32
Coastal Sage Scrub	0.18	0.42	0.15	0.57	0.16
Chaparral	0	0	0.16	0	0.39
Valley and Foothill Woodlands	0	0	0.36	0.04	0
Riparian Wash (Alluvial Scrub)	0	0.20	0.17	0	0.14
Riparian Forest	0.09	0.22	0.07	0	0
Wet Meadow	0	0.13	0	0	0
Salt Marsh	0.50	0	0	0	0
Freshwater Marsh	0	0	0	0	0
Lake	0	0	0	0	0
Salt Marsh Meadow	0.23	0	0	0	0
Vernal Pool	0	0	0	0	0

Povuu'unga

Povuu'unga was situated on a highland near the location of California State University Long Beach, overlooking the estuary at the mouth of the San Gabriel River, and therefore was in close proximity to salt marsh and riparian forest conditions. The dominant riparian trees in this area would have been willow (*Salix* spp.) and cottonwood (*Populus* spp.) which are adapted to dynamic hydrologic conditions such as scouring and flooding. The name Povuu'unga in the Uto-Aztecan dialect refers to the cotton ball that is formed from the seeds of the cottonwood and willow trees identifying the sustained existence of the riparian forest conditions. The San Gabriel River estuary, including the river and marshes, were likely important for resource acquisition e.g., water, food, medicine, salts for meat preservation, and shells for trade. Thus, the upland location would have been most suitable for perennial occupation to avoid flooding that would have been common on this river as it was the major watershed of the region.

Shevaanga

Shevaanga was located in the present-day Whittier Narrows, at the confluence of the Rio Hondo and San Gabriel Rivers. Shevaanga was generally dominated by coastal sage scrub, which was common in the uplands of the Montebello Hills (current name and location) and terraces that overlooked the village site. Intertwined within the coastal sage scrub, especially on the north slopes of the Montebello Hills, were coast live oak (*Quercus agrifolia*) and California black walnut (*Juglans californica*) woodlands (see Chapter 8). The two dominant trees of the woodlands (oaks and walnuts) were critical resources for Shevaanga. Additionally, within the woodlands and coastal sage scrub were likely other plants that were important to the indigenous peoples of Shevaanga, including blue elderberry (*Sambucus cerulea*), chaparral pricklypear (*Opuntia oricola*), and various sages (e.g., Chia, *Salvia columbariae*). The location of Shevaanga i.e., confluence of two major rivers, was strategically important as the site harbored alluvial strata deposited by winter floods. The word Shevaanga in the Uto-Aztecan dialect refers to stones, identifying the alluvial deposits i.e., rocks, that were often used as tools (Figure 7-3). Further, the location was situated within riparian forest and wash. Red Willows (*Salix laevigata*), California Sycamore (*Platanus racemosa*), and Fremont Cottonwood (*Populus fremontii*) were located throughout the village site and would have served numerous purposes for ropemaking (willows) and wood for canoes and paddles (cottonwood).

Figure 7-3. Andrew Salas, chairperson, of the Kizh Gabrieleño Band of Mission Indians, holding a grinding tool found at Shevaanga (9/7/2023).

Yaanga

Yaanga was located in the foothills and upland terraces overlooking the Los Angeles River. The location is where portions of present-day downtown Los Angeles sit. Like Povuu'unga and Shevaanga, Yaanga was near a major water source, yet in the uplands to avoid flooding, and was embedded within an ecosystem that harbored woodlands and coastal sage scrub. Moreso than Povuu'unga and Shevaanga, the location of Yaanga was dominated by more extensive woodland cover. Importantly, the density of the woodland may have been that of savanna (< 30% tree cover, Wood et al. 2013) given the location was near the drier south facing slope of present-day Elysian Park (location of Dodger Stadium). Other important features of Yaanga were riparian forest and wash, which was widespread in the Elysian Valley, which was just north of the village site. The riparian conditions likely harbored many resources — food, water, wood — for individuals from Yaanga. The name Yaanga in the Uto-Aztecan dialect refers to the place of the poison oak (*Toxicodendron diversilobum*) identifying the riparian and woodland conditions that occurred during the indigenous landscape. Further, Yaanga was likely located on the western terrace overlooking the river, which may have been strategically important. The dominant flow of the Los Angeles River in the southern end of the Elysian Valley likely flowed from northwest to southeast, thus carrying floodwaters and alluvial deposits away from the village site.

Siutcanga

Siutcanga was located along the upper course of the Los Angeles River near present-day Encino Park, and south of the 101 Freeway from the Sepulveda Basin Recreation Area. The location, like the others, was near a freshwater source and embedded within a mosaic of coastal sage scrub and associated woodland ecosystems. Distinct from Povuu'unga, Shevaanga, and Yaanga was the presence of California grasslands and flower fields, an ecosystem type prevalent throughout the San Fernando Valley due to a rain shadow effect of the Santa Monica Mountains. In addition to key plants discussed from the first three village sites, which were all within the area of Siutcanga, the grasslands may have harbored important plants such as deergrass (*Muhlenbergia rigens*) and distinct animals that may have been preferable for hunting.

Achoicomenga

Achoicomenga was located in the northern portions of the San Fernando Valley. The village site was likely the driest and hottest, but was, also near the mouth of Tujunga Canyon, which funneled the Big Tujunga Creek. The location was adjacent to the steep foothills of the San Gabriel Mountains and close to riparian wash (or alluvial scrub habitat) due to the alluvial deposits of Big Tujunga Creek. Alluvial scrub is distinct in that it harbors plants of both chaparral and coastal sage scrub ecosystems (Mooney and Zavaleta 2016). Additional plants of the alluvial scrub and adjacent chaparral ecosystems (in the foothills and mountains) included Chaparral Yucca (*Hesperoyucca whipplei*) (all parts of the plant were used, from edible fruits and flowers to fibers), Yerba Mansa (*Anemopsis californica*) and Yerba Santa (*Eriodictyon crassifolium*) (both medicinal plants), and White Sage (*Salvia apiana* – similar uses to Chia).

Historical Avifauna of Village Sites

Birds, like many animals, have distinct preferences for habitat conditions and resources (Wood et al. 2012). Thus, if habitat conditions and resources vary across a region, avifaunal communities will shift in predictable ways to mirror the shifts in available resources (Block and Brennan 1993). The habitat conditions were generally similar among village sites e.g., coastal sage scrub and woodland. However, there were important distinctions that influenced the assembly of birds among villages, such as the presence of nearby wetlands or grassland ecosystems (Table 7-2). Below, we detail each village site and focus on distinct birds that were likely associated with the ecosystems of and surrounding the sites. We then discuss an example of a bird that was common at the site but has been greatly affected by the urbanization of the region.

Povuu'unga

Povuu'unga, being upland and coastal, was on a small highland that was dominated by coastal sage scrub. It is important to note that our models for birds did not extend to Povuu'unga, and we are using information for the BBA location immediately to the west for guidance. At the Povuu'unga site, birds affiliated with shrubby habitats e.g., Bushtits (*Psaltriparus minimus*, predicted proportional occupancy = 1), Blue Grosbeaks (*Chamaea fasciata*, predicted proportional occupancy = 1), Lesser Goldfinches (*Spinus psaltria,* predicted proportional occupancy = 0.99), Lazuli Buntings (*Passerina amoena,* predicted proportional occupancy = 0.86), and Wrentits (*Passerina caerulea*, predicted proportional occupancy = 0.57) would likely have been common. Further, species that would have been embedded in either grassland or woodland ecotones of the coastal sage scrub, such as the Loggerhead Shrike (*Lanius ludovicianus,* predicted proportional occupancy = 0.99) and Burrowing Owl (*Athene cunicularia,* predicted proportional occupancy = 0.60), two grassland and coastal sage scrub associated birds, and the Anna's Hummingbird (*Calypte anna,* predicted proportional occupancy = 0.57), an oak woodland associated bird, may also have been common in and around Povuu'unga.

Table 7-2. Family, common and scientific name and the proportion of occupancy (0 = no predicted occupancy; 1 = 100% predicted occupancy) for 95 bird species among five indigenous village sites.

Family	Common Name	*Scientific Name*	Povuu'unga*	Shevaanga	Yaanga	Siutcanga	Achoicomenga
Anatidae	Cinnamon Teal	*Anas cyanoptera*	0.04	0.93	0.34	0.04	0.15
Odontophoridae	Mountain Quail	*Oreortyx pictus*	0.04	0.04	0.07	0.04	0.15
Podicipedidae	Pied-billed Grebe	*Podilymbus podiceps*	0.07	0.79	0.28	0.07	0.16
Columbidae	Mourning Dove	*Zenaida macroura*	0.45	0.42	0.28	0.40	0.27
Cuculidae	Greater Roadrunner	*Geococcyx californianus*	0.24	0.81	0.73	0.98	0.99
Cuculidae	Yellow-billed Cuckoo	*Coccyzus americanus*	0.04	0.51	0.20	0.04	0.10
Caprimulgidae	Common Poorwill	*Phalaenoptilus nuttallii*	0.15	0.15	0.18	0.15	0.22
Trochilidae	Black-chinned Hummingbird	*Archilochus alexandri*	0.93	0.77	0.84	0.91	0.43
Trochilidae	Anna's Hummingbird	*Calypte anna*	0.57	0.44	0.48	0.54	0.31
Trochilidae	Allen's Hummingbird	*Selasphorus sasin*	1	0.95	0.41	0.99	0.45
Rallidae	Ridgway's Rail	*Rallus obsoletus*	0.10	0.10	0.10	0.10	0.10
Rallidae	American Coot	*Fulica americana*	0.07	0.07	0.07	0.07	0.07
Recurvirostridae	Black-necked Stilt	*Himantopus mexicanus*	0.02	0.02	0.02	0.02	0.02
Recurvirostridae	American Avocet	*Recurvirostra americana*	0.05	0.05	0.05	0.05	0.05
Laridae	California Least Tern	*Sternula antillarum browni*	0.07	0.07	0.07	0.07	0.07
Laridae	Forster's Tern	*Sterna forsteri*	0.07	0.07	0.07	0.07	0.07
Ardeidae	American Bittern	*Botaurus lentiginosus*	0.02	1	1	0.02	0.88

Ardeidae	Green Heron	*Butorides virescens*	0.23	0.88	0.54	0.23	0.40
Accipitridae	Northern Harrier	*Circus hudsonius*	0	0.85	0	0	0
Accipitridae	Cooper's Hawk	*Accipiter cooperii*	1	0.36	1	0.31	0.21
Accipitridae	Red-shouldered Hawk	*Buteo lineatus*	0.08	0.23	0.14	0.08	0.11
Tytonidae	Barn Owl	*Tyto alba*	0.49	0.31	0.17	0.42	0.17
Strigidae	Western Screech-Owl	*Megascops kennicottii*	0.19	0.38	0.48	0.21	0.24
Strigidae	Burrowing Owl	*Athene cunicularia*	0.69	0.44	0.20	0.87	0.49
Strigidae	California Spotted Owl	*Strix occidentalis occidentalis*	0.09	0.09	0.09	0.09	0.09
Strigidae	Long-eared Owl	*Asio otus*	0.13	0.17	0.08	0.20	0.12
Picidae	Acorn Woodpecker	*Melanerpes formicivorus*	0.19	0.19	1	0.80	0.19
Picidae	Red-breasted Sapsucker	*Sphyrapicus ruber*	0.08	0.08	0.08	0.08	0.08
Picidae	Downy Woodpecker	*Dryobates pubescens*	0.08	0.38	0.21	0.08	0.14
Picidae	Nuttall's Woodpecker	*Dryobates nuttallii*	0.11	0.29	0.41	0.12	0.15
Picidae	Hairy Woodpecker	*Dryobates villosus*	0.06	0.06	0.09	0.06	0.18
Picidae	Northern Flicker	*Colaptes auratus*	0.05	0.05	0.05	0.05	0.05
Falconidae	American Kestrel	*Falco sparverius*	0.48	0.36	0.40	0.45	0.25
Tyrannidae	Contopus.spp		0.16	0.16	0.22	0.16	0.32
Tyrannidae	Ash-throated Flycatcher	*Myiarchus cinerascens*	0.48	0.36	0.40	0.45	0.25
Tyrannidae	Western Kingbird	*Tyrannus verticalis*	0.42	0.30	0.20	0.56	0.33
Tyrannidae	Southwestern Willow Flycatcher	*Empidonax traillii extimus*	0.30	0.96	0.63	0.30	0.30
Tyrannidae	Western Flycatcher	*Empidonax difficilis*	0.30	0.22	0.24	0.27	0.16
Tyrannidae	Black Phoebe	*Sayornis nigricans*	1	0.20	0.99	0.18	0.13
Tyrannidae	Say's Phoebe	*Sayornis saya*	0.38	0.30	0.22	0.48	0.31

Vireonidae	Least Bell's Vireo	*Vireo bellii pusillus*	0.04	1	1	0.04	1
Vireonidae	Hutton's Vireo	*Vireo huttoni*	0.15	0.15	0.34	0.17	0.15
Laniidae	Loggerhead Shrike	*Lanius ludovicianus*	0.99	0.85	0.27	1.00	0.90
Corvidae	Steller's Jay	*Cyanocitta stelleri*	0.08	0.08	0.08	0.08	0.08
Corvidae	California Scrub-Jay	*Aphelocoma californica*	0.48	0.38	0.41	0.45	0.29
Paridae	Mountain Chickadee	*Poecile gambeli*	0.16	0.16	0.20	0.16	0.27
Paridae	Oak Titmouse	*Baeolophus inornatus*	0.23	0.23	0.29	0.23	0.38
Alaudidae	Horned Lark	*Eremophila alpestris*	0.48	0.29	0.15	0.69	0.33
Hirundinidae	Tree Swallow	*Tachycineta bicolor*	0.02	0.08	0.04	0.02	0.03
Hirundinidae	Purple Martin	*Progne subis*	0.01	0.01	0.01	0.01	0.01
Hirundinidae	Barn Swallow	*Hirundo rustica*	0.05	1	1	0.05	0.94
Hirundinidae	Cliff Swallow	*Petrochelidon pyrrhonota*	0.13	1	1	0.13	0.91
Aegithalidae	Bushtit	*Psaltriparus minimus*	1	0.49	1	0.38	0.22
Sylviidae	Wrentit	*Chamaea fasciata*	0.57	0.33	0.24	0.47	0.44
Sittidae	White-breasted Nuthatch	*Sitta carolinensis*	0.05	0.05	0.05	0.05	0.05
Sittidae	Pygmy Nuthatch	*Sitta pygmaea*	0.01	0.01	0.01	0.01	0.01
Polioptilidae	Blue-gray Gnatcatcher	*Polioptila caerulea*	0.36	0.09	0.24	0.09	0.08
Polioptilidae	California Gnatcatcher	*Polioptila californica*	0.14	0.99	0.98	0.14	0.94
Troglodytidae	Rock Wren	*Salpinctes obsoletus*	0.11	0.11	0.11	0.11	0.11
Troglodytidae	Canyon Wren	*Catherpes mexicanus*	0.04	0.04	0.06	0.04	0.10
Troglodytidae	Coastal Cactus Wren	*Campylorhynchus brunneicapillus sandiegensis*	0.06	0.46	0.35	0.06	0.27
Troglodytidae	Bewick's Wren	*Thryomanes bewickii*	0.35	0.20	0.15	0.28	0.27
Troglodytidae	House Wren	*Troglodytes aedon*	0.22	1	1	0.22	1

Troglodytidae	Marsh Wren	*Cistothorus palustris*	0.10	0.10	0.10	0.10	0.10
Mimidae	Northern Mockingbird	*Mimus polyglottos*	0.87	0.58	0.21	0.78	0.23
Turdidae	Western Bluebird	*Sialia mexicana*	0.08	0.08	1	0.27	0.08
Ptiliogonatidae	Phainopepla	*Phainopepla nitens*	0.25	0.25	0.49	0.27	0.25
Passeridae	House Sparrow	*Passer domesticus*	0.19	0.08	0.15	0.08	0.08
Fringillidae	House Finch	*Haemorhous mexicanus*	1	0.94	1	0.90	0.72
Fringillidae	Lesser Goldfinch	*Spinus psaltria*	0.99	0.25	0.94	0.23	0.20
Fringillidae	Lawrence's Goldfinch	*Spinus lawrencei*	0.23	0.96	0.66	0.23	0.47
Passerellidae	Grasshopper Sparrow	*Ammodramus savannarum*	0.14	0.14	0.14	0.99	0.97
Passerellidae	Lark Sparrow	*Chondestes grammacus*	0.97	0.75	0.86	0.94	0.24
Passerellidae	Chipping Sparrow	*Spizella passerina*	0.10	0.10	0.10	0.10	0.10
Passerellidae	Dark-eyed Junco	*Junco hyemalis*	0.02	0.02	0.02	0.02	0.02
Passerellidae	Bell's Sparrow	*Artemisiospiza belli*	0.26	0.19	0.14	0.35	0.21
Passerellidae	Savannah Sparrow	*Passerculus sandwichensis*	0.08	0.08	0.08	0.08	0.08
Passerellidae	Song Sparrow	*Melospiza melodia*	0.98	0.88	0.48	0.96	0.50
Passerellidae	California Towhee	*Melozone crissalis*	0.55	0.44	0.47	0.52	0.32
Passerellidae	Rufous-crowned Sparrow	*Aimophila ruficeps*	0.15	0.10	0.08	0.12	0.12
Passerellidae	Spotted Towhee	*Pipilo maculatus*	0.65	0.47	0.53	0.61	0.29
Icteriidae	Yellow-breasted Chat	*Icteria virens*	0.03	0.26	0.12	0.03	0.07
Icteridae	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	0.07	1.00	0.97	0.07	0.68
Icteridae	Western Meadowlark	*Sturnella neglecta*	0.60	0.13	0.60	0.12	0.11
Icteridae	Hooded Oriole	*Icterus cucullatus*	0.78	0.19	0.60	0.18	0.16

Icteridae	Red-winged Blackbird	*Agelaius phoeniceus*	0.23	0.23	0.23	0.23	0.23
Icteridae	Tricolored Blackbird	*Agelaius tricolor*	0.02	1	0.99	0.02	0.75
Icteridae	Brewer's Blackbird	*Euphagus cyanocephalus*	1	0.20	0.99	0.18	0.13
Parulidae	Common Yellowthroat	*Geothlypis trichas*	0.20	0.94	0.60	0.20	0.42
Parulidae	Yellow Warbler	*Setophaga petechia*	0.23	0.98	0.84	0.23	0.60
Parulidae	Black-throated Gray Warbler	*Setophaga nigrescens*	0.13	0.13	0.17	0.13	0.23
Cardinalidae	Western Tanager	*Piranga ludoviciana*	0.02	0.02	0.02	0.02	0.02
Cardinalidae	Black-headed Grosbeak	*Pheucticus melanocephalus*	0.27	0.98	0.76	0.27	0.55
Cardinalidae	Blue Grosbeak	*Passerina caerulea*	1	0.92	0.31	0.99	0.35
Cardinalidae	Lazuli Bunting	*Passerina amoena*	0.86	0.12	0.66	0.11	0.10

Table notes

* The Povuu'unga bird data were from a breeding bird atlas (BBA) grid cell that was immediately to the west of the upland terrace that the village rested on. We were unable to fit models for the Povuu'unga location as it was outside the boundaries of the potential natural vegetation map (PNV), which was focused within the Los Angeles River Watershed. The location used for the bird list below is more upland, and thus the birds are reflective of a community that does not incorporate as many wetland species as would have been present at Povuu'unga.

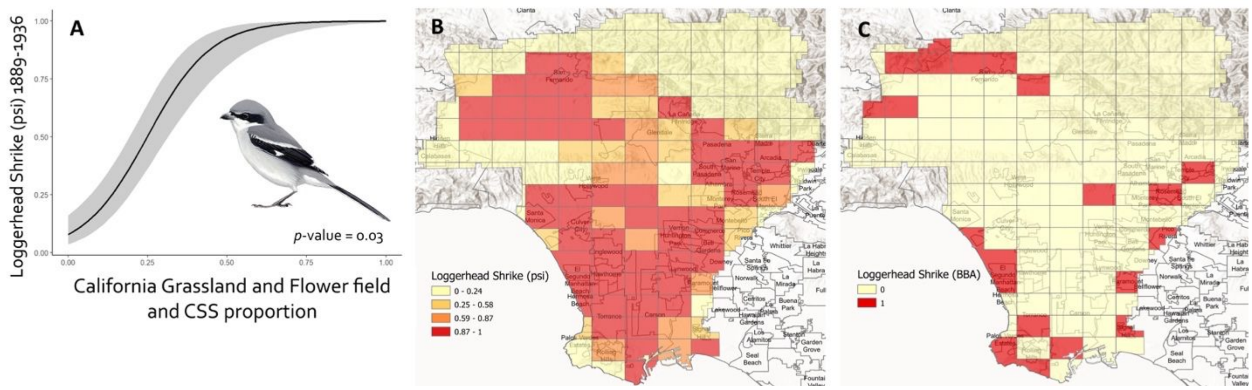

*Figure 7-4. (A) Graph depicting the positive relationship between the Loggerhead Shrike (*Lanius ludovicianus*), based on an occupancy modeling routine, and the proportion of grassland and coastal sage scrub habitat. (B) The Loggerhead Shrike was historically common throughout all lowlands in the region that had either grassland, coastal sage scrub, or importantly, a mixture of the two. (C) The Loggerhead Shrike has seen a drastic decrease in its breeding range primarily due to the reduction in its preferred habitat types. Illustration credit: Tim Worfolk.*

A focus of change at Povuu'unga can be centered on the loss of coastal sage scrub, and its associated habitats e.g., grasslands and coastal woodlands. Coastal sage scrub is a dominant upland ecosystem of the valleys and low hills of coastal Southern California (Mooney and Zavaleta 2016). Given that coastal sage scrub occurs in some of the most highly desirable locations for development, the ecosystem has been greatly reduced for the development of homes and other urbanized areas throughout the region. With the drastic reduction in habitat comes the drastic reduction in wildlife that depends on it. The Loggerhead Shrike, a grassland and coastal sage scrub-associated bird (Figure 7-4A), was formerly common throughout the region (Figure 7-4B) but has lost 73% of its breeding range in the study area (Figure 7-4C).

Shevaanga

Shevaanga, more than the other village sites, was embedded within a riparian and wetland complex in the Whittier Narrows region. Therefore, birds affiliated with riparian and associated wetland conditions would have been common (Table 7-2). This included the Least Bell's Vireo (*Vireo bellii pusillus*, predicted proportional occupancy = 1), the American Bittern (*Botaurus lentiginosus*, predicted proportional occupancy = 1), the Tricolored Blackbird (*Agelaius tricolor*, predicted proportional occupancy = 1), the Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*, predicted proportional occupancy = 1), the Black-headed Grosbeak (*Pheucticus melanocephalus*, predicted proportional occupancy = 0.98), the Yellow Warbler (*Setophaga petechia*, predicted proportional occupancy = 0.98), the Southwestern Willow Flycatcher (*Empidonax traillii extimus*, predicted proportional occupancy = 0.96), the Common Yellowthroat (*Geothlypis trichas*, predicted proportional occupancy = 0.94), the Cinnamon Teal (*Anas cyanoptera*, predicted proportional occupancy = 0.93), the Green Heron (*Butorides virescens*, predicted proportional occupancy = 0.88), and the Yellow-billed Cuckoo (*Coccyzus americanus*, predicted proportional occupancy = 0.51), which would have all been common in the habitats surrounding the village site (Table 9-2). Further, given the proximity to hillside coastal sage scrub habitats, species such as the California Gnatcatcher (*Polioptila californica*, predicted proportional occupancy = 0.99), would have been common in the uplands (Table 7-2).

Given the high occupancy of Shevaanga by riparian-associated birds, it is appropriate to focus on an emblematic species of western riparian systems when comparing change over time. The Yellow-billed Cuckoo requires gallery forests (riparian woodlands) with dense willows and tall overstory trees, e.g., cottonwoods. Throughout the early portion of the 20th century, it was clear that the development of L.A. and its surrounding municipalities could not contend with the intense flooding that would occasionally occur along the major riverways. Surrounded by mountains, as winter or monsoonal rains would hit the region, the water would flow violently through the valleys on its way toward the Pacific Ocean. Thus, coordinated efforts by the city, county, state, and federal governments led to the channelization of most rivers and washes in the area. The purpose was to allow for water to be managed and moved towards the ocean efficiently so that flooding could be avoided. With the channelization came the near and total destruction of the region's riparian forests. The Yellow-billed Cuckoo was formerly a common breeder along the Los Angeles, Arroyo Seco, Rio Hondo, and San Gabriel Rivers (Figure 7-5A-B) but has since been extirpated from the region (Figure 7-5C). The loss of the cuckoo was representative of the loss of critical and culturally important resources used by the Indigenous peoples of Shevaanga.

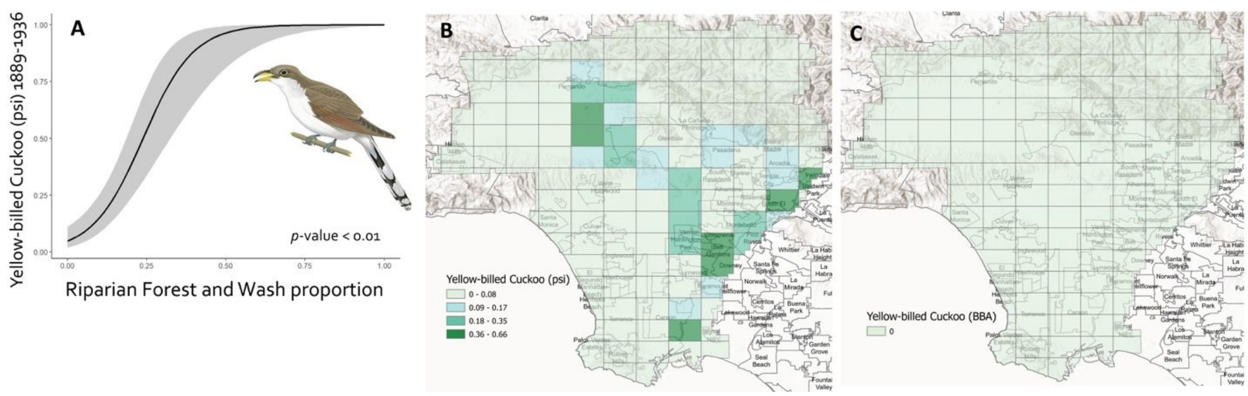

Figure 7-5. (A) Graph depicting the strong positive relationship between the Yellow-billed Cuckoo (Coccyzus americanus), based on an occupancy modeling routine, and the proportion of riparian forest and wash. (B) The historical distribution of the cuckoo was highest along the Los Angeles and San Gabriel Rivers, as well as the Arroyo Seco. (C) The Yellow-billed Cuckoo has been extirpated from the region due to the near total loss of its preferred habitat, riparian gallery forest, due to the channelization of the major rivers and washes that used to flow freely from the mountains, through the valleys, and to the ocean. Illustration credit: Jan Wilczur.

Yaanga

Yaanga represents a mixture of oak woodland, coastal sage scrub, chaparral, and nearby riparian and wetland habitats. Thus, Yaanga harbored a broad collection of birds affiliated with the high variability of habitat types of the area (Table 9-2). Woodland and savanna birds, such as the Acorn Woodpecker (*Melanerpes formicivorus*, predicted proportional occupancy = 1), and

Western Bluebird (*Sialia mexicanas*, predicted proportional occupancy = 1), riparian and wetland species, such as the Least Bell's Vireo (predicted proportional occupancy = 1), the American Bittern (predicted proportional occupancy = 1), the Tricolored Blackbird (*Agelaius tricolor*, predicted proportional occupancy = 0.99), and the Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*, predicted proportional occupancy = 0.98), and shrub-associated birds, such as the California Gnatcatcher (predicted proportional occupancy = 0.98), all would have been common either in the woodlands, savanna, and shrublands located on the terraces where the village likely occurred, or the riparian and wetlands in the adjacent channel of the Los Angeles River (Table 9-2).

Wetlands in particular, freshwater marshes, may have been common where the Los Angeles River opened up from the Elysian Valley to the Los Angles Plain. Therefore, a story of change for Yaanga could thus be reflected in birds that required marsh — particularly freshwater marshes. For example, the Tricolored Blackbird (Figure 7-6A) was likely historically common in the wetlands near Yaanga (Figure 7-6B) but has been severely restricted in its distribution in the region (Figure 7-6C). An interesting pattern for wetland birds is that some do still use the heavily urbanized area of Los Angeles as long as there are managed wetlands present. Nevertheless, the changes in the bird distributions mirror the changes in the habitat, which of course included the many resources that were necessary for the indigenous peoples at Yaanga and the other village sites.

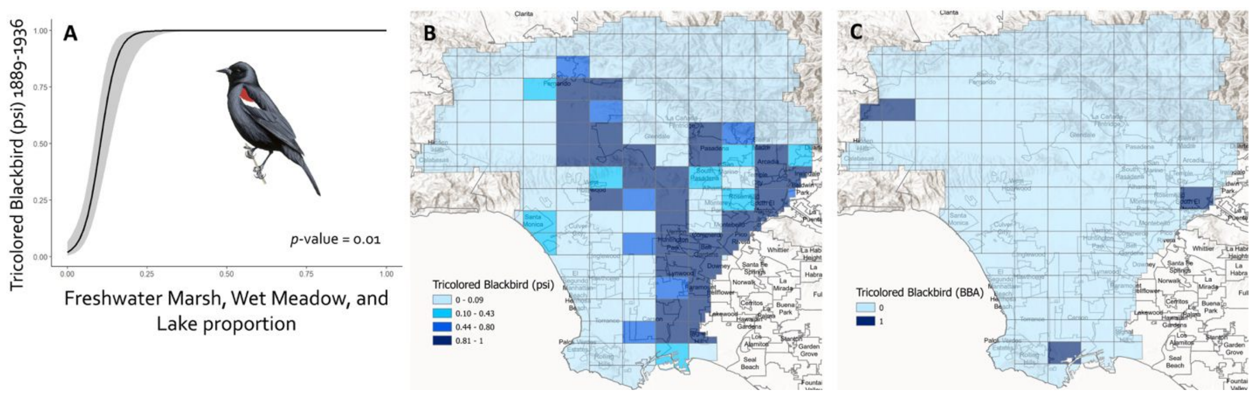

Figure 7-6. (A) Graph depicting the strong positive relationship between the Tricolored Blackbird and the proportion of freshwater marsh, wet meadows, and lakes, based on an occupancy modeling routine. (B) The historical distribution of the birds was highest in the Ballona Area, as well as wetlands in Compton and Long Beach, which were near the flows of the Los Angeles and San Gabriel Rivers. (C) The distribution of the birds has shifted based on the 1995-1999 Breeding Bird Atlas Survey. Tricolored Blackbirds have been severely reduced in number in the region. The number of cells (the Breeding Bird Atlas grids visible in the maps) occupied during the historical and contemporary times has decreased from 15 to 6 (2.5x less). Further, the location of occupied wetlands has shifted, which reflects the heavily managed water system of the region. Illustration credit: Tim Worfolk.

Siutcanga

Siutcanga represents a mixture of grassland, coastal sage scrub, and woodland. Therefore, Siutcanga harbored grassland associated birds along with species requiring woodland or shrubland habitat types (Table 7-2). Grassland birds that were common at Siutcanga included the Loggerhead Shrike (predicted proportional occupancy = 1), the Grasshopper Sparrow (*Ammodramus savannarum*, predicted proportional occupancy = 0.99), the Lark Sparrow (*Chondestes grammacus*, predicted proportional occupancy = 0.94), the Burrowing Owl (predicted proportional occupancy = 0.87), and the Horned Lark (*Eremophila alpestris*, predicted proportional occupancy = 0.69). Shrub-associated birds that would have been common included the Blue Grosbeak (predicted proportional occupancy = 0.99), and the Greater Roadrunner (*Geococcyx californianus*, predicted proportional occupancy = 0.99), and woodland birds that would have been common included the Black-chinned Hummingbird (*Archilochus alexandri*, predicted proportional occupancy = 0.91), the Acorn Woodpecker (predicted proportional occupancy = 0.80), and the Anna's Hummingbird (predicted proportional occupancy = 0.54) (Table 9-2).

The Anna's Hummingbird is an interesting case study considering change over time of the woodland bird community. Woodland birds, more than any other group of birds associated with a distinct habitat, have either maintained in their occupancy across L.A. or expanded in their distribution since the late 1880s and early 1900s. Anna's Hummingbirds are associated with woodland and shrubland habitats (Figure 7-7A), but were most likely common in their range — especially near Siutcanga — in foothill areas (Figure 7-7B). The valleys were primarily open and covered in grasses and forbs outside of strips of riparian forests and thus were less suitable for Anna's Hummingbirds. Over the course of the 20th century, L.A. boomed in development, covering nearly all low-lying areas in suburban sprawl. As a sign of wealth, it was common to landscape with exotic plants and trees — many, which had exuberant flowering. The conditions created throughout the suburban sprawl of L.A. greatly benefited the Anna's Hummingbird, which has greatly expanded its range (Figure 7-7C). The change in conditions not only benefited the hummingbird, but also many other synanthropic species (those associated with people) (Wood and Esaian 2020, Smallwood and Wood 2023).

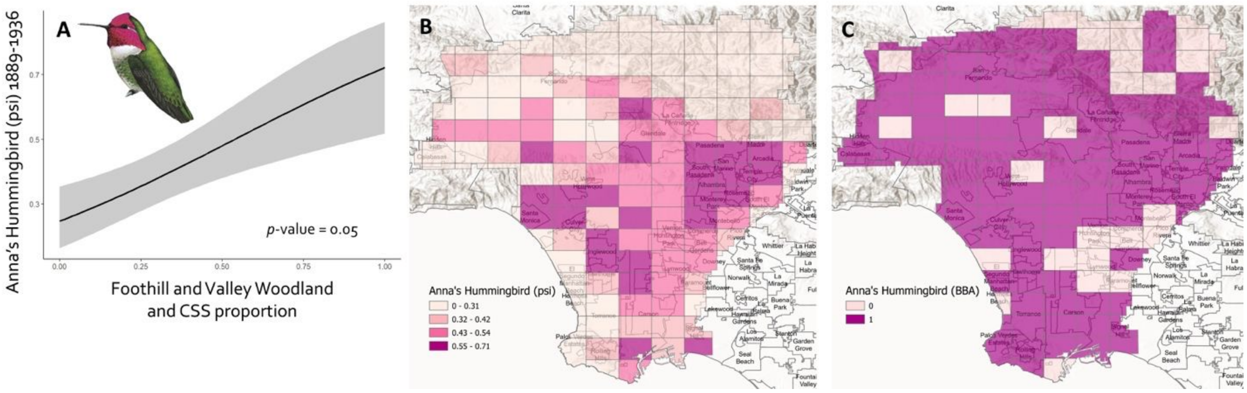

Figure 7-7. (A) Graph depicting the positive relationship between the Anna's Hummingbird and the proportion of proportion of foothill valley and woodland and coastal sage scrub habitat, based on an occupancy modeling routine. (B) The historical distribution of the Anna's Hummingbird was generally focused on the foothills of the Santa Monica, San Gabriel, and Verdugo Mountains, and the Montebello and Puente Hills. (C) The distribution of the birds has dramatically increased, presumably due to the large increase in urban forest conditions and resources e.g., exotic flowering plants, that the birds use throughout the annual cycle. Illustration credit: Dave Nurney.

Achoicomenga

Achoicomenga was embedded within a habitat mosaic harboring grassland, coastal sage scrub, chaparral, and alluvial scrub (riparian wash). Within the coastal sage scrub and chaparral were likely patches of oak woodland, while the alluvial scrub likely also hosted riparian forest conditions. Thus, birds associated with the high mixture of ecosystem types were likely present in and around the village site (Table 7-2). Grassland birds, including the Grasshopper Sparrow (predicted proportional occupancy = 0.97), and the Loggerhead Shrike (predicted proportional occupancy = 0.90), shrubland birds, such as the Greater Roadrunner (predicted proportional occupancy = 0.99), and the California Gnatcatcher (predicted proportional occupancy = 0.94), riparian birds, such as the Least Bell's Vireo (predicted proportional occupancy = 0.94), and woodland species, such as the House Wren (predicted proportional occupancy = 0.94), all were predicted to have high probably occupancy of Achoicomenga and the adjacent lands.

Like many other ecosystems of the region, grasslands have been servely reduced in their historical extent due to agricultural development, followed by urban development. Further, grasslands of the area have been inundated with invasive plant species for hundreds of years following the Spanich missionary period (Mooney and Zavaleta 2016). Thus, we likely do not understand what a historical grassland and flower field resembled in the area, let alone which wildlife occurred there. Neverhtheless, our historical modeling routine highlighted a handful of grassland specialists that were formerly common in the region.

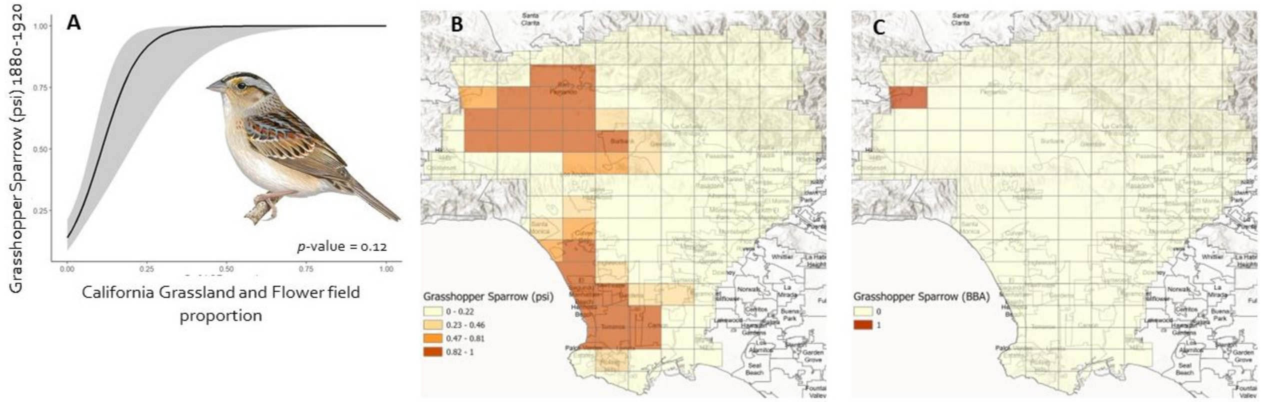

Figure 7-8. (A) Graph depicting the positive relationship between the Grasshopper Sparrow and the proportion of California grassland and flower field habitat, based on an occupancy modeling routine. (B) The historical distribution of the Grasshopper Sparrow was focused on the grass and forblands of the San Fernando Valley and the grassland and dune system of the Santa Monica Bay. (C) Grasshopper Sparrows have been nearly extirpated as breeding birds from the region, with potentially only one location in the northwest corner of the San Fernando Valley left as suitable habitat. Illustration credit: David Quinn.

The Grasshopper Sparrow is a grassland associated bird (Figure 7-8A) that was predicted to have high occupancy of the grasslands of the San Fernando Valley, where Achoicomenga sat, and the grassland and extensive dune system of the Santa Monica Bay (Figure 7-8B). Grasshoppers Sparrows require patchy grasslands, often with bare ground (Billerman et al. 2021). The dense growth of plants within California annual grasslands — the name given to reflect the natural history of invasive annual grasses (Mooney and Zavaleta 2016) —is poor habitat for a bird such as a Grasshopper Sparrow. Thus, the bird likely occurred in the grasslands of the region that harbored bunch grasses e.g., deergrass, and forbs, with patches of bare ground. Grasshopper Sparrows are effectively extirpated from the region (Figure 7-8C) and thus highlight a broader trend in the extirpation of historical grasslands and flower field ecosystems of California (Minnich 2008).

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Chapter 8 Historical Distributions of Culturally Important Tree Species in the Los Angeles Region

Travis Longcore, Beau MacDonald, Matthew Teutimez, and John P. Wilson

Introduction

One of the most characteristic elements of the historical landscape of Los Angeles would have been the distribution of trees across an area where many regions were treeless. Trees would have been associated with certain areas where the combination of rainfall and groundwater was sufficient to support larger vegetation, and absent in large expanses of scrubland, grassland, and chaparral (Ethington et al. 2020). During the Rancho era, followed by agricultural development, native trees would have been lost from many areas where they did occur, which we know because most neighborhoods developed in the twentieth century on the flatter zones within the region started with no trees and only developed an urban forest through tree planting efforts (Gillespie et al. 2012).

Trees were also important to the diet of the Indigenous population, with extensive systems of tending trees, especially oaks, but also walnuts, to promote growth and maximize yield. The location, quality, and health of native trees, especially those with food or fiber value, were therefore of utmost importance and in many ways defined space use in the pre-European period. Outside of areas where key species persist today, however, it is difficult to know where upland forests of oaks, walnuts, and elderberries might have been found with confidence. For example, were oaks commonly found on the Palos Verdes Peninsula during the Indigenous era? Were they in the Baldwin Hills? To what extent were oaks and walnuts found across the San Fernando Valley, if at all?

To investigate the historical distribution of these culturally important forests we must take knowledge about where the key species grow today and predict where they might have grown historically under similar environmental conditions. Such prediction involves developing what is known as a "presence only" habitat distribution model, which uses information about the presence of a species relative to environmental variables and predicts what other places with similar environmental profiles would have a high probability of the species being encountered (Phillips and Dudík 2008, Elith et al. 2011). The important statistical aspect of the approach is that it makes no assumptions at the outset that the species is absent from any location, even if it has never been located in that spot. The question that is being asked is whether any places not currently occupied are so similar to those currently (or historically) occupied that conclusions can be drawn.

In this investigation, we selected a set of culturally important tree species from upland areas. We then built a series of habitat models based on known locations of the species from current and historical sources. The resulting maps provide an additional information source for our broad and fine-scale mapping of the potential natural vegetation of the region and serves as a complementary data source for understanding the distribution of Indigenous villages, hunting grounds, and other landscape use.

Methods

Study Area

For this investigation we used an expanded study area that included the region from Ventura County south to northern San Diego County and extending inland to encompass portions of San Bernardino County and Riverside County. We included this additional area so that the environmental layers and training data for the species would include a large enough range of variation so that the models would not be "overfit" to the areas where species currently persist. The larger area increased the training data available along with that environmental variability of the locations where training data were found. Our preliminary delineation considered the distribution of Indigenous groups by language and known forest resource use. We then included the portion of the initial area contained within the southwestern California Floristic Province, a botanically diverse geographic unit that trends northwest to southeast along the southern California coast and includes mountain ranges but excludes deserts.

Species Selection

We selected a group of trees that were important culturally and in defining the vegetation of the region. All of the lowland oak species were included: Coast Live Oak (*Quercus agrifolia*), Valley Oak (*Quercus lobata*), Mesa Oak (*Quercus engelmannii*), and the scrub oaks (*Quercus dumosa/berberidifolia*). California Black Walnut (*Juglans californica*) and Blue Elderberry (*Sambucus nigra*) were also selected.

Although the project team was interested in species associated with riparian zones, such as cottonwoods and alders, the historical digital elevation model was only available late in the project period and the riparian zones are so altered topographically that modeling was not considered feasible.

Training Data

Training data for each species was obtained from field observations, historical maps (Figure 8-1), and early surveys. This included sets of points generated from the georeferenced and digitized version of 1930s Wieslander vegetation type mapping surveys (Thorne and Le 2016); we extracted the top three species from the geospatial data and proportionally allocated randomly placed points. We also used the CalFlora database and iNaturalist research grade observations Additional data for large oak and walnut specimens were contributed by local researchers and municipal foresters. Points were reviewed individually and excluded if any evidence suggested that the trees had been planted.

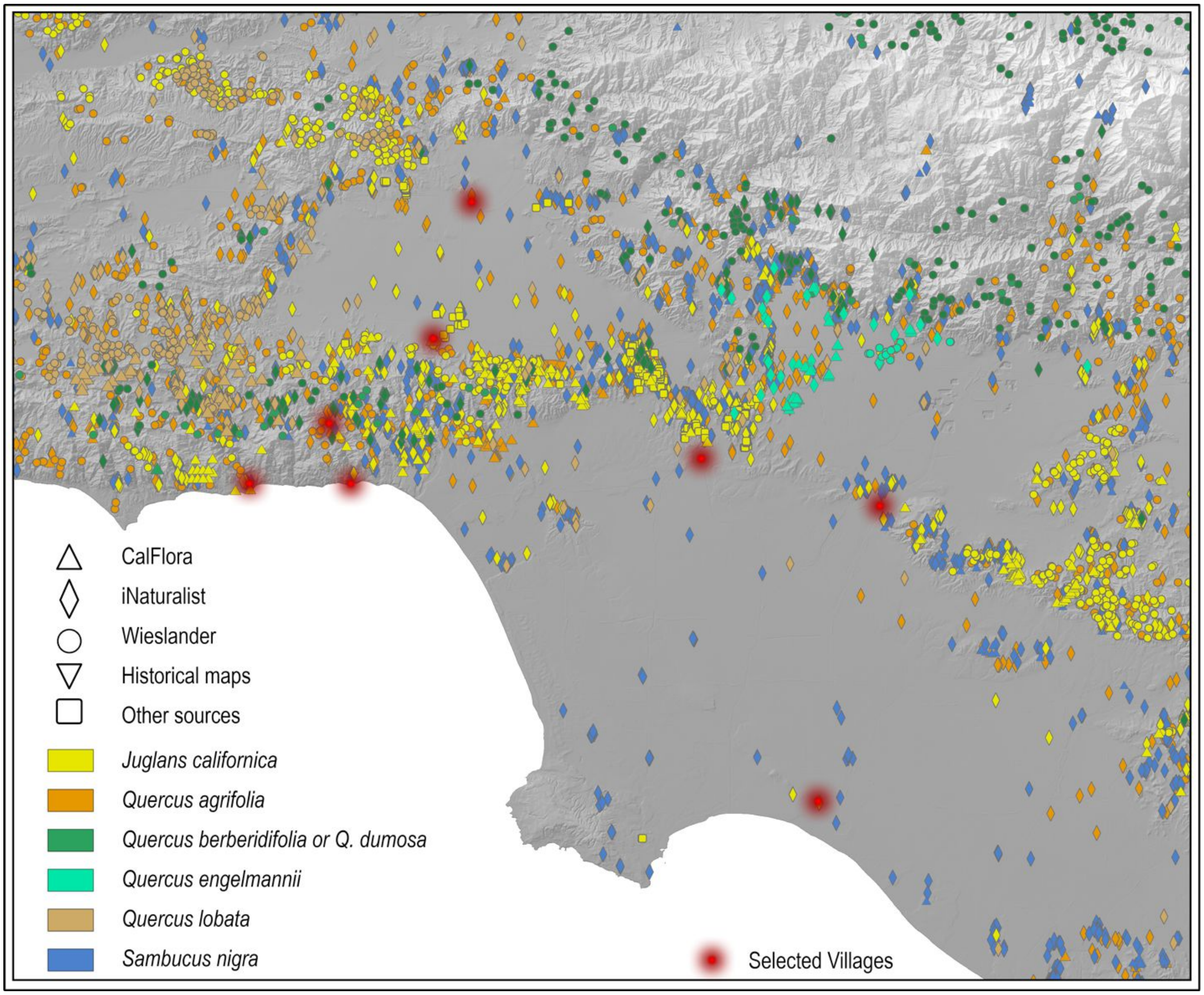

Figure 8-1. Example of training data for a portion of the modelled region, with locations of focal indigenous villages.

Environmental Data

Environmental layers are listed in Table 8-1and illustrated in Figure 8-2. Six land surface parameters were derived from a USGS 30m (1 arc-second) present-day DEM mosaic clipped to the study area boundary: aspect, slope, elevation, north-eastness, topographic roughness, and topographic wetness. Available water storage capacity and soil root zone depth were extracted from the USDA NRCS 30m gridded gSSURGO soil database. Gridded 800m PRISM Climate Group 30-year long-term averages for maximum and minimum temperatures and precipitation were aggregated by quarters by season (i.e., winter, cold; spring, rainy; summer, dry; fall, warm) and input as separate layers for each variable.

Table 8-1. Environmental layers used for habitat niche models for selected tree species.

Layer	Description	Source
Aspect	Direction of maximum downward gradient	(Wilson 2018)
Slope	Slope gradient	(Wilson 2018)
Elevation	Land surface height above sea level	(Wilson 2018)
North-eastness	Combines orientation with slope and correlates with moisture availability	(Amatulli et al. 2020)
Topographic Roughness	Quantitative measure of terrain heterogeneity	(Riley et al. 1999)
Topographic Wetness	Describes the effects of topography on location and size of soil saturation zones	(Amatulli et al. 2020)
Available Water Storage	Volume of water (mm) the soil type can store, to 0.25 m, that is available to plants	(Natural Resources Conservation Service 2020)
Root Depth	Depth to soil root growth restrictions (e.g., bedrock, hardpan) in top 150 cm	(Natural Resources Conservation Service 2020)
Minimum Temperature	Daily minimum temperature averaged over all days in the month; long-term averages aggregated by quarter	(Daly et al. 2015)
Maximum Temperature	Daily maximum temperature averaged over all days in the month; long-term averages aggregated by quarter	(Daly et al. 2015)
Precipitation	Monthly total precipitation (rain+melted snow); 30-year long term averages, aggregated by quarter	(Daly et al. 2015)

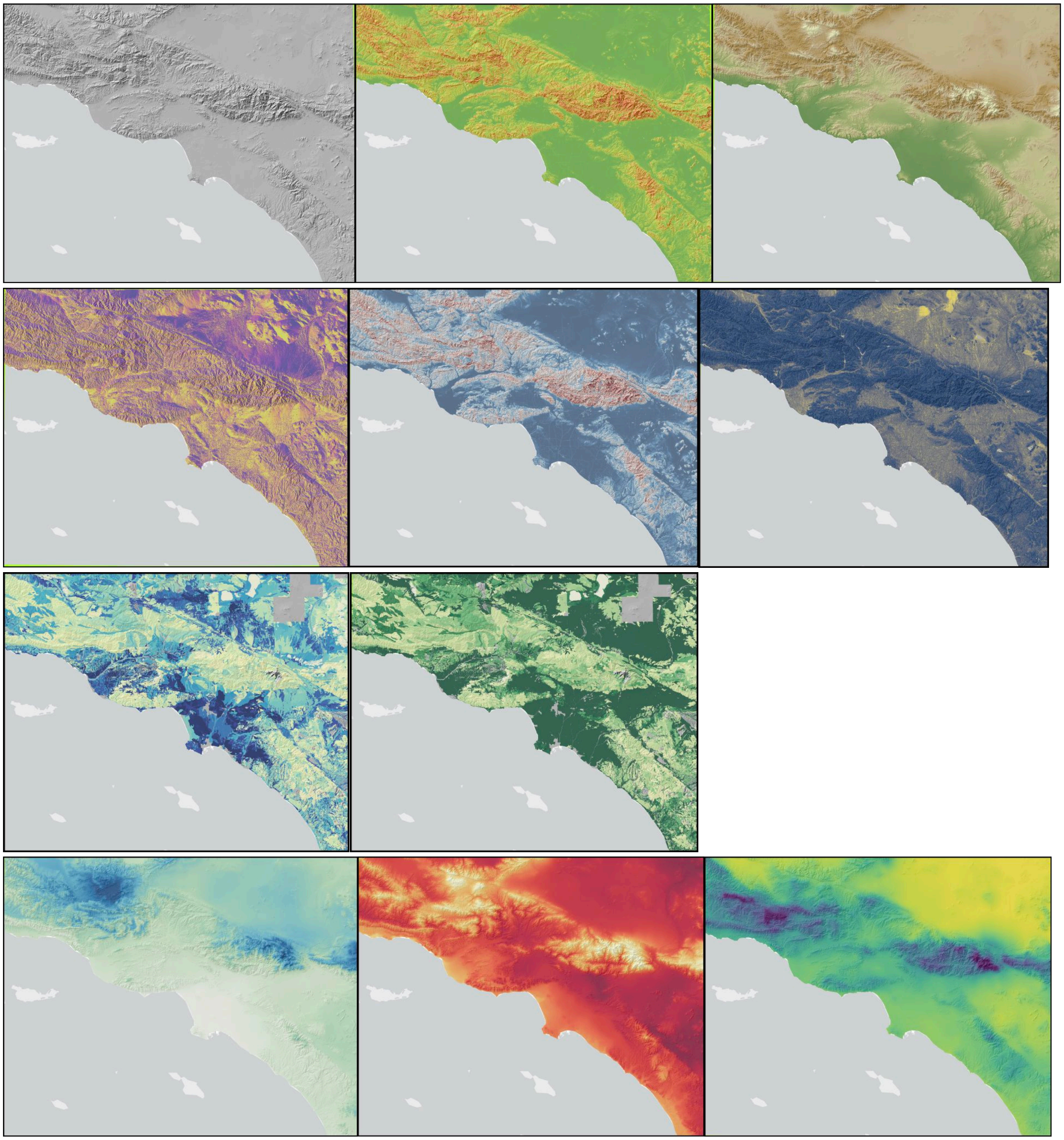

Figure 8-2. Environmental variables used in tree distribution models: Aspect, Slope, Elevation, North-eastness, Topographic Roughness, Topographic Wetness, Available Water Storage, Root Zone Depth, Minimum Temperature, Maximum Temperature, Precipitation.

Modeling Approach

We used the open source software Maxent (Phillips et al. 2017) to model potential natural vegetation. Maxent uses training data from known locations to create a "presence-only" species distribution model that can be interpreted as a percentage possibility of presence at any location across the study area. We used those percentages to visualize the results. For these 20-variable versions, we ran 500-iteration models with 500 replicates, subsampling with replacement, using training and test data at both 50/50 and 80/20 ratios. Expanding from Moravec (1998) and our previous effort for Santa Catalina Island (Longcore et al. 2018), we used contemporary and historical natural history observations and vegetation maps as training data with the current topography. Maxent provides accurate results when extrapolated to contexts different from the training data (McCune 2016), with few localities (Hernandez et al. 2008), and at the local scale (Gogol-Prokurat 2011).

Results

Training Data

Number of location points from the varied sources ranged from 477 for Mesa Oak, 1,236 for Valley Oak, 2,432 for Scrub Oak, 3,036 for Blue Elderberry, and 5,025 for Coast Live Oak (Table 8-2). The most data were obtained from iNaturalist, with additional points extracted from polygons from the Vegetation Type Maps by Wieslander and other important areas filled in by historical maps with characteristic symbols indicating Coast Live Oaks (Figure 8-3). For the species with more than 1,500 available points, 50% was used for training and 50% for testing. For less than 1,500 available points, 80% was used for training and 20% for testing.

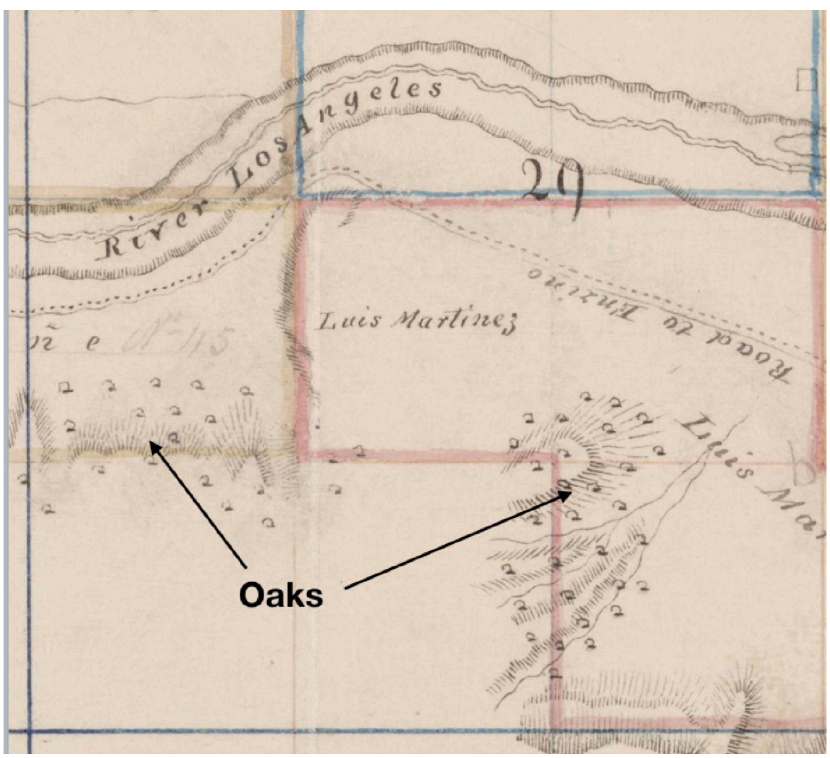

Figure 8-3. Example of oaks depicted on historical map that was georeferenced and used as model training data.

Table 8-2. Training data compiled for tree species modeling.

Name	Species	CalFlora and Others	iNaturalist	Weislander
Coast Live Oak	*Quercus agrifolia*	497 CF; 9 + 10 maps; 59 other	3,082	1,368
Valley Oak	*Quercus lobata*	71 CF	369	796
Mesa Oak	*Quercus engelmannii*	0	277	200
Scrub Oak	*Quercus berberidifolia/dumosa*	30 CF	446	1956
California Black Walnut	*Juglans californica*	208 + 69 other + 236 City of Los Angeles	826	505
Blue Elderberry	*Sambucus nigra*	329 CF	2,707	0

Model Performance

As assessed by the test Area Under Curve (AUC), the models ranged from good (Coast Live Oak, Scrub Oak), excellent (California Black Walnut, Blue Elderberry) to outstanding (Valley Oak, Mesa Oak) (Table 8-3). Climatic variables were among the top variables for most species, contributing >10% to model performance. Additionally, topographic roughness was an influential variable for Coast Live Oak, Scrub Oak, and Blue Elderberry. Elevation had high permutation importance in two models and correlates with other variables.

Table 8-3. Model performance and most influential variables by permutation importance (>10%, in order of importance).

Species	Test AUC	Top Variables
Coast Live Oak	0.7947	Elevation, topographic roughness, winter precipitation
Valley Oak	0.9017	Winter max temp; spring min temp; elevation, winter precipitation
Mesa Oak	0.9452	Winter max temp, spring max temp
Scrub Oak	0.7629	Spring precipitation, topographic roughness, elevation
California Black Walnut	0.879	Spring precipitation, winter max temp, spring max temp
Blue Elderberry	0.8103	Elevation, topographic roughness, spring max temp, winter min temp

Distribution Maps

Maps of the resulting distribution models were produced for the six taxa, using a two-level color ramp that can be interpreted as high and moderate probability of presence.

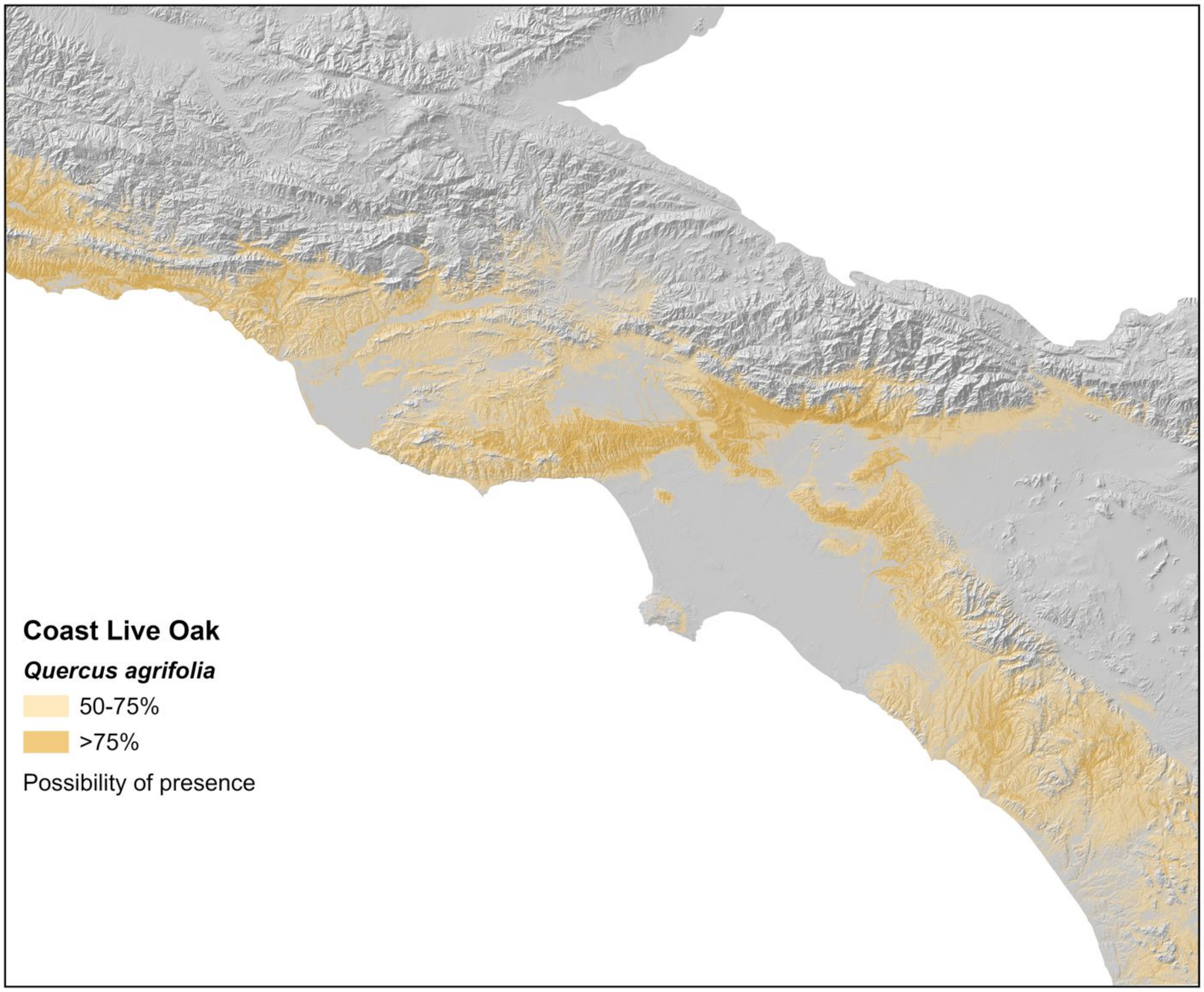

Figure 8-4. Modeled probability of presence of Coast Live Oak in Los Angeles Region.

The modeled probability of presence for Coast Live Oak reveals the Santa Monica Mountains, foothills of the San Gabriel Mountains, Repetto, Montebello and Puente Hills as likely supporting extensive oak woodlands. Riparian forests supporting oaks would have been found in the drainages into the San Fernando Valley and up through Ventura County, with denser blocks on the south-facing terraces of Santa Barbara County and in its inland valleys. High probability of presence was predicted for the Baldwin Hills, suggesting that this species was present there. The question of the Palos Verdes Peninsula remains open, with some areas mapped at 50–75% probability. The open valleys and alluvial fans of the Los Angeles and San Gabriel River watersheds appear not to have been highly suitable for Coast Live Oak.

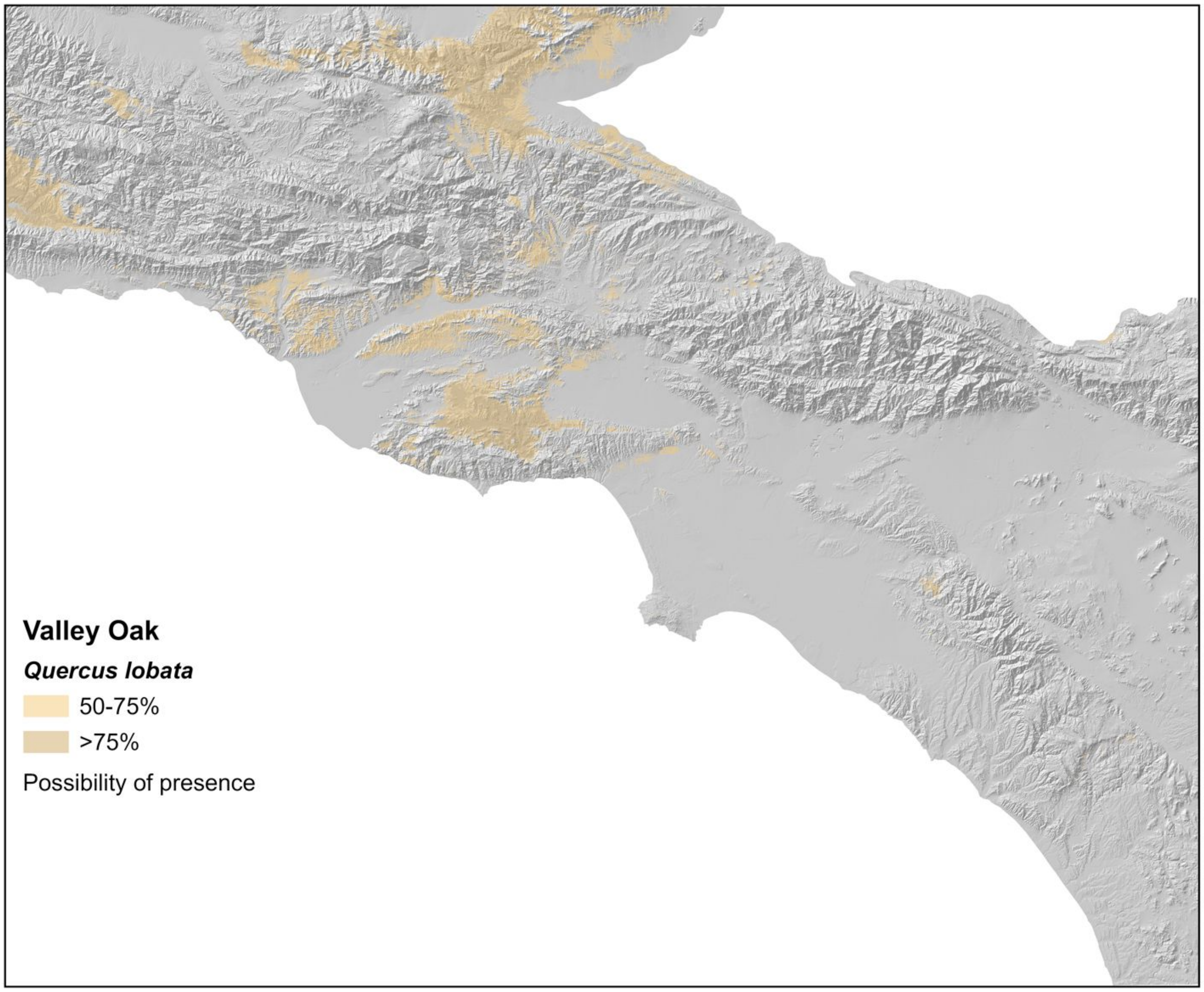

Figure 8-5. Modeled probability of presence of Valley Oak in Los Angeles Region.

Valley Oak, consistent with its current day distribution, shows high probability of presence in the Conejo Valley and in northern Los Angeles County (Figure 8-5). Highly similar environmental conditions were not found further east beyond roughly Encino, with the exception of a few areas on the southern foothills of the Santa Monica Mountains, in the Elysian Valley, and even a little in the Baldwin Hills.

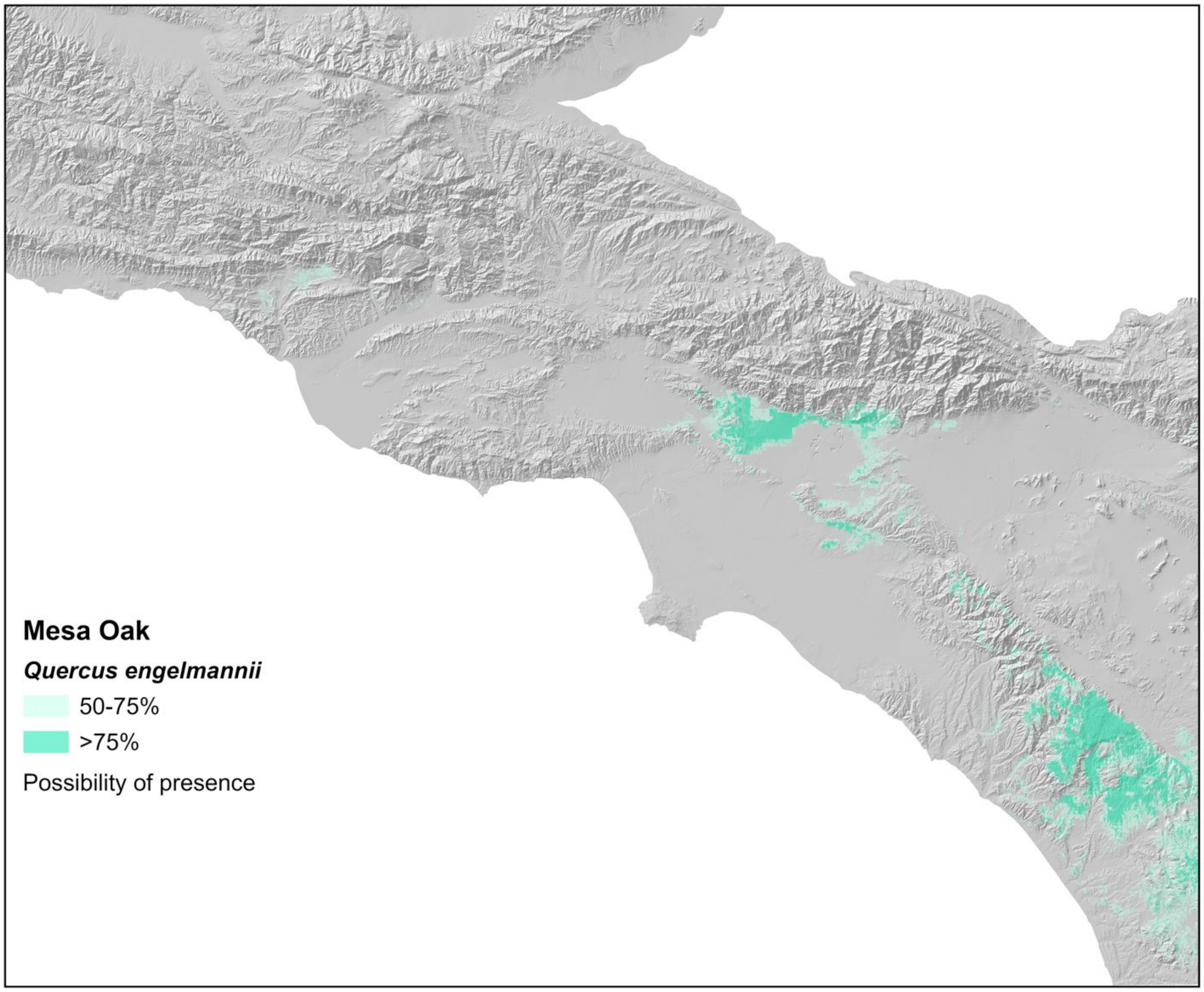

Figure 8-6. Modeled probability of presence of Mesa Oak in the Los Angeles Region.

Mesa Oak, which has always been known as a restricted-range species, is mapped as having high probability of presence in the area surrounding Pasadena and along the San Gabriel Mountain foothills heading east as well as in its known San Diego County range (Figure 8-6). High probability is mapped in the area of La Habra Heights on the Los Angeles/Orange County boundary and this may be a location of greater prevalence historically.

The distribution of Scrub Oak (*Q. berberidifolia* and *Q. dumosa*) provides an indicator of the distribution of a chaparral species in comparison with the other oaks (Figure 8-7). The highest probability of presence is found at higher elevations within the Santa Monica Mountains, Simi Hills, San Gabriel Mountains, Santa Susana Mountains and the coastal ranges to the south.

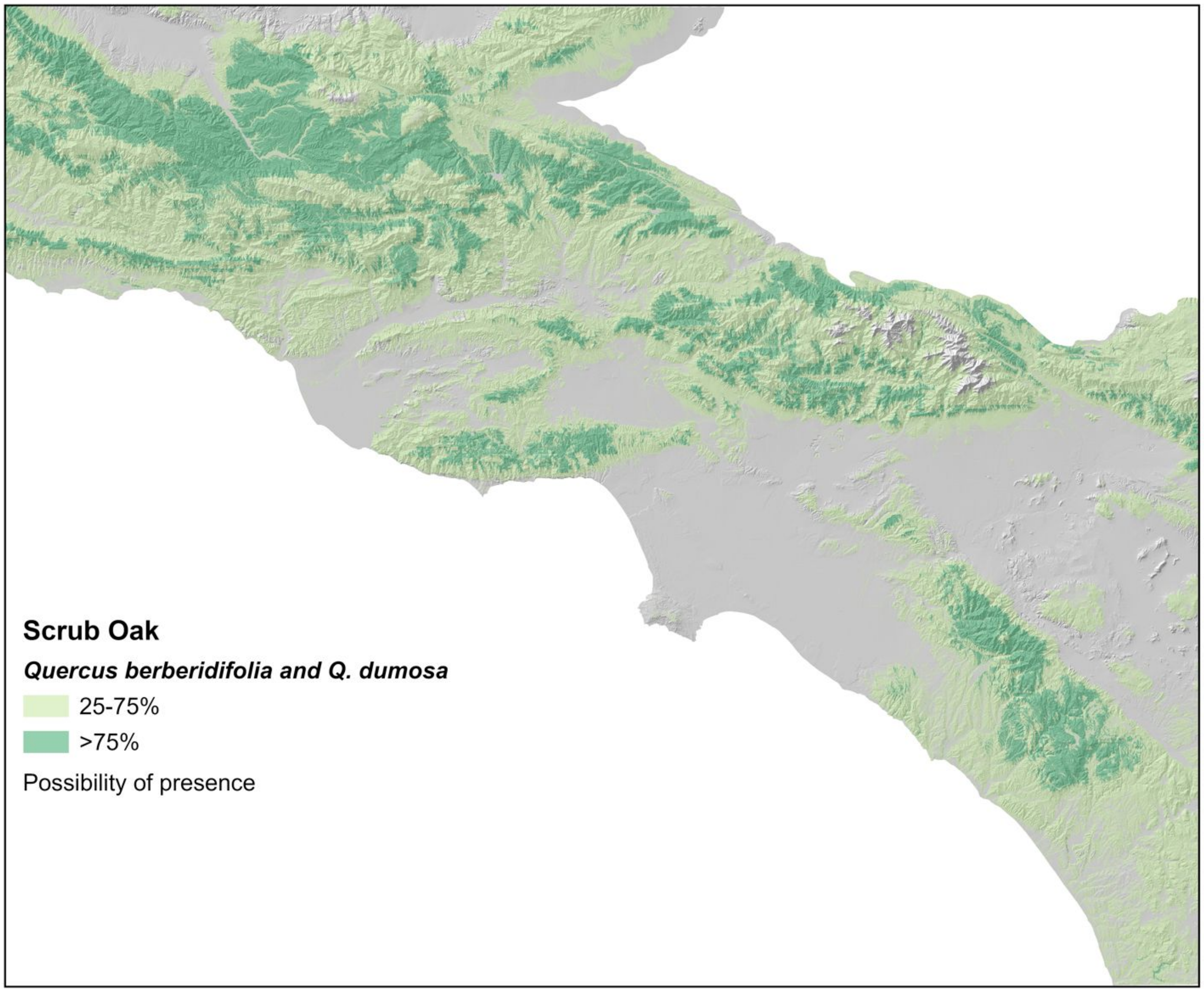

Figure 8-7. Modeled probability of presence of Scrub Oak in the Los Angeles Region.

California Black Walnut is predicted to be present throughout the Santa Monica Mountains, Simi Hills, Santa Susanna Mountains, as well as in the east Los Angeles hill, Repetto Hills, Montebello Hills, and Puente Hills, and generally along the foothills of the San Gabriel Mountains (Figure 8-8). It was also found on the Palos Verdes Peninsula, and at a lower probability of presence across the alluvial soils of the San Fernando Valley. The modeled distribution implies a considerably broader distribution than its current extent, suggesting its widespread availability to Indigenous communities and highlighting its loss to urbanization.

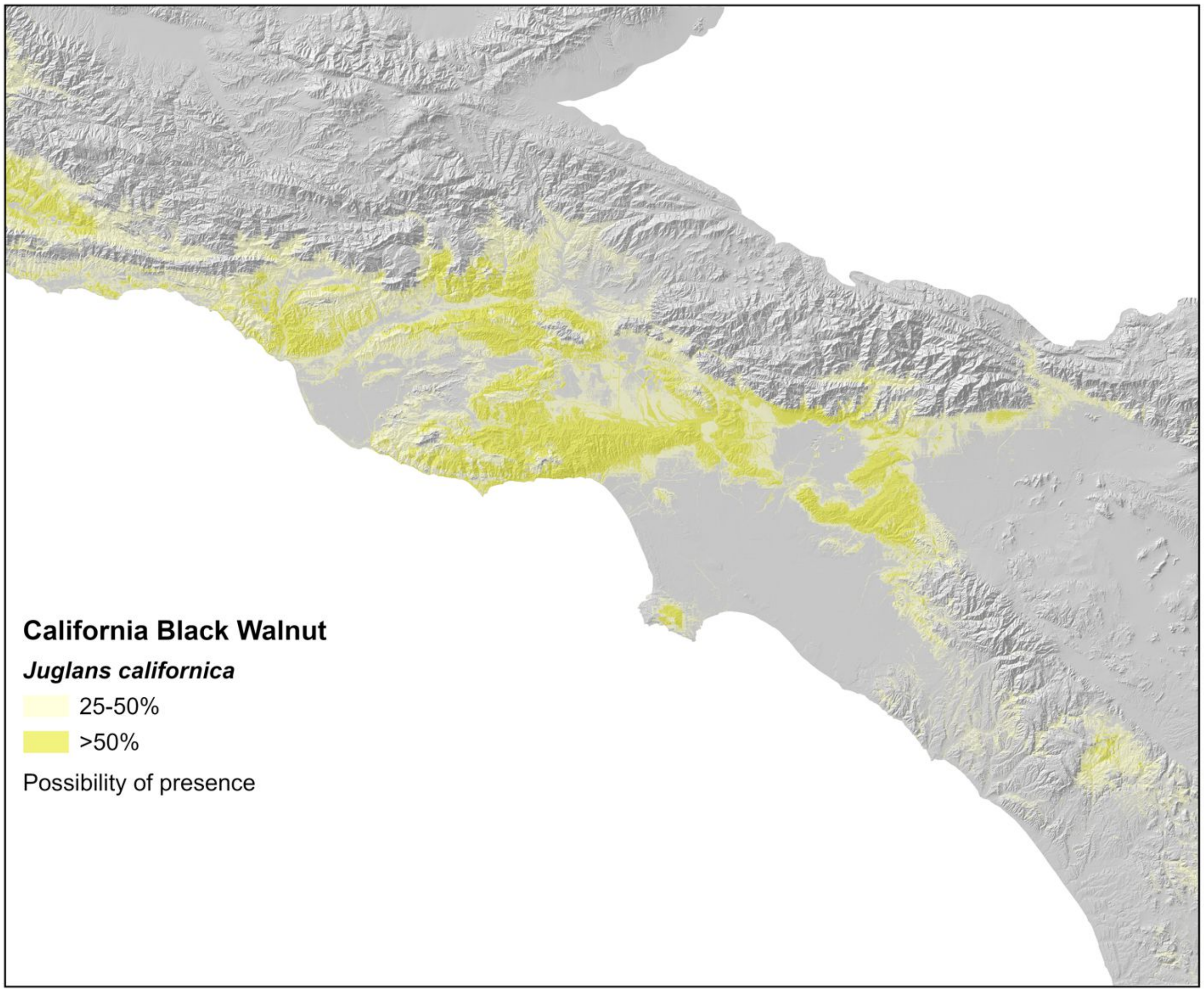

Figure 8-8. Modeled probability of presence of California Black Walnut in the Los Angeles Region.

Blue Elderberry has a high probability of presence across the mountainous regions at lower altitudes, but not on any of the flat plains or valleys (Figure 8-9). Because modeling was undertaken with the current DEM, various landscape modifications, including freeways and flood channels (which are still called rivers and creeks) appear as suitable habitat when those locations historically would not have had the appropriate conditions. The models do suggest a widespread adaptability of the species to appropriate conditions within localized drainages.

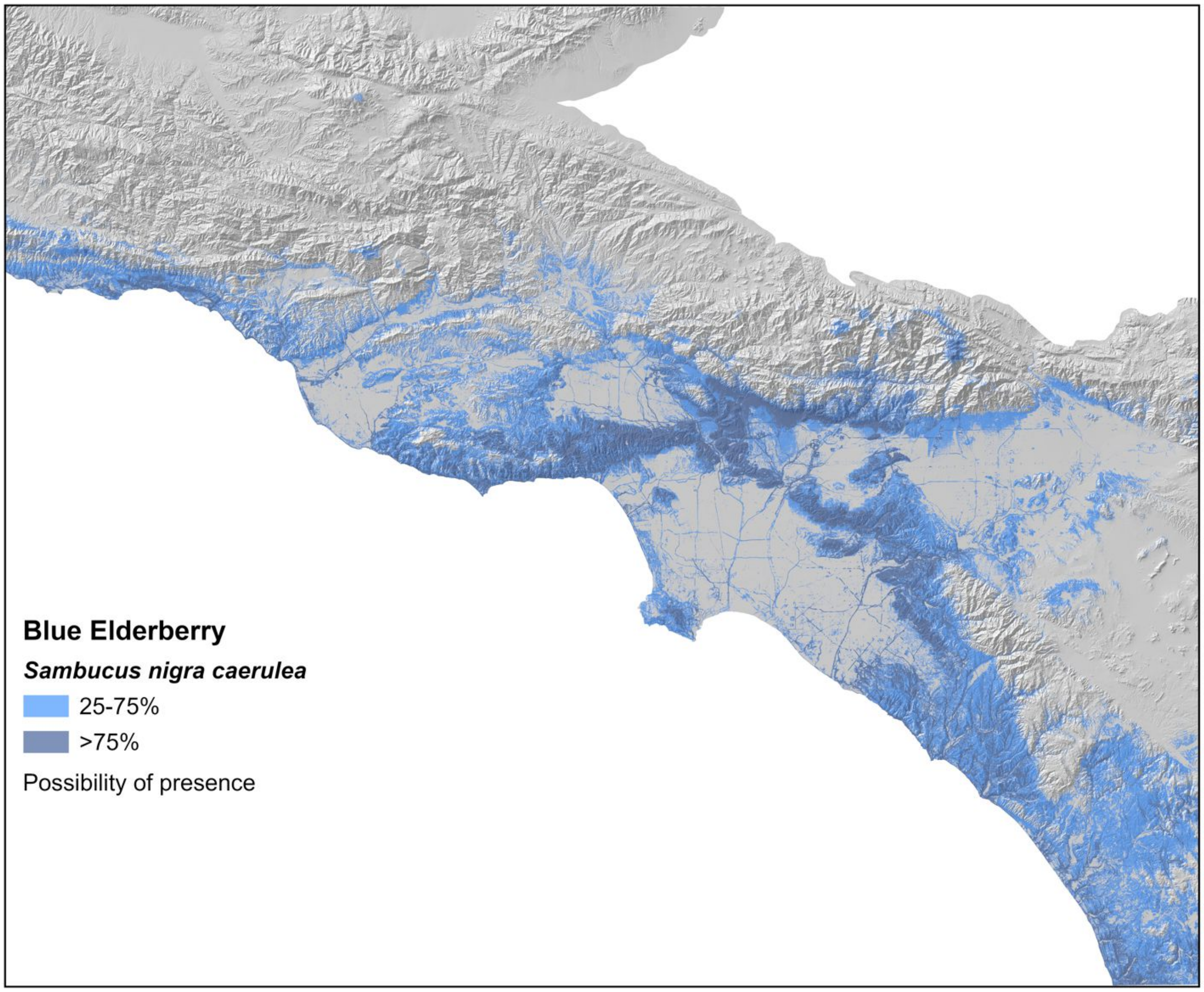

Figure 8-9. Modeled probability of presence of Blue Elderberry in the Los Angeles Region.

Discussion

The regional habitat suitability maps produced for these culturally important species provide additional insight on the historical landscape and its management. Our approach reflects an extrapolation of current and historical patterns that can identify areas that were similar to occupied areas but for which we do not have current records. This provides a parallel line of evidence for understanding human landscape use.

The three tree oak species (*agrifolia*, *lobata*, and *engelmannii*) each show major areas of prevalence, with *agrifolia* being the most widespread. The models suggest high suitability on both the north and south slopes of the Santa Monica Mountains, and eastward through the foothills of the San Gabriel Mountains, which is reasonably consistent with, but provides much greater spatial resolution than our previous potential natural vegetation maps (Ethington et al.

2020). Whether there were native oaks on the Palos Verdes Peninsula is not clearly answered. It certainly has greater than average habitat value for *Q. agrifolia*, although not the highest values. For *Q. lobata*, it has high similarity with that species core habitat in the inland portion of the western Santa Monica Mountains. There are not, however, any remnant Valley Oaks recorded from the Palos Verdes Peninsula, so it is entirely possible that it simply did not have the appropriate conditions. Habitat values for California Walnut are modeled to be higher on the peninsula and indeed old walnuts still persist there.

The modeled distribution for California Walnut is especially interesting because it contains so many areas that have been converted to urban land uses. Its modeled distribution surrounding Shevaanga is consistent with Indigenous descriptions of walnut collecting areas in this region. The models also suggest higher suitability values on the washes that extend across the San Fernando Valley than on the surrounding plains, suggesting the possibility that these seasonal features produced deep soils that were preferred by the species and that it was found scattered across the otherwise open plain (see historical distribution maps compiled in Longcore and Noujdina 2022).

The habitat models do indicate that many areas of the upland hills and plains of the Los Angeles plain and the surrounding valleys were not originally treed. Our previous assumptions that the landscape outside of the foothills and floodplains was dominated by a mix of coastal sage scrub, grassland and flowerfields, and seasonally inundated wet meadows and alkali meadows (Ethington et al. 2020) were upheld by the distribution models for these tree species.

We did not model riparian associated trees because those layers were only produced late in the current project, and certainly there were trees associated with the creeks and ponds (willows, mule fat) and with the Los Angeles River, Arroyo Seco, Rio Hondo and San Gabriel Rivers as previously documented (Stein et al. 2007, Longcore 2016), both in the active floodplain (willows, cottonwoods, alders), and on low terraces (oaks, sycamores). Because we lacked training data for riparian terrace *Q. agrifolia* distributions, a future refinement of these models could focus on such areas. For example, old growth *Q. agrifolia* are known from El Dorado Regional Park and additional locations could be gleaned from notes and old topographic maps to contribute to modeling the riparian distribution of this species along with other active channel and gallery forest species. Results are likely to mirror floodplain forest dynamics reported from archival sources for the Santa Clara and Ventura rivers (Beller et al. 2011).

The models also raise the possibility that Indigenous people were moving species around the landscape to suitable locations. We cannot know if the California Black Walnuts found on the Palos Verdes Peninsula (and still persisting) were dispersed there naturally or by humans. The Mesa Oak has the greatest probability of presence values on inland mesas from Los Angeles to San Diego County. An individual that may be naturally occurring is found on the south slope of

Catalina Island and apparently thriving (https://www.inaturalist.org/observations/16142749). Our models did not extend to the Channel Islands, but such instances support the possibility that additional areas where these native plants can survive exist and that Indigenous travel and trade patterns are highly likely to have contributed to the distributions of culturally important tree species before their first mapping by Western botanists.

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Chapter 9 Spontaneous Urban Vegetation: Echoes of the Past

Anthony E. Baniaga

Introduction

The California Floristic Province is a global hotspot for vascular plant diversity (Mittermeier et al. 2011), and Southwestern California, a physiographic unit of the province, contains some of the highest species diversity and endemism in the state (Burge et al. 2016; Baldwin et al. 2017). This region includes the entirety of the Los Angeles Basin, which has experienced a layering of human induced landscape modification and changes in stewardship practice over the last several hundred years. The Los Angeles Basin today is an urbanized landscape home to over four million people. How people interact with this landscape has a direct effect on plant diversity, at both regional and local scales.

Floristic studies of the Los Angeles Basin to date have included it as part of a larger regionwide work such as the *Flora of Los Angeles and Vicinity* by LeRoy Abrams (1904), have included it as part of the lower foothills of the Santa Monica Mountains (Raven et al. 1986), or have used herbarium specimens to reconstruct historical plant communities and associations (Mattoni & Longcore 1997). Few studies have studied contemporary plant diversity in the urban landscape of the Los Angeles Basin, and those that have were focused exclusively on cultivated plants (Clarke et al. 2013; Pataki et al. 2013; Avolio et al. 2015; Avolio et al. 2020). In order to better understand spatial patterns of plant diversity in the urban landscape of the Los Angeles Basin, and at a time of rapid environmental change, a floristic study of this area was conducted. This study was done via a series of walking transects and checklists of spontaneously growing plants of urban parkways throughout neighborhoods distributed throughout the city. These neighborhoods represented all four of the Home Owners' Loan Corporation (HOLCs) grades for the region as well as a mix of hypothesized potential upland and wetland vegetation plant communities.

Methods

Site Selection

A total of sixteen different sites were chosen throughout the Los Angeles Basin (Figure 9-1 and Figure 9-2), that roughly correspond with named neighborhoods. Sites were chosen by intersecting ArcGIS Feature Layers of LA County Home Owners' Loan Corporation (HOLC) "redlining" with the Hypothesized Potential Natural Vegetation of the Los Angeles River Watershed and Environs layer (Longcore et al. 2020). Sites were chosen so that each HOLC grade (A, B, C, D) had two types of potential upland and two types of potential wetland plant community types (Table 9-1). The types of potential upland plant community types included Coastal Sage Scrub and Foothill and Valley Woodland. The types of potential wetland plant community types included Vernal Pool, Wet Meadow, Salt Marsh, and Freshwater Marsh. Further site selection included limiting transect areas to areas away from main car-trafficked roads, selecting only neighborhoods with sidewalks that had parkways, and requiring that each site had at least twenty parkway blocks to sample.

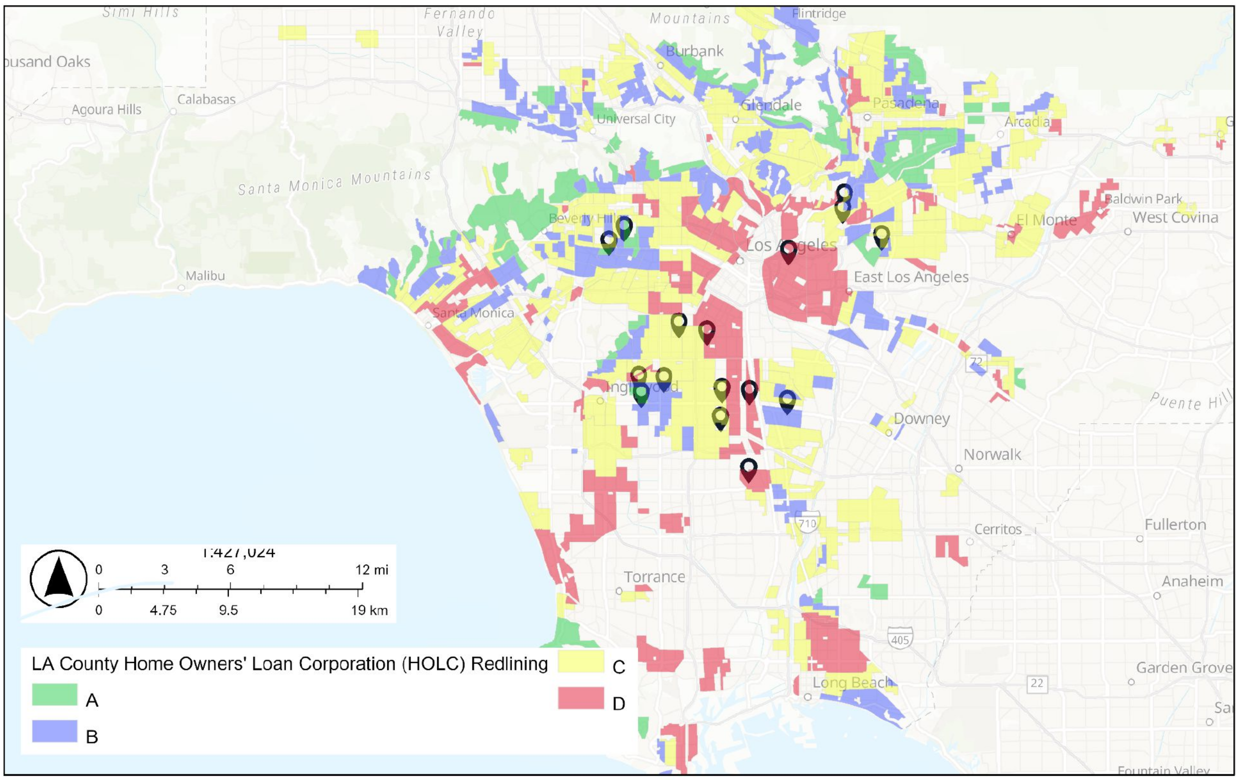

Figure 9-1. Map of the Home Owners' Loan Corporation (HOLC) redlining for the study area with all sixteen sites marked.

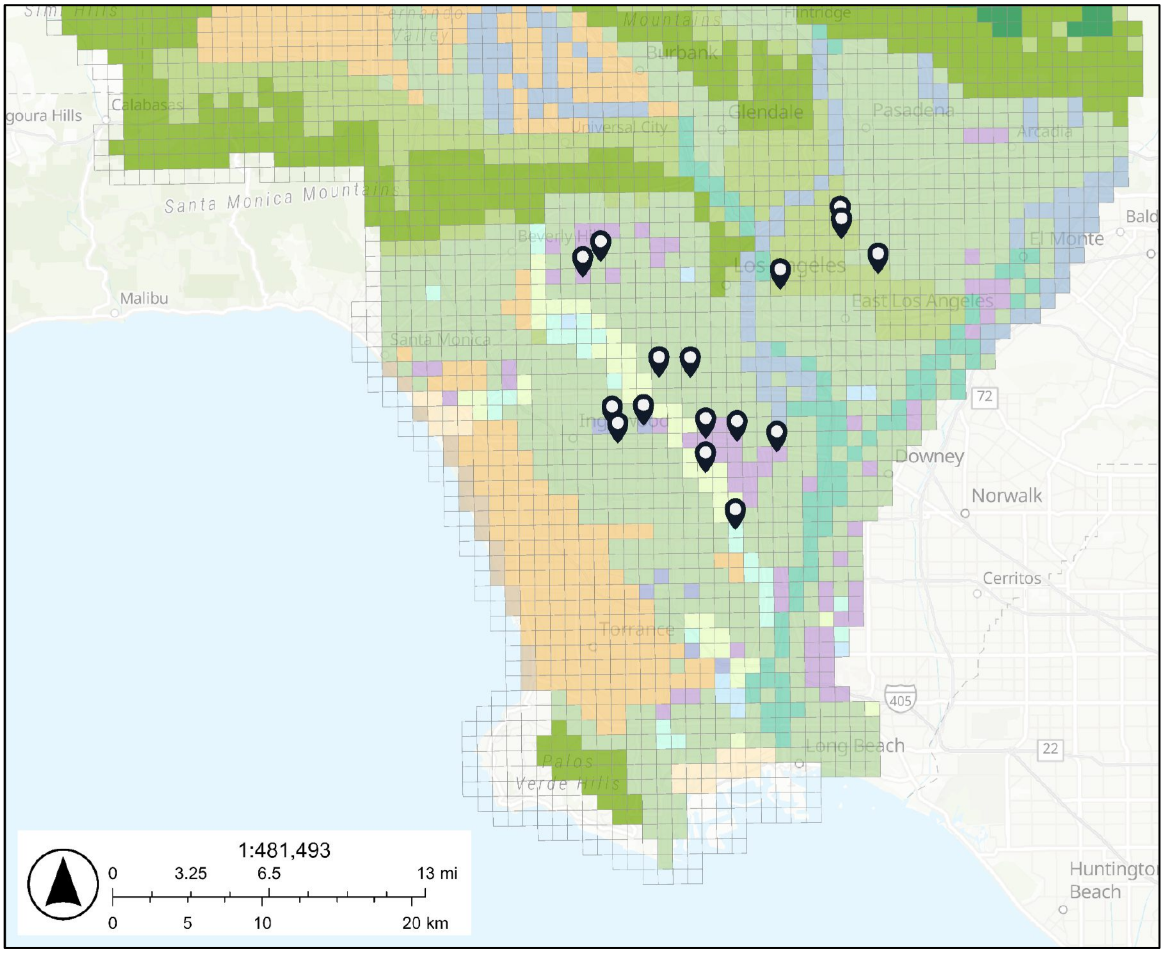

Figure 9-2. Map of Sites Relative to Hypothesized Potential Natural Vegetation of the LA Basin (Longcore et al. 2020).

Table 9-1. List of sites and neighborhoods sampled by transects across the LA Basin.

Site	HOLC Grade	Potential Natural Vegetation	Neighborhood
ACS	A	Coastal Sage Scrub	Hancock Park
AFW	A	Foothill and Valley Forests and Woodlands	Monterey Park
AVP	A	Vernal Pool	Inglewood
AWM	A	Wet Meadow	Miracle Mile
BCS	B	Coastal Sage Scrub	Hyde Park
BFW	B	Foothill and Valley Forests and Woodlands	Aurant, El Sereno
BVP	B	Vernal Pool	Van Ness, South LA
BWM	B	Wet Meadow	South Gate

CCS	C	Coastal Sage Scrub	Vermont Square
CFW	C	Foothill and Valley Forests and Woodlands	Aurant, El Sereno
CSM	C	Salt Marsh	Avalon, Hacienda Village
CWM	C	Wet Meadow	Avalon Gardens
DCS	D	Coastal Sage Scrub	Vermont, South Park
DFM	D	Freshwater Marsh	Florence, Graham
DFW	D	Foothill and Valley Forests and Woodlands	Boyle Heights
DWM	D	Wet Meadow	Rosewood

Field Methods

After each site was selected, a hand drawn map of the blocks at each site was made to connect transect numbers to each block sampled and facilitate field sampling and spatial navigation. Each transect corresponded to one block, from the intersection of one street to the intersection of another street, regardless of length. For each transect the presence of every single vascular plant was recorded. A custom data sheet checklist was devised of commonly encountered spontaneously growing vascular plants in the region, with space for additional taxa and notes. Spontaneously growing plants were defined as individuals that were reproducing vegetatively or sexually beyond their initial introduction point or phase in their life cycle. This definition permitted the inclusion of taxa that were likely introduced to the area by seed, such as that from bird seed mixes, that germinated and were beginning a different phase of their life cycle.

Unknown plants were identified using a variety of resources including the Jepson Manual (Baldwin et al. 2012), the UCLA Herbarium (LA), the Consortium of California Herbaria (CCH2 Portal 2023), and iNaturalist (iNaturalist.org). Herbarium vouchers were deposited at the UCLA Herbarium (LA) at the University of California, Los Angeles campus. Certain taxa did not permit the accurate identification at the time of observation and were lumped into a single genus. This occurred for *Erigeron* spp., which includes *Erigeron bonariensis*, *E. canadensis*, and *E. sumatrensis*; *Polycarpon* spp., which includes both *Polycarpon depressum* and *P. tetraphyllum*; *Solanum* spp., which includes *Solanum americanum*, *S. nigrum*, and *S. douglasii*; as well as several prostrate *Euphorbia* spp. that were lumped into that taxonomic unit.

Area based measurements were performed using a combination of methods. In the field, at the start of each transect the width of the transect was estimated by recording the number of steps and later converting the number of steps to meters with meter tape. After transects were conducted, the length measurement tool of Google Maps was used to estimate the total transect length of each transect. Both the length and width of transects were used to calculate total area sampled per transect and across all transects at a given site. These measurements were used to normalize species richness per transect by area sampled by transect. This was done by calculating the number of species observed (species richness) per m^2 of transect.

Results

Overall Patterns of Diversity

Between the end of January and middle of March 2022, 370 transects were walked with a cumulative sum of over 48 total linear transect miles. On average, about three transect miles were walked per site via twenty to thirty transects. Across all transects and sites, 168 total spontaneous taxa were observed across all sites with an average of 26 taxa per transect and range of 13 to 40 taxa observed per transect. This data is publicly available on Data Dryad (https://doi.org/10.5068/D1469S) as a matrix of 370 rows of labeled transects by 168 columns of taxonomic units presence/absence for all transects.

The most commonly encountered taxa were introduced herbaceous annuals or short-lived perennials. Many of these taxa were routinely observed regardless of transect site (Table 9-2). Perennial woody taxa or those that attain secondary woody growth were nearly restricted to trees (Table 9-3), with few exceptions. Many of these spontaneously growing trees likely escaped from plants of nearby yards or descended from street trees. Similarly, a number of spontaneously growing herbaceous taxa likely reflect local escapes from human cultivation for medicinal and/or culinary properties (Table 9-4).

Table 9-2. The most commonly encountered spontaneously growing plants. The number of total transects each taxon was observed is listed in parentheses following the scientific name.

Family	Taxon	Common name
Asteraceae	*Sonchus oleraceus* (341)	sow thistle
Poaceae	*Pennisetum clandestinum* (337)	kikuyu grass
Asteraceae	*Taraxacum erythrospermum* (336)	red-seeded dandelion
Poaceae	*Cynodon dactylon* (335)	Bermuda grass
Poaceae	*Poa annua* (334)	annual blue grass
Poaceae	*Ehrharta erecta* (329)	panic veldt grass
Fabaceae	*Medicago polymorpha* (328)	California burclover
Asteraceae	*Cotula australis* (328)	Australian cotula
Brassicaceae	*Lepidium didymum* (327)	lesser swine cress
Malvaceae	*Malva parviflora* (320)	cheeseweed

Table 9-3. Commonly encountered spontaneously growing trees.

Family	Taxon	Common name(s)
Arecaceae	*Washingtonia robusta*	Mexican fan palm
Moraceae	*Ficus carica*	edible fig
Moraceae	*Ficus microcarpa*	Chinese banyan, indian laurel
Myrtaceae	*Psidium guajava*	guava, yellow guava
Sapindaceae	*Cupaniopsis anacardioides*	tuckeroo, carrotwood
Ulmaceae	*Ulmus parvifolia*	Chinese elm, lacebark elm

Table 9-4. Commonly encountered spontaneously growing plants with medicinal and/or culinary properties.

Family	Taxon	Common name(s)
Asteraceae	*Bidens pilosa*	beggar-ticks
Asteraceae	*Galinsoga parviflora*	gallant soldier, guasca
Asteraceae	*Chrysanthemum parthenium*	feverfew
Amaranthaceae	*Dysphania ambrosioides*	Mexican tea, epazote
Cannabaceae	*Cannabis sativa*	cannabis
Lamiaceae	*Mentha spicata*	spearmint
Lamiaceae	*Origanum vulgare*	oregano
Papaveraceae	*Papaver somniferum*	opium poppy
Rutaceae	*Ruta graveolens*	rue, ruta

Native Plants

Observations of spontaneously growing native plants were uncommon in urban parkways of the Los Angeles Basin. Native plants were observed in 32 of the total 370 transects, and of the total 168 observed taxonomic units, 12 were considered native. The most commonly encountered native taxon was California poppy (*Eschscholzia californica*), which was found in both potential upland and wetland vegetation communities and in all four HOLCs.

Most observations of native taxa were found in sites determined as hypothesized potential Foothill and Valley Forests and Woodlands, regardless of HOLCs (Table 9-5). These hypothesized potential vegetation layers match that habitat type where these taxa might be found naturally. Additionally, two observations of wetland plants also match the potential vegetation layer in which they were found. This includes the observation of the native marsh pennywort (*Hydrocotyle verticillata)* in potential Wet Marsh vegetation, and alkali weed (*Cressa truxillensis*) in potential Salt Marsh (Figure 9-3). These observations hint at possible but extremely rare remnant natural wetland vegetation in urban parkways of the LA Basin.

Table 9-5. List of native taxa and the sites of observation. Site acronyms follow those of Table 9-1.

Family	**Taxon**	**Common name**	**Site(s) Observed**
Araliaceae	*Hydrocotyle verticillata*	marsh pennywort	DWM
Asteraceae	*Ambrosia psilostachya*	western ragweed	DFM
Asteraceae	*Helianthus annuus*	annual sunflower	DCS, DFW, DWM
Boraginaceae	*Amsinckia menziesii*	fiddleneck	DFW
Fabaceae	*Lupinus succulentus*	arroyo lupine	AFW
Fagaceae	*Quercus agrifolia*	coastal live oak	ACS
Malvaceae	*Malvella leprosa*	alkali-mallow	AFW
Onagraceae	*Epilobium ciliatum*	willowherb	ACS, AVP, AWM
Papaveraceae	*Eschscholzia californica*	California poppy	AWM, BFW, BVP, CCS, CFW, DWM
Plantaginaceae	*Cressa truxillensis*	alkali weed	CSM
Rosaceae	*Heteromeles arbutifolia*	toyon	AFW
Rosaceae	*Prunus ilicifolia* ssp. *lyonii*	Catalina cherry	AFW

Figure 9-3. Field photos of native wetland plants found in urban parkways of the LA basin in hypothesized potential wetland plant communities. The photo on the left depicts Hydrocotyle verticillata *(marsh pennywort) which was found in Wet Marsh, and the photo on the right depicts* Cressa truxillensis *(alkali weed) found in Salt Marsh. Photos taken by Anthony Baniaga.*

Site Patterns of Species Richness

Area normalized species richness (taxa/m^2) varied among the sites sampled by an order of magnitude (Table 9-6). The sites with the highest species richness (0.042 taxa/m^2) were both A redlining grades and from hypothesized potential wetland (Freshwater Marsh, Wet Meadow) sites. The site with the lowest species richness was a 'C' redlining grade of hypothesized potential Coastal Sage Scrub (0.021 taxa/m^2). In general, 'A' redlining grade sites tended to have higher species richness than other redlining grades and hypothesized potential Foothill and Valley Forests & Woodlands tended to have higher species richness than other plant community types regardless of redlining grade.

Table 9-6. Metrics of species richness and area transected by site.

Site	Total Area Transected (hectares)	Mean Transect Species Richness	Mean Taxa per m^2
AFW	1.52	27	0.042
AWM	1.34	26.1	0.042
BFW	2.65	29.7	0.039
CSM	1.61	22.9	0.036
DFW	1.66	27.1	0.036
AVP	1.91	26.5	0.035
DCS	1.97	22.5	0.035
DFM	1.65	21	0.035
BCS	1.41	20	0.033
BVP	1.95	25.4	0.031
DWM	1.92	25.2	0.029
ACS	2.53	28.5	0.027
BWM	2.38	27.9	0.026
CWM	2.04	24.4	0.025
CFW	3.21	29.3	0.023
CCS	2.61	27.7	0.021

Discussion

The public urban parkways of the LA Basin contain a surprising number of spontaneously growing vascular plant taxa. The plants found in these parkways are filtered by the interaction of cultural attitudes of these spaces and also by abiotic factors such as temperature and water availability. This study aimed to record this vascular flora at a time of rapid environmental and socio-economic change for the LA basin by sampling sites and neighborhoods graded by the HOLC and also areas with hypothesized potential upland and wetland natural vegetation communities.

Although many of the taxa encountered in the urban parkways were introduced short-lived annuals or perennials, a few native plant taxa were found. Some of these native taxa are likely recently established, such as that of the California poppy (*Eschscholzia californica*) or annual sunflower (*Helianthus annuus*), which likely came from wildflower seed mixes, and can be found in a variety of HOLC and hypothesized potential vegetation communities. However, others such as the arroyo lupine (*Lupinus succulentus*), marsh pennywort (*Hydrocotyle verticillata*), and akali weed (*Cressa truxillensis*) may represent remnants of plant communities of which they are hypothesized to inhabit. The possibility of this rare remnant native flora in public urban parkways needs more attention and study.

This floristic work was done during the winter months of January through the middle of March. For the LA Basin, this coincided well with the growth and reproduction of many cool season adapted taxa such as those from Mediterranean regions. However, the timing of the transects may have excluded warm season adapted or C4 taxa that had not yet germinated or grown to a suitable phase for field observation and identification. Future work should consider sampling during summer months.

This study demonstrated that simple floristic checklists of neighborhood blocks can produce valuable ecological data, and that the methods are replicable in both space and time. The data generated by this research is publicly available on Data Dryad for future work on the ecology of the LA Basin and other urban ecosystems worldwide. This study shows that the spontaneous urban flora of the LA Basin is worth investigating, and this study was just the start.

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