

# FINAL REPORT

## SOUTH SANTA CLARA VALLEY HISTORICAL ECOLOGY STUDY

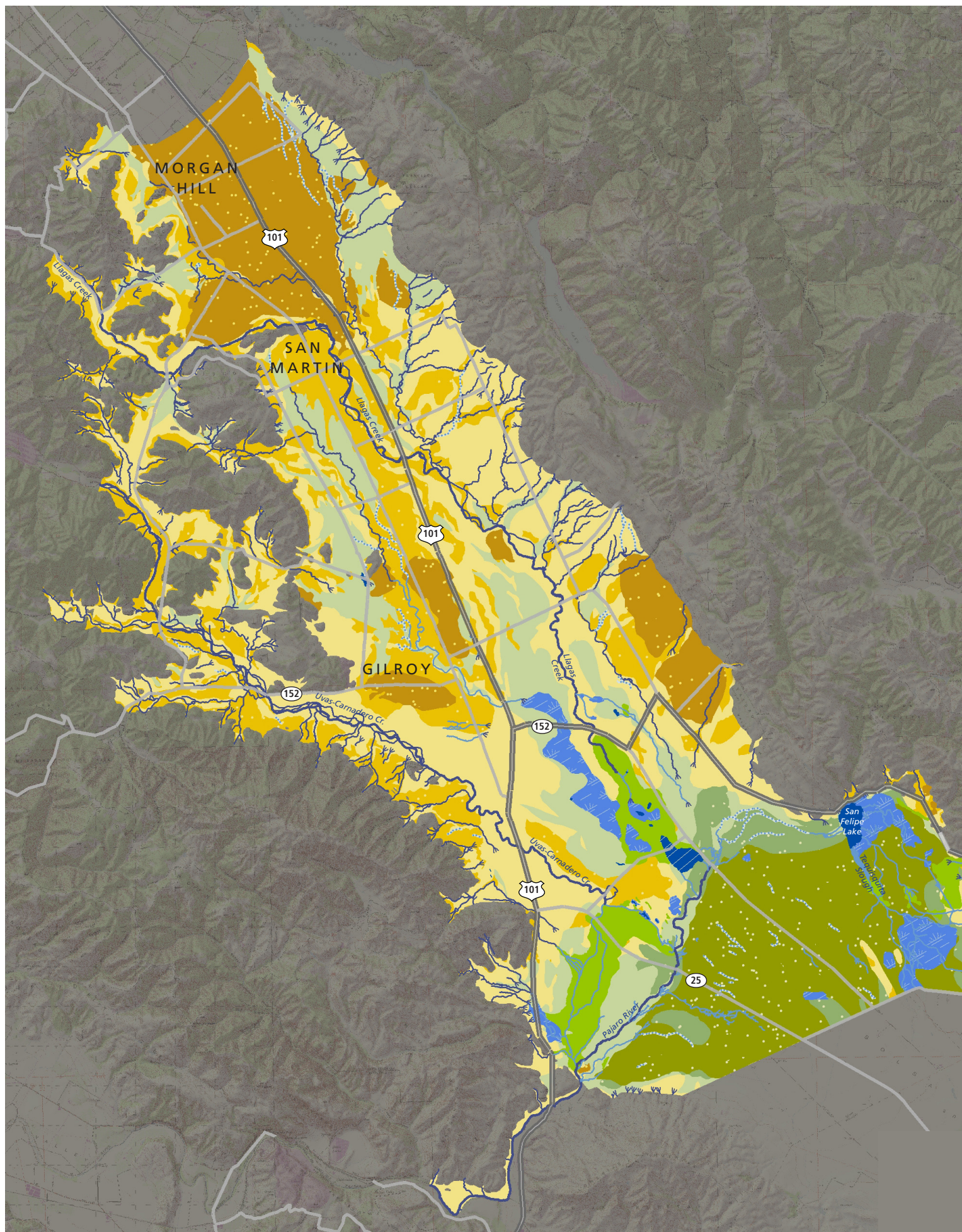
INCLUDING SOAP LAKE, THE UPPER PAJARO RIVER, AND LLAGAS, UVAS-CARNADERO, AND PACHECO CREEKS



SAN FRANCISCO ESTUARY INSTITUTE

PREPARED FOR THE SANTA CLARA VALLEY WATER DISTRICT  
AND THE NATURE CONSERVANCY  
MAY 2008

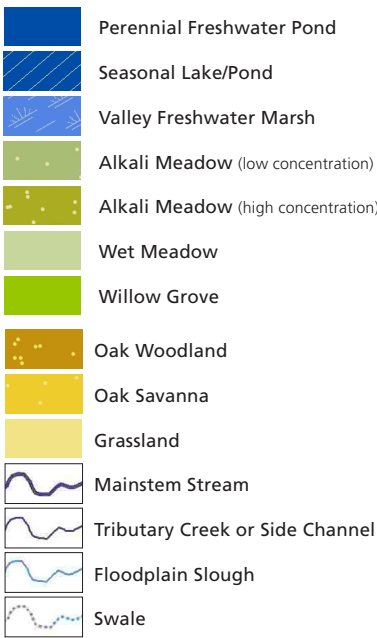




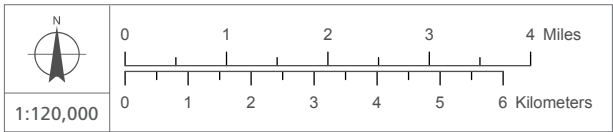
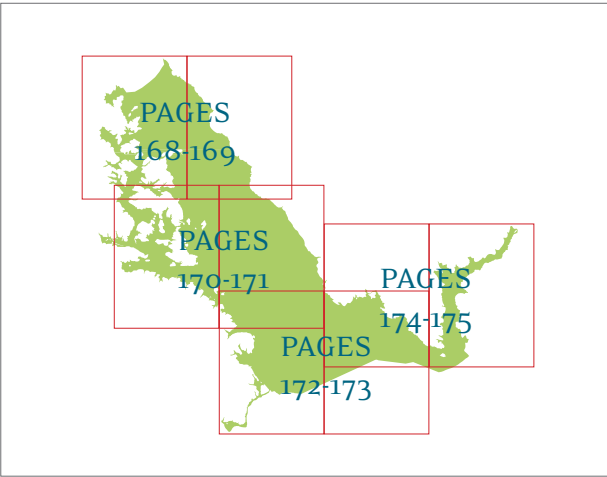




HISTORICAL CONDITIONS, CIRCA 1800



The map at left reconstructs the habitat characteristics of south Santa Clara Valley prior to significant Euro-American modification. More detailed views are provided on pages 168 through 175, in the map sections shown below.







**FINAL REPORT MAY 2008**

## **SOUTH SANTA CLARA VALLEY HISTORICAL ECOLOGY STUDY**

**INCLUDING SOAP LAKE, THE UPPER PAJARO RIVER, AND  
LLAGAS, UVAS-CARNADERO, AND PACHECO CREEKS**



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Front cover: Irrigation canal on Emery Ranch, Soap Lake, looking downstream, ca. 1900.  
Courtesy of the San Benito County Historical Society

Title page: Diseño showing Llagas and Carnadero creeks.  
Courtesy of The Bancroft Library, UC Berkeley



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# EXECUTIVE SUMMARY

## OVERVIEW

This report synthesizes an array of historical records to document historical conditions, landscape trends, and restoration opportunities in the southern part of the Santa Clara Valley. It has been developed at the request of the Santa Clara Valley Water District (SCVWD) and The Nature Conservancy (TNC) to inform strategies for natural flood protection, habitat conservation and restoration, and other environmental management challenges.

To develop the historical data set for this study, we reviewed thousands of historical records at local and regional archives. Several hundred of these contributed useful information to the study. Historical records were compiled into a geo-database and synthesized into a composite map describing landscape conditions prior to significant Euro-American modification. Data collection and analysis focused on the south Santa Clara Valley, from Morgan Hill south to Shore Road. This area includes the heavily modified alluvial channels, fans, and floodplains of Uvas-Carnadero, Llagas, and Pacheco creeks, the upper Pajaro River, and most of the Soap Lake floodplain. Approximately 80% of the study area is located in Santa Clara County; the southern portion of the study area extends across the Pajaro River (the county line) into San Benito County to include its floodplain. This area includes San Felipe Lake and its surrounding lowlands, often called the Bolsa.

The historical record for south Santa Clara Valley (“South Valley”) represents a robust resource for understanding how contemporary conditions have evolved and identifying the potential strategies for environmental recovery. The map of historical habitats shows how the local landscape successfully supported native species in the relatively recent past and, in many cases, suggests the physical factors that control habitat formation and maintenance. In the context of information about present-day conditions and future projections, historical ecology can be used by scientists, policy makers, and local residents to design locally appropriate plans that are supported by persistent landscape processes.



## FINDINGS

### LANDSCAPE LEVEL

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The native South Valley landscape supported a diverse array of habitats, from dense valley oak woodlands in the north to repeating wetland mosaics in the southern part of the study area. The valley was almost evenly divided between grassland, oak savanna/woodland, and wetlands (including seasonal and perennial wetlands).

Historical habitat distribution was heterogeneous and can be largely explained by identifiable physical characteristics. Factors such as topography, soils, and hydrology are still likely to affect restoration potential. Consideration of historical habitat controls should improve the likelihood of restoration success.

Some of the native habitats and species that have experienced greatest local decline – such as sycamore alluvial woodland, lesser nighthawk, and least Bell’s vireo – are at the northern margin of their historical range. Given anticipated climate changes and associated shifts in species range, these may be of greater local conservation importance in the future.

### STREAMS AND RIPARIAN HABITATS

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Prior to Euro-American settlement, the South Valley drainage network was much more discontinuous and diffuse. Streams commonly did not maintain defined channels across the entire valley floor. Instead, they sank into their alluvial fans and recharged groundwater, or spread into wetlands. Many channels were relatively shallow and prone to flooding. Sloughs and swales were common.

The drainage network has been expanded to drain the valley floor. Over 40% of the contemporary channel network was artificially constructed using new alignments.

Most of the valley floor stream reaches were historically intermittent. Extensive historical evidence confirms that long reaches of Uvas-Carnadero, Llagas, and Pacheco creeks were seasonally dry across the valley floor.

Some intermittent reaches had persistent pools fed by subsurface flow. Pools were valued as fishing and swimming holes from native times through the early 20th century.

There were limited perennial stream reaches on the valley floor. Perennial flow on major creeks appears to have extended some distance downstream from the canyon mouth and, in some cases, reappeared where the lower reaches of streams intercepted groundwater.

The Pajaro River had unique ecological and hydrogeomorphic characteristics. Located in the historical artesian zone, the upper Pajaro River (San Benito River to Llagas Creek) had perennial flow and a dense, mixed riparian forest canopy, in contrast to other major South Valley streams.

**Braided stream morphology was common on the major South Valley creeks.** These broad reaches were interspersed with narrower, single thread reaches. Corresponding riparian habitat patterns were observed.

**Open riparian savannas and woodlands dominated by California sycamore characterized the braided stream channels of South Valley.** These high energy habitats included riparian scrub, occasional other riparian trees, and broad, unvegetated gravel beds and bars. Sycamore patterns varied from occasional, widely spaced trees along narrower channels to larger woodland groves on broad bars and terraces.

**Riparian forest typically extended downstream from the canyon mouth on major South Valley creeks.** The spatial transition from riparian forest to open riparian canopy was quite abrupt.

**As a result of reservoir construction and operation, there has been a general conversion of open riparian canopy habitat to more densely wooded environments.** The total length of forested reaches on the valley floor has more than doubled, while savanna and woodland reaches have decreased substantially.

**Stream corridors have also consistently been constricted by land use changes.** While riparian corridors wider than 60m (200 ft) were historically prevalent on the Uvas-Carnadero, Llagas, Pacheco, and Pajaro (70% of their valley floor length), now 70% of their length is narrower than 60 m (200 ft).

**The lower reaches of Uvas-Carnadero, Llagas, and Pacheco creeks had substantial wetland reaches, where they spread into broad mosaics of willow groves and freshwater marsh.** These areas provided an array of functions, including flood peak attenuation, fine sediment storage, and habitat for a diverse array of plants and wildlife, including a number of special status species.

**While sycamore riparian habitat has been altered on most stream reaches, a significant remnant still exists on Pacheco Creek.** This habitat is a regionally significant example of Central Coast Sycamore Alluvial Woodland.

### *Management considerations*

**Stream restoration could potentially reestablish natural stream benches and associated sycamore riparian habitat as part of natural flood protection efforts.** For example, large remnant sycamore trees still remain along Llagas Creek, and could potentially be reconnected to the channel through restoration. Without specific efforts, this major element of the local natural heritage will probably disappear. Stream benches with scattered sycamores could also be re-created.

**The Pacheco Creek sycamore alluvial woodland should be considered for its conservation value.** Further research is needed to evaluate whether its long term health that would be

improved through the use of scouring flood flows, carefully timed moistening flows for seedling recruitment, grazing management, and/or other stewardship actions.

**Natural flow regimes have been altered on streams with large reservoirs.** There may be further opportunities to adjust the timing and size of managed releases for ecological and geomorphic benefits. Higher flow pulse releases could potentially benefit natural stream maintenance processes, sycamore regeneration, and native fish populations. Well-timed late spring/early summer releases could potentially benefit both steelhead smolt outmigration and sycamore seedling establishment.

**Different aquatic and riparian conditions may be appropriate targets for different stream reaches.** Stream reaches can be evaluated in the context of the overall upper Pajaro River watershed by scientists, engineers, and water managers for appropriate, achievable reach-specific targets. Otherwise, stream habitat objectives may be in conflict. For example, summer water releases intended to benefit steelhead may have negative effects on remaining sycamore woodlands. Comparing historical conditions and existing potential may help identify viable strategies to balance competing resource objectives.

## WETLAND HABITATS

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**Prior to Euro-American drainage efforts, wetlands occupied about 9,000 ha (22,000 ac) in South Valley.** Most of these (83%) were seasonal wetlands, including wet meadows and alkali meadows. There were also 700 to 800 ha (1,700-2,000 ac) of perennial valley freshwater marsh and of willow groves.

**Wetlands occurred in distinct landscape positions.** Perennial freshwater ponds and marshes were always associated with fine-grained, clay-rich soils. Willow groves consistently occupied the margin between these poorly drained soils and adjacent coarser materials. Willow groves also followed groundwater discharge, associated with the outer margin of artesian conditions. Similar positions can be identified today.

**Wetlands have experienced dramatic changes in total extent and other spatial characteristics.** When compared with contemporary maps, historical sources indicate that the area of valley freshwater marsh has decreased by 90%. Willow riparian forest has decreased by a lesser amount (~60%), but the edge-to-area ratio of the remaining, more linear habitat patches has increased by over 700% compared to the historical habitats.

**Alkali meadows dominated the Bolsa.** These now rare habitats were extensive along the southern side of the Santa Clara-San Benito County line. Perennial marshes – both freshwater and saline – and ponds were scattered throughout the alkali meadows. Except for willow groves on the margins, trees were rare or absent.

**Most of the wetlands in the study area were associated with the Soap Lake floodplain, a broad natural basin that historically supported a diverse and extensive array of wetlands.** Topographic position, poorly drained soils, persistent alkaline soil effects, and seasonal flooding continue to give the area relatively high potential for wetland restoration.

**Some significant wetland remnants remain.** San Felipe Lake retains some of its historical size and function (see below). Several of the smaller historical willow groves are still intact.

**Small portions of historical wetlands have recently reestablished as groundwater levels have recovered and some areas have become less intensively managed.** In particular, small willow groves and scattered individual willow trees can be seen within the extent of historical willow groves.

**Mosaics of willow groves, freshwater marsh, perennial pond, and seasonal wetland provided an array of species support functions.** Willow groves and freshwater marsh almost always co-occurred. Both habitats were always fully or partially bordered by seasonal wetlands. Perennial ponds were generally surrounded by freshwater marsh.

**San Felipe Lake, an Audubon Important Bird Area, has decreased in size and depth, and the surrounding wetland mosaic has been reduced.** This rare regional example of a natural perennial freshwater lake was a cultural and ecological centerpoint for hunting, fishing, and soap-making. While the lake retains 50-60% of its historical area, the freshwater marshlands bordering the lake have been almost completely eliminated (93%).

**San Felipe Lake historically overflowed into a series of sloughs, swales, and wetlands that converged into the Pajaro River at the Llagas Creek confluence.** This diffuse drainage system had no well-defined channel or riparian corridor but rather a chain of seasonal and perennial wetlands.

### ***Management considerations***

**Historical wetland locations offer a number of sites that should be considered for conservation and stewardship.** Significant remnants include San Felipe Lake and the nearby remnant willow groves. There is also significant potential for wetland restoration along Tequiquita Slough and lower Pacheco, Llagas, and Ulvas-Carnadero creeks.

**The potential to restore wetland mosaics in the Soap Lake floodplain is regionally significant.** A number of factors suggest that restoration is technically feasible. Restoration could potentially benefit numerous species, including an array of native songbirds, shorebirds and waterfowl, floodplain-associated fish, outmigrant juvenile steelhead, and amphibians.



Historical wetland mosaics present a template for wetland restoration design. Dynamic floodplain wetland mosaics – incorporating willow groves, freshwater marsh and pond, and wet/alkali meadows – are likely to be able to support multiple life history stages of numerous species within relatively small areas. Restoration strategies can recognize existing topographic, edaphic, and hydrologic gradients to reestablish these kinds of patterns.

## OAK SAVANNA AND WOODLAND

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Valley oak savannas and woodlands occupied much of southern Santa Clara Valley outside of the Soap Lake floodplain. These oak lands covered an estimated 9,000 ha (22,000 ac) and have declined by 98%. We estimate that there were 60,000 oak trees, of which about 1,000 remain.

Oaks occurred on the valley floor in a range of densities. Relatively open savanna with scattered trees was most common (5,700 ha/14,000 ac), corresponding to an average stand density of about three trees/ha and an estimated canopy cover of 12%. There were also much denser valley oak woodlands. We identified an estimated 3,300 ha (8,000 ac) of woodland, with an average of 13 trees/ha, and an estimated canopy cover of approximately 50%.

Valley oaks dominated the oak lands of South Valley. 84% of the oaks recorded to species level by mid 19th-century General Land Office surveyors were valley oaks. Black oak and live oak were minor components overall, but there are indications that they could be more dominant in certain places.

Valley oaks declined dramatically during late 19th century conversion of woodlands to orchards. While the presence of large oak trees conflicted directly with the development of densely planted orchards, the trees have posed less direct conflict with other local land uses, including grazing, hay and grain farming, and even residential development, where they have been valued for shade and aesthetic value.

There are just a few remaining historical oak groves. These provide the last remaining local examples of the habitat.

### *Management considerations*

While the extent of valley oak lands has declined precipitously, there are many trees and a few groves that have been preserved to date. In addition to stewardship of remaining individual trees, these significant remnant groves may be worthy of conservation attention.

The historical spatial patterns of valley oak in South Valley suggest that reintegration of oak habitat within the contemporary landscape is possible. Within the context of an urban forestry plan, valley oaks could be strategically reintroduced (in medians, parks, yards, and along road and fence lines) to achieve densities similar to historical conditions.

**Increasing the density of oaks may be important to allow successful oak reproduction and maintain a healthy population.** Existing trees may be genetically isolated and thus have less ability to successfully adapt to changing conditions.

**Valley oak restoration could benefit a number of native species whose ranges have been declining in South Valley, such as acorn woodpecker and Pacific pallid bat.** Certain oak-associated species are largely precluded from the valley by the lack of oak trees.

**Valley oak restoration can have a number of practical and aesthetic benefits.** As shade trees, they are recognized for being attractive, deciduous, relatively fast-growing, and drought tolerant.

## ACKNOWLEDGMENTS

Like any historical research effort, this one is indebted to the expertise and assistance of staff at a number of archives. We would like to express our appreciation to Susan Snyder, Lorna Kirwan, Cynthia Rollins, and Erica Nordmeier at The Bancroft Library, UC Berkeley; Virgil Bella, Ramona Ramstead, Lonnie Spin, and Bob Teeter at the SCVWD vault and archive; Robert Rohde at the USDA-NRCS; Sheila Prader and Earlene McCabe at the San Benito County Historical Society; Tom Howard and Susan Voss at the Gilroy Museum; Bud O'Hare at the Morgan Hill Historical Society; Gwen Gee and Jack Schepens at the Santa Clara County Surveyor's Office; Lillian Perreira at the San Benito County Recorder's Office; and Arman Nazemi and Cindy Cecena at San Benito County Public Works. In addition, staff at the California Historical Society provided invaluable help and resources.

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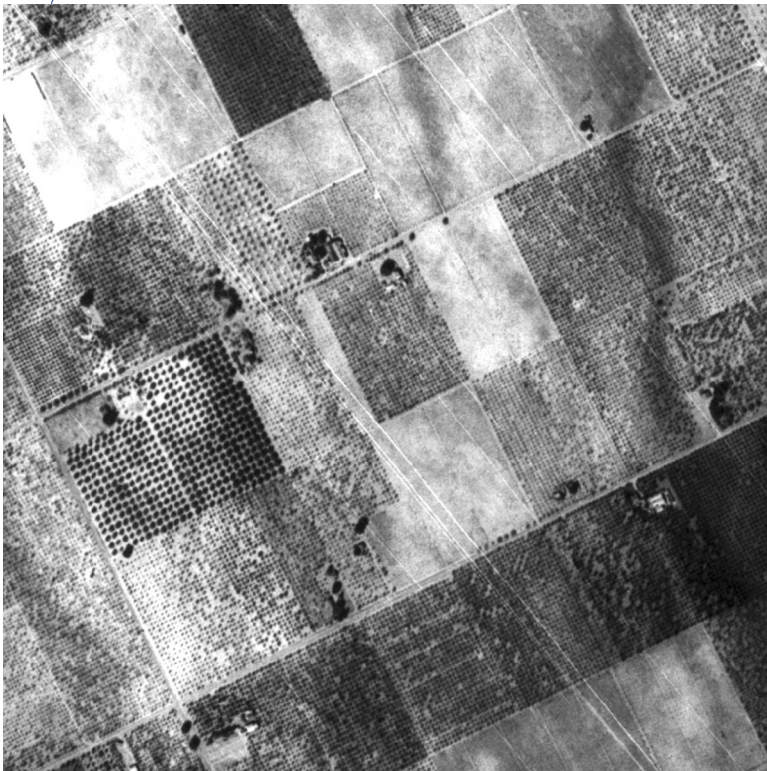
We would especially like to thank Carol Presley, who greatly facilitated the project as our SCVWD contract manager, and Marc Klemencic, Uvas/Llagas Watershed Manager at the SCVWD, for his support of the project. We would like to recognize the Board of Directors of the Santa Clara Valley Water District, especially Rosemary Kamei, District 1 Representative, for their support of historical ecology as a tool for watershed management. Finally, Trish Mulvey helped initiate these efforts and provided guidance and inspiration along the way.





1

# INTRODUCTION



*Above.* Llagas Creek ca. 1895. *Below.* Grid patterns of orchard plantings in 1939.

## INTRODUCTION

This report synthesizes an array of historical records to document historical conditions, landscape trends, and restoration opportunities in the southern part of the Santa Clara Valley (“South Valley”). A number of local environmental planning efforts have recognized the need for a better understanding of the historical ecology of the area to inform the protection and enhancement of local natural resources. Accordingly, this historical analysis has been developed to inform strategies for restoration and conservation, natural flood protection, and other environmental management challenges.

While substantial ecological resources currently remain in South Valley, landscape change has been extensive. Little knowledge currently exists about the pre-modification distribution of habitats, the processes that controlled their formation and maintenance, and the changes that have resulted from subsequent land use patterns. The study of historical ecology can address these information gaps, providing a technical basis for successful environmental planning (NRC 1992, Montgomery 2008).

This report and the associated geo-database provide a spatially comprehensive dataset about the natural distribution, abundance, and functions of the native habitats of South Valley. This information is designed to support current planning efforts such as the conservation program of the Santa Clara Valley Water District, the Llagas Creek Flood Protection Project, the Santa Clara Valley Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP), and the Mt. Hamilton Project of The Nature Conservancy. This information is also made publicly available as an information resource to other local and regional planning efforts such as city and county general plans, city and county parks planning, and flood protection planning for the overall Pajaro River watershed.

## ENVIRONMENTAL SETTING

The South Santa Clara Valley Historical Ecology Study focuses on the habitats and drainage patterns of the valley floor, where change has been greatest. We identify landscape characteristics prior to significant Euro-American modification and discuss some of the subsequent impacts and changes.

The study examines the alluvial reaches and adjacent valleys of the major streams of South Valley. The study area includes Llagas Creek, Uvas-Carnadero Creek, and

Pacheco Creek, downstream of their canyon mouths; the upper Pajaro River (to which the above-mentioned creeks are tributary); and the Soap Lake/Upper Pajaro floodplain as far south as Shore Road (fig. 1.1). Our project boundary crosses the Santa Clara County border into San Benito County, since the Pajaro River and its floodplain straddle both counties. The contact between Quaternary alluvial deposits and bedrock defines the valley floor, and was used as the eastern and western study area boundary (Knudsen et al. 2000). At the northern end of the study



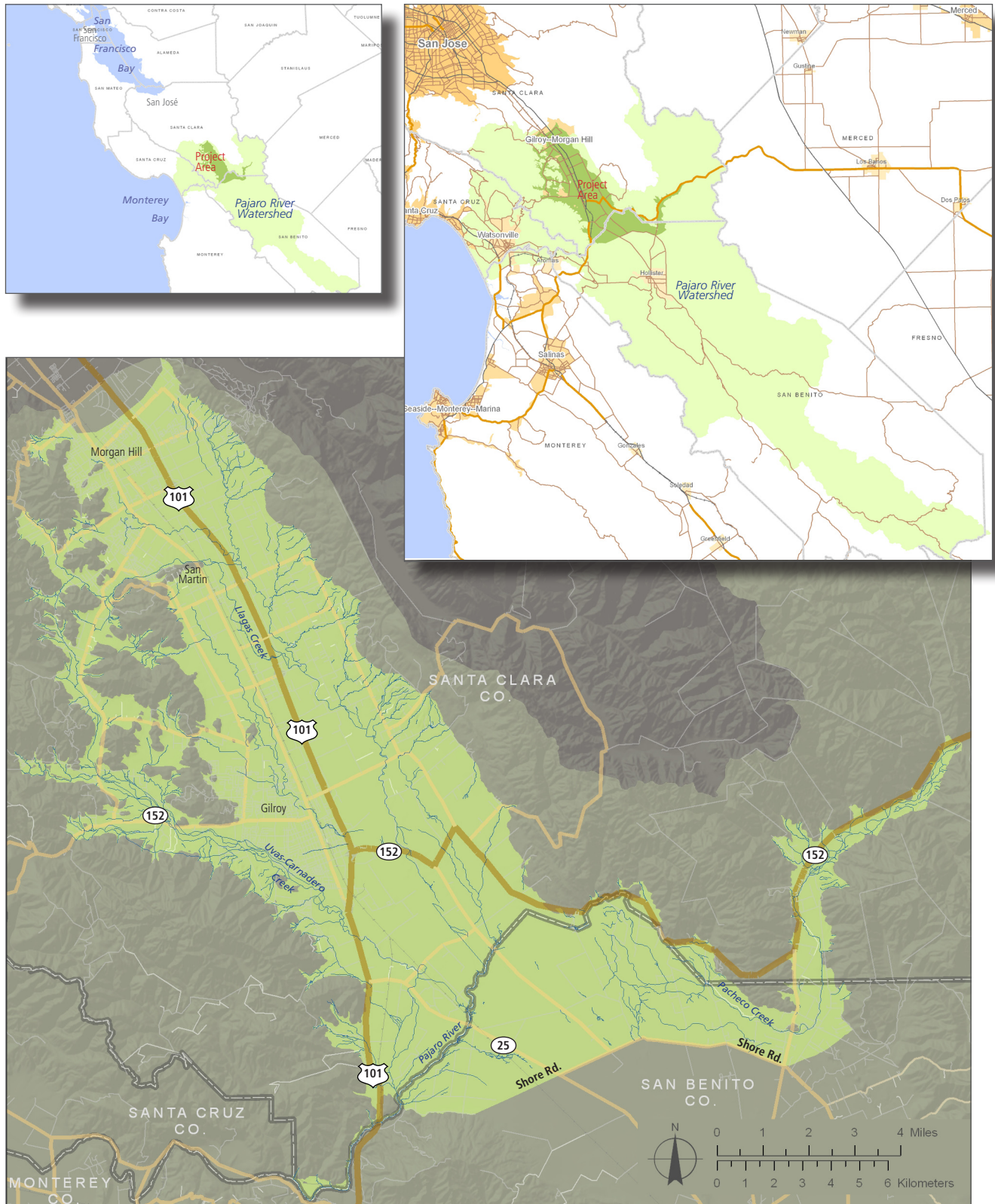


Figure 1.1. Study area and geographic locator maps.

area, the historical ecology mapping and research adjoins the Coyote Creek watershed, previously described in the Coyote Creek Historical Ecology Study (Grossinger et al. 2006). The southern boundary was defined by Shore Road. While this extent includes most of the floodplain wetland areas of the upper Pajaro River, it does exclude all but the lower reaches of several tributary creeks that enter from the south (e.g., Santa Ana, De las Víboras, and Dos Picachos).

Southern Santa Clara Valley is the very southern portion of the regional topographic depression that forms San Francisco Bay, Santa Clara Valley to the south, and Petaluma, Sonoma, and Napa valleys to the north (Norris and Webb 1990). While most of Santa Clara Valley drains north into San Francisco Bay, the streams of South Santa Clara Valley flow south to the Pajaro River and eventually into Monterey Bay. A subtle topographic inflection near the city of Morgan Hill divides these two parts of the valley. At its southern end, south Santa Clara Valley crosses the Santa Clara County line and merges into the Bolsa and Hollister Valley.

The primary population centers of South Valley are Morgan Hill and Gilroy. As the eighth and tenth largest cities in Santa Clara County respectively, these rapidly growing cities are nevertheless still smaller than the historically dominant cities to the north. Other recognized communities in the area include San Martin, Dunneville, and San Felipe. Hollister and San Juan Batista are located within 5 miles south of the study area. While most of South Valley lies in Santa Clara County, its southern end continues into neighboring San Benito County.

Oriented in a northwest fashion, southern Santa Clara Valley is bordered by the western front of the Diablo Range to the east and the Santa Cruz Mountains to the west. These portions of California's Coast Range are dominated by units of the Jura-Cretaceous Franciscan Complex and Great Valley Complex. The valley itself is a

gently sloped alluvial plain of Late Quaternary origin, its surface shaped by patterns of floodplain deposition. The streams of South Valley converge with Pacheco Creek and drainages from the east into the Bolsa, a broad, low-lying area bridging the Santa Clara-San Benito County line. Referred to as the Bolsa (pocket) since Spanish times, the area has alternatively been called the San Felipe Sink (Milliken et al. 1993), the Pajaro Plains (Taylor 1850), the Soap Lake Floodplain (RMC 2005), or simply Soap Lake. The Calaveras Fault crosses the southern portion of the study area, contributing to the formation of San Felipe Lake. The region is characterized by a mild Mediterranean-type, semi-arid climate, with nearly all of the annual precipitation occurring from November through April, and a dry season May through October.

Population expansion and other land use change trends in South Valley have generally lagged several decades behind those of the dominant population centers to the north. Accordingly, the region still maintains a mix of urban, suburban, and agricultural land uses. The region is also shaped by the long-term presence of several major transportation corridors. The west side of the valley was well traveled during pre-colonial, colonial, and modern times as the link between the San Francisco Bay area and the Monterey Bay area, as well as areas further to the south. El Camino Real connected Monterey and San José through South Valley. Highway 101 is a major transportation corridor linking the south San Francisco Bay area and Silicon Valley to Monterey Bay and southern California. Highway 152 is also part of a major north-south corridor, but here follows a generally east-west orientation. It connects Highway 101 at Gilroy to Highway 5 in the Central Valley over Pacheco Pass, largely following Pacheco Creek. Transportation infrastructure and related development patterns may continue to affect South Valley, as the proposed route of the high-speed rail between the San Francisco Bay area and southern California crosses the Soap Lake floodplain and follows the general Highway 152-Pacheco Creek alignment.



## REPORT STRUCTURE

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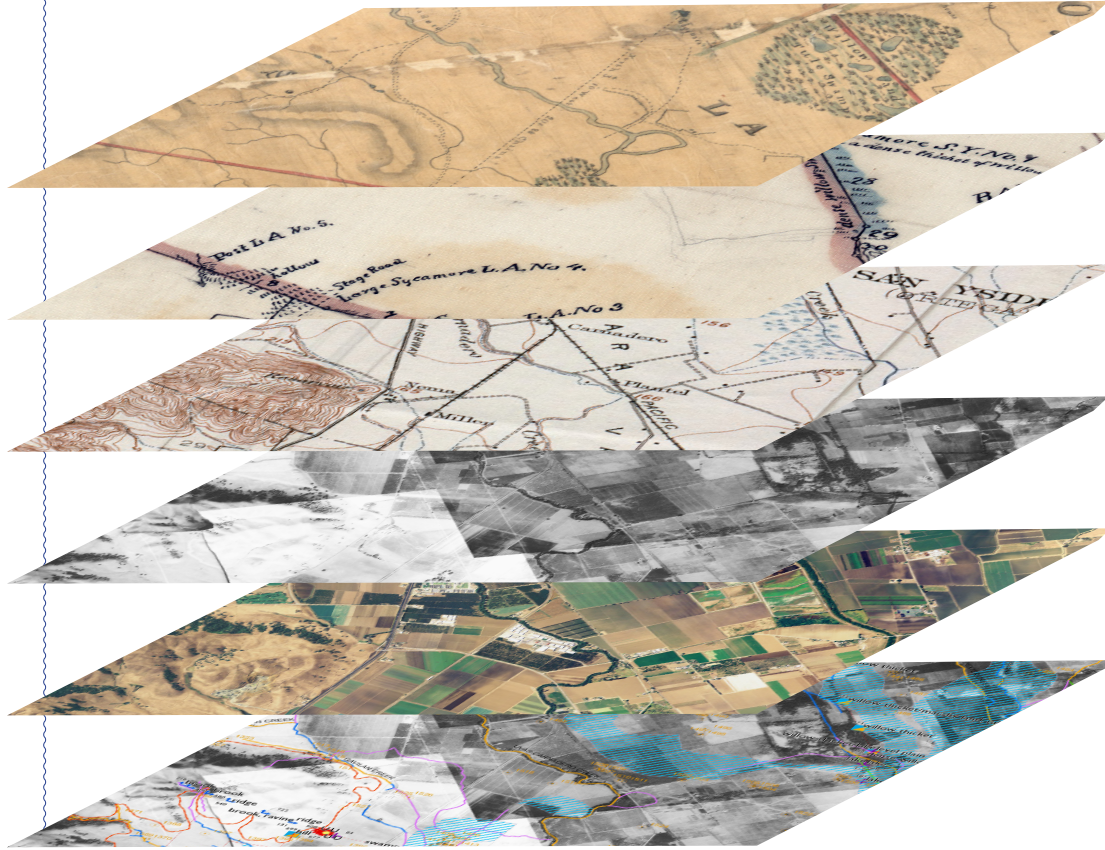
The report is divided into eight chapters. This introductory chapter describes the project, its spatial extent, and the general environmental and geographic setting. The second chapter, General Methods, describes the basic approaches used to acquire, interpret, and synthesize information about the historical landscape. The third chapter is a Land Use History for the region. This history provides important context for interpreting historical data from these time periods. Chapters 4-6

describe specific methods and present our findings about each of the major habitat types found in the study area: Stream and Riparian Habitats, Wetland Habitats, and Oak Savannas/Woodlands. In Chapter 7, Local Landscape Descriptions, we describe the native landscape geographically, showing how the different landscape elements fit together at a regional scale, and then describe local features subregion by subregion. Finally, Chapter 8 summarizes key findings. Appendices discuss the local climate history and present information about historical fish assemblages.



## 2

## GENERAL METHODS



Above. Maps assembled from different time periods in a geographic information system.

## GENERAL METHODS

This section describes the general research methods used throughout the study. Additional description of methods specific to each habitat type is provided in the landscape analysis chapters (Chapters 4-6).

### DATA COLLECTION

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A substantial variety and quantity of historical records are needed for accurate assessment of the historical ecological landscape (Grossinger 2005, Grossinger et al. 2007a). With this in mind, we assembled a diverse range of historical records spanning more than a century and compiled these data into a map of landscape patterns prior to significant Euro-American impact.

Assembled materials include narrative data (e.g., Spanish explorers' accounts, Mexican land grant case court testimonies, General Land Office records, early travelogues, and Santa Clara County histories and reports); maps (e.g., Mexican land grant maps, early city and county maps and surveys, U.S. Department of Agriculture soil surveys, and U.S. Geological Survey maps); photography (both ground-based and aerial), and paintings. We used SFEI's customized Endnote database to catalogue these historical data sources both to avoid duplication and produce bibliographies.

To acquire these sources, we visited local historical archives (Gilroy Museum, San Benito County Historical Society); public libraries (Hollister Public Library, San José Public Library); county offices (San Benito County Public Works Department, San Benito County Recorder's Office, Santa Clara County Surveyor's Office, Santa Clara Valley Water District vault and library), and regional archives (California Historical Society, The Bancroft Library at UC Berkeley, Bureau of Land Management). We also reviewed material available online and conducted searches of over twenty electronic sites and databases, including the Online Archive of California, California Natural Diversity Database, the Searchable Ornithological Research Archive, and the Library of Congress Online Catalog.

We reviewed an estimated 10,000 documents (maps, photographs, and written materials) and acquired full or partial copies of over 2,000. We collected sources

of different kinds and from different eras to provide intercalibration or triangulation of landscape features by independent sources (Grossinger et al. 2007a). Each historical source—whether written or graphic, Spanish- or English-language, professional survey or not-to-scale—provided a new perspective on the historical ecology of the area. While we reviewed a large amount of information for this study, the local historical record is voluminous. Additional information will likely be discovered in future years that can contribute to further refinement of our understanding of the local landscape.

### INTERPRETATION OF HISTORICAL DOCUMENTS

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Accurate interpretation of documents produced during different eras, within differing social contexts, and by different authors, surveyors, or artists can be challenging

(Harley 1989, Grossinger and Askevold 2005). To address these concerns, we used a number of independently produced documents, covering a range of eras and surveyors, to assess the accuracy of each individual document and to promote accurate interpretation of landscape characteristics. This approach, which requires document redundancy, provides the only independent verification of the accuracy of original documents and of our interpretation of them, given absence of replicate samples and predetermined methods (Grossinger 2005, Grossinger and Askevold 2005). Additionally, we conducted background research on the techniques and reliability of the creators of historical records. This included investigation into the reliability of individual surveyors from local histories, comparison between contemporary and modern surveys, and our own assessment of multiple documents by the same surveyor.

We examined historical data for evidence of landscape characteristics prior to significant Euro-American modification. Despite inter-annual and decadal-scale variability, climatic characteristics during the period for which historical data were obtained (1770s-1940s) were relatively stable (Dettinger et al 1998). Since land use was much more variable during this time, we focused on discerning natural from anthropogenic features. We developed a detailed understanding of the temporal trends in land use history and local climate, and were careful to map only features that were clearly not the result of recent land use or extreme climatic periods. Quantitative and narrative descriptions of climatic conditions (floods, droughts, and rainfall) and land use regimes (native management, grazing, dry-farmed and irrigated agriculture) were recorded and compiled. We attempted to document features using multiple sources across the focal time period to assure persistence and accurate interpretation. For example, features whose general presence was indicated by Spanish/Mexican era sources could often be confirmed and mapped in greater detail based upon later American sources, despite surrounding land use changes. Our goal was

to map landscape features as they existed, on average, prior to and during the early decades of Euro-American settlement (1770s-1850s). For convenience, we refer to this time period as *circa 1800*.

## MAPPING METHODOLOGY

A geographic information system (GIS) was used to collect, catalog, analyze, and display the spatial components of the study area. The relational database component of the GIS allows for storing many attributes about each feature, making a GIS ideal for these tasks. We were able to look through time by assembling maps and narrative information from different periods (fig. 2.1), which allowed us to both assess the different data sources and to better understand change.

The following text first describes the sources and how they were integrated into the GIS, and then discusses how these sources contributed to habitat synthesis and analysis. ArcGIS 9.1 (ESRI) software was used.

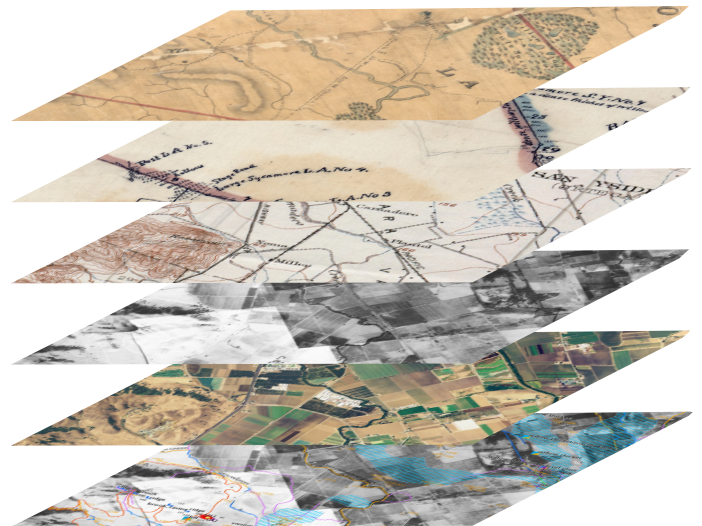


Figure 2.1. The geographic information system allowed us to assemble maps and information from different time periods.



### *Collection of historical spatial data*

During data collection, sources were evaluated for their potential usefulness in the GIS. Historical maps, aerial photography, narrative accounts describing a location, and surveyor point data are all potential data layers.

### *Addition of historical data to the GIS*

Sources that were suitable for use in the GIS were added by georeferencing raster maps or by digitizing narrative or survey data. This allowed us to compare historical layers to each other and to contemporary aerial photography and maps.

Accurate historical maps with pertinent land cover information were georeferenced to contemporary orthorectified aerial imagery (USDA 2005), using ArcGIS 9.1 (ESRI). We also developed a continuous historical aerial photomosaic for the study area based upon the earliest available imagery (75 images, USDA 1939) using the Leica Photogrammetry Suite module of ERDAS Imagine 8.7. The photomosaic was particularly useful for identifying residual valley oak savanna, wetlands, and former creek alignments within the pre-urban, agricultural setting.

We developed a GIS database for the Public Land Survey data of the General Land Office, based upon a database and data entry form originally developed by the Forest Landscape Ecology Lab at the University of Wisconsin-Madison. The use of these data is discussed further in Chapter 6. Additionally, the GIS was used to locate and hold textual information gathered from surveyor notes, early explorers' journals, travelers' accounts, and newspaper articles.

### *Synthesis into a composite map*

We synthesized selected georeferenced historical data into a GIS to create a picture of historical habitat distribution and abundance. Reliable historical evidence was found for mapping eight historical habitat or land

cover types. These are shown in table 2.1, along with corresponding contemporary wetland and vegetation classes. To record the variations in source data and confidence level associated with different features, we developed a set of attributes to record both historical sources and estimated certainty levels. The application of attributes on a feature-by-feature basis allows users to assess the accuracy of different map elements and identify the original data, serving as a catalog of information sources (Grossinger 2005).

***Sherman Day (1806-1884)*** was Surveyor General of California, a state senator, and superintendent of the New Almaden Quicksilver Mines. Day developed many of the General Land Office Public Land Survey data used in this report. Sherman Island in the San Joaquin Delta and Mount Day in the Sierra Nevada were both named after Day.

Day is pictured with survey equipment in front of a Almaden Mine tunnel in a 1880s photograph by Carleton E. Watkins.



Table 2.1. Habitat “Crosswalk” to Wetland and Vegetation Classifications. NDDB refers to the California Natural Diversity Database (2005); MCV refers to the Manual of California Vegetation (Sawyer & Keeler-Wolf 1995).

	WETLAND CLASSIFICATION AND WATER REGIME (Cowardin 1979)	VEGETATION CLASSIFICATION (NDDB: Holland 1986, MCV: Sawyer and Keeler-Wolf 1995)
Alkali Meadow	Palustrine emergent saline wetland. Temporarily flooded, seasonally to permanently saturated.	Saltgrass alliance, Alkali sacaton alliance,  Ashy ryegrass alliance, Creeping ryegrass alliance (MCV);  Alkali Meadow (NDDB)
Wet Meadow	Palustrine emergent wetland. Temporarily flooded, seasonally to permanently saturated.	Ashy ryegrass alliance, Creeping ryegrass alliance (MCV);  Valley wild rye grassland (NDDB)
Valley Freshwater Wetland	Palustrine persistent emergent freshwater/saline wetland. Temporarily to seasonally flooded, permanently saturated.	Bulrush series (MCV)
Seasonal Lake/Pond	Palustrine persistent emergent freshwater/saline wetland. Seasonally flooded, permanently saturated.	Bulrush series (MCV)
Perennial Freshwater Pond	Permanently flooded.	Bulrush series (MCV)
Willow Grove	Palustrine forested wetland. Temporarily flooded, permanently saturated.	Arroyo willow alliance (MCV)
Oak Savanna/Woodland	Intermittently flooded, saturated at depth.	Valley oak alliance (MCV);  Valley Oak Woodland (NDDB); Valley oak/grass association (Allen et al. 1991)
Grassland	-	Ashy ryegrass series (MCV)

Certainty levels were assigned based upon qualitative and quantitative assessment. Our confidence in a feature’s interpretation, size, and location was assigned on a relative scale based upon the number and quality of sources, and our experience with the particular interpretation (table 2.2; Grossinger et al. 2007a).

### *Comparison to present-day conditions*

For the Santa Clara County portion of the study area, we were able to use recent land cover mapping by Jones and Stokes (2006) to compare historical and modern spatial extent of several habitat types. Corresponding classes were selected based on narrative descriptions of

the modern land cover classes (Jones and Stokes 2006). For the San Benito County portion of the study area, we used mapping by the National Wetlands Inventory (USFWS 2007). We also compared historical land cover patterns to existing land use to determine potential restoration opportunities at the conceptual level, and conducted limited field surveys to confirm landscape changes and identify the residual or recovered features at these sites. Additional assessment of contemporary and projected future conditions was beyond the scope of this project, but would be important to evaluate site-specific feasibility of conceptual restoration strategies identified here.

Table 2.2. Certainty level standards.

Certainty Level	Interpretation	Size	Location
High/ "Definite"	Feature definitely present before Euro-American modification	Mapped feature expected to be 90%-110% of actual feature size	Expected maximum horizontal displacement less than 50 meters (150 ft)
Medium/ "Probable"	Feature probably present before Euro-American modification	Mapped feature expected to be 50%-200% of actual feature size	Expected maximum horizontal displacement less than 150 meters (500 ft)
Low/ "Possible"	Feature possibly present before Euro-American modification	Mapped feature expected to be 25%-400% of actual feature size	Expected maximum horizontal displacement less than 500 meters (1600 ft)

## TECHNICAL ADVICE AND REVIEW

We recruited advice and review from experts in a number of different fields, including ecology, geomorphology, geology, archaeology, and landscape history. Members of the Technical Advisory and Review Group provided comments on the draft report and/or guidance and review on specific topics during the course of the project.

### Technical advisory and review group

Timothy Babalis, Landscape Historian,  
National Park Service

Josh Collins, Wetland Scientist, SFEI

Andy Collison, Fluvial Geomorphologist,  
Philip Williams & Associates

Frank Davis, Landscape Ecologist,  
UC Santa Barbara

Todd Keeler-Wolf, Vegetation Ecologist,  
California Department of Fish and Game

Randy Milliken, Anthropologist

Randy Morgan, Botanist

Janet Sowers, Fluvial Geomorphologist,  
William Lettis & Associates