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HISTORICAL VEGETATION AND DRAINAGE PATTERNS OF WESTERN SANTA CLARA VALLEY:

A technical memorandum describing landscape ecology in Lower Peninsula, West Valley, and Guadalupe Watershed Management Areas

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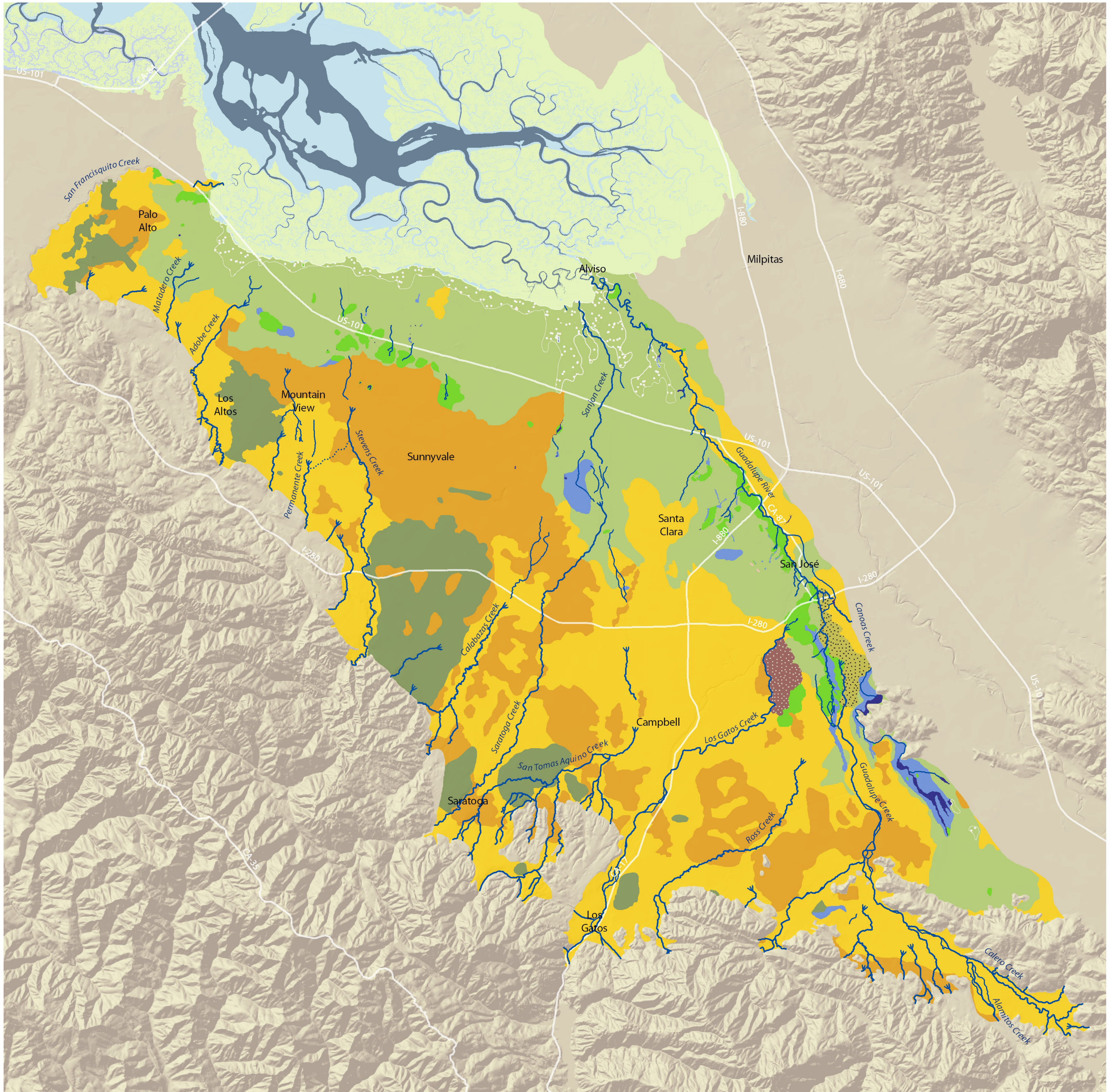

HISTORICAL CONDITIONS, CIRCA 1850

The map at left reconstructs the habitat characteristics of west Santa Clara Valley prior to significant Euro-American modification.

Subtidal Water
Tidal Flat
Tidal Marsh

Alkali Meadow
Wet Meadow
Valley Freshwater Marsh
Perennial Freshwater Pond
Willow Grove
Sycamore Grove
Wild Rose Thicket
Box Elder Grove
Oak Savanna
Oak Woodland
Chaparral

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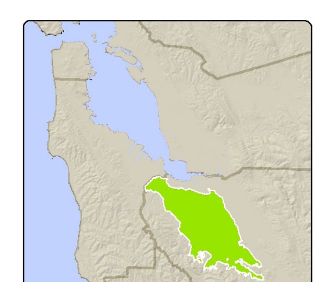


TABLE OF CONTENTS

Title page: Detail from *Map showing topography of the country in the vicinity of the head of Arroyo Guadalupe as it existed under Mexican occupation.* (Herrmann ca. 1879, courtesy of the Office of the Santa Clara County Surveyor)

DEDICATION • The Santa Clara Valley has been the subject of a number of outstanding studies documenting the historical nature of its landscape. In particular, research conducted by William S. Cooper (1926), Jan Otto Marius Broek (1932), and Alan K. Brown (e.g., 1963, 2002, 2005) was indispensable in the preparation of this report. We hope that this research builds upon and provides new insights into their work.

This research is dedicated to Alan Kelsey Brown (1933-2009), a luminary in the world of early California and (in particular) Santa Clara Valley history. Dr. Brown's depth of knowledge of the historical ecology of the Santa Clara Valley was unsurpassed, and his translation of early texts (in particular Crespí's journals), research on inference of oak woodland existence through interpretation of *A. mellea* root rot damage, and manuscript and map reconstructions of landscape patterns in western Santa Clara Valley paved the way for our research, and were heavily used and cited. While we were only able to work with him in the early stages of the project, his research significantly contributed to our own.

INTRODUCTION

Since the beginning of the written record in 1769, residents and travelers have described the Santa Clara Valley in superlatives. Writer Bayard Taylor, traveling in 1859, described the valley as "unlike anything else in the world; with a beauty so new and dazzling, that all ordinary comparisons are worthless" (Taylor 1951); land surveyor Tracy (1853) described a valley "remarkable for its beauty and fertility." Though this kind of hyperbole was applied to many places across the state in the 19th century, it is clear that the Santa Clara Valley was considered one of the most agriculturally productive and beautiful places in California (cf. Vancouver [1798]1984, Bryant 1848, Bartlett [1854]1965, Muir [1872]1974). Its fertile soils, sheltering oaks, artesian water, and temperate climate made the area, especially near Guadalupe River, an early focus of settlement with the establishment of both Mission Santa Clara and the city of San José in 1777. By the mid-1800s, substantial modifications had been made to the valley ecology, particularly (but not restricted to) near San José and Santa Clara.

The extremely rapid and early settlement of the Santa Clara Valley is both a benefit and a challenge to the historical ecologist. On one hand, an extensive array of historical sources for the region extends further back than in neighboring areas without similar settlement histories. However, early settlement meant early landscape modifications. Ecological impacts are documented for the region firsthand as early as Mission times, when officials described that due to sheep grazing around San Francisquito Creek "nature ceases to act on the land…barrenness prevails" (Abeys 1808, in

WHAT THIS REPORT IS (AND WHAT IT ISN'T)

This report summarizes mapping of the historical landscape of the western Santa Clara Valley. It documents an array of habitats over a nearly 100,000 acre area, presenting the first detailed, comprehensive, well-documented historical mapping of western Santa Clara Valley. This research provides an important perspective on the current ecological and hydrological landscape of the valley.

Unlike other recent Santa Clara Valley historical ecology reports (Grossinger et al. 2006, 2008), however, this project had a more limited focus. We do not here interpret or analyze landscape change or discuss implications for management. While we documented historical habitat and creek pattern in the region, we did not investigate historical ecological dynamics such as trends in riparian vegetation and summer flow.

These initial findings, paired with subsequent research supported by data collected and synthesized through this project, can support the development of restoration strategies and management decisions for streams and habitats in western Santa Clara Valley. Next steps could build on these mapping efforts to evaluate changes, identify restoration opportunities, and discuss implications for local environmental management, as already completed for other regions of the Santa Clara Valley.

Milliken n.d.). As a result, even relatively early historical sources must be closely examined to determine the extent to which they represent pre-modification conditions.

This report synthesizes an array of historical records to document pre-modification conditions in western Santa Clara Valley. It describes some of the predominant characteristics of each major habitat type in the western Santa Clara Valley, and describes the historical form of major creeks. Along with the habitat map and associated geo-database, it provides a spatially explicit, comprehensive dataset describing creek extent and alignment and the distribution and abundance of native habitats prior to significant Euro-American modifications.

The geographic focus of this work is the western Santa Clara Valley, including all watersheds from San Francisquito Creek to the Guadalupe River watershed, from the historical tidal boundary to the base of the surrounding hills (fig. 1). This includes regions defined by Santa Clara Valley Water District as three separate Watershed Management Areas: Guadalupe, West Valley, and Lower Peninsula. The project excludes San Francisquito Creek, which acts as the northern boundary for the study area, but includes the Santa Clara County portion of the San Francisquito Creek watershed. Because the most extensive land use and channel modifications have typically taken place on the valley floor, the compilation described here focuses on the alluvial plain (i.e., not including bedrock-confined canyons and hills). It does not include the adjacent south San Francisco Bay baylands, which were mapped in an earlier project (Grossinger and Askevold 2005, SFEI 2010). This project is contiguous with the Coyote Creek Historical Ecology Study (Grossinger et al. 2006). A separate report addresses the historical ecology of the southern Santa Clara Valley (Grossinger et al. 2008).

A detailed understanding of the history of land and water use for the western Santa Clara Valley, while outside the purview of this study, is essential for contextualization and interpretation of historical ecological data. In addition to numerous local histories, many previous studies have detailed the agricultural and water use history of the region (e.g., Broek 1932, MacGraw 1961, Friedly 2000, McArthur and Wessling 2005). We encourage the reader to refer to these publications for better understanding of historical time periods discussed in this report.

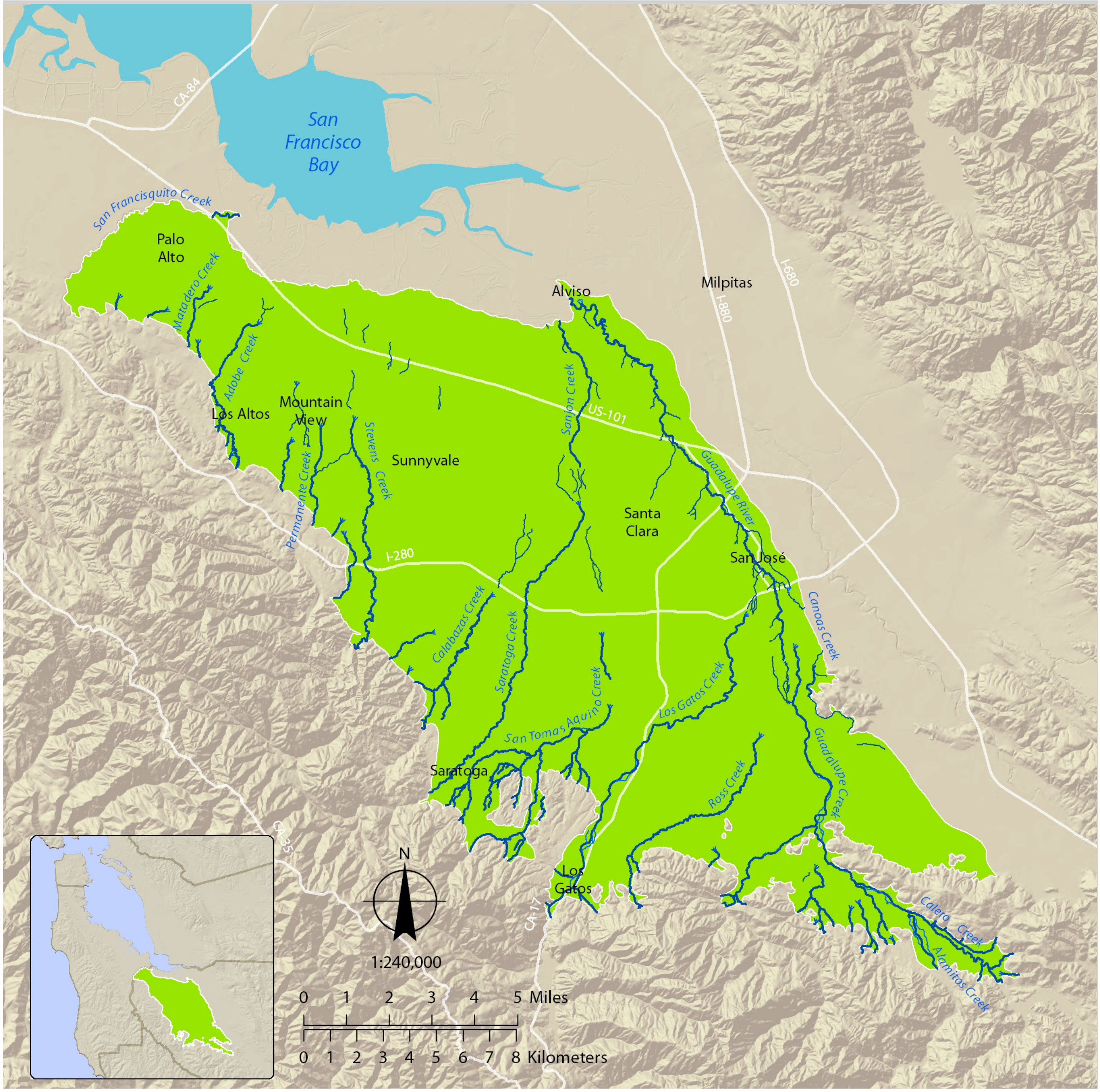


Fig. 1. Project area for the western Santa Clara Valley historical ecology study (with historical stream network).

METHODS

The foundation of this project is the historical sources that cumulatively compose it. Early surveyors, tourists, local residents, and photographers who recorded their measurements, opinions, and observations are crucial to the success of the project. This section details how these sources were collected, interpreted, and mapped.

Data Collection and Compilation

Like any historical research project, this study took advantage of a huge number of records from a variety of different archives, agencies, libraries, and historical societies across the Bay Area. The 22 institutions visited through the course of this research are listed below (table 1).

Hundreds of documents were collected pertaining to the condition of western Santa Clara Valley before its substantial modification. Assembled materials include written accounts (e.g., Spanish explorers' accounts, Mexican land grant case court testimonies, General Land Office records,

Table 1. Source institutions visited for the western Santa Clara Valley Historical Ecology study.

Source Institution	Location
Bureau of Land Management	Sacramento
California Historical Society	San Francisco
California History Center and Foundation	Cupertino
Campbell Historical Museum	Campbell
Cupertino Historical Society	Cupertino
History San José	San José
Los Altos History Museum	Los Altos
Los Gatos Public Library	Los Gatos
Mountain View Public Library	Mountain View
Palo Alto Historical Association	Palo Alto
California Room, San José Public Library	San José
Santa Clara County archives	San José
Santa Clara County Surveyor's Office	San José
Santa Clara University Orradre Library and University Archives	Santa Clara
Santa Clara Valley Water District vault and archive	San José
Saratoga Historical Museum	Saratoga
Society of California Pioneers	San Francisco
Stanford University Special Collections and Map Library	Stanford
Sunnyvale Historical Society	Sunnyvale
The Bancroft Library	Berkeley
UC Berkeley Earth Sciences and Map Library	Berkeley
Water Resources Center Archives	Berkeley

and early travelogues), photographs (landscape and aerial), and maps (e.g., Mexican land grant maps, property maps, soil surveys, and U.S. Geological Survey maps). While our efforts focused on 19th century sources, a few comprehensive data sets from the 20th century (e.g., 1939 aerial photography, 1958 soils map) were also collected. Through this process, we developed a diverse, often overlapping array of historical records providing remarkably complete coverage of the study area. Overlapping sources – from different eras, or produced with differing goals – each provided a new perspective on ecological pattern and function in western Santa Clara Valley, and often provided additional nuance of habitat distribution and complexity.

Once collected, photographs, maps, and textual data were organized geographically and by topic. Two sources required additional processing before use in landscape interpretation: aerial photographs and General Land Office (GLO) survey notes. Three orthorectified aerial photomosaics were used to provide complete aerial photo coverage of the study area. The photomosaic of 1939 aerial photos assembled for the Coyote Creek Historical Ecology study (Grossinger et al. 2006) covered the far eastern edge of the study area. A 1948 photomosaic compiled by USGS was used for the western part of the study area, extending from the Palo Alto area to western Sunnyvale. The third photomosaic, covering the center of the study area (including Guadalupe River and Los Gatos Creek), consists of about 70 aerial photos from 1939 which we orthorectified and mosaicked using Leica Photogrammetry Suite.

These aerials allowed us to map probable oak trees (based on landscape position and canopy size, cf. Davis et al. 2000) historically present in the valley. Just over 4,000 trees were mapped from the historical aerial coverage of the study area. These trees were non-riparian (i.e., at least 200 ft/60 m from a channel) with a crown over 40 ft/11.5 m in diameter. Of these oaks, 21% (845 trees) were inferred from *Armillaria mellea* root rot damage in orchards. In these cases, no tree was present, but a non-cultivatable zone was visible in the imagery. Inference of probable tree presence based on *A. mellea* root rot damage is well documented in this region (cf. Brown 2002). These trees were used as confirmation of oak presence where also documented by a historical source, and were used in a few cases to shape oak woodland polygons or to confirm oak savanna presence.

Additional ecological information came from the General Land Office (GLO) Public Land Survey (PLS). This survey was initiated in 1785 by the Land Ordinance, and progressed from Ohio to the west coast, reaching western Santa Clara County in 1851 and continuing in the region until 1889. The survey created a grid of townships of 36 mi^2 divided into square-mile sections, excluding private Mexican land grants. Surveyors gathered a variety of ecological and hydrological information, including tree cover, soil quality, and presence of major natural features such as marshes and streams, as well as recording "bearing" trees each mile when possible. Over 1,000 survey points fall within the study area. To manipulate this large dataset, we adapted tools developed by the Forest Landscape Ecology Lab at the University of Wisconsin-Madison to store, display, and analyze the GLO data within a GIS environment (Manies 1997, Radeloff et al. 1998, Sickley et al. 2000).

Interpretation of Historical Documents

The conduct of this work has been extremely difficult and affording no renumeration to the surveyor, who has been compelled to resort to every acknowledged method of surveying and lose much time in passing from one part of the country to the other...

–PLS SURVEYOR C.C. TRACY 1853

Accurate interpretation of documents produced during different eras, within differing social contexts, for differing purposes, and by different authors, surveyors, or artists can be difficult (Harley 1989, Grossinger and Askevold 2005). To address these challenges, we collected a number of independently produced documents covering a range of eras and authors. These sources, often overlapping in geography and depiction, allowed us to compare an array of documents, and in doing so assess the accuracy of individual documents and to promote accurate interpretation of landscape characteristics. This approach provided independent verification of the accuracy of original documents and of our interpretation of them (Grossinger 2005, Grossinger and Askevold 2005).

We examined historical data for evidence of landscape characteristics prior to significant Euro-American modification. Our goal was to map landscape features as they existed, on average, prior to and during the early decades of Euro-American settlement (1770s-1850s; Grossinger et al. 2007). Despite inter-annual and decadal variability, climatic characteristics during the period for which historical data were obtained (1769-1940s) were relatively stable (Dettinger et al. 1998). Many later sources (i.e., outside of the target time period) record features that clearly correspond to features documented by earlier sources, and provide more accurate mapping ability. In this manner, a feature shown on an early source (e.g., a *diseño*) that confirms the general presence of the feature but not its location, could be confirmed and mapped from a later source (e.g., a historical aerial), despite surrounding land use changes. We attempted to document each feature using multiple sources from varying years and authors to ensure persistence and accurate interpretation. Given the high data density in the western Santa Clara Valley, this was possible for many features, though others (notably some ponds and wetlands) were only documented by one source.

Mapping Methodology

In culmination of the data collection and interpretation performed for this study, we produced a map of historical stream conditions and habitat distribution and abundance in the western Santa Clara Valley. Stream characteristics mapped include former channel meanders, side channels, distributaries, distributary channels, and sloughs. Reliable historical evidence was found for mapping both dryland (grassland/oak savanna, oak woodland, chaparral, sycamore grove, box elder grove) and wetland (wet meadow, alkali meadow, pond, freshwater marsh, willow grove) historical habitat types. This map is designed to be broadly consistent and compatible with maps produced for the Coyote Valley and South Santa Clara County historical ecology studies (Grossinger et al. 2006, 2008).

Q. What instruments did you use in making this survey or measurements you have spoken of? Ans. The most natural of instruments—eyes and hands, and ropes.

—ANTONIO SUÑOL 1862

Mapping was completed in a geographic information system (GIS). GIS was used to collect, catalog, compile, analyze, and display available, spatially explicit data. Using GIS, we were able to synthesize complex arrays of sources by assembling maps and narrative information from different periods, allowing us to assess each data source, more accurately map each feature, and better understand change over time.

ArcGIS 9.3 (ESRI) software was used to integrate multiple historical sources, and ultimately to produce the habitat map. Sources suitable for use in the GIS (i.e., spatially locatable with mappable ecological features) 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. Additional maps, either not accurate enough to be georeferenced or clearly confirming already mapped features, were added as sources to a feature where appropriate, but not georeferenced. Overall, over 130 maps were georeferenced.

Reliable evidence for habitat location and extent was digitized from these sources, then synthesized into a single picture of landscape pattern based on historical evidence and landscape form (e.g., topography). For historical channel mapping, the modern creek layer (acquired from the Santa Clara Valley Water District) was used as a base layer and modified where sources showed historical position to be at least 15 m (50 ft) from the modern creek. 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 (for a feature's interpretation, size, and location). These attributes, assigned on a feature-by-feature basis, allow users to assess the accuracy of different mapped elements and identify the original data (Grossinger 2005). Wetland features and chaparral patches of any size were mapped, reflecting their ecological importance and relative accuracy of historical mapping. For oak savannas and woodlands, only patches greater than 25 acres were mapped to reflect the often coarser scale of historical mapping for these features. Riparian willow groves greater than 100 meters (330 ft) in extent on either side of the river were mapped, in recognition of their increased contribution to riparian function (Collins et al. 2006). These were only documented on Guadalupe River.

CREATION OF THE HABITAT MAP. Historical ecology in the western Santa Clara Valley is not new; as early as the 1870s others documented ecological changes through time in the region (Herrmann ca. 1879, fig. 2). Previous researchers (e.g., Cooper 1926; Brown 1963, 2005; Lajoie 2002) have also produced ecological mapping of portions of the Santa Clara Valley. Cooper mapped broad zones of willows, oaks, and chaparral, while Brown mapped the location and extent of these habitats, with more detailed mapping of sycamores, marshes, ponds, and streams. In addition, a series of maps published through the Oakland Museum provide a detailed look at the

Fig. 2. "Map showing topography of the country in the vicinity of the head of the Arroyo Guadalupe as it existed under Mexican occupation," ca. 1879. Perhaps the earliest example of historical ecological research in the Santa Clara Valley, Santa Clara County surveyor A.T. Herrmann sketched this depiction of "Mexican era" conditions nearly thirty years later, around 1879. The map documents the extent of historical change in the mid-19th century, noting places where trees had "been cut" or where they were "still standing." Herrmann completed a GLO survey in the area the same year this map was likely produced; this survey may have prompted his drafting of this map. (Herrmann ca. 1879, courtesy of the Office of the Santa Clara County Surveyor)


LOS GATOS CREEK
ROTAL
Alders
AL ABRA ROAD
TRAIL TO SAN JOSE
OPENING
OR
JOSE GALE
LOS GATOS WILLOW
D
OPEN COUNTRY
Southeast line of Los Coches
TRAIL
NARVAEZ SPRING
GUADALOUPE
Sycamore
C
GROVE
B
AT THE
ALUPE
OPEN GROUND
Open Ground
Sycamore grove
OPEN GROUND
135

historical channel network and distributary location for western Santa Clara Valley (Sowers 2004, Givler and Sowers 2005, Sowers and Thompson 2005, Thompson and Sowers 2005, Sowers et al. 2005, Sowers and Givler 2006), and previous research by SFEI mapped wetland habitats and streams (SFEI 1998). Our research builds on these previous efforts to cover a larger area, providing a comprehensive, often more detailed, and spatially specific ecological map. In contrast to previous efforts, our mapping, based largely on features digitized from georeferenced maps, also records the sources used to map each feature and assigns certainty levels.

While these texts were used to shape our understanding of the region, our mapping is largely independent. The maps accompanying these reports were used predominantly as secondary sources (i.e., to confirm presence of a feature depicted by a historical source), rather than as evidence of presence of a historical feature. As a result, a few features (channels and habitats) shown by A.K. Brown for which we found no primary source are not included in our mapping. In a few places near Palo Alto where no other evidence was available, we used his (1963) research in a limited way to map habitats in deference to his extensive experience as a researcher in the area. It is likely that additional historical research will reveal more information about these features.

The habitat map depicts landscape features as they likely existed prior to and during the early decades of Euro-American settlement (1770s-1850s; referred to as "circa 1800" for simplicity). Many well-documented features, represented multiple times by a variety of sources, are mapped with a high level of certainty, while other features (perhaps depicted only by one or two sources) may have a lower level of confidence associated with their shape or size. Undoubtedly, many details of the historical landscape were undocumented in areas where we lacked data. For example, while historical meanders are well documented for many stream reaches, others would have had many more meanders than we were able to capture in our mapping, and similarly many small ponds and wetlands within the wet meadow are likely missing from our map. Because of this, the map is not intended to provide a street- or parcel-scale analysis of landscape pattern, though in many cases it may well do so. Rather, it is designed to display the diversity and heterogeneity of habitats present in western Santa Clara Valley at the watershed scale, and to provide a sense of overall landscape pattern and function across the region.

In addition to limitations in spatial scale, there are also inevitable limitations in temporal scope. It should be recognized that the systems described in this report reflect their own historical context, and are products of long-term patterns in climate, flood regime, and native land management in addition to underlying geologic and edaphic controls. The dynamic nature of these features over a long time frame does not diminish the overall accuracy of the patterns portrayed, or the utility of the map for developing a regional understanding of conditions prior to major Euro-American modifications.

HABITAT DESCRIPTIONS

Samphire, frankenia, tule and other marsh grasses covered the swamp lands of the bay; willows in damp places, meadow grasses, and great patches of mustard covered the black sedimentary soil of the lowlands. …Oaks and the dense underbrush between, did not begin until the gravelly lands were reached, which was generally a short distance below the railroad.

—GATES 1895

The historical ecology of the western Santa Clara Valley is at once straightforward and complex. Broad bands of habitats create ecological zones at a regional scale, as noted (and mapped) by William Cooper in 1926. Vast areas of chaparral occupy older, well-drained alluvial soils near the foothills, while oak savannas and woodlands dominate the alluvial fans below. Wet meadows occur on lower clay soils, and alkali meadows ring the tidal marsh. Willow groves and wetlands occur in a four-mile long band running southeast along the interface between oak woodland and wet meadow near Stevens Creek, formed as a result of rising groundwater at the soil interface. These discrete ecological transitions are captured even on seemingly imprecise sources, which depict the boundaries between willows and oaks, and oaks and brush, with impressive accuracy (e.g., U.S. District Court ca. 1842, Lyman 1847b). The well-defined spatial organization of plant communities, clearly controlled by topography and edaphic factors, has been recognized by researchers and residents for over a century.

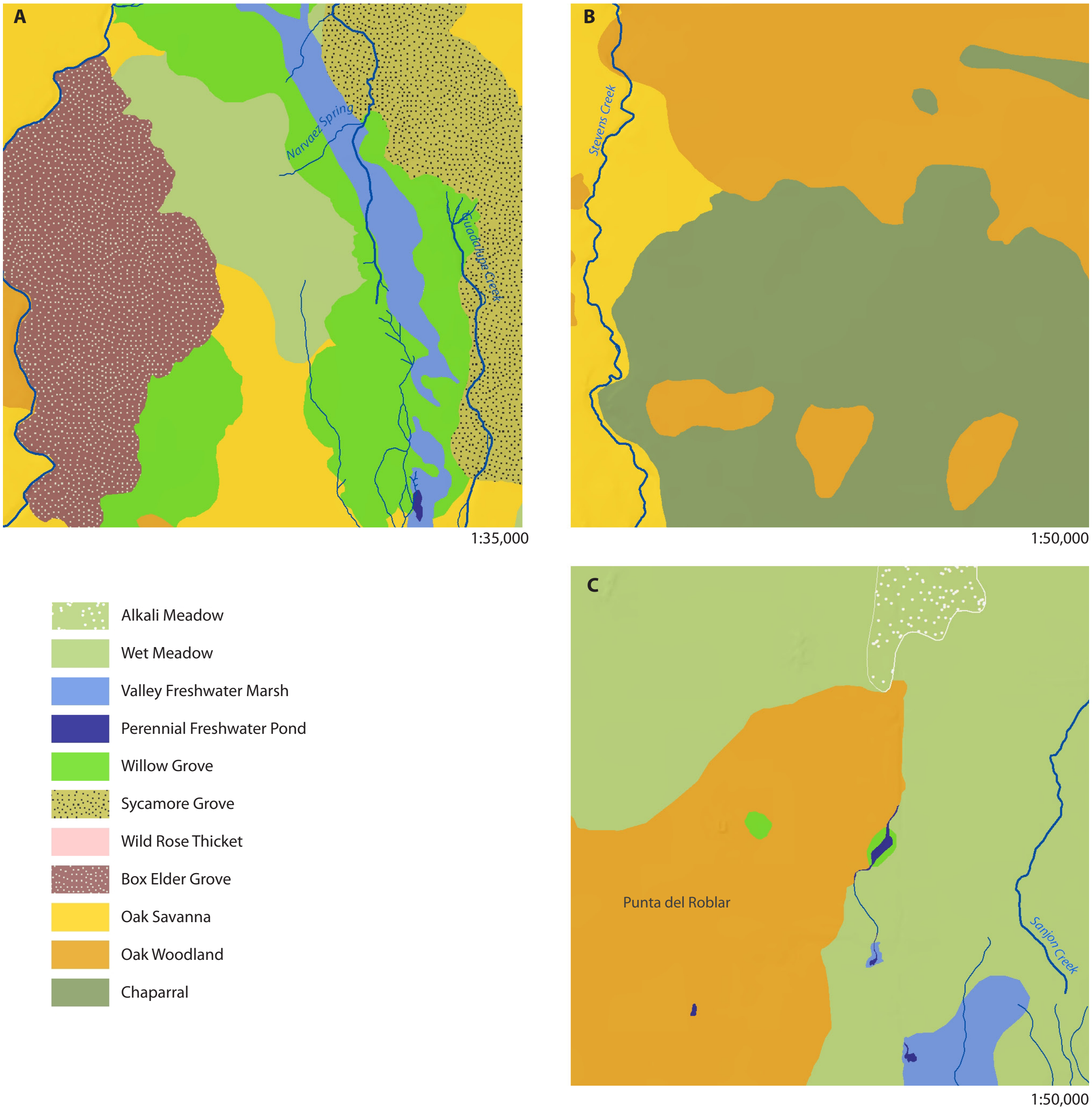
However, a closer look reveals an extremely heterogeneous ecology, full of surprises (ponds in oak groves, chaparral adjacent to a freshwater marsh), diffuse ecotones rather than discrete boundaries (scattered oaks in the wet meadow), uncommon habitats (box elder and sycamore groves), and complex mosaics of features such as at the head of Guadalupe River (fig. 3). While some of this complexity is captured by our habitat map, much more was either not documented in the historical record, or impossible to show using habitat polygons. This report provides some of the ecological texture evident in the textual and cartographic record that we could not map.

The following pages include brief descriptions of spatial distribution and characteristics for the primary habitat classes mapped. Though they provide only a broad overview of the region's ecological patterns and present only a fraction of the available data for each habitat type, they aim to support our mapping efforts by highlighting some of the patterns and features illustrated in the habitat map. Greater depth of analysis can be accomplished through subsequent research efforts.

Streams

This section describes the historical characteristics of the channel network, as mapped for this study. It covers aspects of channel form included on the habitat map (e.g., channel plan form and location of creek terminations). Historical data on additional aspects such as dry season flow, channel geometry, and riparian corridor width and composition were collected, but not synthesized or analyzed, in this phase.

We mapped 184 miles of streams based on multiple historical sources (with particular emphasis on historical aerials and survey maps). While



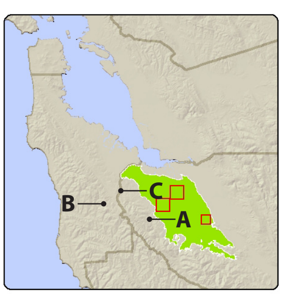


Fig. 3. Areas of ecological diversity and complexity. (A) Freshwater wetlands, willow groves, and wet meadow trace areas of rising groundwater at the head of the Guadalupe River, while nearby box elder and sycamore groves mark slightly higher ground. (B) The boundary between oak woodland and chaparral between Stevens and Calabazas creeks is diffuse; chaparral patches are documented within the oak woodland, while patches of oaks occur within and at the margins of the brush. (C) Protruding into the wet meadow, the Punta del Roblar includes ponds, marshes and willow groves within the Punta and at its margins.

substantial analysis was not performed as part of this study, several themes emerged from our mapping efforts. These themes are briefly discussed below. For the remainder of the section, we focus on the discontinuous nature of western Santa Clara Valley streams in each of the three Watershed Management Areas.

First, it is apparent that the channel network was far less connected historically. In contrast to the present-day drainage network, where each major creek is connected via engineered channels to the Bay, the historical western Santa Clara Valley drainage network was characterized almost entirely by discontinuous stream channels (fig. 4). With the exception of San Francisquito (not included in this study), every creek in western Santa Clara Valley either sank into gravelly soils or spread into impermeable soils at at least one point on the valley floor. No creek maintained a continuous, single thread channel between the hills and the Bay. Even the Guadalupe River had its source near Willow Glen; above its head the upper portion of the river – historically called Arroyo Seco de los Capitancillos or Arroyo Seco de Guadalupe – diffused into multiple channels, spreading into sloughs through marshes and willow groves before coalescing into what we recognize today as the Guadalupe River. This trend is discussed in more detail below.

Second, many reaches of Santa Clara Valley creeks were much more sinuous prior to substantial modification than they are today. Creeks were straightened to accommodate development, allow ships to navigate further upstream, or to improve conveyance of flood waters. An extreme example of this is lower Guadalupe River, a highly sinuous reach that has been engineered to a nearly straight channel (fig. 5). However, many creeks experienced this transformation on a smaller scale. Even between the relatively late historical aerial coverage (1939-1948) and modern (2009) aerial imagery, it is evident that many creek meanders have been lost. Many meanders no longer present are documented in the historical record, and have been included in the habitat mapping accompanying this report. However, there are undoubtedly many other stream reaches where historical meanders were not captured by early maps, and thus many more instances of creek straightening than we were able to portray on the habitat map.

Both of these trends – decreases in sinuosity and increases in connectivity – have implications for the density of the drainage network in the region. Decreases in sinuosity have lowered total stream length in the region, while increases in channel connectivity has raised total stream length. Overall, a net increase of 40 miles of stream length was calculated based on comparison of our historical mapping (134 mi) to the modern stream layer (174 mi).

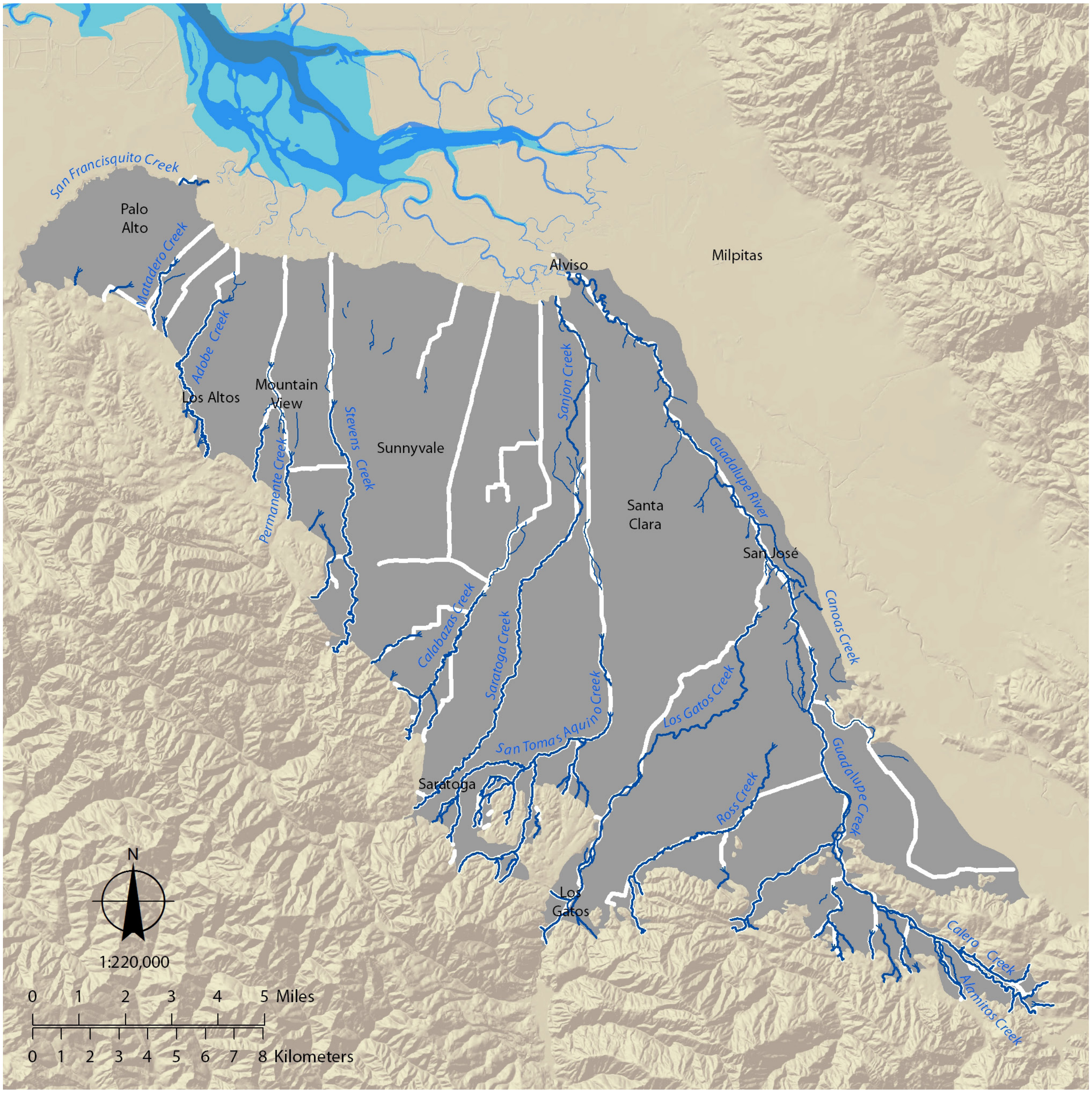


Fig. 4. Historical drainage network (ca. 1800) and modern drainage network (2007) in western Santa Clara Valley. In the early 19th century, not a single creek (with the exception of San Francisquito) maintained a defined channel from the hills to the Bay. Today, every major drainage has been connected.

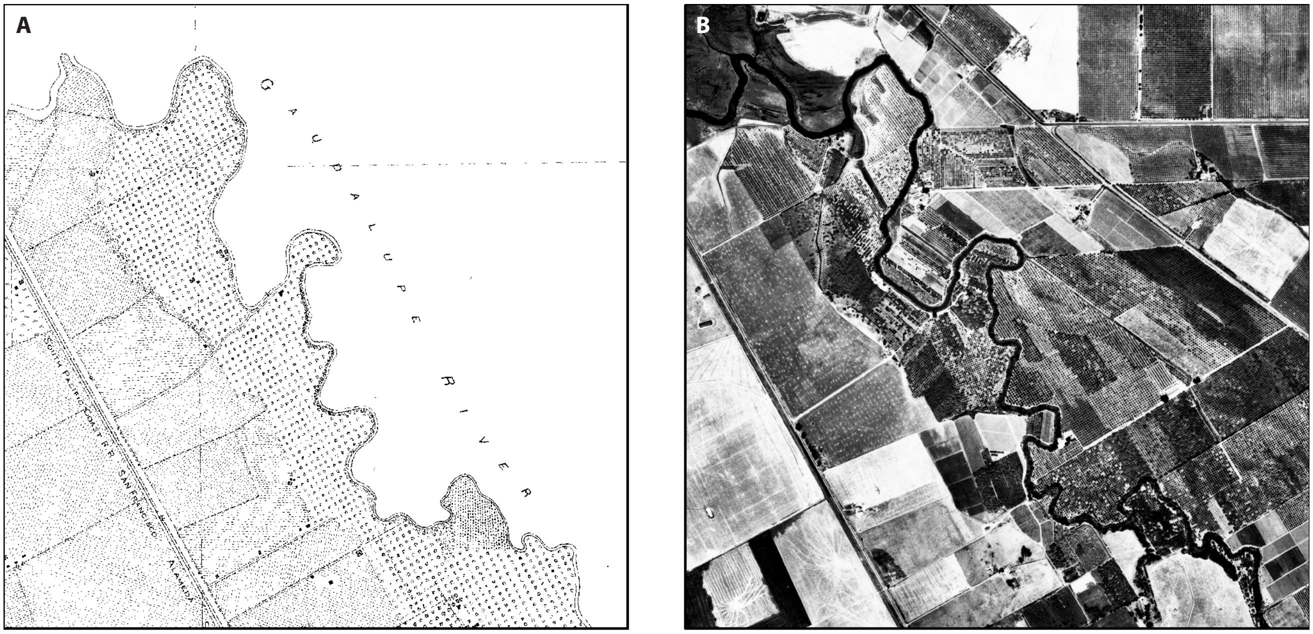


Fig. 5. Lower Guadalupe River, 1897-2005. Between Agnew and Alviso (reach shown above and at right), the Guadalupe River was extremely sinuous (A, B) before being engineering into a straight channel in the 20th century (C). (A: Westdahl 1897a, courtesy of the National Ocean Service, Rockville, MD; B: USDA 1939, courtesy of the Science & Engineering Library Map Room, UC Santa Cruz; C: USDA 2005, courtesy of NAIP)

Channel connectivity

In our mapping, we signified the terminus of defined channels with a distributary symbol. A distributary, signified on the habitat map with a forked symbol, signifies either the sinking or the spreading of a creek (fig. 6). Both types of discontinuous streams result in the loss of a single defined channel across the valley floor, and both were present in the valley. Some streams (e.g., Permanente and Stevens creeks) sank into the coarse gravels of their alluvial fans, recharging groundwater and often re-emerging downslope as sloughs, springs, and wetlands. Other streams (e.g., upper Guadalupe and Saratoga creeks) spread out through multiple channels into wet meadows, wetlands, and willow groves located on impermeable clay soils.

Both types of distributaries were well-recognized historically in the region. The point at which a single thread channel terminated was often referred to as the "spread," "sink," "scatters," or "point of overflow" of the creek (e.g., Forbes 1861a). Owen (1873) described one type of discontinuous Santa Clara Valley stream, with "waters sinking into the gravel as they reach the

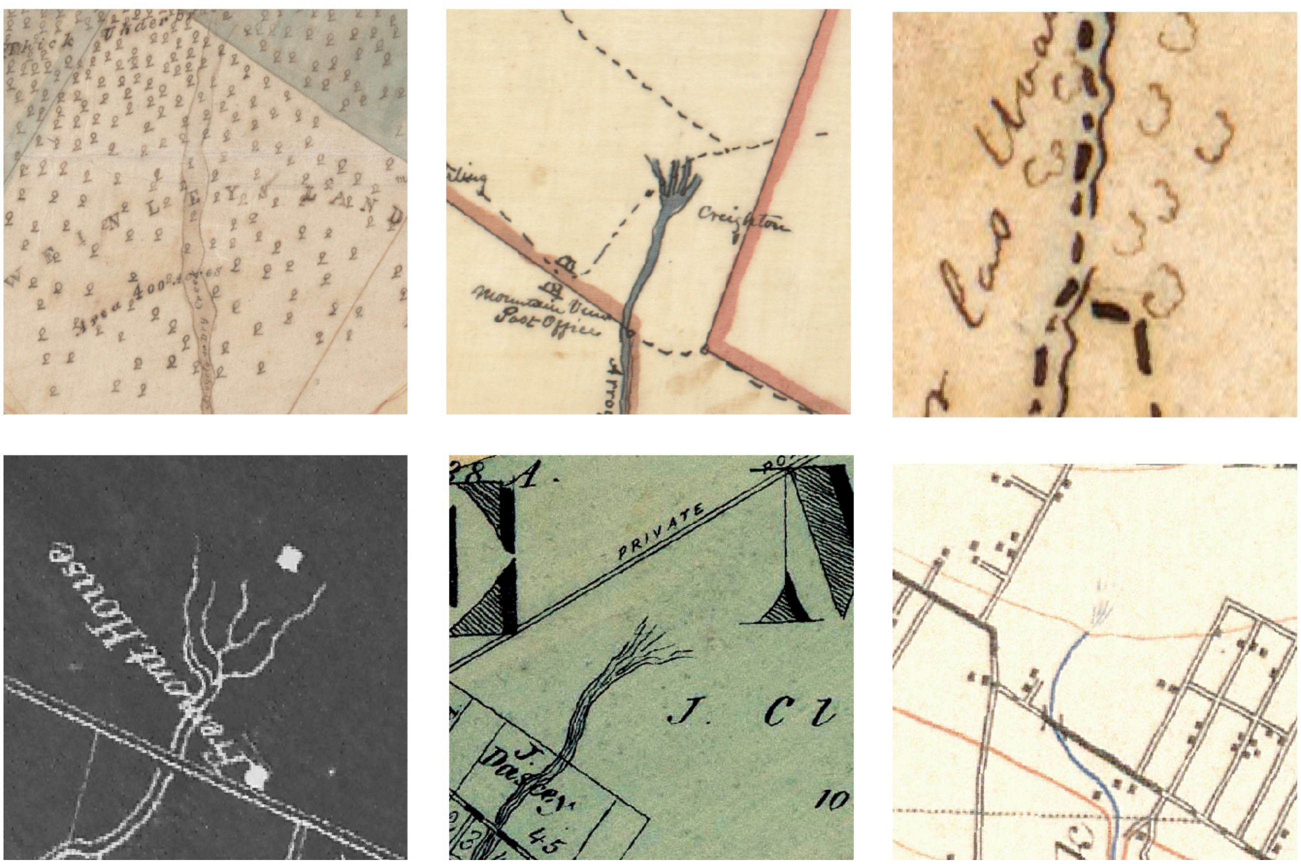


Fig. 6. Distributaries are depicted on historical maps with a variety of symbols. The above early maps provide examples of the array of symbols interpreted as distributaries from the historical record. (Top row: Lyman 1847a, U.S. District Court ca. 1850, and Healy 1861b, courtesy of The Bancroft Library, UC Berkeley. Bottom row: Allardt 1862, courtesy of the Earth Sciences & Map Library, UC Berkeley; Thompson & West 1876, courtesy of David Rumsey Map Collection; USGS 1899a, courtesy of the Earth Sciences & Map Library, UC Berkeley)

plain." Lewis (1851c) also described this characteristic, noting that the streams would sink into alluvium, only to reemerge downslope:

> The streams which issue from the mountains, sink in the higher parts of the valley, and reappear on the low lands, and form springs and marshes. During the rainy season, the accumulated waters from the mountains rush through deep channels cut in the gravelly soil, and spread themselves over the alluvial lands below.

Forbes (1861a) described the other type of distributary, wherein water spread out in the wet season into wetland habitats and multiple undefined channels. Referring specifically to San Tomas Aquino Creek, when asked to define his terms during a deposition related to the Quito land grant, Forbes explained:

> 11. What do you mean by the termination of the Arroyo San Tomas Aquino?
>
> Ans. The point at which in the rainy season the waters of said creek spread out in the plain…some distance from it the concentration of the waters forms a ditch or Zanjon.

In March 1776, Font also observed this phenomenon, describing "arroyos which… become lost in those plains and flats" (Font and Bolton 1933).

Downslope of distributaries, a series of discontinuous distributary channels typically transported flood overflows from the spread of the creek downslope to the Bay. The nature of this drainage network is suggested by Allardt (1862), whose map shows arrays of channels spreading over a large area on many creeks below where we have mapped distributaries (e.g., Adobe, Stevens, and Saratoga creeks; fig. 7). The majority of these distributary channels are not represented on the habitat map, though a few notable portions were mapped where supported by multiple independent sources. These channels represent only a fraction of the undoubtedly extensive distributary channel and slough network between discontinuous streams and the Bay, and their location would have been unstable over the long term as floods filled old channels with sediment and created new ones. However, they serve to provide a more complete picture of the nature of the connection between alluvial streams and the estuary. It is also important to note that the lack of a well-defined surface channel between creek and bay does not necessarily preclude anadromy (Grossinger et al. 2006).

The creation of channels (e.g., Sunnyvale East and West) and the extension of previously discontinuous streams to the Bay has altered the transport of water in the region (fig. 8). Floodwaters that once would have recharged

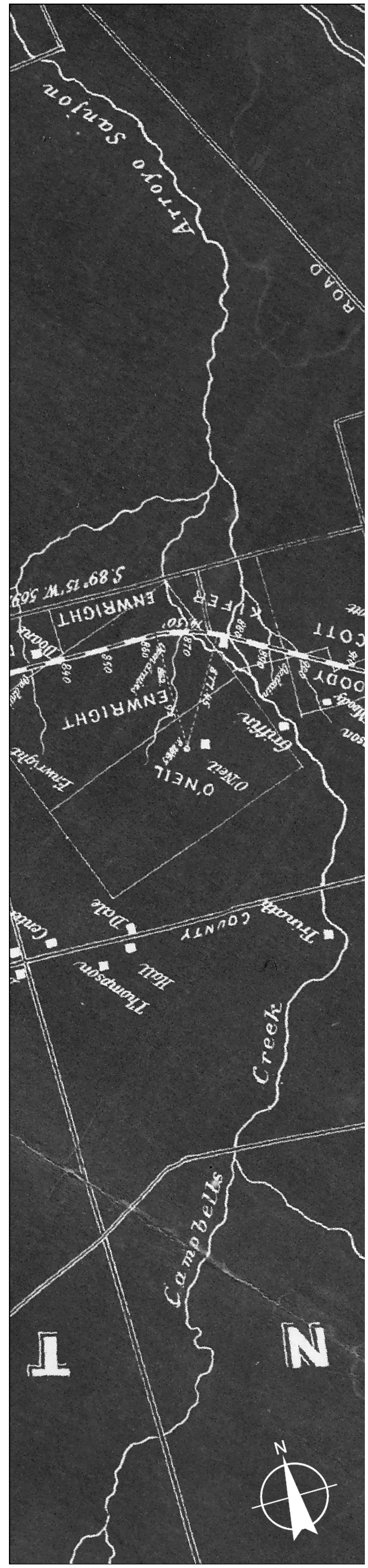


Fig. 7. Mouth of Saratoga Creek and head of Arroyo Sanjon, 1862. Multiple overflow channels conveyed water from Saratoga (Campbell) Creek to the Arroyo Sanjon below. Though detail is only provided for the channels that crossed the line of survey for the railroad, this map illustrates the complex, multi-thread nature of the connection between Saratoga Creek and the Bay. (Allardt 1862, courtesy of The Bancroft Library, UC Berkeley)

groundwater or spread into wetlands are now conveyed through man-made channels directly to the Bay. The increase in channel connectivity has increased the drainage density (stream length per unit area) of the region, especially in the lower reaches of each watershed.

LOWER PENINSULA STREAMS. Excepting San Francisquito Creek (outside the purview of this report), Lower Peninsula streams spread out into undefined channels on the valley floor. Matadero, Adobe, Permanente, and Stevens creeks, in addition to many smaller watercourses, all terminated before reaching the Bay, either sinking into the coarse sediments of their alluvial fans or spreading into wet meadows, marshes, and willow groves (fig. 9).

Matadero Creek terminated in the wet meadow just south of Middlefield Road, while Adobe Creek lost definition in a diffuse area between the

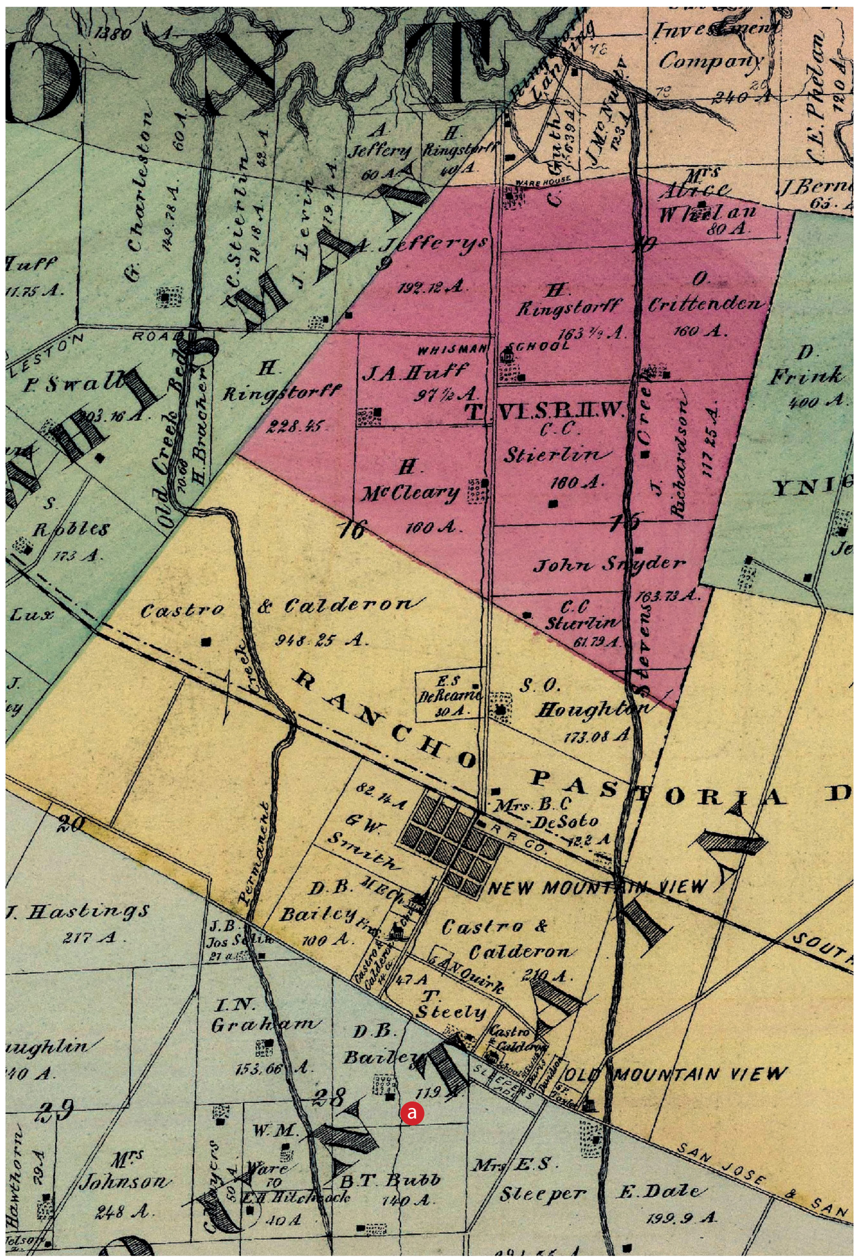


Fig. 8. By the late 1800s, many creeks (including Permanente and Stevens creeks, at right) had been connected through constructed channels to the Bay. Some of these connections would have been enlargements of existing drainages, perhaps following articulations of existing channels. Others were completely new. Modern Permanente Creek is a combination of both processes: In the mid-1870s, a ditch was dug to divert Permanente Creek into another small creek around modern Cuesta Drive (at the very bottom of the map at right), apparently part of the Hale Creek drainage. This is the origin of the Permanente-Hale Creek confluence, and the route the creek follows today in the vicinity of El Camino Real. (The former course of Permanente Creek, also ditched to the bay by the time this map was drawn, is shown as a smaller channel at 'a.')(Thompson and West 1876, courtesy of David Rumsey Map Collection)

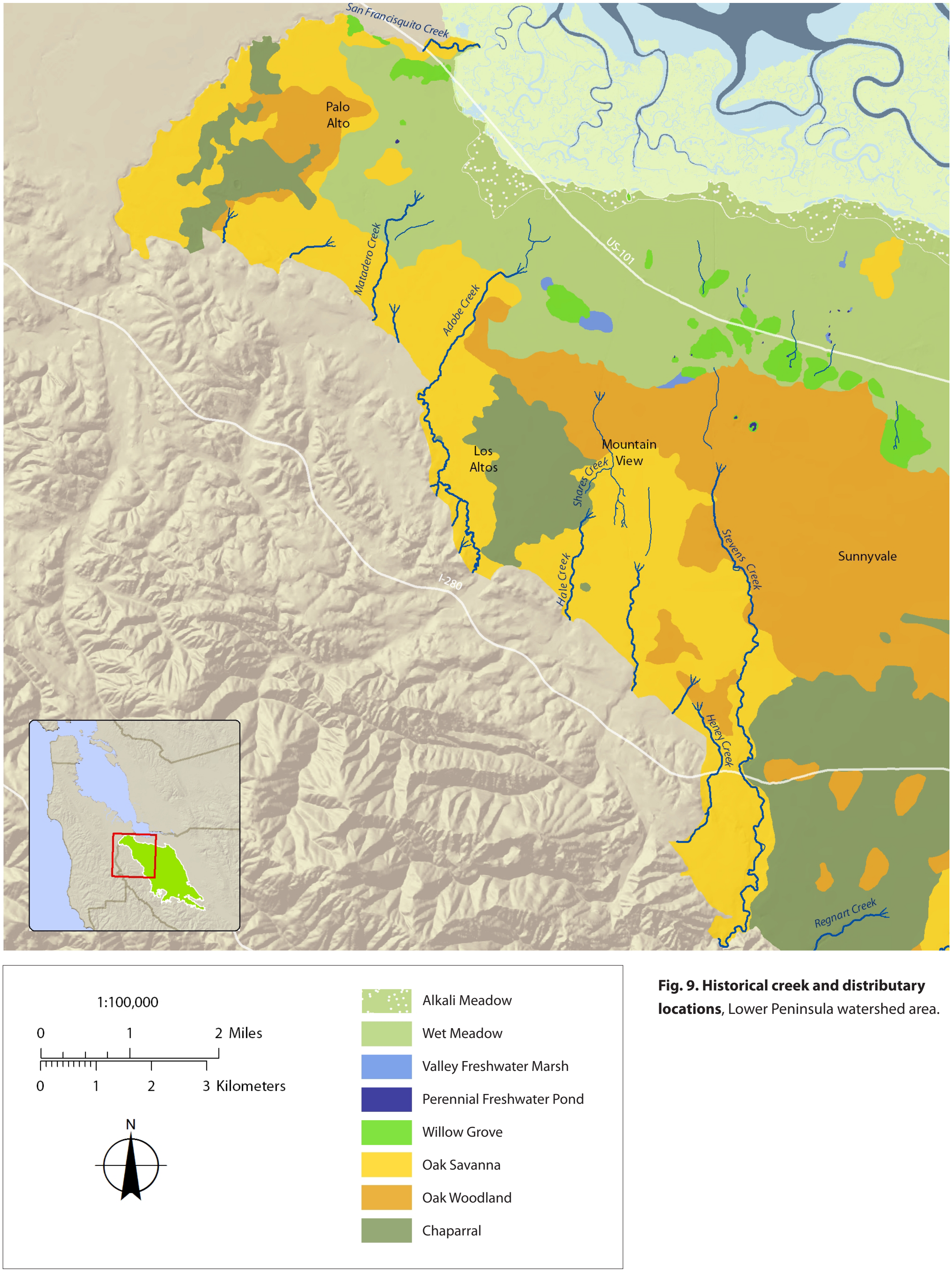


Fig. 9. Historical creek and distributary locations, Lower Peninsula watershed area.

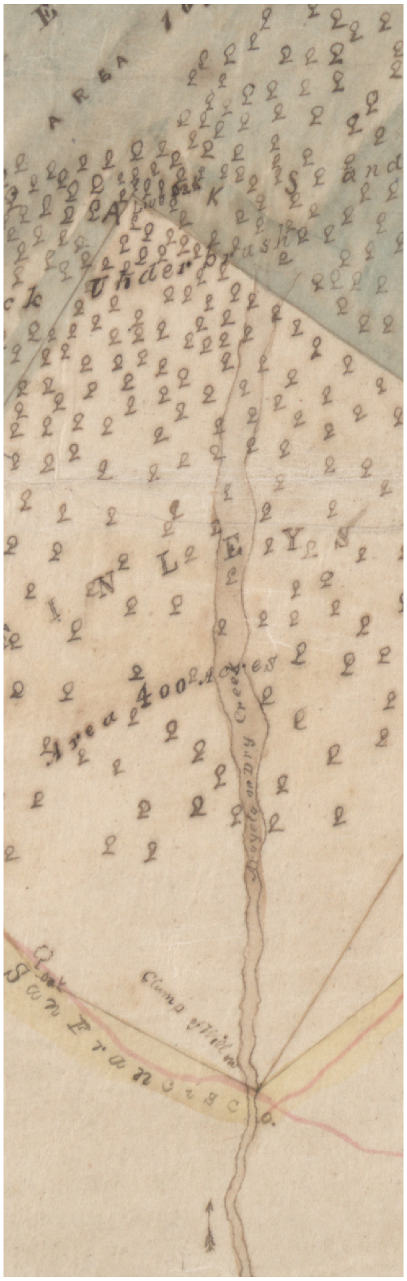


Fig. 10. The spread of Stevens Creek, 1847. Below El Camino Real, Stevens Creek spread into a large oak woodland well before reaching San Francisco Bay. This map captures the diffuse nature of the creek as it traveled north through the oak grove. (Lyman 1847a, courtesy of The Bancroft Library, UC Berkeley)

railroad and modern Highway 101. County surveyor Lewis (1850) wrote that "the Arroyo de las Yeguas [Adobe Creek] terminates…without coming to the Bay"; twelve years later he testified that the creek "has no well defined channel within about a mile of the Bay" (Lewis 1862). Instead, it spread into a high groundwater area which included freshwater wetlands and willow groves (Lewis ca. 1850, U.S. District Court ca. 1850, Matthewson 1860).

Stevens Creek had its terminus at a similar elevation, somewhere between El Camino Real and present-day Middlefield Road during the mid- to late 19th century, though the downstream extent of the defined channel undoubtedly varied somewhat from year to year. The creek spread into a small wetland area (see U.S. District Court 1842) and then a large area of oaks and brush (Lyman 1847a,b; fig. 10).

Permanente Creek's terminus was further upslope, near St. Francis High School and El Camino Hospital (around the 160 foot elevation contour), before being rerouted into another small creek around the mid-1870s (Herrmann 1877; see fig. 8). Curiously, several early maps (1862-1872) show a connection between Permanente and Stevens creeks. Each depicts Permanente Creek north of Foothill Expressway/Grant Road flowing more easterly than it does presently, and intersecting with Stevens Creek just above the location of Old Mountain View on El Camino Real (Allardt 1862, Lewis 1865, Healy 1866, Hare 1872, Whitney 1873). However, all these maps are coarse maps of the Santa Clara Valley or larger portions of the state, and the extent to which they were produced independently is unclear (many of them are railroad maps). Other early maps (Thompson & West 1876, Bailey & Phillips 1887, Herrmann Bros. 1890) do not show such a connection, though they are all later and already show modifications to Permanente Creek. Additionally, there is no topographic signature of permanent flows in that direction readily visible on the early soils map (Lapham 1903) or aerial (USGS 1948). Given the lack of other available early documentation, we mapped the two creeks separately. However, it is possible that an early connection between the two creeks was modified in the 19th century, or that the two shared a connection only during periods of high flows (as documented for the lower reaches of San Francisquito and Matadero creeks; Snyder 1905).

While defined channels for each creek terminated before reaching the Bay, most of these creeks would have maintained a surface water connection with the Bay during the rainy season (Woltor 1881). During winter high flows, water would have flowed continuously to the Bay through a complex network of shallow, discontinuous channels and swales. Lewis (1862) described these channels below the termination of Adobe Creek: "There are many inferior channels by which the water in the rainy season finds its way to the bay, but there is no main channel, and near the bay the water spreads so that there is no channel whatsoever." G.F. Allardt, mapping for the San Francisco and San José Railroad in 1862 (an extremely wet year), showed many of these diffuse pathways to the Bay below the spreading of

Adobe, Permanente, and Stevens creeks. While these creeks may not have maintained a continuous, defined channel to the Bay, they would have been frequently connected by surface water during high flows.

WEST VALLEY STREAMS. West of the city of Santa Clara, Calabazas, Saratoga, and San Tomas Aquino creeks flow from the Santa Cruz Mountains northward toward the Bay. Like Adobe, Matadero, and Stevens creeks to the northwest, these three West Valley streams maintained single thread, meandering channels across the alluvial plain before spreading into shallow, discontinuous distributary channesl around the 100-200 foot elevation contours (fig. 11).

In contrast to the well-drained sandy and gravelly loams surrounding the upper alluvial portions of the creeks, bodies of the "very fine, heavy" Oxnard silt loam covered large areas at the spread of each creek (Lapham 1903, 1904). This soil is described as "sticky when wet, puddles readily" and "deposited from slack water in flood plains of streams" (Lapham 1904). These would have been areas of multiple shallow sloughs rather than a single, defined channel. This is in contrast to Permanente and Stevens creeks, which lost definition in oak groves on gravelly sandy loams. While there was not sufficient evidence to delineate wet meadows on Oxnard silt loam on the habitat map, it is likely that portions of these areas, particularly at the termini of creeks, may well have been seasonally inundated as indicated by the early soils report.

Calabazas Creek spread around Cupertino High School at Stevens Creek Boulevard. Early settlers cultivated squash (*calabazas*) in the moist soil at its terminus (Healy 1864a). One resident, who had lived in Santa Clara County since 1830, distinguished Calabazas Creek from the other West Valley streams, classifying it as a spring-fed *arroyo* rather than a true creek: "several springs…rise on the slope of the hills and do not form arroyos in the summer season, except one – the Arroyo de las Calabazas" (Forbes 1861a). Early drainage and flood control efforts altered the channel's connectivity: by 1876, it was shown connected to Sanjon Creek/lower Saratoga Creek (Thompson and West 1876). This probably reflects channels composing the creek's natural high-flow pathways as well as artificial channels created (or natural channels enlarged) through early ditching efforts. This combination of natural and artificial channels is also reflected in an 1890 map that shows a channel below the creek's historical distributary, some of which looks natural and some of which is clearly engineered (Herrmann Bros. 1890).

Like Calabazas Creek, San Tomas Aquino Creek channel lost definition well before reaching the Bay. Campbell (1861b) describes the "scatters" of the creek around Hamilton Avenue, while Healy (1864a) and Tracy (1859b) note the "sink" (Tracy) of the creek around Williams Road, a mile further north. Disconnected distributary channels flowed north below the terminus of the San Tomas Aquino Creek, hydrologically connecting diffuse wet season flows to Sanjon Creek (Forbes 1861a).

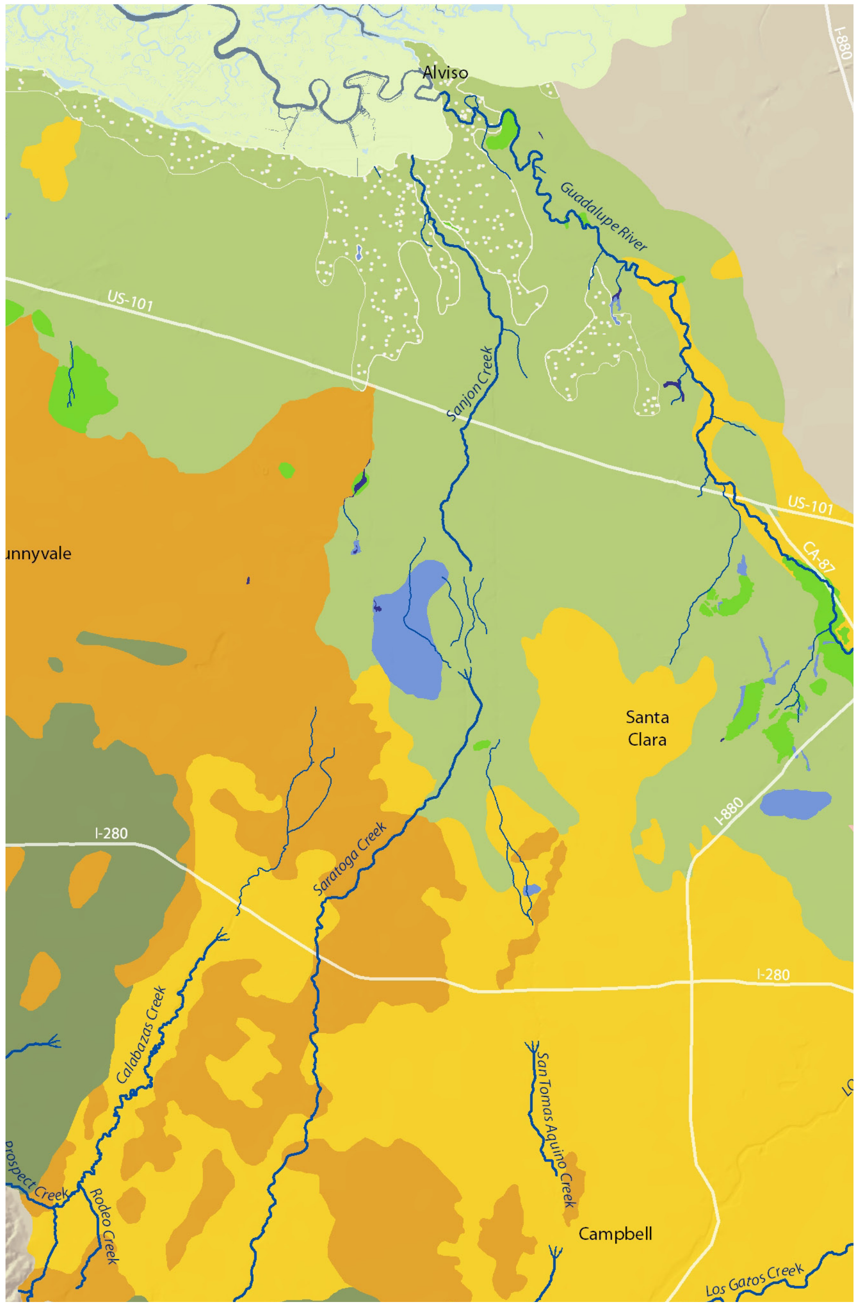
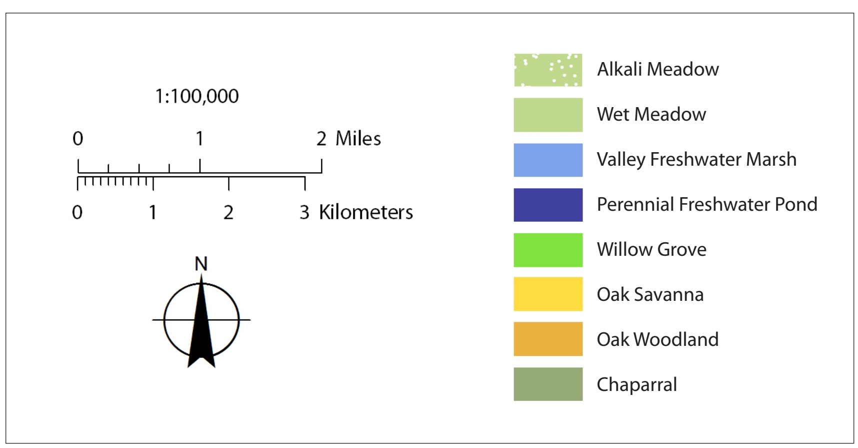


Fig. 11. Historical creek and distributary locations, West Valley watershed area.



Even above its terminus, the channel of San Tomas Aquino Creek was notably shallow and poorly defined. Many maps show a break in the channel from Campbell Avenue to Hamilton Avenue, a distance of about 2/3-3/4 mile (Tracy 1859a, Thompson and West 1876, Herrmann ca. 1878). As Tracy (1859b) colorfully notes, the creek "loses its banks." Healy (1861b) also shows a discontinuous channel upstream of the creek's terminus, depicting it as a series of broken lines. One early map even shows two termini of the creek, both labeled "sink of creek" (Tracy 1859a). These descriptions illustrate the shallow, discontinuous nature of the channel, which presumably spread into a freshwater marsh (although no such feature has been documented) or disappeared into coarse gravels. This interpretation is further corroborated by GLO survey notes, which describe the creek in this reach as "shallow" (Tracy 1859b) or "very shallow" (Wallace 1858) and about 13 feet wide.

Q. What do you mean by the termination of the Arroyo San Tomas Aquino?

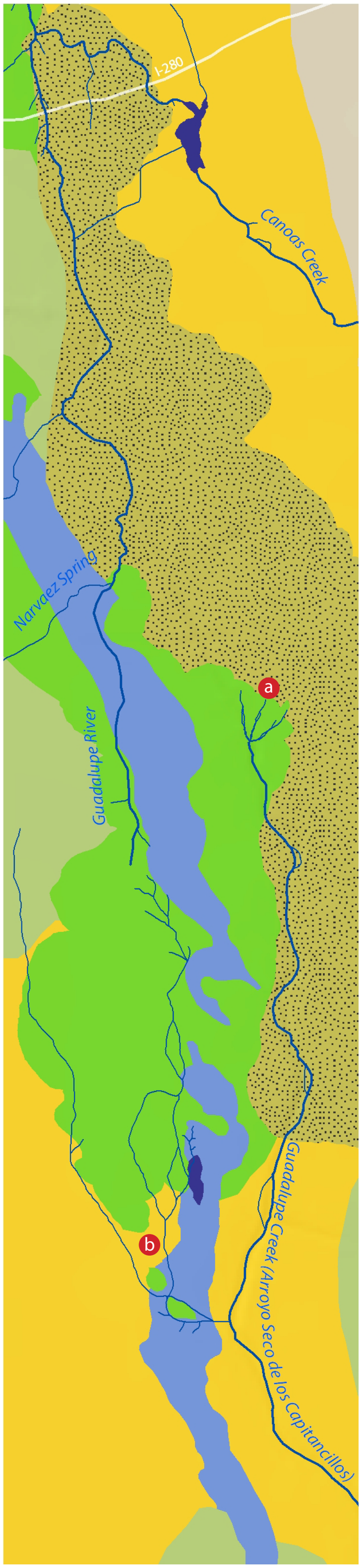
A. The point at which in the rainy season the waters of said creek spread out in the plain…some distance from it the concentration of the waters forms a ditch or Zanjon.

—FORBES 1861A

Saratoga Creek (known historically as Tito, Quito, or Campbell Creek) also spread into moist soils west of Santa Clara and southwest of the intersection of El Camino Real and the San Tomas Expressway (Lewis 1851b, Healy 1864a, Lapham 1903). About a mile downslope of the spread, a series of distributary channels coalesced into a single channel, called Sanjon Creek in the Spanish and early American eras, which fed into the sloughs and marshes below (e.g., White 1850a, Lewis 1851b). A *zanjón* is a big ditch, indicating that Sanjon Creek would have been a relatively small, shallow watercourse. However, it was defined enough to be used as a land grant boundary (between Ulistac and Pastoria de las Borregas), and was not a ditch in the modern sense of an artificially constructed channel:

> 9th Question. When was the sanjon first formed?
>
> Answer. It has been there ever since I have known it [1835]. It was formed by the natural course of the water. (Pico 1854)

Sanjon Creek would have funneled water from Calabazas, Saratoga, and San Tomas Aquino creeks to the Bay during times of high flow. Allardt (1862) even shows the three creeks converging, perhaps representing the hydrological connection they would have had to Sanjon Creek during flooding. However, the head of Sanjon Creek was physically closest to the spread of Saratoga Creek, a fact taken advantage of by early settlers. A direct artificial connection between Saratoga Creek and Sanjon Creek was constructed fairly early, and is represented on a number of 19th century maps (e.g., Thompson and West 1876, Herrmann Bros. 1890). Though these maps show Saratoga Creek and Sanjon Creek as a continuous channel to the Bay, they still preserve the two names, labeling the lower portion of the creek as "Sanjon" (Herrmann Bros.) or "San Jon or Campbell Cr." (Thompson and West). By the early 20th century, however, Sanjon Creek was more consistently considered to be lower Saratoga Creek, and was not often labeled separately (e.g., Westdahl 1897a, USGS 1899b, McMillan 1902, Holmes and Nelson 1917). Today, the watercourse that roughly follows the former course of Sanjon Creek is known as San Tomas Aquino Creek.



GUADALUPE RIVER AND ARROYO SECO DE GUADALUPE. Currently, the stream we call Guadalupe River begins at the confluence of Guadalupe Creek and Alamitos Creek near Coleman Avenue, at the mouth of Almaden Valley. Until the late 19th century, however, Guadalupe River originated in an array of springs and wetlands in the Willow Glen area, more than four miles north of the contemporary origin at the Guadalupe Creek/Alamitos Creek confluence (fig. 12). The upper portion of today's Guadalupe River (south of Willow Glen) was called Arroyo Seco de Guadalupe, Arroyo Seco de San José de Guadalupe, or Arroyo Seco de los Capitancillos. It dissipated into groves of willows and sycamores adjacent to the Willow Glen wetland complex and just south of the railroad.

The historical Guadalupe River emerged from springs 1,500 feet to the west of the Arroyo Seco de Guadalupe's termination. That the distinctly named streams were discontinuous is explicitly shown by several maps (e.g., U.S. District Court 1860, Rayner 1871, Herrmann ca. 1879, Thompson and Herrmann 1879), and documented by other early descriptions which refer to the Willow Glen area as the head or source of the Guadalupe River. Surveyor Charles T. Healy (1860b), following the Guadalupe River upstream in May 1860, noted that he was "standing in the bog, or swamp, at the head of the said Guadalupe river" at the modern intersection of Pine and Bird avenues in San José. Other sources refer to this area as the "willow grove at the head of the Guadalupe" (now Willow Glen; Herrmann ca. 1879), the "head of Guadalupe River" (Thompson and Herrmann 1879, U.S. Surveyor General 1880), or the "sources of Guadalupe Creek [referring to the river]" (Vischer ca. 1865). One early map labels the willow grove as the *nacimiento*, or source, of Guadalupe River (U.S. District Court ca. 1840; fig. 13).

By 1871, the Lewis Canal had been created to connect Guadalupe River to the mouth of Arroyo Seco de Guadalupe (Rayner 1871). The half-mile long, straight canal bypassed the head of Guadalupe River, connecting to the river south of Willow Street. By the turn of the century, surveyors no longer distinguished these different reaches and the Arroyo Seco-Lewis Canal-Guadalupe River alignment became simply the "Guadalupe River" (USGS 1899b), as it remains today.

The extensive complex of willow groves, wetlands, and sycamores at the head of Guadalupe River, an area known today as Willow Glen, is discussed in more detail in the Willow Groves section (see p. 41).

Fig. 12. Mouth of Arroyo Seco de Guadalupe and head of the Guadalupe River. The mainstem of Arroyo Seco de Guadalupe terminated in a grove of sycamores and willows to the east of the Guadalupe River (a); series of sloughs (b) also carried water northward through the willow groves toward the Guadalupe River.

Fig. 13. Head of the Guadalupe River, ca. 1840. An early rendition of the city of San José and surroundings also shows the "Nacimiento del Río de Guadalupe," or the origin of the Guadalupe River. The colorful depiction of trees illustrates the densely vegetated area at the head of the river. (U.S. District Court ca. 1840, courtesy of The Bancroft Library, UC Berkeley)

LOS GATOS CREEK. A number of early sources clearly document a confluence of Los Gatos Creek with the Guadalupe River (e.g., Lewis 1851a, Lewis 1854, Rayner 1871, Herrmann 1875, Thompson and West 1876; fig. 14). In 1861, one surveyor asserted that while the two streams did spread into sloughs in the region's willow groves, "the main point of junction is well defined" (Smith 1861). These sources make it clear that by the mid-1850s, Los Gatos Creek and Guadalupe River joined at a clearly defined confluence near their present junction.

However, the earliest available sources (1850-1853) are not as clear regarding the existence of a defined confluence of the two channels. Each pre-1854 map we discovered that depicts the reach of Guadalupe River where the Los Gatos confluence is today (e.g., Duval 1850, White 1850b, Lewis and White 1853b) shows a slough at the location of the present-day confluence, but none show its connection to upstream Los Gatos Creek, and none label the channel "Los Gatos." The lack of identification of the creek as Los Gatos, the cessation of the channel a short distance from Guadalupe River, and the size of the depicted channel suggest that the confluence as we know it today did not exist at that time. This channel may have been one of a series of sloughs to transport water from the spread of Los Gatos Creek to the Guadalupe River. This interpretation is supported by some later maps which also show multiple channels of the Los Gatos near its confluence, suggesting a more diffuse connection between it and Guadalupe River (Lewis 1851a, Arnold 1855, Allardt 1862).

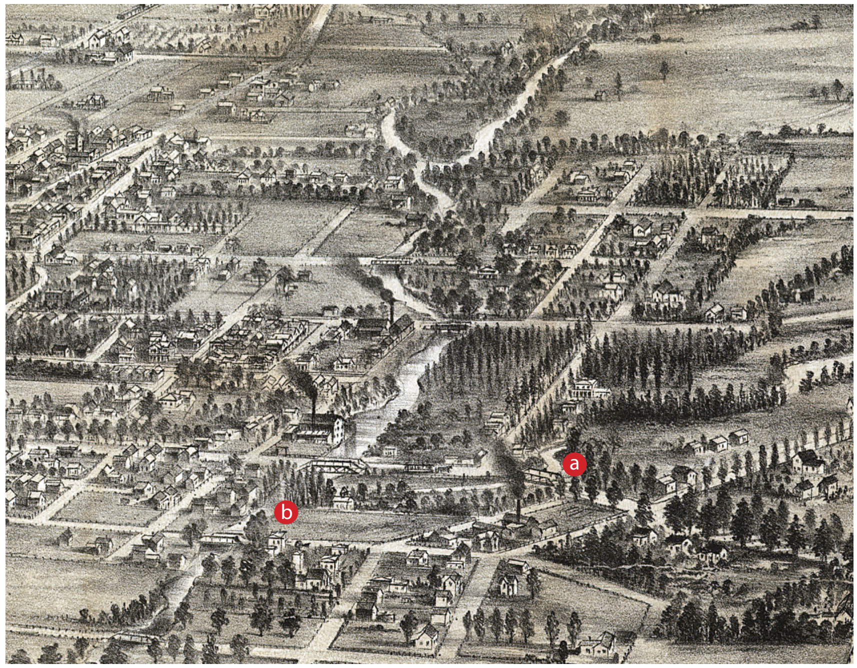


Fig. 14. An early (1869) lithograph showing a bird's eye view of San José also shows the well-defined channel of Los Gatos Creek (a) entering Guadalupe River (b) near its present confluence north of The Alameda/Santa Clara Street. (Gray and Gifford 1869, courtesy of The Bancroft Library, UC Berkeley)

Detailed testimony by former Santa Clara County surveyor William J. Lewis (1857a) strongly supports this interpretation of the earliest available maps:

> In February, 1850 I made a survey along the left bank of the creek [Los Gatos] and found that below the point indicated on the map by station 29 [about 1,000 feet north of the Western Pacific Railroad crossing] the channel ceased and the water spread itself over the country finding its way to the river by various minor channels.
>
> During the heavy rains which occurred in the winter of 1852-3, a new channel was formed below this point, which is represented on the accompanying map and marked "new channel".
>
> The before named Fernandez and Chabollo [José Fernandez and Pedro Chabollo, two early residents of the area] went with me on the ground and testified that at the date of the Grant the channel of the Los Gatos terminated near the crossing of the road by the Splinoes [Splivalo] house [near Riverside Drive]. They separately testified that they never heard of any stream below this point or any one entering the Guadalupe River called the "Los Gatos." They also pointed out the minor channels and indications of former channels of both sides of the line run from station 28 to station 29 by which the water found its way to the river...

This description indicates that what we recognize today as the confluence of Guadalupe River and Los Gatos Creek was established relatively recently, after the flooding of 1852-3. Before that time, Los Gatos Creek spread above Lincoln Avenue into multiple sloughs, which passed through the willow grove between Los Gatos Creek and Guadalupe River before water from the creek reached the river (fig. 15).

Fig. 15. Los Gatos Creek and the Guadalupe River. Before the mid-1850s, water from Los Gatos Creek (a) found its way to the Guadalupe River (b) through a series of overflow channels traversing the willow groves and wet meadows of the area. By the late 1850s a more defined confluence of the two streams had been established, though testimony confirms that no such connection had existed previously. While this undated map was drafted after a connection between the two streams was established, it appears to be a composite of multiple surveys. It is possible that the cartography near Santa Clara predated the change. (Unknown ca. 1870, courtesy of The Bancroft Library, UC Berkeley)

Wetlands

We mapped several different types of wetlands (including a few riparian habitats): wet meadows, alkali meadows, ponds, freshwater marshes, willow groves, one box elder grove, a sycamore grove, and a few small wild rose thickets. In total, we mapped approximately 30,800 acres of wetland habitats, or over 30% of the study area. Wet and alkali meadows covered large portions of the flat clay adobe land ringing the Bay, extending far inland along depressional areas near Guadalupe River and Canoas Creek. Freshwater marshes, willow groves, springs, and ponds occurred in high groundwater areas or areas of emergent groundwater and limited drainage, often within the wet meadow matrix.

In this section, we discuss the general characteristics of each habitat type, and describe notable locations where they occur.

Wet meadows

Wet meadows, which covered broad portions of the Santa Clara Valley prior to hydromodification, are characterized by poor drainage conditions associated with dense clay soils and nearly flat topography. They are flooded for days or weeks depending on rainfall events and their landscape position. As a result of high water retention (from rainfall/surface runoff) and/or high groundwater levels, these areas stay moist longer than adjacent, more well-drained lands. Wet meadows occupied a large portion of the study area (**24%**), covering much of the area just upslope from the Bay tidal marshes and extending further inland south along the west side of Guadalupe River.

Historical descriptions of wet meadows capture their treeless, seasonally inundated nature. In his reconstruction of pre-modification vegetation patterns in the vicinity of Palo Alto, Cooper (1926) described the habitat as an "open meadow-like belt" around the edge of the Bay. In 1827, Beechey ([1831]1941) described the wet meadow near Santa Clara as "more marsh than that part of the ground over which they had just traveled," and Bryant (1848) noted a "fertile plain" between the Bay and San José that "at certain seasons of the year, is sometimes inundated."

More spatially specific references to wet meadow lands, captured in historical maps and GLO survey notes, refer to wet meadow lands as "rich black clay" (Reed 1866), "level rich land" (Tracy 1853),"open prairie" (Reed 1866), "adobe lands" (Reed 1866), and "low wet meadow land" (Tracy 1853). Along Canoas Creek south of Capitol Expressway, surveyor Sherman Day (1854) described "moist land," "meadow land; stiff clay wet in winter," and "stiff black mould, wet in winter and baked in summer." In the 1840s near Santa Clara, it was known as the *bajío* or lowland (as opposed to the *alta* or high ground of Santa Clara) and was described as "good fertile soil, being subject to overflow, and the retention of its humidity in the Summer" (Forbes 1862a).

Wet meadows were widely recognized as fertile soil and rich grazing land. An early survey of the wet meadows around The Alameda classifies them as "rich moist soil," "rich moist land," and "fine rich soil" (Duval 1850). These areas of rich grass growth were heavily used by the Mission's cattle, which "ran about the Mission and watered there" (Campbell 1861a). The "swampy lands," or wet meadows, surrounding Santa Clara were considered the "best grazing lands" (Forbes 1861a). This remained true even into the 1930s, when dairy cows also made use of the rich grazing available on these soils (fig. 16).

During the dry summer, these areas would have been ideal for traveling quickly through the region from Palo Alto to San José (and indeed the "summer road" passed through the wet meadows; Brown 1963). In the winter months, though, inundated wet meadows would have been impassable – or nearly so – for hundreds of acres (Forbes 1861b). Pedro Font, traveling through the Santa Clara Valley in March 1776, noted that west of the Guadalupe River parts of the valley, "being such low ground," were "somewhat miry in spots, and plainly, if it rains very much it becomes untravelable" (Brown 2005). Vancouver ([1798]1984), traveling in November 1792, was not so fortunate:

> Having passed through this imaginary park [of oaks northwest of Santa Clara], we advanced a few miles in an open clear meadow, and arrived in a low swampy country; through which our progress was very slow, the horses being nearly knee-deep in mud and water for about six miles.

…after walking through about 2 miles of mud and water I arrived at Santa Clara.

—BURRELL, IN FEBRUARY 1853

Fig. 16. "Dairy lands of a shallow depression east of San José," ca. 1936. From the cattle of Mission times to dairy cows of the 20th century, wet meadows have been identified as valuable grazing land for stock. (Torbert 1936)

> The badness of our road rendered this part of the journey somewhat unpleasant. About dark we reached better ground, and soon after the night closed in, we arrived at the mission of Santa Clara.

In the Santa Clara/San José area, wet meadows extended further inland, nearly surrounding Santa Clara and extending back along Canoas Creek and into the Willow Glen area of San José. Abundant references to wet meadow areas in early accounts of the Santa Clara-San José area reflect their dominance in the region. Mission Santa Clara itself was first built on wet meadow land in order to be near a steady water supply, though it was eventually moved (in the late 1810s and early 1820s and after a number of other moves; Bojorquez 1862, Skowronek and Wizorek 1997) to a tongue of coarser soils and higher ground jutting into the wet meadows, where Santa Clara University stands today (Pacheco 1862, Bojorquez 1862, Lapham 1903, Broek 1932).

These areas were largely without trees, except for scattered willow groves and swamps which sometimes occurred along or at the terminus of creeks (e.g., Guadalupe River and Stevens Creek), or where supplied by emergent groundwater at springs. Occasional oaks colonized protrusions of higher, gravelly soil within the meadow or at their edges. (Early shade trees planted in the area, such as those along The Alameda, would have been notable, and striking, on the otherwise treeless plain.) The dominant plant species were probably rhizomatous ryegrasses (*Leymus* spp.) with a significant component of obligate and facultative wetland plant species such as wire rush (*Juncus balticus)*, irisleaf rush *(Juncus xiphioides)*, buttercup *(Ranunculus californicus*), and blue eyed grass *(Sisyrinchium bellum)* (Ratliff 1988, Holstein 2000). Hoover's button-celery (*Eryngium aristulatum* var. *hooveri*) was collected in the wet meadow east of Palo Alto in 1899 (CNDDB 2010). Other historically documented species in the wet meadow include the California wild rose (*Rosa californica)*, wild nettles, and blackberries (Duval 1850, Howe 1851, U.S. District Court ca. 1860, Herrmann 1879).

Ponds and perennial wetlands formed in low depressional areas and in places of emergent groundwater within the wet meadow. Numerous features ranging from ponds under 0.2 acres to wetlands well over 300 acres were documented within the wet meadow area (see p. 32 for further detail). Many of these sources of perennial fresh water would have been heavily used – and perhaps exhausted – fairly early. As early as 1861, James Alex Forbes (1861a), testified that "in former times there were many water holes" in the wet meadows surrounding the Mission, emphasizing their relatively early disappearance.

MAPPING METHODOLOGY. We used the 1958 soils map (Gardner et al. 1958) as the foundation of our mapping of the historical extent of wet meadow. This survey identifies a number of heavy textured, poorly drained basin soils which coincide with historical descriptions of wet meadow conditions. These soils are described as "developed under various degrees of slow or very slow runoff and high groundwater levels," typically having "smooth and nearly level relief (<0.5% in slope)," and mostly "heavily textured." They report that these soils had, either at the time of survey (1940-41) or in recent historical times, poor drainage and herbaceous vegetation. Basin soils with an alkali component were mapped as alkali meadows (see p. 31).

In addition to the basin soils, a few other soils classified as "over basin clays" were included in wet meadow mapping based on descriptions by Gardner et al. (1958) of the relatively recent nature of these deposits. Gardner attributes these shallow deposits to large-scale erosion since 1850 due to agricultural practices, which buried downstream basin clay soils under lighter loams of the Mocho series: "Differences in depth of Mocho soil material on either side of old levees or road embankments…indicate that nearly all of the material that has become the Mocho soils has been deposited since about 1850" (Gardner et al. 1958). For example, the historically swampy Willow Glen area was identified by Gardner et al. 1958 as basin clays with a recent silty overlay. The underlying clays presumably correspond to the historical habitats, while recent deposition from Guadalupe River has buried the historical clay-dominated surface in several feet of siltier material. In addition to the Mocho series, we also included other "over basin clays" soils in our mapping, including Yf (Yolo loam over Clear Lake clay) and Cc (Campbell silty clay over basin clays). Inclusion of these soils is supported by the historical record, with reports of "no timber" (Herrmann 1879) and willow groves in these areas. While wet meadow presence in these areas is only inferred from these descriptions, they cover a very small portion of the study area.

A few additional modifications were made where evidence from earlier historical sources directly contradicted our interpretation of Gardner's mapping. For example, Orestimba loams were excluded from wet meadow mapping around Santa Clara, based on evidence that the Mission occupied significantly higher and drier ground (Lewis 1861, Lapham 1903). In a few places (e.g., gravelly soils northeast and east of Mountain View) the older historical soils survey (Lapham 1903), though more coarsely mapped than the later survey, was found to more closely reflect the distribution of oaks and wet meadows as shown on detailed historical sources. In these areas, the wet meadow boundary was modified to exclude areas with documented oaks, and reflect the earlier soils mapping effort. Lastly, we relied on the earlier soils report in the vicinity of the San José International Airport, where Lapham's depiction of clay soils extending almost to the Guadalupe River more closely matches GLO surveyors' descriptions of landscape pattern. It is possible that in this area, the 1950s mapping may have been affected by earth fill associated with airport construction.

Alkali meadows

Alkali meadows occurred as an ecotone in a narrow band in the low areas between wet meadow and south San Francisco Bay tidal marshlands. As Reed (1862) describes the alkaline area just east of San José, "it was a medium between the two, it was neither like the upland nor like the Salt marsh, but it partook of the character of both." It included both lands subject to extreme high tidal flooding and poorly drained non-tidal soils.

Despite covering a small proportion of the study area (less than 3%), the presence of alkali meadows is significant: they are recognized today as a relatively rare native grassland type (Holstein 2000, Faber 2005). The characteristic vegetation was saltgrass (*Distichlis spicata*; Reed 1866, Lapham 1904, Cooper 1926, Gardner et al. 1958), though other species were also recorded in Santa Clara Valley alkali meadows, including alkali milk vetch (*Astragalus tener* var. *tener*; CNDDB 2010) and common tarweed (*Centromadia pungens*, Cooper 1926).

Alkali meadow lands were agriculturally unproductive, seasonally inundated, and often far from inhabited areas. As a result, little direct historical documentation exists for these areas. Local resident G. F. Beardsley, interviewed by Cooper (1926) about conditions circa 1870 in the Palo Alto area, described a strip of "wiry hard grass" (interpreted as *Distichlis* by Cooper) "several hundred yards to one-quarter mile wide" at the upland edge of the tidal marsh. This statement corresponds with a similar description from a survey of Rancho Las Pulgas (north of San Francisquito Creek), stating that "the precise demarcation between the Tide Marsh and the firm land is well defined by the growth of a peculiar species of aquatic plant, a salt grass which covers the flat along the edges of the Bay, and on its inner margin grows slightly above the elevation of ordinary high tide. It varies in width from a few hundred yard to more than a mile" (Stephens 1856). Both statements are roughly consistent with our alkali meadow mapping in the Lower Peninsula area. A GLO surveyor crossing the alkali meadow area at the mouth of Saratoga Creek (then Sanjon Creek) in 1866 makes no distinction between the alkali meadow and surrounding wet meadow lands, possibly suggesting somewhat slight alkali influence in that area (Reed 1866). Just east of the study area boundary, a patch of alkali southeast of the Highway 17/Highway 101 interchange was described by surveyor Sherman Day (1854): "...on the plain, among 'salt wood'...Surface level. Soil a stiff clay loam, with some alkali on the last half mile very tenacious of water in winter. No timber..." This description would probably also pertain to the small (<25 acres) pockets of alkali meadow in the Canoas area (north of Blossom Hill Road).

Previous research in Coyote Valley suggests that alkali soils as mapped by Gardner et al. in the early 1940s correspond closely to historical testimony regarding alkali extent in that area (Grossinger et al. 2006). To delineate the extent of alkali meadows, we used mapping of alkali extent in the 1958 soils report (Gardner et al. 1958). The report identified areas slightly (S), moderately (M), and strongly (A) affected by soluble salts or alkali. Slightly affected areas contain from 0.20-0.49% alkali, moderately affected areas contain 0.50-0.99% alkali, and strongly affected areas contain over one percent alkali (Gardner et al. 1958). While the majority of the mapped areas were only slightly affected by alkali, a few had alkali concentrations of over 0.70%.

Freshwater marshes and ponds

Freshwater marshes are seasonally flooded areas with groundwater at or near the surface throughout most, if not all, of the year. They would have typically been dominated by bulrushes (*Schoenoplectus* sp.), cattails (*Typha latifolia* and *domingensis*), sedges (*Carex* sp.), spikerushes (*Eleocharis* sp.), and rushes (*Juncus* sp.). Perennial ponds are permanently flooded, non-vegetated areas, often occurring within larger complexes of marshland and willow groves.

In comparison to other habitats, marshes and ponds covered a small proportion of the study area (under two percent). However, perennial ponds were important sources of year-round water in this semi-arid environment, and many were documented by early sources. The vast majority of ponds and marshes in western Santa Clara Valley were mapped within the wet meadow area on impermeable basin soils. Some occurred at the spread of terminal creeks (e.g., Saratoga Creek), and others in areas of springs and emergent groundwater (e.g., at the head of Guadalupe River). Called *lagunas* (ponds or lakes) or *ciénegas* (marshes) by Spanish-speaking residents, many of these features were captured by early surveys. Undoubtedly, however, given the often small size of the features and their potential early disappearance, there were a number of historical marshes and ponds that were not captured by our historical data set.

VALLEY FRESHWATER MARSH AND TULARES DE LAS CANOAS. While a few freshwater marshes were documented in the Lower Peninsula and West Valley watershed areas (e.g., at the mouth of Saratoga Creek), the majority were identified in the Guadalupe River/Canoas Creek watershed area. These features were associated with the Arroyo Seco de Guadalupe distributary, as well as with wet areas along the Guadalupe River, where marshes were interspersed with extensive willow groves and swamps on the west side of the river (Duval 1850, Lewis 1857b; fig. 17).

A major concentration of freshwater marshes in the study area was in the Canoas Creek watershed. One of the valley's largest freshwater wetland complexes – the Tulares de las Canoas – ran through the middle of what is now called Blossom Valley. More than ½ mile wide, the Tulares de las Canoas included tule marshes, perennial ponds, willow groves, and wet meadows. Vista Park, Meadows Park, and much of western Martial Cottle Park lie within the former wetland area. Subdivision-sized oak groves on slightly higher lands surrounded the wetlands to the west and east. The area was a notable source of perennial fresh water, and was used as a water

Fig. 17. This early map depicts willow groves, marshes (a), and wet meadows (b) between Santa Clara and the Guadalupe River, 1850. (Duval 1850, courtesy of the Office of the Santa Clara County Surveyor)

supply for the city of San José through the mid-1850s (Wyatt and Arbuckle 1948).

The Tulares de las Canoas extended from north of the San Juan Bautista Hills southeast to at least Blossom Hill Drive. The area's present drain, Canoas Creek, roughly marks the broad slough or chain of open water ponds as much as 700 ft wide that formed the spine of the wetlands, called Arroyo de las Tulares de las Canoas. The name presumably referred to the canoes made from tules and likely used to travel the slough and, when flooded in the winter, the entire wetland area.

Perennial marsh surrounded the central slough, extending a few hundred feet to the west and up to a thousand feet to the east (fig. 18). Lewis' maps show an array of ponds and marshes, but the 1853 map also shows early ditching (Lewis 1851a, Lewis and White 1853a). Similarly, Herrmann's (1868) survey of lands between Monterey Road and Gulnac's Island shows dry channels and "reclaimed ponds" bordered by a dam and mill race, supporting Brown's (2005) contention that the area was significantly drained by the mid-1850s. These remnant features, drained features, and the width observed by Day in 1854 suggest a general width substantially wider than that shown a few decades later (e.g., Thompson and West 1876).

One of the most well-documented elements of the Tulares was a large pond in the present-day Martial Cottle farm location. The pond and evidence of surrounding wetlands is well evidenced in early aerial photography of the area, and the distinctive pond outline remains visible today (fig. 19).

FRESHWATER PONDS. Perennial freshwater ponds were often part of larger wetland complexes dominated by emergent vegetation, such as in the Tulares de las Canoas area described above. They also appeared as discrete features, and a few even had individual names that have been preserved in the historical record (e.g., Laguna de la Punta del Roblar or Laguna de los Patos). Many of the small lakes in the study area were surrounded by small complexes of willows and marsh (fig. 20; Suñol 1862).

In addition to wetland-associated ponds, a few instances of ponds occurring in oak groves were also documented. Former resident G. F. Beardsley, interviewed by Cooper (1926) about historical conditions in the Santa Clara Valley, recalled "small ponds with willow about them" in the oak woodland east of the modern crossing of Stevens Creek by Central Expressway. Fernandez (1864) described "little lakes…inside of the Roblar" in the oak grove (Punta del Roblar) formerly near the intersection of Lawrence and Central expressways.

As early as the mid-1860s, settlers began to notice the disappearance of some ponds as a result of their utility for irrigation and domestic use (and possibly from artesian extraction). San Jose Mercury editor J. J. Owen editorialized that "many of our early settlers are aware that numerous lagunas or ponds once existed in various parts of the valley, which of late

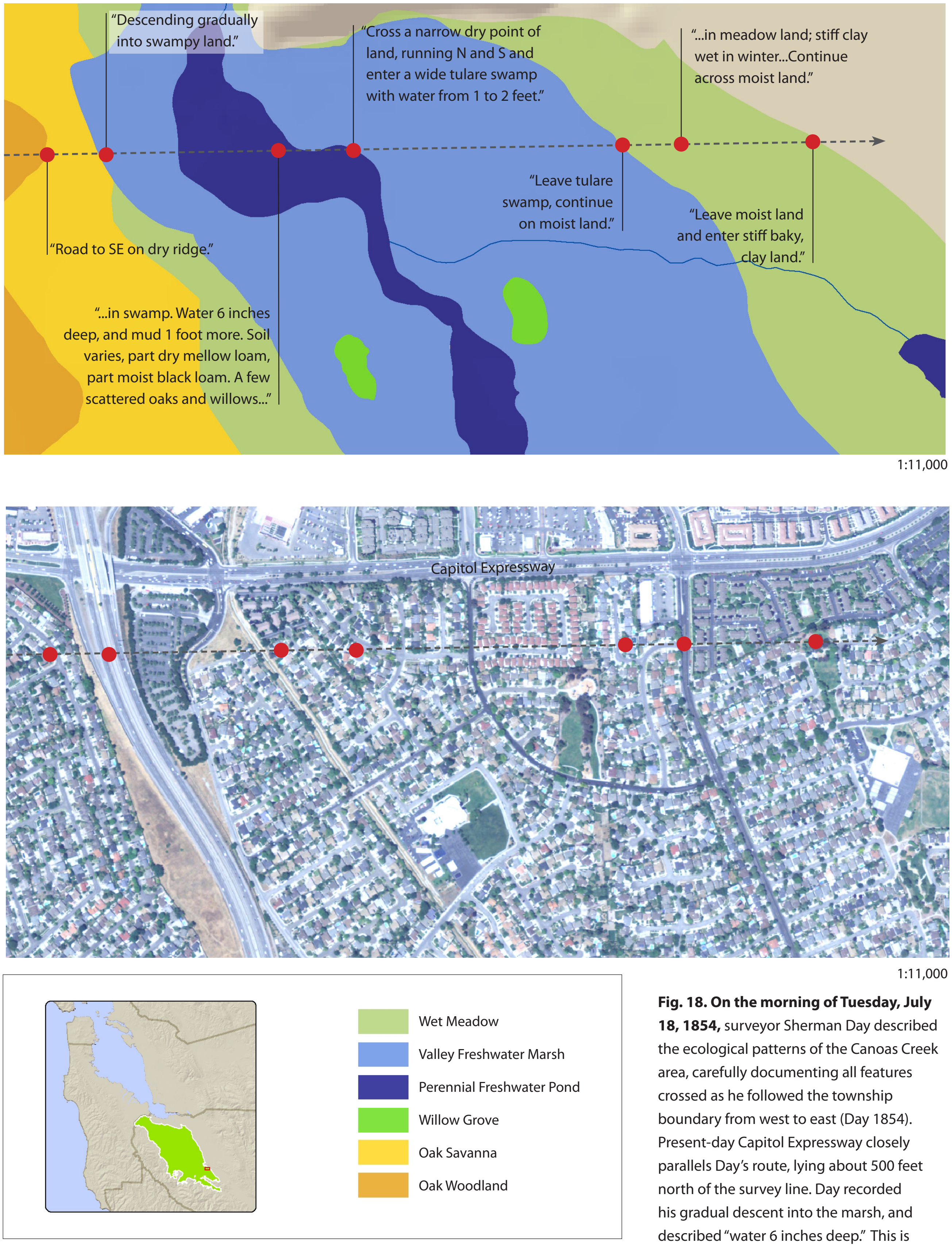


Fig. 18. On the morning of Tuesday, July 18, 1854, surveyor Sherman Day described the ecological patterns of the Canoas Creek area, carefully documenting all features crossed as he followed the township boundary from west to east (Day 1854). Present-day Capitol Expressway closely parallels Day's route, lying about 500 feet north of the survey line. Day recorded his gradual descent into the marsh, and described "water 6 inches deep." This is substantial standing water for mid-July. The marshes were bordered by moist wet meadow land.

Fig. 19. Pond on Martial Cottle property, Canoas Creek watershed. A 4.5 acre pond mapped in 1853 (a) is still visible in 1939 aerial photography, though it appears to be dry (b). Unlike the higher land to the east, the area around the lake has been left unfarmed. Remarkably, in modern (2005) imagery the former location of the lake is still faintly visible (c). (Lewis and White 1853a, courtesy of the Office of the Santa Clara County Surveyor; USDA 1939, courtesy of Science & Engineering Library Map Room, UC Santa Cruz; USDA 2005, courtesy of NAIP)

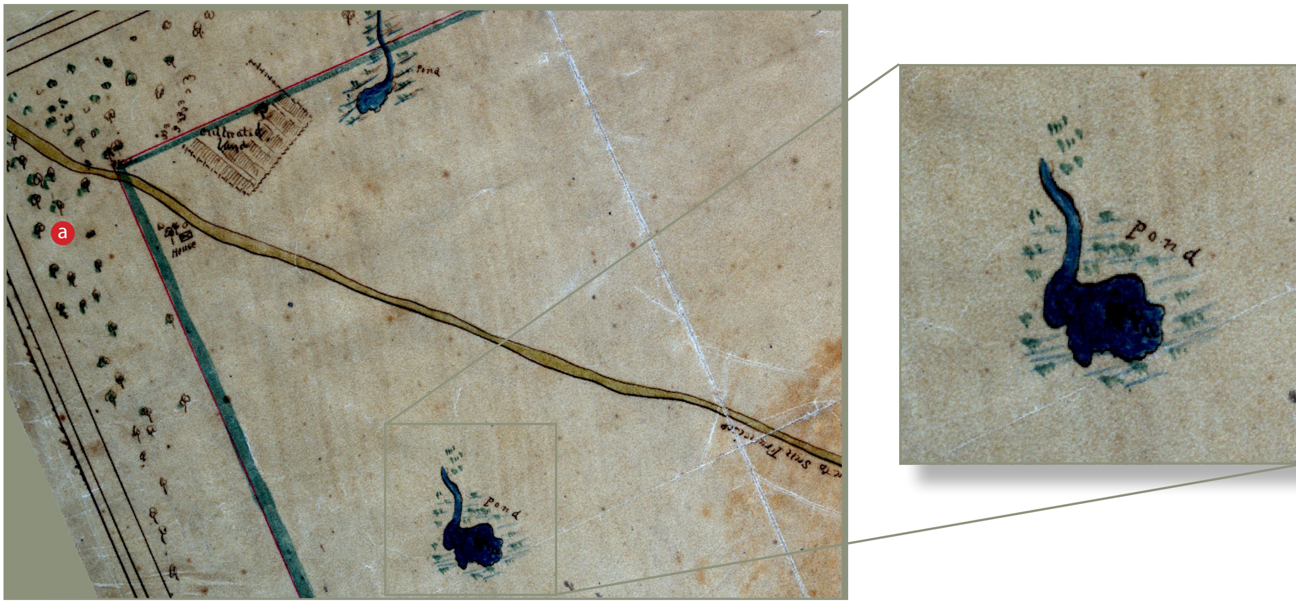


Fig. 20. Laguna de los Patos (Duck Lake), 1850. Located on the eastern edge of the large oak grove (a portion of which can be seen here; see 'a'), the mapper shows the pond surrounded by marsh. (White 1850a, courtesy of The Bancroft Library, UC Berkeley)

years have been entirely dry" (Owen 1865), while another article a year earlier described that "in many places where springs and ponds once existed naturally they are now no longer to be found" (*San Jose Mercury* 1864). (While 1864 was an extraordinarily dry year, the context of both these sources suggests that the disappearance of ponds began years before the date of writing.) However, a few ponds did persist well into the 20th century (fig. 21).

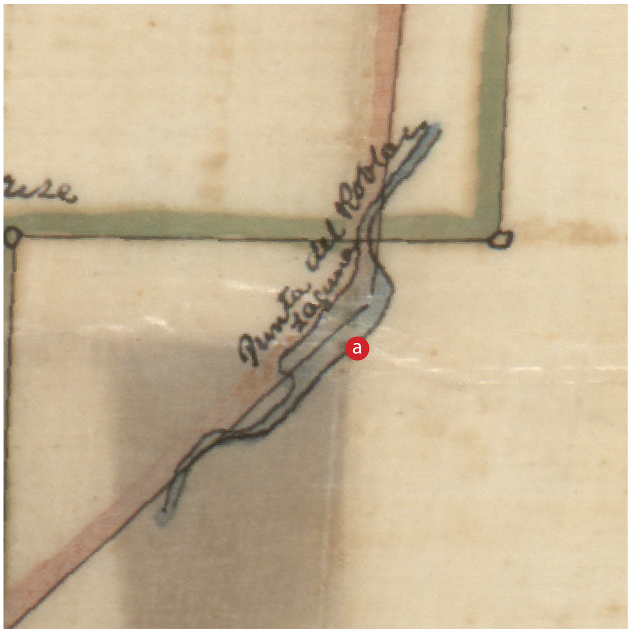
At ten o'clock, we came in sight of the mission of Santa Clara, and as we approached it the little ponds and damp places on the prairie were literally covered with wild geese, which would but barely open a way for us to pass through.

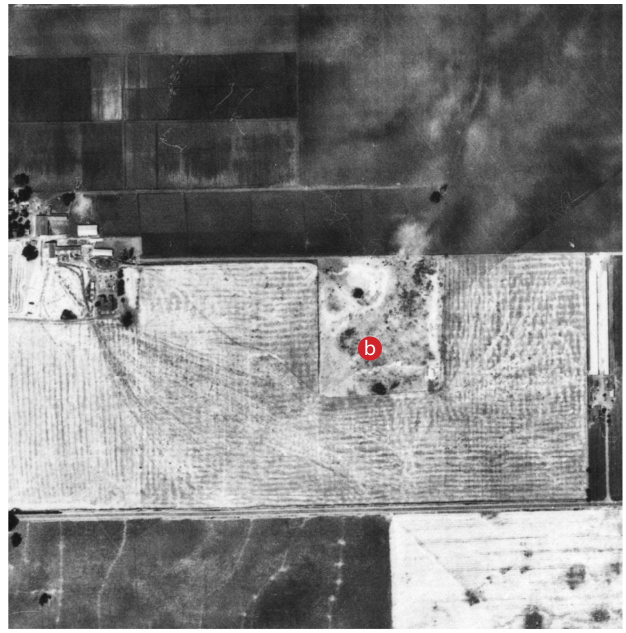
— WILKES 1845, TRAVELING IN FALL 1841

Willow groves

Willow groves or thickets (*sausal* in Spanish) were a prominent feature of the Santa Clara Valley, occurring along stream courses and in lowland portions of the region. They indicate areas where surface water is usually present temporarily or seasonally, and the water table is consistently close to the surface. In this region, they frequently occurred in areas of emergent groundwater; for example, along the boundary between the loam soils of the alluvial fans and low wet soils or meadow lands at the lower end of many terminal creeks. Because of this, springs and spring runs were often documented in association with willow groves.

The dominant tree in willow groves was arroyo willow (*Salix lasiolepis*), which could reach up to 30 feet high (Cooper 1926, in Coyote II-30). Cooper (1926) documented other common tree species present in the groves, including cottonwood, box elder, and Oregon ash. Other species contributed to an often dense understory of wild rose, blackberry, and ninebark *(Physocarpus capitatus)*.





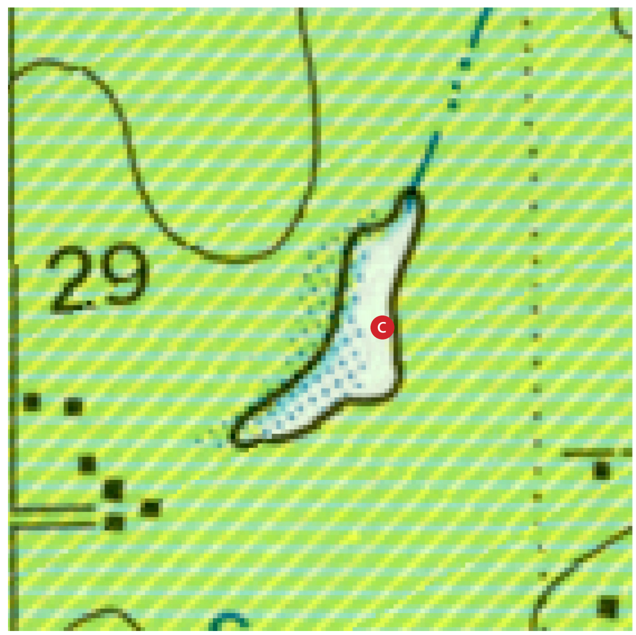


Fig 21. The Laguna de la Punta del Roblar (pond of the oak grove point) was a small pond in the wet meadows right at the edge of the vast oak grove to its west, which made a distinctive point near the pond, jutting thousands of feet out into the largely treeless wet meadow to the north. The Laguna was shown by several maps in the mid-1800s (a), since it was one of the boundary points of the Pastoria de las Borregas Rancho. The feature correlates with a distinct topographic low and a wetland area fenced off from surrounding agriculture in 1939 (b). However the feature appears dry, as would be expected given the extremely dry conditions of previous years. The feature was shown as a "Lake," however, by the USDA soil survey conducted just a year or two later (c), following greater rainfall. The lake appears to have returned after the 1930s drought conditions. (U.S. District Court 1850, courtesy of The Bancroft Library; UC Berkeley, USDA 1939, courtesy of Science & Engineering Library Map Room, UC Santa Cruz; Gardner et al. 1958)

Because of the nature of the land occupied by willow groves – rich, moist soils with readily available groundwater – the groves were considered very valuable farming land. Stratton (1865) described willow thickets around Stevens Creek as "very desirable land when cleared up and prepared for cultivation." This desirability was reflected in high land prices: in the 1880s, "willow land" was sold at $400 to $1,000 an acre, while adobe lands ($75-$125/acre), loamy or gravelly lands ($50-$100/acre), and hilly fruit land ($10-$40/acre) sold for far less (Belden 1887). As a result, willow groves were one of the earliest features to be disappear from the Santa Clara Valley.

Cattle herds enjoyed the shade and water provided by the groves, which also contributed to their disappearance. One early settler complained that cattle would hide in the willow thickets, and would "not come out when they are run after" (Alivirez 1841). Other residents also described the impacts of cattle:

> There is a *sausal* from here to the Posita in various places, not so much now as in earlier days. It has been destroyed by cattle and I presume some has been cut down. (Forbes 1862b)

> By glancing at Lyman's map, it will be perceived that in 1848 they [willow thickets] extended along nearly the whole southern boundary; but even at that time they had been partially destroyed by cattle. In 1844 they extended the whole length of this line, to back of Yñigo's house… (Murphy 1862)

Willow groves not immediately bordering streams occurred predominantly in two places in western Santa Clara Valley: below the sink of Stevens Creek (along the boundary between the oak lands and wet meadows of this area), and in the Willow Glen area near the mouths of Los Gatos, Canoas, and Arroyo Seco de Guadalupe (now upper Guadalupe River) creeks. Additional groves were present along the lower Guadalupe River, near the mouth of Adobe Creek, and south of San Francisquito Creek near the tidal marsh. In total, we mapped approximately 2,200 acres of willow groves in the study area. Because of their desirability for farming and early cattle impacts, willow grove extent as mapped from mid-1800s sources is likely a conservative estimate of the original area.

...according to the testimony of old residents much of the original willow thicket has been destroyed by cutting...

—COOPER 1926

STEVENS CREEK WILLOWS. Water from Stevens Creek and other adjacent watersheds reemerged downslope at roughly the 50 foot contour, contibuting to the establishment of a series of willow groves that occupied an area generally south of Highway 101 and extending from around Highway 85 east to North Mathilda Avenue (fig. 22). Many of these willow groves were quite large, some over 100 acres in extent.

The majority of the groves occurred in a chain right along the boundary between the higher oak lands and the lower wet meadows. This ecological transition corresponds to the physical landscape transition between higher elevation alluvial loams and the lower, flatter, clay basin soils, often an area of emergent groundwater at the distal end of an alluvial fan. The willow

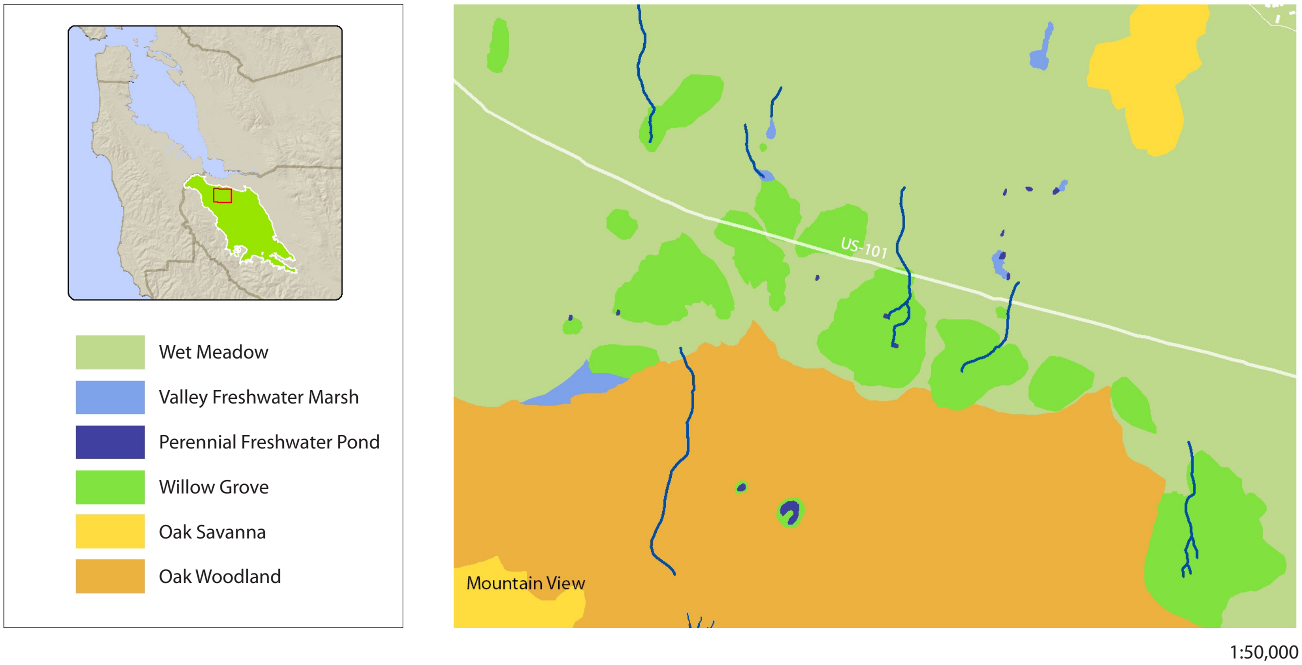


Fig. 22. A chain of willow groves at the boundary between the oak woodland and the wet meadow below Stevens Creek marks a region of rising groundwater. Springs, spring runs, ponds, and wetlands were also common.

groves occurred nearly exclusively on the wet meadow (clay) soils side of this boundary.

Apart from scattered oaks on microtopographic high areas within the wet meadow, the willow groves were the site of some of the only trees present in the extensive wet meadow area. They were notable landmarks, as well as fertile areas for grazing animals. As a result, their presence is well documented by numerous early surveyors (e.g., U.S. District Court ca. 1842, Lyman 1847b, Van Dorn 1854, U.S. District Court ca. 1850, Healy 1859, Healy 1860a). GLO surveyors recorded the presence of "dense willow thickets" (Healy 1857a, Stratton 1865). While the groves would have been fairly dry land during the summer months, during the winter they were noted to be "swampy" and "almost impassable" (Forbes 1861b).

Like Willow Glen to the south, the ready availability of water, timber, and fertile land made this area a location of early use and settlement. Mission cattle and sheep were sent to pasture here; José Mariano Estrada (1841), an early petitioner for the Pastoria de las Borregas grant, noted that cattle were "fond" of the area covered by the grant. However, the area was primarily used by Mission workers to pasture sheep –hence the rancho name *Pastoria de las Borregas*, or pasture of the lambs. Tens of thousands of sheep were pastured in the area by the Mission (Suñol 1862), and one document even refers to the area as the *sausal de las borregas*, or willow thicket of the lambs (Alvarado 1842). Early farmers took advantage of the *Posita de las Animas*, a marshy spring near the extensive willow groves in the area. Yñigo (a.k.a. Lope Inigo), an Ohlone and early owner of Rancho Posolmi, built his home on a small outcropping of gravelly soils completely surrounded by the wet meadows and willow groves of the surrounding clay soils (Lyman 1847b, Lapham 1903).

Grazing, cultivation, and cutting for timber took a heavy toll on the willow groves of this area. Even by the 1840s, local residents testified that willow groves had been "partially destroyed by cattle" (Murphy 1862). By the end of the 19th century, nearly all traces of the former extensive tracts of willows had been erased (fig. 23).

WILLOW GLEN. At the historical head of Guadalupe River (see p. 24) and east of Los Gatos Creek, an immense area of willow groves, wet meadow, springs and wetlands extended from around Highway 280 south to around Curtner Avenue (fig. 24). The area was an ecological and cultural keystone of the Santa Clara Valley. It is no coincidence that San José is located immediately north, just downstream of the perennial water that emerged from Willow Glen through the Guadalupe River. Willow Glen was renowned for its fertility, and was one of the first areas to be intensively cultivated in the San José area.

Willow Glen was a valley within a valley, a low-lying area between the higher, nearly converging alluvial deposits of Los Gatos Creek and Arroyo Seco de Guadalupe (now upper Guadalupe River). Surface flows from three distinct drainages converged into the Willow Glen area before coalescing into Guadalupe River: Los Gatos Creek, Arroyo Seco de Guadalupe (now the upper Guadalupe River), and Arroyo Tulares de las Canoas (Canoas Creek). The converging natural levees of Los Gatos Creek and Arroyo Seco de Guadalupe formed a barrier to surface water drainage for the lower lying Willow Glen area lying in between these active channels. In a region of scattered oaks and open grasslands, Willow Glen stood out as a massive, moist, densely wooded area with an array of wetlands and springs covering well over two square miles.

Known locally as "The Willows" through the late 19th century, Willow Glen derived its name from the extensive areas of willow groves present in the area. Water from the distributaries of Los Gatos Creek and Arroyo Seco de Guadalupe spread into multiple channels on the silty clay soils, where high groundwater levels and slow drainage contributed to the willow thickets and wetlands present near the mouths of both creeks. These willow groves are documented by several early maps (e.g., Day 1850, Lyman and Day 1850, Herrmann ca. 1879); one (Herrmann ca. 1879) differentiates between the "Los Gatos willows" and the "willows at the head of the Guadalupe." Another map (Rayner 1871) also provides a name for a willow grove near the head of the Guadalupe: "Boulieu Willows," after land owner Oliver Boulieu. Abundant early textual sources refer to the willows in this area: "willow grove with which the source of the river Guadalupe is covered" (Aquello 1801); "wet land covered with willows which surround the head of the Guadalupe river" (Hall 1871).

Pioneer William Manly recalled the character of these willow groves in 1850:

> Taking the most direct course to camp I came, when within two or three miles of San Jose, to a large extent of willows so thick, and so thickly

1:20,000

1:20,000

Fig. 23. Where Chester Lyman found extensive willow groves in the 1840s (a), U.S. Coast and Geodetic Survey (USCGS) mapper Ferdinand Westdahl found almost none exactly 50 years later – only a few tiny patches near the now-ditched Stevens Creek (b). By the 1890s, the area had been converted nearly entirely to agriculture. The modern alignment of Stevens Creek is shown on both images as a blue line for reference. (Lyman 1847b, courtesy of The Bancroft Library, UC Berkeley; Westdahl 1897a, courtesy of the National Ocean Service, Rockville, MD)

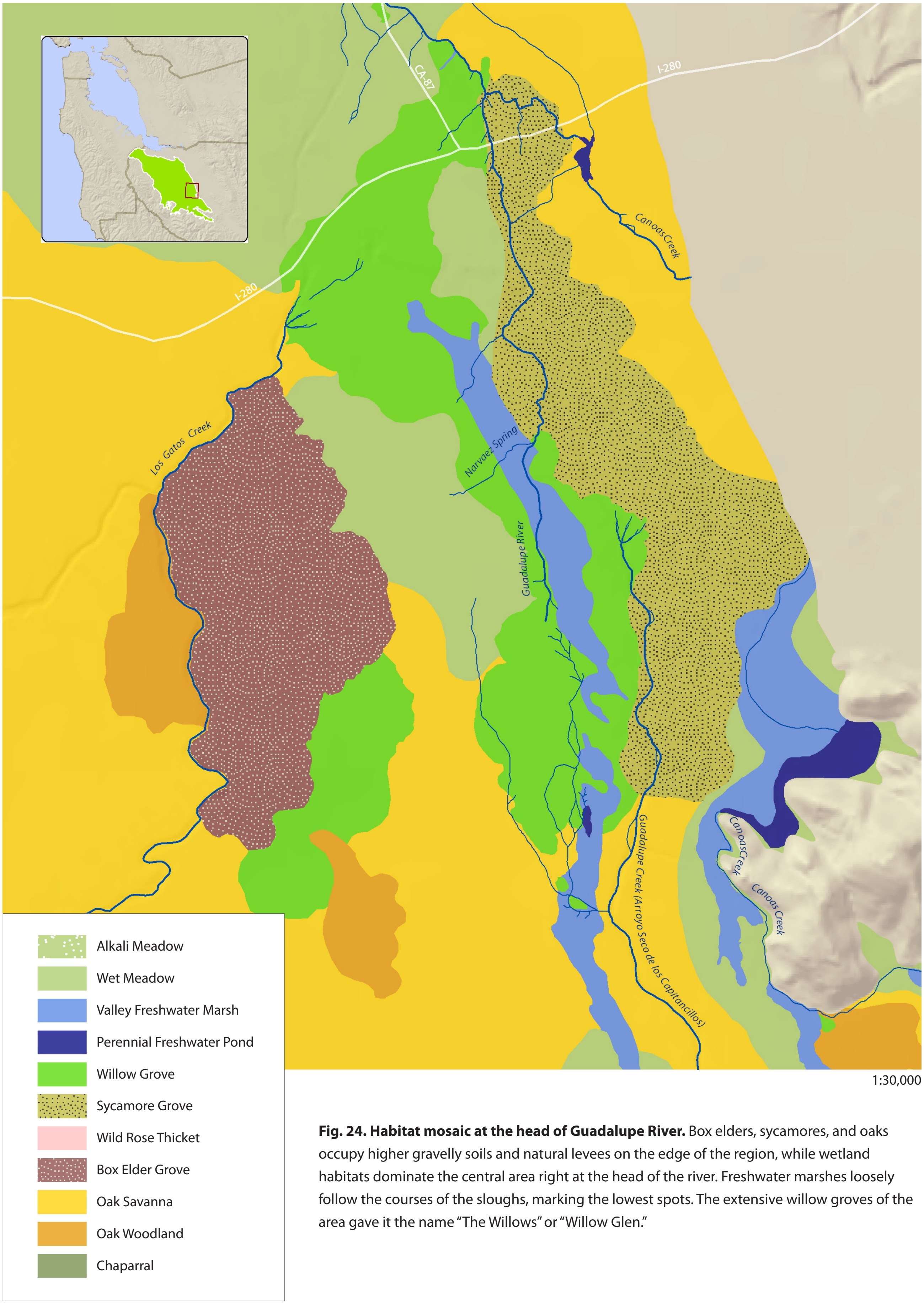


Fig. 24. Habitat mosaic at the head of Guadalupe River. Box elders, sycamores, and oaks occupy higher gravelly soils and natural levees on the edge of the region, while wetland habitats dominate the central area right at the head of the river. Freshwater marshes loosely follow the courses of the sloughs, marking the lowest spots. The extensive willow groves of the area gave it the name "The Willows" or "Willow Glen."

> woven together with wild blackberry vines, wild roses and other thorny plants, that it appeared at first as if I never could get through. But I found a winding trail made by the cattle through the bushes and mustard, and this I followed, being nearly scared occasionally by some wild steers as they rushed off through the thickets. I got through safely, though it would have been difficult to escape a wild, enraged steer, or a grizzly had I met him face to face even with a rifle in hand. I could see nowhere but by looking straight up, for the willows were in places fifty feet high and a foot in diameter. The willows where I came from were mere bushes, and these astonished me. (Manly 1894)

The area was renowned predominantly for its willow groves, but early records document a remarkable array of other unique and rarely documented habitat types (fig. 25; see also fig. 2). While hinting at some of the complexity occurring at the margins between habitat types, the historical record is also quite consistent in identifying a heterogeneous array of habitat types (willow groves, sycamore groves, freshwater marsh, and others) occupying distinct positions within a mosaic. Along Los Gatos Creek on the western edge of Willow Glen, willows merged into a regionally unique feature called the Torotal (Herrmann ca. 1879). The word *torotal,* not known in conventional Spanish, was presumably a hybrid of a native California word for box elder (*torote*) and a Spanish suffix for a grove (*-al*). This is supported by Lewis (1857a), who (along with two long-time San José area residents and Spanish speakers) defines a *torote* as a box elder, and describes the Torotal as a "dense wood" of box elders, oaks, and sycamores. (Early California history scholar Alan K. Brown translates *torote* as "buckeye bushes" (Crespí and Brown 2001), though it is not likely that such

Fig. 25. "Scene near the sources of Guadalupe Creek, Santa Clara County," ca. 1863. Edward Vischer, an artist known for his sketches of California landscapes, drew this romantic version of the head of Guadalupe River (which he calls "creek") in the 1860s. People stroll through the clearing; a picnic basket rests on the live oak (according to Vischer) in the center. Dense growths of sycamores, oaks, and willows are shown surrounding the clearing. While parts of the drawing are undoubtedly fanciful (the park bench in the background, for example), the image provides a rare glimpse into how the area would have looked – and felt – to early residents. (Vischer ca. 1865, courtesy of Edward Vischer Collection, Special Collections, Honnold/Mudd Library, Claremont University Consortium)

moist soils would have supported bukeyes; Baye pers. comm.) The Torotal also included willow patches (Lyman and Day 1850).

Along the eastern margin of the Willow Glen area, at the spread of the Arroyo Seco de Guadalupe and along the head of Guadalupe River, a continuous, several mile long sycamore grove occupied the coarser, more well-drained soils of the Arroyo Seco de Guadalupe natural levee. This elongate feature, known as the Alisal (sycamore grove in California Spanish; Day 1855), consisted of large sycamores spreading from the Highway 280/87 interchange south to Curtner Avenue. At the edges of the sycamore groves, sycamores merged into willows and other underbrush; Herrmann (ca. 1879) describes one large area between the sycamore grove and a large willow grove as "sycamore and willow grove," and an adjacent area as "sycamore grove with scattered undergrowth of willows and dogwood." Day (1861) also describes this transition from moister, more willow-dominated habitats to drier areas with sycamores in the Alisal area: "near Kell's house [around the Curtner Avenue crossing of Guadalupe River] it is moist, sometimes overflowed covered with bush and willows, and farther West it is interspersed with Sycamores live oaks and willows, and bushes."

At the heart of Willow Glen, an open area called the Abra (opening) was the site of a number of residences and the major artery through the Willow Glen area, known historically as El Abra Road (now Lincoln Avenue). This central area was a natural clearing in an otherwise densely forested area, and was an extensive low area of seasonally flooded wet meadow.

Clearing of these lands, so highly desirable for farming and in close proximity to Mission Santa Clara and San José, was rapid. Large scale clearing and agricultural development in the area began in the early 1860s (Jacobson 1984). Land prices for the extremely productive land skyrocketed:

> As an instance of what the soil will produce, and what small farming will do, the district known as the "Willows," about two miles from San Jose, may be cited. …It is less than 10 years since this tract, embracing about 2000 acres, was covered with a dense growth of willows, with the exception of a few small patches here and there. To-day the bulk of the strawberries and blackberries which come to the San Francisco market are raised on this land, which has been divided and subdivided into small farms ranging from five to thirty acres each. Ten years ago it could have been purchased for $50 an acre. To-day the average price is about $1000. (*San Francisco Chronicle* 1876)

By the end of the 1870s, the extensive willows of Willow Glen were still well remembered by local residents, but were clearly a feature of the past. Writers referred to the area as "formerly dense willow thickets, but now in the highest state of cultivation" (Foote 1888) and stated that "it is but a short time since that very land was covered with a dense growth of trees" (*San Francisco Chronicle* 1895). William Manly, who had been so awestruck by the dense, tall willows of the area in 1850, wrote that by 1894 the area "is still locally known as 'The Willows,' but the trees are all gone."

Drylands

The truth is that grass grows better in their shade; besides they are a refuge for cattle from the burning rays of the sun. These trees impressed me the same as did those on the foot-hills around my old Sonoma home in their resemblance to old apple trees; whether singly or in groups. In many instances they stood at an incline, as if constant winds had bowed them down. Some of their trunks were three feet across, and they shaded a diameter of sixty to eighty feet. Scattered over grain-fields and pasture lands, or thickly wooding the hills, they were a very picturesque feature of the landscape...

–KENDERDINE 1898, ON OAKS IN WESTERN SANTA CLARA VALLEY

We mapped several different types of dryland habitats: grassland/oak savanna, oak woodland, and chaparral. In total, we mapped approximately 67,600 acres of these habitats, or just under 70% of the study area. Oaks occurred consistently on the surface of nearly all the alluvial fans of the valley, with a large area of oak woodland concentrated from Mountain View to beyond Saratoga. Chaparral patches were found on the coarse gravelly loams of older alluvial fans between the oak lands and the foothills.

In this section, we discuss the general characteristics of each habitat type, and describe notable locations where they occur.

Oak savannas and woodlands

Oaks are the emblematic tree of the Santa Clara Valley. Explorers noted the abundance of live and valley oaks across the western valley, earning it the name *Llano de los Robles*, or Plain of the Valley Oak (Font 1775-6, in Bolton et al. 1930). Early travelers remarked on the abundance of oaks in many places: a plain "very thickly grown with oaks" (Palou 1774 in Bolton et al. 1930) and "very thickly grown with oaks of all sizes" (Font 1775-6, in Bolton et al. 1930); "the entire plain much grown over with a great many large white oaks and live oaks" (Crespí and Brown 2001); oaks "in such numbers…that I wondered the farmers tolerated them" (Kenderdine 1898). Many of these oaks were quite large: GLO survey bearing trees data records oaks up to 6.7 feet in diameter (fig. 26).

Santa Clara Valley oaks were also recognized for their beautiful appearance in the landscape; oak groves were often compared to parks or orchards (e.g., Vancouver [1798]1984, Kenderdine 1898, *San Francisco Chronicle* 1913). GLO surveyor Howe (1851) noted that in oak lands near Hillsdale and Camden Avenue in San José "the growth of wild oats on the ground and the

Fig. 26. "Oak tree near San Jose," ca. 1905. The enormous oak tree in this postcard dwarfs the man standing below it. The hand-tinted photo was taken somewhere near San José; the exact location is unknown. Smaller oaks in the oak savanna can be seen in the background. (Thorps ca. 1905, courtesy of California Room, San José Public Library)

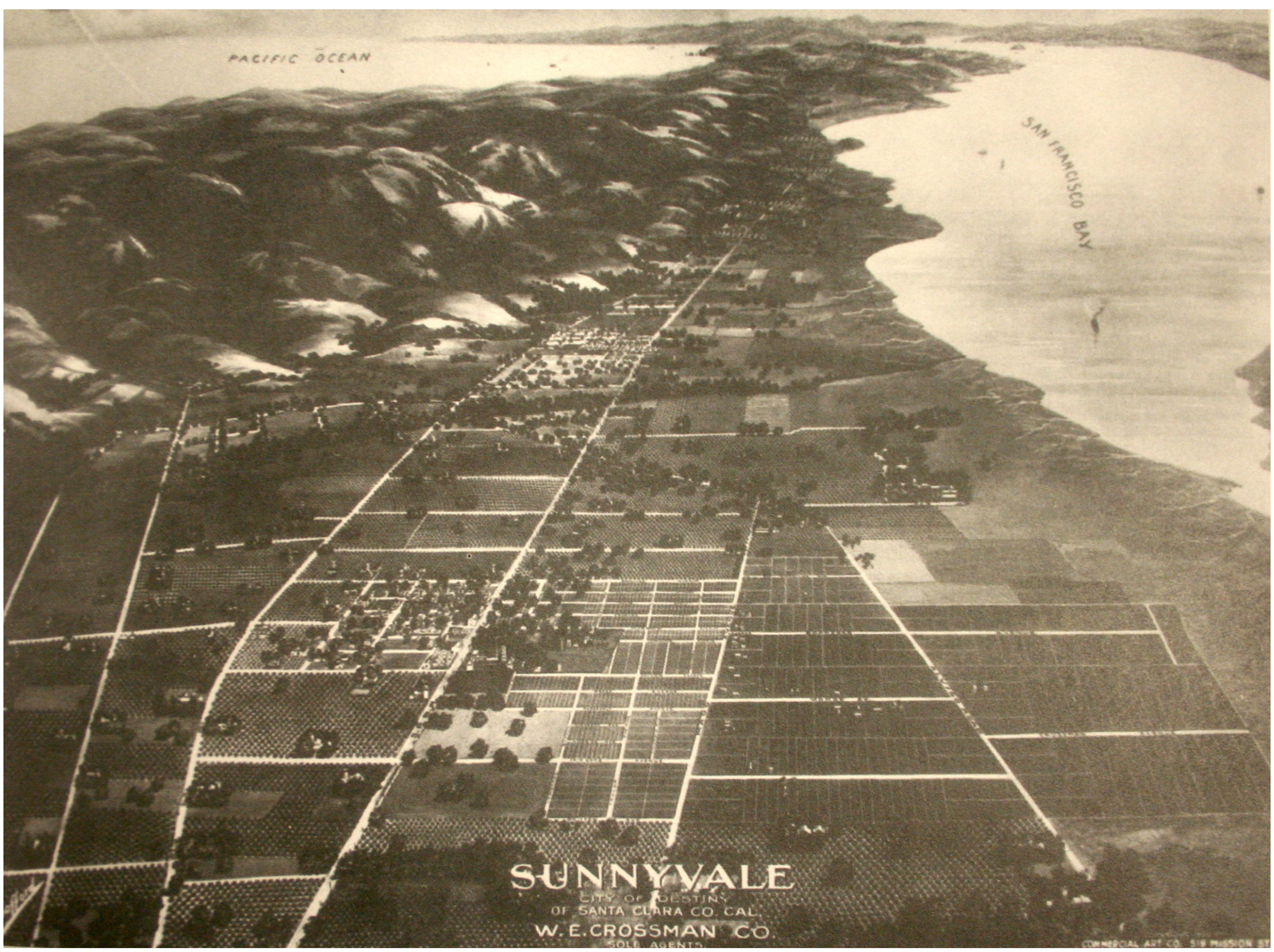
scrubby spread of the trees [oaks] gives it the appearance of a stubble field in an old orchard."

Significant groves of oaks spread across the entire region, from the predominantly live oak grove at Palo Alto to the extensive woodlands south of San José. A vast woodland, locally known as the Roblar (valley oak grove in Californian Spanish) well into the American era and considered to be a continuous and distinct body of timber, stretched continuously from Mountain View to at least Saratoga (Bellamy 1861, Fernandez 1864, Healy 1864b, Noriega 1864).

In addition to these woodlands or groves, less dense oak timber dotted much of the valley (fig. 27). Samuel Blythe (1864) described "scattering timber pretty much all over" the Quito land grant (now the Cupertino vicinity) south of the Roblar, a description which (based on historical aerials and other historical maps and descriptions) applies to much of the rest of the valley, too. Oaks were also found scattered through portions of the wet meadow, though this is mostly not represented on the habitat map.

The large Roblar, in particular, was a well documented feature in the valley, at least ten miles long (as we have mapped it from historical sources).

Fig. 27. In spite of extensive timber cutting, substantial numbers of oaks were still present in the valley even in 1906, when this image was created. (Many of the oaks shown are remnants of the large oak woodland formerly covering the area.) Sunnyvale is in the foreground and Mayfield (Palo Alto) in the background; El Camino and the Southern Pacific Railroad are left of center. Stevens Creek, by then connected to the Bay, is visible in the mid-ground (Commercial Art Co 1906, courtesy of the California History Center)



Residents consistently described the grove as extending from Los Gatos Creek to beyond San Francisquito Creek, and in places over three miles wide. Portions of the woodland were described as "covered with an enormous growth of large and magnificent oaks" even in the 1890s (*San Francisco Chronicle* 1896). A large protrusion of oak woodland extended over a mile and a half into the wet meadow in Sunnyvale (south of the Lawrence Expressway/Highway 101 interchange), creating a notable (and presumably highly visible across the wet meadows of Santa Clara) landmark within the Roblar known as the *Punta del Roblar*, or "point of the oak grove". This feature occupied soils mapped as basin (clay) soils by Gardner et al. (1958) in the early 1940s, but the shape of the feature clearly relates to a point of gravelly loams mapped in the same area by Lapham (1903) nearly 40 years earlier. The historical ecology of the *Punta del Roblar* reflected this discrepancy in soils; willow groves, lakes (including the *Laguna de la Punta del Roblar*; see p. **38**), and marshes were documented on the edge of – and even within – the oak point.

A few oaks lie about the Presbyterian church, at Castro's, Dossee's, and in old Mountain View, with occasionally a stray one or two in many fields. But of all the great belts of woods that originally covered the lower hills and swept down the whole plain of the Santa Clara valley, the only oak groves of any size which remain, are those of the Murphy and Emerson ranches.

–GATES 1895, SPEAKING OF THE MOUNTAIN VIEW AREA

OAK STAND DENSITY AND CLASSIFICATION. Oaks visually dominated much of the western Santa Clara Valley. While specific estimates of oak density can be difficult to interpret from historical sources, many accounts provide a qualitative description of the patterns of oak distribution and relative density. Surveyors describe some areas of "thick growth" of oaks, while other areas have only "very scattering" trees (Stratton 1865, 1866). Within this range of oak density, we distinguish denser woodland areas and less dense oak savannas. These terms are described in more detail below.

Within the less dense oak savannas, oaks often formed a relatively dispersed, open pattern. In some places trees occurred in scattered clusters or groves separated by areas of no or few trees, while in others individual trees were more evenly spaced across the landscape. Some observers emphasized the relative consistency of oak distribution across the valley at a coarse scale, describing a valley "dotted with large oaks and sycamores" and oaks "thinly scattered over the plain" and "dot[ting] the entire valley" (Brackenridge 1841, Bartlett [1854]1965, Carroll 1903). Other accounts focus on the spatial heterogeneity of oak distribution at a finer scale (emphasis added):

> The California oak is a low-branching and far-spreading tree, disposed in *irregular masses*, which give a lovely, park-like effect to the landscape, and add very much to the rural beauty of this part of the country. (Nordhoff 1873)

> These trees, in great numbers, have been left standing in the fields or grounds of the large land owners, and are scattered, so that no landscape gardener could improve upon the *regular irregularity*, so to speak, of their distribution. (Phillips 1877)

> The plain in many parts is covered with *scattered groves* of a species of oak... (Lyman 1847c)

Van Denburgh (1899) describes “open oak groves,” Tracy (1853) notes “open oak timber”; Healy (1857b) further describes the open nature of these savannas, noting that oaks “form what are termed in the western country Oak openings, which are not close enough together to prevent the growth of grass and gave appearance from a distance, of vast orchards.” Overall, these accounts are quite consistent in their descriptions of this landscape-scale pattern of scattered groves and trees in the oak savanna. This open pattern was at least partially a result of indigenous fire management, wherein burning was used to maintain open meadows and savannas (Jepson 1910, Stewart et al. 2002, Anderson 2005).

Within the oak savanna were large – often vast, as in the case of the extensive oak grove extending in a band from Mountain View to beyond Saratoga – woodland areas of greater oak density. These areas were often depicted on local survey maps as areas of dense trees, accompanied by the term *roblar*, a Spanish term used well into the 19th century (fig. 28). Within these areas were small grassy openings, often referred to as “glades” (e.g., Howe 1851).

...the word “roblar” is a technical term of very definite signification, and means in English, "a tract of land of greater or less extent thickly studded with a particular variety of oak trees, so as to resemble an orchard or park, and generally surrounded by country more or less open and uncovered with timber...

—MEZES 1858, SPEAKING OF THE QUITO RANCHO

Capturing the complexity of oak density and distribution across the western Santa Clara Valley in our mapping efforts was a challenge, and distinctions between savanna and woodland are necessarily somewhat diffuse. This difficulty is not unique to our mapping process; it was also recognized by Santa Clara County Surveyor Charles T. Healy (1864b), whose testimony reflects the challenge of mapping patterns of heterogeneous oak density even in the field in the 19th century: “There are many openings and places where the timber is scattering and others where there are dense groves. It would be difficult perhaps to designate any particular division of the timber although as I said before there are many places where the timber is more dense than at others.” (Incidentally, this testimony relates to a key map used to distinguish woodland from savanna in our mapping, as drawn by Healy himself in the same year as this deposition was taken; fig. 29.)

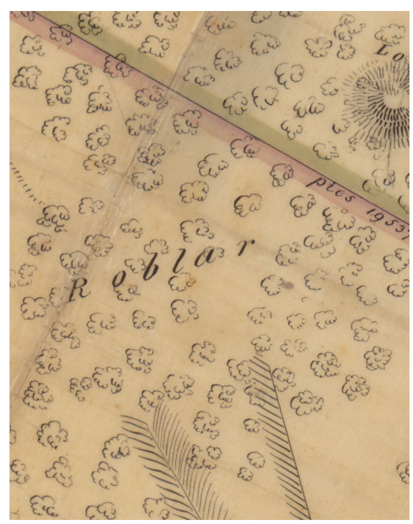


Fig. 28. Roblar or oak grove near Los Gatos Creek, 1850. Areas labeled “*roblar*” by early surveyors and shown with densely drawn tree symbols were interpreted as oak woodlands. (Lyman and Day 1850, courtesy of The Bancroft Library, UC Berkeley)

Modern vegetation classification mapping conventions define oak habitats based on percent cover: roughly 10-25% for oak savanna and 25-60% for oak woodlands (Sawyer and Keeler-Wolf 1995, FGDC 1997, Allen-Diaz et al. 1999, Davis et al. 2000). These provide useful metrics for assessing oak density, though in practice assessing percent cover from historical sources can be difficult, if not impossible.

Given the difficulties outlined above, both in drawing discrete polygons around heterogeneous oak patterns and in applying modern classification criteria to historical sources, our habitat mapping is necessarily only a coarse representation of actual historical spatial patterns of oak density; boundaries between savanna and woodland would have been diffuse. That said, large areas of greater oak density were consistently mapped across the region, and these areas have been captured to the best of our ability as oak woodlands. The presence and extent of dense woodlands were identified in the historical record from explorer’s narratives specifying denser areas,

Fig. 29. Oak savanna and woodland, 1864. Complex patterns of oak density and distribution in the Quito land grant, a large area between Stevens and San Tomas Aquino creeks. In court case testimony given the same year the map was produced (1864), surveyor Charles Healy stated that he used the stumps of already cut trees to produce this map. While each circle does not represent an individual tree, the map provides an incredibly detailed picture of savanna and woodland distribution in the region. (Healy 1864a, courtesy of The Bancroft Library, UC Berkeley)

early maps depicting densely spaced trees (often labeled "*roblar*") next to open plains or scattered oaks, landscape photography of areas with high oak densities, the GLO bearing tree dataset and associated notes describing "thick timber," and dense areas of probable oaks mapped from historical aerial photography (figs. 30 and 31).

Extent of oak savanna was illustrated by the same types of historical sources: maps showing scattered individual trees or small (<25 ac) clumps of trees, GLO survey notes describing "scattered timber" (where not contradicted by an earlier map showing a denser grove), narrative accounts of scattered oaks, and probable oaks mapped from historical aerial photography. We did not differentiate between oak savanna (10-25% cover) and grassland (<10% cover) in our mapping. The broad, consistent distribution of probable oaks mapped from aerial photography across the alluvial areas of the region, the lack of explicit data defining grassland areas, and the complicating effects of early woodcutting across the region in identifying true areas of former grassland made it impossible to distinguish between the two classes, and contributed to the decision to conflate them. Thus the "oak savanna" category includes true oak savannas, as well as many likely areas of grassland and grassland with occasional oaks (see species composition section).

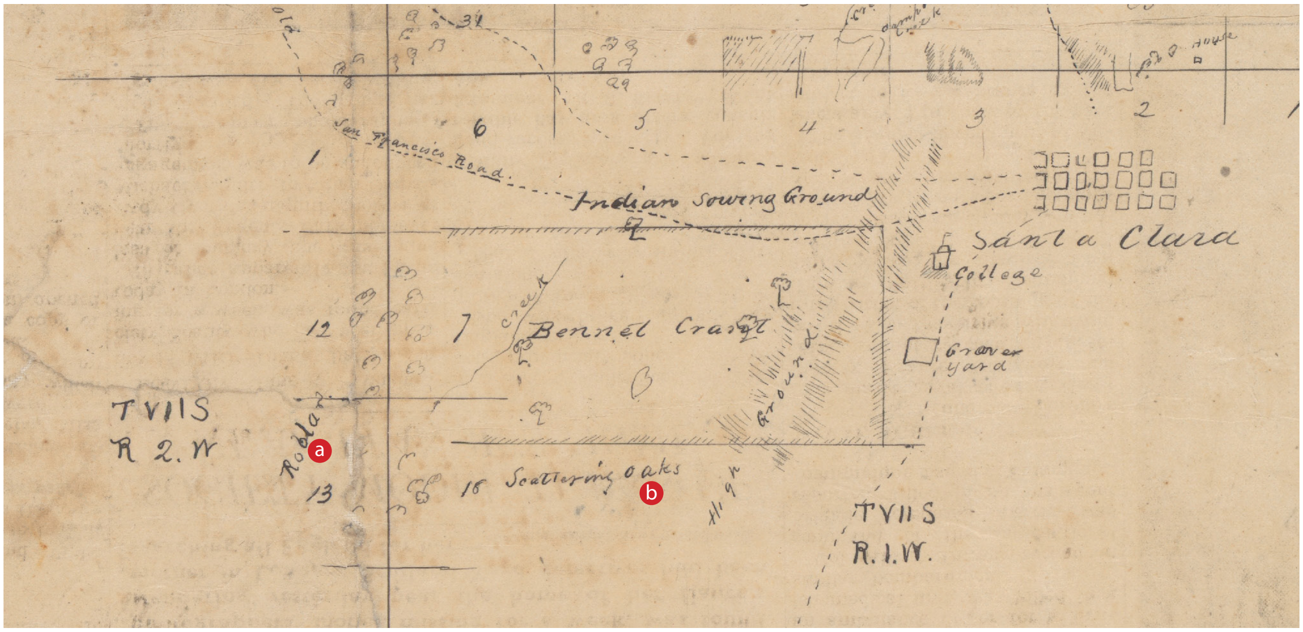


Fig. 30. The edge of the roblar, 1855. Though somewhat spatially imprecise (the alignment of the Township and Range lines are inconsistent with the alignment of the Bennett Tract, for example), this map depicts the transition from the massive oak woodland to the west (labeled "*roblar*"; a) and the scattering oak savanna to the east (b). These terms were used in our mapping to define oak densities across the region. (Healy 1855b, courtesy of The Bancroft Library, UC Berkeley)

Fig. 31. Oak woodland between Guadalupe and Alamitos creeks. GLO surveyors Thompson & Bannister noted "timbered land" to the west of their survey point (the red dot, above left) in 1871. Dense oaks are still present in 1939 (a) and even 2005 (b). (a: USDA 1939, courtesy Science & Engineering Library Map Room, UC Santa Cruz; b: USDA 2005, courtesy of NAIP)

I have represented timber at points where there are now only stumps of trees, but I have not used any different marks to designate them.

—HEALY 1864B, SPEAKING OF HIS 1864 MAP

The forrest [sic] of oaks in the vicinity of Mountain View is being rapidly cleared and orchards planted instead.

—WESTDAHL 1897B

DESTRUCTION OF OAK GROVES. Substantial evidence of early destruction of oak groves, especially around San José and Santa Clara, implies even greater densities of oaks than represented by relatively early (mid-1800s) historical sources. Santa Clara Mission authorities complained of the lack of wood in the area as early as 1787, writing that "the neighbors of the town of San José have cut down all the trees for their houses, fences, and dams" (Friedly 2000). Agricultural clearing, building, and firewood all contributed to the elimination of oaks. In the 1840s, the Mission cut timber for firewood near Santa Clara, as well as on the eastern side of the extensive Roblar stretching from Mountain View to past Saratoga (Campbell 1861a). Early residents testified to the effect of woodcutting on the extent of that enormous oak grove; one remarked that it had been "a good deal destroyed since the Americans came" (Fernandez 1864).

While a few historical sources do portray the distribution of stumps or removed trees (e.g., Healy 1864a, USDA 1939), it is likely that many more were long gone by the time of survey. Because of this, 19th century sources describing "scattering" timber, recognized in other, more slowly developed areas as representing savanna densities (Whipple et al. 2010), may in fact be referring to a woodland-turned-savanna through harvesting in many places in western Santa Clara Valley.

OAK LANDS SPECIES COMPOSITION. The species composition of oak savannas and woodlands varied across the Santa Clara Valley. In most places on the valley floor, valley oaks (*Quercus lobata*) were the dominant woodland species, though there were notable exceptions (e.g., the live oak grove near Palo Alto; fig. 32). In addition to valley oaks, live oaks (*Quercus agrifolia*), and in a few places black oaks (*Quercus kelloggii)*, oak lands included sycamores *(Platanus racemosa*), wild cherry (*Prunus ilicifolia*), California bay laurel (*Umbellularia californica*), madrone (*Arbutus menziesii*), and buckeyes (*Aesculus californica*) (Stratton 1865, 1866; Cooper 1922, Brown 2002).

The open grassland below much of the region's oak lands attracted many comments from early travelers, many of whom were reminded of a maintained park (not necessarily a coincidence, given the probable connection between the lack of understory and Native American fire management). Explorer George Vancouver ([1798]1984), traveling in 1792, described the character of the oak understory in the Santa Clara Valley:

> For about twenty miles it could only be compared to a park, which had originally been closely planted with the true old English oak; the underwood, that had probably attended its early growth, had the appearance of having been cleared away, and had left the stately lords of the forest in complete possession of the soil, which was covered with luxuriant herbage, and beautifully diversified with pleasing eminences and vallies…Having passed through this imaginary park, we advanced a few miles in an open clear meadow…

This was still largely the case even fifty years later, when surveyor Chester Lyman, en route from San Francisco to Mission Santa Clara, wrote in his journal that "the plain in many parts is covered with scattered groves of a

Fig. 32. Oak grove near Palo Alto, 1904. This photo, taken from Bryant Street east of Coleridge Avenue, shows Embarcadero Road (in foreground) and the oak woodland behind it to the northwest. Unlike much of western Santa Clara Valley's oak lands, this grove was composed of predominantly live oaks; only a few valley oaks are visible (not yet in leaf). (Unknown 1904, courtesy of the Palo Alto Historical Association)

species of oak, wh[ich] has a short trunk with a full spreading top + makes a beautiful appearance, there being no underbrush" (Lyman 1847c).

The low herbaceous vegetation beneath and between oak groves was characterized by native grasses and wildflowers. Community composition is poorly documented in Santa Clara Valley, as elsewhere in California, where early changes in species composition nearly coincident with Spanish contact quickly obscured pre-contact grassland characteristics (Mensing and Byrne 1999). Even relatively early accounts of the area reflect the rapid colonization of non-native species such as mustard and wild oats (Lyman 1847c, Bryant 1848, Wise 1850, Manly 1894, Stephens 1916, Taylor 1951). As a result, the character of native herbaceous cover is a topic of much debate in California ecology (see Bartolome et al. 2007, Minnich 2008).

Nineteenth century accounts emphasize wildflowers present within grassland. Near San José in 1850, Manly (1894) observes areas "covered with wild flowers and luxuriant live oaks," and Shortridge ([1896]1986) describes "a rich carpet of grass, adorned with myriads of wild flowers" at Palo Alto in the spring. Mary Bowden Carroll (1903) describes the area from Palo Alto to Mountain View as "a continuous park of nearly ten miles long and three miles wide, carpeted during the entire year by green sward and blue grass, all of which is bedecked with violets, poppies, roses, lillies, and wild flowers in endless variety" (though this may also refer to the extensive wet meadows of the region).

However, not all areas followed this pattern of low herbaceous understory. At the boundary between oak lands and chaparral, for example, patches of chaparral underbrush occurred in some places beneath the oaks (U.S. District Court ca. 1842, Van Dorn 1854). At the mouth of Stevens Creek, close to the oak woodland-wet meadow boundary, Lyman (1847a,b) documented dense thickets below the oaks, which he described as "dense underwood" and "thick underbrush" (fig. 33). Recollecting his childhood in this area, G. F. Beardsley described elder, scrub oak, and blackberry in the oak understory; ecologist William Cooper adds poison oak, toyon, coffeeberry, nightshade, and honeysuckle (Cooper 1926).

Chaparral

Upslope of the broad belt of oak savanna and woodland stretching from west of Santa Clara nearly to San Francisquito Creek, large areas of brush and chaparral were found on the coarse gravelly loams of the upper valley. Large bodies of chaparral – up to 4,300 acres in extent – occurred near Stanford University, Los Altos, Cupertino, Saratoga, and Los Gatos (fig. 34). By far the largest patch of chaparral occurred at the site of present-day Cupertino between Stevens and Calabazas creeks.

In total, we documented an estimated 7,900 acres of chaparral on the flat lands of western Santa Clara Valley, with much more extensive occurrence in the foothills. While extensive areas of chaparral still cover steep slopes above the Santa Clara Valley, chaparral patches on valley alluvial areas were historically rare in the Bay region (occurring notably in the Santa Clara Valley and eastern Contra Costa; Stanford et al. 2010), and have been largely eliminated over the past two centuries. Chaparral in low elevation areas (under 500 m/1,600 ft) is currently uncommon, comprising less than 4% of total chaparral cover in California today (Keeley and Davis 2007). Chaparral, also commonly called chamisal or chemisal (a misspelling) by early surveyors, was a notable component of the western Santa Clara Valley landscape. Priest and explorer Francisco Palou, traveling around Calabazas Creek in 1774, described "places thickly grown with some small trees which looked like junipers. Among them there were some madroños which were larger, and had fruit of the size of a large chick pea" (Bolton et al. 1930). Later historical sources refer to chaparral patches as "brushwood Chaperal [sic]" (Forbes 1853), the "vast cedar brake known as Chamisal" (Tracy 1859b), or simply "scrub" (Tracy 1853) or "chemisal brush" (Thompson and Bannister 1871).

Thick, dense growths of chaparral posed an obstacle to GLO surveyors and county residents. In many places it was so overgrown as to be impassable to surveyors, who described dense, impenetrable areas of chaparral (Tracy 1853, Stratton 1865). Tracy (1853) described "dense chaparral, vines and thorns, impassable" in the Saratoga area, and in the hills just above Los Gatos Herrmann (1881) noted a "dense thicket of scrub oak, chaparral, and

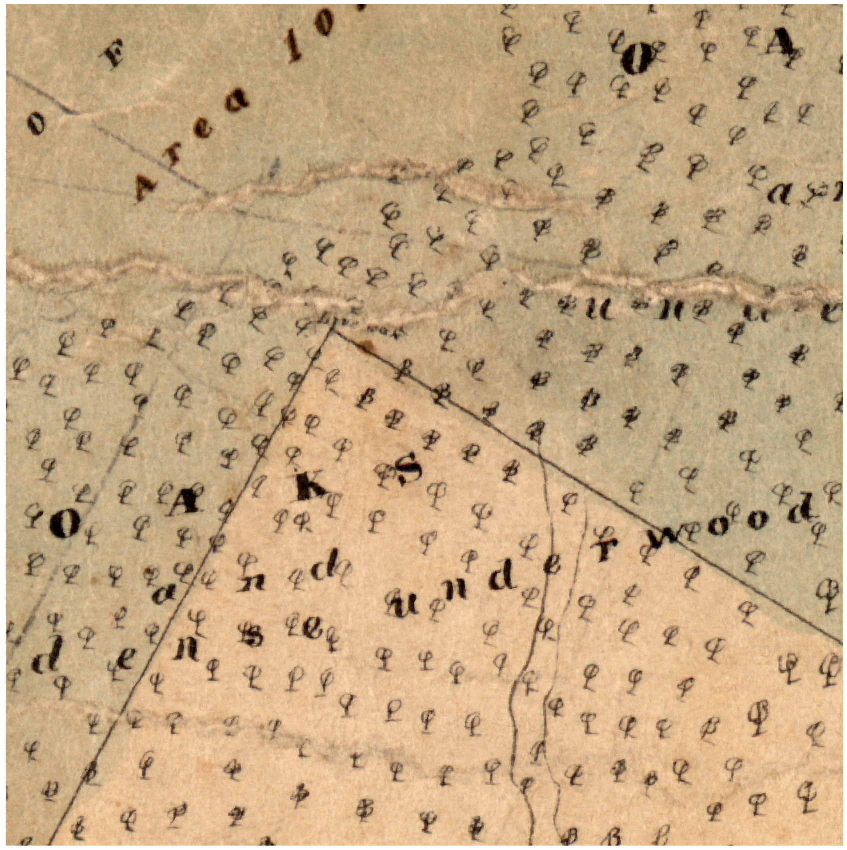


Fig. 33. Oaks and dense understory near the former mouth of Stevens Creek, 1847. This early survey map shows an area of oaks and brush (labeled "oaks and dense underwood" and "oaks and dense underbrush") in the oak woodland at the former mouth of Stevens Creek. (Lyman 1847b, courtesy of The Bancroft Library, UC Berkeley)

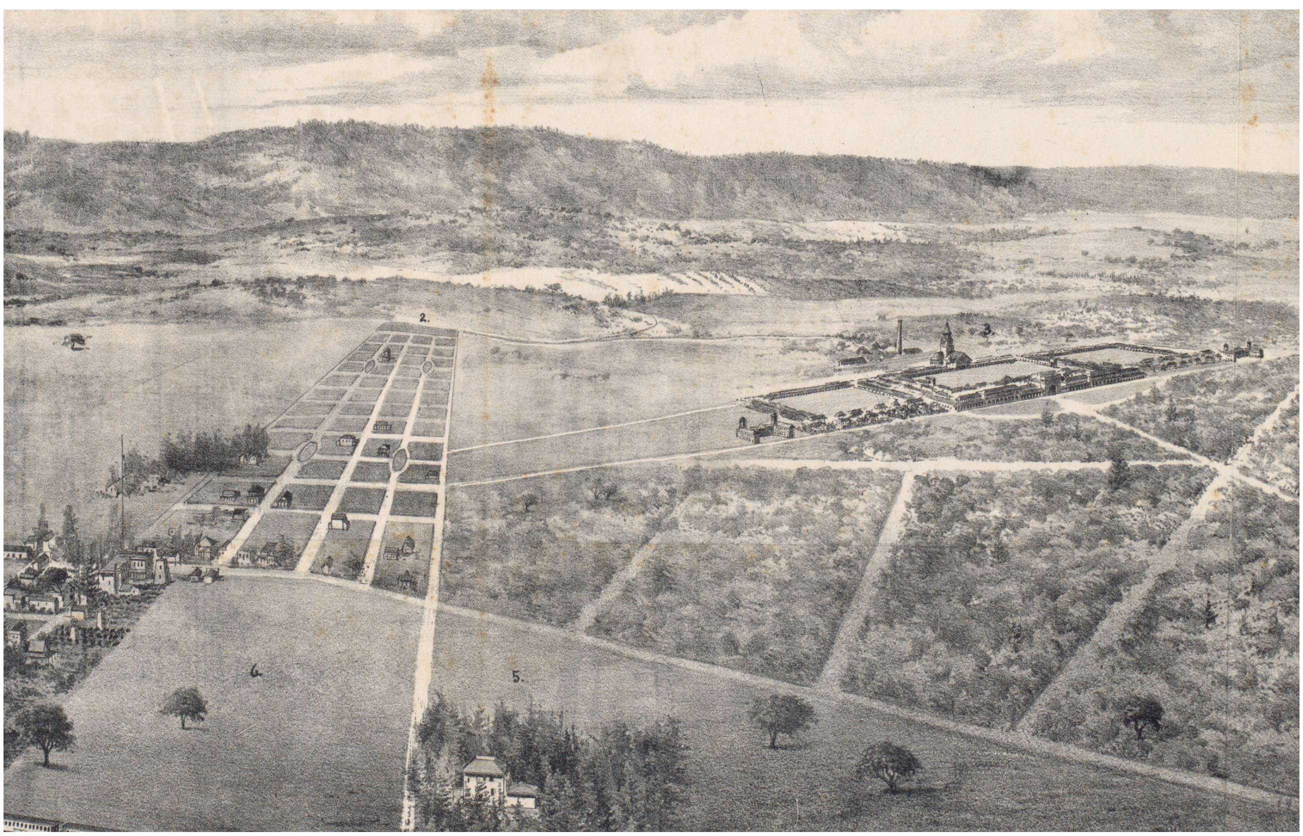


Fig. 34. Chaparral at Stanford University, 1889. A rare glimpse at a chaparral patch (foreground) along current Palm Drive, looking southwest. Memorial Church and the early quad can be seen behind the chaparral, while early Mayfield (now the College Terrace area) are at left. Note the lack of trees within the chaparral (only a few scattered oaks and other trees are shown). (Carnall-Fitzhugh-Hopkins Co. 1889, courtesy of The Bancroft Library, UC Berkeley)

poison oak." Early explorers encountered the same difficulty; Palou (1774, in Bolton et al. 1930) complained that "the journey… has been very hard, for it has been difficult because of the thick groves of juniper and madroño trees." Of course, not all areas of chaparral were densely vegetated; Palou also mentions that the chaparral patches were "separated by patches of good land, grown with pasture and having good oaks and live oaks," and another surveyor describes "open places" within the brush (Healy 1861a).

The species that composed the chaparral plant community on the Santa Clara Valley floor are not well documented, and certainly would have varied within and between patches of chaparral. Chamise (*Adenostoma fasciculatum*), manzanita (*Arctostaphylos spp.*), scrub oak (*Quercus spp.*), coyote brush (*Baccharis pilularis*), and poison oak (*Toxicodendron diversilobum*) would have likely been common in chaparral patches (Cooper 1926, Keeley and Davis 2007). Surveyor Chester Lyman, writing in December 1847, described the more unpleasant aspects of chamisal encountered during a survey of a tract now in Sunnyvale:

> The poisonous shrub resembling ivy somewhat, very abundant – had to run lines thro dense thickets of it. The lines thro these thickets wh are called chemisals, were worse to run than anything I have yet found. (Lyman 1847c)

Early surveyors use the terms chaparral and chamisal interchangeably; however, the term chamisal does not necessarily imply chamise-dominated chaparral communities (Brown 2005). While chamise was likely a part of many of the chaparral patches in the area, it is not clear that it would have been the dominant species. Beardsley (in Cooper 1926) uses the terms greasewood and *Adenostoma* interchangeably to describe the dominant vegetation in the lower portions of the chaparral, and Cooper writes of remnant chamise patches in the Santa Clara Valley in the 1920s, providing evidence for significant chamise presence. However, Brown (2005) believes that Beardsley (who refers to his teenage self as interested in "dodging school, not botany") may have meant to use "greasewood" to refer to coyote brush.

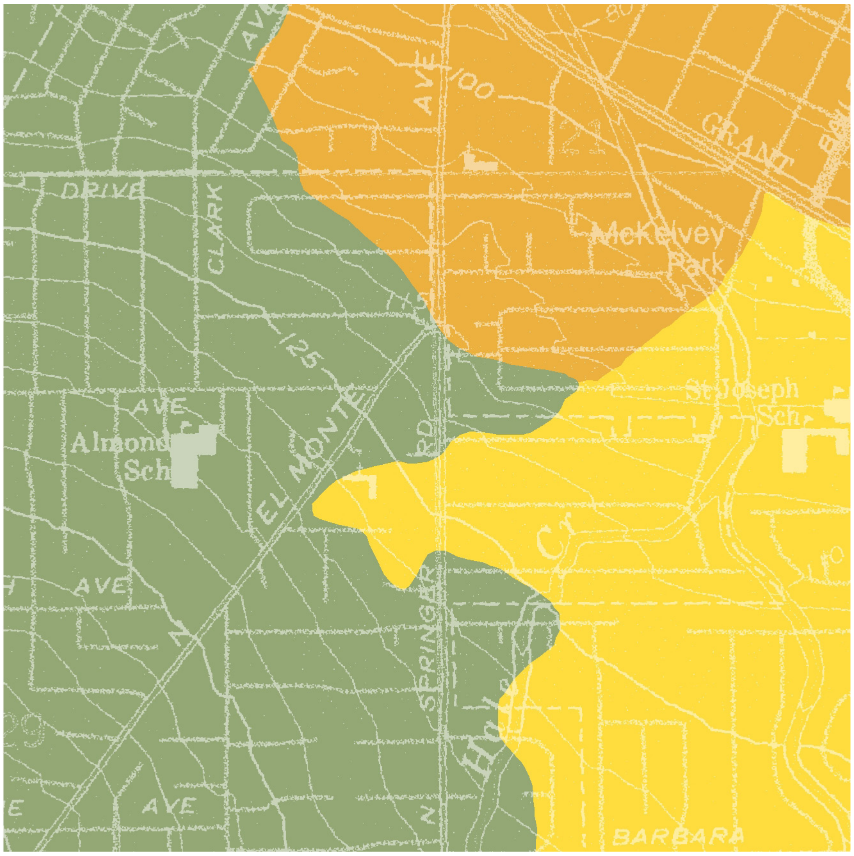
While we have mapped a clear line between oak lands and chaparral, on the ground the line would have been in many cases much more diffuse. Chaparral community species occurred as underbrush in oak savannas and woodlands, and historical maps often show patches of oaks within and on the borders of the chaparral (Healy 1855a, Healy 1864a). In the vicinity of Cupertino, an oak woodland was described as "white oak, intermixed occasionally with live oak, with several chemisals" (Campbell 1861b). A small chaparral patch in Palo Alto was recorded by surveyors as a "thicket interspersed with oak trees" (Tracy 1853), and an early account from near Menlo Park described oak trees "varied with shrubberies" (Beechey [1831]1941). However, not all chaparral patches included timber: an area on San Tomas Aquino Creek was described as "Timber, none in chamisal, outside of it a few live oaks and white oaks" (Stratton 1866). Grassy, open areas also would have been found within the chaparral, as in the large chaparral patch between Stevens and Calabazas creeks: "In the chemisal… oak timber occurs at some points and also open places where grass grows. The chemisal is several miles in extent some portions of it very dense" (Healy 1861a).

An examination of the later historical soils map (mapped in 1940-1) shows that the chaparral areas of the region were almost entirely confined to soils of the older alluvial fans. Only 13% of chaparral mapped in western Santa Clara Valley did not occur on these soil types. G. F. Beardsley, quoted in Cooper (1926), recollected that chaparral "as a rule grew on the more or less gravelly red land. As soon as this merged into the darker soil the live oaks commenced to flourish and the chaparral die out." This "red land" appears to correspond to the soil survey's Pleasanton and San Ysidro soil series (Gardner et al. 1958).

In the early and mid-1800s, chaparral was generally considered to be subprime farmland (e.g., Alviso 1860, Stratton 1865). Two particularly extensive sections of chaparral, one between Adobe and Permanente creeks and the other south of Stevens Creek, were not included within any land grant, a relatively rarity in an otherwise heavily settled region. However, by the mid-1860s, a market had grown for chaparral roots as fuel, and for cleared chaparral land for vineyard culture (Cooper 1926): "It has been discovered lately…that the chaparral land along the borders of Santa Clara Valley, near the base of the mountains, heretofore considered worthless, is peculiarly valuable for grapes…The wood on the land pays for the expense of clearing" (*Daily Alta California* 1866). Beardsley estimates that most of the clearing of chaparral occurred in the late 1880s to early 1890s. Some evidence points to even earlier clearing; Owen (1873) uses the past tense to refer to the chaparral patches of the land: "The country in its native state was covered with scrub oak, with scattering white and live oaks, and occasional patches of chaparral."

While valley floor chaparral has completely disappeared, at least one modern day place name preserves the locations of former chaparral patches. El Monte Avenue in Mountain View follows an old road that cut through a dense area of chaparral, terminating at the edge of the brush (fig. 35). (*Monte* means "bushes, brush, woods"; Gudde and Bright 1998).

It has been noted that the extent of chaparral in the Santa Clara Valley in the mid-1800s may have been substantially greater than previously, due to cessation of native land management such as burning (Stewart et al. 2002). Stewart writes that the "Santa Clara Valley must have rapidly changed between 1848 and 1870, so that the grassland [maintained by native burning] changed into a chaparral thicket and had to be cleared again to make way for orchards." While this may have been the case in some portions of the valley, there is also evidence for older patches of chaparral. One surveyor (Matthewson 1861) described chaparral on the



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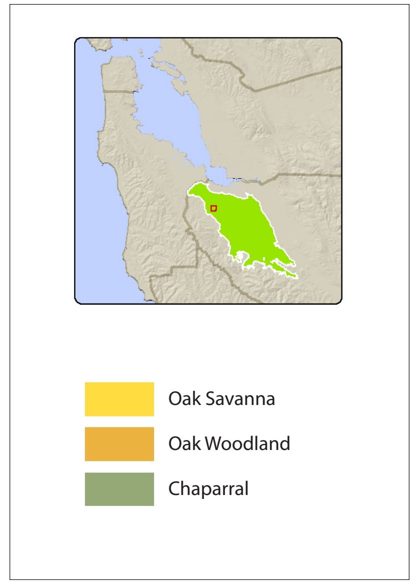

Fig. 35. Modern El Monte Avenue in Mountain View marks the former northerly extent of chaparral in the area at its intersection with Springer Road. The road dates at least to the late 19th century; it is shown on the modern topographic quad.

San Francisquito grant as "an old growth of chemisal," and additional descriptions of chaparral too dense to run survey lines through suggest the presence of mature stands of vegetation. Although this does not preclude the possibility of encroachment of chaparral on previously maintained open areas, it does suggest that at least some chaparral was well established at this time. In addition, extensive grazing in many of these regions would have likely worked to curtail substantial new chaparral growth and maintain open spaces. It is also possible that chaparral burning worked to promote the growth of brush at the expense of oak lands for hunting purposes; if chaparral was burned less frequently this may have been the case (Cooper 1922, Mayfield 1978, Brown 2005).

NEXT STEPS

While this report provides a comprehensive assessment of landscape-scale patterns of habitats and creeks across the historical western Santa Clara Valley, additional research and analysis of previously collected data will greatly enhance our understanding of landscape-level functions and the implications for local environmental management. Potential next steps supported by this project are described below.

Technical Information Development

Data collected to date represents a broad cross-section of available sources from local and regional archives. Additional data likely exists in private family collections, and interviews with long-time residents of the area could provide local detail on ecological change. In addition, other voluminous, potentially relevant sources not included in our research for this project, include court cases, review of County Surveyor field notebooks, and early local newspapers. Further research, particularly into specific areas of interest, could include these sources. Lastly, compilation of land- and water-use changes, in addition to historical climatic data, would be valuable to contextualize early habitat and creek patterns and changes over time. This would include additional research on the history of water and land modifications of the 19th and 20th centuries such as stream diversions, woodcutting, and groundwater extraction.

Regional planning efforts could benefit from further analysis of the already collected historical data. In particular, we did not synthesize and interpret many relevant riparian and hydrologic aspects of the region. Already discovered data represents a rich set of information on the character and distribution of riparian vegetation, channel morphology, and dry season flow. Analysis of changes in drainage density and creek sinuosity across the study area could also be performed with already collected data.

An updated soils map for the region has just been released (August 2010) by the USDA. Correlations between modern soils and documented oak presence using these data may be useful to refine the grassland-savanna-woodland matrix. Additional analysis of already collected data sets (e.g., GLO surveys) could also provide detail on woodland community composition and species distribution.

Management Applications

Information revealed through subsequent historical ecology research has the potential to inform current managment strategies. The following outlines some of the possible applications of further research:

- Comparison of historical dry season flow to contemporary conditions will help managers understand contemporary fisheries support functions, identify riparian habitat restoration opportunities, help optimize use of imported water, and evaluate ecologically-appropriate summer water releases by creek.

- Synthesizing information on riparian community species composition and distribution will help guide riparian assemblage targets for flood protection and stream restoration vegetation management.
- Analysis of changes in drainage density and stream network connectivity will help in understanding the effects of historical hydromodification, and in designing approaches for flood peak attenuation, stormwater management, and reduction of erosive forces.
- Documentation of locally-specific changes in groundwater levels will assist with understanding of natural recharge potential and effects of extraction.

Comparison of similarities and differences across watersheds with regard to ecosystem and hydrogeomorphic functions will help determine appropriate stream management measures at the watershed and regional scale, supporting effective project prioritization and allocation of resources. Designing systems with these data will help create sustainable, climate-adaptive stream systems.

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