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HISTORICAL ECOLOGY RECONNAISSANCE FOR THE LOWER SALINAS RIVER

Prepared for The Nature Conservancy

Monterey County Project

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By the San Francisco Estuary Institute

Erin Beller

Robin Grossinger

Alison Whipple

San Francisco Estuary Institute

7770 Pardee Lane, 2nd Flr, Oakland, CA 94621

p: 510-746-7334 (SFEI), f: 510-746-7300, www.sfei.org

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Cover image: Johnson 1854b, courtesy of the National Oceanographic and Atmospheric Administration.

EXECUTIVE SUMMARY

This report summarizes the results of an initial study of historical conditions (i.e., prior to significant Euro-American modification) on the lower Salinas River (downstream of Arroyo Seco). The Salinas River was a dynamic and complex system with a broad array of habitat types. Our research suggests that there may be significant potential for increasing the ecological services of the Salinas River through restoration of historical patterns among habitat types.

This reconnaissance indicates that the river corridor consisted of a sandy active channel with little vegetation, bordered in many places by extensive stands of riparian thicket and forest. Above the riparian corridor, multiple terraces (i.e., abandoned floodplains) of different elevation and extent corresponded to different inundation frequencies and had different plant communities. The wooded riparian areas adjacent to the river were commonly thousands of feet wide, and in some places as much as a mile wide. These riparian forests have been mostly developed into agricultural areas, and are little represented today. Hydrophilic tree species such as willows and cottonwoods were more common than oaks and sycamores; perennial pools and quicksand were well-documented. Freshwater marshes and ponds commonly occupied abandoned channels adjacent to the active mainstem channel.

Historical information about dry season flow presents a complex picture of inter-annual variability and reach-scale variation. But descriptions of summertime flow correspond with riparian vegetation characteristics and aquatic habitats to suggest significant year-round aquatic resources. Preliminary evidence suggests that the Salinas maintained substantial summer baseflow in many reaches, though this would have varied greatly with inter-annual variations in rainfall. We found little early evidence that the Salinas River completely or consistently dried out in the summer, although flow was restricted such that much of the active channel was an exposed sand surface. The Salinas River appears to have had summertime pools of water fed by hyporheic flow.

This reconnaissance suggests that substantial data are available for the Salinas River, and that these data may assist in the development of a better understanding of historical characteristics and function of the river. Potential opportunities to advance this research are described at the end of the report.

INTRODUCTION

This report summarizes the results of a reconnaissance[1] survey of historical conditions (i.e., prior to significant Euro-American modification) on the lower Salinas River in Monterey County, California. We explored a large variety of data sources to assess their usefulness and availability, and to begin understanding the historical characteristics of the Salinas River. We compiled these data to identify general spatial patterns among habitat types and physiographic elements, to generate preliminary hypotheses regarding the nature of these patterns, and to identify potential opportunities for further research. As part of the reconnaissance, we evaluated the region's information resources and management needs to determine whether a full historical ecology study might be warranted, and what the goals of such a study would be.

The Salinas River historical ecology reconnaissance was developed at the request of The Nature Conservancy's Monterey County Project to inform future discussions regarding conservation and management strategies for the river. Given the dramatic land use changes in California over the past two centuries, accurate information about historical conditions is often not readily available. The challenge is to move beyond competing, contradictory, or incomplete accounts to a reconstruction of likely conditions based on the weight of all credible evidence. Gaps in historical research can hinder the development of a consensus approach to environmental management (Hanley et al. 2009), or even lead to unsuccessful stream restoration strategies (Kondolf et al. 2001, Montgomery 2008). Where historical information is developed, however, it can help identify previously unrecognized conservation options and strategies (Grossinger et al. 2007, Walter and Merritts 2008).

For the Salinas River, as for other river systems, there are differing opinions about the historical nature of the river. Some envision a narrow sandy bed with little riparian structure, while others suggest broad (several miles wide) riparian forest (Boughton et al. 2006). There are also different opinions about the extent of dry season flow prior to water diversions, groundwater withdrawal, and summer releases from reservoirs. This reconnaissance establishes a starting point for a more thorough historical analysis of the lower Salinas River. We have focused on information about historical river characteristics — such as riparian forest, channel morphology, and dry season flow — from the confluence with Arroyo Seco to the river outlet at Monterey Bay, a distance of about 50 miles ("lower Salinas River," fig. 1). The project was limited to preliminary research and may serve as a foundation for future historical ecology analyses.

The historical river was a dynamic and complex system with a broad array of habitat types that is perhaps surprising from the contemporary perspective. While the physical and land use controls on the system have been altered over time, this reconnaissance of historical conditions suggests that there may be significant potential for increasing the ecological services of the Salinas River through restoration of historical patterns among habitat types. This report provides an initial glimpse into the historical river as a tool for considering future options and trajectories for the system.

While we have collected a substantial amount of historical data, much remains available that could be assembled to develop a more detailed and authoritative assessment. At the end of this report, we identify data gaps and opportunities for further analysis. A more thorough compilation and analysis is likely to advance

[1] A reconnaissance is an initial examination of the general characteristics of a region, as used in the geologic and soil sciences.

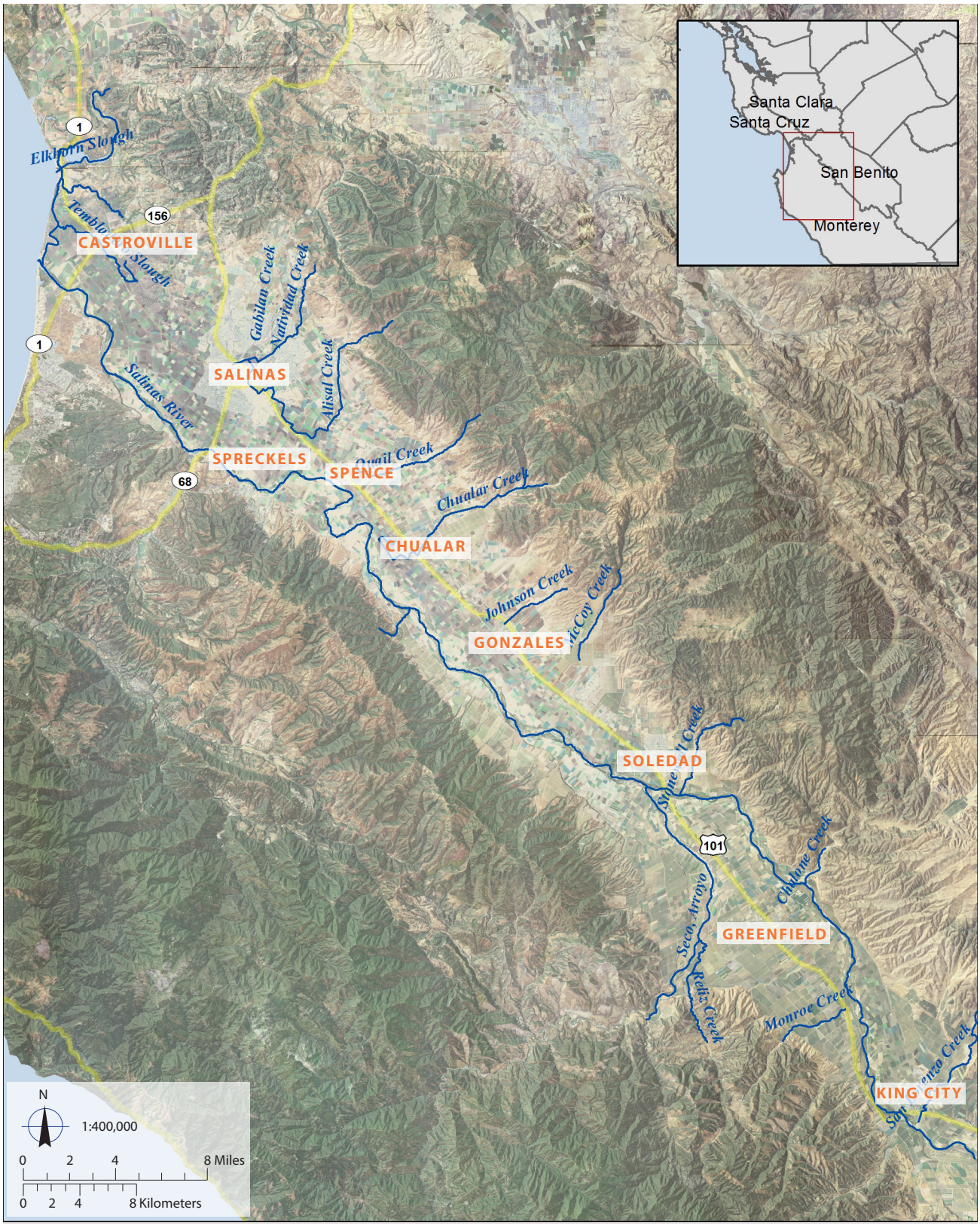

Figure 1. The study area for the Salinas River reconnaissance extends from its confluence with Arroyo Seco downstream to Monterey Bay. Place names mentioned in the report are shown in orange. (Aerial imagery courtesy of NAIP)

contemporary understanding of the river and planning for its future.

METHODS

Data Collection

Maps, photographs, and textual documents pertaining to the lower Salinas River and valley were collected from a selection of local and regional archives and searchable online databases. We also consulted contemporary data, including vegetation mapping for the Salinas River (courtesy of The Nature Conservancy) and 2005 aerial imagery.

While we focused on documents related to the Salinas River, limited data on other features (such as valley floor habitats) were also collected. We examined documents produced between 1769 and about 1940 for evidence of ecological conditions prior to major modifications. The data were assessed for relevance, then photographed, photocopied, or transcribed. In total, we compiled approximately 120 historical maps, 25 pages of relevant text, and 30 photos.

A number of local and regional institutions provided support and sources for the study, including local historical societies, regional archives, and county agency archives (table 1).

Data Compilation

We modified the compilation and synthesis methods used in more extensive projects (see Grossinger 2005, Stein et al. 2007, Grossinger et al. 2008) to fit the scope and timeline of this reconnaissance. These methods involve drawing various sources together along ecological themes such as historical vegetation types, channel geometry, seasonality, and land use. We extracted and organized relevant quotes from explorers' accounts, travel journals, surveys, reports, and other narrative texts. We also organized collected maps and early landscape photography along landscape themes in order to facilitate data synthesis.

Table 1. Source institutions visited for the Salinas River Historical Ecology Reconnaissance.

Source Institution	Location	Historical Data Type
Monterey County Historical Society	Salinas	photographs, maps
Monterey County Public Library	Monterey	county histories
Monterey County Assessors Mapping Department	Salinas	maps
Monterey County Department of Public Works	Salinas	maps
California Views	Monterey	photographs
Bureau of Land Management	Sacramento	General Land Office notes
UC Berkeley Earth Sciences Library	Berkeley	maps
The Bancroft Library	Berkeley	diseños, land grant case files
Water Resources Center Archives	Berkeley	technical reports, maps
UC Santa Cruz Science & Engineering Library Map Room	Santa Cruz	maps, aerial photos

Our projects often rely heavily on a Geographic Information System (GIS) to integrate georeferenced historical data, enabling data comparison and intercalibration. GIS allows detailed mapping at a reach-by-reach scale and spatial assessment of change over time. In most full-scale studies, enough data can be assembled to analyze historical temporal and spatial changes in conditions for specific river reaches. For this reconnaissance we only used GIS in a very limited fashion. Our mapping was less detailed and assessment of historical conditions and change are more generalized.

We used a GIS tool developed by the Forest Landscape Ecology Lab at the University of Wisconsin-Madison to georeference selected General Land Office (GLO) survey data from fourteen townships in the Salinas Valley. GLO data have been used extensively by ecologists in other regions. They offer some of the earliest, most detailed, and spatially accurate information available describing historical habitat features. The main township lines intersecting the Salinas River were surveyed in 1854 and 1855, before large-scale river reclamation and regulation. Making this dataset available in the GIS was a key component of our data compilation and synthesis process. We selected survey points along the primary township and range lines that contained information about vegetation or river characteristics. We used only a subset of the available data in order to limit data entry, and entered just over 500 survey points.

We also selected several key maps to georeference, such as early USGS topographic maps (1912) and soil surveys (1901 and 1924). To efficiently synthesize information from other maps and texts, we produced several base maps with GLO data points and associated notes printed on top of the historical U.S. Geological Survey (USGS) topographic maps. We annotated these base maps by writing and sketching relevant information from key sources on the maps. This process identified where different sources supported or contradicted each other, and enabled us to begin conceptualizing patterns among habitat types and physical gradients (fig. 2).

PRELIMINARY FINDINGS

This reconnaissance indicates that the lower fifty miles of the Salinas River were composed of a sandy riverbed surrounded by a broad bottomland colonized by dense willow thickets, mixed willow-cottonwood forest, and patches of grass. Slightly higher areas supported live oaks and sycamores. Willows appear to have been the dominant tree species throughout most, if not all, of the riparian forest (see fig. 13). In many places, the river was surrounded by complex sets of floodplain benches colonized by different vegetation, with grass and scattered trees on higher terraces and willows, cottonwoods, grasses, and marshes predominant on the lower, more frequently flooded surfaces.

The historical Salinas River corridor appears to have been relatively wet compared to other systems studied along the California coast (e.g., Grossinger et al. 2007, 2008, and 2009). Accounts of willows, cottonwoods, lakes,

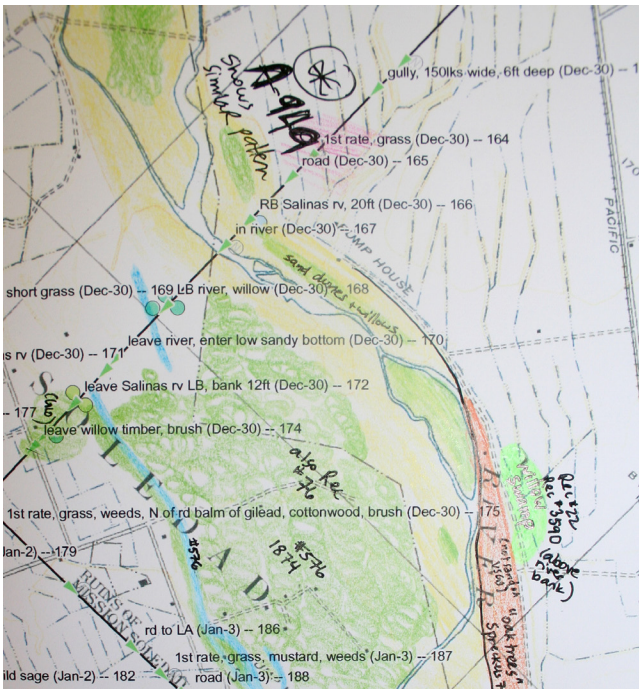

Figure 2. Detail of hand-drawn base maps, illustrating the manual compilation process. Typed text is associated with GLO points, while handwritten text and sketches are associated with features depicted on early maps. (Base map is USGS 1915, courtesy of the Water Resources Center Archives, UC Berkeley)

freshwater wetlands, and other high-groundwater features were common along the length of the river. There are relatively few early descriptions of drier conditions. Many early sources indicate that while high-volume summer flows were largely absent on the lower Salinas River, many reaches had baseflow and substantial summertime pools.

The following sections review information about the channel morphology, riparian habitat, and flow of the historical Salinas River.

Channel Morphology

The morphology of the Salinas River seems to have been broadly consistent over much of its lower course (figs. 3-5). Sets of bluffs and broad benches bounded the river. These benches were often called "bottoms" or "bottomland" by surveyors and travelers, who distinguished between "low bottoms" or "first bottoms" immediately adjacent to the riverbed, and higher terraces or "high bottoms" representing previous floodplain levels of the river. The ages of the terraces are unknown.

The low bottoms were clearly subject to periodic flooding, and may have been part of what today we would term the river's floodplain. However, we do not have sufficient information about flood frequency to confirm this designation at this time. Instead, throughout this report we refer to the low bottom areas adjacent to the river as "bottomlands," consistent with historical local vernacular. While "bottomland" is not a common contemporary ecological term on the West Coast, it is still widely used in the eastern U.S. to refer to a periodically flooded forested area (NRCS 2008).

Different features characterized the riverbed, its bottomland, and the lower and higher terraces. The sandy riverbed was generally a broad channel up to about a half

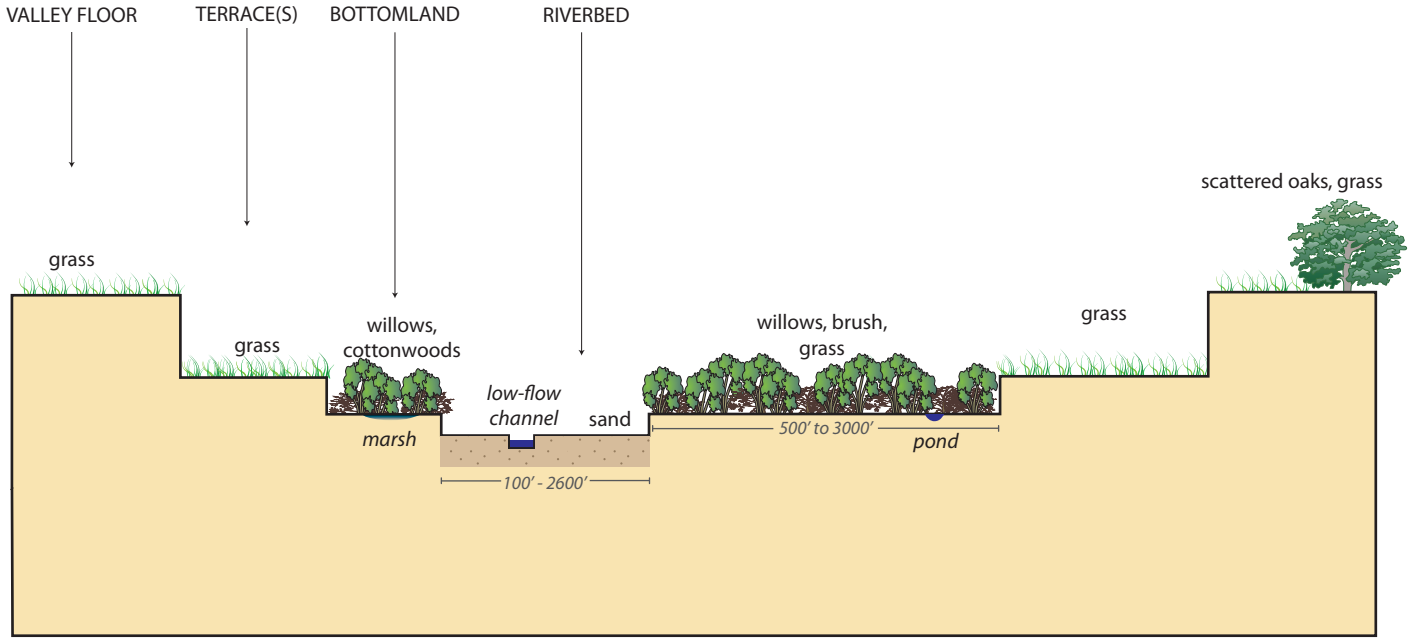

Figure 3. Preliminary conceptual model of channel morphology and riparian habitat along the Salinas River. The sandy active channel is flanked by bottomland riparian forest on one or both sides of the river. Riparian forest included willows, cottonwoods, and other trees (plus brush, grass, lakes, and wetlands). Abandoned terraces (of variable number, depending on the reach) were characterized by drier vegetation, such as grasses and scattered oaks. Characteristics varied by reach; in some instances, broad bottomland occurs on only one side of the channel (see fig. 4).

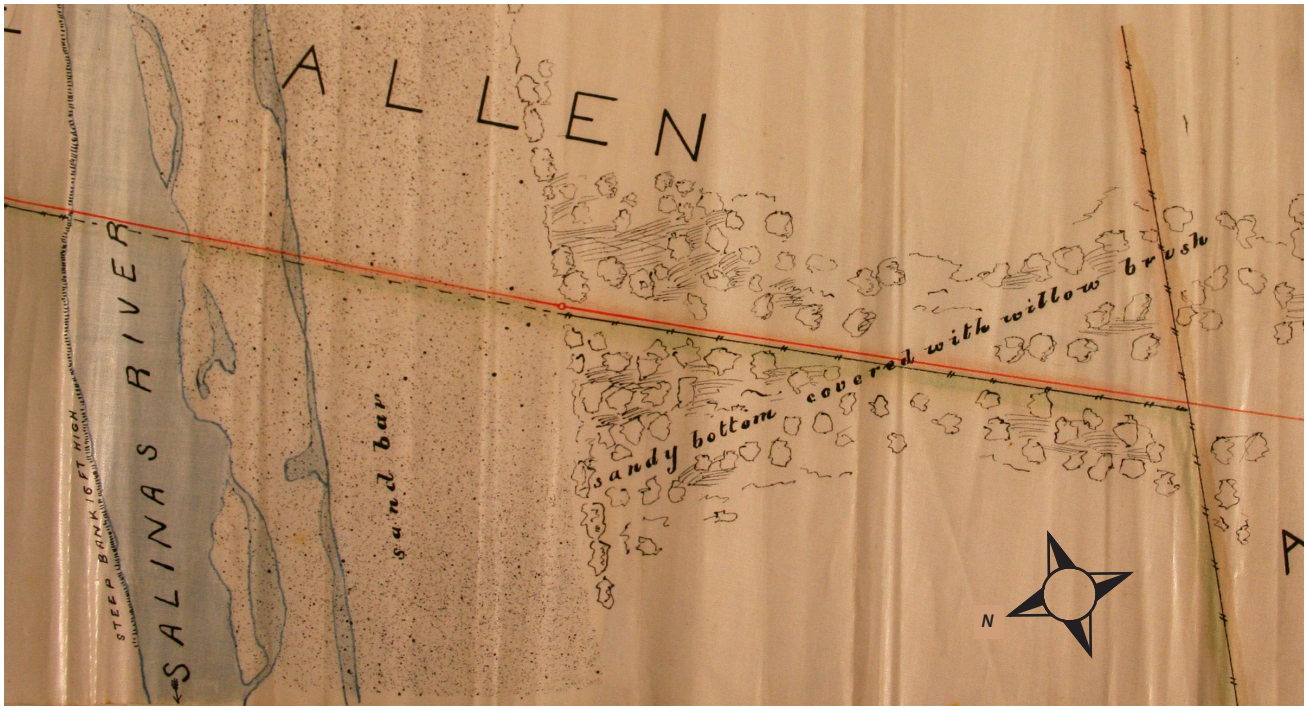

Figure 4. Salinas River near Soledad, 1895. The preliminary conceptual model in figure 3 is supported by many historical documents, such as this 1895 map. The map depicts the river morphology in plan form: a steep bluff bank on the right bank, and a sand bar in the riverbed below the left bank. The bottomland along the left bank is covered with willows. (Hare 1895, courtesy of Monterey County Department of Public Works)

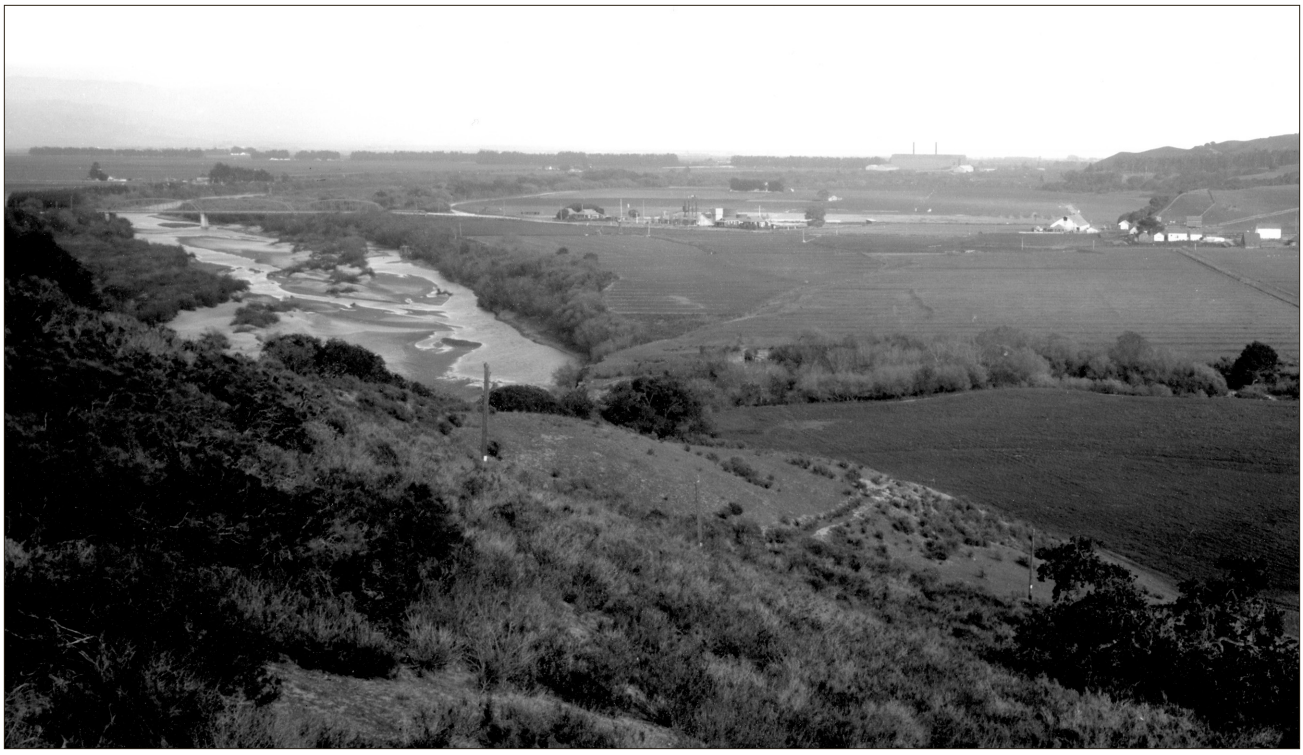

Figure 5. Salinas River downstream of the Highway 68 bridge, looking upstream, ca. 1900. In contrast with the reach depicted in figure 4, this birdseye view shows the river in an area with relatively narrow riparian forest. Dense riparian vegetation occupies the bottomland between the plain and the riverbed, while the riverbed itself is sandy, mostly unvegetated, and not far below the level of the plain. (Unknown ca. 1900, courtesy of California Views)

mile wide, bare or sparsely vegetated with willows and grasses (Lapham and Heileman 1901, Carpenter and Cosby 1925; fig. 6). Low-flow channels occupied a small portion of the riverbed. Unlike the extremely sandy bed of the Salinas River, the sediment load of Arroyo Seco was coarse. Arroyo Seco was described as a "broad wash of gravel and sand" (Hamlin 1904), and surveyors encountered granite boulders in its bed just west of Greenfield (Freeman 1855).

In contrast to the largely bare riverbed, the adjacent bottomland appears to have been well-vegetated along much of the river. The botanical characteristics of the bottomland are described more fully in the Riparian Species section (see page 12). Willows, cottonwoods, brush, grasses, and some oaks appear to have occupied this plain. In addition, ponds and depressional wetlands were often noted (figs. 7 and 8).

Above the bottomland, older, higher terraces appear to have been colonized predominantly by grasses (and in later years dense mustard; Day 1854, Antisell 1856). The highest of these terraces could be quite far from the riverbed — in 1861 William Brewer (1974) described the valley floor "from 75 to 150 feet above the present river." The complex set of terraces of varying widths and heights would have experienced different frequencies and depths of inundation by river floods. The highest terrace might never be flooded.

CHANNEL GEOMETRY. Understanding the width and depth of the Salinas River is a complicated undertaking:

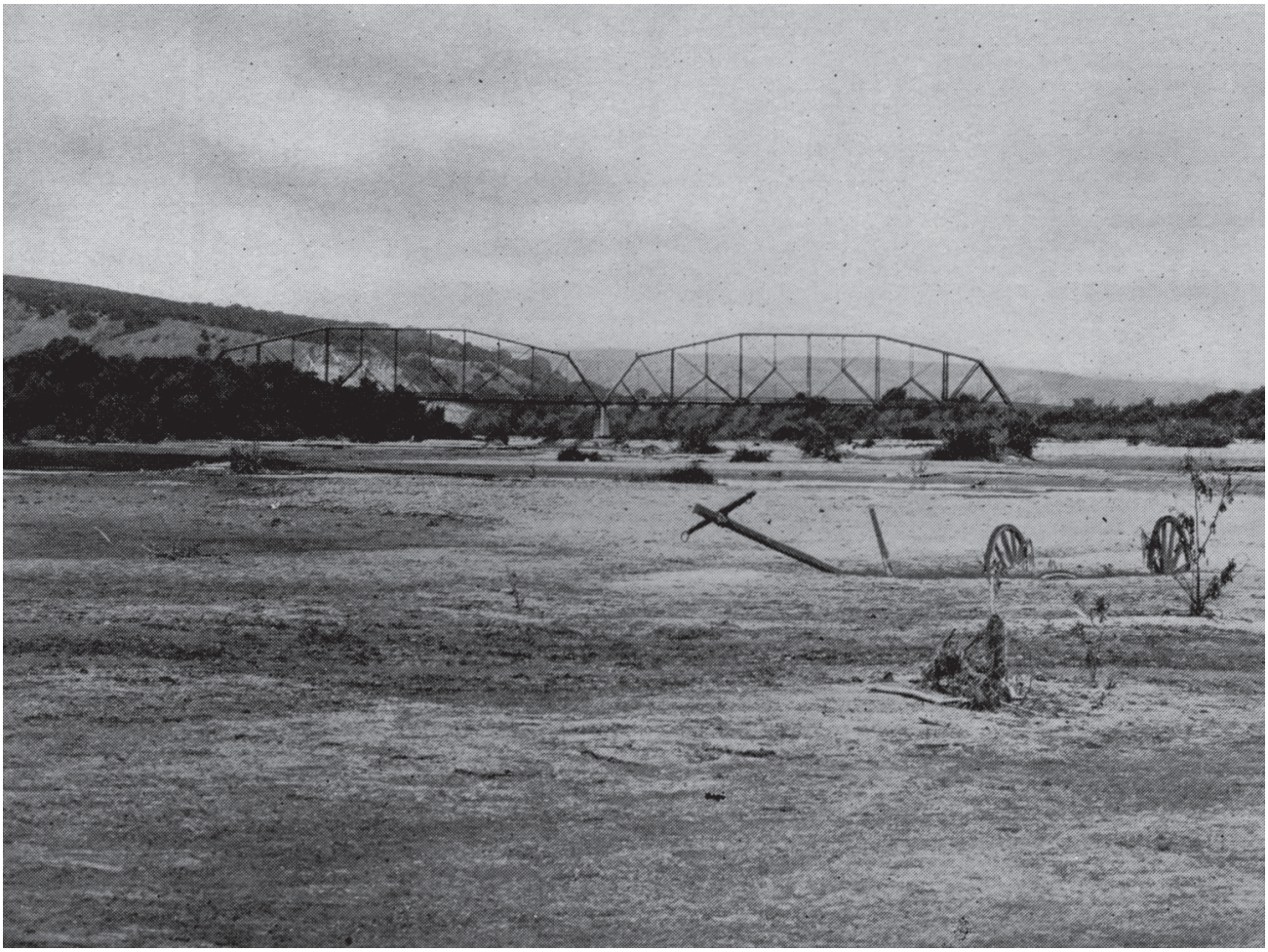

Figure 6. "Salinas River above gaging station at Monterey Road bridge, near Salinas — shows quicksand in bed of stream," ca. 1901. This photograph shows the bare, nearly unvegetated sandy bed of the river. The vegetated bottomland is visible in the background. (Hamlin 1904)

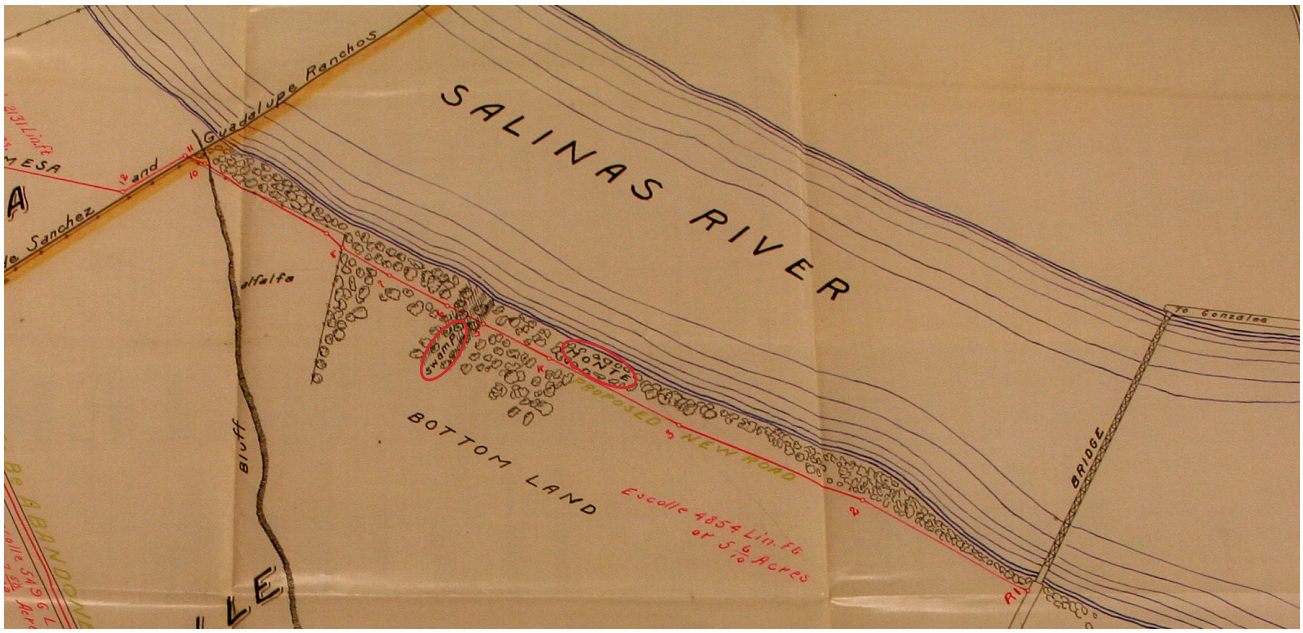

Figure 7. Bottomland near Gonzales, 1902. A swamp within a larger patch of "monte" (likely mixed willow cottonwood forest). (Unknown 1902, courtesy of Monterey County Department of Public Works)

Figure 8. Rancho San Vicente, ca. 1840. This early diseño shows what is likely the Salinas River bottomland between Gonzales and Soledad, with the "Río de Monterrey" (Salinas River) running through. The bottom is labeled "bajío empastado," or grassy lowland. Other features are depicted within the lowland, such as a thicket (the large dark oval on the right; Soto 1835), a pool of water ("posa"), and scattered trees. (U.S. District Court, Southern District 184-?, courtesy of The Bancroft Library, UC Berkeley)

the complex terracing makes it challenging to relate information about bank height or channel width to a specific location or terrace level. However, a few generalizations may be made.

It appears that the historical riverbed has occupied a position well below the valley floor for a long time. Eighteenth-century explorers noted steep river banks along the river (Bolton et al. 1930, Costansó and Browning 1992). In many accounts banks are described as fairly steep or nearly vertical. Surveyors' maps, narrative accounts, and GLO surveys record riverbanks (the sides of the riverbed) from 4 to 25 feet high (e.g., Antisell 1856, Hare 1895, San Francisco Call 1907). One surveyor described the river banks west of Gonzales as "mostly steep but varying from 5 to 25 feet" (Freeman 1855).

Channel width can also be challenging to determine from historical sources. Observers and surveyors often do not specify what portion of the river is being measured — the width of the water at a particular flow, the bank-to-bank width of the channel, or the width of the river including its bottomland and terraces. However, sources suggest that the width of the sandy riverbed varied widely across the river, from fairly narrow (less than 100 feet wide) to over 2,600 feet. This would have varied spatially, from a relatively narrow active channel in the lowest fifteen miles to a much wider channel further upstream (Carpenter and Cosby 1925, USDA 1937). Freeman (1855) described a channel "15 or 20 chains [1000-1300 feet] wide, all a bed of gulch sand" near Gonzales. The low-flow channel would have occupied a small portion of this larger, sandy bed.

CHANNEL MIGRATION. Constrained by the mountains on either side of the valley and the alluvial fans of major tributaries, the Salinas River was constantly scouring and rebuilding the channel bed and floodplain. Over the time period we examined, it appears that the active riverbed shifted substantially in several locations. In one instance, the active channel today appears to occupy a former channel noted as abandoned in the 1860s (Foreman 1867). Changes are also evident where land grant boundaries, many of which were originally set by the channel configuration, no longer coincide with the river course. Changes in channel location appear to have been largely reach-specific, consisting of cutoff meander bends or accentuated curves.

The character of these changes is discussed by several surveyors, and shown in a map depicting the "old channel" of the Salinas (fig. 9). GLO surveyor Sherman Day (1854) encountered a swale (i.e., an abandoned channel with indistinct banks due to its age) and called it an old water course, presumably of the Salinas River. Near Highway 68, Foreman (1867) encountered the "old Bed of Salmas [sic]" and noted that it "is filled up here." Some of these old beds, or swales, became depressional wetlands, while others were mostly filled in:

> In the Salinas there are evidences of frequent changes in the beds of streams: these were carefully surveyed and represented as they now appear. In some of the old beds, we still find marsh, and [othe]rs again can only be traced as a slight depression on the Plain. (Johnson 1854a).

The most dramatic lateral shifts in channel alignment occurred in the river's lowest 15 miles. Many old channels are identified as lowland sloughs today, such as Tembladero and Alisal (Carpenter and Cosby 1925). Another area of change was likely at the confluence between the Salinas River and the Arroyo Seco, as suggested by a comparison between the current condition and that indicated on a plat map from the late 1800s.

Throughout the valley, lakes and wetlands occupied topographic lows that were likely segments of former channels (see fig. 9). Downstream of Spreckels, these features were widely distributed across the valley because of the frequent migrations of the river. Lagoons were noted along the valley floor near Spence, Salinas, and close to the river mouth near Castroville. Large, linear, depressional wetlands are also identified just north of the current

river mouth (Carpenter and Cosby 1925). In the vicinity of Spence, Day (1854) states "these lagunas and others appear to form part of an ancient circuitous channel of the Salinas."

Depressional wetlands also formed behind the river's natural levees. This was especially evident along the northeast margin of the valley (Gabilan Creek watershed). Unable to access the mainstem directly, runoff from some watersheds created a "chain of swamps and lakes" along the landward margins of the river's natural levees (Carpenter and Cosby 1925). Such wetlands are not uncommon in narrow coastal valleys (e.g., Grossinger et al. 2007, 2008). Extensive artificial drainage has been required to reduce local flooding in these areas (Casagrande and Watson 2006).

Changes in the configuration of the river's coastal mouth were frequent. The U.S. Coast Survey topographic map sheet (Johnson 1854b) suggests a former mouth south of its present location, and the most prevalent route seen and described in the decades prior to 1908 was to the north, with an outlet near Moss Landing (Gordon 1985, Casagrande and Watson 2006).

Initial comparisons between maps from within only a few decades of each other indicate that in some places the active channel bed location was quite dynamic. Channel migration, meander cutoffs, and oxbows led to a diverse array of riparian habitats, including freshly scoured surfaces, riparian forest of varying ages, and wetlands occupying abandoned channel segments.

It is noteworthy that (except in the river's lowermost reaches) migration has been confined to a relatively small portion of the Salinas Valley. Recent migration has been restricted to the areas between the outer bluffs defining the margin between the river corridor and the valley floor.

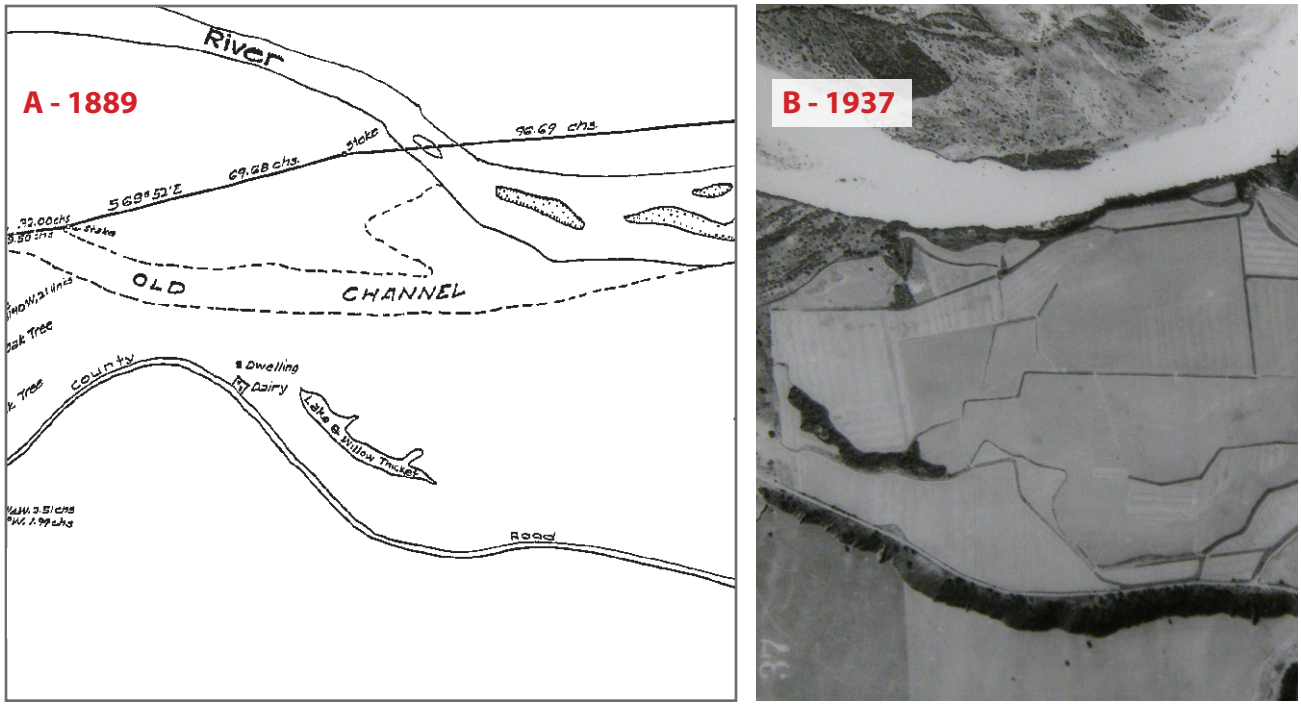

Figure 9. A lake and willow thicket within a topographic low formed by an old channel of the Salinas River, 1889 (A). The feature is still visible in 1937, with surrounding ditches (B). (A: Garber 1889, courtesy of the Monterey County Assessors Mapping Department; B: USDA 1937, courtesy of the Science and Engineering Library Map Room, UC Santa Cruz)

Riparian Habitats

Extensive, often dense riparian vegetation along the Salinas River occurred on low bottomland benches adjacent to the sandy, high-flow river channel. These areas were colonized predominantly by willows and other riparian species in large areas of mixed riparian forest or willow scrub. Riparian forests were common along one or both sides of the river, commonly 500 to 3,000 feet wide (fig. 10).

Early accounts of the area describe a river nearly continuously flanked by riparian vegetation. In 1769, Crespí describes a "vast amount of trees on the river" (Crespí and Brown 2001). He observes that the riparian forest continued all the way to the Bay. Many observers describe identifying the river from a distance by its riparian corridor: William Brewer (1974) noted in 1861 that he had "never been in a land before with so many extensive views — the wide valley, brown and dry, the green belt of timber winding through it, like a green ribbon," and Elliott and Moore (1881) refer to the majority of trees on the plain in "the belt which skirts the river." Another early traveler described the valley from above, the river "marked out for many a league, with fringes of drooping willows" (Wise 1850).

RIPARIAN SPECIES. Willows appear to have been the dominant tree species in many parts of the riparian corridor. Various terms were used to describe riparian scrub and forest: "river timber" or "willow timber," "grove," "willows and brush," or just "willows" (fig. 11). Crespí describes the river timber north of Chualar as "white and black cottonwoods, willows most of all, and a good many live oaks" (1769, in Crespí and Brown 2001). Willow prevalence is indicated throughout early historical records (e.g., Crespí's notes, Mexican land grant records, GLO surveys) prior to significant clearing for agriculture or firewood (fig. 12).

However, many other species of trees, brushes, and grasses were associated with the riparian corridor. Fremont and black cottonwoods (often called poplars) were repeatedly mentioned in narrative descriptions, sometimes even as a dominant species. Font (1776, in Bolton et al. 1930) describes the river south of King City as "very thickly grown with cottonwoods and other small trees," while another surveyor mentioned only that "cotton-woods grow on the river bank" (Antisell 1856). Father Uria of the Soledad Mission wrote in 1827 that "in the way of groves and forests the Mission has only some poplar, alder and willow trees along the river valley" (Engelhardt 1929; table 2).

While willows, Fremont cottonwoods, and black cottonwoods (called Balm of Gilead; Zybach 2002) were the most common corner bearing trees used by GLO surveyors, oaks and sycamores were also used (fig. 13). Single oaks and oak groves were suggested as part of the riparian community by travelers who would often use them as a camping spot. Explorers on the Portolá expedition in 1769 camped "in the river bottom amid a clump of live oaks" downstream from Soledad (Costansó and Browning 1992), and a later traveler in 1849 ran across a group of bandits camped in an oak grove on the river south of Soledad:

> [I]n the course of an hour I was rejoiced to see a point of woodland jutting into the plain, not over a few hundred yards distant, in the midst of which there was the glimmer of a fire….As I descended from the plain into the oak grove bordering upon the bed of the creek, I observed that there were only two men in camp… (Browne 1864)

Brush, bushes, and grasses also comprised the bottomland community. Members of the Portolá expedition were much impressed with the quantity of Rose of Castile bushes (*Rosa californica*; Minnich 2008) found on the river bottomland. Found on "moist valley flats, along river and creek banks" (Jepson 1936), *Rosa californica* seemed nearly ubiquitous along the river in Crespí's 1769 journal, where he describes "countless Rose of Castile bushes…large plains full of them…the whole river bottomland, which is quite sizeable, is one entire patch of them, dense as the tufts of grass":

> All along its banks this river makes a low bottomland, pretty wide, with a vast lushness of brambles,

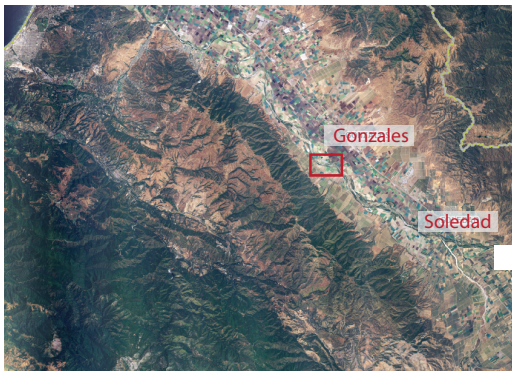

Figure 10. Cross section across the Salinas River southwest of Gonzales, based on 1855 GLO survey data. Willows, brush, briar, and a pond occupy the broad bottomland twelve feet above the left bank, while the riverbed itself is sandy and bare. While the channel appears to have shifted in the contemporary aerial (2005), the riparian vegetation is substantially narrower, though still broader on the left bank. (Freeman 1855; USDA 2005, courtesy of NAIP)

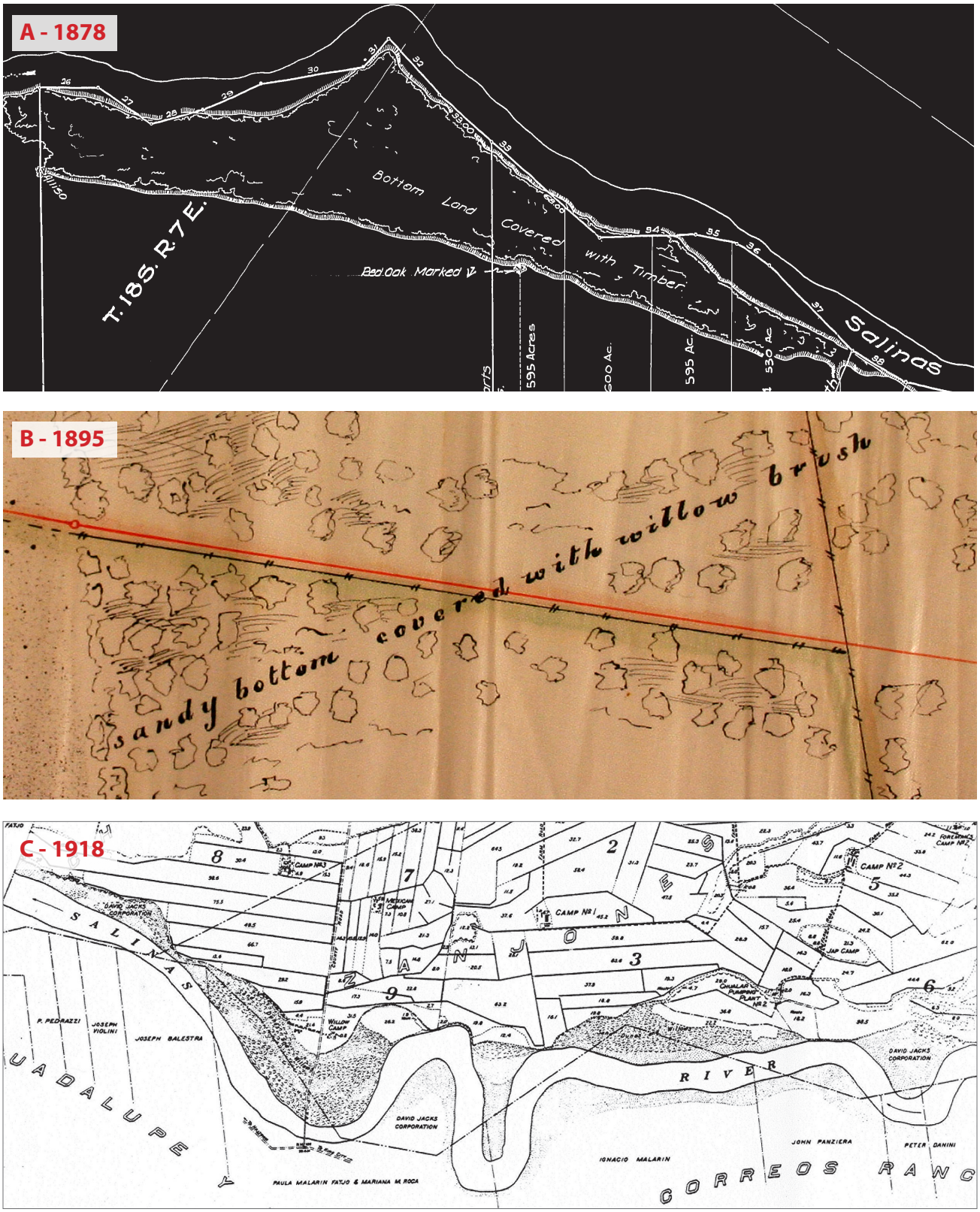

Figure 11. Depictions of extensive riparian timber along the Salinas River. Maps often specified riparian characteristics with labels such as "willow brush," "sand dunes and willows," "bottom land covered with timber," or "willow and cottonwood grove." (A: Cahill 1878, courtesy of the Monterey County Assessors Mapping Department; B: Hare 1895, courtesy of Monterey County Department of Public Works; C: Unknown 1918, courtesy of the Monterey County Historical Society)

Figure 12. Salinas River mouth, 1854. Dense willow thickets were shown on the lower Salinas River where it was deflected north by the sand dunes on the shores of Monterey Bay. Both the U.S. Coast Survey (June) and the GLO (November) surveyed this area in 1854, five months apart, affording an opportunity for independent validation of the datasets. The GLO descriptions of "willow thicket" correspond closely to the tree symbol mapped by the USCS. The georeferenced positions of these historical datasets match well in the east-west direction, but are misaligned by about 250 feet in the north-south direction (as can be seen by the location of the "sand butte" near the top of the image). (USCS: Johnson 1854b, courtesy of the National Oceanographic and Atmospheric Administration; GLO: Freeman 1855)

> countless rose bushes—so that many double-hundred-weight [measures] of roses could be loaded in season—and all sorts of other very lush plants; so that all this soil could be placed under irrigation with very little trouble. (Crespí and Brown 2001)

Travelers wrote of abundant grass "six or eight inches high in the bottom, the blades standing so thick as to present a matted appearance" (Bryant 1849), and bottomlands "very much overgrown with very large grass clumps and a great many other kinds of plants and weeds" (Crespí and Brown 2001).

RIPARIAN CORRIDOR WIDTH AND STRUCTURE. Several early sources provide information about riparian corridor width along the Salinas River. E.J. Carpenter and Stanley Cosby carried out some of the earliest detailed soil surveys of

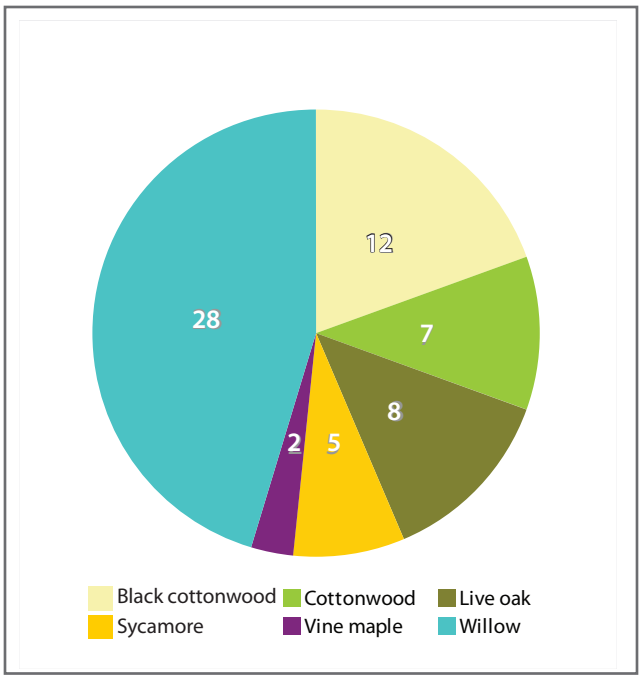

Figure 13. Number and proportion of tree species from the General Land Office bearing tree dataset. Willows represented almost 50% of the riparian trees encountered, black cottonwoods ("Balm of Gilead") were 20%, Fremont cottonwoods and live oaks were each just over 10%, sycamores were 8%, and vine maples were 3%.

many parts of coastal California; they are renowned for their useful observations and accurate mapping (Swinchatt and Howell 2004). In their 1925 Salinas Valley soil survey, Metz fine sand (Mf) and Metz very fine sandy loam (Mv) were the predominant soils adjacent to the river, Mf often closest to the active channel and Mv somewhat more removed. The Metz fine sand (Mf) was intermittently flooded, and prior to cultivation was "covered with a dense growth of willows and other water-loving trees and brush"; the Metz very fine sandy loam (Mv) also supported a "rank growth of willows and other brush" (Carpenter and Cosby 1925). While the extent of these soils is fairly limited downstream of Spreckels, from Chualar upstream there are extensive, broad areas of these bottomland soils bordering the river in many places. This suggests many wide areas of riparian vegetation, especially south of Salinas. The areas demarcated by these soils are generally between 500 and 3,000 feet wide along either or both sides of the river. In a few places (for example, near Soledad), these areas are up to one mile wide.

The historical distribution of vegetation indicative of riverine flooding provides a more resolute estimate of riparian corridor width. Many maps show extensive areas of brush and willows along the river, often much wider than the sandy channel bed (see fig. 10). Narrative accounts describe bottom lands about 1,300-2,600 feet wide (Hilgard 1884). Crespí (1769, in Crespí and Brown 2001) describes needing to "clear and open a path" along the Salinas River before crossing it near King City "because of its large woods"; shortly after he estimates that the vegetation along the river "in places must be four hundred yards [1,200 ft] and more through." Brewer (1974) estimated the riparian corridor to be "twenty to a hundred rods [330-1,650 ft] wide" in 1861. A few "points of timber" along the river were recognized and used as landmarks, such as the Punta del Monte de la Soledad (the origin of the grant name) and the wood of "de la Poza," indicating some areas of notable width (Soto 1835; see fig. 8).

GLO surveys also illustrate many wide areas of riparian vegetation. The area near the Soledad Mission, for example, appears to have had multiple side channels within a very broad riparian forest (fig. 14).

Some early observers, however, do not emphasize the extent of timber along the river, describing "narrow belts of small timber" (Bryant 1849) and a river "more or less fringed with trees" (Elliott and Moore 1881). Some maps and narrative descriptions depict patches of willows and other trees within a matrix of sand, brush, grass, ponds, and wetlands. There were undoubtedly areas of sparser vegetation (such as near the Highway 68 crossing) and variations in response to major floods.

Riparian vegetation structure also varied along the Salinas River. Near Spence, one surveyor passed through "willows in scattered groups" on one side of the river and a thicket so dense that it was impenetrable on the other: a "grove

Table 2. Selected descriptions of riparian vegetation along the Salinas River bottomland.

Quotation	Location	Citation
"willow, 'Balm of Gilead' and so forth. Undergrowth briars and vines"	Near Salinas	Freeman 1855
"dense thicket of willows and bushes"	Near Spence	Day 1854
"grove of sycamores, willows, and cottonwood, amid a dense undergrowth"	Near Spence	Day 1854
"timber grove on the river bottom…cottonwood, willow, live oak, elder, buckeyes"	Near Spence	Day 1854
"thicket of willows, poison bushes, gooseberries and other varieties"	Near Spence	Day 1854
"oaks, willows, hazel, buckeye, spicewood, elders, sycamores, and cottonwood"	Near Spence	Day 1854
"white and black cottonwoods, willows most of all, and a good many live oaks"	Near Chualar	Crespí 1769, in Crespí and Brown 2001
"mostly rich land, willows, brush and briars"	Near Gonzales	Freeman 1855
"willow timber and brush"	Near Soledad	Freeman 1855
"balm of gilead, cottonwood and brush"	Near Soledad	Freeman 1855
"poplar, alder and willow trees"	Near Soledad	F. X. Uria 1827, in Engelhardt 1929
"thickly covered on both sides with willows, poplars, oaks, and other kinds of trees"	Near King City	Costansó 1769, in Costansó and Browning 1992
"fringes of drooping willows"	General	Wise 1850

of sycamores, willows, and cottonwood, amid a dense undergrowth" (Day 1854). Observers noted relatively dense vegetation along many parts of the river. Costansó recorded that the river was "very thickly covered on both sides" with trees in 1769, and in 1774 Palou also noted the "heavy growth of trees with which the bed of the river is covered" (Bolton et al. 1930, Costansó and Browning 1992). However, some did note areas of sparse vegetation: Caldwell (1870) describes "shores sparsely wooded for a short distance from its banks," and in 1849 Frémont was forced to camp in a place with "not much timber… [and] only a thicket of tall brush for shelter" on her way to Monterey (Frémont 1878).

To better understand the time frame for riparian forest development, we examined tree trunk diameters as recorded for bearing trees in the GLO surveys. We assembled trunk diameter data within the likely riparian zone. Both willows and maples had an average diameter of 7 in. Black and Fremont cottonwoods had average diameters of 9 in and 16 in, respectively. The average live oak diameter was 16 in, and the average sycamore diameter was 21 in. Only three diameter measurements (of any species) exceeded 24 in. Tree species that likely represent a more mature riparian forest, such as live oaks and sycamores, were larger than those species dominant in younger forests, such as willows (fig. 15).

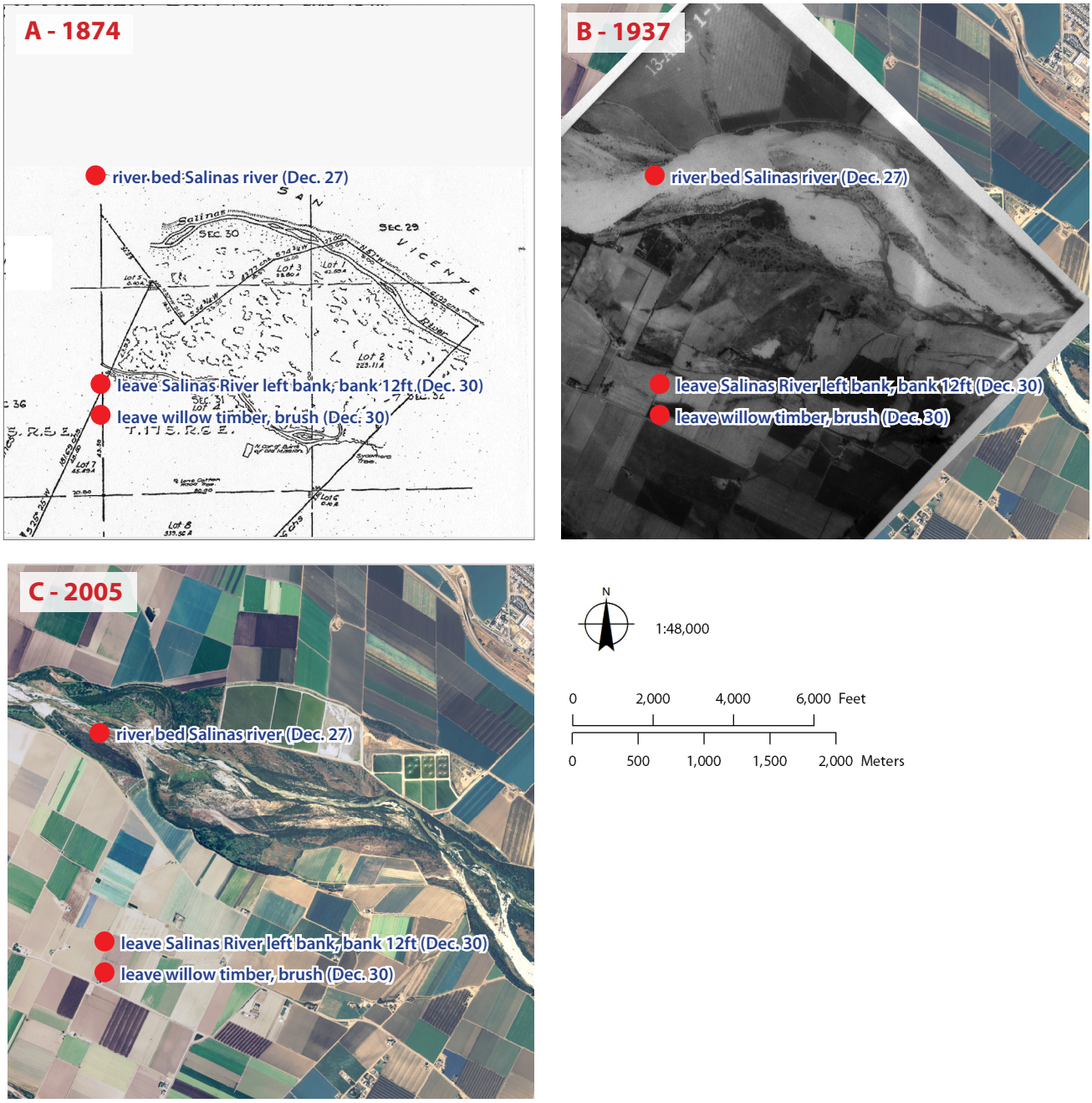

Figure 14. Change in riparian vegetation along the Salinas River, near Soledad. This was one of the widest areas of riparian forest we encountered in historical records, with dense willows and multiple side channels (A). It illustrates loss of riparian vegetation along the lower bottomland, largely by 1937 (B). Narrowing of the riparian corridor has likely occurred over many areas along the river (C; Gordon 1985). (A: Von Leicht 1874, courtesy of the Monterey County Assessors Mapping Department; B: USDA 1937, courtesy of the Science & Engineering Library Map Room, UC Santa Cruz; C: USDA 2005, courtesy of NAIP; GLO: Freeman 1854)

Clearly, major channel movements removed and created new areas of riparian forest. Some willow forest groves were persistent enough to be used as local landmarks (e.g., la Punta del Monte) while others reappear consistently in documents of different decades (e.g., Johnson 1854b, Barker 1866, Herrmann 1879). We have not compared evidence through time systematically to assess the persistence of particular riparian features and their sensitivity to minor or major flood events.

Areas of extensive timber as described by historical documents are largely absent in the contemporary landscape (figs. 16 and 17). Willows and cottonwoods along the river provided a significant source of wood for early settlers, and were an impediment to farming the rich bottomland. Because of this, much of the forest was cut down and grubbed out. Near the river mouth, willows "contribut[ed] to the wood traffic" (Elliott and Moore 1881), while the Soledad Land and Water Company's pumping plant near Soledad was powered with willows and cottonwoods from the river, "burned at the rate of about 1 cord every six hours" (Hamlin 1904).

Flow

The Salinas River was subject to considerable seasonal variability in average flows, and inter-annual variability in maximum wet season flows and minimum dry season flows. During floods, the sediment-laden Salinas would overflow its banks onto the adjacent bottomland (Johnson 1854b). Many early observers of floods referred to the wide sandy channel as evidence of the large volume of water and sand carried by the river in the winter:

> But the width between banks and dreary stretch of sand are evidences of the torrents which rush down here in winter. To see the little narrow stream in the summer, playing hide and seek in the sand, one could

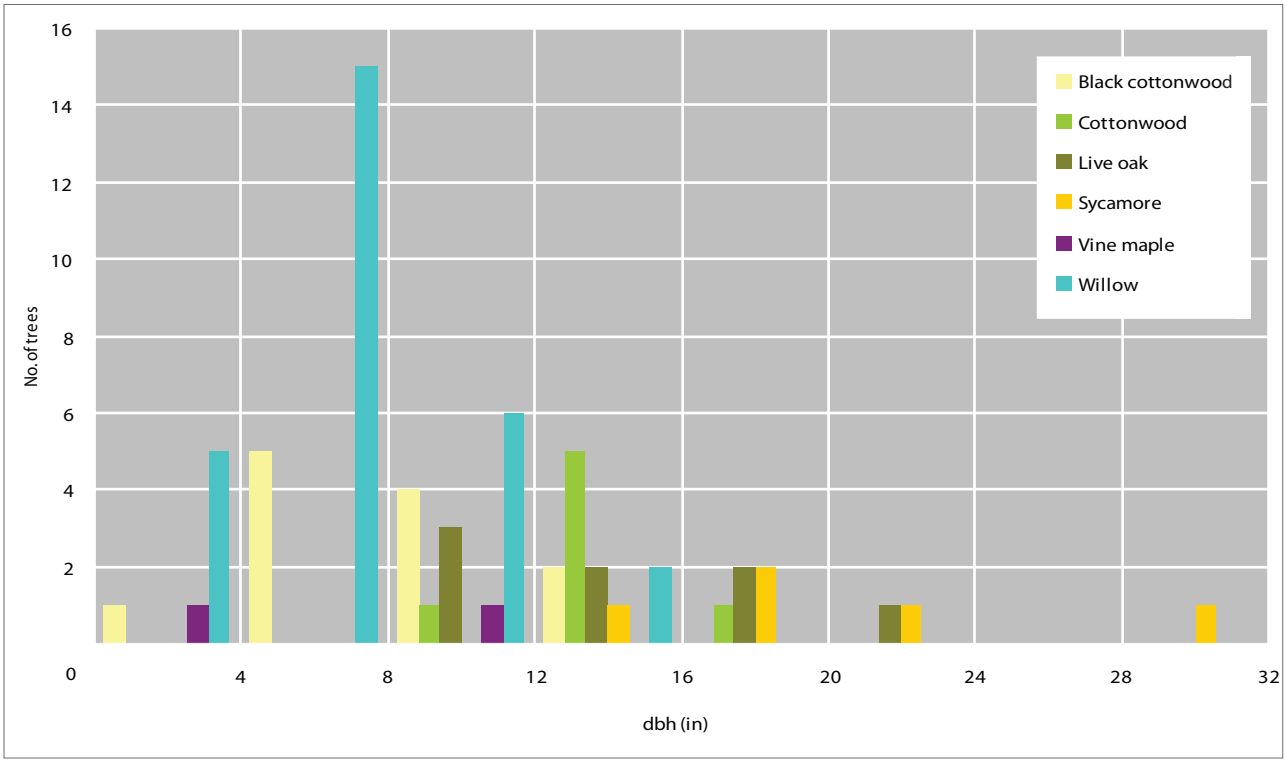

Figure 15. Histogram of tree diameter at breast height (in 4 inch bins) for General Land Office bearing trees located within riverwash and floodplain sands. The extent was determined by the Metz soils of the 1925 soils map (Carpenter and Cosby 1925).

Figure 16. Change in dense riparian forest along the Salinas River, near Spreckels. Areas shown by Ml, Mf, and Mv soil types were reported as dense willows by the 1925 soil survey (A), much of which can still be seen in the 1937 aerial (B). Bottomland bluff boundaries and a relatively large riparian remnant can be seen in 2005 (C). (A: Carpenter and Cosby 1925; B: USDA 1937, courtesy of the Science & Engineering Library Map Room, UC Santa Cruz; C: USDA 2005, courtesy of NAIP)

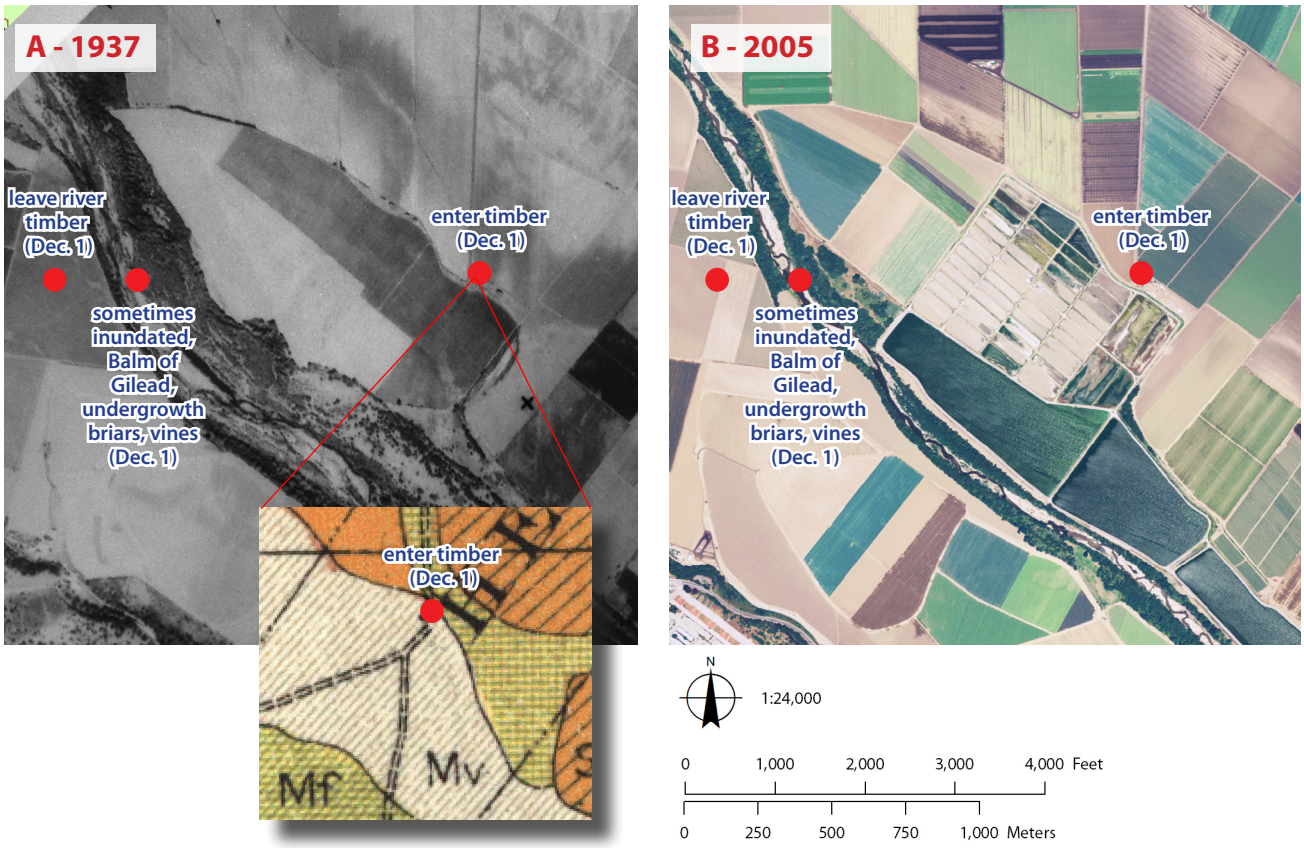

Figure 17. Change in riparian vegetation along the Salinas River, near Salinas. In 1854, a GLO surveyor noted willow timber ("enter timber") far before it occurs in either the 1937 (A) or 2005 (B) aerial imagery. This coincides with the bottomland boundary of the river, visible on each aerial, and with the Mv soils boundary (inset). (A: USDA 1937, courtesy of the Science & Engineering Library Map Room, UC Santa Cruz; B: USDA 2005, courtesy of NAIP; inset: Carpenter and Cosby 1925; GLO: Freeman 1854)

> hardly dream of its winter turbulence; and to see it in the winter, thick with the sands stirred up from its shifting bottoms, more dangerous and fearful than the swollen Tiber, it would be difficult to associate it with its midsummer meekness. (Harrison 1889)

During the dry season, however, one geographer described it as "no more than a very shallow brook of fresh water" (Findlay 1851) and others noted that the sandy channel bed was exposed in the summer. However, early explorers and travelers did describe the Salinas River as a river where water could be found through the summer at many points along its length. Crespí, who followed the river for about fifty miles downstream to its mouth at the end of September 1769, remarked on the surprising amount of water in the channel: "so much water as there is in the river which laves [carries, flows] it all for so far along" (Crespí and Brown 2001). It was a watering place for cattle in the 1860s (Brewer 1974), some reaches had deep pools and known fords (Crespí and Brown 2001), and some observers called it a perennial river (Phillips 1877).

However, summer surface water in the river was also described in early sources as discontinuous. The 1901 soil survey describes the dry season river as a "small stream of water, which disappears at intervals in the porous quicksands to reappear farther down the course" (Lapham and Heileman 1901). These reappearances of surface flow likely corresponded to decreases in depth to bedrock below the porous sandy riverbed (Devore 1909). At the turn of the century, geologist William Fairbanks summed up the character of the river:

> If you should dig down a few feet it [the sand in the bed] would become moist, and a little farther, you would meet water... They [cattle] are fortunate if they at last find a little spot where the sand is so shallow that the river has to come to the top. It peeps out for a few rods, and then disappears again in the sand. (Fairbanks 1899)

We found little early (pre-1890) evidence that the Salinas River completely or consistently dried out in the summer, although flow was restricted such that much of the active channel surface was exposed sand. Overall, preliminary evidence suggests that the Salinas may have maintained substantial summer baseflow in many reaches, though this would have varied greatly based on inter-annual variations in rainfall (fig. 18).

The Salinas River seems to have supported summertime pools of water fed by hyporheic flow (table 3). Summertime pools are frequently mentioned in early narrative accounts. These dry season pools intersected the subsurface flow, and were often quite deep. Several newspaper articles about summer drowning incidents mention deep pools or holes along the river course. One noted a pool 16 feet deep at the end of June and warned of the "many deep holes which abound" (San Francisco Call 1900). In early fall, 1769, Crespí encountered "large deep pools where the water was over a man's head" between King City and Greenfield, and was forced to cross where the water was over two feet deep (Crespí and Brown 2001). On the same expedition, substantial flowing water was also observed at the end of the dry season: Costansó wrote that near Chualar the river "flowed with greater force and noise" than it had upstream (Costansó and Browning 1992).

Many of these accounts of summer flow conditions were written after groundwater pumping and surface diversions had begun in the Salinas Valley. Further research would help us understand changes in summer flow conditions in the mid- to late-1800s, as well as summer connectivity and inter-annual flow variability. Given the large regional inter-annual variations in rainfall amount and timing, the Salinas River probably had fewer summertime pools in some years, and had more continuous surface flow throughout other years.

Construction of Nacimiento Dam and subsequent increases in summertime flows in the Salinas River due to releases from the dam prompted joyful reactions from those who knew the river at the turn of the century:

> "Ever see so much water in the river at this time of year?" is the cry going up all over the valley as old-timers and pioneers reminisce of the "good old days" when the Salinas ran all year around. Then, some recall, the water was "crystal clear" with chest-deep holes for fishing and swimming…Minor Bolton, senior engineering aide of Monterey county engineer department, and another native of Salinas, remembers seeing water in the Salinas during the early part of the century. He said there was enough to fill the deeper holes for swimming and yet little enough to allow him to ford the river bed near the present Hilltown bridge or at Spreckels. (Salinas Californian 1958)

Quicksand is also mentioned in many accounts of the river. Quicksand was a notable feature along the Salinas, supporting the idea that near surface flow was substantial. Quicksand made the river difficult to ford. Even in the summer, as one surveyor noted, "the Salinas is an insignificant stream foardable [sic] were it not for the quicksands" (Johnson 1854b). The occurrence of quicksand is further evidence of dry season hyporheic flow or very high groundwater within the riverbed and along its bottomland.

Information concerning groundwater levels clearly indicates a much higher historical water table than is observed in the valley today. The water table historically varied with proximity to the river and fluctuated seasonally. A 1901 groundwater map shows water levels within ten feet of the surface in many parts of the lower valley, especially near the river channel (Lapham and Heileman 1901; fig. 19). Even in drought, a few early documents claimed that water could be found within twenty feet of the ground surface (Unknown 1875, Elliott and Moore 1881). In an

Table 3. Descriptions of summer conditions along the Salinas prior to 1900.

Quotation	Location	Citation
"partially dry in the summer… the little narrow stream in the summer, playing hide and seek in the sand"	General	Harrison 1889
"insignificant stream foardable [?], were it not for [?] the quicksands" (Sept 30)	General	Johnson 1854b
"nothing but a course of ripple-marked sand"	General	Hyacinth 1869
"sinks in its sandy, gravelly bottom in summer"	General	Barrows and Ingersoll 1893
"dry, or almost dry, during the summer months…seldom contains any water after the month of June, unless it be in holes formed in the sand during the winter months"	Near King City	California State Mining Bureau 1888
"everywhere else it is standing in large deep pools where the water is over a man's head…not a very large flow of water in its bed where we crossed it, some three or four yards' width and three quarter-yards' depth" (Sept 26)	Near King City	1769, in Crespí and Brown 2001
"some pools of water"	Near Greenfield	1769, in Crespí and Brown 2001
"broad, sluggish stream"	Near Soledad	California State Mining Bureau 1888
"the Rio Salinas stops running during the summer & fall"	Near Soledad	1858, in Hamilton ca. 1953
"flows throughout the year"	4 mi S of Gonzales	Hamlin 1904
"many deep holes which abound in the river at that point… water, which was sixteen feet deep"	Unknown	San Francisco Call 1900
"deep hole"	Near Salinas	Daily Alta California 1889
"very shallow brook of fresh water"	Near Bay	Findlay 1851

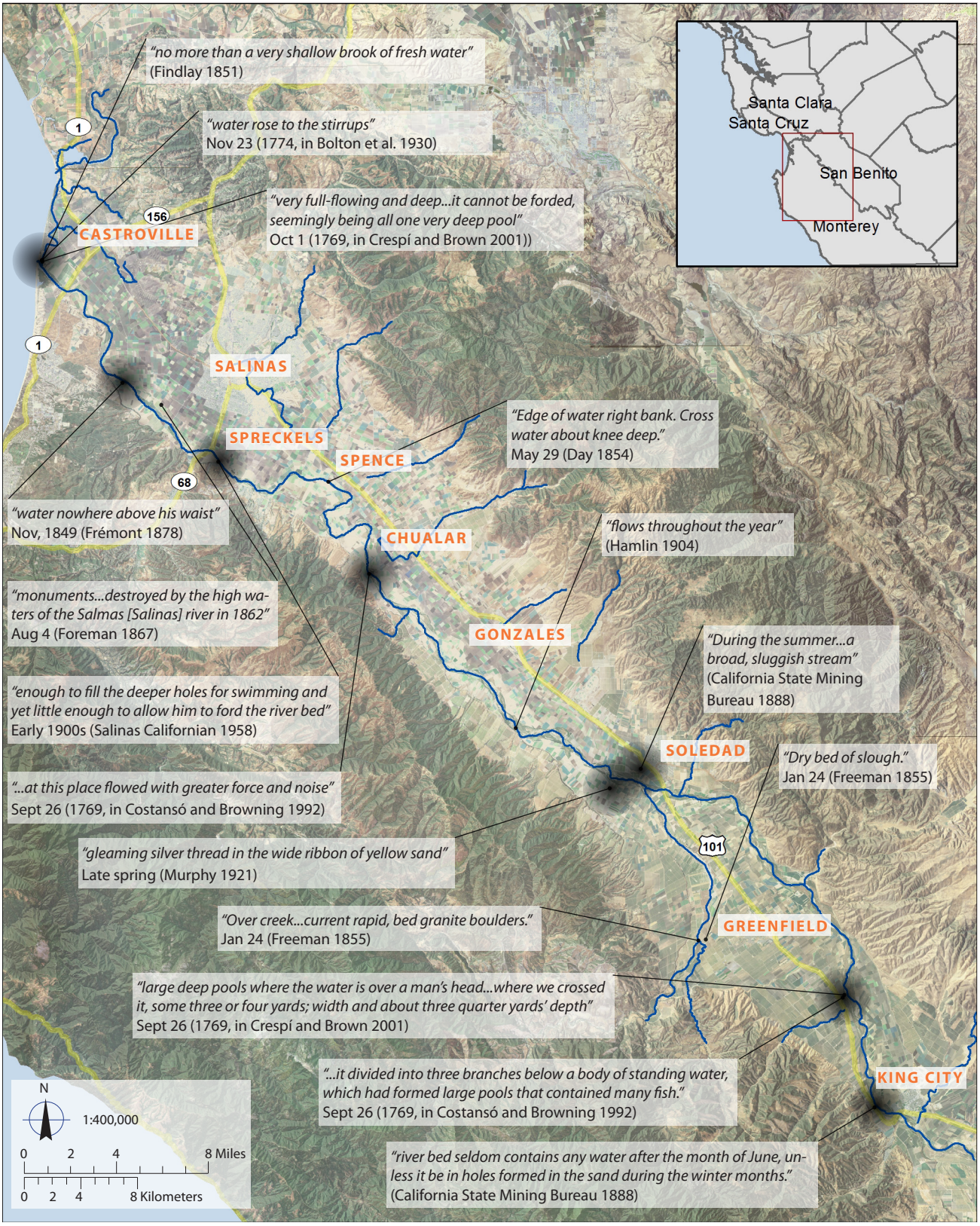

Figure 18. Historical evidence of flow conditions and water depth along the Salinas River. Solid dots represent location-specific information, and dissolved points are more general descriptions of an area.

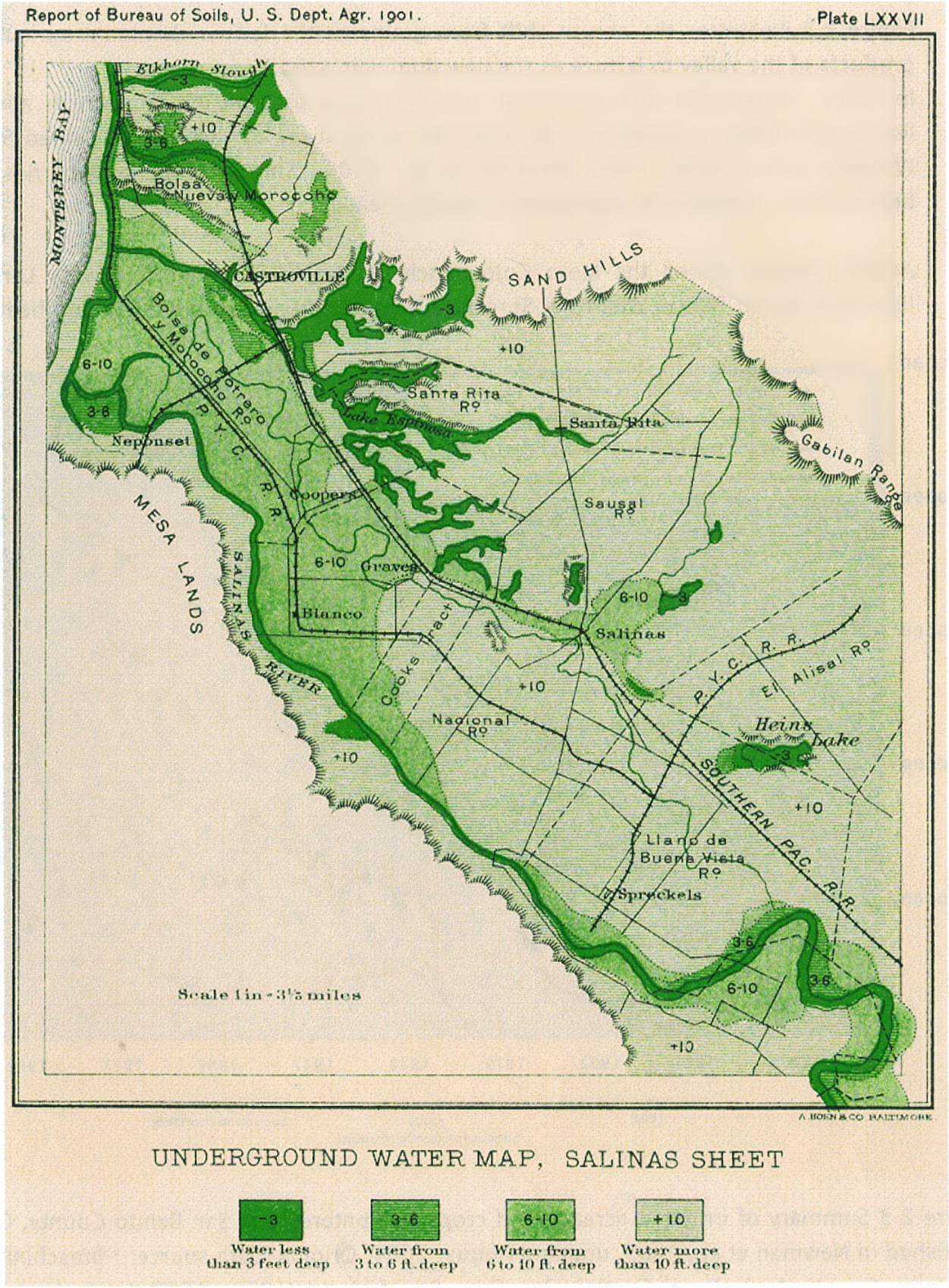

Figure 19. Map of groundwater conditions around 1901 shows a relatively high groundwater tables along the river downstream of Spreckels. (Lapham and Heileman 1901)

early description of groundwater salinity, GLO surveyor James Foreman described the groundwater in the township covering the valley from Highway 68 to Castroville (Township 14S Range 2E) as "brackish but cold and not unpallatable [sic] - when first drawn from the wells, which do not exceed 15 or 20 feet in depth" (Foreman 1867).

OPPORTUNITIES FOR FURTHER ASSESSMENT

The emerging picture outlined in this report can be advanced to be more spatially explicit and authoritative. Several steps would help take this information from general qualitative observations to more detailed maps and reach-scale understanding of stream characteristics, as well as provide an understanding of change through time. These steps are described below.

Data Collection

Data collected to date represent a subset of accessible, relevant historical information. We identified many additional sources of historical ecological information that could be collected and analyzed. In order to compile a more comprehensive historical data set, further steps could be taken.

- We did not visit several relevant historical societies and libraries as part of this reconnaissance. A next phase would include visits to local collections such as the Monterey County Agricultural and Rural Life Museum and the Pajaro Valley Historical Association. It would also include research at regional archives such as the California Historical Society, the Society of California Pioneers, the California State Library and State Archives, the California State Railroad Museum Library, and the State Lands Commission.

- Many sources that we briefly reviewed as part of this initial study could provide more detailed information. While we were able to review all 23 land grant case files pertaining to the study area, a more in-depth study would involve a closer reading of the texts. This is an important source that could reveal more information about pre-1850 conditions. The full set of GLO survey data for the valley could be used in the GIS. Scans (rather than digital photographs, as acquired for this study) of the 1937 aerial photographs could also be collected and orthorectified. Full compilation of this data set would allow the reconstruction of a much more functional picture of historical conditions and changes in the Salinas River and valley.

- There were a number of relevant data types not utilized at all in this reconnaissance. Land use and irrigation history could be compiled to provide context for ecological change. Ecological databases (such as the California Natural Diversity Database and Consortium of California Herbaria) could be searched for relevant early specimen records for selected species of interest as indicators of habitat type and hydrology. Archaeological reports would provide insight into land use and habitation patterns. To assess the current potential of the river to support desired functions, geomorphic and hydrologic data (e.g., cross-sectional data and flow records) could be collected to define changes in hydrograph, water and sediment supply, and hydraulic geometry. Hydrological records and accounts and photographs of flooding could be analyzed.

- Contemporary data, such as GIS layers and modern soils maps, would help define notable historical trends. A literature review of contemporary works could be conducted, and groundwater, climate, land use information could be collected and used to contextualize and better comprehend historical trends in river and valley condition.

- Interviews with long-time residents and local specialists add depth to historical findings. Collaboration with local residents, historians, and key stakeholders would be an essential component of any further research.

Additional data will inevitably adjust the emerging picture and lead to a more complex understanding of riparian vegetation associations, which would be useful for restoration planning. Given contemporary water limitations, it would be particularly useful to pinpoint the settings in which the more xeric riparian species occurred, as one element in the Salinas River "restoration palette."

Compilation, Synthesis, and Analysis

Once collected, data can be organized in a number of different ways to aid interpretation. GIS-based data compilation would enable the synthesis of data from a wide array of sources into digitized layers representing local, spatially specific historical landscape characteristics. Data are available to map features such as channels, perennial and seasonal wetlands, coastal features, woodlands and savannas, riparian vegetation, and other habitats.

- Georeferencing maps with sufficient spatial accuracy would allow comparison of historical to modern conditions at specific sites.
- Orthorectifying Salinas valley historical aerials would create a complete photomosaic of the valley, creating opportunities for further comparison across datasets, digitizing efforts, and GIS analysis.
- Synthesizing historical data in GIS would make the information more useful in several ways. Documenting the historical extent of floodplain and riparian habitats would provide the spatial detail needed for local stewardship and project design, such as how the width of different riparian components varied by reach. Compiling riparian forest evidence in GIS would allow for assessment of persistence in relation to flooding and other disturbances, giving a better idea of the range of ecological functions of the native river system.
- Developing GIS layers would also allow quantification of the historical extent of different riparian habitat types, allowing for comparison between reaches, between the Salinas past and present, and between the Salinas and other California rivers. This would provide a basis for quantitative conservation targets.

A full report with GIS layers and additional data sets would make the information more broadly accessible to land managers, planners, scientists, and the public as tools for local resource management.

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