5 WETLAND HABITATS

Above. Flooded intersection of Frazier Lake Rd. and Bloomfield Ave., 1952. *Below.* Northern San Felipe Lake.

WETLAND HABITATS

In a semi-arid region such as south Santa Clara Valley, wetlands tend to be relatively uncommon and ecologically significant. Accordingly, perennial and seasonal wetlands serve as essential habitat for a number of special status species, such as the California tiger salamander *(Ambystoma californiense)*, California red-legged frog *(Rana aurora draytonii)*, southern Pacific pond turtle *(Actinemys marmorata pallida)*, and tricolored blackbird *(Agelaius tricolor),* and are important to migrant and resident shorebirds and waterfowl. Permanent surface waters within perennial wetlands can be particularly important as year-round sources of water for a variety of wildlife. Wetlands can also perform important hydrogeomorphic functions, including the attenuation of flood peaks by temporarily storing surface waters and the storage of fine sediment carried by streams. Because of their widely recognized value, there is significant interest in the potential for local wetland conservation and restoration (Jones and Stokes 2006, SCVWD 2006a,b). This interest has led to questions about the historical extent of wetlands, the distribution and abundance of different wetland types, and the potential for the recovery of wetland resources. To address these questions, we documented the range of native wetland habitat types that occurred within the study area prior to significant Euro-American modification.

METHODS

We used several strategies to identify historical wetlands of different kinds. First we determined the major types of wetlands historically common to the study area, including valley freshwater marsh, open water ponds and lakes, intermittent lakes/playas, and wet/alkali meadows. A fourth type – willow groves – could also be considered riparian habitat, but is discussed here because it is more closely associated with the other wetland types.

Valley freshwater marsh refers to persistent emergent freshwater wetlands typically dominated by bullrushes *(Scirpus* sp.*)*, cattails (*Typhas* sp.), sedges (*Carex* sp.), and rushes (*Juncus* sp.). These wetlands are seasonally flooded (Cowardin 1979); soils generally have a high organic content and are usually saturated. Perennial ponds are permanently flooded, unvegetated areas, typically within larger surrounding marshes.

Wet meadows are temporarily to seasonally flooded grasslands characterized by poorly drained, clay-rich soils. Alkali meadows, or alkaline grasslands, are characterized by fine-grained soils that have a high residual salt content supporting a distinctive, salt tolerant plant community, including some species characteristic of salt marshes or vernal pools/swales (Baye et al. 1999, Holstein 1999). Soils of the wet and alkali meadows can remain moist for much of the year (e.g., "Moist Grassland"; Goals Project 1999). Playas are intermittently flooded lakes characterized by unvegetated, alkali-affected clay substrate. Willow groves are forested wetlands dominated by *Salix lasiolepis* (Cooper 1926) that are distinct from the narrower strands of willow riparian forest commonly found along streams. These features are often associated with groundwater emergence (Collins and Grossinger 2004).

Perennial ponds, large playas, freshwater marshes, and willow groves were important landmarks in 19th-century south Santa Clara Valley and thus were clearly identified by many early maps. Cartographic evidence was often also confirmed by historical textual accounts. Characteristic wetland signatures in early aerial photography (dark, mottled patterns) often corresponded with earlier historical evidence. Where earlier evidence was incomplete, early aerial photography was occasionally used to refine historical habitat boundaries. It is likely that we were able to document most of the relatively large features, accounting for most of the area of these perennial wetlands, but many smaller features that occurred historically are likely not revealed through this process.

Perhaps due to their broad, more diffuse character, habitats such as wet meadows and alkali meadows did not serve as important historical landmarks and are not explicitly indicated on most early maps. However, historical and contemporary soil surveys carefully assess the soil and drainage characteristics associated with these habitat types because of their limiting effects on agriculture, producing effective maps of these significant components of the landscape. Applying equivalent criteria used in earlier mapping efforts in north Santa Clara Valley, we evaluated the hydrogeomorphic characteristics of historical and modern soil types in south Santa Clara Valley to identify wet meadow and alkali meadow areas (Grossinger et al. 2006, 2007a). Some descriptive evidence from 19th-century surveys and maps was found to corroborate these areas, as well as early aerial imagery. Wet meadows were divided into three classes based on the degree of soluble salts affecting plant community composition (i.e., alkali effects) as described by the soil surveys. Modern soil boundaries published at 1:31,680 scale "should be accurate within at least 100 feet" (USDA 1951), indicating a fairly high level of confidence in soil boundary location. Since we also used earlier soil surveys produced at twice this scale (1:62,500), we classify these boundaries within our medium level of certainty (150 m/500 ft). We adjusted the boundaries of wet/alkali meadow slightly where it conflicted with well-documented oak woodlands.

> *"Soils, then, are landscapes as well as profiles. The soil mapper has always recognized this in drawing soil boundaries. Commonly they come at the foot of an escarpment, at the margin of the swamp forest, or at some other obvious boundary among natural landscapes."*
>
> – USDA 1951

For the Santa Clara County portion of the study area, we were able to use recent land cover mapping by Jones and Stokes (2006) to compare historical and modern spatial extent of several habitat types. Earlier data (based on 1981-82 aerial photography) from the National Wetland Inventory (USFWS 2007) were available for the San Benito County portion of the study area.

RESULTS

Regional spatial patterns

Wetlands, either seasonal or perennial, covered approximately one-third (34%) of the study area prior to agricultural and urban drainage efforts. Of the 9,000 ha (22,000 ac) of wetlands, most (83%) were seasonal wetlands. The seasonal wetlands were almost evenly divided between salt-affected alkali meadows and wet meadows unaffected by salt accumulation: each covered about 3,700 ha (9,000 ac). Willow groves and freshwater marshes were smaller but substantial components of the landscape. Each represented roughly 3% of the study area and covered 700-800 ha (1,700-2,100 ac). There were at least 64 ha (158 ac) of perennial freshwater ponds.

Wetlands of different types occurred in distinct landscape positions, resulting in their heterogeneous geographic distribution. At the largest scale, wetlands were typically located in the nearly flat or basin-like lowlands at the foot

of, or in between, alluvial fans and natural stream levees. In south Santa Clara Valley, where the major drainages flow roughly south, this led to a general pattern of dry oak lands and grasslands in the north, and large wetlands in the south. Accordingly, almost all of the perennial freshwater marshes, ponds, and willow groves were located south of Highway 152/Pacheco Pass Road. (This is not a coincidence, as the road alignment was likely chosen to avoid overflows.)

Over one-third of the study area consisted of wetlands of one type or another. Most wetland types were found exclusively in the southern part of the study area.

As large streams moved high sediment loads from erosive Franciscan geology down their valleys, they built up natural levees of coarse sediment (Helley and LaJoie 1979). These high spots were overtopped by flood flows, carrying finer sediment into adjacent bottomlands (figs. 5.1 and 5.2). The low areas had little available drainage and often were effectively trapped by their low topographic gradient and/or converging natural "dams" of alluvial levees. Similar patterns have been observed in other regions such as north Santa Clara Valley (Torbert 1936) and Napa Valley (Carpenter and Cosby 1938).

Wetlands formed in this fashion were common in the region, and often had a distinctively linear orientation. Levee-side wetlands included: the narrow strand of wet meadows, ponds, and swales that ran alongside Pacheco Creek, trapped between the Pacheco Creek levee and adjacent hills; and the broad parallel strands of wetlands on either side of the Llagas Creek levee, which reached widths of 1.5 km (1 mi) and extended for several miles. Wet meadows were found in similar valley bottom positions scattered throughout South Valley, and many have continued to be subject to flooding, such as the wet meadows and swales historically along Tennant Creek (USACE 1975).

These patterns of alluvial topography created an area of particularly restricted drainage along the lower end of Llagas Creek, caused by neighboring Carnadero Creek. At Bloomfield Road, the natural levee of Carnadero Creek spread into a broad cone of sediment built from deposition along the different routes the stream has taken in recent geological history. One lobe of this cone extends almost due east for over a mile, effectively blocking drainage from the wetlands alongside and at the base of Llagas Creek (Cosby and Watson 1927a). This slightly higher levee land, now traced by Bloomfield Road, can be seen in both local soils and topography (figs. 5.1 and 5.2).

The largest area of seasonal wetlands occupied the broad Bolsa basin, where the distal ends of each of the major stream levees dissipated into the shared Soap Lake floodplain (SCCFC&WD 1972). These meadowlands were dominated by alkali conditions, resulting from seasonal evaporation of shallow flood waters in these exceptionally flat lands. In south Santa Clara Valley , the alkali meadows dominated, and were limited to, the Bolsa.

While freshwater ponds and marshes are always located on the wet meadow soils, willow groves straddle the boundary between the moist and well-drained soils.

Perennial freshwater marshes, ponds, and willow groves were closely associated with the clay-rich, wet/alkali meadow soils. Freshwater marsh and a few perennial ponds occupied the lowest, wettest portions of the wet meadows, located in depressions and/or associated with springs. While mapped from independent sources, 96% of the valley freshwater marsh area coincided with wet/alkali meadows soils. The coincidence between perennial freshwater ponds and the wet/alkali meadows soils was 100%. Like the wet meadows, valley freshwater marshes were often neatly positioned between the fingers of natural stream levees. Examples include the extensive marshes downstream of Miller Slough (between the Llagas and Uvas-Carnadero natural levees) and the marsh between San Felipe Road and Lovers Lane, between radiating levee strands of Pacheco Creek.

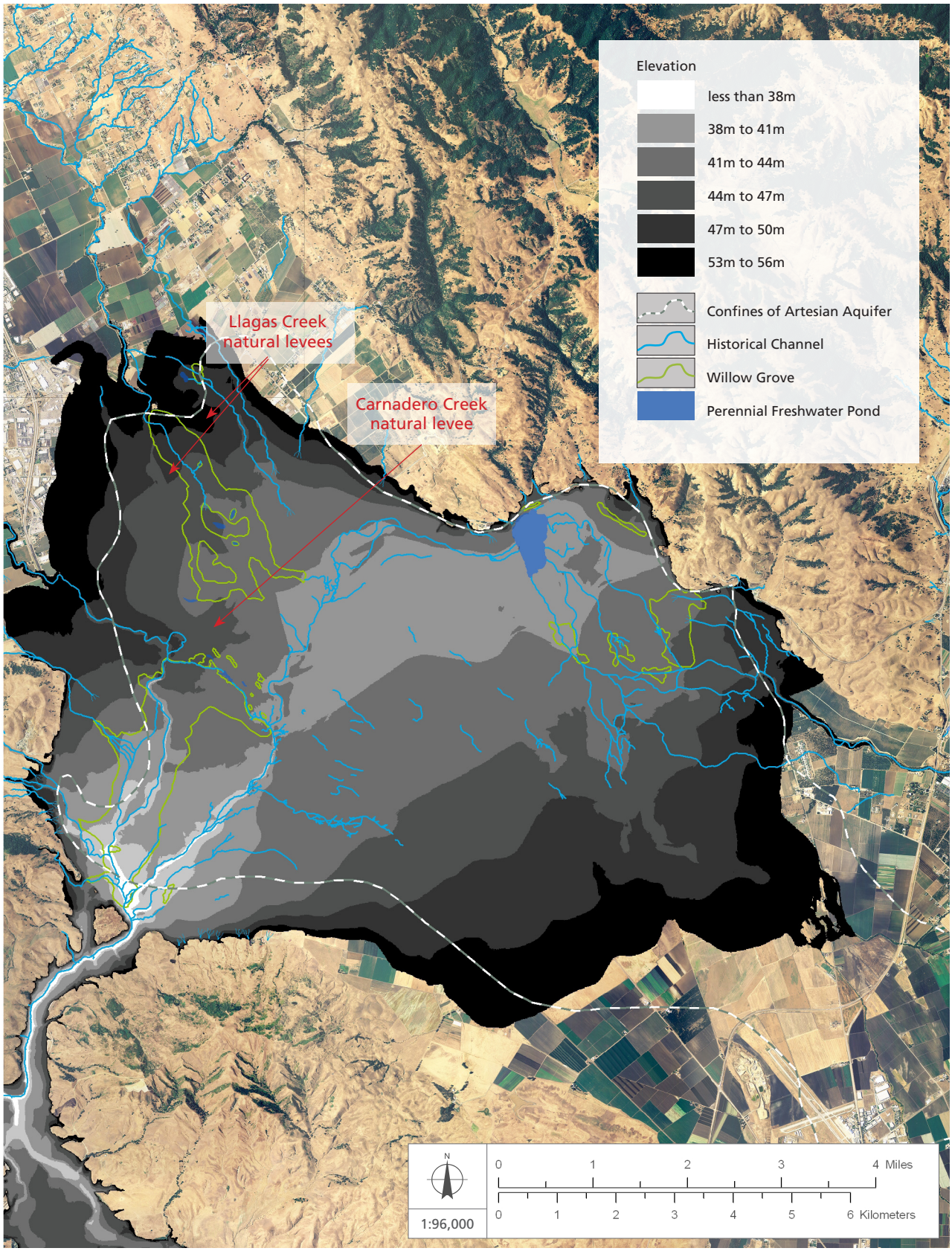


Figure 5.1. This shaded relief map shows the Soap Lake floodplain (lighter grays) and adjacent topography, with an overlay of historical features. Willow groves, shown in green, commonly intercept the historical boundary of artesian conditions (Clark 1924; dashed line). Historical creeks are shown in blue. Natural levees can be seen as higher (darker) ground following historic or pre-historic stream courses. These protrusions create adjacent, bottomland basins. (USDA 2005, courtesy of NAIP)

In contrast, willow groves consistently occupied the interface between the poorly drained wet meadow soils and the adjacent, coarser alluvium. The coincidence between willow grove and wet/alkali meadow soils was 60%, and this interface position was consistent among the three large willow groves at the base of Carnadero, Llagas, and Pacheco creeks (which account for most of total willow grove area). Thus each of the three major willow groves was positioned at the mouth of the stream where it spread into wet meadows. Each grove had 54-66% of its area in the wet meadow soils and the remainder on the adjacent, coarser levee soils.

Not coincidentally, this landscape position also correlates with the outer boundary of the historical artesian zone. Most of the willow groves intercepted the artesian boundary, with most of this area within the artesian zone (fig. 5.1). They occupied a consistent landscape position at the interface of wet/dry soils, artesian conditions, and 40-50 m (130-170 ft) elevation. Willow groves formed at the transition between silt and clay soils, where there was access to reliable water near the surface but soils were not completely waterlogged and anaerobic.

Historically, the South Valley study area had proportionally more wetlands than the Coyote Creek area to the north (Grossinger et al. 2006, Grossinger et al. 2007a). Excluding the baylands portion of the Coyote Creek watershed, the south Santa Clara Valley study area covers a slightly larger area (26,500 ha/65,500 ac vs. 23,000 ha/57,000 ac). Despite covering only 15% more area, the region had 50% more wet meadow, more than twice as much alkali meadow and valley freshwater marsh, three times as much area of perennial freshwater pond, and five times as much willow grove habitat. This high proportion of wetlands, predominantly in the southern part of the study area, suggests the significance of the area for wetland conservation and restoration.

Habitat changes

Based upon the combined Jones and Stokes (2006) and National Wetland Inventory (USFWS 2007) mapping, valley freshwater marsh has declined by about 90% in the study area (672 ha/1,660 ac historical to 66 ha/160 ac modern). The reduction in habitat area is particularly dramatic around San Felipe Lake, recognized as one of the most important remaining wetland habitat areas today. San Felipe Lake, which was historically bordered by over 100 ha (250 ac) of valley freshwater marsh, was mapped in 1981-82 as having only 8 ha (20 ac) of marsh on its margin.

The changes in willow grove habitat are somewhat more complex. We mapped 831 ha (2,050 ac) of willow grove in the study area, historically. Jones and Stokes (2006) recently mapped 307 ac (760 ac) of "willow riparian forest and scrub" in the Santa Clara County portion of the study area. In addition, U.S. Fish and Wildlife Service (2007) mapped almost 10 ha (25 ac) of "freshwater forested/shrub wetland" in the San Benito County portion of the study area. Comparing the historical and modern totals indicates a decline of 62% in willow habitat.

> While the area of willow riparian habitat has declined by about 60%, the edge-to-area ratio of the current habitat has increased by over 700%.

However, changes in the shape and distribution of the remaining habitat have probably caused an even greater decline in functional habitat for many species associated with the interior of riparian areas. In contrast to the wide, contiguous areas of historical willow groves, most of the present-day habitat is in the form of narrow linear strips alongside stream channels. Historically, the ratio of habitat perimeter to area was 62 m/ha (80 ft/ac). The perimeter to area ratio for the present-day willow riparian areas is 446 m/ha (600 ft/ac), an increase of over 700%. This increase in edge effect is likely to have greatly reduced the value of the remaining willow habitat for many endemic riparian species.

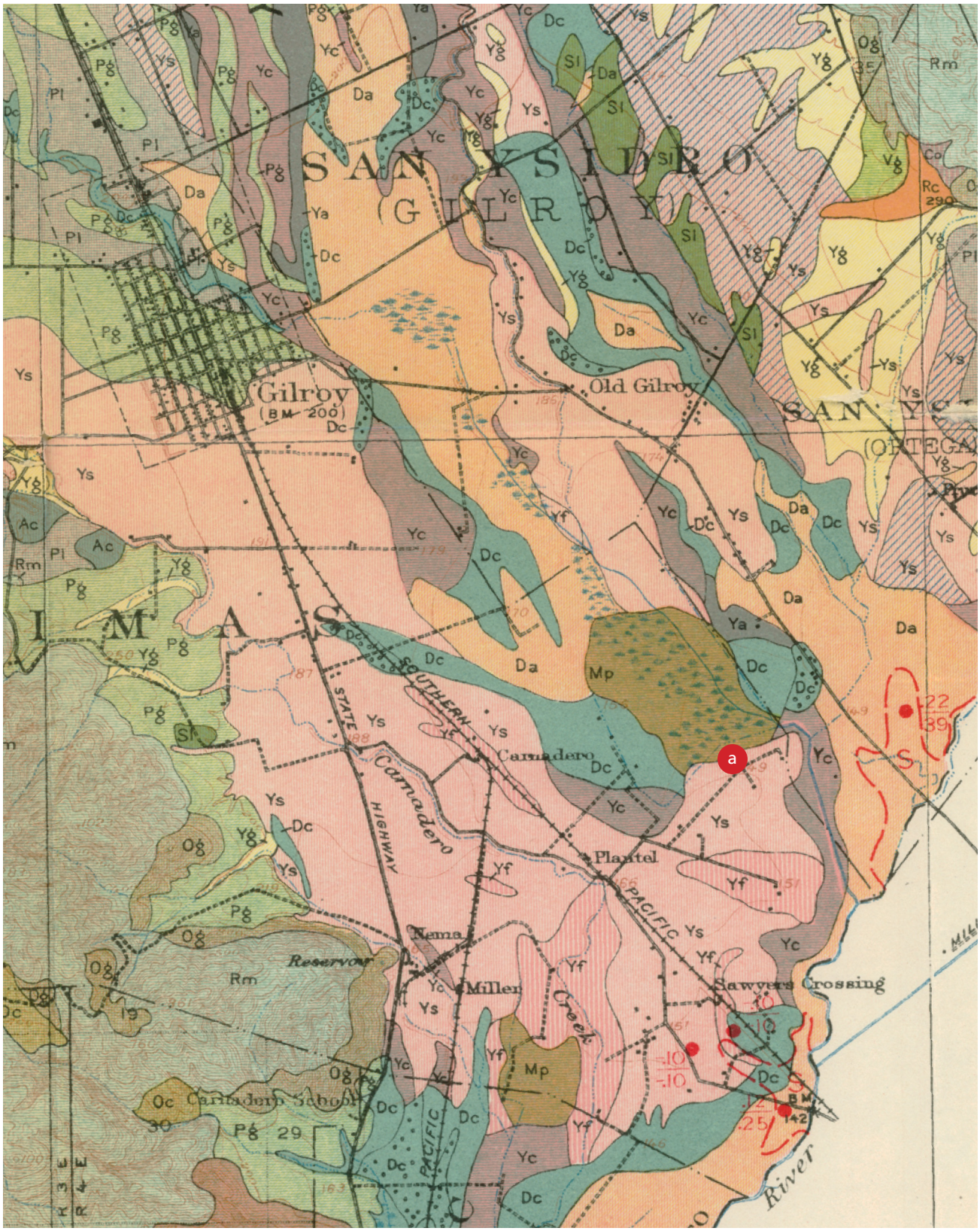


Figure 5.2. Patterns of alluvial topography, as shown by the 1923 soils map (Cosby and Watson 1927a). The natural levees of Carnadero and Llagas creeks can be seen in the shapes of the pink Yolo silt loam soils (Ys). The Carnadero levee branches out at Plantel, backing up the wetland shown at (a). Almost all of the roads, railroads, and townsites are located on the higher loams (Ys, Pg), rather than the flood-prone, bottomland clay soils (Da, Dc, Mp, Yc).

Wet meadows and alkali meadows

Wet/alkali meadows were mapped from eight historical soil types and four modern soil types. The selected soil types all had strong indicators of wetland conditions such as poor drainage, heavy clay soils, salt accumulation, vegetation, and/or agricultural limitations (table 5.1). These characteristics are distinct from most of the other relatively well-drained, coarser soils in the study area (SCCFC&WD 1972). As might be expected, a substantially greater area was documented in the historical surveys, conducted in 1923 (Cosby and Watson 1927a,b), than in the modern surveys, conducted during the 1960s (Isgrig 1969, Lindsey 1974).

Wet meadows are characterized by poor drainage conditions associated with dense clay soils and nearly flat topography, and are flooded for days or weeks depending upon rainfall events and their landscape position (fig. 5.3). These lands typically retain nearly all of the water that falls as rainfall and receive additional surface runoff or seepage from adjacent uplands (USDA 1951). As a result of high water retention and/or high groundwater level, these areas stay moist longer than adjacent, more well-drained lands.

Earlier historical descriptions affirm the hydrogeomorphic characteristics identified by soil surveys, with descriptions of meadows, overflowed lands, and late-season grazing.

Figure 5.3. Historical landscape photographs of wetlands are not common, but this "Scene on the San Martin Ranch" shows a seasonal pond in the wet meadows on the east side of Morgan Hill. (Unknown ca. 1896c, courtesy of History San José)

Table 5.1. Soil types indicative of wet and alkali meadow conditions.

Soil type (symbol)	Description	Source
Capay silt loam (Cs)	"restricted drainage" "injurious accumulations of alkali"	Cosby and Watson 1927b
Capay silty clay loam (Cy)	"restricted drainage" "flat and basinlike" "injurious accumulations of alkali are common"	Cosby and Watson 1927b
Dublin clay adobe (Da)	"black heavy clay with an adobe structure" "low basinlike areas where drainage is deficient"; "basinlike depressions"	Cosby and Watson 1927a
Dublin silty clay loam (Ds)	"restricted drainage"	Cosby and Watson 1927b
Conejo clay adobe (Ca)	"poor or restricted drainage"	Cosby and Watson 1927a
Dublin clay loam (Dc)	"flat, smooth surfaces, a high content of organic matter, and poor or restricted drainage"	Cosby and Watson 1927a
Yolo clay adobe (Ya)	"heavy clay or adobe structure"; "because of its heavy texture... planted to grain for hay"	Cosby and Watson 1927a
Yolo silt loam, compact subsoil phase (Ys)	"compact heavy clay loam or clay [subsoil]"; "relatively flat and shallow and not so suitable for orchards" [west side instances]	Cosby and Watson 1927a
Clear Lake clay (Cg/Ck) and Clear Lake clay, drained (Ch)	"poorly drained clays"	Lindsey 1974
Pacheco clay loam (Pd)	"poorly drained"	Lindsey 1974
Sunnyvale silty clay, drained (Sv)	"poorly drained silty clays"	Lindsey 1974
Willows clay (Wa)	"generally ponded during winter"; "no well-defined drainage channels"	Lindsey 1974

Figure 5.4. The former wet meadows east of Llagas Creek, flooded in February 1952 (A) and the same site in 2007 (B). Modifications to reduce overflow (inset) include drainage channel (note cattails in foreground), culvert under bridge crossing, and raised roadway. (A: Unknown 1952, courtesy of the Gilroy Museum)

Surveyor Sherman Day reported that he was in a wet meadow (Dublin clay adobe) in June 1854: "in meadow land, wet in winter." Overflow of the wet meadows east of Old Gilroy was described as "[T]he water, or I might term it a moving lake, has been known to be between two and three miles wide, and from thee [sic] to ten feet deep" (Gilroy Advocate 1869a; fig. 5.4). Bayard Taylor was impressed at finding that in the Soap Lake floodplain, the "meadows were still green" even though the soil of the surrounding valley "was more parched and arid than when I passed before" (Taylor 1850). The long-lived meadow grasses of the Soap Lake floodplain were much of the engine behind the Gilroy dairy industry, the Hollister hay industry, and supra-regional ranching operations such as Miller & Lux, providing rare late-summer pasture (Shortridge [1896]1986, Broek 1932, McCallum 1974).

The wet and alkali meadows were dotted with small depressions and swales, creating topographic and botanical variation. For example the wet meadows between San Felipe Lake and Llagas Creek included a broad "swale" described as 300 m (1000 ft) wide by Healy in 1858. The feature remains visible as an expansive darker area in early aerial photography, and was also depicted as "overfl[owed] lan[ds]" in the partially damaged map of the Las Animas Rancho (McDonald 1852(?)c). Broad and shallow swales such as these would have had deeper, more annually consistent overflow with longer duration than surrounding portions of the wet meadows. Local residents recollect observing numerous "potholes" in the western Bolsa, on both sides of Highway 25 (Morgan pers. comm.).

After extensive drainage by the 1970s, the wettest of these areas were described as being flooded about once every five years since "[d]rainage has been improved because of the general lowering of the water table in the valley," suggesting that these areas probably flooded on a substantially more frequent basis under natural conditions (Clear Lake, Pacheco, and Sunnyvale series; Lindsey 1974). Within these vast seasonal wetlands were smaller areas of perennial wetland. Except for occasional willow groves, taller vegetation was uncommon on the "treeless plain" (Broek 1932).

> *"During the winter most of this 'Bolsa' is wet, evaporation after the rains leaving a white alkali cover on the fields and roads."*
>
> — BROEK 1932

A substantial portion of the seasonally wet meadow lands was affected by the accumulation of soluble salts. While seasonal wetlands extended widely on both sides of the Santa Clara-San Benito County line, the alkali-affected portion was confined almost exclusively to the San Benito County side – the "Llano del Tequisquita." This area (the Hollister plain west from roughly the Hollister Airport to the county line, and crossing into Santa Clara County in several places) was known as "the land of alkali" – a broad, open plain with an unusual mosaic of saline and non-saline wetland habitat types, and also called the Bolsa ("pocket"; fig. 5.5).

Historical data describe ecological and hydrological characteristics that we would ascribe to alkali meadow (or alkaline grassland), including salt-tolerant vegetation associated with inland playas and saline marshes. Common species in the "salt grass pastureland" (Broek 1932) were saltgrass (*Distichlis* sp.) and pickleweed (*Salicornia virginica*). Numerous now rare plant species were also probably found. Jepson (1896) reported San Joaquin saltbush (*Atriplex joaquiniana*) in the area. Day (1854) noted a clover, likely saline clover (*Trifolium depauperatum var. hydrophilum*), which has been found in the vicinity as recently as 1995 (Hillyard 1995) – suggesting some persistence of alkali conditions despite agricultural drainage and flushing.

A white alkali crust was common on the surface after rains: "During the winter most of this 'Bolsa' is wet, evaporation after the rains leaving a white alkali cover on the fields and roads" (fig. 5.6; Broek 1932). These areas may have had shorebird habitat value similar to the playa-like salt

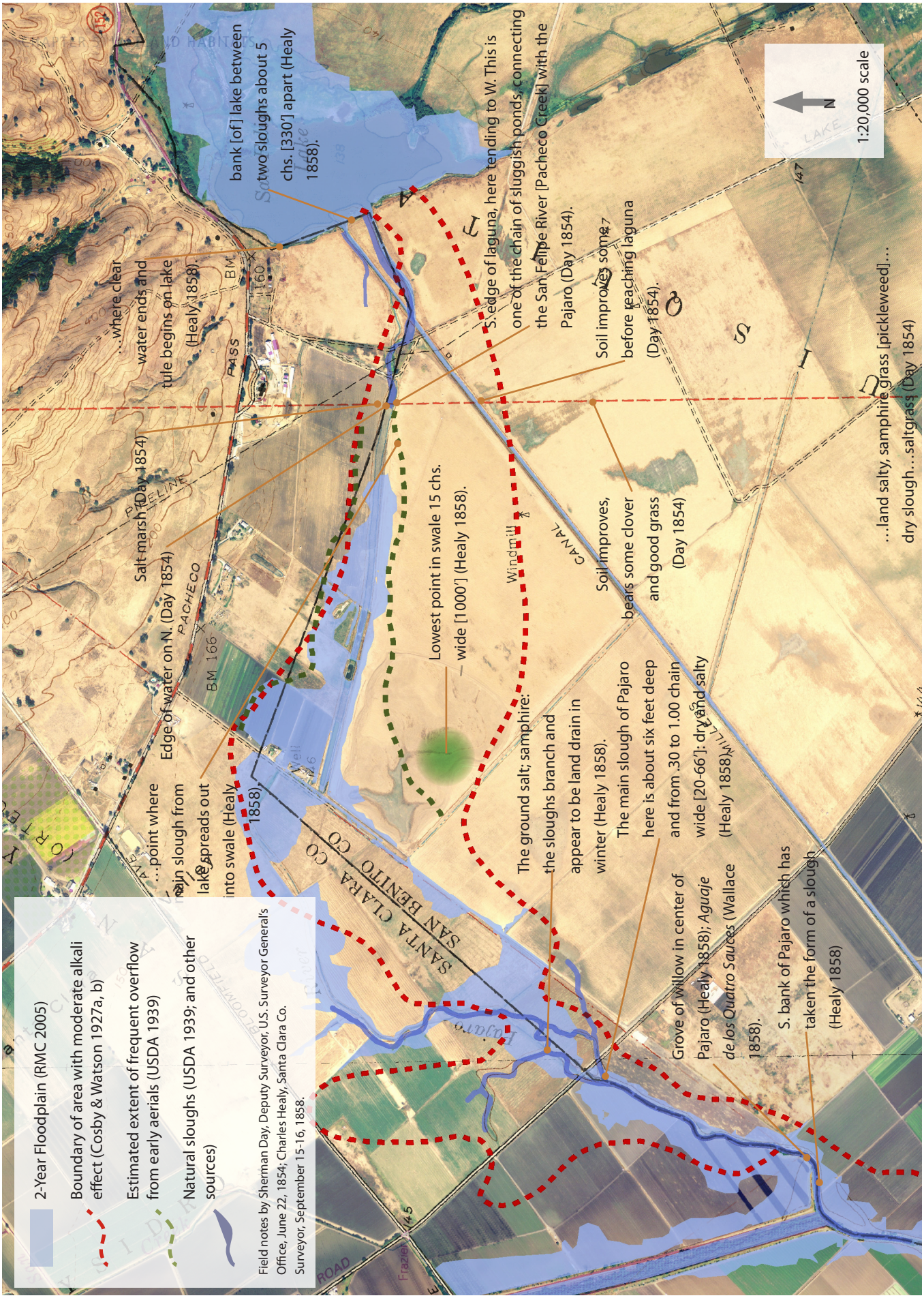


Figure 5.5. Selected historical evidence describing the alkali meadows, sloughs, swales, and wetlands between San Felipe Lake and the Pajaro River.

pans found along the edge of South San Francisco Bay (Goals Project 1999); a number of shore bird species are still observed in the area today (PWA 2008). In the alkali meadows on the Santa Clara County side of the county line, Cosby and Watson (1927a) described "a great deal of common spikeweed (*Hemizonia pungens*)," which is presently common in alkaline seasonal wetlands in the Central Valley. Broek also emphasized saltgrass as the dominant vegetation in the larger alkali plains of the Bolsa. Evidence of alkali deposits is prominent in 1939 aerial photography (fig. 5.7). While such areas are less prominent today, alkaline soil conditions and salt marsh/alkaline meadow plant communities (e.g., saltgrass and alkali heath) can still be found in the area (PWA 2008).

There is also evidence that the alkali meadows of the Bolsa could be considered "flower fields," herbaceous communities dominated by showy wildflowers (Roof 1971). When subject to disturbance in recent years, fields along Highway 25 have displayed native wildflowers (e.g., *Plagiobothrys stipitatus*, *Downingia* spp., large stands of bull clover (*Trifolium fucatum*)), likely reflecting the historical floristic community still present in the soil seedbed (Morgan pers. comm.).

Freshwater ponds and marshes were scattered within the alkali meadow matrix. Henry Coletto observed numerous small depressions, particularly in the western Bolsa before more intensive agricultural modification post-1970. These seasonal ponds held water during winter and spring, attracting large numbers of waterfowl and shorebirds (Morgan pers. comm.). Early aerial photography may show evidence of this "pothole" landscape. Several dozen distinct features that could be ponds are visible in early imagery in the western Bolsa, ranging in diameter from about 6 m (20 ft) to 24 m (80 ft). One of the pre-colonial place names for the Bolsa area was "We-leh-lish-mo," or "place of the salamanders" (Ketchum pers. comm.), which is consistent with the picture of seasonal ponding, likely supporting the California tiger salamander and other amphibians.

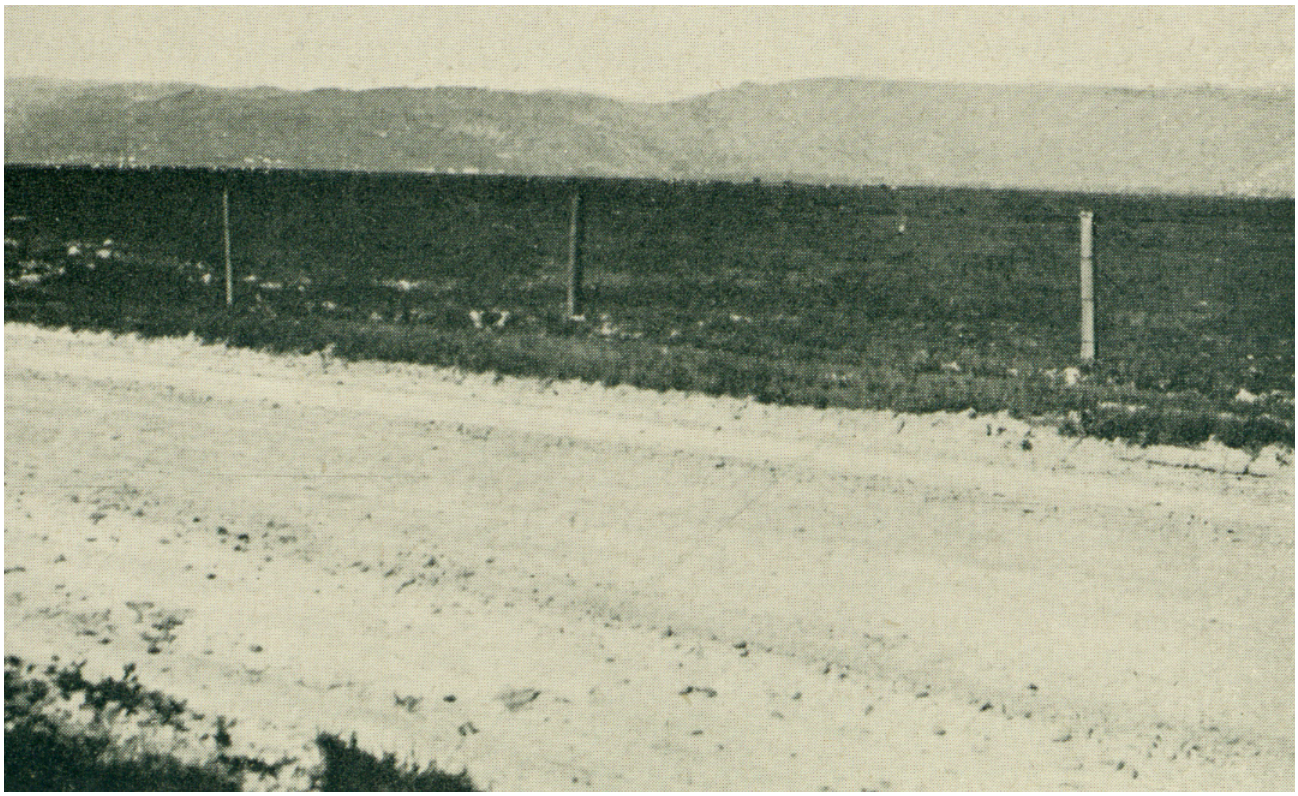


Figure 5.6. Jan Otto Marius Broek took this photograph in 1931 to illustrate the salt effects in the Bolsa. The caption reads "View towards the northeast over the alkali flat of the 'Bolsa'; the dirt road covered with a white salt crust." (Broek 1932)

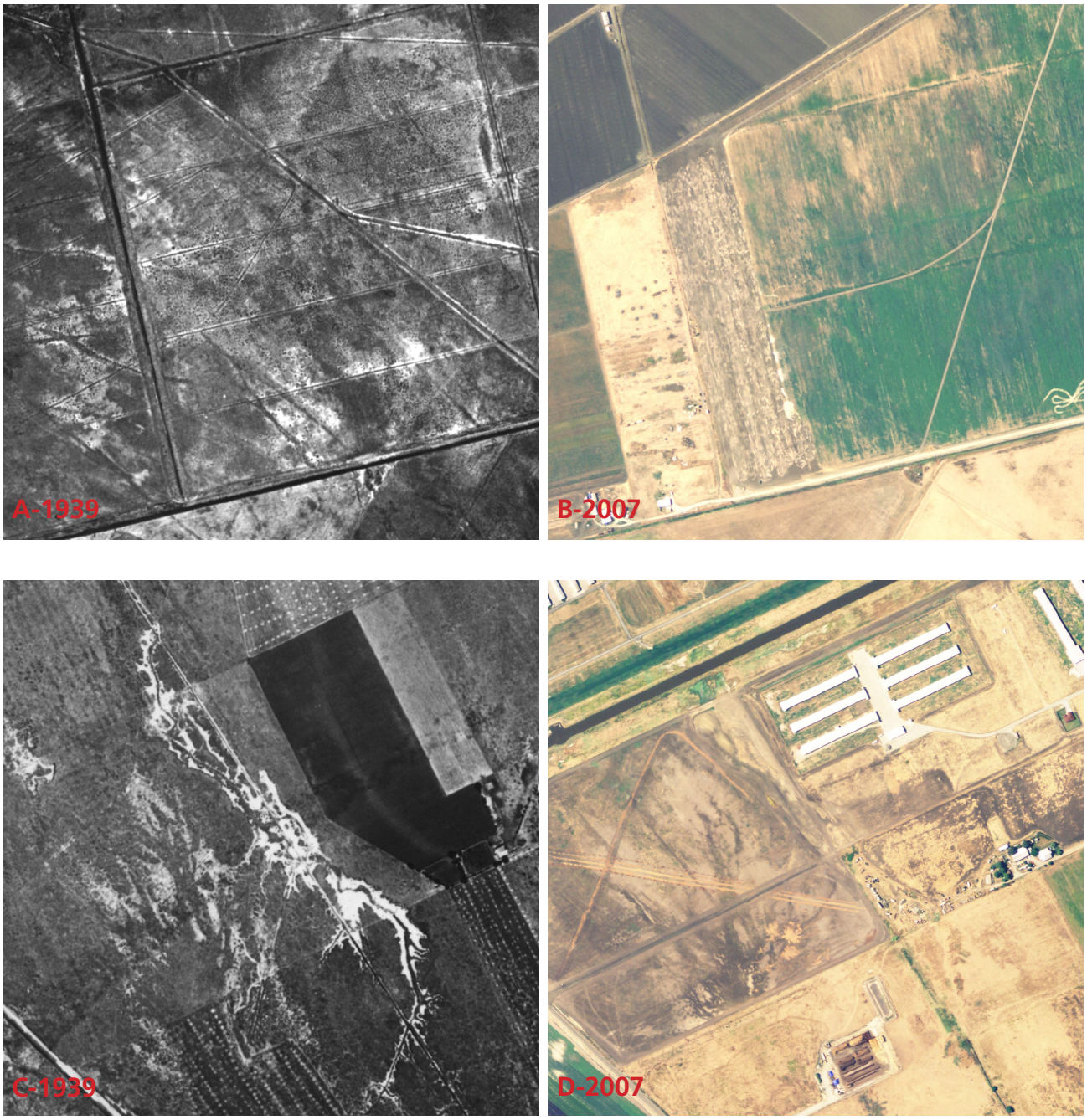


Figure 5.7. Mineral deposits evaporated from seasonal standing waters can be seen as white patches in early aerial photography of the Bolsa (A). A network of large and small ditches drain the area. Alkali deposits can be seen within a complex pattern of sloughs and swales in 1939 (C); small remnants may be visible in contemporary imagery (D). (A and C: USDA 1939, courtesy of the Science & Engineering Library Map Room, UC Santa Cruz; B and D: USDA 2005, courtesy of NAIP)

Some permanently wet features are recorded in earlier documents. For example, about a mile west of the Frazier Lake Road-Shore Road intersection, Day (1854) struck a "tulare pond" about 10 m (30 ft) in diameter within a "wet marsh with tulares" over 150 m (500 ft) wide. This chance encounter suggests that there were likely other similar features distributed within the alkali meadow, and several freshwater marshes were in fact shown by McCray (1907). Additionally, freshwater ponds and marshes were found along the Calaveras fault trace in the Tequisquita Slough area. Seasonally wet swales and sloughs and a few perennial freshwater sloughs (e.g., Tequisquita) coursed through the alkali meadows.

Valley freshwater marsh

Perennial valley freshwater marshlands were important features in the native landscape, providing water sources during the long dry season. They are also relatively distinct features in the field, evidenced by characteristic, and generally tall wetland plant communities and associated hydrological conditions. The habitat type appears to have been consistently recognized within different cultural and professional contexts because of basic practical characteristics. These were places that were difficult to walk through but that might have water for cattle or horses. Given their relatively restricted distribution, they also served as landmarks or boundaries.

> *"... the peculiar property of tule land, i.e., shaking or trembling as one walks or drives over it."*
>
> – HARRISON CA. 1888

In Mexican-era maps, the terms ciénega (swamp or marsh; e.g., U.S. District Court, Northern District 1873a) and tular (place of tules) serve as indicators of valley freshwater marsh. These features often coincided with equivalent depictions by early American surveyors. Conventional map symbology for perennial freshwater marsh has been remarkably consistent for centuries, represented, in various permutations by parallel, often broken, horizontal lines with vertical "tufts." Such conventions were observed by McDonald (1852(?)a,b,c), Healy (1858b), Thompson and West (1876), USGS (1917), and others.

Textual descriptions provide additional evidence. Indicative terms include swamp, marsh, and tule, referring to the distinctive tall rush in the genus *Schoenoplectus* (formerly *Scirpus* sp.). For example, surveyor Dyer (1861), writing in September, recorded "low marshy land covered with tule and flags" in the area of the present day Llagas Creek flood control channel and South County Regional Wastewater Plant. A map of the Las Animas Rancho confirms the presence of tule swamps here (fig. 5.8), while Cosby and Watson (1927a) note that "sedges and water-loving plants are the main vegetation" and the water table, despite a drainage ditch, remained within 1 m (3 ft) of the surface in the dry season (and floods to a depth of 2 m/6 ft in places). Local residents referred to this place as "the swamp" (Sturla pers. comm.).

Healy (1858a) confirms the boundary between open water and freshwater marsh on the margin of San Felipe Lake: "... where clear water ends and tule begins on lake." Harrison (ca. 1888) notes the extent of valley freshwater marsh surrounding San Felipe Lake: "near the lake much of the country possesses the peculiar property of tule land, i.e., shaking or trembling as one walks or drives over it. In this section vegetation grows very rank..." Tules around San Felipe Lake were tall, requiring one observer looking for a drowning companion to climb a fence in order to "[overlook] some tules intervening" (Gilroy Advocate 1869b).

Valley freshwater marshes commonly included open waters too small to map. For example, surveyor Day described "a tulare pond ½ chain diameter [10 m/33 ft]" in a "marsh" encountered while crossing the Soap Lake alkali meadows (Day 1854). Similarly, the diseño of Rancho de Las Animas shows several ponds within the large willow grove/tule marsh at the bottom of Llagas Creek (McDonald 1852(?)c; fig. 5.8).

Figure 5.8. Freshwater wetlands and willow swamps at the confluences of Llagas Creek and Uvas-Carnadero Creek with the Pajaro River. Llagas Creek enters a "Willow and Tule Swamp" with significant freshwater ponds at top; Uvas-Carnadero Creek spreads into a "Willow Swamp below". The Pajaro River flows from top to bottom at right. (MacDonald 1852(?)c, courtesy of The Bancroft Library, UC Berkeley)

Valley freshwater marsh was often associated with willow groves. This was particularly notable at the Llagas Creek wetlands, which were referred to as "willow and tule swamp" by American maps and alternately as ciénega/tule marsh or sausal/willow grove by other sources. While the Carnadero willow grove does not seem to have had as much freshwater marsh (it was consistently referred to as willow grove/sausal), it did apparently have a significant adjacent freshwater marsh or ciénega at the mouth of Tar Creek (U.S. District Court, Southern District [184-?]c; USGS 1917).

Perennial freshwater ponds and lakes

One major freshwater lake was identified in the study area, the still extant San Felipe Lake. In addition, several perennial ponds were noted along Gavilan and Llagas creeks which were probably large, persistent stream pools.

San Felipe Lake, a sag pond along the Calaveras fault, is a rare and ecologically significant wetland resource in the region. Here, water depth was sufficient to maintain a perennial open water lake. Under natural conditions, the boundary between perennial open water and emergent wetland vegetation can vary substantially over time in lakes. Wetland plants can invade shallow ponds when inundation depths decline due to sedimentation or reduced rainfall years. Conversely, wetter conditions can drown out vegetation, resulting in expanded open water area. There is no evidence that the open water portion of San Felipe Lake dried up in historical times, as it is illustrated by a number of sources over the past two centuries. It is possible that little or no open water persisted in times of extreme drought, as was observed in 1977 (Smith 2007), but higher historical groundwater levels probably made drying out unlikely.

San Felipe Lake is deep enough to have persisted through variations in climate and drainage, with depth presumably controlled by the Calaveras fault and sedimentation rates. Historical evidence suggests the lake had sufficient depth and size to be termed a "lake" according to contemporary definitions (> 10 ha/25 ac and 2 m/6 ft deep; Cowardin 1979).

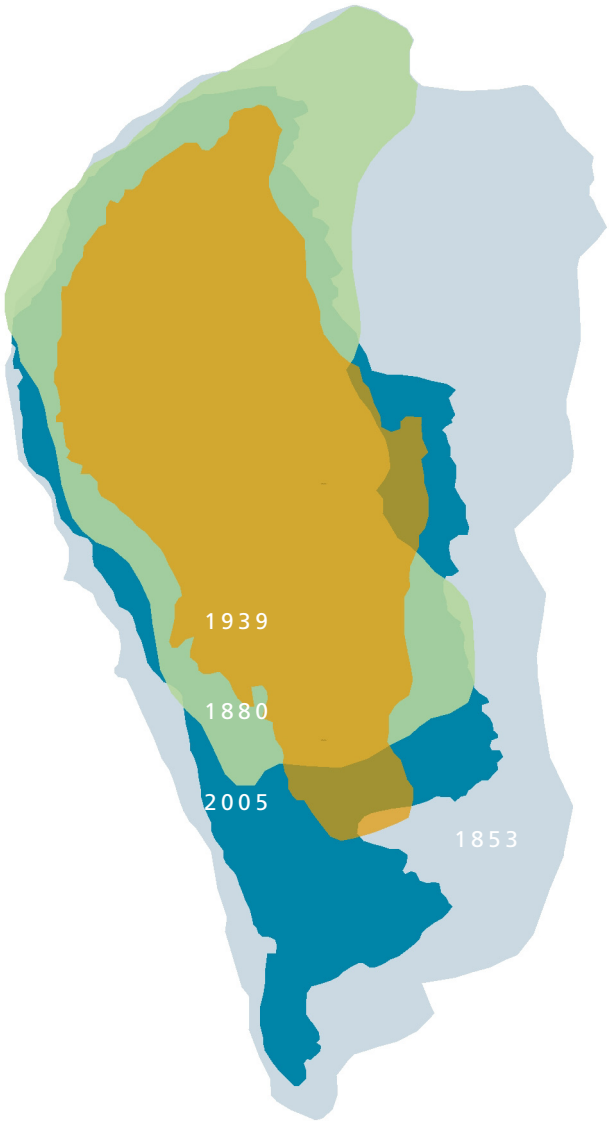
In a tragic account from 1869, the *Gilroy Advocate* describes a duck hunter drowning in the margins of the lake: "in 8 feet of water, about 60 feet from shore" (Gilroy Advocate 1869b). While the location of the incident is not stated, the water depth this close to shore in a lake hundreds of meters across across suggests that depth was commonly equal or substantially greater than 8 ft (2.5 m). This contrasts with present day summer water depths of 1 m (3 ft; Smith 2007).

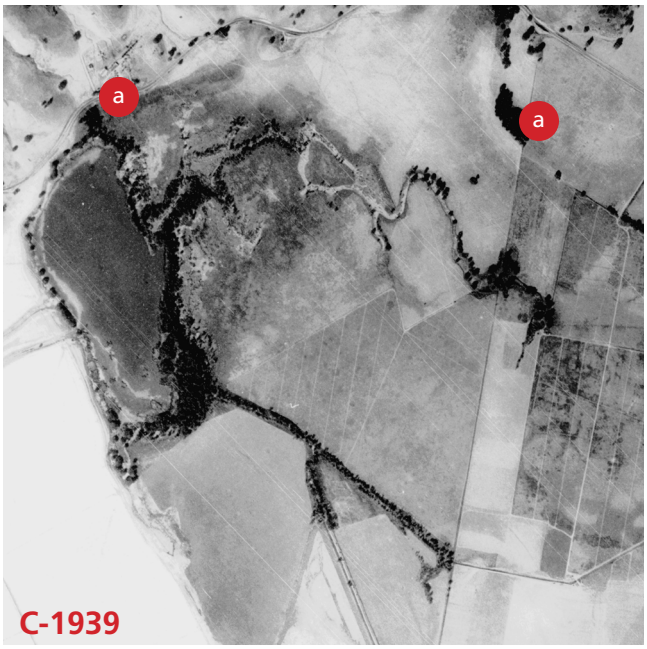
> *"The land is very good, with abundant pasturage, and it has innumerable large lagoons of fresh water and three our four villages of heathen, who, by means of rafts, catch a great deal of fish in the lagoons."*
>
> – CRESPÍ DESCRIBING SAN FELIPE LAKE AND SURROUNDING WETLANDS IN THE SPRING (MARCH 23) OF 1772

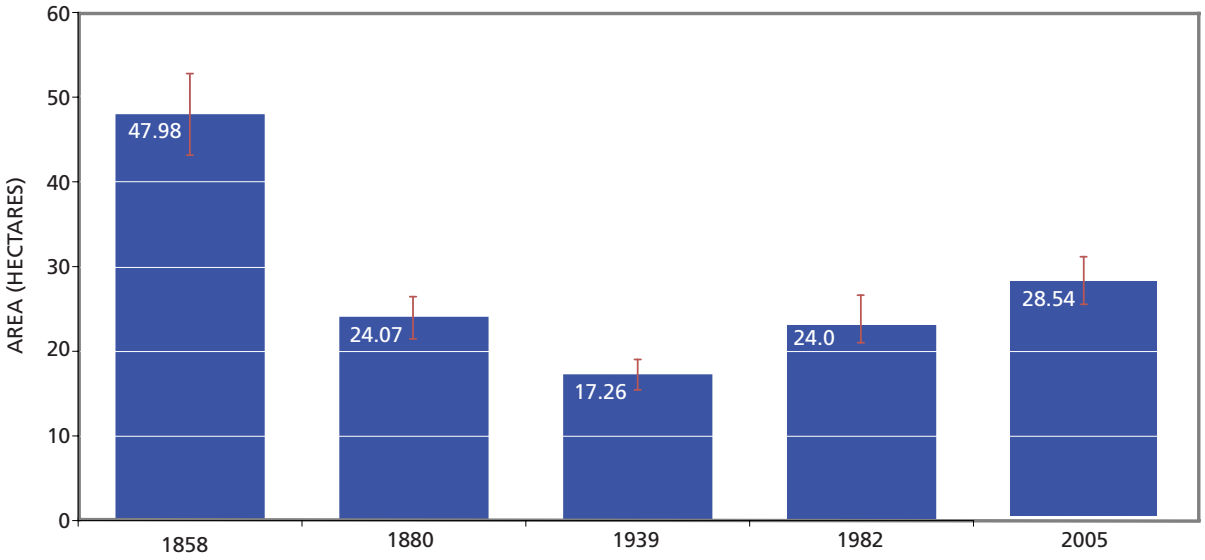
While the lake has persisted through climatic and land use changes, the extent of open water appears to have been substantially larger in the 1850s and 1860s, prior to major hydromodification. A newspaper article from 1860 describes the lake as "about three square miles in dry season." While this account is no doubt substantially exaggerated, it does imply that the lake used to be significantly larger than it is at present (Daily Alta California 1860, in Roddy 1995). More precise information comes from Healy's 1858 map establishing the county boundary, which is confirmed by his detailed survey notes (Healy 1858a,b; Healy 1868). He depicts the open water portion of "Lake San Felipe" as extending substantially farther west than do most later documents, and emphasizes this with the label "deep water." This depiction is reaffirmed by his field notes. The location of this observation corresponds with the open water/freshwater marsh margin depicted in his map (fig. 5.9). The survey was accomplished in September, so the greater lake extent is unlikely to have been a seasonal phenomenon (1856-58 were also relatively average water years).

Healy's map and survey represent the earliest reliable picture of the area and suggest the lake was at least 48

Figure 5.9. The history of San Felipe Lake is shown in a series of maps and aerial photographs. The lake is shown as substantially larger in 1858 (A) than in the subsequent views, with prominent sloughs in both 1858 and 1880 (B). Digitizing the open water areas from the georeferenced sources allows a comparison of area (right) and in the bar chart (facing page). The lake appears to have receded substantially in 1939 (C), following drought; lake bottom sediments were exposed and willow trees invaded the lake margin at that time. Apparent expansion of willows into the former "Tules and Salt grass" between 1858 and 1880 can be seen in the lower right of those images. Several historic willow groves that have maintained their position through time are identified at (a). (A (Healy 1858b) and B (Healy 1880a), courtesy of the San Benito County Recorder's Office; C: USDA 1939, courtesy of the Science & Engineering Library Map Room, UC Santa Cruz; D: USDA 2005, courtesy of NAIP)







San Felipe Lake area over time, with estimated measurement error

ha (120 ac) in size, compared to < 30 ha (70 ac) today (fig. 5.9). The 1858 measurement is conservative - the open water area could be reasonably interpreted to have extended farther to the east, which would add about 8 ha (20 ac). These data indicate that the lake has decreased in size by 40-50%. This change in the middle decades of the 19th century is corroborated by an observer in 1888, who noted that "by the slow but sure processes of nature and the ingenuity and industry of man, the boundaries of this water have been reduced until now they circumscribe a lake (Soap Lake) covering not more than 100 acres" (Harrison ca. 1888; the phrase "Soap Lake" sometimes referred to San Felipe Lake). This suggests that hydromodifications of the 1870s and 1880s – for example, Millers Canal – had an immediate impact on the extent of San Felipe Lake.

The next detailed map of the area, produced in 1880, shows an open water portion similar to that seen in 1939 aerial photography and subsequent maps. It is possible that the construction of Millers Canal in 1873-4, and associated adjustments to the outlet mouth, had already lowered lake levels by this time. Aerial imagery following the droughts of the 1930s shows a heavily receded lake extent, with the expansion of willow trees into former marshland areas (fig. 5.9).

The construction of Millers Canal and Emery Canal, among other channel modifications, had a considerable impact on the entire Bolsa. "Due to the construction of drainage canals and to improvements on the natural water courses," writes Broek (1932), "a number of lagoons and swamps formerly covering this eastern part of the flat have disappeared."

We also mapped one large playa (a seasonal or intermittent lake). We refer to the feature as playa because it was, at least in part, associated with alkali soil conditions. The feature was part of the wetland complex at the downstream end of Llagas Creek and was exceptionally well documented. A number of mid-19th-century surveys described the feature as "Lake" (fig. 5.10) and some indicate boundaries quite precisely. One survey, by county surveyor Day (1854), calls the feature the "Pajaro Lake," presumably referring to its location at the head of the Pajaro River, transitional between Llagas Creek and the Pajaro. Because of the lake's position on the boundary of two adjacent land grants, it was described and/or mapped a number of times in different seasons, providing a substantial data set indicating seasonal variation (fig. 5.10). The lake was clearly inundated regularly, and to a sufficient depth that surveyors were compelled to go around its margin well into late spring. Size decreased into summer months and the indication from Dyer (1861) is that the feature was, in an average water year, dry by the late summer.

Willow groves

Willow groves were documented by a number of historical sources with indicative terms such as sausal, willow swamp, or willow lands. Map symbols commonly indicated trees within wetland areas (e.g., figs. 5.8 and 7.29). Sources of independent origin often confirmed the same feature. Where county surveyor Healy described a willow grove in 1858, soil scientists Cosby and Watson observed a "poorly drained" area "support[ing] a growth of water grasses and willows" (Cosby and Watson 1927a), both confirming the feature and indicating substantial persistence for multiple decades.

Willow groves, or sausals, are commonly associated with springs. Groundwater often emerges at the distal end of alluvial fans, where silt or loams meet the clay-rich, fine-grained soils of the lowlands. Historically, artesian waters often emerged at this point (e.g., associated with springs and the clay/loam transition near Stevens Creek, and at similar positions on Guadalupe River and Willow Glen; SFEI unpublished data) . Similar patterns were found around Soap Lake.

Around San Felipe Lake, willow grove locations closely correspond to the margin of alkali soils, primarily where

the salinity was weakest. In fact, Healy – in the absence of any other defining feature in the flat Soap Lake landscape – used the margin between saltgrass and willows to demarcate the county boundary. Similarly, willow groves were often found at the very edge of tidal marsh in south San Francisco Bay, indicating some limited salt tolerance (Collins and Grossinger 2004).

Historical documents provided some evidence for the interior features of willow grove habitat. Herrmann (ca. 1870) showed multiple sloughs running through the Carnadero grove. Both McDonald (1852(?)a,b,c) and Dyer (1861) showed, in the same position, patches of freshwater marsh within the Llagas willow grove. McDonald also indicated freshwater ponds. It is likely that these components existed within the other large willow groves but were not shown.

Native Fish Assemblages

The following section uses historical evidence for wetland habitat conditions and historical records of fish in the watershed (Appendix 2) to reconstruct probable native fish assemblages associated with major habitat types (Appendix 3).

Perennial freshwater ponds, lakes, and lagoons

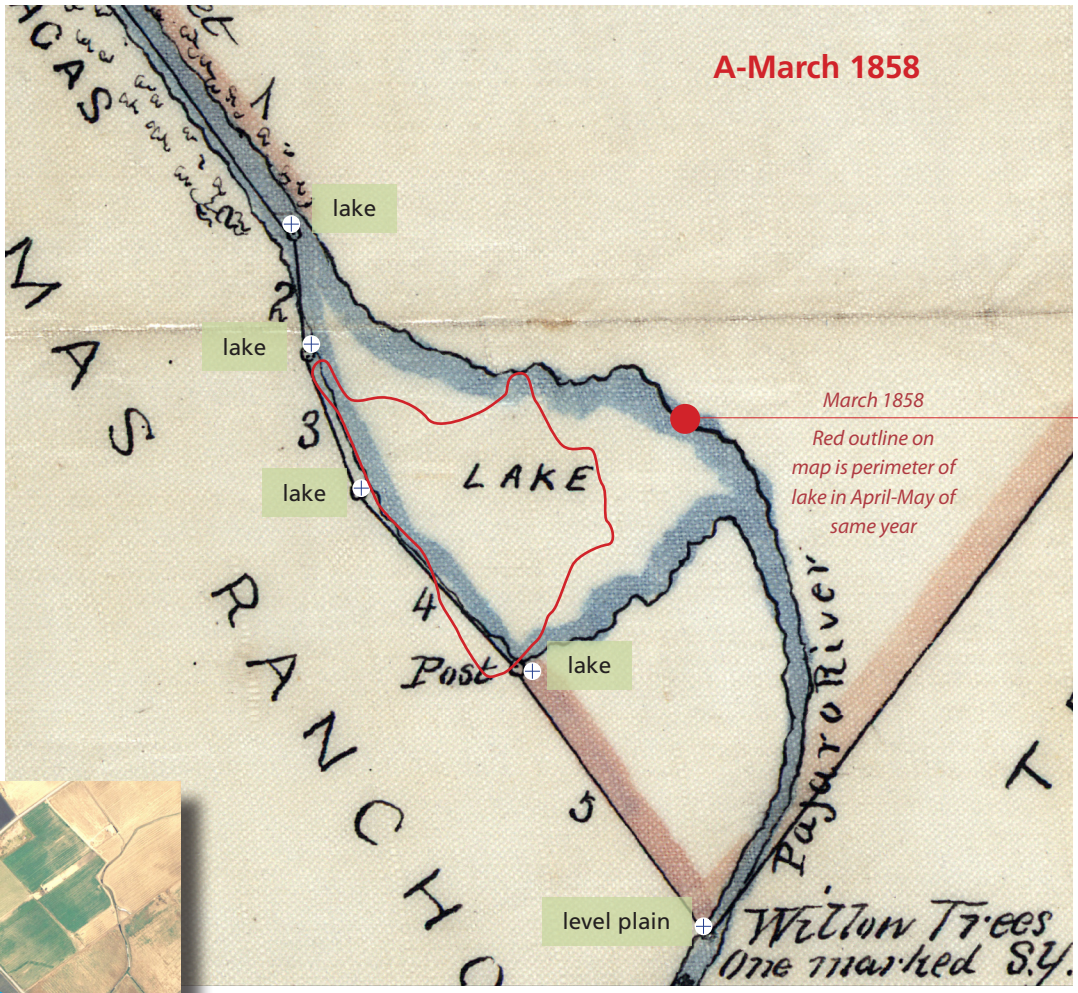
Perennial ponds, lakes, and lagoons shared many of the same fishes found in similar lowland habitats of the Central Valley (Gobalet and Fenenga 1993, Moyle 2002) and lower Pajaro River floodplain (Gobalet 1990). San Felipe Lake formed the most extensive perennial lake in the upper Pajaro River watershed and, as such, consisted of a complex mosaic of open water bordered by permanently flooded valley freshwater marsh, wet meadow, alkali meadow, willow grove, floodplain sloughs, and swales (see fig. 7.5). The aerial extent of flooding and persistence of ponded water would vary from year to year depending on regional and local precipitation and runoff patterns, which would in turn affect fish assemblage membership and distribution. Fishes collected from San Felipe Lake in 1916 include the extinct thicktail chub (SU 23795), hitch (SU 37850), and Sacramento blackfish (SU 37876; see Appendix 2 for specimen numbers). Other lowland fishes collected by Snyder (1912) and identified from archeological sites adjacent to Elkhorn Slough, also probably found in San Felipe Lake (Gobalet 1990), include Sacramento pikeminnow, Sacramento sucker, prickly sculpin, threespine stickleback, Sacramento perch and tule perch. Steelhead adults and smolts likely used these floodplain habitats as migratory pathways when flooded.

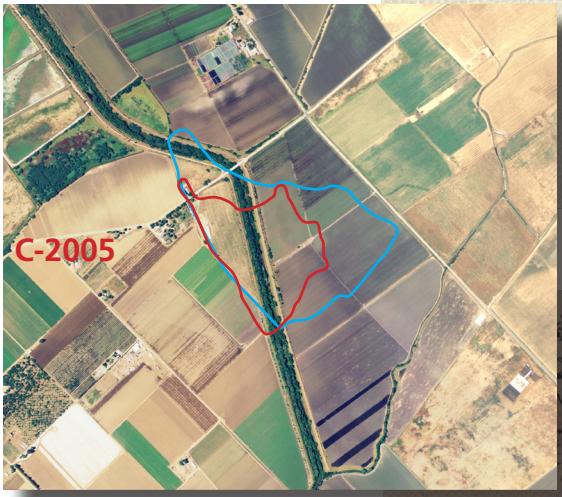
Intermittent ponds, lakes, and lagoons

Pajaro Lake was a large seasonal lake/lagoon on lower Llagas Creek (fig. 5.10). The lake fluctuated widely in size and apparently dried completely in some years (Wallace 1858a,b; Dyer 1861). During years when Pajaro Lake was persistently flooded, fish assemblages were likely similar to those found in perennial lakes, ponds, lagoons, and valley freshwater marsh habitats. During drier years fishes would likely either migrate into tributary streams or floodplain sloughs as the lake dried and/or be trapped and perish. Fishes likely occurring in intermittent ponds, lakes, and lagoons such as Pajaro Lake include Sacramento blackfish, hitch, thicktail chub, Sacramento pikeminnow, Sacramento sucker, threespine stickleback, prickly sculpin, Sacramento perch, and tule perch. Steelhead adults and smolts likely used these floodplain habitats as migratory pathways when flooded. Many native fishes are well adapted to seasonal flooding patterns, with the ability to move downstream as water levels recede (Moyle et al. 2007). However, under some conditions it is probable that as floodwaters receded some steelhead would be trapped in temporary wetlands.

Perennial valley freshwater marsh

Perennial valley freshwater marsh was often closely associated with perennial lakes, ponds, lagoons, and floodplain sloughs, typically following a hydrologic gradient of increasing water depth and duration towards





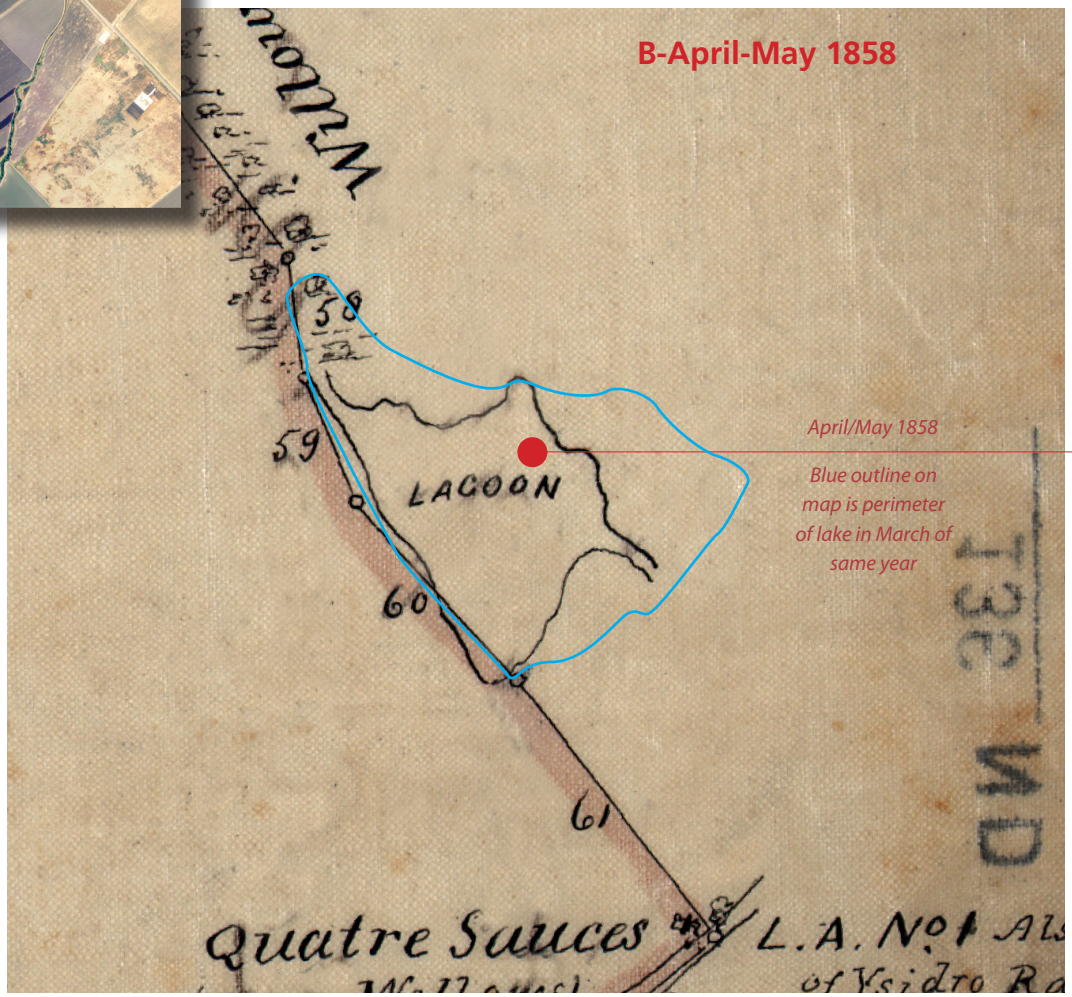


Figure 5.10. Seasonal variation of the "Pajaro Lake." The large seasonal lake or lagoon on lower Llagas Creek at Bloomfield Road was a unique feature in the region. Called "Pajaro Lake" by Sherman Day, it formed the boundary between the Las Animas and the San Ysidro ranchos, which is still evident in contemporary property lines. Maps made by Wallace in March (A) and April-May (B) of 1858, in which he showed the decreasing size of the lake, are shown at right. Some of the survey points are labeled with his field notes. Willow grove and marsh are shown along the survey line as it extends towards the upper left. The outlet forming the Pajaro River can also be seen. In the diagram on the facing page, repeated surveys describe the site in different seasons and years. The lake was sufficiently large and persistent to be seen from several miles away in June of an average water year and serve as a grant boundary (see Chapter 7). Yet by September (in another average water year), the area was dry enough to be referred to as "a level plain." (A (Wallace 1858a) and B (Wallace 1858b), courtesy of The Bancroft Library, UC Berkeley)

January
February
March
April
May
June
July
August
September
October
November
December

"Lake"

2 January 27
"To SW edge of Lake, station. Thence along edge of Lake"
Hardenburg (1872)

4 January 27
"To post at the SW corner of Lake"
Hardenburg (1872)

"Lake"

"Lake"
Identified on map surveyed in March 29 Wallace (1858a)

1 March 29
Wallace reaches end of willow thicket and notes that at that point *"the water [is] beginning to spread out into a lake"*
Wallace (1858c)

3 March 29
Wallace records he was *"along edge of lake"*
Wallace (1858c)

"Lagoon"

"Lagoon "
Identified on map surveyed in April & May, Wallace (1858b)

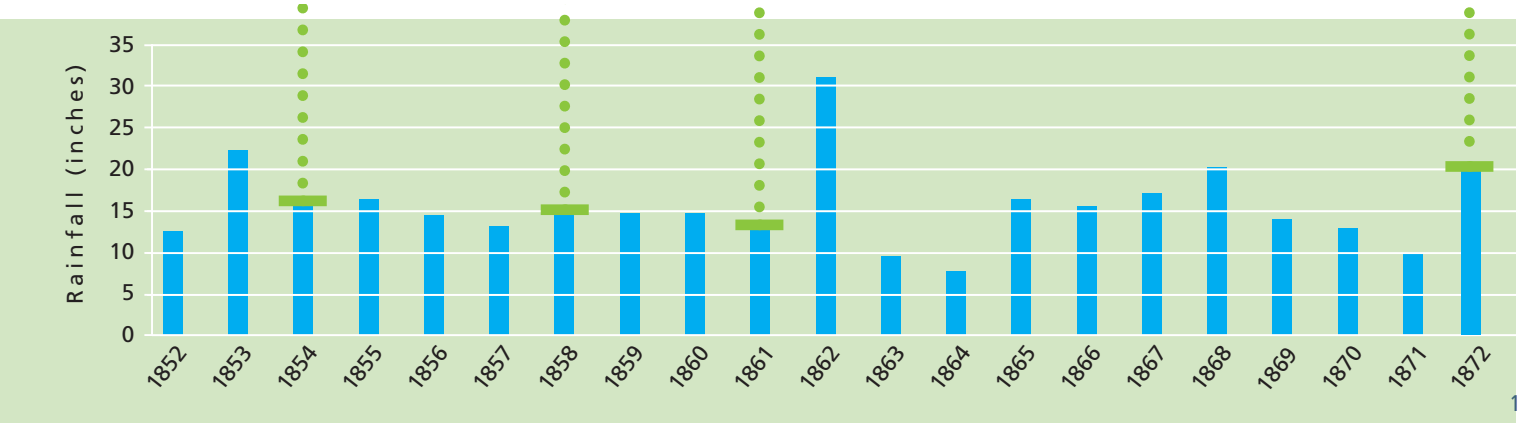
"Pajaro Lake"

In June 1854, there was still enough of a lake present for Day (1854) to note *"Pajaro Lake"* from the hills three miles away

"a level plain"

From the same point as Wallace in March, Dyer now notes he's at *"a level plain..."*
Dyer, September 3, 1861

These observations were all made during relatively average water years.



the lake or slough. Large expanses of freshwater marsh were found bordering Tequisquita Slough and at the confluences of Miller Slough and Llagas Creek and Uvas-Cardanero creeks with the Pajaro River (see fig. 5.8). Presumably because of their immediate proximity to perennial ponds, lakes, and lagoons, valley freshwater marsh supported lowland native fishes such as Sacramento blackfish, hitch, thicktail chub, Sacramento pikeminnow, Sacramento sucker, threespine stickleback, prickly sculpin, Sacramento perch, and tule perch. Steelhead adults and smolts likely used floodplain sloughs as migratory pathways. The significance of these permanent wetlands, as well as the other wetland habitats, for steelhead rearing within the Pajaro River watershed is unknown. However, steelhead are known to rear on the floodplain of the Cosumnes River, a low elevation, perennial stream in the Central Valley (Moyle pers. comm.).

DISCUSSION

Wetland area has decreased precipitously since historical times for each of the major wetland types of south Santa Clara Valley. These changes have led to population declines for numerous wetland-associated species, requiring the designation of several species as threatened or endangered. At the same time, there is some evidence that in many places the topographic and hydrogeomorphic conditions are sufficiently intact to support significant habitat restoration (PWA 2008). We identified a number of remnant historical wetlands as well as recently recovered wetlands. These could

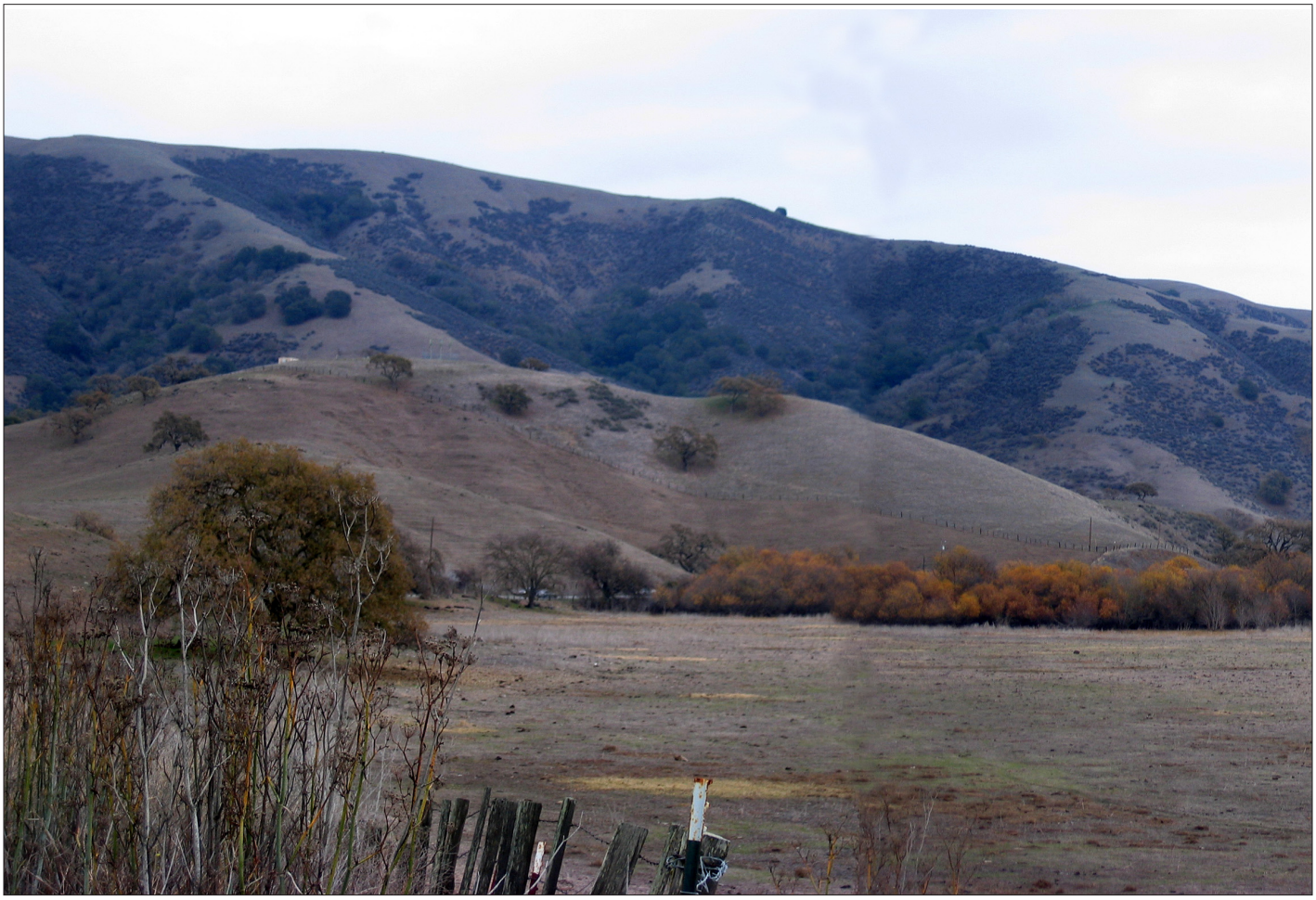


Figure 5.11. This willow grove appears similar in size and location in historical documents since 1858 (see fig. 5.9). Here the leaves of these deciduous trees (arroyo

provide models for future restoration and serve as nuclei for the recovery of larger functional systems. Despite the history of modifications, current conditions appear to have the potential to support successful wetland restoration projects in a number of places.

Residual features

Several fragments of the historical wetland landscape can be identified in the present-day landscape, particularly within the Soap Lake floodplain. While these are relatively isolated and fragmentary compared to the larger wetland mosaics of which they were historically part, they represent valuable landscape elements that should be recognized in conservation planning. For example, significant remnant willow stands occupy their precise historical position and appear to be thriving on the northern margin of San Felipe Lake (fig. 5.11). San Felipe Lake also represents a partial remnant of a major and unique geographic feature in the region – a large natural lake. Patches of alkali meadow vegetation persist in places throughout the Bolsa, indicating the persistence of alkali soil conditions (PWA 2008), and native wildflowers have returned in recent years under particular disturbance regimes (disking or plowing; Morgan pers. comm.).

Some of the small freshwater wetlands remaining in the vicinity around San Felipe Lake appear to be remnants of much larger historical wetlands.

willow, *Salix lasiolepis*) are changing color in December. Note the well-defined "browse line" in the willows' lower canopy, as nibbled back by cattle and deer.

"Accidental" recovery

In addition to these residual habitat features, we encountered several sites where portions of former wetlands have returned in the past several decades. Since water imports began in 1987, groundwater levels have recovered, enabling the recovery of wetlands in some places (figs. 5.12 and 5.13). Extra efforts to drain water or remove vegetation have been required to prevent reversion to wetlands in other places.

Willows have recolonized a portion of their historical extent at the South County Regional Wastewater Plant along Llagas Creek in Gilroy. Because of high artesian water, the southernmost percolation pond has been allowed to revert to natural vegetation since about 1984, such that a willow grove now occupies about 6 ha (15 ac), roughly half of the pond. Without regular vegetation management, willows would expand into neighboring ponds. In addition, an adjacent landowner has voluntarily fallowed 8-12 ha (20-30 ac) of his land, allowing wetland vegetation to reestablish next to the south pond, largely because high groundwater precludes successful farming on that patch (Rodriguez pers. comm.).

Mature willow trees can also seen along Bolsa Road, within the historical Llagas Creek willow grove, and Lovers Lane, within the extent of the historical Pacheco Creek willow grove. Along Lovers Lane, many of the street trees and yard trees are also willows (fig. 5.14).

Artesian flow has been maintained or returned to many parts of the Bolsa, and the fine-grained clay soils and depressional topography still remain fundamentally intact. While extensive drainage efforts have reduced the extent and frequency of seasonal flooding compared to historical conditions, the Soap Lake floodplain still remains subject to flooding on a two to five year basis (RMC 2005). Recent analysis of the potential for restoring floodplain wetlands suggests that many of the historical wetland habitats and functions could be successfully recovered through a coordinated conservation and restoration effort (PWA 2008).

Wetland mosaics

As wetland restoration efforts are considered, the historical landscape provides a template for the design of wetland landscapes. One of the prominent historical landscape characteristics was the repeating pattern of wetland habitat mosaics that occurred, in varying arrangements, at the major wetland areas of South Valley. This common pattern for south Santa Clara Valley wetlands includes open water ponds or lakes surrounded by perennial freshwater tule marsh, bordered by willow stands, and surrounded by wet meadow and/or alkali meadow (fig. 5.15). Large seasonal lakes or playas were also sometimes present. Where the topographic and hydrologic gradient was less steep, these habitat mosaics covered hundreds of acres; in other places they were compressed into a relatively small area.

This general pattern was highly consistent. As can be seen in the map of historical conditions (inside front cover), willow groves and freshwater marsh almost always co-occurred. Both habitats were always fully or partially bordered by seasonal wetlands, either wet meadows or alkali meadows. Perennial ponds were generally surrounded by freshwater marsh.

> Well-designed mosaics of freshwater marsh, willow grove, perennial ponds, and seasonal wetlands could provide a wide array of native species support functions within relatively small areas.

In contrast, today's permanent water bodies (such as reservoirs, water treatment ponds, and other water storage features) typically have little or no surrounding wetlands. The historical pattern (few freshwater ponds surrounded by large wetlands) has been inverted, such that modern ponds or lakes typically have only occasional fringes of wetlands at their margin. Similarly, willow thicket habitat is now almost completely limited to the

margins of streams and flood control channels, while the historical groves were bordered by grasslands, wet meadows, and freshwater marshes.

The historical mosaics provided an array of habitat characteristics needed to support the different resting, foraging, and breeding support functions required by native species. For example, the small perennial ponds surrounded by open meadows likely provided ideal habitat for the California red-legged frog. (In fact, South Valley's wetlands may have accounted for some of the 40,000+ frogs harvested annually from Santa Clara County in the mid-1890s; Jennings and Hayes 1985.) California tiger salamander, tricolored blackbird, southern Pacific pond turtle, least Bell's vireo, and other wetland-associated special status species were likely well supported in these local wetland mosaics. The floodplain wetland mosaics located at the bottom of Uvas-Carnadero, Llagas, and Pacheco creeks also probably provided important food resources for native fishes, including outmigrating steelhead smolts. Loss of these habitats may be a contributing factor in the overall decline of local steelhead populations. While there is some concern about the potential for stranding within restored floodplain wetlands, recent research on the Cosumnes River floodplain has found minimal stranding of native fishes (Moyle et al. 2007). Floodplain restoration should be designed to minimize stranding while increasing habitat for rearing and feeding by native fishes.

Given that modern, restored habitats will inevitably be smaller than their historical counterparts, having an appropriate array of related, contiguous habitats can maximize the benefits of wetland restoration for target species. For example, while San Felipe Lake retains a significant portion of its historical extent (50-60%), the freshwater marshlands bordering the lake have been almost completely eliminated (93%). Willow groves and seasonal wetlands have declined dramatically as well. Recovery of some of the wetland habitat mosaic around the lake might greatly increase the ecological functions of the site.

There are a number of opportunities to reestablish wetland mosaics in each of the three major historical wetland areas. There is potential along lower Llagas Creek, along the Pajaro River-San Felipe Lake-Pacheco Creek alignment, and along lower Carnadero Creek, where the SCVWD Carnadero Preserve is located. Restoring functional wetland mosaics in these areas, coordinated with invasive species/predator management (e.g., Western cowbirds, bullfrogs), could make a significant contribution to the recovery of a wide range of native species.

Potential sites for restoration and conservation

The heterogeneous distribution of wetlands within the historical landscape can help target priority sites for restoration and conservation. These areas are most likely to possess the physical characteristics conducive to wetland formation and maintenance, such as clay soils, depressional topography, and near-surface groundwater. Identifying these sites can help improve the chances of restoration success. There are a number of such sites on the south Santa Clara Valley floor.

In addition to the wetland restoration opportunities at the downstream end of major creeks, there is also potential to recover some of the alkali plain habitats that characterized much of the Bolsa and Soap Lake floodplain (especially the western Bolsa). The unusually flat topography, relatively high groundwater, persistent alkaline soil conditions, and observations of salt-tolerant vegetation and occasional native wildflower displays suggest a generally conducive physical context for restoration. Reestablishment of alkali meadow mosaics – which included alkaline grasslands and wetlands, with scattered seasonal and perennial ponds – would involve several components. The natural topographic and hydrological variation that created these patterns

Figure 5.12. Wetlands such as this small marsh in an older orchard on Lovers Lane (planted when groundwater levels were lower) are an indicator of changes in near surface groundwater levels in the past two decades.

Figure 5.13. Reestablished willow grove at the South County Regional Wastewater Plant.

Figure 5.14. In the former Pacheco Creek willow grove, willows remain part of the landscape, alongside roads and houses.

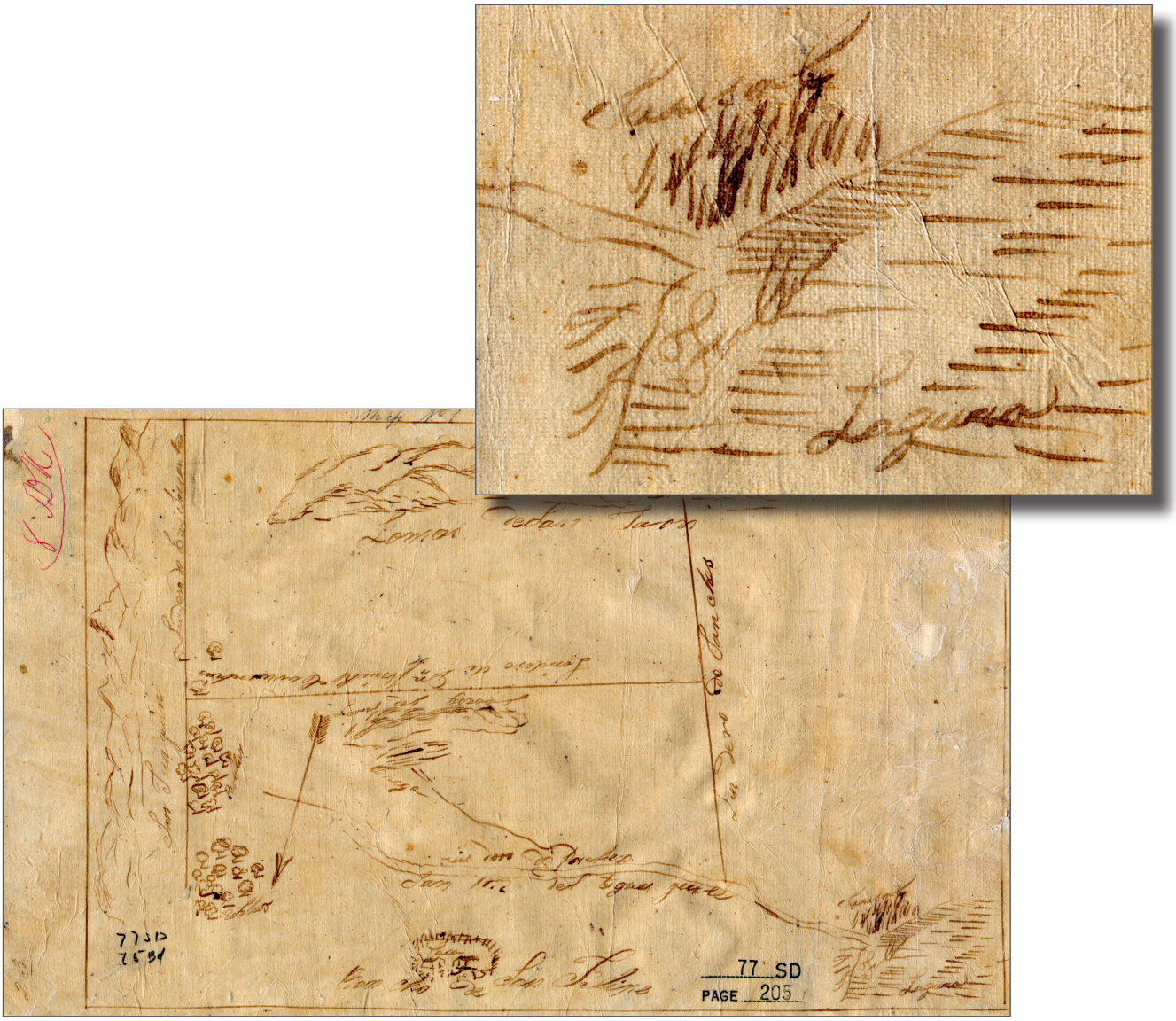


Figure 5.15. The classic wetland mosaic of open water-tule marsh-willow grove found in the larger south Santa Clara County Valley wetlands is illustrated in this diseño of the Rancho Bolsa de San Felipe produced circa 1840. The inset shows "Sausal," "Tular," and "Laguna" at the mouth of Tequisquita Slough into San Felipe Lake. (U.S. District Court, Southern District [184-]f, courtesy of The Bancroft Library, UC Berkeley)

may exist in places, and might be able to be re-created in other places through excavation and decommissioning of drainage ditches, based upon historical patterns. Carefully structured disturbance regimes such as the disking of fallow and grazed lands may allow expression of the dormant native seed bank.

Although not directly studied here, wetlands were also not uncommon in the hills of south Santa Clara County (Grossinger et al. 2007b). Cosby and Watson (1927a) noted vernal pool-like conditions in certain clay-rich upland soils: "numerous basinlike depressions occur in which the storm waters tend to become impounded, resulting in small temporary lakes or ponds." Several perennial wetland features were documented by other sources, including Twin Lakes, a historical chain of ponds and wetlands that are still present in a small valley (USGS

1917). Many of these moist, upland valleys were chosen for reservoir sites, but the lagunas recorded by Day (1854) just north and west of San Felipe Lake appear also to still be intact, based upon contemporary aerial photography (Grossinger et al. 2007b). These extant upland wetlands may be important features to consider for conservation.

Disturbance regimes and stewardship

The habitat patterns within historical wetland mosaics were controlled by broad scale, slowly changing hydrogeomorphic controls, such as microtopography, soil type, and artesian conditions. But the finer scale attributes of these habitats were shaped by disturbance regimes that created variations in stand structure, canopy structure, plant distribution, and other characteristics that are important to native species. In the absence of such disturbance, habitat support functions may become limited. For example, willow groves that provide a mix of dense, mature thickets (favoring interior species), and younger, open areas (favoring taxa such as least Bell's vireo) likely support greater overall ecosystem function than single age, homogenous stands (Rottenborn pers. comm.). Similarly, wildflower populations in former alkali meadows appear to benefit from occasional plowing or disking (Morgan pers. comm.).

Ideally, wetland mosaics would be restored within a floodplain context, where they would be subject to regular disturbance by floods to maintain a diverse array of habitat characteristics. Within watersheds regulated by large dams, pulse flows timed to maximize ecological benefits could be part of maintaining an appropriate disturbance regime.

When not part of an active floodplain, willow groves could also be artificially disturbed through a stewardship plan designed to mimic natural processes. These kinds of activities might be modeled on native management practices, which likely affected the canopy structure of willow groves and associated species support functions for thousands of years prior to Euro-American settlement. An often overlooked aspect of willow riparian restoration is the management practices of pre-colonial peoples that likely contributed to the habitat characteristics of these features.

It has been well documented that local tribes made great use of various willow taxa for basket material, construction material, medicines, and other utilitarian uses–often harvesting a tremendous volume of plant material annually (Bocek 1984, Anderson 1999). This historical habitat modification, while poorly studied, likely had substantial effects on the form and function of existing habitats and the associated support functions, particularly for native bird species. Plants were managed for specific characteristics, including flexibility, straightness, minimal lateral branching, bark color/lack of blemishes, diameter, and length (Anderson 1999).

Given their cultural importance, it is likely that significant portions of willow groves were managed by Mutsun-speaking people for specific products in the South Valley area, probably focusing on different areas for different products (i.e. smaller basket shoots vs. larger, more robust shoots for construction material). Long-term modification of these plants' architecture would have influenced the structure of nesting and foraging habitat for species such as least Bell's vireo and other riparian-associated species. Regularly harvested plants would have generated a greater number of epicormic shoots when compared to unmanaged plants, resulting in greater leaf and root surface areas. Additionally, regular coppicing would have exposed inner branch anatomy to insect fauna and, depending on the timing of such harvests, could have enhanced breeding success for some avifauna. Natives are also known to have manually controlled gall-forming insects to prevent stem damage. Rotation of harvest areas would have led to a combination of unmodified (temporarily fallow) and more intensively managed patches. While this is a poorly studied aspect of community ecology, these themes may be worth incorporating into restoration practice as other research is advanced in these areas (e.g., Anderson 1999, 2005; Striplen 2005).

Values of the willow lands

As one of the more prominent features of local historical landscapes, willow groves were notable for their remarkable size, associations with freshwater marsh and perennial ponds, and range of cultural and ecological functions. In addition to providing important resources for indigenous peoples, the willow lands also played a cultural role in the early American era, serving as social centers for local gatherings. Mylar ([1929]1985) recalled "camp-meetings in the willow grove over near old Gilroy" in the 1860s, likely referring to either the small grove northeast of Old Gilroy or the larger one to the south. On their drier margins, and in summer months, willow groves were surprisingly accommodating to human social activity. Throughout the Bay Area, historical willow groves were sculpted into shaded, idyllic landscapes, such as Willow Grove Park in Berkeley (Cianciarulo 2001) and the San Lorenzo Grove, which was described as "The Picnic Paradise of California" (Grossinger and Brewster 2003). Willow groves can provide aesthetic and recreational functions in park and reserve design, in addition to their ecological benefits.

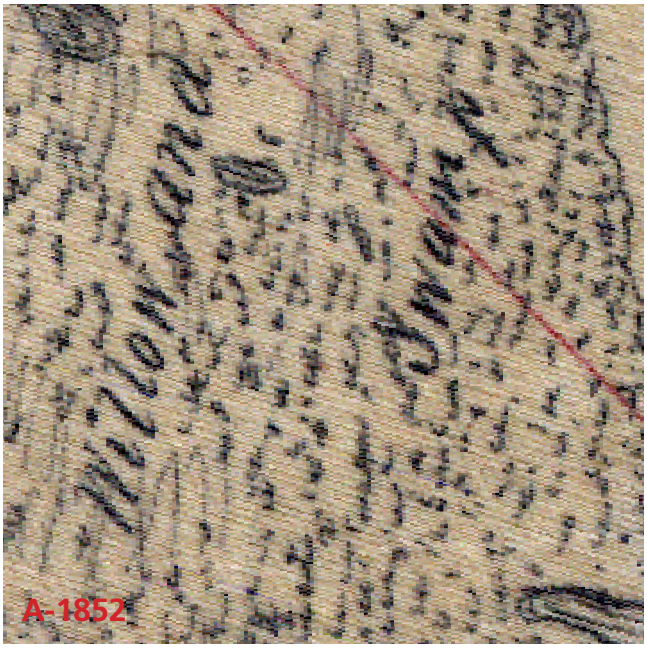
The restoration of willow lands is increasingly being considered because of the wide range of species support functions these broad riparian areas can provide, particularly when part of a surrounding landscape context including perennial wetlands and seasonally flooded meadows. Mature groves had a complex canopy structure that included large trees up to 15 m (50 ft) tall and lower, younger growth. Arroyo willow was the characteristic, dominant species, but sources also suggest the presence of cottonwoods and alder (e.g., Herrmann ca. 1880(?)). While the groves were consistently described as "dense thickets" with understories of blackberry and wild rose, historical accounts also indicate openings, which were used as refuges by both cattle and people (Cooper 1926, Brown 2005).

While willow groves were removed throughout the county relatively early, similar habitats in other areas are well recognized for their benefits for a wide range of bird species. For example, Evens (1993) describes over 80 species of birds that have historically used one of the few significant regional remnants – the Olema Marsh, a large alder-willow thicket in the Point Reyes area. Similarly, the small, recovered willow grove at the South County Wastewater Authority Treatment Plant is well valued by local birders for its ecological functions. In the Santa Clara Valley, historical willow groves probably supported yellow billed cuckoo (*Coccyzus americanus*) and willow flycatcher (*Empidonax traillii)* before they were removed in the late 19th century (Bousman 2007). Local avifauna that would likely benefit dramatically from the restoration of willow grove-floodplain wetland mosaics include yellow warbler *(Dendroica petechia)*, yellow-breasted chat *(Icteria virens)*, Swainson's thrush *(Catharus ustulatus)*, common yellowthroat *(Geothlypis trichas)*, and possibly Wilson's warbler *(Wilsonia pusilla;* Rottenborn pers. comm.). Many of these species have experienced precipitous local declines as these habitats have been removed (Bousman 2007). In addition, these areas would be expected to support a wide range of amphibians.

Least Bell's vireo habitat and willow groves

Willow grove restoration might also play a significant role in the recovery of least Bell's vireo. A state and federally endangered species, least Bell's vireo has been found sporadically in recent years along lower Llagas Creek (Padley 2001, Rottenborn 2007) – the first observations of local breeding attempts since 1932. Breeding habitat for these songbirds is often dense, early/mid-successional riparian thickets (Goldwasser 1981, Franzreb 1989). Accordingly, the recent sightings were associated with the dense, relatively young willow vegetation currently present within the modern flood control channel. The presence of the species has precluded the periodic removal of sediment and vegetation for the maintenance of channel capacity (Presley pers. comm.).

The return of the species to south Santa Clara Valley, the northern extent of its range outside the Central Valley, has raised questions about its historical and potential future habitat. Prior to agricultural drainage efforts in the second half of the 19th century, it is likely that the broad willow grove-freshwater marsh complexes at the downstream ends of Uvas-Carnadero, Llagas, and Pacheco creeks provided highly suitable habitat for least Bell's vireo. Whether these habitats supported vireos in any abundance is unknown; there is only a single historical record from Santa Clara County, though perhaps the highest-quality habitat was destroyed before significant ornithological attention was paid to the Pajaro River valley. The current habitat differs in that the in-channel willow corridor is quite narrow and isolated from other wetlands (fig. 5.16).



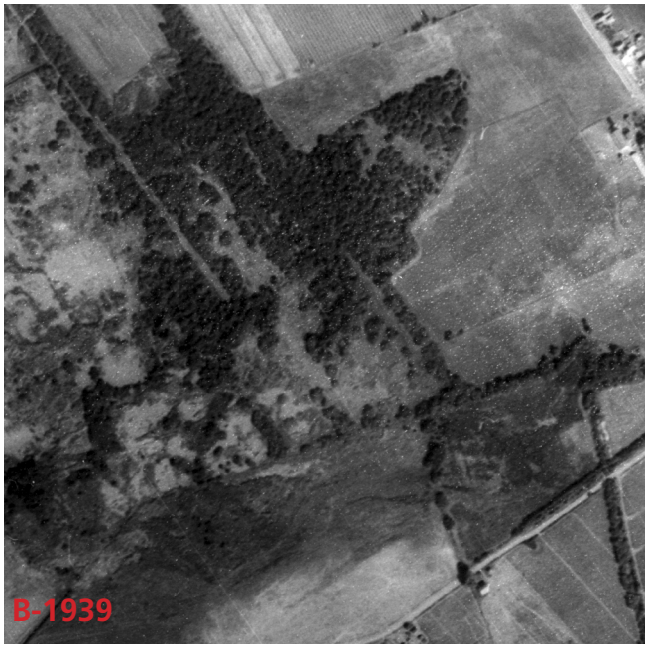


Figure 5.16. The history of the "Willow and Tule Swamp" at the downstream end of Llagas Creek can be seen in this series, starting with McDonald's ca. 1852 map. This map shows willows (hatch marks), freshwater marsh (parallel lines), and ponds (concentric circles). Independent surveys along the red grant line confirm these features. Remnants of the willow grove are still visible in 1939; these were subsequently cleared from the area as part of continued agricultural expansion and the construction of the South County Regional Wastewater Authority Treatment Plant and the Llagas Creek flood control channel. In recent years, willow thickets have returned within the flood control channel (a) and the south pond of the wastewater treatment plant (b). (A: McDonald 1852(?)b, courtesy of The Bancroft Library, UC Berkeley; B: USDA 1939, courtesy of the Science & Engineering Library Map Room, UC Santa Cruz; C: USDA 2005, courtesy of NAIP)

In other regions, especially wide (greater than 250 m/820 ft) riparian areas have been found to have disproportionately high vireo population densities (Kus 2002). The expansive historical willow groves, which were 500-1000 m (1,600-3,300 ft) wide with connectivity to perennial ponds and freshwater sloughs and marshes, likely provided excellent habitat. With the rapid loss of the agriculturally valuable willow lands after California statehood, most of this habitat disappeared by 1900. Contemporary willow thickets along the Llagas and other channels are generally narrower than 50 m (160 ft).

The vireo observed nesting in 1932 was found "near Sargent, Santa Clara County" in a willow tree within "a dark thicket" (Unglish 1937). This nest could have been in the riparian forest along the Pajaro River or in the remnant patches of the Carnadero willow grove near Sargent (which are visible in 1939 aerial photography, especially along Tick Creek).

As southern California populations of least Bell's vireo continue to increase in response to habitat restoration and cowbird management, the number and frequency of pioneering vireos in the northern part of the species' historical range are expected to increase. The successful recovery of a breeding population of least Bell's vireo in south Santa Clara Valley appears to be hindered by the lack of suitable breeding habitat and likely by high levels of nest parasitism from cowbirds (Rottenborn 2007). Given the historical prevalence of broad willow thicket habitat in the area, and the accidental recovery of several small groves in recent decades, it is possible that vireo habitat could be significantly expanded in the near future. Successful restoration of broad willow forest-freshwater marsh mosaics would establish habitat of better quality than the narrow patches within the Llagas Creek flood control channel where vireos have recently occurred. Nest parasitism by cowbirds might also be reduced by increased habitat patch sizes with concomitant reduced edge effects, though direct control would likely be needed given the abundance of cowbirds in the Pajaro River valley. Habitat restoration and cowbird control have been effective strategies for least Bell's vireo recovery in other regions (Brown 1993).

While least Bell's vireos place their nests in dense, low vegetation, a structurally diverse canopy provides the highest-quality foraging habitat, and nests are often placed near canopy openings (Kus 2002). As a result, the habitat mosaic of early- to mid-successional riparian forests provides the highest-quality breeding habitat. Shading by older trees may inhibit the development of a dense understory, potentially relegating the highest-quality habitat to forest edges. Ideally, willow grove restoration would be part of re-creating broader floodplain areas – such as through levee setback along lower Llagas Creek – so that habitat mosaics and disturbance regimes are established (PWA 2008, Rottenborn pers. comm.). Where levee alignment cannot be adjusted, however, off-channel willow grove habitat such as that currently developing in the South County Wastewater Authority Treatment Plant could also benefit the species along with a number of other riparian-associated birds, such as yellow warblers, yellow-breasted chats, and Swainson's thrushes. In addition, a sediment/vegetation maintenance regime within the Llagas Creek channel that maintains a mosaic of young and middle-aged riparian habitats may be of greater benefit to least Bell's vireos (while increasing channel capacity for flood control) than avoiding alteration of these channels altogether.

The large size of the historical willow groves means that there are many potential sites for reintroducing significant portions of the groves within their historical extent. Willow grove restoration could be considered on lower Llagas Creek, lower Pacheco Creek and San Felipe Lake, and on Carnadero Creek, potentially as part of the wetland restoration at the Carnadero Preserve. Willow grove restoration at the latter site could reestablish habitat in the vicinity of the vireo nest observed in 1932.

San Felipe Lake

While San Felipe Lake was historically part of a broad floodplain wetland mosaic, it now is primarily an isolated pond, with relatively small fringes of wetland and riparian vegetation. Nevertheless, the Bolsa de San Felipe is recognized as an Audubon Important Bird Area (Cooper 2004). Historical data indicate that the lake was bordered by about 1,000 ha (2,500 ac) of freshwater marsh and a surrounding array of willow groves and alkali meadow. Historical evidence such as the size of the lake, the extent of freshwater marsh, and artesian conditions suggests that groundwater was consistently very close to the ground surface – even higher than current levels (generally within 4 ft/1.2 m; PWA 2008).

There are indications that drainage efforts reduced the depth and duration of inundation in the lake as early as the late 19th century. After the completion of Millers Canal in 1874, willow groves occurred much closer to the lake than they were mapped by Healy in 1858. While these differences could possibly be due to surveyor variability or natural dynamics, the apparent trend continued in the early 20th century. No significant riparian vegetation could be seen on the lake's eastern margin in an 1895 landscape photograph (see fig. 7.28), but by 1939, willows had colonized the lake's east side, a general pattern that persists today (see fig. 5.9). Additionally, intensive cattle grazing has limited the growth of emergent freshwater marsh vegetation where conditions remain otherwise suitable (PWA 2008).

> *"Thousands of geese, sandhill cranes, plover, and curlew darkened the air at intervals"*
>
> – SHAW 1857(?), DESCRIBING THE SOAP LAKE FLOODPLAIN

With its surrounding wetlands intact, San Felipe Lake supported a greater number of species, and in larger populations than are currently observed. For example, a number of fish species associated with floodplain wetlands have been extirpated from the Pajaro River watershed, such as thicktail chub *(Gila crassicauda)*, tule perch *(Hysterocarpus traski)*, and Sacramento perch *(Archoplites interruptus)*; these were all found in San Felipe Lake (Smith 1982, Gobalet 1990, Hildebrandt and Mikkelsen 1993). In fact, thicktail chub, a now extinct species associated with floodplain wetlands, was specifically reported from "Soap Lake" (Miller 1963). In 1860, the *Daily Alta California* stated that in the "Lake of San Felipe" (which they note is "commonly called Soap Lake") there is a popular local fish for sportsmen: "A very good fish called Soap Lake Trout, a kind of perch" (Milliken n.d.). The lake was also an important source of fish for the native people for centuries prior to contact (Fages and Bolton 1911, Crespí and Bolton 1927, Hildebrandt and Mikkelsen 1993).

The areas around the lake were also considered the "best snipe ground in state" (Daily Alta California 1860, in Milliken n.d.) and the value for waterfowl was well-recognized:

> ... flocks of wild geese and brant, cleaving the air with their arrow-shaped lines, descended to their roost in the meadows. On their favorite grounds, near the head of Pajaro River, they congregated to the number of millions, hundreds of acres being in many places actually hidden under their dense ranks. (Taylor 1850)

> . . . several good-sized sheets of water, notably the Soap lake, are covered with wild fowl of all kinds. (Munro-Fraser 1881)

> "Several sportsmen from Hollister and Gilroy tried their luck at shooting last Sunday, in the vicinity of Soap lake. H. Frutig led the score at 70, Geo. Eustice and D.L. Dunham having good records at 60. About 300 birds of different kinds were bagged." (Hollister Free Lance 1886a)

With the recovery of floodplain slough and wetland habitat, species such as tule perch and Sacramento perch could potentially be reintroduced. Such range expansion could be desirable given the decline of the species and the

limited opportunities for floodplain wetland restoration within the larger region (Smith 1982, Leidy 2007). These habitats could also provide increased support for shorebirds and waterfowl, and food resources for outmigrating steelhead smolts.

Fine sediment storage

The dense clay and adobe soils of the Soap Lake floodplain represent the long-term deposition and storage of massive amounts of fine, stream-borne sediment. These areas served as natural sinks for fine sediment as stream gradients decreased and flows spread widely through marshlands. The Soap Lake floodplain effectively served as a filter for fine sediment, reducing some of the transmission from the upper Pajaro watershed to the river's mainstem. With flows now more confined through channel excavation and/or levee construction and increased disturbance of the watershed, fine sediments tend to be retained within these low gradient channels, reducing channel capacity and necessitating occasional or frequent excavation (e.g., Millers Canal; Hollister Evening Free Lance 1959) and Pacheco Creek (Hanna 1947, 1948(?)). The reduced function of historical areas of fine sediment deposition may have contributed to the apparent infilling of San Felipe Lake and the upper Pajaro River, which each appear to have been substantially deeper historically (Snyder 1912, Smith 1982, Gilroy Advocate 1869b). The fine sediment deposits of Soap Lake wetlands may also be, or could become, sources of fine sediment to the Pajaro River downstream – particularly given any future increases in upstream drainage density and bank erosion. Alternatively, wetland restoration in these areas could help attenuate fine sediment transport downstream, providing benefits to water quality and fish habitat.

Natural flood protection

The seasonally flooded floodplain areas of Soap Lake are recognized as providing natural attenuation of flood peaks for the lower Pajaro River (Stimson 1944, RMC 2005). Minimizing the extent of human settlement, infrastructure, and development susceptible to flooding reduces the risk to human safety and property without expensive flood protection infrastructure. Many parts of South Valley are already extensively developed and require such infrastructure approaches, but some areas may be suitable for natural flood protection approaches (RMC 2005). Naturally ponded areas can limit the height of downstream flood peaks by delaying the contribution of local runoff to peak flows; this was recognized by flood control engineers designing the current generation of South Valley drainage systems (USACE 1975). Seasonally flooded wet meadows and alkali meadows that still provide some peak flow attenuation could be reconnected to the floodplain to maintain and/or enhance such functions, in addition to the associated ecological values. This approach to reducing flood risk could have particular benefits for the Pajaro River because of the importance of the Soap Lake floodplain (RMC 2005), but there may be a number of other potential areas, as evidenced by the map of historical wet/alkali meadows.

Regional distribution

While wetlands were a major component of the south Santa Clara Valley landscape – representing a third of the study area – they occupied distinct landscape positions and were not evenly distributed through the region. The vast majority of the region's wetlands were found within the Soap Lake floodplain – the several mile wide lowlands bordering the Santa Clara-San Benito County line. Except for wet meadows (which were found in occasional lowlands to the north) nearly the entire extent of all other wetland types was found within this contiguous array of wetland mosaics occupying the bottomlands watered by the Uvas-Carnadero, Llagas, and Pacheco creeks.

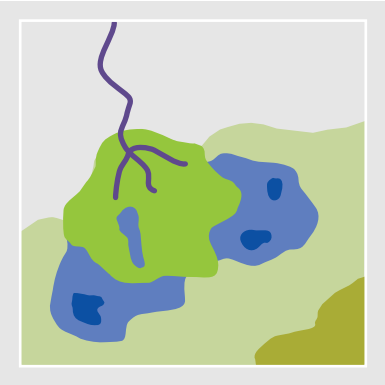
Because of both this naturally restricted distribution and the subsequent urbanization of lowland areas throughout the Bay Area and Central Coast, the Soap Lake area has unusual potential for large-scale wetland restoration.

From a regional perspective, the Soap Lake floodplain likely has the highest restoration potential for non-Bayland wetlands within Santa Clara County and is one of the most important sites in this regard within the nine county Bay Area. A number of local planning efforts have recognized these values (e.g., RMC 2005, Jones and Stokes 2006), but restoration concepts have only begun to be discussed (PWA 2008).

Landscape trajectories

The wetlands of south Santa Clara Valley experienced particularly rapid change following statehood. Among local habitats, the rate of change was probably only exceeded by the invasion of native grasslands during Spanish colonization and the harvest of redwoods in the 1850s. Because of the high value placed on agricultural lands in the second half of the 19th century, and the concomitant need for drainage, most of the freshwater marshes and willow groves areas were severely reduced in extent by 1900.

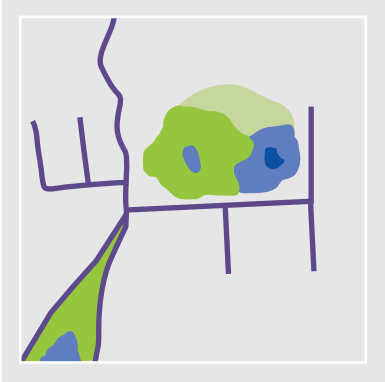
Drainage systems have continued to expand during the 20th century. However, intensive development has been limited in wetland areas due to the dense soils, alkali conditions, depressional landscape position, and associated flooding. These factors and the return of high water tables in recent decades suggest that significant elements of the historical wetlands landscape could potentially be restored in coming decades (fig. 5.17).



Circa 1800: Willow groves, freshwater marshes, perennial ponds, seasonally wet meadows, and alkali meadows form complex mosaics of wetland habitat. Small sloughs, not shown, spread through the wetlands.

Pre-World War II: Most of the wetlands have been drained for agriculture. Remaining wetlands are impacted by grazing.

2008: Drainage networks have continued to expand and only small wetland remnants remain. Some agricultural ditches have been replaced by larger engineered channels which have been colonized by willows.



Conceptual Restoration Model: With high groundwater levels, wetland mosaics could be re-designed in dedicated areas to provide flood capacity and support ecological functions. Setback levees could allow natural wetland mosaics to form.

Figure 5.17. Wetland mosaics on the lower reaches of streams: conceptual model of landscape trajectory.