Chapter I. Introduction

Background

Analysis of Historical Conditions

The San Joaquin River has changed dramatically since the early part of the 19th century. A multitude of human activities, including agricultural and urban development, water storage reservoirs, flood control projects, and mining, have modified the river's hydrology and vegetation associated with the river. Understanding the history of these human activities and their effects on the ecosystem is necessary to provide a rational basis for any attempts at restoring the riparian ecosystem. This report presents an analysis of the historical vegetation conditions of the San Joaquin River between Friant Dam and the river's confluence with the Merced River (Figure 1). Along with a concurrent study of the effects of human activities on the physical processes in the river, this study provides a basis for planning specific riparian restoration projects and management prescriptions in the study area as part of the San Joaquin River Riparian Habitat Restoration Program (SJRRHRP).

San Joaquin River Riparian Habitat Restoration Program

The SJRRHRP is a collaborative effort of the Friant Water Users Authority (FWUA), the Natural Resources Defense Council (NRDC), the Pacific Coast Federation of Fishermen's Associations (PCFFA), the U.S. Bureau of Reclamation (USBR), and the U.S. Fish and Wildlife Service (USFWS). The SJRRHRP, a stakeholder-driven program seeking the involvement of all interested parties and the public, was created out of discussions between the FWUA, NRDC, and PCFFA about mutually beneficial actions that support the goal of improving the environmental conditions in and along the San Joaquin River. The analysis of the historical biological conditions presented in this report was conducted by Jones & Stokes Associates under the direction of the SJRRHRP Management Team.

Study Objectives

The main objective of this study was to develop an understanding of historical changes in the spatial distribution of riparian habitat types and adjacent land uses along the San Joaquin River and to develop an interpretation of the factors that may have caused these changes. The report presents a quantitative analysis of historical changes in aerial extent and spatial distribution of riparian habitat and adjacent land use at five points in time: prehistoric, 1937, 1957, 1978, and 1993.

An understanding of the factors that led to changes in the historical vegetation and the spatial and temporal distribution of these factors is developed in this study and in the accompanying analysis of physical processes. The combined results of these studies are intended to form a basis for riparian restoration and river corridor management in the study region. This report does not make specific recommendations about habitat restoration; recommendations are, however, included in the accompanying report concerning physical processes.

The second study objective was to develop a geographic information system (GIS) database of historical riparian habitats and adjacent land uses in the study area. The database was used to quantify vegetation change and create high-quality maps. In the future, the database will be used to provide a detailed historical reference for restoration projects.

The third objective of the study was to document data sources for the condition and extent of historical riparian vegetation and adjacent land uses.

Previous Studies of Historical Riparian Vegetation

Studies of the historical riparian habitat in the San Joaquin River Basin have generally been based on anecdotal accounts of early travelers, historic maps, or historic and contemporary soil maps. Dawdy (1989) quotes several travelers' logs from the 18th and 19th centuries in which the lower San Joaquin River Basin is described as having extensive fields of tules with scattered willows in the river bed and "some nice groves of willows" at the confluence of the Merced and San Joaquin Rivers. Dawdy (1989) also points out that estimates of the extent of prehistoric riparian vegetation in the San Joaquin River Basin vary widely, from as little as 187,500 acres (Katibah 1984) to as much as 298,000 acres (Fox 1987, in Dawdy 1989). Dawdy (1989) states that Fox's map overestimated the extent of riparian forest in the Central Valley. Fox (pers. comm.) has confirmed that her estimates are high by a factor two, due to a planimetry error, and were based on Kuechler's (1977) map. More recent analysis by Fox (pers. comm.) based on early soil surveys of the San Joaquin River Basin resulted in an estimate of approximately 267,000 acres.

Kuechler (1977) published a map of "potential natural" vegetation in California at a scale of 1:1,000,000. Kuechler's mapping of the study area conforms to an 1886 map by Hall that shows "swamp and overflowed" lands (mainly tule marsh) along the river north of Mendota and "bottom lands" (woody riparian habitat) between Friant and Gravelly Ford (Figure 2).

Recent mapping of wetlands in the Central Valley, including riparian wetlands, was performed by the Central Valley Riparian Mapping Project (1979), a cooperative effort of the Geography Departments of California State University, Chico, and

California State University, Fresno. Maps were created at a scale of 1:24,000 using aerial photography from the 1970s (Nelson and Nelson 1984). The riparian acreage data were tabulated by USGS 7.5-minute topographic quadrangle (Katibah et al. 1984) and cannot be interpreted in terms of their association with particular watercourses. Furthermore, summaries of the findings (Katibah et al. 1980, 1984) are very general and, therefore, not very informative. The original maps were filed with the Department of Fish and Game's Natural Diversity Data Base; extracting quantitative information from these maps could have been used to validate the findings of this report but that was not within the scope of this study.

Cain (1997) compared riparian vegetation cover classes between 1939 and 1993 for the reach between Friant Dam and Lanes Bridge (11.3 miles or 7.5% of the current study area). He found an 18% reduction in the area of riparian shrub and tree vegetation and an 86% reduction in the area of "sparsely vegetated and exposed sand and gravel." Unfortunately, changes in the area of specific riparian plant communities were not quantified.

The National Wetland Inventory (NWI) of the U.S. Fish and Wildlife Service has mapped wetlands in the study area, including riparian scrub and riparian forest categories, based on 1980s aerial photography. The data are mapped on USGS 7.5-minute topographic quadrangles (scale = 1:24,000); these data are available on the Internet in digital form and can be converted to an ARC/INFO format. The conversion to a seamless coverage that could be used to compare the acreage figures in this study with NWI's findings would require extensive editing, which was not within the scope of this study. However, hard copies of NWI maps were used in this study to help identify signatures of riparian communities.

More recently, the Department of Fish and Game has produced a digital map of wetlands and riparian vegetation for the Central Valley based on 1993 Landsat Thematic Maper satellite imagery (released April 1997). These data are raster based with a cell size of 30x30 meters, and are not comparable to the data presented in this report because of their lower level of resolution.

Additional information about historical riparian vegetation in the San Joaquin River Basin is presented in Warner and Hendrix (1985) and Moore et al. (1990). The quantitative information in these reports has a limited level of detail.

Physical Conditions of the Upper San Joaquin River

Geology and Soils

The upper watershed of the San Joaquin River in the Sierra Nevada is composed of granitic rock, with outcrops of metamorphic and volcanic rock. In the foothills, the river cut through a basalt-capped plateau, leading to a relatively confined, gravel-bottomed channel (Smith 1939) and entered the floor of the San Joaquin Valley from a narrow granitic gorge.

Soils of the alluvial fans along the east side of the San Joaquin Valley are generally level, very deep, well drained, and not affected by salt or alkali. These soils are well suited for a variety of crops (Moore et al. 1990). Soils in the valley basin bottom are poorly drained and fine textured, with extensive areas affected by salt and alkali. These areas are currently used for pasture or rangeland, wildlife refuges, or duck hunting clubs.

Climate

The climate of the valley floor is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be over 100°F. for extended periods of time; winter temperatures are only occasionally below freezing. Although the San Joaquin Valley averages only 10 inches of rainfall annually, significant precipitation can occur from mid-October to approximately mid-May and infrequent subtropical storms can cause intense precipitation exceeding 4 inches in a 24-hour period (Cain 1997).

Because of the low levels of rainfall in the valley, snowmelt is the main source of the river's water. But, foothill rain storms may often generate significant short duration flood flows fron November to March. Peak snowmelt is often delayed until late spring or early summer. During dry years, snowmelt can peak as early as March or April, but during years with heavy snowfall and cool summers, peak runoff from snowmelt can occur as late as July (Cain 1997).

Hydrology

Major events that have affected the hydrology and land use of the study area between 1949 and 1997 are shown in Table 1.

Most of the water in the river is contributed by permanent Sierra Nevada streams. Very little water originates from streams on the west side of the Central Valley because the east side of the Coast Ranges is in a rain shadow and the mountains in the Coast Ranges are too low to accumulate a snowpack.

Since the construction of Friant Dam in 1944, the hydrology of the San Joaquin River in the study area has been regulated to meet irrigation and flood control needs. Before the dam was built, the hydrologic regime of the San Joaquin River was extremely variable. Droughts extended over periods of several years, while intense subtropical storms dropping rain on top of snow in midwinter could cause large floods. Part of the variability of inflow above the dam is attenuated by reservoir storage and canal diversions from the reservoir.

The largest peak flows recorded at the Friant gauge before construction of the dam in 1944 occurred in the 1910-1911, 1913-1914, 1936-1937, and 1937-1938 water years (>35,000 cubic feet per second [cfs]) (Cain 1997). The peak flows in the 1913-1914 and 1937-1938 water years were exceptionally high (>53,000 cfs). Peak annual

Table I
Major Events that Affected Hydrology and Land Use in the Study Area from 1849-1993

Year	Event
1849	Gold Rush started
1860s	San Joaquin River flows high enough to allow shipping to Herndon
1860s	Agricultural colonies established in San Joaquin Valley
1861-1862	Major floods
1863-1864	Drought
1870	Drought
1870	Railroad constructed to Modesto
1871	Mendota Dam (Weir) constructed, navigation impaired east of dam
1872	Miller-Lux Canal constructed along west side of San Joaquin Valley
1872	Railroad constructed to Bakersfield
1880s	Artesian wells constructed throughout San Joaquin Valley
1890s	Electric and natural gas pumps installed in San Joaquin Valley
1892	Railroad constructed to Fresno
1910	5,000 electric or gas pumps on wells
1916	Newer Mendota Dam constructed with movable section to allow navigation
1916-1920	Construction of James Bypass (Fresno Slough)
1920-1930	Drains installed in over 5,000 farms
1928-1934	Drought
1930	23,500 electric gas pumps on wells in San Joaquin Valley
1938	Major floods (February)
1939	Construction of Friant Dam began
1944	Friant Dam became operational
1949	Friant Dam completed
1950-1951	High precipitation
1951	Completion of Delta-Mendota Canal and reduction of releases from Friant Dam
1955-1958	High precipitation
1959-1966	Implementation of Lower San Joaquin River Flood Control System, including construction of bypass system above Merced River
1962-1969	High precipitation
1968-1970	Channel clearing of vegetation at Gravelly Ford by USCOE
1976-1977	Drought
1982-1983	High precipitation
1987-1992	Drought
1985-1986	High precipitation

Sources: USBR 1997, USCOE 1993, Cain 1997

flows after 1944, including the very high flows measured above Friant Dam in 1955-1956 and 1996-1997, have been mostly attenuated by the dam (Cain 1997). Since 1944, annual peak flows below Friant Dam have remained below 18,000 cfs, with the exception of 1997 when
a peak flow of 60,000 cfs was released.

A minimum stream flow of 35-230 cfs is released from Friant Dam to support riparian water rights between the dam and Gravelly Ford, and releases at the gauge at Gravelly Ford are maintained at or above 5 cfs during the irrigation months, requiring releases of 100 to 250 cfs (Cain 1997). The San Joaquin River is permanently wetted between Friant Dam and Gravelly Ford, but is generally seasonally dry between Gravelly Ford and Mendota Pool.

Friant Dam was completed in 1942, although the gates were not closed until 1944. In addition to Friant Dam, two other dams, Sack Dam (at RM 182) and Mendota Dam (at RM 205), have been constructed in the San Joaquin River study area. Before a concrete structure was built, Sack Dam was reconstructed every year to retain irrigation water that was diverted through the Arroyo Canal. Sack Dam was originally constructed of sacks filled with sand and soil that were either removed or allowed to wash out annually at high flows.

Mendota Dam was constructed at the confluence of the Kings River North and the San Joaquin River. Initially, it was a weir-type dam that prevented navigation east of the structure. In 1916, Mendota Dam was replaced by a structure with a movable section to allow navigation. Sediments accumulate behind the dam in Fresno Slough and are flushed periodically into the San Joaquin River. During high water periods, historical Tulare Lake drained into Summit Lake, which in turn spilled into Fresno Slough, which drains into the San Joaquin River. Historical accounts suggest that underground seepage from the Tulare Lake Basin may have doubled the volume of the San Joaquin River and maintained its flow during dry summer and fall months (Moore et al. 1990).

The hydrology of the San Joaquin River is affected by a system of canals that divert and supply irrigation water and high water bypasses that reduce the flood potential along the mainstem river. Diversion canals for irrigation were first constructed in the 1860s after agricultural colonies were established to pool funds to develop irrigation. One of the early large irrigation canals was the Miller-Lux Canal, which was constructed in 1872 to irrigate portions of the western San Joaquin Valley. Fresno Slough, also known as the James Bypass, was constructed between 1916 and 1920; Fresno Slough carries excess runoff from the Kings River to Mendota Pool and can carry irrigation water south. The Friant-Kern and Friant-Madera Canals divert irrigatin water from Millerton Lake, above Friant Dam, since the 1940s. In 1951, construction of the Delta-Mendota Canal was completed as part of the Central Valley Project; this canal conveys water from the Sacramento-San Joaquin Delta to Mendota Pool. After the completion of the Delta-Mendota Canal, releases from Friant Dam were reduced.

A major state and federal flood-control project, the Lower San Joaquin River and Tributaries Project, was authorized by the 1944 Flood Control Act. Improvements to the channel and levee system below the confluence with the Merced River were authorized today's Mendota). In 1849, during the Gold Rush, some 80,000 settlers entered the area (Smith 1939). Gold was extracted mainly through placer mining; only very little hydraulic mining occurred in the area, resulting in a much smaller impact on natural resources than in areas further to the north. However, the dredging associated with placer mining did affect the gravel bed of the river.

Agriculture

After the end of the Civil War in 1865, large numbers of settlers immigrated from the southern states to the San Joaquin Valley. These settlers pooled their resources to create irrigation companies. Major engineering projects were launched to irrigate the valley, and, by the turn of the century, 350,000 acres in the San Joaquin River Basin were irrigated (U.S. Bureau of Reclamation 1986). In 1856, 1,620 acres of grain were in production in Fresno County. In the late 1850s, grape vines were planted, and, in 1874, cotton and citrus were introduced. Shipping of agricultural products was facilitated by the construction of railroads to Modesto (1870) and to Fresno (1892). In the 1880s, artesian wells were constructed throughout the San Joaquin Valley, and electric and natural gas pumps were installed in the 1890s.

Most uplands in the study area are currently used for agricultural crops or rangeland for cattle. Increased urban development has also created a need for gravel from the study area, which is mainly mined from the riverbed north and northeast of Fresno.

Study Reaches

The study area has been divided into five reaches (Figure 1; Table 2), chosen to reflect basic differences in hydrology and geomorphology.

Reach I: Friant Dam to Gravelly Ford (RM 267 to RM 228)

Reach 1 has the steepest gradient of the five study reaches: the water surface profile (measured in January 1989) drops from approximately 300 feet elevation at 1 mile below Friant Dam to approximately 184 feet elevation at Gravelly Ford (Cain 1997). Since 1939, the thalweg (i.e., the deepest part of the channel bed) has incised several feet in this reach (Cain 1997). The river has entrenched into a Pleistocene fan and is confined between bluffs. The reach has extensive gravel mines; Cain (1997) reports that there are more than 2,100 acres of gravel pits in this reach. Recently, the City of Fresno has expanded into the vicinity of this reach.

Reach 2: Gravelly Ford to Mendota Pool (RM 228 to RM 205)

Twelve miles below Gravelly Ford, the Chowchilla Canal connects the mainstem of the San Joaquin River to the East Side Bypass system. The Chowchilla Canal can divert floodflows of up to 5,500 cfs. In this reach, the river is no longer confined by

Table 2
Study Reaches

Name	Description	River Miles	Area (acres)	Length (miles)	Average Width (feet)
Reach 1	Friant to Gravelly Ford	267–229	15,300	38	3,300
Reach 2	Gravelly Ford to Mendota Dam	229–205	9,600	24	3,300
Reach 3	Mendota Dam to Sack Dam	205–182	8,400	23	3,000
Reach 4	Sack Dam to Bear Creek	182–136	12,900	46	2,300
Reach 5	Bear Creek to Merced River	136–118	7,700	18	3,500

alluvial bluffs and meanders somewhat. The river flows over sand and, below the sand, gravel deposits that, due to their porosity, have historically caused the river to lose water through infiltration. Approximately 10 miles below Gravelly Ford, the river is confined by levees. The reach is dry most of the year.

Reach 3: Mendota Pool to Sack Dam (RM 205 to RM 182)

Most of the water in Reach 3 is diverted from the Delta through the Delta-Mendota Canal. Above Sack Dam, the Delta water is diverted from the river channel into the Arroyo Canal. The floodplain of the river in this reach is confined by levees and canals and ranges between 200 and 1,000 feet wide. Below RM 190, the river is confined between the Poso and Columbia Canals, and the distance between the levees is no more than 500 feet.

Reach 4: Sack Dam to Bear Creek (RM 182 to 136)

The river along Reach 4 is fed mainly by irrigation return water. In the upstream portion of the reach (above RM 151), the river is narrowly constrained between levees and is between 200 and 1,000 feet wide. The river channel is well vegetated.

Between RM 151 and the Mariposa Bypass, the levees are set back to a corridor width of 750 to 1,000 feet. Below the Mariposa Bypass (at RM 147), the corridor between the levees widens to 1,200 to 2,000 feet. The river in this reach is bordered on the west by the San Luis National Wildlife Refuge, and large areas of land on both sides of the river are undeveloped.

Reach 5: Bear Creek to Merced River (RM 136 to 118)

There are no levees close to the channel along portions of this reach. Where there are levees, they are set far back. The land in this reach is largely undeveloped. The river is very sinuous, and there are remnants of former channels vegetated with riparian scrub and forest. The width of undeveloped land between levees ranges from 1,500 to over 3,000 feet.

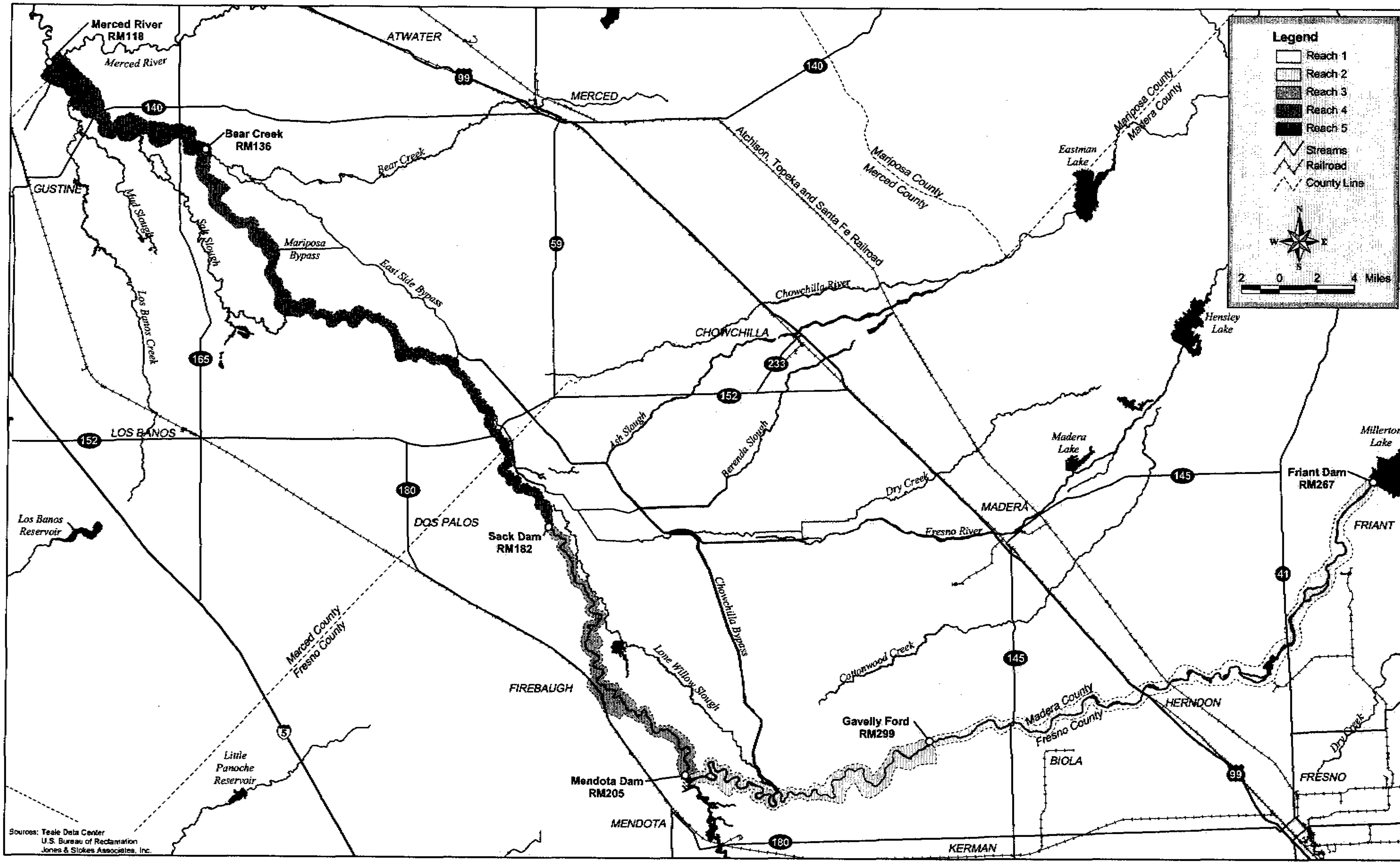

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Figure 1
Study Reaches

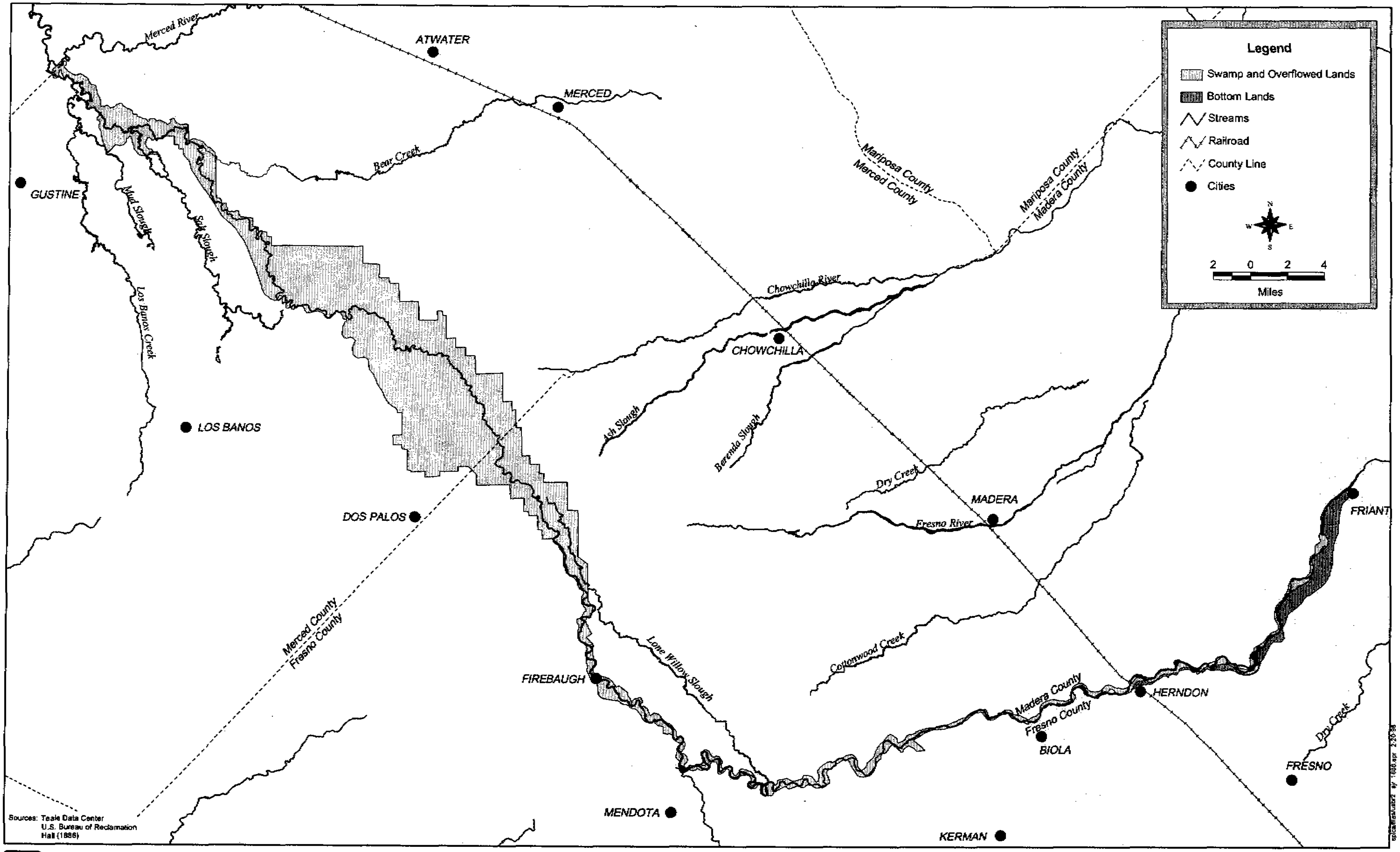

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Figure 2
Wetlands and Riparian Habitats Mapped by Hall in 1886