Preferred Citation: Warner, Richard E., and Kathleen M. Hendrix, editors *California Riparian Systems: Ecology, Conservation, and Productive Management.* Berkeley: University of California Press, c1984 1984. http://ark.cdlib.org/ark:/13030/ft1c6003wp/

A Brief History of Riparian Forests in the Central Valley of California[1]

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Abstract.—Riparian forests once occupied substantially greater areas in the Central Valley of California than they do today. This paper explores the hydrologic influences which allowed the original riparian forests to establish themselves, the extent and reasons for the decline of the pre-settlement forests, as well as an estimate of the extent of today's remaining forests.

Introduction

One hundred and fifty years ago, California's Central Valley was endowed with a natural environment the scope and magnitude of which it is difficult, if not impossible, to fully comprehend today. Two major river systems, the Sacramento and the San Joaquin, drained the Valley. Flooding in the winter and spring, these rivers and their tributaries formed vast flood basins and huge, shallow seasonal lakes. Marsh vegetation (primarily Scirpus spp. and Typha spp.) occupied these wetter sites. Extensive perennial grassland (Stipa spp.) and scattered valley oak (Quercuslobata) woodlands were found on the drier uplands, while the southern end of the Valley had large areas of saltbush (Atriplex spp.) desert. Through all of these vegetation communities, along the major river and stream systems, were strips of dense forest. These riverine, or riparian, forests developed on the natural levees of river-deposited silt, lining most of the Valley's drainages.

Riparian forests are structurally and floristically complex vegetation communities. These forests are difficult to characterize, for they occur in many different forms throughout the Valley. Under ideal conditions, these forests consist of several layers with dense undergrowth, similar in some cases to tropical jungles (Holmes etal . 1915). Fremont cottonwood (Populusfremontii), California sycamore (Platanusracemosa), willow (Salix spp.), and valley oak are common upper canopy species found throughout the Valley. Such species as box elder (Acernegundo subsp. californicum), Oregon ash (Fraxinus latifolia), and various species of willow generally occur in intermediate layers. Vines (lianas) are characteristic of many riparian forests, with wild grape (Vitiscalifornica), poison oak (Rhus diversiloba), Dutchman's pipe vine (Aristolochiacalifornica), and wild clematis (Clematis spp.) growing through the various layers. Riparian forest undergrowth has a very diverse flora which varies widely throughout the Valley. Too many characteristic undergrowth plant species occur to mention but a few: mugwort (Artemisia douglasiana), mulefat (Baccharisviminea), wild rose (Rosacalifornica), and blackberry (Rubus spp.).

Riparian forests have been greatly reduced or eliminated throughout much of the Valley. Ecologically they continue to play an important role with many plant and animal species dependent on them. Riparian forests are popular recreation sites, providing a wide range of beneficial values for the Valley's populace. These facts, among others, have recently aroused an interest in riparian forest ecology and management by both the general public and various Federal, State, and local agencies. This new interest has prompted questions as to why these forests occurred more along some river systems than others; how extensive the pre-settlement forests were; what caused their decline; and how many of these forests remain today. This paper attempts to provide a brief, informative look into these questions.

Hydrology of the Central Valley

There is significant hydrologic diversity throughout the Central Valley, and it was this diversity which was in part responsible for differences between individual riparian forests. For example, the Valley has two major riverine hydrologic systems: that of the Sacramento Valley component in the north and of the San Joaquin Valley component in the south. The influences of these major hydrologic systems on the nature of

[1] Paper presented at the California Riparian Systems Conference. [University of California, Davis, September 17–19, 1981].

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the riparian forests associated with them were profound. Figure 1 depicts the Central Valley and its major surface hydrology as it may have appeared under pre-settlement conditions.

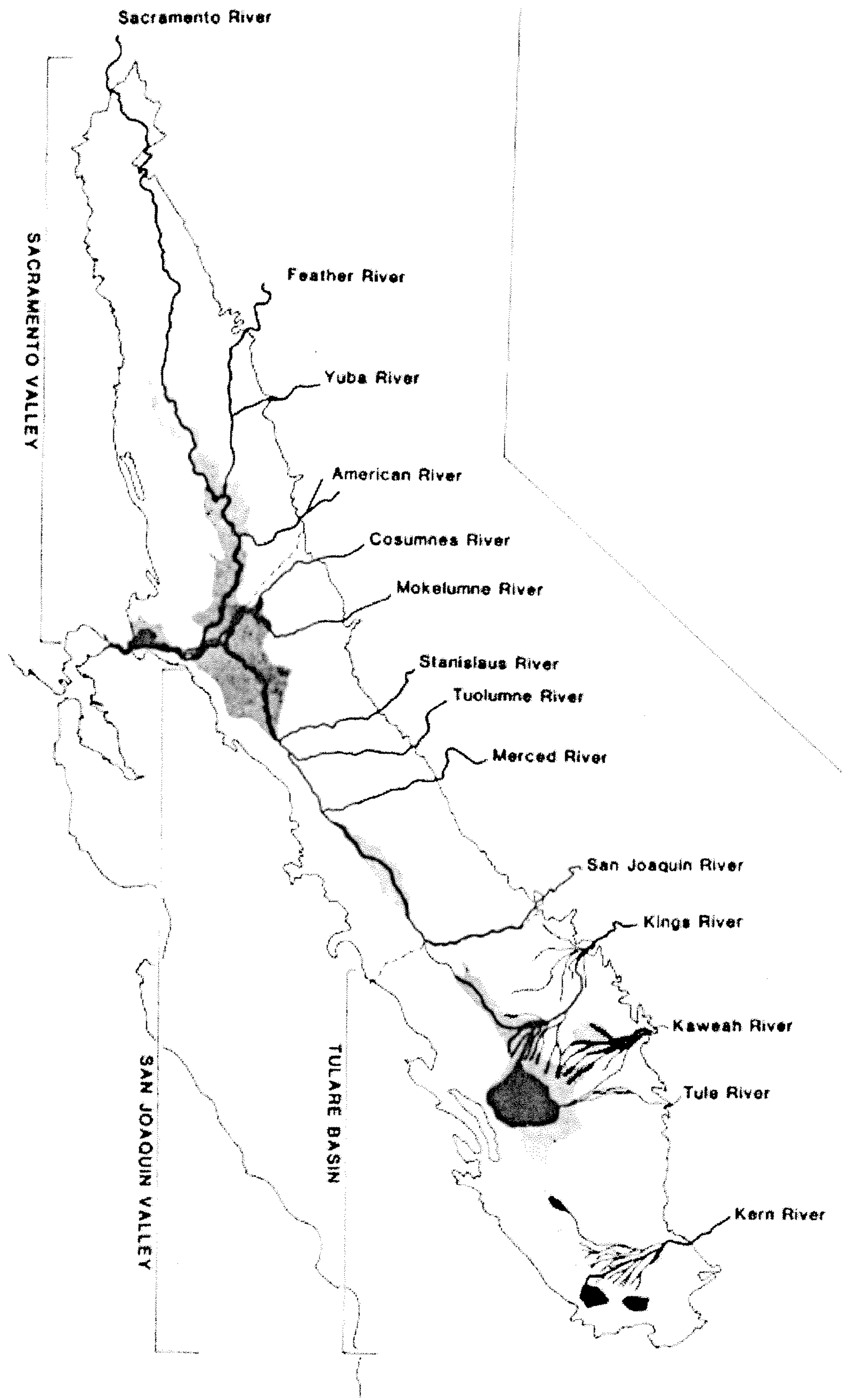

Figure I.
Surface hydrology of the Central Valley as it may have appeared around 1850. Areas in black within the Tulare Subbasin represent

seasonal lakes. Shaded areas, shown throughout the Valley, indicate flood basins and freshwater marshes.

Hydrology of the Sacramento Valley

The Sacramento Valley is bordered by the mountains of the Coast Ranges to the west, the Klamath and Cascade Ranges to the north, and the Sierra Nevada to the east. To the south, the Sacramento Valley joins the San Joaquin Valley at the Sacramento/San Joaquin River Delta. The comparatively dry interior Coast Range mountains have no large rivers draining into the Valley, only streams, some of the larger being Stony, Cache, and Putah Creeks. The Sacramento River originates in the Klamath Mountains and is joined by two rivers, the McCloud and the Pit, in what is now Shasta Lake. The Sierra Nevada mountains to the east provide the greatest number of rivers and major streams draining into the Sacramento Valley—the Feather, Yuba, Bear, and American Rivers, and Butte and Big Chico Creeks.

Numerous other streams also flowed into the Sacramento Valley from the surrounding mountains. Not all of these streams actually reached the Sacramento River. Historically, natural levees and naturally occurring flood basins prevented some streams from reaching the main rivers. Instead, these streams spread out "through a welter of distributaries" (Thompson 1961) on the Valley floor. These distributaries typically ended in "sinks" of tule marsh. Putah, Cache, and Butte Creeks are among those streams which never joined the main river network in the Sacramento Valley.

The Sacramento Valley and its surrounding foothills, unlike the San Joaquin Valley region, receive substantial rainfall in the winter and early spring. This resulted in Sacramento Valley rivers experiencing maximum flows from December through March instead of May and June as is characteristic of most western rivers, including those in the San Joaquin Valley (Fortier 1909). Snowmelt fortified the river flow in the Sacramento Valley through the late spring. Annual summer drought brought the low flow rates found in these rivers through late fall.

During the peak flows of the Sacramento Valley rivers, the flood basins were filled by sediment-carrying waters. The natural levees dividing the flood basins from the major rivers were initially developed and then augmented by this annual flood cycle. Impressive natural levees along the Sacramento River, ". . . from 5 to 20 feet above the flood basins . . ." and 1.6 –16 km. (1–10 mi.) in width, averaging 4.8 km. (3 mi.), ". . . formed corridors of generally dry land during times of flooding . . ." (Thompson 1961). The other major Sacramento Valley rivers and streams also formed well-developed natural levees.

Hydrology of the San Joaquin Valley

The San Joaquin Valley is bounded by the flat relief of the Sacramento/San Joaquin River Delta to the north, the mountains of the Sierra Nevada to the east, the Coast Ranges to the west, and the Tehachapi Mountains to the south.

The Coast Ranges and the Tehachapi Mountains bordering the San Joaquin Valley are very arid. Thus, the streams which originate from these mountains were characteristically intermittent in flow. Probably the most notable of these intermittent streams was Los Gatos Creek, whose alluvial fan helped form the Tulare Subbasin, a major influence in the hydrology of the San Joaquin Valley.

Numerous Sierra Nevada rivers and streams flowed into the San Joaquin Valley, including the Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, Chowchilla, Fresno, San Joaquin, Kings, Kaweah, Tule, White and Kern Rivers.

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The San Joaquin Valley is itself divided into two distinct hydrologic subbasins: the San Joaquin and the Tulare. The San Joaquin Subbasin is drained by the San Joaquin River; the Tulare Subbasin has no perennial surface outlet.

The Tulare Subbasin was formed at the south end of the San Joaquin Valley by the merging of alluvial fans from the Kings River to the east and Los Gatos Creek to the west

(Cone 1911). Water originating from the major Tulare Subbasin rivers—the Kings, Kaweah, Tule, White, and Kern—flowed into this subbasin and found no normal outlet to the sea. Instead, large inland lakes formed—the Tulare, Buena Vista, Kern, and Goose. These largely temporary lakes, extremely shallow as they flooded the nearly flat landscape, rose dramatically as winter and spring runoff filled them. As the seasonal lakes filled beyond capacity they flowed into one another, finally rising above the natural alluvial barriers which divided the Tulare and San Joaquin Subbasins, sending tremendous quantities of water down the Fresno Slough into the San Joaquin River.

Later in the season, after the overland flow of water had ceased, substantial quantities of water were still drained from the Tulare Subbasin into the San Joaquin River via subsurface flow. This underground accession may have doubled the San Joaquin River's volume (Irrigation in California 1873). This undoubtedly helped to maintain the flow of the San Joaquin River in its southern reaches during the long, dry California summers.

The San Joaquin Valley rivers, whose waters were primarily snowmelt, tended to reach maximum flow in May and June. In contrast, peak flow of the Sacramento was usually in March, although some of the major peak flow rainfloods have occurred much earlier in the winter (1955–56 flood—December and January; 1964–65 flood—December and January; 1970 flood—January). In addition, the San Joaquin River's flow into the Delta in its peak flow period was less than onehalf the discharge rate of the Sacramento River during its usual peak flow period in March. Despite this difference in peak flow timing, the two rivers discharged approximately equal amounts of water into the Delta.

San Joaquin Valley rivers and streams in some instances did not produce the large, natural levees characteristic of the Sacramento Valley. Peak water flows in San Joaquin Valley rivers and streams were typically less than those in the Sacramento Valley, thus limiting their ability to pick up and carry sediment for great distances. Natural levees did form along the major northern San Joaquin Valley rivers—the Tuolumne, Stanislaus, Merced, Mokelumne, Cosumnes, and northern San Joaquin.

The southern (upper) reaches of the San Joaquin River developed natural levees only poorly, and only as the river entered the Valley floor. Never a particularly big river, it ranked third in peak flow after the Tuolumne and Kings Rivers (Cone 1911). Relatively low-energy peak flows resulted in suspended sediment deposition and natural levee formation only where it first entered the Valley. From there until it reached Fresno Slough, the San Joaquin River received no surface tributaries. At that point it received the surface floodwater flows through the Fresno Slough from the Tulare Subbasin and the underground flow through the extensive Tulare Subbasin aquifer.

Both of these flows were substantial, but both lacked significant sediment content. The overland flow through Fresno Slough had already deposited its sediment load in the shallow Tulare Subbasin lakes. The subsurface waters had been filtered of any sediment long before they joined the San Joaquin River. Thus while the southern San Joaquin River gained a large water accession, especially during the peak spring flood, it was unable to build any significant natural levees because of the low sediment load. With no natural levees to contain its waters, the San Joaquin River spread out over the flat Valley floor, sustaining the large freshwater marshes still found there today. The first major sediment-carrying waters to reach the San Joaquin River for many miles occurred at its confluence with the Merced River. From here to the Delta, substantial natural levees were built along the San Joaquin River.

The Tulare Subbasin rivers developed natural levees where these rivers first entered the Valley. The shifting courses of these rivers undoubtedly allowed many miles of levees to be formed, though they were quite narrow and confined compared to the levees of the Sacramento Valley rivers.

Extent of Pre-Settlement Riparian Forests

While the largest and most diverse riparian forests occurred on rivers having natural levees, well-developed riparian systems were found along virtually all watercourses in the Central Valley. Most riverine floodplains supported riparian vegetation to about the 100-year flood line. Virtually all watercourses supported dense vegetation from the water's edge to the outer edge of the riparian (moist soil) zone, whether or not natural levees were present. The overall presettlement riparian vegetation pattern was one of stringers or corridors of dense, mesic, broadleaf vegetation of varying widths bounding the watercourses, the widths being determined by local hydrologic and landform characteristics.

According to various accounts, the Sacramento Valley had approximately 324,000 ha. (800,000 ac.) of riparian forest remaining after 1848 (Smith 1977; Roberts etal . 1977). No comparable estimate for riparian forests is available for the San Joaquin Valley. However, based on a map compiled by J. Greg Howe (ibid .) showing presumptive original riparian forest distribution, and estimates by this author, it is

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conservatively estimated that the Central Valley had greater than 373,000 ha. (921,000 ac.) of riparian forest under pre-settlement conditions.

Howe's map is based on early soil maps and covers an area in the Central Valley from the Sacramento River at Redding in the north to the Merced River in the south. I measured for areal extent the presumptive riparian forests shown on Howe's map. This estimate, presented in table 1, yields a value of 312,400 ha. (771,600 ac.) of pre-settlement riparian forest. This value must be considered conservative for that area, as Howe's map depicts only the large, contiguous riparian forests. The many smaller areas of riparian-indicator soil-types were below the mapping level of the historic soil maps used in the presumptive-riparian-forest map preparation.

In addition, Howe's map excluded the southern rivers of the San Joaquin Valley—the San Joaquin below its confluence with the Merced; and the Kings, Kaweah, Tule, and Kern. The above figure reflects that exclusion. I judged the riparian systems associated with those rivers to have totalled an estimated 20,200 ha. (50,000 ac.) (table 1). Furthermore, I estimated approximately 40,500 ha. (100,000 ac.) to account for the riparian forest vegetation present along the small streams, sloughs, lakes, ponds, and marsh borders throughout the entire Central Valley (table 1). These estimates are undoubtedly quite conservative and subject to considerable refinement.

Table 1.—Estimates of areal extent of pre-settlement riparian forests in the Central Valley of California.[1]

Forest name	Description	Estimated size ha. (ac.)
Central Valley Riparian Forest Area Estimated From Howe Map		
Upper Sacramento River	Sacramento River from Table Mountain to near Redding (includes forests along Cottonwood, Stillwater, and Cow Creeks).	17,500 (43,200)
Big Bend	Sacramento River in the vicinity of Big Bend.	800 (2,000)
Antelope Creek	Antelope Creek east of Red Bluff.	300 (700)
Sacramento River	Sacramento River from below Sacramento to above Red Bluff (includes Elder, Mill, Thomes, Deer, Rice, Stony, Pine, Rock, Big Chico, Little	206,000 (508,800)

	Chico, Butte, Honcut, and Cache Creeks; Feather, Yuba, Bear, and American Rivers).	
(Near) Knight's Landing	An area near Knight's Landing	500 (1,300)
Putah Creek	Putah Creek from above Winters to the Putah Creek Sinks.	8,900 (22,000)
Dixon	An area in the vicinity of Dixon.	2,200 (5,400)
Lower Sacramento River	Sacramento River below Courtland.	1,100 (2,600)
Cosumnes/Mokelumne Rivers	Upper reaches of Cosumnes and Mokelumne Rivers to below their confluence.	23,400 (57,800)
Calaveras River	Calaveras River north of Stockton.	9,500 (23,500)
Upper San Joaquin River	San Joaquin River west of Stockton.	300 (700)
San Joaquin River	San Joaquin River from its confluence with Merced River to just outside Stockton (includes Merced River, parts of Stanislaus and Tuolumne Rivers).	36,700 (90,600)
Middle Tuolumne River	Middle Tuolumne River near Modesto.	3,100 (7,700)
Upper Tuolumne River	Upper Tuolumne River from where it enters the Valley downstream.	2,100 (5,300)
Total		312,400 (771,600)

Table 1.—Estimates of areal extent of pre-settlement riparian forests in the Central Valley of California.

Forest name	Description	Estimated size ha. (ac.)
Additional Riparian Forest Area Based On Estimates By Katibah		

South San Joaquin Valley	Series of forests along major southern San Joaquin Valley rivers (includes upper San Joaquin, Chowchilla, Fresno, Kings, Kern, and Tule); and the alluvial floodplains from these rivers.	20,200 (50,000)
Miscellaneous	Riparian forest present along small streams and sloughs; and lake, pond, and marsh borders throughout the entire Central Valley.	40,500 (100,000)
Total		60,700 (150,000)
Total Estimated Pre-Settlement Central Valley Riparian Forest Area		373,100 (921,600)
[1] Based on a map by J. Greg Howe (Roberts etal . 1977) and estimates by E. Katibah.		

Decline of Central Valley Riparian Forests

"No natural landscapes of California have been so altered by man as its bottomlands" (Bakker 1972). The once-lush riparian forests, forming natural vegetation corridors along many of the Central Valley's watercourses, are mostly gone today. These forests were, in Thompson's words, ". . . modified with a rapidity and completeness matched in few parts of the United States" (Thompson 1961).

The reasons for the rapid decline of this once extensive ecosystem are not hard to find; one needs only to review the cultural history of the Central Valley for the last 150 years.

Prior to 1822 the land known as California was claimed and ruled by Spain. Little development occurred during this period, and at the cessation of Spanish rule in 1822 only about 30 ranches or farms had been granted in California (Fortier 1909). Mexico assumed control of California until 1848. By ". . . 1846 no less than eight hundred large tracts containing some of the best land in the State had been given away" (ibid .). The character and size of the large Mexican land grants had a profound influence on the social, commercial, and agricultural development of the Central Valley (ibid .), development which would ultimately and adversely affect riparian vegetation.

With the annexation of California to the United States in 1848, rapid development of the Central Valley began. The Gold Rush, beginning in 1849, exerted enormous land use pressures and led to rapid and often unplanned development of the Valley.

Riparian vegetation removal was one of the first significant losses in the natural environment. The large number of immigrants seeking their fortunes in the gold-bearing Mother Lode rivers and streams soon found that agriculture provided a much more stable and practical existence. The riparian forests, often the only significant woody vegetation on the Valley floor, were utilized by the growing agricultural community for fencing, lumber, and fuel (Thompson 1961). Steamships using the Sacramento River were also heavy users of local wood fuel. Knight's Landing on the Sacramento River was a site where cordwood was loaded onto these ships. It has been speculated that this wood came from the Cache Creek and Sacramento River riparian forests because Knight's Landing is adjacent to the treeless Yolo flood basin (ibid .). This supplying of fuel wood to the numerous woodburning vessels on the Sacramento River must have made a significant contribution to the early destruction of the local riparian forests (ibid .).

As early as 1868 the general scarcity of woody vegetation was noted in the Valley by some of its inhabitants (ibid .). The pressures on riparian forest vegetation continued as farmers found that the soil on the natural levees was highly fertile, easily managed, and not subject to the seasonal flooding of nearby lower-lying ground (ibid .). As agriculture expanded in the Central Valley, water demand began to exceed water supply. Farmers also found that the Valley had too much water in the winter and spring and not enough in the summer. Water development and reclamation projects were started, primarily for agriculture and community flood protection, and rapidly eliminated many of the Valley's native wetland systems.

With agricultural expansion, cities grew to support the new industry. Many Valley towns and cities were built in flood basins and upon active floodplains, and were subject to seasonal flooding. The city of Sacramento suffered a tremendous flood in 1850, and its response, the buil-

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ing of levees around the town, ". . . set the course for Valley development over the next several generations" (Karhl 1979). To promote the reclamation of the tule marsh and floodplain lands, the Arkansas Act of 1850 was applied in California. This act gave the State of California millions of acres of federally owned floodplains, provided that the State drain and reclaim these lands. The Arkansas Act of 1850 stipulated that all manmade levees were to be constructed along natural drainage systems. The Green Act of 1868, passed by the California Legislature, however, freed the reclamation process of most controls. The effects of the Green Act were devastating to riparian forests. Levees were built for the convenience of landowners with little or no regard for the natural hydrologic systems. Remaining riparian forests, occupying natural levees along river courses, were destroyed in the quest to protect lands from flooding.

As in the Sacramento Valley, artificial levees were built along major San Joaquin Valley rivers. San Joaquin Valley agriculture faced different water-related problems. Winter and spring rainfall there is substantially less than in the Sacramento Valley, thus San Joaquin Valley land needed to be irrigated if it was to reliably produce crops. With the Green Act as guiding legislation, more than 1,600 km. (1,000 mi.) of irrigation canals were developed by 1878 in Fresno County alone (ibid .).

In the following years, and continuing up to the present time, numerous and controversial water projects have been the hallmark of Central Valley development. The demand for water, so tied to the agricultural, commercial, and urban development of the Valley, was, at least indirectly, responsible for the degradation of many of the remaining riparian forests. Artificial levees, river channelization, dam building, water diversion, and heavy groundwater pumping were among the factors which reduced the original riparian forest to the small, scattered remnant forests found today.

Present Extent of Remnant Riparian Forests

In 1979, the Geography Departments of California State University, Chico, and California State University, Fresno, under contract to the California Department of Fish and Game, compiled riparian vegetation distribution maps for the Central Valley (Nelson and Nelson 1983). This mapping effort provided an essentially complete inventory of all extant riparian vegetation (not just mature forest) in the Central Valley.[4]

Using these maps, the areas and lengths of riparian systems were calculated on an individual map and county basis.[5] Even though there is no explicit riparian forest category on these maps, applicable classifications were determined which should represent riparian forests. Using this approach, it was determined that approximately 41,300 ha. (102,000 ac.) of riparian forest remain in the Central Valley today (Katibah etal . 1983). Of the 41,300 ha. of forest, approximately 19,800 ha. (49,000 ac.) are in a disturbed and/or degraded condition based on the riparian mapping category code. Approximately 21,500 ha. (53,000 ac.) were identified as mature riparian forest, with no indication of condition. However, based on recent research findings (Katibah etal . in press), it can be surmised that the majority of these 21,500 ha. of mature riparian forest have been and are currently being heavily impacted by human activities.

Conclusions

The complex hydrologic systems found in the Central Valley of California under pristine conditions are gone. The original riparian forests, dependent on the diverse Valley hydrology, are likewise gone for the most part. Today's riparian forests are in a precarious position as the demand for greater land utilization by the agricultural industry and the spread of urbanization threaten the remaining forest tracts.

Offsetting this trend, however, is a greater apreciation of the values (economic and noneconomic) of riparian forests by Valley landowners and the general public. Riparian forests are present in some of the finest and most popular parks in the Central Valley. These forests provide habitat for many of the Valley's wildlife species. They also contain numerous and diverse native plant species.

These values, among others, must compete with the most complex and controversial issue of all: water. In California as in the rest of the West, water equals development, and California does not have adequate water to meet its anticipated future demands. How the remaining riparian forests will fare in the future is not known. As interest in and knowledge about this resource develops, and as hindsight provides an understanding of the past, it is hoped that a reasonable compromise can be achieved between this unique and valuable resoure and the needs of society.

[4] Central Valley riparian mapping project. 1979. Interpretation and mapping systems. Report prepared by the Riparian Mapping Team, Geography Department, California State University, Chico, with the Department of Geography, California State University, Fresno. Unpublished report to the Califronia Department of Fish and Game, Planning Branch, Sacramento. 24 p.

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