

FEASIBILITY OF MAPPING RIPARIAN FORESTS UNDER NATURAL CONDITIONS IN CALIFORNIA¹

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Abstract: The California State Water Resources Control Board is conducting hearings to set quantity and quality standards for river flows into San Francisco Bay. Comparisons of present conditions with "natural conditions" prior to European settlement were introduced into the hearings. Consumptive use relations were developed for various riparian and water-related plants, and estimates of the total annual volume of runoff production and consumptive use were developed. A discussion of those computations and a general discussion of the relation of historic riparian forests to "natural flows" into San Francisco Bay is presented.

The California State Water Resources Control Board presently is holding hearings concerning standards for fresh water inflows into San Francisco Bay. During those hearings, the State Department of Water Resources (DWR) introduced data concerning "unimpaired flows" into the Bay Delta (DWR, 1987). They stated "Unimpaired flow could be synonymous with natural flow if all of the items in the unimpaired computation matched the natural flow computation." The data were "better described as unimpaired data, primarily because of the difficulty in computing four items of significance." One of those four items was "Consumptive use of the riparian vegetation... of the Central Valley under a natural state could be significant but (is) difficult to estimate." A first step in the reconstruction of natural flows would be to estimate the areal extent of riparian forests under natural conditions.

Sacramento River System

The Sacramento River and its major tributaries built natural levees along their banks. When they overflowed, the water slowed in the vicinity of the overbank and deposited the sediment that was carried by the river. The deposition created natural depressions which drained through sloughs. When enough water entered the basin to fill it to overflowing, the water would cut through the natural levee and erode a channel or slough. "The connecting slough channels, together with the steep slope of the trough, provide sufficient drainage so that all flood waters above Chico Creek flow back quickly into the

Sacramento River upon the subsidence of each flood, covering the lands flooded for only a period of two or three days. . . From a short distance below Stony Creek to its mouth, the Sacramento River has built up its banks on both sides by the deposit of sediment from the overflowing flood waters, to an elevation of from five to fifteen feet above the basins left on each side." (McClure, 1925, p. 19).

McGowan (1961) wrote "valley streams were generally confined to their banks. However, when a river in flood escaped... its banks and spread out over the surrounding countryside, it dropped its coarser sediments first along the edge of the river and... built a natural levee up to ten feet in height on top of its banks... As flood waters moved farther away from the river... their velocity was further decreased so that they now deposited the finer type of sediments... The overflow waters, which built up the land so that it slanted away from the river, eventually reached a trough. . . where they met water being drained from streams which flowed toward them. These troughs, called "basins", became the reservoirs for winter flood waters... Originally, tules, fifteen feet high, covered these basins from which water did not drain off sometimes until August." The Sacramento River overflowed its natural banks when peak flow exceeded stream capacity. The natural levees, basins and overflow lands, and sloughs which drained them created the environment for the riparian system.

Travelers' Accounts of Riparian Vegetation

Descriptions of the Central Valley, such as those above and by earlier explorers, can be used to determine the areal extent of the riparian vegetation before extensive modification by European settlement. The routes described by individuals in their diaries can be compared with published maps of vegetation to help to modify or verify those maps. Kuchler (1977) and Fox (1987) have published maps which can be used to plot estimated routes based on written accounts. (Fox's map is used later in this paper because it is at a good scale, about 1:2,000,000, to show most of the Delta and the riparian forest on one page.) Some accounts of areal extent

¹ Presented at the California Riparian Systems Conference; September 22-24, 1988; Davis, California.

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of riparian vegetation can be used with the maps and travellers' accounts.

Extent of Natural Tule Areas

Cronise wrote in 1868 "Along the San Joaquin River, which spreads out into numerous sloughs, there is, in the northwestern part of (San Joaquin County), an immense expanse of tule marsh—not less than 200,000 acres, much of which is covered at all times by a few inches of water, nearly the whole being submerged at high stages of the tide. Late in the season...large sections of these lands become dry on the surface—the dense body of rushes... having meantime wilted and dried up, the latter often take fire, and burning with terrific fierceness and living tules. In all counties of tule lands, these fires are common, generally occurring in the fall and winter." Based on Cronise's figures and calculations based on his statements, the estimate of the area of tule lands in the Central Valley in 1868 is about 600,000 to 700,000 acres before any major drainage projects.

Savannas, Not Tules, Recorded

Spanish Expeditions

The first Spanish explorers described the immense plains in the Delta. On September 23, 1776, a joint river and land expedition of Spanish explorers started up the river (Bolton, 1926), but only the land exploration continued, and "as soon as it crossed the mountains through a pass of low hills... found itself in the plain which is crossed by the large river (San Joaquin)... they were much farther up than had been agreed upon... decided to continue through the plain up the river. He (followed) the stream for three entire days, traveling rapidly. . . The plain through which that river runs... is as level as the palm of the hand, without any trees except in the bed of the river. It is an immense plain, for he did not see the end of it... After traveling much further on the bank of the river. . . he crossed the great river (and) On the other side of the river he found that the same plain and level land continued. They traveled over it all day."

The Moraga expedition of 1808 gave a similar report (Cutter, 1957). He wrote "Today we left (near present-day Livermore) travelling northeast. After about 12 leagues we arrived at the (West Channel of the San Joaquin in its delta area). Having crossed a branch of that river, we spent the night safely... Leaving camp where it was pitched yesterday, this morning...I continued on toward the east, and after about 2 leagues I found the river and I followed it south for about 4 leagues. No ford could be found in this distance... In the afternoon I sent the corporal in a northerly direction in search of

the ford in the river. He found it, but on the opposite side he was confronted by a very large tular and could not continue." (9 Oct 1808) "Today we... moved to the river discovered yesterday...I sent the corporal downstream... He couldn't reach (the mouth of the American River) because of the abundance of tules." (15 Oct 1808) "Today we left for the (Mokelumne River). I went downstream towards the marshes and found nothing good except an immense oak grove." (20 Oct 1808) "Today we followed the (Merced) river downstream, exploring it to its junction with the San Joaquin.. . the low plains of the river are nitrous to within a distance of 2 leagues, more or less, before reaching the San Joaquin.. . There are some beautiful willow groves..."

von Kotzebue

The Spanish were interested in the exploration of the San Joaquin inland from their line of missions. They reported extensively on the tules which grew along the San Joaquin in the Delta. Other explorers tended to go up the Sacramento. The Russian, Admiral von Kotzebue, ventured up the Sacramento to the fork with the Feather. He wrote of his trip (von Kotzebue, 1967) "On the 18th of November (1824) the weather was favorable, and we set out... working our way between the islands into the northern portion of the bay... We reached... at a distance of thirty miles from our ship, the common mouth (Carquines Straits) of the two before-mentioned rivers which here fall into the bay... I ascended the highest hillock on the shore... to the north flowed the broad beautiful river formed by the junction of the two, sometimes winding between high, steep rocks, sometimes gliding among smiling meadows, where numerous herds of deer were grazing. In every direction the landscape was charming and luxuriant... we continued our voyage up the stream... We landed... after working only a few miles, and pitched our tents for the night in a pretty meadow... When we had proceeded eighteen miles from our night camp, and twenty-three from the river's mouth, we reached the confluence of the (Sacramento and San Joaquin) . . . Since the river Pescadores (San Joaquin) was already known, I chose the other... after we had ascended it some miles, a violent ... wind forced us ashore; latitude 38 22' (about mile 38) . . . we were obliged to give up for this day. . . pitched our tents in a pleasant meadow . . . I then climbed a hill... and observed that the country to the west swelled into hills of a moderate height, besprinkled with trees growing singly... Between (the mountains) and the river, the country is low, flat, thickly wooded, and crossed by an infinite number of streams, which divide... it into islands... At sunrise... we continued our voyage... The river now took a north-westerly direction.. . The country on the west bank was of moderate height; that on the

east was low. The power of the current impeded our progress, though our rowers exerted all their strength.. . . .Early the next morning we prepared for our return, and soon quitted these lovely and fertile plains..."

Leonard

Zenas Leonard traveled to Suisun Bay from the Merced River in early November 1833. He wrote (Ewers, 1959) "This plain (going down the Merced to the San Joaquin) is well watered and is quite productive, as we found a large quantity of wild pumpkins and wild oats... The land is generally smooth and level, and the plains or prairies are very extensive, stretching...as far as the eye can reach... (rivers run) parallel with each other through the plain... with their banks handsomely adorned with flourishing timber of different kinds... This grove of timber may be found along the river at any point, and generally extends about four miles into the plain. Between this grove of timber and the forest extending from the foot of the mountain, there is a level prairie of the richest soil, producing grass in abundance large prairie covered with wild oats... This plain lays on the south side of the river." (February 15, 1834) "Continued our journey up Sulphur River (San Joaquin), passing through a fine country, most of which is prairie, covered plentifully with wild oats and grass."

Belcher

The English Captain Belcher explored the Sacramento in 1837. He wrote (Pierce and Winslow, 1969) "Having entered the Sacramento... The marshy land now gave way to firm ground, preserving its level in a most remarkable manner, succeeded by banks well wooded with oak, planes, ash, willow, chestnut, walnut, poplar, and brushwood. Wild grapes in great abundance overhung the lower trees, clustering to the river...On the 30th (October 1837), about four p.m., we found the deep boats stopped at (the forks of the Feather and the Sacramento)... Throughout the whole extent... the country is one immense flat...Our course lay between banks, varying from twenty to thirty feet above the river-level... These were, for the most part, belted with willow, ash, oak, or plane,... which latter, of immense size, overhung the stream... Within, and at the verge of the banks, oaks of immense size were plentiful. These appeared to form a band on each side, about three hundred yards in depth, and within (on the immense park-like extent, which we generally explored when landing for positions) they were to be seen in clumps... wandering over what might otherwise be described as one level plain or sea of grass..."

Phelps

William Dane Phelps traveled up the Sacramento in 1841 to visit Capt. Sutter, at his fort at Sacramento. Phelps wrote (Busch, 1983) "About a mile inside the Sacramento we passed the mouth of the St. Joachin... we continued on for about 20 miles. All the distance the banks were low and covered with rush flags or Tules as they are called here. At 11 PM having passed all the Tule, we ran along the high banks on which were many high trees... stopped by the side of a beautiful wood, and dined under the wide spreading limbs of a gigantic oak... The immense size of the trees, the dense thickness of the unpenetrated forests in some places, and the level plains with here and there a bunch of scrub oaks without underbrush in others, together with a profusion of wild flowers... The forests consist mostly of sycamore, a variety of oak, but mostly the white, ash & some walnut." (29 July 1841) "The river here is broader than below, and the banks higher. The country looks fertile and with just trees enough to give it a pleasant appearance. . . (We) started (for Sutter's Fort) at 1/2 past 4 and riding over a beautiful gently undulating country abounding with rich feed and agreeably diversified with trees & wild shrubbery."

M'Collum

M'Collum (Morgan, 1960) describes the San Joaquin in 1849. "Bound for the southern mines... we were... going up. . . the San Joaquin to Stockton... The passage up the San Joaquin was a dreary one. The river for the greater portion of the way winds like a tape worm, through low marshy ground, where the tules, grow to an enormous height, not allowing us to see out... As you approach Stockton, the uplands, oak-openings and glades of timber, begin to approach the river. . . The tide of the ocean... sets up here, from one to two feet."

Bryant

Edwin Bryant came overland to California (Bryant, 1985). On August 30, 1846, his party reached Johnson's farm on Bear Creek, 40 miles upvalley from Sacramento. August 31 they "marched south seven miles, and encamped on the bank of a chain of small ponds of water. The grass around the ponds was rank and green, and we were protected from the hot rays of the afternoon sun by the shade of evergreen oaks." They traveled on south down the valley 26 miles to the American River. "The valley of the Sacramento, as far as we have travelled down it, is from 30 to 40 miles in width, from the foot of the low benches of the Sierra Nevada, to the elevated range of hills on the western side. The composition of the soil is trodden up by immense herds of cattle and horses which grazed here early in the spring, when it was

wet and apparently miry. We passed through large evergreen oak groves, some of them miles in width." They marched down the overflow basin from the Bear River on the east side of the Sacramento to the American River, and noted evidence of previous spring overflows, but no tules.

Bryant continued "September 13th.-We commenced to-day our journey from New Helvetia to San Francisco ... we travelled in a south course over a flat plain... and encamped on a small lake. . . near the Coscumne river.. . The stream is small, but the bottom lands are extensive and rich... The grass on the upland plain over which we have travelled, is brown and crisp from the annual drought. In the low bottom it is still green." "September 14.-We crossed the Coscumne river... and travelled over a level plain covered with luxuriant grass and timbered with the evergreen oak, until. . . we crossed the Micklemees river... and encamped on its southern bank in a beautiful grove of live-oaks... The soil of the bottom... produces the finest qualities of grasses. The grass on the upland is also abundant... Our route has continued over a flat plain, generally covered with luxuriant grass, wild oats, and a variety of sparkling flowers... Large tracts of the land are evidently subject to annual inundations. About noon we reached a small lake surrounded by tule... Passing through large tracts of tule we reached the San Joaquin at dark, and encamped on the eastern bank... The ford of the San Joaquin is about forty or fifty miles from its mouth... Oak and small willows are the principal growth of wood skirting the river... Entering upon the broad plain we passed, in about three miles, a small (alkali) lake. The grass is brown and crisp... We passed during the afternoon several tule marshes, with which the plain of the San Joaquin is dotted. At a distance, the tule of these marshes presents the appearance of immense fields of ripened corn. The marshes are now nearly dry, and to shorten our journey we crossed several of them without difficulty. A month earlier, this would not have been practicable... While pursuing our journey (across the Delta to the Ranch of Dr. Marsh) we frequently saw large droves of wild horses and elk grazing quietly upon the plain."

Bryant visited with Dr. Marsh. "Sept.17... After breakfast I walked with Dr. Marsh to the summit of a conical hill... from which the view of the plain on the north, south, and east, and the more broken and mountainous country on the west, is very extensive... The hills and the plain are ornamented with the evergreen oak, sometimes in clumps or groves, at others standing solitary... the San Joaquin, at a distance of about ten miles, is belted by a dense forest of oak, sycamore, and smaller timber and shrubbery. The herds of cattle are scattered over the plain,—some of them grazing upon the brown, but nutritious grass; others sheltering them-

selves from the sun, under the wide-spreading branches of the oaks." The southern part of the San Joaquin Delta as seen from its western edge, prior to the coming of the Americans, seemed to have scattered tracts of tules in some parts.

Bryant travelled up the Sacramento. "October 24 (1846)... About two o'clock, P.M., we entered the mouth of the Sacramento. The Sacramento and San Joaquin rivers empty into the Bay... at the same point ... and by numerous mouths, or sloughs... These sloughs wander through an immense timbered swamp.. . The banks of the river and several large islands which we passed during the day, are timbered with sycamore, oak, and a variety of smaller trees and shrubbery. . . The islands of the Sacramento are all low, and subject to overflow in the spring of the year. The soil of the river bottom, including the islands, is covered with rank vegetation, a certain evidence of its fertility..." Bryant continued "October 25... As we ascended the stream the banks became more elevated, the country on both sides opening into vast savannas, dotted occasionally with parks of evergreen oak."

Comparison with the Fox Natural Vegetation Map

Figure 1 is a partial copy of Fox's map (1987) of natural vegetation for the middle part of the Central Valley. Point A is in the vicinity where the 1776 Spanish expedition hit the San Joaquin and traveled upstream without mention of trees. The band of riparian forest shown by Fox is 5 miles in width. B1 to B2 show the reach that the Moraga expedition of 1808 explored along the San Joaquin and at the mouth of the Mokelumne and the Merced Rivers.

Point C is the farthest point reached by Captain Belcher and by von Kotzebue. They reported oaks and savannah after the first few miles up the Sacramento. Tules shown by Fox north of the Sacramento should be riparian forest and savannah. Point D1 is about the point at which Phelps in 1841 reported he ran along high banks on which were many high trees. This report agrees with those of Belcher and von Kotzebue. Point D2 is where Phelps traveled overland. The area of tules shown by Fox should be much reduced in size.

The line marked E is the approximate route of Edwin Bryant in 1846, and is close to the "road across the plains" on Lt. Derby's map of 1849 (Thompson, 1961), which shows the road about 4 miles from the river, with riparian forest a mile wide on the west bank and about three miles wide on the east bank from the Feather to the American.

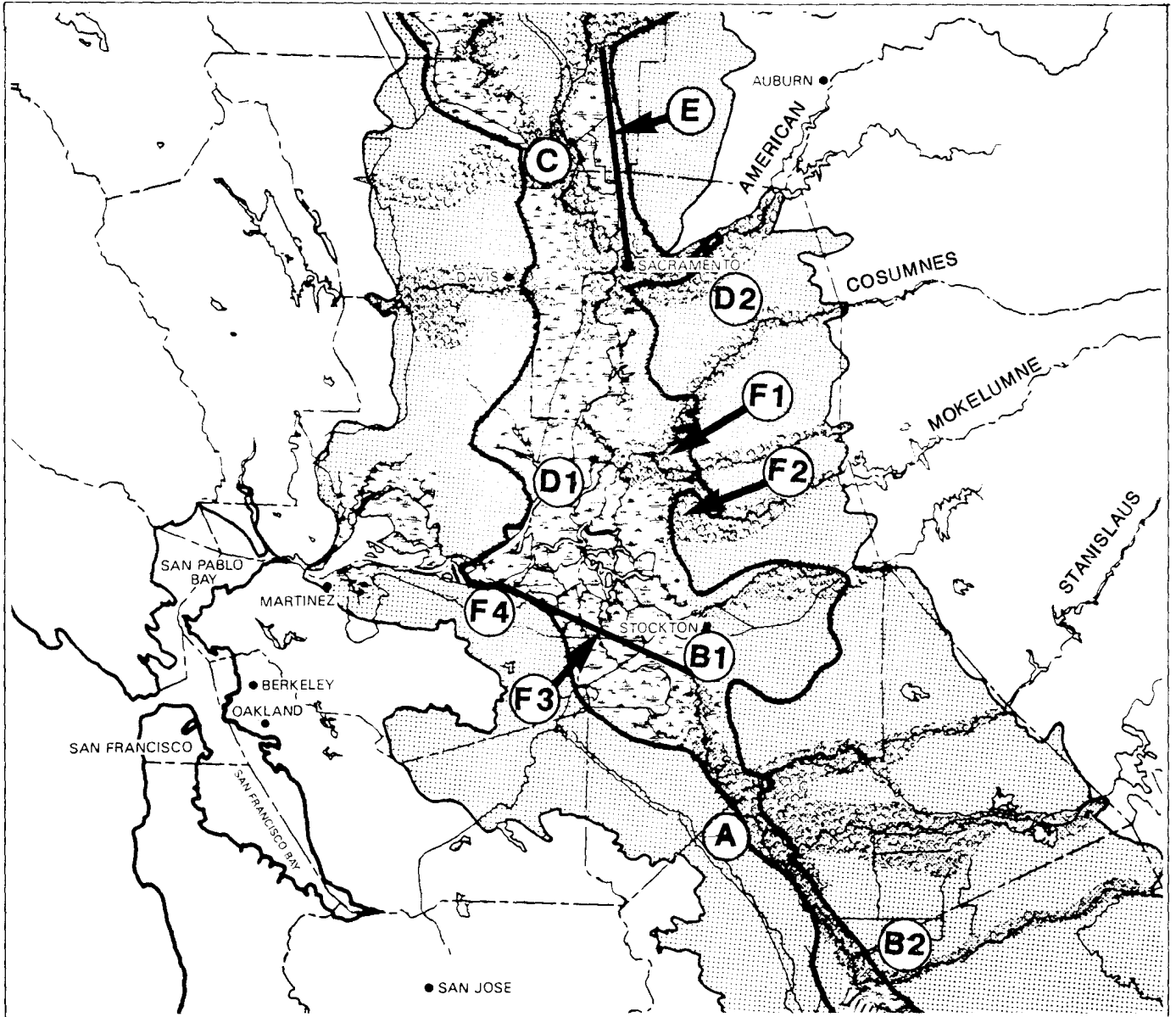


Figure 1 — Partial copy of Fox's map for Central Valley showing location and routes of early travelers.

Points F1 to F4 trace the route of Bryant. At F1 on the crossing of the Cosumnes he reported grass in the "low bottom" of the river, at F2 on the crossing of the Mokelumne "the bottom... produces the finest qualities of grasses." The line marked F3 is in the vicinity of where Bryant broke off the usual road and struck off across the south part of the Delta. Much of the area shown as tules by Fox was mixed plains dotted with tule marshes which went dry late in the summer. Point F4 is where Bryant climbed a hill south of Antioch and looked over the south Delta.

Estimates of Extent of Riparian Forests

Smith (1977) says "The riparian woodlands occurred on the natural levees formed by the Sacramento, Lower Feather, American, and other aggrading streams... Based on historical accounts, it has been estimated that there were about 775,000 acres of riparian woodlands in 1848-1850." Roberts and others (1977) estimated 800,000 acres in 1848, and Fox estimated 938,000 acres

(1987, Table 3) for the Sacramento Basin. Katibah (1984) gave a more detailed listing of the locations of the riparian forest stands in presettlement times. Katibah's listing cannot be matched precisely with Fox's, but an approximate comparison is as follows:

Location	Fox Table 3	Katibah Table 1 acres
Sacramento Basin	938,000	583,400
Delta	198,000	100,700
San Joaquin Basin	298,000	187,500
Tulare Basin	515,000	50,000
Total	1,949,000	921,600

Katibah's estimates are conservative and subject to refinement. Sacramento plus Delta, 684,100 acres is compared with 775,000 of Smith and 800,000 of Roberts. Katibah appears to be about 15 percent below the others. Scott and Marquiss (1984) agree with the 800,000 acres, quoting an unpublished report. Fox appears high.

Conclusions

A more extensive study of the routes of the various travelers, the study of unpublished diaries, and a comparison with published maps and accounts of extent of riparian vegetation can be used to map more thoroughly the areas covered by various types of vegetation during the time immediately prior to European settlement and, in particular, before the time of American settlement in the Central Valley. A more accurate mapping of the riparian forests can be helpful in the determination of natural water use and water availability in the Central Valley.

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