

between 20 and 1600 m, from Shasta County to Butte County in the foothills of the Sierra Nevada and to Contra Costa County in the Coast Ranges.

Jepson's description of *A. californica* states that "the leaflets are always smaller and usually much thinner" than in *A. tomentosa*. In addition, he notes that *A. tomentosa* is "hoary-tomentose, has equal rays, and solitary depressed oil-tubes in the intervals", as compared to "3 oil-tubes in the intervals" of *A. californica*. It is puzzling that Jepson neglected to consider ovary pubescence, ray orientation, and glaucousness of leaflets in his comparison of the two taxa. I have found these characters to be very effective in separating *A. californica* and *A. tomentosa* in the field. However, several of the important field characters, e.g., glaucousness, ray orientation, umbel shape, and orientation of the mature fruiting stem, are not always evident in herbarium material. This, and the presumed restriction of *A. californica* to the Vaca Mountains, may have contributed to Jepson's later decision, in 1901, and that of Mathias and Constance (1944-45) to include *A. californica* in *A. tomentosa*.

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COMPOSITION OF NATIVE GRASSLANDS IN THE SAN JOAQUIN VALLEY, CALIFORNIA

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ABSTRACT

The native grasslands of California have undergone great change since European contact but early accounts of Spanish and Anglo-Americans provide some information about their former condition. They suggest that the dry alluvial fans of the San Joaquin Valley, which account for 60 percent by area of California grasslands, were dominated by annual species and xerophytic shrubs. Perennial bunchgrasses were common only on certain well-watered floodplains.

Alterations in the grasslands of California as a result of European contact and settlement were great and began so early in the historic period that the former condition of these grasslands will always be open to question. Evidence from written documents and contemporary field observations supports the view that perennial bunchgrasses were abundant in communities now composed largely of exotic annuals. This had led to the conclusion, now widely accepted, that all native grasslands were dominated by perennial species (Munz and Keck, 1949; Clark, 1956; Oosting, 1956; Benson, 1957; Burcham, 1957; Munz, 1959; Muller and Muller, 1964; Wells, 1964; Dasmann, 1966; McCown and Williams, 1968; Crampton, 1974; Ornduff, 1974; Heady, 1977; Kuchler, 1977). Some of the interpretations of fact have been questioned and doubt has been expressed that the bunch grasslands were as extensive as has been assumed (Biswell, 1956; Twisselmann, 1963, 1967; Klapp, 1964; Naveh, 1967; McNaughton, 1968). The objective of this paper is to review the evidence on the nature of the prehistoric grasslands, giving emphasis to documentary information from the southern Central Valley. It was here on the dry alluvial fans that the largest tracts of native grassland occurred (Fig. 1), yet most of the evidence that has been used to reconstruct the former condition of the community is derived from much more humid sites either along the coast or at higher elevations.

DOCUMENTARY EVIDENCE

Perennial bunchgrasses. Toward the end of the nineteenth century the deterioration of the quality of California rangelands was investigated in several important surveys reviewed by Talbot and Crone-miller (1961). Of particular concern was the invasion by annuals and

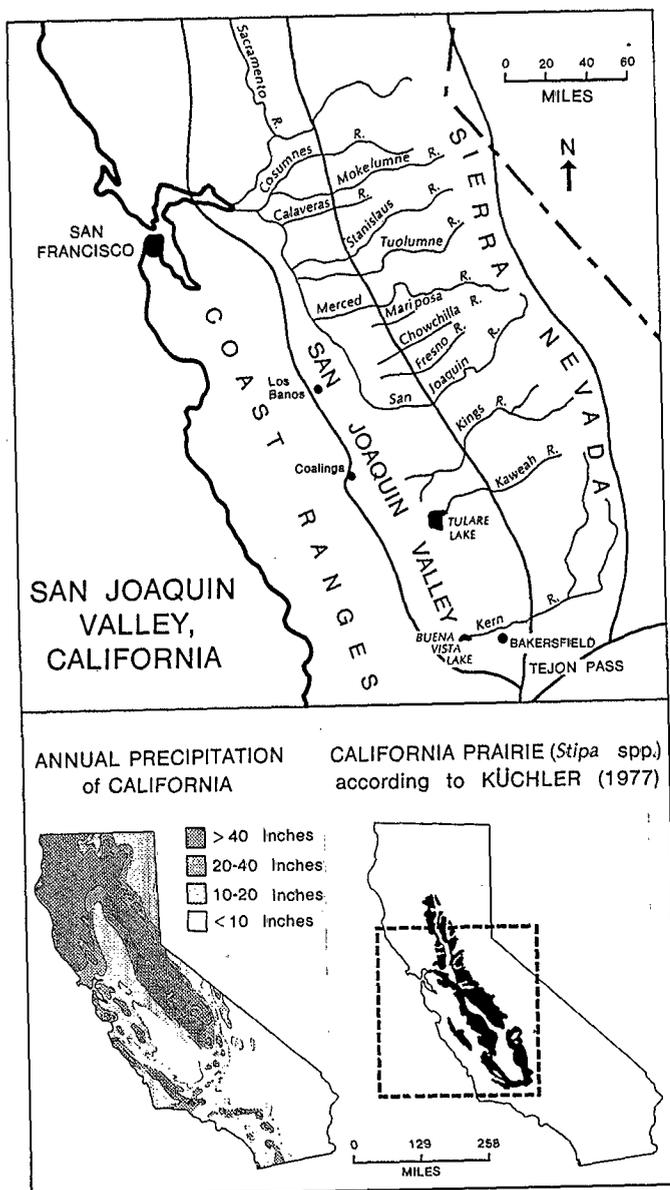


FIG. 1. The natural setting of native grasslands in California. Upper: The San Joaquin Valley. Lower: California precipitation (left); California prairie (right), after KÜchler, 1977.

replacement of perennial grasses that reduced the carrying capacity of the range. In a study of a portion of northwestern California Davy (1902) carefully documented reports of residents who observed the decline of bunchgrasses over many years. More recently Burcham (1957), in his detailed history of California rangeland, collected further early written descriptions of bunchgrass where annual grasslands stand today. Almost all of these sites are in northern coastal locations (Mendocino, Humboldt, and Monterey Counties) where mild, humid conditions prevail all year. One exception is an account from Bryant (1848, p. 309) which was made during a journey from the San Joaquin Valley to San Jose in 1847.

From this plain we entered a hilly country, covered to the summits of the elevations with wild oats and tufts or bunches of a species of grass, which remains green throughout the whole season.

The reference is unmistakably to the hills of the Coast Range where pockets of bunchgrasses may still be found. Yet this description stands in strong contrast to the scene in the San Joaquin described by the same person at another point along the way. The more arid Valley plains which stood above the river bottoms were characterized as "dry and crisp" with "large tracts of wild oats" (Bryant, 1848, p. 300). No mention was made of bunchgrasses at these locations.

The absence of information about natural conditions in the San Joaquin Valley is often attributed to the lack of detail in the first accounts by the Spanish and the disruption of the ecosystem by feral herbivores before Anglo-Americans made more accurate descriptions. It is true that feral horses were present in the Valley at least by 1807 (Cook, 1960) and extremely large herds were noted after 1830, when hunting by Indians ceased as a result of decline in human populations (Bryant, 1848; Fremont, 1848; Leonard, 1904; Farquhar, 1937). However, there are instructive Spanish accounts, made even before feral livestock could have had significant effect, which leave no doubt about the scanty natural plant cover at least during certain times of the year. Zalvidea described the area around Buena Vista Lake in July 1806 in the following manner:

The area covered in the morning consisted of extensive plains. In quality the land is alkaline. The shore of the lake is completely covered with a great deal of tule. Elsewhere, and in the hills bordering the plains, I saw neither pasturage nor watering places. (Cook, 1960, p. 245)

Muñoz, diarist on the Moraga expedition, in October of the same year judged the country he saw in present day Merced and Madera Counties to be equally barren.

All the country traversed today has very poor grass and is very stony . . . All the country we observed between the Tecolote [Chowchilla River] . . . and the Santa Ana [Fresno River] is worse than bad. From the Santa Ana to the San Joaquin there is a little pasturage, although it is sparse and spread out widely. (Cook, 1960, p. 251)

The Martinez expedition in 1816 saw the same region in May and even reported a bunchgrass growth form that almost certainly referred to *Sporobolus airoides*, a plant tolerant of high salinity and common in the marshes of the Valley even now. Otherwise the herbaceous vegetation was very poor.

In all our trip we did not see a good tree, nor wood enough to cook a meal, nor a stone, nor even grass enough for the horses, more than bunchgrass, or what grows in the swamps. (Cook, 1960, p. 271)

Similarly in June, 1824, Portilla said: "The road was flat and the land quite poor, with no grass" (Cook, 1962, p. 155).

Similar observations were made by early Anglo-American travellers after 1840 and, quoted alone, they are often cited as evidence of environmental degradation caused by feral cattle and horses. In fact barrenness may have been a natural condition of the landscape. Serious overgrazing may not have occurred until the droughts of 1861 and 1864, the first since stock had been brought to the Valley in large numbers in response to the demand for meat created by the gold rush.

When Fremont passed over the land between the Kings and Kern Rivers in April 1844 he noted:

To-day we made another long journey of about forty miles, through a country uninteresting and flat, with very little grass and a sandy soil. (Fremont, 1845, p. 253)

Others reported similar conditions in the 1850's.

The Tularé Valley, from the mouth of the Mariposa to the Tejon pass at its head, is about one hundred and twenty miles in extent, and varies from eight to one hundred miles in width. With the exception of a strip of fertile land upon the rivers emptying into the lakes from the east, it is little better than a desert. The soil is generally dry, decomposed and incapable of cultivation, and the vegetation, consisting of artemisias and wild sage, is extremely sparse. (Farquhar, 1937, p. 262)

The plains between the streams are destitute of foliage, and the soil generally gravelly and poor. (Williamson, 1855, p. 13)

There was but little or no vegetation, and the surface was dry and gravelly. (Blake, 1855, p. 41)

After leaving the grove by the [Kern] river, we entered at once among the most desolate hills. Not a sign of herbage was seen on them—not enough to attract a bee. (Kip, 1954, p. 92)

One might expect that had bunchgrasses been present at least the basal tussock would have been obvious throughout the year and might have attracted some attention. In fact, Fremont, whose descriptions are the most detailed of any explorer, does mention bunchgrasses on two occasions. Both of these were in exceptionally well-watered sites east of the delta in the Sierra Nevada foothills. Those sites receive runoff from the mountains in addition to the local precipitation.

Leaving the Mo-Kel-um-ne, . . . we travelled about twenty miles through open woods of white oak, crossing in the way several stream beds—among them the Calaveras creek. These have abundant water, with good land above; and the Calaveras makes some remarkably handsome bottoms. Issuing from the woods, we rode about sixteen miles over an open prairie, partly covered with bunch grass, the timber reappearing on the rolling hills of the river Stanislaus in the usual belt of evergreen oaks (Fremont, 1848, p. 16). Emerging from the woods, we travelled in a southeasterly direction, over a prairie of rolling land, the ground becoming somewhat more broken as we approached the To-wal-um-ne river, one of the finest tributaries of the San Joaquin. The hills were generally covered with a species of geranium, (*erodium cicutarium*), a valuable plant for stock, considered very nutritious. With this was frequently interspersed good and green bunch grass, . . . (Fremont, 1848, p. 17)

Fremont makes it clear that this verdant condition was confined to the northeast portion of the San Joaquin Valley, because only a little farther south, beyond the Merced River, he noted:

. . . the country had lost its character of extreme fertility, the soil having become more sandy and light . . . (Fremont, 1845, p. 250)

Annual herbs. If perennial bunchgrasses were not common the question arises what were the dominant herbaceous species. Other accounts from the more typical dry plains of the Valley make no mention of bunchgrasses but describe in some detail the annual herbs that grew abundantly, at least in wet years, and appeared to be the dominants in the community. For example, in the spring of 1850 a traveller making his way through the Coast Ranges at the latitude of Los Banos observed the change in aspect of vegetation as he approached the Valley.

By this time we could see what had caused the mass of color so noticeable from the mountain the day before. The entire plain,

as far as we could see, was covered with wild flowers. Almost all of the flowers were new to us. . . .

As we passed below the hills the whole plain was covered with great patches of rose, yellow, scarlet, orange and blue. The colors did not seem to mix to any great extent. Each kind of flower liked a certain kind of soil best and some of the patches of one color were a mile or more across. (Mayfield, 1929, p. 9)

A few years later Muir described a similar phenomenon:

The Great Central Plain of California, during the months of March, April, and May, was one smooth, continuous bed of honey-bloom, so marvelously rich that, in walking from one end of it to the other, a distance of more than 400 miles, your foot would press about a hundred flowers at every step. Mints, gilies, nemophilas, castilleias, and innumerable compositae were so crowded together that, had ninety-nine per cent of them been taken away, the plain would still have seemed to any but Californians extravagantly flowery. . . . Because so long a period of extreme drought succeeds the rainy season, most of the vegetation is composed of annuals, which spring up simultaneously, and bloom together at about the same height above the ground, the general surface being slightly ruffled by the taller phacelias, pentstemons and groups of *Salvia carduacea*, the king of the mints. (Muir, 1894, p. 342)

Fremont also mentioned fields of wildflowers during his 1845 expedition even though it was early in the season (January and February).

The California poppy, (*Eschscholtzia Californica*), the characteristic plant of the California spring; *memophila insignis* [sic], one of the earliest flowers, growing in beautiful fields of a delicate blue, and *erodium cicutarium*, were beginning to show scattered bloom. (Fremont, 1848, p. 19)

Descriptions of spring wildflower blooms have not been found in the Spanish records because most expeditions were made in summer months. However, in July, 1806, Zalvidea reported flowering of a summer growing herb, probably *Hemizonia pungens*, in the southern San Joaquin Valley.

All this territory is covered with a species of herb which has a little stem with a yellow flower, the stalk being no more than a quarter [of a yard] high. (Cook, 1960, p. 246)

The occurrence of *Erodium* as a component of herbaceous cover at an early date is of special interest because the common species (including *E. cicutarium*) are generally considered to be native of Mediterranean Europe (Robbins, 1951; Clark, 1956; Munz, 1974).

Fremont mentioned it on a number of occasions during both his 1844 and 1845 expeditions (Fremont, 1845, 1848) and leaves no doubt about its abundance in the Central Valley, and the fact that Indians made use of the plant.

Instead of grass, the whole face of the country is closely covered with *erodium cicutarium*, here only two or three inches high. Its height and beauty varied. . . . being, in many low places which we passed during the day, around streams and springs, two and three feet in height. (Fremont, 1845, p. 253)

Other accounts from the first ranchers to settle a portion of the West Side plains near present day Coalinga emphasize how *Erodium* appeared to dominate the ground cover presumably in the absence of tall growing perennial grasses.

This valley was covered with the finest possible stand of dry alfileria, remaining from the extremely wet winter of 1852. (Latta, 1949, p. 333)

Erodium cicutarium was apparently common throughout the Southwest at the time of the first scientific explorations (Torrey, 1859) and was so widely naturalized in California even early in the nineteenth century that Brewer and Watson (Calif. Geol. Survey, Bot., 1880) doubted that it was an exotic. The discovery of the species in the earliest known adobe bricks made by the Spanish suggested to Hendry (1931) that it spread into California before European settlement, a possibility that Jepson (1933) also accepted. The plant has very effective dispersal mechanisms and others of the genus are native to North America and Australia. It is possible that *E. cicutarium* itself may have reached the New World without human assistance. If the species was either indigenous to California or spread ahead of settlement, then its presence, especially in more arid sites, cannot be used as an indication of environmental degradation.

Hoover (1935) felt grasses were relatively unimportant in the "primitive" flora of the San Joaquin Valley. References to them in the written records are rarely specific enough to allow identifications to be made with confidence. Several early references to 'wild oats' have been found (Bryant, 1848; Perkins, 1863; Leonard, 1904; Latta, 1949), but the name may have been applied to many annual grasses in the same way that 'sage brush' was used to describe any grey-green shrub and not specifically species of *Artemisia*. It is less likely that *Avena* could be mistaken for a bunchgrass that possesses a quite different life-form.

RELICT ANALYSIS

Observations by Davy (1902) in northwestern California strongly suggested that sites protected from grazing tended to contain more

abundant native perennial bunchgrasses. In 1917 and 1918 Clements found the bunchgrass *Stipa pulchra* (probably including *S. cernua*) common in fenced railroad rights-of-way in the Central Valley and, believing them protected from grazing and burning, concluded that this drought-tolerant perennial must have dominated the grassland before grazing caused its replacement (Clements, 1934; Clements and Shelford, 1939). However, Biswell (1956) has pointed out that these sites were burned almost annually to prevent accidental fires and this *Stipa*, which is favored by burning, probably became established only as a result.

In the southwestern San Joaquin Valley other relict sites protected from grazing, such as fenced road sides, oil fields, quarries, and arroyos were searched but no perennial grasses were seen. Instead, xerophytic shrubs, particularly of *Atriplex polycarpa*, were often found growing more prolifically than on adjacent grazed rangeland. This saltbush is rated highly as a browse (Piemeisel and Lawson, 1937; Chatterton, 1970) and its decline under grazing has been noted (Love and McKell, 1966). It is quite possible that in the drier portion of the Central Valley, especially the West Side, this community of low shrubs was once more extensive than at present.

PRESENT DISTRIBUTION PATTERNS

It is often stated that *Stipa pulchra* and *S. cernua* were dominants in the grasslands and occupied more space than all the other species combined. *Poa scabrella*, *Aristida divaricata*, *Koeleria macrantha*, *Melica imperfecta*, and *M. californica* may have been generally widespread whereas *Danthonia*, *Festuca*, *Deschampsia*, *Agrostis*, and *Muhlenbergia* species may have had more restricted distributions (Shantz and Zon, 1924; Clements, 1934; Clements and Shelford, 1939; Beetle, 1947; Munz and Keck, 1949; Burcham, 1961; Crampton, 1974; Ornduff, 1974). Twisselmann (1963, 1967) observed *Stipa* to be uncommon where annual precipitation falls below 245 mm and does not occur at all in places receiving less than 200 mm. The distribution map of *Stipa* published by Stebbins and Love (1941) supports Twisselmann's observation by showing *Stipa* to be absent from the dry western San Joaquin Valley and elsewhere confined largely to riparian or foothill sites. Furthermore, this is in close agreement with an early report by Brewer to Watson when the former made collections for the first flora of the State in 1863.

Stipa setigera [*S. pulchra*, *S. cernua*]. It is common on the Coast Ranges and on the foothills of the Sierra Nevada and according to Prof. Brewer, is the most common and, valuable "Bunchgrass" of the dry hills. (Calif. Geol. Survey, Bot., 1880, vol. 2, p. 286)

Botanical reconnaissance made in conjunction with the railroad surveys of the Central Valley indicates that 75 grass species were collected, of which only one or perhaps two, *Poa douglasii* and *Elymus* sp., are perennials (Durand and Hilgard, 1855). Had bunchgrasses been as abundant as supposed, one would expect them to be better represented in the collections made before significant settlement occurred in the region.

Areas of bunchgrass identified by Crampton (1974) in the delta region occupy relatively moist sites influenced by the cool, humid, maritime air able to penetrate to this part of the Central Valley through the San Francisco Bay gap. These conditions are not typical over the remainder of the Valley.

In California, variable and unpredictable moisture, temperature, and light at the time of germination and the cool winter months cause extraordinary variation in productivity and floristic composition from year to year (Heady, 1956; Naveh, 1967). Klapp (1964) has concluded that ephemeral annuals are best adapted to this unpredictable and inconsistent climate. In its drier phases the climate is unsuitable for most perennial herbs, and the grasslands of this region are composed mainly of annual species, standing in marked contrast to communities in other temperate areas.

CONCLUSIONS

Evidence for the former importance of perennial bunchgrasses in the grasslands of California, and their subsequent decline as a result of grazing, exists for many places in the Coast Ranges, the Sierra foothills and in some localized, well-watered floodplains in the interior. However, the San Joaquin Valley, which contained much of California's native grasslands, was either wetland of fluctuating extent or dry alluvial fan. The degree of its natural aridity may not have been appreciated because earliest settlement was concentrated along the riparian oases and later large scale irrigation schemes caused almost all of the thin natural vegetation cover of the plains to be replaced by highly productive agriculture. Observations used to reconstruct the former composition of grassland communities comes from humid parts of the State that were settled first. This information cannot be extrapolated to explain conditions in drier locations such as the San Joaquin Valley.

Accounts of the San Joaquin Valley by Anglo-Americans are said to represent descriptions of an environment already degraded by the grazing of feral livestock, yet observations made by the Spanish before any significant impact of European civilization are quite consistent with those of the middle of the nineteenth century. Neither indicate the existence of perennial bunchgrasses but instead emphasize the lack of vegetation cover during the dry months and the abundance of bril-

liantly flowering herbs in the spring. This leads to the conclusion that, except for riparian and wetland sites, much of the southern Central Valley supported a grassland of annual species or, in the most arid parts on some soils, a community of xerophytic shrubs with an understory of annuals.

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