

Burning and the Grasslands in California

HAROLD F. HEADY

*Professor of Forestry (Range Management)
University of California, Berkeley, CA 94720*

THIS paper reviews historical, observational and quantitative studies to develop a viewpoint toward fire in the California grasslands west of the Sierra Nevada Mountains. No more than a half dozen papers report grassland measurements following experimental fire treatments, from the same plots before and after fires, and from paired plots on burned and unburned sides of a fireline. Chaparral and mixed conifer vegetational types in the State have an abundant fire literature and long-standing controversies about the use and control of fire. The contrast may gauge the unimportance of fire as an ecological factor and a management tool in the California grasslands.

THE GRASSLANDS

These grasslands occur separately and intermingled with other vegetational types below 4,000 feet elevation in the foothills surrounding the Central Valley and in the coastal mountains of California. The climate is typically Mediterranean with cool-wet winters and hot-dry summers. Geographical variation in precipitation ranges from 100 inches per year in northwestern California where the grassland alternates with redwood forest to a low of 5 inches per year along the western side of the San Joaquin Valley. Dry vegetation and grassland fires may be restricted to a few autumn weeks in the northern end of the grassland and occur in any month of the year in the southern portion.

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Throughout their ranges, the grass types intergrade with chaparral and occur as an understory in oak woodland (Fig. 1). Between 4,000 and 5,000 feet elevation, they combine with meadow vegetation and the understory of mixed conifer forest, if it is open. The California grassland proper has an estimated area of 10 million acres and another 10 million acres in association with woody vegetation (Burcham 1957).

By far the most important perennial grass in the pristine grassland was *Stipa pulchra*. In 1957 Burcham described the Central Valley and the southern portions of the grasslands as being originally dominated by several perennial species of *Stipa* and discontinuous grasslands along the northern California coast as principally *Danthonia californica*, *Deschampsia caespitosa*, and two perennial *Festucas*.

The introduction of mostly Mediterranean annual species into California and their replacement of the perennials is a separate



FIG. 1. California annual grassland occurs as a broad expanse of grassland, as an understory in the oak-woodland type and intergrades with chaparral. Fire and grazing alter the boundaries between these types.

story that needs further study. Perhaps descriptions of fire in grasslands previous to 1850 should be considered as applying to perennial grasslands and later work to annual grasslands. This can be only relative because the major territorial expansion by annuals occurred during the half century of 1850 to 1900. In fact, adjustments between annual and perennial grass species are still taking place. Numerous north coastal grasslands remain perennial under proper grazing management.

Intensive studies of herbage cover at two locations have found the grassland to be 90 to 98 percent annual species, of which 60 to 85 percent was contributed by introduced species (Talbot et al. 1939; Heady 1958). Over most of the grassland there is little doubt that the introduced annuals have become naturalized and are in the type to stay. They form diverse mixtures of species which differ according to rainfall, temperature, soil, and managerial inputs. The name California Annual Grassland is appropriate. Although it has been classified as a dis-climax of annuals dominated by species of *Avena*, *Bromus*, *Hordeum*, *Festuca*, and *Erodium*, the type should be considered climax in its highest successional development.

Three kinds of superimposed changes in botanical composition and herbage production occur rapidly in the California Annual Grassland. One is seasonal or phenological. It results in fewer plants per unit area as the growing season progresses (Biswell and Graham 1956; Heady 1958), and in a progression of dominant species each year (Ratliff and Heady 1962). A second type of change is associated with different patterns of rainfall and temperature from year to year, as illustrated by at least 100 percent variation in standing crop at the end of the growing season (Bentley and Talbot 1951; Heady 1961). In 1 year grasses may be dominant, in another *Erodium botrys* will be the principal species, and in other years annual legumes compose a sizeable proportion of the crop. The third type of change is successional (Fig. 2). For example, predictable patterns of species replacement occur after overgrazing and abandonment of cultivation. Fire can cause changes in this vegetation, but its effects have not been separated from those due to season, year, overgrazing, abandonment, and others.

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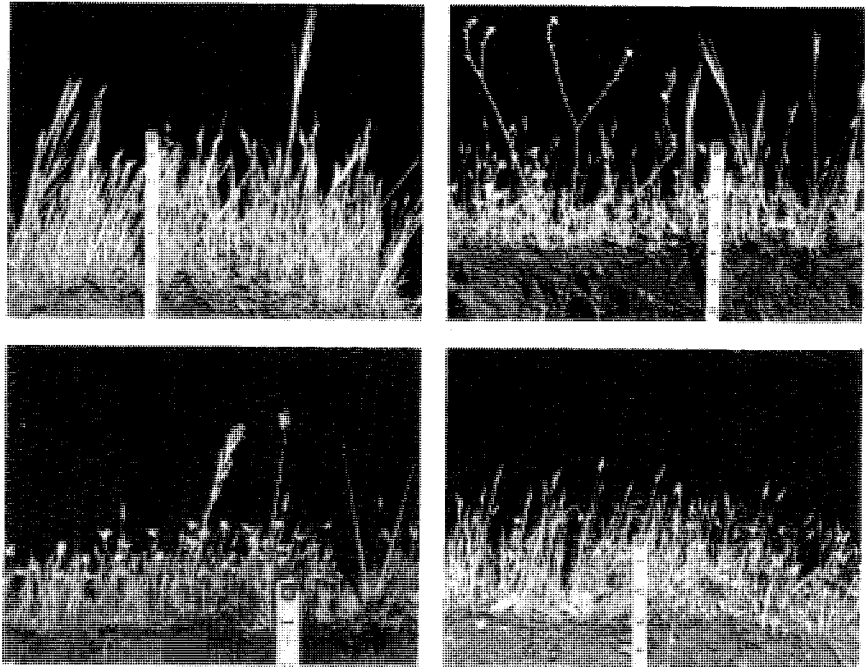


FIG. 2. Low composites, small grasses, and short stature characterize the pioneer successional stage in contrast to dominance by taller grasses in the climax annual grassland. These photographs of plants on a 1-inch-thick strip of soil illustrate successional stages in the California annual grassland.

FIRES SET BY LIGHTNING

If one accepts that frequency of fires set by lightning today approximates past occurrences, one arrives at the conclusion that fires have occurred in California grasslands and woodlands for as long as they have been in existence. During a 22-year period (1945–1966), the California national forests sustained an average of 775 lightning fires per year (Komarek 1967). They were set in grassland and on lower forested slopes in about the proportion that these conditions occurred in the national forests. An average yearly number of 414 lightning fires burned on all state and private land between 1959 and 1969 (United States Forest Service 1960–1970). Much of the private land is forested but a high proportion is chaparral, grassland, and woodland-grass. The California

Division of Forestry reports¹ a 10-year average (1960–1969) of 312 lightning fires per year on their 27,427,119-acre protection area, which is 43 percent grass and woodland-grass. These two reports, although not completely covering the same area nor the vegetation types of concern here, suggest that lightning fires (actual number unknown) occur in and burn into California grasslands. Evidence is all deductive but the conclusion that lightning caused fires have been a part of the grassland and woodland-grass areas of California for their entire evolutionary history seems reasonable. Perennial bunchgrasses dominated those grasslands.

BURNING BY INDIANS, 1542–1853

Heizer and Whipple (1971) concluded that about 260,000 Indians occupied the territory in California west of the Cascade—Sierra Nevada crest at the time of discovery by Europeans. Kroeber (1953) shows them as occupying over 100 separate tribal and family territories. About half lived along the coast. The major inland occupation sites were the lowlands and especially the stream-sides. Permanent residence above 4,000 feet elevation appeared rare. California tribes can not be considered as nomadic, although all moved about their territories. Small numbers of these sedentary peoples and localized permanent habitation which left extensive unoccupied areas suggest that Indian fires were seldom extensive (Burcham 1959).

Perhaps as many as 500 narrative reports between 1572 and 1853 describe California Indians (Sampson 1944). This spans the time from the first European landing by Juan Rodriguez Cabrillo at San Diego to the placement of Indians on reservations. The first mission and the first domestic livestock arrived in 1769. From 1542 to 1845, Indian numbers greatly declined due to disease, but their territory and area of occupancy changed little. The Spanish with an estimated population of 10,000 in 1843 (Künzel 1848) penetrated inland California between 1776 and the end of the mission period in 1834, but they did not stay. They preferred the coastal valleys instead. During the first 5 years after gold was discovered,

¹ Personal correspondence, 12 May, 1972.

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Anglo-Americans increased in numbers to 255,000 (Thompson 1955). They completely dominated the Indians, and removed them from their land. Before that time extensive man-caused burning of grassland and woodland should have been of Indian origin and should have been abundantly documented in narrative reports.

In an undated manuscript by Knowles but one which Sampson (1944) obviously used to prepare his review of burning by Indians in California, references to fire and burning by Indians were summarized from approximately 400 reports; most of which were not listed. Only 71 mentioned fire. Of these, 8 gave no opinion about its usefulness, 8 condemned the practice of burning, and 55 described reasons for burning, without analyses of season and locality of burning. For the most part, fires were used to uncover acorns in the grass, to clear small areas for tobacco (the only planted crop), to foster seed-bearing annuals, and perhaps to promote oak orchards. Fires were used to roast grasshoppers, crickets, and caterpillars and to secure larger game species such as rabbits and deer. Clearing for easier travel and for stimulating green feed to attract animals appeared unimportant as reasons for burning. A prevalent view for several decades holds that California Indians burned small areas located near the coast or inland streams and that extensive areas burned infrequently (Barrett 1935).

Another widely held view stipulates that small fires frequently escaped and that Indians learned to use extensive fire at certain seasons and frequencies for specific purposes. Among these were easier travel with less brush, easier gathering of acorns, concentrated acorn crops from large trees, and abundant edible seeds during certain successional stages. One of our students is re-evaluating the older references in light of recent anthropological studies of Indian food habits. Although the review is far from finished, it tends to substantiate the latter viewpoint.

On a longer time scale, burning by Indians probably had little to do with evolution of the grassland species. The oldest positively dated Indian artifacts that have come to light in California are between 7,000 and 8,000 years old (Heizer and Whipple 1971). Plant and animal species in California vegetation are much older. Indian burning in California is historically fascinating but of

marginal consequence in helping us to understand present day grassland changes.

BURNING BETWEEN 1853 AND 1905

From gold discovery to establishment of the national forests and the California Division of Forestry a short time later in 1905, records confirm extensive burning in chaparral and forest types by settlers, stockmen, and lumbermen (Sampson 1944; Burcham 1959). This burning, together with overgrazing and undesirable forest practices in the late 1800's resulted in less dense woody vegetation and more successional vegetation dominated by annual grasses than in the earlier period. It also resulted in the conservation movement of the early 1900's which included effective legislation against promiscuous burning.

The extent of burning in lower elevation climax grasslands during that exploitative period may not have been great because high numbers of livestock overgrazed large areas. The reduced amount of grass fuel could have resulted in fewer or less intense grassland fires. Frequent fires in the chaparral and mixed conifer forests probably burned into the lower elevation types. From 1853 to 1905, the California landscape was greatly altered by extremely destructive forces used by the mining, agricultural, and forest industries. Fire was one of these forces but describing its separate effect in any vegetational type remains an exercise in interpretation. Overgrazing probably had more influence on the grasslands than overburning.

BURNING SINCE 1905

Forty years elapsed before the California Legislature permitted burning for rangeland improvement, beginning in 1945. The primary purpose in that program has been to convert brushland to grassland and to maintain brush-free grasslands. Shrub conversion to grass by fire is not a part of this paper. Only a few reports on burning grassland for grassland management purposes are available.

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Burning in the California annual grassland, unless woody debris and accumulated mulch are present, results in soil surface temperatures less than 200 degrees Fahrenheit, some uncharred stubble, black ash from charred litter, and abundant live seed (Bentley and Fenner 1958). These authors reported as many as 500 seedlings per square foot after a fire; a number more than adequate for all species to regenerate. Sampson (1944) showed earlier that most seeds in soil were killed only at temperature from 250 to 300° maintained for 5 minutes. On balance, fires in the California annual grassland do not significantly reduce seed supplies.

Changes in percentage species composition of plants and animals in the annual grassland for a year or more are the most striking effects of burning. Hervey (1949) quantified the change as 83 to 45 percent grasses and 17 to 55 percent annual broadleaved plants for a fire in the hills near Berkeley. Burning did not change soil moisture, soil temperatures, soil organic matter, and botanical composition where grazing was heavy. Herbage production was less due to fire on lightly grazed areas than where little standing dead material was available to burn. Hart, Guilbert, and Goss (1932) could not find consistent differences in nutritive content of plants between burned and unburned areas. Lawrence (1966) and Cook (1959) documented immediate reduction in rodent numbers due to fire but a few of all species survived. During the next 3 years their numbers responded and adjusted to varying availability of food and cover. Hand removal of mulch resulted in the same changes in percentage botanical composition as those resulting from burning (Talbot, Biswell, and Hornmay 1939; Heady 1956). None of these changes have been detected beyond the third year after burning.

The one attempt to prescribe fire in the California annual grassland has been to control medusahead (*Taeniatherum asperum*), an undesirable annual grass (Furbush 1953). This plant matures and sheds its seed 2-4 weeks after the majority of annual species. A fire in the dry grass when the medusahead is in the soft-dough stage should destroy the seed crop (Fig. 3). However, substantial numbers of seed escape damage (Sharp, Hironaka, and Tisdale 1957). This practice has been abandoned.

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FIG. 3. Burning in the California annual grassland to control medusahead, an undesirable annual grass.

SUMMARY

1. The California grasslands occur in a Mediterranean climate and have the following characteristics:

a. The pristine perennial dominants differed from inland and southern to coastal and northern. Probably, annual grasses and broadleaf species composed the understory and lower successional stages.

b. The present dominants are naturalized introduced annual grasses, except in native perennial north coastal grasslands.

c. Annual grasslands change rapidly in botanical composition during each growing season, from one year to the next, and in response to management inputs.

d. Vegetational changes of the three kinds always occur together, so determination of the cause of a specific change is difficult.

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e. Practical grazing intensities and fire do not significantly alter the current seed crop in the annual grassland.

2. Infrequent fires set by lightning have occurred in the California grasslands for as long as they have existed.

3. Indians burned grasslands occasionally until 1853 but their influence was late in the evolution of the grassland species and probably of minor importance for maintenance of the perennial grassland and woodland-grass climaxes.

4. Between 1853 and 1905 the lands of California were subjected to the severest overgrazing, greatest acreage plowed, least informed forest practices, and the most extensive promiscuous burning of any time in known history. Permanent changes in the grassland during that period more likely resulted from grazing and cultivation than from burning.

5. Fires in the California annual grassland have little impact beyond temporary changes in botanical composition, which are similar to the effects of mulch removal and overgrazing.

6. Prescribed burning to control medusahead has been abandoned and no other positive reason for extensive burning of annual grassland has been accepted. Burning of grassland to control chaparral regrowth and to develop firelines are common practices.

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