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# California Annual Grassland and Oak Savannah

**James W. Bartolome**

The grasslands and savannahs of California cover approximately 15 million acres or 15 percent of the State, but provide 80 percent of the range forage for sheep and beef cattle (California Department of Forestry 1987). With a growing population, rangelands are foci for suburban development, water, wildlife habitat, and recreation. Annual forbs and grasses introduced from other regions with winter rains and summer drought (Heady 1977) dominate the vegetation of the herbaceous layer. The woody overstory, where present on suitable sites, is most often an open canopy of oak, a genus *(Quercus)* shared with savannahs of the Mediterranean Basin (Griffin 1977).

The original California grassland, a mix of perennial bunchgrasses and annuals, formed the resource, enabling settlement by Europeans. Cattle and sheep, introduced from Baja California upon the founding of Mission San Diego in 1769, and later resupplied from Tubac in Arizona, numbered in the millions by the early 1800's (Burcham 1957). The few thousand non-native people in California depended upon these livestock as the mainstay of the economy for eighty years. The only major exports were hides and tallow shipped from points along the coast. Not until gold was discovered and populations of hungry miners formed a local market, did meat production become important in livestock ranching. The forage base of native bunchgrasses, not adapted to this kind of heavy use, was rapidly destroyed. Later expansion of cultivation in the 1860's and 1870's further contributed to the demise of the native grasses. As with other fertile rangelands of the U.S., the best sites in the Central Valley were those put to the plow.

New plants, survivors of thousands of years of livestock use in a climate similar to California's, arrived from the Mediterranean region with the earliest settlers. Verified by the presence of their seeds in adobe bricks used to construct the missions, successive waves of plant immigrants moved into California (Burcham 1957). Some weedy species from Europe arrived in the 1700's, but most of the annual grasses, the wild oats (*Avena* spp.), filarees (*Erodium* spp.), bromes (*Bromus* spp.), and fescues (*Vulpia* spp.), which produce most of the forage annually, arrived in the middle 1800's. Soft chess *(Bromus mollis)*, now the most widespread annual, was a late comer and only became abundant in the 1890's (Heady et al. in press). By the mid 1800's the take over from native perennials was complete and no areas free of exotic annuals are left. Although grazing started the process of change by damaging or destroying the native grasses, the new immigrant plant species made the change permanent and irreversible, even under complete protection.

The present annual grasslands and oak savannahs (Fig. 1) intergrade across a wide geographic range and could be separated into numerous subtypes. The most commonly described divisions are the Coastal Prairie, Valley Grassland, and Oak woodlands (Barbour and Major 1977). The Coastal Prairie extends from the Monterey Bay in Central California northward to the Oregon Border near the immediate coast and along the San Francisco Bay. The cooler coastal climate, with annual rainfall from about 20 inches to over 80 inches annually, should place less summer drought stress on perennial grasses than the hot inland Central Valley. Indeed, native and exotic perennial grasses are common along the coast, even under livestock use. The dominant grasses are California oat grass *(Danthonia californica)*, Pacific hairgrass *(Deschampsia holciformis)*, and Pacific reedgrass *(Calamagrostis nutkaensis)* (Heady et al. 1977). Average forage production exceeds 3,000 lbs/acre/year. Little has been published about management of grazing or burning in Coastal prairie and much of the type is in Parks or other reserves.

The Valley Grassland forms a ring around the Central Valley, extending into the Mountains of Southern California

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**Fig. 1.** *California annual grassland with blue oak savannah in the background.*

and the Central Coast (Heady 1977). Average annual rainfall ranges from less than 6 inches in the Southern San Joaquin Valley to 30 inches or more in northern Sacramento Valley. Perennial grasses are rare, with only a few scattered relicts (Barry 1972). Even with complete production from grazing, the introduced annuals can maintain dominance. Originally, the native grasses were thought to have been present throughout the Valley Grassland. In the San Joaquin Valley, stands were more scattered, with pine bluegrass *(Poa scabrella)* as the likely dominant. Perennial grasses increased in density with increasing rainfall. Purple needlegrass *(Stipa pulchra)* was the likely dominant in these regions (Heady 1977). Recent evidence from soil microfossils has shown that one site in the Sacramento Valley, now exclusively introduced annuals, was occupied by purple needlegrass at densities that would not have excluded annuals (Bartolome et al. 1986).

The Mediterranean annuals of the Valley Grassland produce abundant forage. The amount is correlated with annual rainfall, and varies from about 1,000 lbs/acre with 12 inches of rain to 2,000 lbs/acre with 25 inches on a typical range site (Bartolome et al 1980). Soft chess is the most widespread species, found throughout the grassland in areas with more than 12 inches of annual rainfall (Bartolome et al. 1980). Broad-leaved filaree *(Erodium botrys)* accompanies soft chess on almost as many sites, and both extend into the Coastal Prairie. Associated with these two species, and locally dominant, are annual fescues, wildoats, and several other grasses. Red brome *(Bromus rubens)* replaces soft chess and red-stem filaree *(Erodium cicutarium)* replaces broad-leaved filaree in the portions of the Valley Grassland with less than 12 inches annual precipitation.

Unpredictable annual weather patterns dictate forage productivity and composition. The first range research by the Forest Service at the San Joaquin Range near Fresno documented these yearly changes, referred to as grass, "clover", and filaree years (Bentley and Talbot 1951). The timing and amount of fall rains, coupled secondarily with spring rains, determines the composition and standing crop at maturity. The fluctuating annual legume component of clovers and medics provides important nutrients to grazing animals and the forage crop (Woodmansee and Duncan 1980). Annual changes in composition can have a marked effect on forage quality. For example, fall and winter forage quality provided by early maturing filaree contrasts with rapid disappearance and low forage amounts at the spring peak. This pattern contrasts to the higher and later peak standing crop in a grass year (George et al. 1985), with important effects on grazing capacity.

Because of the obvious links to livestock production, predictions of forage production and composition based on weather have been attempted several times but variation between locations has affected application of results. Murphy (1970) found a good correlation between weather and forage production at the Hopland Field Station, representative of the higher rainfall regions of the Valley Grassland. Duncan and Woodmansee (1975) did not find such a relationship at the drier San Joaquin Range. Pitt and Heady (1978) correlated annual weather patterns with some changes in composition and productivity at Hopland but saw little application to management because of the importance of spring rains, too late to adjust stocking rates.

The annuals respond to changes in grazing use. Ungrazed Valley Grassland pastures are often dominated by either wildoats or ripgut brome. Species diversity may be low. Under grazing use other grasses such as soft chess and broad-leaved species increase. Although the forage species differ in value at maturity and segregate out in a general way to grazing use (Sampson et al. 1951), forage value ratings and range condition evaluations have proven of limited value for management of annual ranges (USFS 1984). The patterns of response to grazing have been successfully recreated using the manipulation of mulch or plant residue as a substitute experimental treatment for grazing (Heady 1956, Bartolome et al. 1980). An outgrowth of these studies, management of yearlong grazing use to leave a targeted amount of residue in the fall has proven the only practical method for influencing composition and production (USFS 1984).

An overstory of oaks changes the grassland into a savannah. The California oak savannah can be divided into three types, the northern, southern, and foothill woodlands (Munz and Keck (1949). The oak types on rangelands can be grouped conveniently by dominant oak species, although other hardwoods and some conifers may be present. The northern type is characterized by blue *(Quercus douglasii)*, garry *(Q. douglasii)*, and interior live *(Q. wislizenii)* oaks. Coast live oak *(Q. agrifolia)* and Englemann oak *(Q. englemannii)* dominate the southern oak woodland. The foothill woodland is dominated by blue oak and interior live oak, often associated with digger pine *(Pinus sabiniana)*. Collectively these types occupy about 10 million acres of rangeland. A Valley oak *(Q. lobata)* savannah, much of which has been cleared for crop production, formerly extended across much of the lowlands of interior California and into foothills where late season moisture is present (Griffin 1977).

Little has been published about response of the herbaceous layer of the oak woodlands to grazing management. Most writers remark that the understory contains many of the same species found in the adjacent annual grassland (Heady 1977) and assume a similar response to management. A few important species are found both in the open grassland and under the oak canopy, such as annual fescues, soft chess, and wild oats. Yet, in a study of five widely separated locations in California, McClaran and Bartolome (1987) found that species composition differed more between open and canopy within sites than between locations within cover type. Miner's lettuce *(Montia perfoliata)* and Italian thistle *(Carduus pyncocephalus)* were exclusively under the canopy but owl's clover (*Orthocarpus* spp.) and lupines (*Lupinus* spp.) were only in the open. The oak savannah will likely require different understory management practices from that of grasslands.

Oaks are widely used for fuel wood and cleared for enhancement of livestock forage. Oaks are a desirable firewood and several hundred thousand cords are cut for this purpose each year. However, the local impacts of fuelwood harvesting probably are not generally endangering the different oak savannahs (California Department of Forestry 1987). Clearing for range improvement has historically altered the structure and extent of oak savannahs. Individual deciduous oaks increase understory production (Holland (1980), while individual coast live oaks decrease productivity (Parker and Muller 1981). In higher rainfall locations moderate stands (less than 50 percent canopy cover) of blue oak decrease understory productivity at all periods of the growing season (McClaran and Bartolome 1987), while in drier, and more southern locations the oak canopy may increase understory production and animal utilization (Duncan and Reppert 1960). Dense stands of liveoaks dramatically reduce understory productivity and removal results in much more herbaceous forage (Pitt and Heady 1978).

Recent concern over management of the hardwood canopy on rangelands led to a joint effort by the University of California and the California Department of Forestry and Fire Protection to increase funding for research, management, and education (Passof and Bartolome 1985). Much public concern centers on present tree stand size distributions with well-publicized lack of small trees. Stand structure suggests that regeneration was more frequent in the past, and present lack of recruitment represents a threat to oak survival (Bartolome et al. 1987). Valley, blue, and coast live oaks are apparently not regenerating in sufficient numbers to maintain existing stands (Muick and Bartolome 1986). The causes have not been determined and are the subject of intensive research, but appear to vary by species, region, and site. Increasingly, traditional extensive use of annual grassland and oak savannah will be constrained by land development, with smaller ownerships and intensive uses.

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# Forest and Meadow Ecosystems in California

**Barbara H. Allen**

Forest and meadow ecosystems occur in all 6 major mountain ranges on about 25 million acres in California. Forest ecosystems are highly diverse with some 18 widely occurring and 12 more restricted conifer species. Meadows range in size from a few square meters to several hundred acres and are interspersed through-out every forest type in the state. The diversity in California forest and meadow ecosystems has its roots in the evolution of California's mountain ranges and subsequent change in the state's climate. Early explorers found a rich natural resource which today provides timber, forage, recreation, wildlife and water to a rapidly growing population.

During the Eocene epoch, California was characterized by a mild, wet climate with year long rainfall. The Sierra Nevada and Cascade mountain ranges had not yet emerged from a lowland plain. Eocene forests, richer in species than any of today's surviving forests, were made up of taxa whose nearest relatives occurred in the conifer forests of the western interior United States and the conifer-deciduous hardwood forests of the eastern U.S. and eastern Asia (Axelrod 1977).

By the Pliocene period, the Sierra Nevada and Cascade ranges were uplifted. This resulted in dramatic changes to the relatively uniform Arcto-Tertiary flora (Ornduff 1974). As the mountain chains were elevated to the east and west, a double rain shadow was created. This largely eliminated forests in the Great Basin region except in favorable upland sites, and created separate forest types on wetter, west slopes and dry, east slopes of the Sierra Nevada. As the mountains rose, climate changed from wet to dry characterized by today's summer drought. The forest and woodlands moved to the coasts and mountains (Munz and Keck 1975).

Meadow ecosystems evolved primarily during the Pleistocene period. The origin of montane meadows has been attributed to the filling of glacial lakes or valleys (Storer and Usinger 1963). However, as meadows also occur in unglaciated areas, other reasons contribute to the current scattered distribution of meadows. Wood (1975) states that the single most important factor explaining the distribution of meadows is the existence of a shallow water table which provides for high soil moisture content year round.

Meadows are often considered fragile and temporary in nature. However, meadow stability can be examined in terms of biological and geological stability (Benedict 1982). Biological stability refers to the persistence of meadow species, while geological stability refers to the persistence of the geological conditions which provide an environment favorable for meadow formation and maintenance. Geological stability is directly related to meadow origin and persistence. For example, a meadow that forms in a bedrock basin as a result of water accumulation is stable as long as the basin is intact and continues to collect water. Such a meadow is more

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