Heady, H.F. 1956. Changes in a California annual plant community induced by manipulation of natural mulch. Ecology 37:798-812.
Heady. H.F. 1977. Valley grassland. *In:* Barbour, M.G. and J. Major (eds.) Terrestrial vegetation of California. Wiley Interscience N.Y. pp. 491-514.
Heady, H.F., T.C. Foin, M.M. Hektner, D.W. Taylor, M.G. Barbour, and W.J. Barry. 1977. Coastal prairie and northern coastal shrub. *In:* Barbour, M.G. and J. Major (eds.) Terrestrial vegetation of California. Wiley Interscience N.Y. pp 733-760.
Heady, H.F., and M.D. Pitt. 1979. Reactions of northern California grass-woodland to vegetation type conversions. Hilgardia 47:51-72.
Heady, H.F., J.W. Bartolome, M.D. Pitt, G.D. Savelle, and M.C. Stroud. (In Press) California prairie. *In:* Coupland, R.T. Ecosystems of the world: Vol. 8 Natural Grasslands. Elsevier Press.
Holland, V.L. 1980. Effect of blue oak on rangeland forage production in central California. *In:* T.R. Plumb (tech. coord.) Ecology, management, and utilization of California oaks. USFS Gen. Tech. Rep. PSW-44. pp. 314-318.
McClaran, M.P., and J.W. Bartolome. 1987. Geographic variation in the effect of blue oak canopy on herbaceous production and composition. Report to Calif. Div. Forestry. 12p. ms.
Mulck, P.C., and J.W. Bartolome. 1986. Oak regeneration in California. Report to Calif. Div. Forestry, 100 p.
Parker, V.T., and C.H. Muller. 1981. Vegetation and environmental changes beneath isolated liveoak trees *(Quercus agrifolia)* in a California annual grassland, Amer. Midl. Natur. 107:69-81.
Passof, P.C., and J.W. Bartolome. 1985. An integrated hardwood range management program. Univ. Calif. Wildl. Res. Center. Rep. No. 6. 18 p.
Pitt, M.D., and H.F. Heady. 1978. Responses of annual vegetation to temperature and rainfall patterns in northern California. Ecology 59:336-350.
Munz, P.A., and D.D. Keck. 1949. California plant communities. El Aliso 2:86-105, 199-202.
Murphy, A.H. 1970. Predicted forage yield based on fall precipitation in California annual grasslands. J. Range Manage. 23:363-365.
Sampson, A.W., A. Chase, and D.W. Hedrick. 1951. California grasslands and range forage grasses. Calif. Agric. Exp. Sta. Bull. 724. 130p.
U.S. Forest Service. 1984. Range analysis handbook. Calif. Region, San Francisco, Calif.
Woodmansee, R.G., and D.A. Duncan. 1980. Nitrogen and phosphorus dynamics and budgets in annual grassland. Ecology 61:893-904.

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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stable than a meadow in a basin formed by a morainal dam, which is more easily eroded.

Evidence indicates that meadow ecosystems may often be as stable as the surrounding forest vegetation (Benedict 1982). Both meadow and forest ecosystems have experienced biological changes caused by human occupation and use. However, meadow ecosystems appear to be more sensitive than forest ecosystems to geologic change,as a result of lower thresholds of tolerance to geological change, and thus appear to fluctuate more widely between forest and meadow species (Wood 1975), than forest types.

Current Vegetation

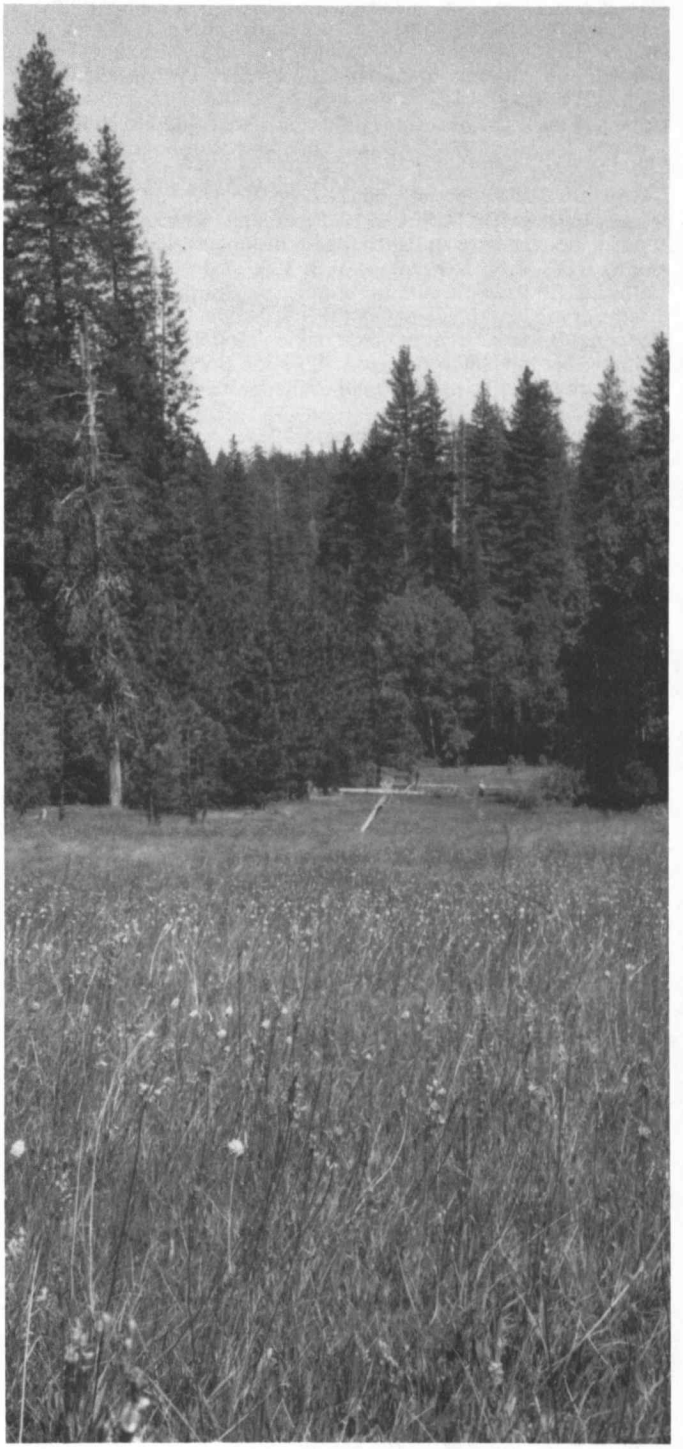
The present forests of California occupy over 25 million acres and can be grouped according to geographical location into coastal, montane, and intermountain types (Barbour and Major 1977). Meadows can also be grouped by geographical location, such as montane, sub-alpine, and alpine, or northern and southern California, but are better described as hydrologic/floristic types (Ratliff 1982, 1985), and can be broadly categorized as wet/mesic and dry types.

The coastal Douglas-fir forests of the state occur at elevations between 1,650 and 13,000 ft in the north Coast and Klamath mountains. Douglas-fir makes up more than 50% of the basal area in this type and may be associated with sugar pine, ponderosa pine, Jeffrey pine, incense cedar, and red fir. Associated hardwoods include tanoak, madrone, and canyon live oak. Understory forage species may include silk-tassle bush, blueblossom ceanothus, western mountain mahogany, and blue elderberry.

Redwood forests occupy areas of the coast of California from San Luis Obispo county to the Oregon border. These forests, which contain some of the tallest trees in the world, are dependent on cool, foggy coastal conditions and extend inland only 80 miles. The closed-cone pine and cypress forests are largely remnant, endemic forests typically dominated by a single species, which may be one of the cypresses: Tecate, Cuyamaca, Piute, MacNab, Sargent, or Monterey cypress; or a pine: knobcone, Monterey, Bishop, or Torrey pine. These forests occur in patches along the coast of California from sea level to 650 ft elevation.

The montane ponderosa pine forests occur primarily on the west slope of the Sierra and east slopes of the Klamath, Coast and Transverse mountain ranges at elevations between 800 and 6,500 ft in the north, and 4,200 and 6,825 ft in the southern part of the state. Ponderosa pine makes up more than 50% of the basal area in these forest and associated species may include sugar pine, Jeffrey pine, incense cedar, Coulter pine, Douglas-fir, canyon live oak, and California black oak. Understory forage species for large ungulates and livestock include deerbrush, willow, mountain mahogany, black oak, and perennial grasses.

The mixed conifer forest, occurs at higher elevation, and consists of three or more species of conifers, where no one species contributes over 80% of the conifer basal area. Conifer species may include Douglas-fir, white fir, ponderosa pine, incense-cedar, sugar pine, and Jeffrey pine, while California black oak, tanoak, and chinquapin are major hardwood associates. Elevation ranges from 2,450 to 4,000 ft in the northern part of the state, and 4,000 to 10,000 ft in the southern part. The mixed conifer forest occurs on western slopes of the Sierra, Peninsular, Transverse and Coast ranges, while a variant of enriched conifer and white fir occurs in the Klamath mountains. Understory forage species are similar to those in the ponderosa pine forests.



Other major conifer types such as red fir, lodgepole pine, and subalpine conifer, occur at higher elevations (5,900 to 11,000 ft) on suitable sites throughout the state. These forests produce significantly less forage for large browsing

animals than the other forest types, although some forage, such as cascara and bittercherry, is available.

The intermountain Jeffrey pine forests (commonly called the eastside pine type) occur over extensive areas on the eastside of the Klamath, Cascade, Transverse, Peninsular, and Sierra Nevada mountain ranges on drier sites. Elevation ranges between 500 and 9,500 ft depending on latitude. Associated species include ponderosa pine, Coulter pine and some sugar pine, lodgepole, incense cedar, and redfir. Major hardwood species include black cottonwood, aspen, sagebrush, and black oak. Forage species include bitterbrush, bluebunch wheatgrass, idaho fescue, and western mountain mahogany.

The pinyon-juniper forest and juniper forest occur primarily on the eastern slopes of the Sierra Nevada from approximately 3,300 to 8,900 ft, and 2,500 to 4,900 ft, respectively. The major pine species are singleleaf pinyon and Parry pinyon, while the main juniper species are western, Utah, or California juniper. Associated species include ponderosa or Jeffrey pine, scrub or canyon live oak, and whitebark pine and sagebrush. Understory forage species may include perennial grasses, bitterbrush, and western mountain mahogany, depending on a site.

Montane meadows are found scattered throughout the forest ecosystems and can be broadly characterized as wet/-mesic meadow and dry meadow types. Ratliff (1982, 1985) has identified 21 distinct meadow vegetation series, 72 theoretical hydrologic series, and suggests that perhaps over 1,500 meadow types may be identifiable. Size varies from a few square meters to several hundred hectares and species composition is diverse.

The wet/mesic meadow type is generally found above 3,900 ft in the north and 6,000 ft in the south and is characterized by a continuous vegetation canopy and standing water all or part of the year. The wet/mesic type grades from sites with standing water, such as *Sphagnum* dominated meadows characterized by acidic, organic muck, highly sensitive to disturbance, or *Juncus* dominated types, which are low in palatability and tolerance to frost, to more mesic, well-drained sites. More mesic meadows include sites dominated by sedges and sites comprised primarily of grasses and forbs. The more mesic subtypes are the most common of the wet meadow types, are significantly more resistant to disturbance, and are of significantly higher forage value (Rundel et al. 1977).

The dry meadow types are found in scattered locations above 6,000 ft. Dominant vegetation is typically sparse grasses and forbs interspersed with conifers, mainly lodgepole pine and poplars with little or no standing water (Rundel et al. 1977). The short-hair sedge meadow is a higher elevation dry meadow type characterized by *Carex exserta* sod and is generally found above 6,900 ft. Though the vegetation is adapted to withstand disturbance and frost, historical use of these meadows by sheep and current use by pack stock and hikers has had a detrimental effect on these meadows. Once the short-hair sedge sod is broken, it becomes reestablished slowly and with great difficulty.

History of Use

Early explorers of the Sierra Nevada, such as Jedediah Smith, Kit Carson, John Fremont and John Muir, faced a steep east-facing slope rising 5,000 to 10,000 feet above the Great Basin, which gave way to the more gradual west slope. However, they encountered numerous notable features including cirques, moraines, lakes, meadows, and glacial valleys in addition to large expanses of red fir, mixed conifer, Douglas-fir, Jeffrey, and ponderosa pine forests. Explorers from the north found similar forests among giant volcanic peaks, serpentine outcrops, and ancient metamorphic and sedimentary intrusions (Sawyer and Thornburg 1977). Roaring rivers filled with salmon, and highly complex patterns of vegetation, including many endemic and relict species, met the early explorers. The forests were little used by Spanish and Mexican settlers, who remained along the coasts.

By the 1840's however, California was a state and people had moved into the interior. Major enterprises in the Sierra Nevada included mining, timber production, and livestock grazing.

Domestic animals grazed the montane forest ranges because they provided summer green feed commonly unavailable at lower elevations, ample water, relative freedom from insects and disease, and high quality forage. With the discovery of gold and subsequent increases in human population, large numbers of livestock began to use California's forest ranges and mountain pastures as a market for red meat surpassed the original hide and tallow market. With the early railroad near Donner summit, a flourishing recreation industry was ensured (Storer and Usinger 1963). A policy of fire suppression was implemented to protect the forests from the destructive effects of periodic wildfires that had turned thousands of acres of productive forests into brushfields by the turn of the century (Kosco and Bartolome 1981).

As people continued to utilize the forest and meadow resources, changes in land ownership and use occurred. The grizzly bear became extinct in 1924; mountain sheep, wolverine, fisher, and marten populations were greatly reduced and coyotes, wolves, and wildcats were hunted to protect deer and livestock (Storer and Usinger 1963).

At the turn of the century, livestock use of federal forest rangelands provided more income to the treasury than any other product (Kosco and Bartolome 1981). Demand for timber increased, and after 1940, the income from harvesting wood quickly surpassed income from livestock grazing, assuming the dominance held today.

Today California forest ecosystems provide 3.4 billion board feet of timber, 100 million recreation visitor days, 50 million acre-feet of water, primary wildlife habitat for some 311 vertebrate species, and superior summer forage for over 497,000 AUMs (animal unit months), (State of California 1987). Managers continue to be faced with often incompatible demands for use of the forest and meadow resources. Continued population pressure and highly consumptive lifestyles require that resource managers understand resource capabilities, design careful plans for resource use, and educate the general public on the wise care and use of their limited, yet highly productive forest and meadows resources.

Literature Cited

Axelrod, D.I. 1977. Outline history of California vegetation. *In:* Terrestrial Vegetation of California; Barbour, M. and J. Majors (eds.); John Wiley & Sons, New York. 1002 p.

Barbour, M., and J. Majors (eds.) 1977. Terrestrial Vegetation of California. John Wiley & Sons, New York. 1002 p.

Benedict, N.B. 1982. Mountain meadows: stability and change. Madrono 29(3):148-153.

Kosco, B.H., and J.W. Bartolome. 1981. Forest grazing: past and future. J. Range Manage. 34(3):248-251.

Munz, P.A., and D.D. Keck. 1975. A California Flora. Univ. California Press, Berkeley. 1680 p.

Ornduff, R. 1974. Introduction to California Plant Life. Univ. California Press, Berkeley. 152 p.

Ratliff, R.D. 1982. A meadow site classification for the Sierra Nevada, Calif. USDA Forest Service, Gen. Tech. Rep. PSW-60. 16 p.

Ratliff, R.D. 1985. Meadows in the Sierra Nevada of California: state of knowledge. USDA Forest Service, Gen. Tech. Rep. PSW-84. 52 p.

Rundel, P.W., D.T. Gordon, and D.J. Parsons. 1977. Montane and subalpine vegetation of the Sierra Nevada and Cascade ranges. *In:* Terrestrial Vegetation of California. M. Barbour and J. Majors (eds.). John Wiley & Sons. New York. 1002 p.

Sawyer, J.O., and D.A. Thornburgh. 1977. Montane and subalpine vegetation of the Klamath Mountains. *In:* Terrestrial Vegetation of California. M. Barbour and J. Major (eds.). John Wiley & Sons. New York. 1002 p.

State of California. 1987. California Department of Forestry, FRRAP Assessment. Sacramento. In Review.

Storer, T.I., and R.L. Usinger. 1963. Sierra Nevada Natural History. Univ. of California Press, Berkeley. 374 p.

Wood, S.H. 1975. Holocene stratigraphy and chronology of mountain meadows, Sierra Nevada, California. Ph.D. thesis. Calif. Institute of Technology, Pasadena. USDA Forest Service Region 5, Earth Resources Monographic #4. 179 p.

Arcata Symposium, July 13

Symposium: Complexities of Land Use and the Decision-Making Process—a California Example

Kate Buchanan Room
University Center

1:30 pm Welcome	**James W. Timmons** California Cattlemen
1:40 pm Welcome	**Donald Neal** President, CA Section
1:50 pm The Rangeland Resource	**Harold F. Heady** Professor emeritus Univ. CA, Berkeley
2:20 pm History of Settlement	**James R. Young** Range Scientist ARS, Reno NV
2:50-3:20 pm Break	
3:30 pm Current Conflicts in Demands for Use of Rangeland Resources	**Gordon Van Vleck** Secretary, California Resources Agency
4:00 pm Complexities of the Decision-Making Process	**Harold R. Walt** Chairman, State Board of Foresty
4:30 pm Open Panel Discussion	
5:30 pm Close	