PLANT COMMUNITIES

Introductory Training of Jasper Ridge Docents
Lecture by Prof. H.A. Mooney
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notes by
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The concepts of vegetation and flora differ. In a flora, each species is given the same weight as every other species. For example, Quercus lobata (Valley Oak) is as important as Avena fatua (Wild Oat). When plants are grouped using the concept of "vegetation" each species is not given equal weight. Numbers, biomass, and forms or physiognomies are considered. Knowing the type of "vegetation" gives a better idea of the general appearance of an area than a "flora".

The history of the study of plant communities is very different in the U.S. than in Europe. Because of this and because of their different plant communities, European ecologists have different viewpoints than American ecologists. European plant ecologists are good taxonomists as well as ecologists. They believe that a plant community can be of any size, but that certain species always occur together. A plant community therefore consists of a characteristic combination of species. The associations are taxonomically based and biomass is not an important criterion. American plant ecologists are familiar with trees, shrubs, and grasses but most are "taxonomically illiterate".

The American plant ecologist, Frederick Clements, worked during the 1900's. He viewed plant communities starting at the macro level (e.g. forest, grassland, etc.). He based his communities largely on physiognomy, with taxonomy of secondary importance. Clements distinguished subunits within the major types of plant communities. These subunits were still large because the United States still contained large areas of wild grasslands and forests at the time he was working. Europe, on the other hand, had already been parcelled into areas, agricultural towns, and managed forests by the time plant ecology began. Clements supported the idea of the dynamic successional nature of the plant community--changes in the vegetation of a community occur. Europeans thought of plant communities as being static. Clements thought of the plant community as being an organism that matures and that the most mature form is the forest. There are different types of communities but they all end up at the same place, a climax vegetation.

W. S. Cooper wrote about succession in plant communities at Glacier Bay and Palo Alto in the 1920's. Many of the chaparral plots that he studied are not accessible now since they are on developed areas. Cooper thought that there is continual successional change in plant communities.

Gleason was a taxonomist in the 1920's who disagreed with other ecologists. particularly Clements. He believed that each species has its own ecological requirements and that certain combinations of species just happened by coincidence. He saw a continuum of species combinations. Plant ecologists have been arguing ever since the 1920's about what constitutes a plant community. In the 1930's the general opinion was that plant communities were arbitrary divisions and that ecosystems were more fundamental units. In the 1940's the importance of energy flow between compartments within ecosystems was discovered. Energy flow continues to be a major theme in ecosystem research. Currently there is much controversy about what criteria should be considered in defining plant communities or ecosystems.

Ecologists in California have always had different ideas about ecology than ecologists in the rest of the United States. Because of a strong taxonomic tradition there were few ecologists in California (in fact, UC Santa Barbara was the only college with a course on plant ecology when Dr. Mooney was in school). The leading people in taxonomy thought that they were also covering the subject of ecology. The implications for today are that very little is know about California plant communities.

Earlier biological surveys in California used Merriam's "life zones" system. He decided that temperature, alone, controlled the distribution of organisms over vast areas. This system is not used as present. Munz, in his A California Flora, gave a description of the plant communities of California in the front of the book. Munz's classifications are based on both the dominant species and the characteristic species in a community. It is a very qualitative system and we haven't progressed much beyond it today.

California vegetation is very diverse. This one state contains the oldest living plant, the tallest tree, the oldest tree, and the most massive tree. There are more than 5000 species of plants and there are more than 70 species of oaks and pines alone. There are twenty to thirty major vegetation types and every known physiognomic type.

Why is there so much variation in California vegetation? Climate, soils, and past history. Climatic variability is the most important factor. There is a strong north-south gradient. California has a Mediterranean climate (there is no rain in summer and lots in winter under normal conditions) caused by a high pressure area that blocks storms in the summer only. The high pressure area shifts position, causing the drought pattern and resulting in more rain in northern California than in the southern part, creating a climatic gradient. The cold coastal current also affects the climate. Fog occurs on the coast because of the temperature pattern of the ocean. There is a cold current directly off the coast of California which gets warmer further out to sea. The air acquires a lot of moisture from the warm water but it condenses and turns into fog when it hits the cold water. Inland there is a greater temperature gradation because there is no coastal current to maintain temperature.

Elevation affects climate. There is a decrease in temperature and an increase in precipitation with an increase in elevation. Rain shadows may exist, causing the interior side of a mountain to be drier. Slope affects climate. A northern slope gets less radiation than a southern slope. Thus, the northern slope has less evaporation. Cold air at night flows down from the mountains and is pooled in the valleys. This can result in timberline inversions which occur in the White Mountains, for example. Infrequent episodic events such as droughts and freezes may have very dramatic effects by the large-scale killing of plants. Such hardy creatures as the creosote bush and the redwoods may even be extinguished in areas.

Soil is the second most important in causing the variety of vegetation in California. There are unusual geologic substrates in California, such as serpentine, which have a dramatic influence on plant distribution. Soil texture can be very important in water relations with the soil and may, therefore, influence the type of plants. Very fine-textured soils, such as clay, have a very large water-holding capacity. The coarser the soil, the less water it can hold. On slopes, usually the upper part has coarse soil and the lower part has fine soil. Soil characteristics not related to the parent material of the soil are also important. For example, huckleberry has difficulty in growing outside of a redwood forest because it is probably associated with a fungus which thrives only in redwood forests and because it prefers acid soil also found in redwood forest.

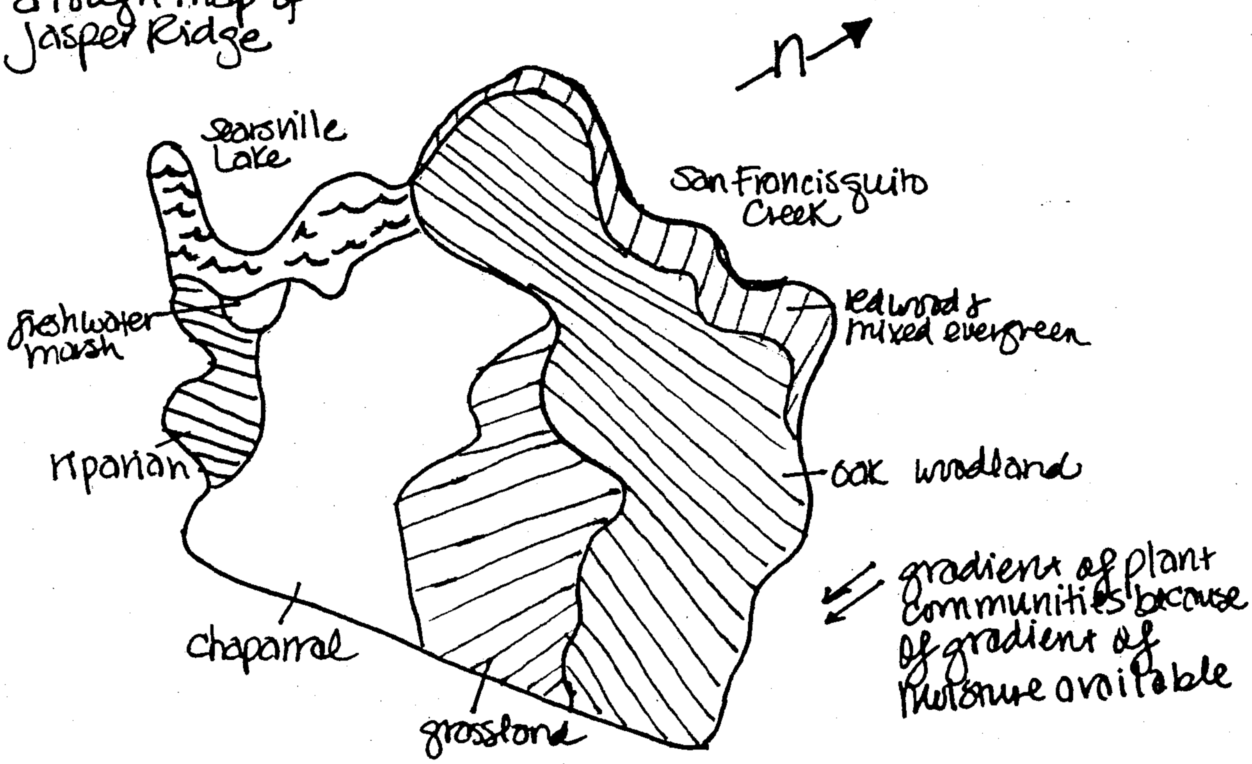
The past history of plant communities is also important in determining the vegetational variety of California. Daniel Axelrod is a paleoecologist (one who studies ecological and vegetational history). His reconstruction of the past vegetation of California suggests that it was a tropical forest in the Eocene era (about 75 million years ago). We have no direct descendants of these Eocene plants today, although there are some species secondarily derived from this tropical forest. Then there was a cooling trend and the Arcto-Tertiary Geoflora emerged. This period left behind the redwoods and was partially responsible for the diversity in plant forms seen today. California then became drier and deciduous forests and chaparral originated.

Axelrod used a technique for determining paleo-history in which he identified the climate in which certain plants are growing today. He could then extrapolate about these plants' paleo-history because the ecological requirements of species are presumed to change only slowly with time. But this last point is arguable because, for example, chaparral in certain parts of Mexico occurs where there is summer rainfall. Tree rings are used for determining paleo-climate because they may date back to 7000 years ago. Tree rings are sensitive to precipitation and temperature changes and so paleo-climatic maps of the United States may be developed. Some limestone caves in the desert have plant materials stored by packrats. It is possible to carbon date this material, which has been well-preserved by the limestone, to up to 40,000 years ago.

The diversity of Jasper Ridge can be explained by micro-climate, soil, and history. There are at least eight plant communities on Jasper Ridge list. From Munz's list (see handout) they are: 3. Freshwater marsh, 4. Northern coastal scrub, 18. Mixed evergreen forest, elements of 19. Northern oak woodland, 21. Foothill woodland, 22. Chaparral, 24. Valley grassland, and remnants of 12. Redwood forest. These communities appear to be scattered in a random fashion (see map handout), but they are not. There are no major macro-climatic differences (e.g. rainfall) between the plant communities on Jasper Ridge. Therefore all variations in the plant communities must be due to small differences in climate and temperature (e.g. slope effects).

The north-facing slope receives the least radiation, causing less evaporation and a lower temperature. Upon investigation, it proves to have the densest vegetation. This vegetation has shallow roots and contains mixed evergreen forest and redwoo forest. There are two main redwood groves along the banks of San Francisquito Creek. The creek provides water and the banks sandstone, which combine to form the correct substrate for the redwoods. Fog accumulates in this little valley. The oak woodland is found directly south of the mixed evergreens. It is not as dense as the mixed evergreen forest nor are the trees as tall, probably because it receives more radiation. The grassland occurs mainly on top of the ridge, which is unusual because grassland usually occurs in valleys. Soil tends to erode down on slopes, so that there is a deep drainage and the water runs out. But on the top of Jasper Ridge the soil hasn't been eroded and the texture is fine, with a resulting higher water holding capacity. Therefore, the presence of grassland on the top of the ridge may be due to soil texture and its effect on water retention, and not chemistry. The grassland vegetation grown on either sandstone or serpentine derived soil. Many European species may be found on the sandstone while serpentine supports many endemic species which can tolerate the "toxic" soil conditions (high levels of MG, Fe, Ni, and Cr). The south-facing slope is the hottest and driest and supports chaparral with an extensive root system for deep water capture. The chaparral grows mainly on the sandy soil of the Franciscan formation which has very little humus. Diplacus aurantiacus, Baccharis pilularis. and Artemisia californica are primarily successional species at Jasper Ridge found only in areas of disturbance (compare with climatically determined species). They frequently surround the chaparral because of disturbance. Small animals and birds may also cause bare areas between the chaparral and the grassland. There is a small freshwater marsh on the southern end of Searsville Lake which supports grasses and grass-like plants (sedges, rushes, cattails). Riparian vegetation occurs along the banks of San Francisquito Creek and around th elower end of Searsville Lake, where a thick layer ofhumus support such trees as California Maple and Bay, willows, alders, and several shrubs and herbs.

a rough map of Jasper Ridge



Alan Grundmann's remarks about plant communities: There are a number of artificial plant communities on Jasper Ridge. The lake is artificial. The swamp is natural but it started because of human caused phenomenon (the lake) and formed due to the silting-in of the lake. There are marshes forming around the edge of the lake in which cattails are the dominant plants. The entire central valley used to be a marsh!

JASPER RIDGE PLANT COMMUNITIES
Introductory Training of Jasper Ridge Docents
Field lecture by Prof. H.A. Mooney
February 12, 1979

notes by
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Professor Mooney, who describes himself as a "physiological plant ecologist", led us on a hike through mixed evergreen forest and chaparral plant communities at Jasper Ridge. He distributed two handouts: "Field Trip to Jasper Ridge (Bio. 94)" and Munz and Keck's list, "California Plant Communities Rearranged Floristically". We were trying to answer the question, "why is there so much diversity on Jasper Ridge?" At appropriate sites, Mooney described several research products conducted at the Preserve.

Using Munz and Keck's classifications, Jasper Ridge has the following plant communities:

1) freshwater marsh
2) northern coastal sage scrub (successional community)
3) coastal sage scrub (successional community)
4) mixed evergreen forest
5) northern oak woodland
6) foothill woodland (elements of this community)
7) chaparral
8) valley grassland
9) redwood forest

In comparing mixed evergreen forest with chaparral communities, it may be interesting to have your tour group look for these things:

- general characteristics of each community (height of canopy, leaf size, and guess the root depth).
- directional location of each community (pull out a compass to orient your group or point out that the length of Searsville Lake runs roughly north/south).
- other specific plant adaptations for dealing with environmental stress

MIXED EVERGREEN FOREST: characterized by tall trees, large leaves that are perennial and sclerophyllous (have hard, thick cell walls), and shallow roots. Plant species typical of this community include:

1) *Quercus agrifolia*. California Live Oak. Jasper Ridge has seven oaks. Three, including Live Oak, are evergreen. Live oaks can be identified by spine-tipped leaves with a tuft of hair that can be felt on the main vein on the back of the leaf.

2) *Ceanothus cuneatus*. Ceanothus, or California Lilac, is a nitrogen fixing plant as are many "successional" plants. Usually found in disturbed areas, Ceanothus has a short life span of about 25 years.
3) *Arctostaphylos crustacea*. Manzanita, an early-bloomer.
4) *Quercus dumosa*. Scrub Oak.
5) *Quercus durata*. Leather Oak. This oak is usually restricted to areas of serpentine soil.
6) *Heteromoles arbutifolia*. Toyon or Christmasberry. Mooney's group studied the transfer of toxins from pulp to seed as Toyon fruit matures. The tannin content in the pulp is high when the fruit is developing, but the berries become more palatable later in the season, attracting birds that eat the fruit, and disperse the seeds. They also noted a couple of things about Toyon leaves. New leaves are eaten by herbivores called generalists because they eat many kinds of leaves, while older leaves are only eaten by specialist herbivores presumably because of their increased toxicity. In the fall, the decomposition of dropped leaves provides a source of nutrients for the Toyon plant. Leaves that were yellow earlier in the fall become greener with the uptake of these nutrients after some rain.
7) *Prunus illicifolia*. Holly-leaved Cherry.

The Jasper Ridge chaparral is distinguished by a lack of an understory. This is probably due to a combination of phenolic inhibitors and small mammal scavenging documented in Bruce Bartholomew's study of the bare zones surrounding chaparral areas. The chaparral on Santa Cruz island is taller than the chaparral on Jasper Ridge, and has grass beneath it. This contrast would make a good future research project. Other chaparral areas around the world have an understory resulting from human clearing for agriculture and removing fallen branches for firewood. In Chile there are no fire annuals since there are few fires. It seems the Andes mountain range blocks the fierce "Santa Ana"-type winds that promote fire.

Northern coastal scrub and coastal sage scrub are climax communities on the California coast. At Jasper Ridge, however, they are successional chaparral communities, found in disturbed areas.

<u>CHAPARRAL SUCCESSIONAL COMMUNITY</u>: plants of this community resemble climax chaparra areas because of their low growth form. Most of the successional plants have larger leaves than their climax chaparral counterparts.

2) *Arbutus menziesii*. Madrone. This tree with large tropical-looking leaves belongs to the same plant family as Manzanita, which also has reddish bark. Like the California Buckeye, Madrones have preformed buds that burst open almost at once as opposed to gradually unfolding. This is a strategy for plants growing in light-limited communities.

3) *Umbellularia californica*. California Bay. Leaves from this tree are used as a spice in cooking spaghetti and other dishes. Someone in our class figured out that according to Spice Islands (a spice company) standards, each leaf is worth about 10¢.

4) *Aesculus californica*, California Buckeye. The relationship of this "mixed evergreen forest" tree to water supply is important because it is deciduous. Its leaves emerge in February and the flowers, in spring. By June or July the leaves are lost and the tree forms large fruits from energy previously stored up. The Buckeye fruits are inedible unless first leached. Mooney's group studied this extreme phenology. Buckeyes in Baja California, flower and fruit on reserves while Buckeyes in the eastern United States fruit when the leaves are still on the trees. The conclusion from this study is that some plants may modify their phenologies according to weather conditions. Another student working with Dr. Mooney researched the fate of Buckeye seeds once they have dropped from the trees. He found that many do not survive. A winter drought may mean the seed cannot germinate, yet rain encourages fungal growth. Some seeds were eaten by mammals who had "forgotten" the seeds are toxic.

Professor Mooney commented on the Old Man's Beard, a lichen of the genus, *Ramalina*. He described it as one of the fastest growing lichen in the world, and one that prefers to grow on deciduous tree because the lichen photosynthesizes and needs sunlight.

CLIMAX CHAPARRAL: plants of this community are shrubs with small, evergreen, and sclerophyllous leaves. Chaparral is a fire-climax community. Plant are adapted for dry conditions with stomata that open and close in response to photosynthetic needs vs. loss of moisture through transpiration. Plants of this community include:

1) *Adenostoma fasciculatum*. Chamise is the most abundant plant in California, covering one-eighth of the state. "If you wanted to engineer a plant that would best promote fires, you would design a plant just like chamise," said Mooney. It's needle-like leaves contain volatile chemicals, and the plant over time dries out leaving behind much potential kindling.

1) *Lepechinia calycina*. Pitcher Sage. This plant is very fragrant which is a good indicator that it is unpalatable for insects. It is an aromatic plant in Chile, Mexico and the U.S. However, at the 6000-feet level of Mt. Haleakala, Maui, it is not aromatic. A "cushy" research project could involve finding out if the loss of fragrance is due to discarding a useless defense against herbivores that did not "follow" the plant to the island. Forming terpenes is energetically expensive-- these are toxic to germinating plants as well as being unsavory for herbivores.
2) *Diplacus aurantiacus*. Sticky Monkey Flower is a food source of *Euphydryas chalcedona* which feeds first on new plant growth which was found to be higher in protein content and lower in phenolics. *E. chalcedona* larva seem to graze only the tops of older leaves although this part of the leaves is higher in phenolics. Researchers speculate that larvae are seeking the warmth of the sun which is biologically more "economical" for them than what is gained by avoiding the phenolics and remaining shaded. These plants may contain up to 15% resins to resist herbivory.
3) *Artemisia californica*. California Sage. Many sages are aromatic and belong to the genus *Salvia*. Our kitchen sage is a European *Salvia*.
4) *Eriodyctyon californica*. Yerba Santa is attacked by a successful fungus-- it does not kill off its host. The fungus and the host plant have dissimilar ranges. Yerba Santa at higher altitudes has no fungal growth.
5) *Baccharis pilularis*. Coyote Bush is the predominant shrub in north coastal scrub communities. Researchers have observed this plant moving in on the Jasper Ridge grassland after grazing was terminated in 1960.

Professor Mooney compared the moisture gradient of plant communities found on Jasper Ridge. Grasslands have the least amount of available moisture, followed by chaparral, and blue oak woodland. The mixed evergreen forest, of these four terrestrial communities, has the most available moisture. Compare the forest Madrone to the chaparral Chamise. Madrone has shallow roots and big leaves because it exists in an area where plants are highly competitive for sunlight, whereas Chamise has deep roots to tolerate dry soil and small leaves because of the abundance of sunlight on south-facing slopes.

At the Green Shack, Professor Mooney described his current research, The Ecosystems Project: Limitations to Productivity. It is a two-part project funded by the National Science Foundation and involves three research groups--those of Professor Mooney, Ehrlich, and Roughgarden.

Part I is called the "optimal production model". They hypothesize that plants have evolved for greatest productive capacity through the optimal use of available resources, and, higher production exists in a mixed community of plants which tap different resources. In this part, Professor Roughgarden is testing some mathematical equations that try to predict the phenology of the plants being studied. Some of the questions the researchers are asking are: Why do plants differ in photosynthetic capacity? There is an evolutionary advantage to producing carbon compounds, but do all leaves do this at the highest rate provided them by the resources available? Why do plants flower when they do? Are they striving for optimal timing in switching from making leaves to reproducing? What are the strategies of plants known to use different resources? This last question is being answered in a study of three plants with the following characteristics.

experimental plant	root length	blooming time
Plantago erecta	shallow	early spring
Clarkia sp.	intermediate	late spring
Hemizonia sp.	deep	late summer

Part II involves herbivory studies. Putting all that protein into leaves means a higher predation of the plant. Again, what is the optimal strategy? The experimental plants, here, are:

1) *Lepechinia calycina*: characterized by a high photosynthetic rate, plenty of terpenes and eaten by Katydids, a generalist insect that eats about anything.

2) *Diplacus aurantiacus:* a perennial. This is the primary food source of *Euphydryas chalcedona* (secondary food source is the California Bee Plant, *Scrophularia californica*.