Vegetation Change in Blue Oak Woodlands in California[1]

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Abstract: A preliminary report of a statewide project investigating vegetation change in blue oak (*Quercus douglasii*) woodlands in California is presented. Vegetation plots taken in the 1930s, as part of a statewide vegetation mapping project, were relocated and surveyed. Species composition, cover and tree stand structure data from the earlier study were compared with the current survey to determine the changes that have occurred in these woodland habitats. Twenty one plots were surveyed from south San Benito and eastern Monterey county rangelands. Changes of note included a general increase in total basal area of blue oak and foothill pine (*Pinus sabiniana*), particularly due to an increase in small trees (4-11 DBH class). An increase in the percent cover of understory annuals including Avena species and *Bromus diandrus,* and a decrease in *Bromus mollis* and *Poa* species were noted.

Oak woodlands form a reservoir of biological diversity and provide resources for human use. This study focuses on changes within blue oak *(Quercus douglasii* (QUDO)) woodlands due to human modification and succession. This study documents changes in blue oak communities over time to project future trends and provide stand information for current assessment and management of blue oak woodland communities within California. Of particular interest are differences in plant species distribution, stand characteristics and associated plant species. The data reported here are the first in a continuing study of changes within blue oak woodlands throughout the state.

Blue oak occurs in a continuous ring around the Central Valley of California from 100 to 1200 meters elevation, from north Los Angeles County to the head of the Sacramento Valley in Shasta County (Munz and Keck 1968, Griffin and Critchfield 1972). It is prominent in the foothill woodland areas of the state and forms a transitional zone between the valley grassland and the higher elevation mixed coniferous forest. Blue oak woodlands cover approximately 10 percent of the state of California; 75 percent is privately owned; 14 percent is in the National Forest system and the remaining in state, county or miscellaneous federal ownerships (Griffin and Critchfield 1972, Griffin 1977, Bolsinger 1988).

Blue oak vegetation forms two layers. The overstory contains blue oak and regional associations of other deciduous and evergreen oaks and pines (particularly *Pinus sabiniana*) (Griffin 1977). Codominance with other overstory species is influenced by water table, slope and location. In many blue oak communities there is little understory shrub cover, instead annual grasses and native annual and perennial forbs account for greater than 80 percent of the ground cover (Griffin 1977).

Griffin (1977) describes the "foothill woodland" as the major oak community in California. The Coast Range and Valley types within the Blue Oak Phase of the foothill woodland are represented in this study. The Coast Range type is often associated with foothill pine (PISA2) and other oak species. The Central Valley type is a savanna-like community where blue oak is the prominent tree with grass species dominating the understory (Griffin 1977).

Allen and others (1989) further refined blue oak types in a classification system that described 10 subseries within the blue oak woodland. These subseries differ in associated overstory codominants, understory species and environmental parameters (Allen and others 1990). Using this classification, four subseries (Blue oak/Grass (QUDO/GRASS), Blue oak-Foothill Pine/ Grass (QUDO-PISA2/GRASS), Scrub oak (*Quercus dumosa*)-Blue oak/Grass (QUDU2-QUDO/GRASS) and Valley oak (*Quercus lobata*)/Grass (QULO/GRASS) are represented in this study.

Succession within blue oak woodlands is thought to proceed from grassland to tree stages, with associated shrubland communities occurring in locally favorable sites (Mayer and Laudenslayer 1988). Disturbance by fire, grazing or harvesting alters this simple scenario of community change. Blue oak occurs throughout most of California and changes within the communities are expected to vary regionally and locally based on differences in climatic, edaphic and historical use regimes. Because blue oak is typically the longest lived tree within the community, its presence in the climax or mature community is expected.

METHODS

Allen and others (1989) described 7 series and 57 subseries of rangeland cover types for California's hardwood rangelands based on Vegetation Type Map (VTM) data from the 1920-30's. From these classified types, blue oak subseries were selected for further study. The first area selected for study was the Priest Valley USGS 30 minute topographic quadrangle, located in southern San Benito and northeastern Monterey counties. Twenty one one-fifth acre plots were chosen randomly from the original

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VTM plots within this quadrangle and investigated for historical vegetation changes.

The landscape of this area is rolling grasslands and oak woodland hillsides with agricultural crops grown in the valleys. Annual rainfall in the area varies from 10 to 45 inches (254 to 1143 mm). Rainfall in the past year has ranged from 20 to 100 percent of normal. The study plots were located on 10 to 70 percent slopes on all aspects. Elevations ranged from 700 to 3500 feet (213 to 1067 meters). Soils also varied, ranging from sandy to clay loams, all easily erodible. Water holding capacity of the soils ranged from 1-8 inches (2.5 to 20.3 cm), with root penetrability from 10-60 inches (25.4 to 152.4 cm) (USDA SCS 1969 and 1978).

All 21 plots were privately owned with several plots owned by the same family. Twenty percent of the plots were held by absentee owners, but were managed as part of working ranches. Only one of the 21 plots had evidence of conversion; a road was built in the middle of the plot. The surrounding vegetation remained similar so the plot was included in the analysis (the new plot only included the vegetation west of the road). All the remaining plots have a history of livestock grazing. All are currently or were recently grazed by cattle or horses.

The data consist of U.S. Forest Service VTM plots collected as part of a statewide effort to map vegetation (Wieslander 1935). These historic records collected by crews in the 1920s and 1930s contain data regarding tree stand structure, percent cover of dominant understory vegetation by species, soil type, parent material, and environmental elements for each site. Along with these data, photographs of representative plots were taken and the location of the sites were noted on U.S. Geological Survey topographic maps. The twenty-one plots chosen were relocated and resurveyed for evidence of change. Data collection methodologies used in the earlier survey were repeated. Additional data were also collected as described below.

VTM plots were initially sampled to provide a validation of the vegetation mapping project and to include information regarding understory species associated with the vegetation type being mapped. The plots selected were representative of the vegetation subtypes encountered. The VTM plots were randomly selected within the boundaries of "well-defined natural associations" (Wieslander and others 1935). Initial site location, county, township, range and distance from a selected reference point were recorded. Slope, aspect and elevation were estimated. Parent material, soil depth and "character" (structure), and penetrability (ability to walk through the vegetation) were recorded. Plot history (fire, harvesting, disturbance and use) was also recorded if known.

In the initial study, tree, shrub and ground cover were recorded using one- tenth acre rectangles (0.5 by 2 chains), divided into 100 squares. The dominant species within each square was recorded. When less than 50 percent of the square was occupied by shrubs or grasses, ground surface characteristics such as bare ground, rock outcrops or tree trunks were noted. In plots where trees over four inch diameter at breast height (DBH) occurred, the trees were tallied, noting species and DBH class. For the tree tally, the sampling strip was 0.2 acres (1 by 2 chains). Plots were surveyed between March and May of 1932.

The procedures above were repeated in the current study to allow for a direct comparison between earlier and current samples. Data were collected in June and July of 1990. Additional data collected included an estimate of plant cover by species from a 100 foot linepoint transect, with species recorded at 1 foot intervals. Stand structure was measured using a standard relascope from three points, one at plot center, one perpendicular to the slope and one parallel to the slope (Avery and Burkhart 1983). The presence of seedlings and saplings within the plot was also recorded. The plots were also located on county soils maps to determine soil series and capability unit designations.

The data were analyzed to determine what changes occurred in the vegetative overstory and understory since the initial survey. The dominant species present on the site in 1932 were compared to those present in 1990. Changes in overstory basal area and understory species percent cover were also compared. The data were first analyzed using all plots, for an overall view of change. Then the newly surveyed plots were classified using the Hardwood Rangeland Type Descriptions (Allen and others 1989). Changes in type classification of the plots were noted. The data were analyzed by cover type to determine what changes could be detected within the various types.

Initial measures of central tendency and dispersion were conducted. Tests for matched pairs, comparing the differences of means, for surveyed vegetation variables were used to determine whether significant differences existed between the early VTM and current data. These tests were stratified to determine if significant differences occurred in tree overstory (basal area, stand structure and composition), tree understory (cover and composition), shrub and/or herbaceous (cover and composition) layers.

RESULTS AND DISCUSSION

The resurveyed plots were classified using Hardwood Rangeland Cover type keys (Allen and others 1989). Four cover types were recognized. Of the 21 plots; 11 were classified as QUDO/GRASS, 5 as QUDO-PISA2/GRASS, 3 as QUDU2-QUDO/GRASS and 2 as QULO/GRASS. Of the original plots classified during the VTM analysis by Allen and others (1989), 71 percent of the plots remained classified as the same type. The 29 percent that changed resulted from a change in the overstory species, such as the appearance or disappearance of foothill pine, scrub oak or blue oak.

Plots were initially compared regardless of cover type designation. Overall differences between the 1932 and 1990 data included an increase in total basal area for all tree species (figure 1). These increases were significant for blue oak and foothill pine. This overall increase in basal area is expected due to growth of trees over time.

Comparing understory cover between the 1932 and 1990 data, a significant increase in the percent cover of bare ground

and litter was also noted. An increase in some annual grasses such as ripgut (*Bromus diandrus*) and wild oats (*Avena* species) and a decrease in the percentage of cover of soft chess (*Bromus mollis*) and bluegrass (*Poa* species) (since the initial survey) were apparent (figure 2). Other genera not noted in the 1932 study which formed a significant cover in the 1990 survey were barley (*Hordeum*), fescue (*Festuca* and *Vulpia*) and needlegrass (*Stipa* species). Total species composition by plot increased on average by two new species per plot between 1932 and 1990.

All of the 21 plots surveyed were currently being grazed. Several plots in the study area were heavily grazed and the land was completely denuded by July. The increase in bare ground is probably due to a combination of the timing of sampling and current heavy grazing, as well as four years of drought in the state. Further sampling of the understory will be taken during the Spring to verify the understory changes noted above.

Of the 21 plots surveyed, only one plot was altered by construction or development. A road was built through the middle of the plot, yet the surrounding vegetation could still be classified into the QULO/GRASS cover type. The remaining 20 plots were classified as blue oak woodlands and largely used for livestock grazing and as wildlife habitat.

After the overall comparisons were made the plots were evaluated by cover type to determine if patterns of change within types could be detected.

Blue Oak/Grass (QUDO/GRASS)

The 11 plots within the QUDO/GRASS type showed an increase in total species composition from 11 in 1932 to 17 species in 1990 (an average increase of 2 new species per plot). Most of this change was in understory vegetation. There was a significant loss in percent cover by *Poa* sp. and *Bromus mollis.* Other grass species including *Avena* and *Hordeum* species and *Bromus diandrus,* not noted as dominant cover in the 1932 survey, were now present. Bare ground also increased in percent cover on several plots.

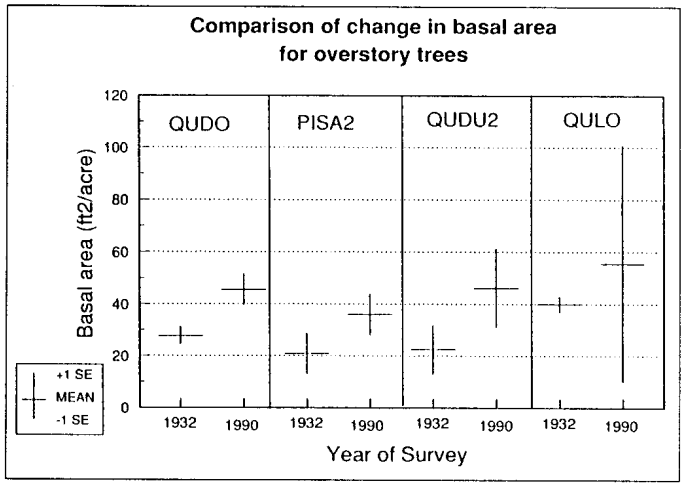

Figure 1—A comparison of total mean basal area (ft^2/ac) by overstory species on plots taken in 1932 and 1990. Means are based on total basal area per species per plot for the 21 plots.

A significant increase in total basal area of blue oak was also apparent. Average total mean basal area increased from 34.6 (± 5.0) ft^2/acre to 50.4 (± 7.1) ft^2/acre in 1990 (for an annual growth of 0.7 percent). A comparison of tree stand structure showed an increase in trees within the small tree size class (4-11 DBH). Average number of trees in the 4-11 class increased from 3.6 (±.53) trees per.2 acre to 7.09 (± 1.18) trees per.2 acre (figure 3). An increase in the number of trees at the larger DBH classes were not significant. Six of the eleven plots had blue oak seedlings present on the plot, averaging 7(± 3) seedlings per plot.

This increase in basal area of blue oak is due to growth over time and an increase in the number of trees in the 4-11 DBH class. The increase trees at the 4-11 DBH classes as well as the presence of smaller trees and seedlings on 50 percent of the plots represents some recruitment of new trees into the area.

Blue Oak-Foothill Pine/Grass (QUDO-PISA2/GRASS)

Within the 5 plots classified as QUDO-PISA2/GRASS cover type, *Bromus mollis* decreased and *Bromus diandrus* and *Avena barbata* increased in percent cover within the plot. Overall understory species present as dominants increased from 10 to 17, (average increase of 2 species/plot) due to an increase in grasses and forbs.

Blue oak total basal area increased significantly. Average total basal area increased from 28.6 (± 2.4) ft^2/acre to 53.2 (± 12.8) ft^2/acre (annual growth rate of 1.5 percent). Foothill pine also increased significantly, from 15.6 (± 5.9) ft^2/acre in 1932 to 40.4 (± 11.0) ft^2/acre in 1990 (annual growth rate of 2.7 percent). These increases were due to an overall increase in the number of trees at all DBH classes (figure 3). Blue oak seedlings were present on 3 of the 5 plots, averaging 10 (± 5) seedlings per plot.

An increase in basal area and total number of blue oak and foothill pine trees since the 1932 study was evident in the

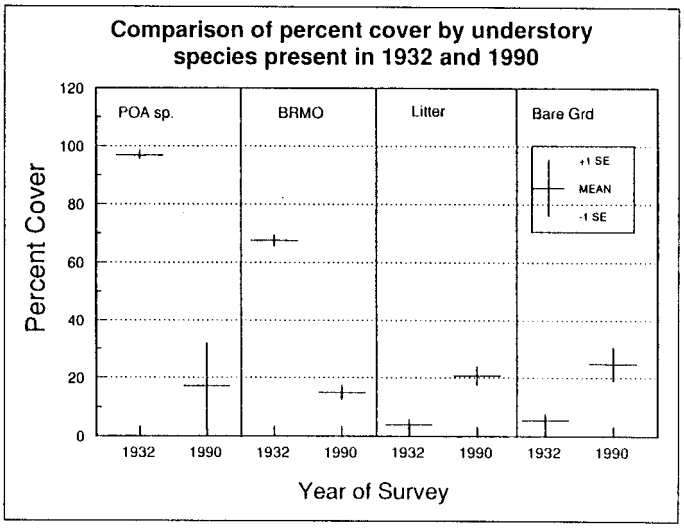

Figure 2—A comparison of percent cover of understory species present on the VTM plots in 1932 and 1990. Note that all have changed significantly since 1932.

QUDO-PISA2/GRASS cover type. With the presence of seedlings and an increase in the number of blue oaks and foothill pines at all DBH classes, this type appears to be stable.

Scrub Oak-Blue Oak/Grass (QUDU2-QUDO/GRASS)

In the three plots in the QUDU2-QUDO/GRASS cover type surveyed in 1932, *Poa* (a perennial grass) was the only dominant understory species, covering 98-100 percent of the plots. In 1990, bare ground, litter and *Hordeum* (an annual grass) are the understory dominants. An increase in overstory cover may be a factor in the decrease in understory vegetation.

In the overstory, an increase in the total basal area of scrub oak was apparent, while blue oak remained similar to the earlier survey. This increase in scrub oak is due to an increase in the number of trees in the 4-11 DBH class (figure 3), particularly on one site, a large number of these represent trees forked at the less than four feet high (thereby counted as two or more trees). No blue or scrub oak seedlings were present, but several shrub size scrub oaks were present on the plots.

In this type, we may see future changes that could include the continued loss of blue oak and an increase in scrub oak leading to change in cover type from QUDU2-QUDO/GRASS to a QUDU2/GRASS type as described by Allen and others (1989).

Valley Oak/Grass (QULO/GRASS)

This type was included in the study because these two plots initially contained blue oak. Upon resurvey no blue oak trees were found, although seedlings were present on one of the two plots. A road was constructed in the middle of one plot. Understory dominant species within these plots also increased due to the increased variety of grasses and forbs. Yellow star thistle (*Centaurea solstitialis*) was also present on the plot where the road was constructed. Numbers of valley oak (*Quercus lobata*) did not increase significantly on these plots. Although the trees present did increase in size, the overall increase was not significant. Few trees in the 4-11 DBH class were present. Blue oak and valley oak seedlings were present in small amounts (averaging 2 and 3 per plot respectively) on both plots.

No trend is apparent from these two plots, the amount of valley oak varied widely, increasing in one plot and decreasing in the other. Future study of this cover type as well as the others mention is needed to further assess the significance of these findings.

Tree Health

Many of the blue oaks in the area were infested with mistletoe (*Phoradendron flavescens* var. *villosum*). Discussion with the landowners indicated an increase in mistletoe growth in the last three years. Ranchers indicated that tent caterpillars (*Malacosoma* sp.) reduced tree foliage in 1988 and 1989, but

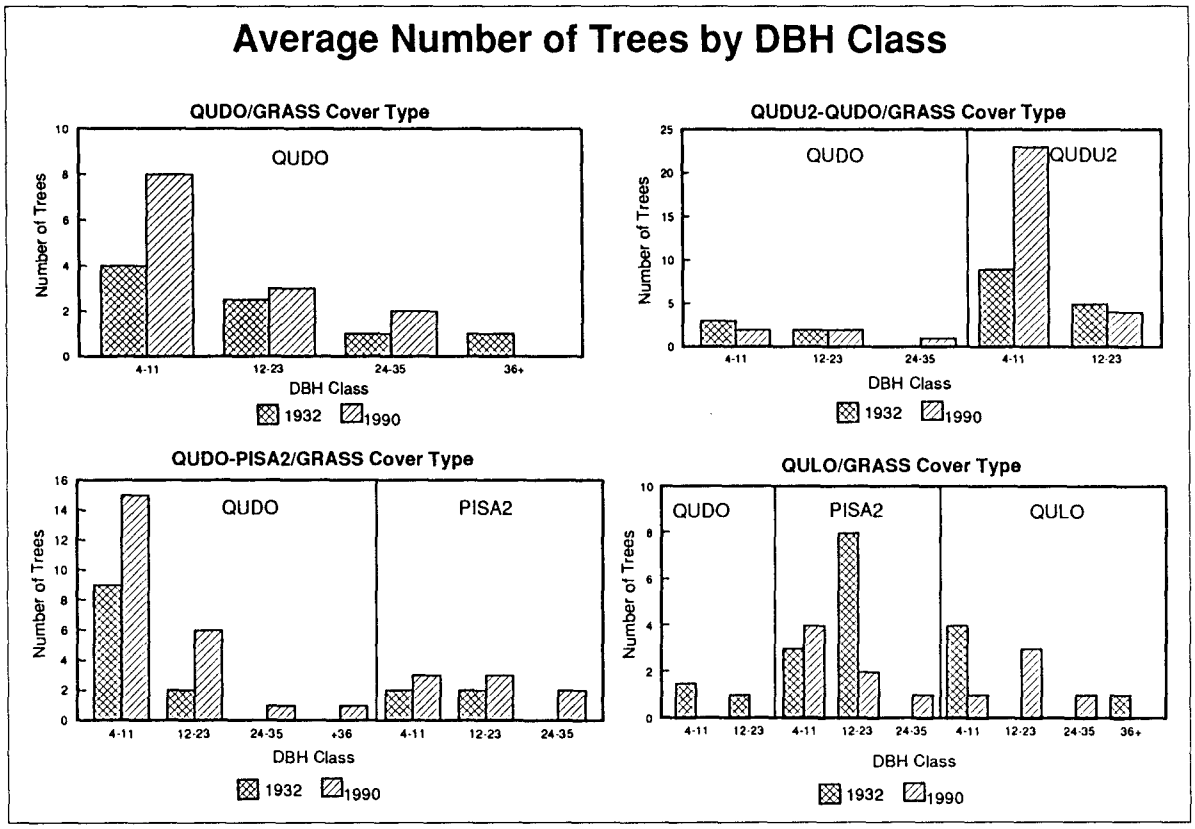

Figure 3—Average number of trees per plot by cover type and DBH class.

there was little evidence of caterpillar presence in 1990. Yellow star thistle was present on one plot which was disturbed by a road. Star thistle is present in the general study area primarily on the valley floor and is a concern to ranchers. It was rarely observed on the blue oak dominated hillsides.

CONCLUSION

Floristically, these initial results show an increase in understory species diversity, favoring species less palatable to livestock. Changes in overstory include an increase in blue oak basal area and an increase in trees present for plots within the QUDO/GRASS and QUDO-PISA2/GRASS types. The only significant mortality was in large trees (DBH 36+) in the QUDO/GRASS type, however these were replaced by increases in other size classes. Foothill pine and scrub oak basal area also increased. No recruitment of valley oak was evident but its inclusion in this study was incidental. Further study of this region during the growing season may include other understory species and show new understory patterns.

Only one plot in this survey showed evidence of conversion or disturbance (i.e. road construction), the remaining plots under private ownership were less affected. This area may not be representative of land use changes in the blue oak woodland statewide since this area is currently not significantly affected by suburban encroachment. Further study in four other regions of blue oak woodlands in the state, including the north coast, north central, northern Sierra foothills and the southern Sierra foothills may provide a different vision of blue oak changes.

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