Size Class Distribution of *Quercus engelmannii* (Engelmann Oak) on the Santa Rosa Plateau, Riverside County, California[1]

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Abstract: Size class distribution of *Quercus engelmannii* (Engelmann oak) on the Santa Rosa Plateau was studied to understand whether current recruitment of young oaks is sufficient to maintain the population in spite of high natural mortality and impacts of development in some portions of the plateau woodland. Sapling-size oaks (1-10 cm dbh) made up 5.56 pct, 4.17 pct and 6.58 pct of total trees sampled at hill (N=252), mesa (N=216) and valley (N=228) sites respectively where cattle were removed in 1986. Approximately 22.5 pct out of 200 trees sampled in an adjacent oak woodland (estimated to have been non-grazed for 20 years) were of sapling size. Peak abundance of *Quercus engelmannii* was in the 46-50 and 51-55 cm dbh size classes on hill, valley and mesa sites and in the 36-40 and 46-50 cm dbh size classes in an adjacent oak woodland. Trees in size classes larger than the 46-50 cm dbh increment declined in abundance at all four sites. Only 17.1 pct of total trees (N=896) were in sizes classes beyond 66-70 cm dbh and only two trees in size class 131-135 cm dbh. Despite the high numbers of young oaks at one of the four sites sampled, current stand size structure of *Quercus engelmannii* on the Santa Rosa Plateau indicates that reproduction is insufficient to maintain the present occurence and abundance of older age classes in the future.

Quercus engelmannii Greene (Engelmann oak) and *Q. agrifolia* Née (coast live oak) are characteristic of the southern oak woodland (Thorne 1976). Griffin (1977) divides the southern oak woodland of California into two phases: 1) the coast live oak phase, which occurs between Orange and Santa Barbara counties where *Juglans california* S. Wats (California walnut) is often co-dominant with *Quercus agrifolia;* and 2) the Engelmann oak phase, which mostly occurs in Riverside and San Diego counties, completes the southern oak woodland. *Quercus engelmannii* has a small total range compared to *Q. agrifolia* (Plumb and Gomez 1983) and occurs only in the southern part of the woodland range where it dominates on drier slopes and savanna-type habitats. It ranges, in dense to scattered stands, south from Los Angeles County to Riverside and San Diego counties and northern Baja California. The purpose of this study was to conduct additional field measurements of size structure of Engelmann oak stands on the Santa Rosa Plateau to extend previous work (Snow 1972, Lathrop and Zuill 1984, Lathrop and Wong 1986, Lathrop and Arct 1987) and to compare stand structure with two grazing situations—four years removed from cattle grazing and twenty years removed. In an effort to determine the gap between the recruitment of *Quercus engelmannii* and the current stand size structure on the Santa Rosa Plateau, four additional sites were measured for size class distribution. The Santa Rosa Plateau, although a relatively small area of the total range of the Engelmann oak phase of southern oak woodland, is considered to be a good representative sample of this type of woodland.

Regeneration Deficiency

While coast live oak is reported to be reproducing normally—enough to replace the present old trees when they die, current establishment of Engelmann oak appears insufficient to maintain current stand size structure on the Santa Rosa Plateau. Bartolome and others (1987) indicate that, regardless of specific causes, current establishment appears insufficient to maintain current stand structure for some sites, although all major species (of California oaks) are reproducing. Previous stand structure studies of southern oak woodland on the Santa Rosa Plateau have shown a relatively sparse density of young Engelmann oaks less than 32 cm diameter breast high [dbh].

Factors Affecting Regeneration

The problems of natural regeneration of California hardwoods were identified by Sudworth (1908), Jepson (1910) and Bartolome, and others (1987). Some California oaks are subject to factors which have serious impacts on their ability to recruit trees into adult age classes. Suggested causes for this lack of regeneration include: 1) anthropogenic disturbances, such as young oak destruction by grazing (Burcham 1956); 2) fires and fire prevention policies (Dodge 1975); 3) introduced exotic plant and animal species (Griffin 1980); and 4) predation upon seedlings and saplings by various endemic insects and vertebrates (Knudsen 1987; White 1966; Griffin 1971, 1976, 1980).

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STUDY AREA

The Santa Rosa Plateau (SRP) is a topographic unit in the southern part of the Santa Ana Mountains of the Peninsular Ranges (Lathrop and Thorne 1978). This 18,218 hectare (ha) Plateau consists essentially of mesas (ca 610 m elevation), canyons, and rolling hills. Vegetation is primarily grassland-oak woodland dissected by scattered chaparral on slopes of mesas and hills. Prior to recent development of single family homes and ranches, the entire plateau was a cattle range, with a long history of ranch use.

METHODS

Engelmann oak trees and saplings (size class increments 1-5 and 6-10 cm diameter breast height [dbh]), were sampled for abundance (no/ha) and basal area (m^2/ha) at 224 points along a series of transect lines in southern oak woodland on the SRP using the quarter method (Brower and Zar 1984) for both trees and saplings. No seedlings were included in the study. This method is applicable to measuring broad size classes in single species stands (Mensing 1977). Data were gathered during the fall of 1988 and spring and summer of 1989 for a total of 896 individual Engelmann oak trees and saplings (N), representing four topographic units—hill (N=252), valley (N=228) and mesa (N=216) on the Santa Rosa Plateau Preserve (SRPP), a 1,255 ha preserve on the plateau, and a saddle (located between two mesas) on Santa Rosa Springs, an oak woodland savanna adjacent to the SRPP (N=200; owned by RANPAC Engineering Corporation, Temecula, California). The hill, valley and mesa sites on the SRPP had been ungrazed by cattle for four years at the time of this study. Stand size structure of Engelmann oak for the three preserve sites was compared to the saddle site on RANPAC land; which had not been grazed for approximately 20 years. This permitted a comparison of impact of grazing on regeneration in the two grazing situations.

The point quarter sampling for each of the four topographic units (sites) was begun with a random point within an oak woodland stand to be measured. A compass direction was then selected which would accommodate the configuration of the long, narrow woodland patterns to permit the maximum distance for sampling. Points along this compass line were located at random, using a random numbers table to pick numbers between 35 m (minimum distance between points to avoid sampling any one tree or sapling twice) and 55 m. The distance between points varied, depending on the random numbers selected. Likewise, distance of the compass line transects varied, depending on the size of the stand. Openings in the oak woodland greater than 46 m were considered grassland intrusions (White 1966) and were not measured—a new line transect was then established at a random point in an adjacent woodland stand. This procedure was repeated until a minimum of 50 quarter points (200 trees or saplings) were measured at each of the four sites. At each point, distances were measured to the nearest Engelmann oak trunk in each of four quadrants, whether the tree was single or multiple trunked; all trunks below breast height were measured and included in its basal area.

Trees and saplings were grouped by 5 cm dbh increments and total abundance (no/ha) and total basal area (m^2/ha) were determined for each topographic site using methods as outlined for point-quarter sampling in Brower and Zar (1984). Abundance (no/ha) of *Quercus engelmannii* saplings and trees are plotted onto 5 cm dbh size class increments for each of four topographic units to observe size structure. However, no attempt is made to estimated age of our size class increments due to the inability to assume any relation between the size of trees and their age (McClaran 1986). However, we do include a regression of age and DBH from our ring counts on cores (N=55) and slabs (N=74) of *Quercus engelmannii* specimens collected over the past few years—using tree-ring analysis with standard guidelines and procedures as outlined by Baillie (1982).

RESULTS

Size class distribution of Engelmann oaks at hill, valley and mesa sites on the Santa Rosa Plateau Preserve (SRPP) are presented in figures 1, 2, and 3 respectively and for the saddle site in an adjacent oak woodland (fig. 4). Peak abundances of *Quercus engelmannii* trees were in the 46-50 and 51-55 cm dbh size classes for each of the three sites on the SRPP (figs. 1-3) and in the 36-40 and 46-50 cm dbh size classes in the saddle site (fig. 4). Saplings (size classes 1-5 and 6-10 cm dbh) made up 5.56 pct, 4.17 pct and 6.58 pct of total trees at hill (N=252), mesa (N=216) and valley (N=228) sites respectively (figs. 1-3). The saddle site (estimated to have been ungrazed for 20 years) had 22.5 pct saplings out of 200 trees sampled (fig. 4). Trees beyond the standard deviation of abundance in the size-class increments declined in number at all four sites. Only 17.1 pct of total trees (N=896) were in size classes beyond 66-70 cm dbh and only two trees in size class 131-135 cm dbh (figs. 1-4).

Abundance values for total *Quercus engelmannii* samples were 30.3/ha, 35.7/ha, and 51.6/ha for hill (N=252), valley (N=228) and mesa (N=216) sites respectively; with basal areas 9.32 m^2/ha, 8.16 m^2/ha and 8.71 m^2/ha for hill, valley and mesa sites respectively (figs. 1-3). The abundance value of *Q. engelmannii* trees and saplings, measured at the saddle site adjacent to the SRPP (N=200), was 51.8/ha; and basal area of 8.17 m^2/ha (fig. 4).

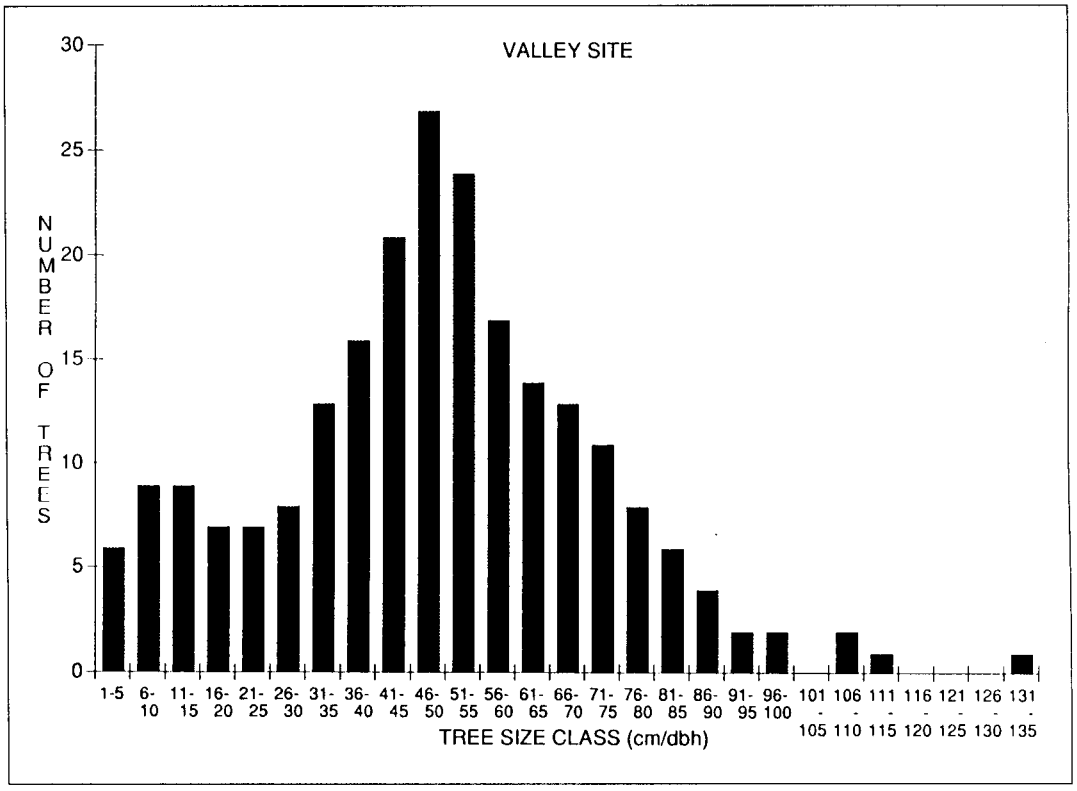

Figure 1—Size class distribution of *Quercus engelmanni* in valley Savanna of the Santa Rosa Plateau Preserve. Number of trees sampled: N = 252; basal area = 9.23 m^2/ha; abundance (no/ha) = 30.3.

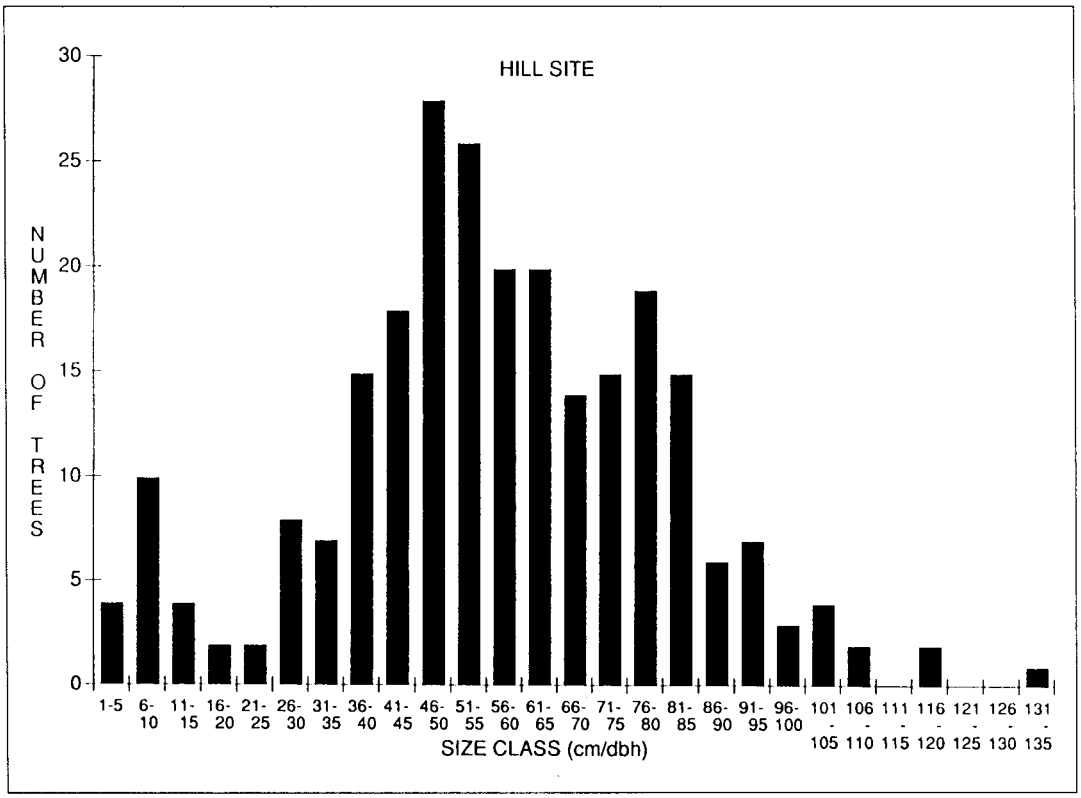

Figure 2—Size class distribution of *Quercus engelmanni* in hill Savanna of the Santa Rosa Plateau Preserve. N = 252; basal area = 9.32 m^2/ha; abundance (no/ha) = 35.7.

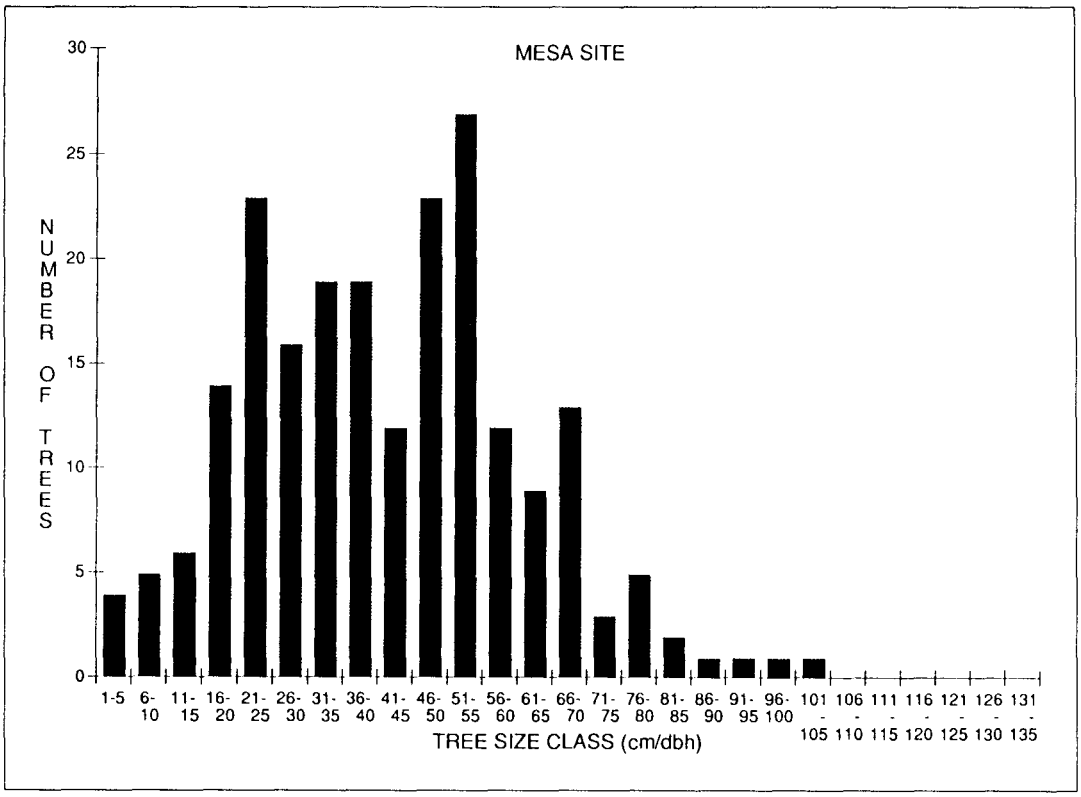

Figure 3—Size class distribution of *Quercus engelmanni* in mesa Savanna of the Santa Rosa Plateau Preserve. N = 216; basal area = 8.71 m^2/ha; abundance (no/ha) = 51.6.

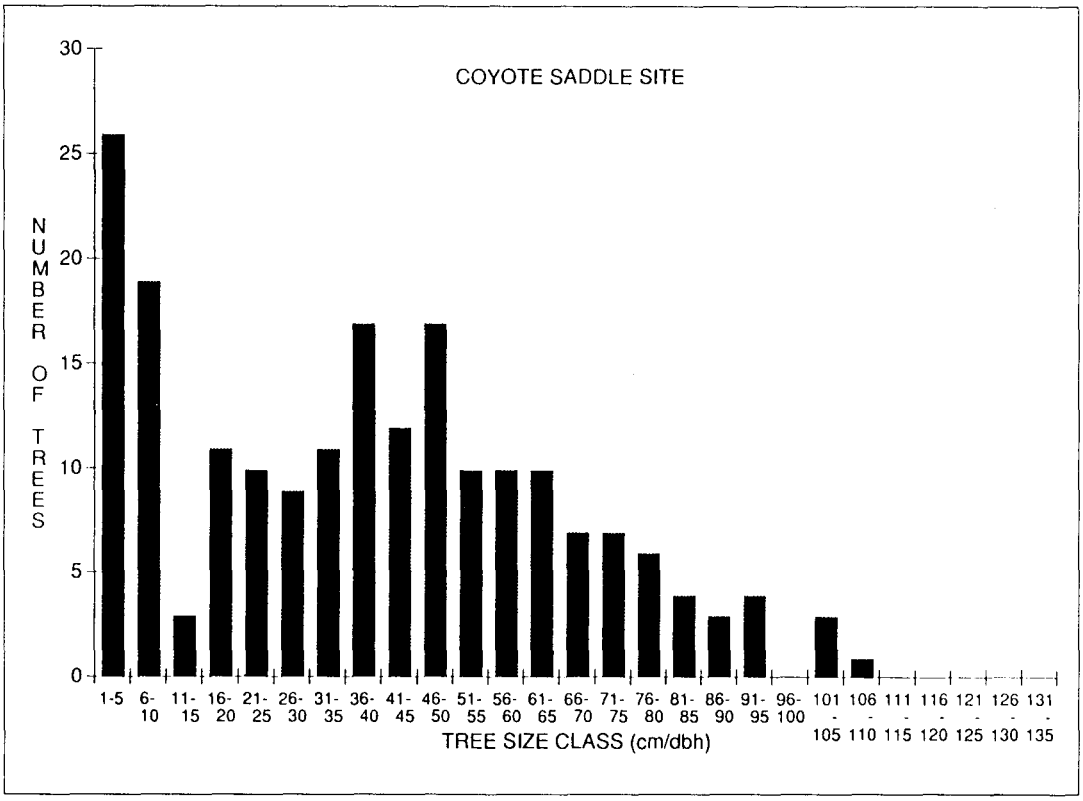

Figure 4—Size class distribution of *Quercus engelmanni* in saddle site adjacent to the Santa Rosa Plateau Preserve. N = 200; basal area=8.17 m^2/ha; abundance (no/ha) = 51.8.

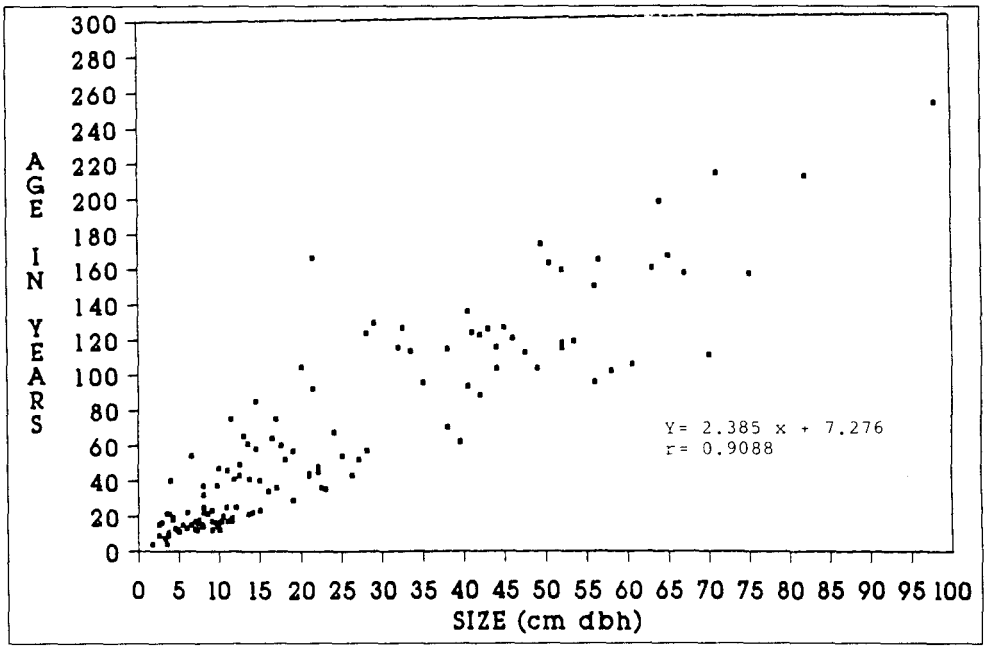

Figure 5—Scatter diagram of regression of age (yrs.) onto size (cm/dbh) of *Quercus engelmannii* ring counts. Number of trees sampled: N = 129; Y intercept = 7.276; slope of line = 2.385; r = 0.9088.

Data from regression analysis of age (yrs) onto size category (cm dbh), using annual ring counts (N=129) of *Quercus engelmannii* samples, are plotted on an age-diameter scatter diagram (Fig. 5; y= 2.385 x + 7.276; r= 0.9088). Although the linear relationship between age and size is highly significant, the 95 pct confidence level spans several decades for the larger trees, hence size cannot be used as a reliable predictor of age of our samples. McClaran (1986) indicates that even if there is a positive relationship between tree diameter and age, it is too weak to use as a predictor of age when trees are similar in size.

DISCUSSION

There was apparently adequate recruitment of *Quercus engelmannii* when the current stand size classes from 31-35 through 61-65 became established (figs. 1-4). However, stand size structure at all four sites indicate a lack of both young and very old oaks, exhibiting standard bell-shaped curves. The saddle site (fig. 4) is a possible exception for lack of young oaks, in that the two smallest size classes (1-5 and 6-10 cm dbh) represent 22.5 pct of total trees (N=200). The 1-5 and 6-10 size classes in the three sites on the SRPP (figs. 1-3) are only 5.4 pct of total trees (N=696). There is a noticeable drop in number for At 11-15 cm dbh size class in the saddle site (fig. 4) before it picks up again, but the relatively high numbers in the first two classes at this site, as opposed to to the other three could possibly reflect the cattle grazing history. The three sites on the SRPP were ungrazed for four years at the time of this study whereas the saddle site is estimated to have been non-grazed by cattle for 20 years. There are no fences around Santa Rosa Springs oak woodland region, where the saddle site is located, but isolation and rugged topography may have kept cattle on adjacent land (SRPP) away from it. Comparing this region with the SRPP sites, leads us to postulate that removing cattle for approximately 20 years has permitted more saplings (increments 1-5 and 6-10, fig. 4) to survive than the number surviving at the other three sites (figs. 1-3) which were only four years removed from cattle grazing.

Outside of cattle grazing, the present low abundance of smaller size classes cannot be taken as proof that the stands are in decline. This depends on a number of factors besides the number of trees. The present sparse density of trees less than approximately 30 cm dbh could be due to lack of seedlings, poor seedbed, or early mortality due to desiccation, disease, or insect and rodent browsing. We conclude that the few older, larger trees above around 65 cm dbh were also the result of natural mortality just as it was in size classes below 30 cm dbh (Lathrop 1989). The Engelmann oak woodland on the Santa Rosa Plateau has evidently been influenced by anthropogenic factors in the past, due to the plateau being nearly continuously grazed (in most areas) for the last 75 years (Snow 1972).

Seedlings of *Quercus engelmannii* were very rare on the four sites when any sizable number were usually found under the canopy of rare nurse trees. That is, mature oaks which have a favorable combination of good acorn production and ecological conditions for germination and establishment. Seedlings often die back in their first year or two, and may suffer considerable mortality. Current stand structure of *Quercus engelmannii* trees on the Santa Rosa Plateau suggest that reproduction has been insufficient to maintain the present size distribution of the species in the future. This lack of recruitment of young oaks is

also reported in stand structure studies of blue oak (*Quercus douglasii*) and valley oak (*Q. lobata*) in central and northern California (White 1966, Griffin 1971, 1976, Mensing 1977, Bartolome and others 1987, and Thomas 1987).

Continued studies are needed to obtain more baseline ecological information on the natural regeneration of *Quercus engelmannii* in southern oak woodland in order to evaluate the impact of regeneration patterns on future stand development. A historical analysis, including stand age structure studies, as a part in future research on this woodland type would also be warranted. However, developing a good stand age structure for the Engelmann oak woodland is beset with the difficulty of adequately aging trees in a stand; growth rates of annual rings of tree stems vary widely with geographic and topographic locations. Further studies on oaks would contribute research data essential to the development of sound management practices which could foster and enhance natural reproduction of the hardwood range habitat in California.

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