



*Quercus
kelloggii*

Ecological Relationships Between Southern Mule Deer and California Black Oak¹

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Abstract: Some ecological relationships between southern mule deer (*Odocoileus hemionus fuliginatus*) and California black oak (*Quercus kelloggii*) are examined in the Cuyamaca Mountains, San Diego County, California. Data are presented suggesting that high deer densities adversely affect regeneration of California black oak. Mule deer consume nearly all acorns produced, and have a substantial negative impact on seedlings and sprouts which arise from fallen trees. A hypothesis is advanced to explain the probable evolution of existing deer-oak relationships. The ramifications of the continued decline of black oak stands are discussed.

INTRODUCTION

There is a vast body of literature dealing with the ecology of mule deer (*Odocoileus hemionus*) in California (for example, see Dixon 1934, Leopold et al. 1951, Linsdale and Tomich 1953, Longhurst et al. 1952, and Taber and Dasmann 1958). Most researchers have noted the importance of oaks (*Quercus* spp.) in the diet of these ungulates; however, there is little quantified information concerning the impact of deer on oaks. Moreover, the most complete studies have dealt with deer inhabiting the Sierra Nevada and North Coast Ranges, while comparative data for deer occupying ranges in southern California are unavailable. The purpose of this paper is to examine and quantify specific ecological relationships between southern mule deer (*O.h. fuliginatus*) and California black oak (*Q. kelloggii*) in montane southern California.

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STUDY AREA

This study was carried out on East Mesa, Cuyamaca Rancho State Park, San Diego County, California. East Mesa is located in the Cuyamaca Mountains at an elevation of 1,525 m, and receives approximately 1,000 mm of precipitation annually, including 950 mm of snow fall. Summer temperatures rarely exceed 35 C and winter lows seldom fall below - 10 C.

East Mesa encompasses 800 ha and consists of extensive upland meadows interspersed with thin fingers of oak and pine habitats. The entire area is surrounded by dense, old-growth chaparral. Upland meadows are situated in hydric areas and oak and pine stands occur on rocky, mesic sites. Old-growth chaparral predominates in xeric areas.

The meadows are characterized by annual grasses and forbs, including cheatgrass (*Bromus tectorum*), ripgut (*B. diandrus*), six-weeks fescue (*Festuca octoflora*), red-stemmed filarree (*Erodium cicutarium*), tumble mustard (*Sisymbrium altissimum*), western ragweed (*Ambrosia psilostachya*), and slender-wooly buckwheat (*Eriogonum gracile*). Deer grass (*Muhlenbergia rigens*), sedge (*Carex* sp.), and rush (*Juncus* sp.) occur in wet portions of meadow habitat. Large concentrations of tumble mustard, a valuable deer forage species, also are found in

meadows with high soil moisture. Wild oats (*Avena barbata*) are common on drier sites adjacent to oak and pine stands. California buckwheat (*Eriogonum fasciculatum*) occurs on the periphery of meadows. Isolated patches of rose (*Rosa californica*) and chokecherry (*Prunus virginiana*) also are present in meadow habitat. Small islands of native perennial grasses, *Agropyron trachycaulum*, *Bromus marginatus*, *Calamagrostis densa*, *Elymus glaucus*, and *Sitanion hystrix*, occur amid broad expanses of annual exotics, but only rarely.

Oak habitat is comprised predominantly of California black oak, but coast live oak (*Quercus agrifolia*) and a scrub form of interior live oak (*Q. wislizenii frutescens*) also are present. Squaw bush (*Rhus trilobata*) and snowberry (*Symphoricarpos mollis*) dominate understory shrubs. Soft chess (*Bromus mollis*) and ripgut occur beneath the oaks and in forest openings. Mexican manzanita (*Arctostaphylos pungens*) and occasionally Jeffrey pine (*Pinus jeffreyi*) also occur in this habitat type. Coffeeberry (*Rhamnus californica*) often inhabits ecotonal zones between oak and meadow.

Pine habitat is composed largely of Jeffrey pine. Within pine stands, California black oak and coast live oak occur at low densities, the latter being more common. Mexican manzanita also is present. Yarrow (*Achillea millefolium*), phlox (*Leptodactylon pungens*), and California brome (*Bromus marginatus*) occur beneath the pines.

Chaparral habitat is characterized by chamise (*Adenostoma fasciculatum*), mountain mahogany (*Cercocarpus betuloides*), mountain lilac (*Ceanothus greggii*, *C. leucodermis* and *C. palmeri*), redberry (*Rhamnus crocea*), holly-leaved cherry (*Prunus ilicifolia*), pink-bracted manzanita (*Arctostaphylos pringlei*), and white sage (*Salvia apiana*).

METHODS

Oak densities were estimated using a combination of toe point (Wood *et al.* 1960) and nearest neighbor (Cottam and Curtis 1956) sampling techniques. Results are based on 1,944 toe points. Diameter at breast height (DBH) and browse line height (BLH) measurements were obtained for 210 California black oaks from seven areas on East Mesa. DBH measurements were made at a height of 150 cm. If an oak branched below that height, only the largest branch was measured. BLH was obtained by recording the lowest new growth available to deer. DBH measurements also were taken from 60 dead California black oaks.

Deer utilization of 93 black oaks was de-

termined by counting the number of "bites" available to deer, and noting the actual number of "bites" removed (Mackie 1970). Furthermore, 200 samples of black oak new growth were clipped, and leader lengths as well as weights of new growth removed by deer were determined.

The abundance and timing of drop for the black oak acorn crop was estimated using five protected 0.22 m² plots and 20 unprotected plots of the same size. Data on acorn removal by deer were obtained by sampling within a 49.21 m² enclosure that allowed the entry of all wildlife except deer. Estimates of the summer densities of southern mule deer are based on direct observation of 1,401 deer. Plant nomenclature is according to Munz (1974).

RESULTS

Density estimates based on nearest neighbor calculations suggest there are 3,500 California black oaks on East Mesa. In oak habitat, these trees occur at a mean density of 48 oaks/ha, while in pine habitat the mean density is 12 oaks/ha. Approximately 200 southern mule deer inhabit East Mesa.

The most apparent impact of mule deer on black oaks is the conspicuous browse lines on many of these trees (fig. 1). Of the 93 black oaks examined at the end of summer, 96 percent exhibited signs of deer browsing. New growth on the remaining 4 percent of these oaks was too high to be available to deer. Black oaks provided a mean of 289 leaders of new growth available to deer on each tree. Forty-six percent of all available leaders showed evidence of deer utilization. The mean length and dry weight of unutilized black oak leaders were 59 mm and 0.31 g, respectively. The mean length and dry weight of utilized leaders were 39 mm and 0.18 g. Thus, deer use of new growth totaled 34 percent by length and 43 percent by dry weight. In



Figure 1--California black oak with a conspicuous browse line from deer overutilization.

aggregate, deer removed 20 percent (by dry wt) of all available new growth. We have calculated that 17 g (dry wt) of new growth per oak, or 58.83 kg (dry wt) of black oak in toto were eaten by deer on East Mesa during summer (Jul-Sep). These data suggest that an average deer consumes about 3.2 g (dry wt) of black oak foliage and twigs during this period.

It is evident that black oak stems and leaves are not preferred forage. Almost all browsing by these mule deer occurs during summer when forbs (primarily tumble mustard and red-stemmed filaree) dry out and become unpalatable^{4/}. Even during summer, southern mule deer take less than 30 percent browse in their diet^{4/}. Yet, deer densities are sufficiently high that even this low level of utilization causes considerable damage to black oaks. In addition to removing new growth from mature trees, deer adversely affect black oak seedlings. During the spring of 1977, these seedlings numbered 6/ha in oak habitat. However, in areas of heavy deer use, no seedlings survived past early July. Moreover, our data suggest that there has been almost no seedling survival in these oak stands in the last 25 years. Only when acorns germinate within dense patches of squaw bush or snowberry are they not substantially damaged or completely consumed by deer.

Where oak and pine habitats adjoin, pine seedlings, which deer do not eat, are encroaching upon traditional oak habitat. Unless the elimination of black oak seedlings by deer overbrowsing is reduced substantially, the conversion of oak to pine habitat appears to be a strong possibility.

Finally, mule deer influence black oak recruitment by consuming large numbers of acorns. Longtime residents of the Cuyamaca Mountains recall that the 1978 acorn crop is the largest in memory. The majority of black oak acorns was dropped on October 2 and 3, 1978. The number of viable acorns produced during fall is estimated at 6,440/oak or 309,100/ha. Yet, wildlife consumed over 85 percent of this mast by October 20 (fig. 2). All acorns had been removed from the 20 unprotected plots by the end of November (fig. 2). Acorns remaining within the enclosure suggest deer consumed 94 percent of the acorns removed by wildlife. Thus, an average deer ingested approximately 315 acorns/day during fall, which would total 1.21 kg (dry wt)/deer/day. Indeed, acorns are preferred over all other forage, and all deer rumen samples examined during fall contained a large percentage of acorns^{4/}.

^{4/} Unpublished data, R. Terry Bowyer, School of Natural resources, The University of Michigan, Ann Arbor, Michigan.

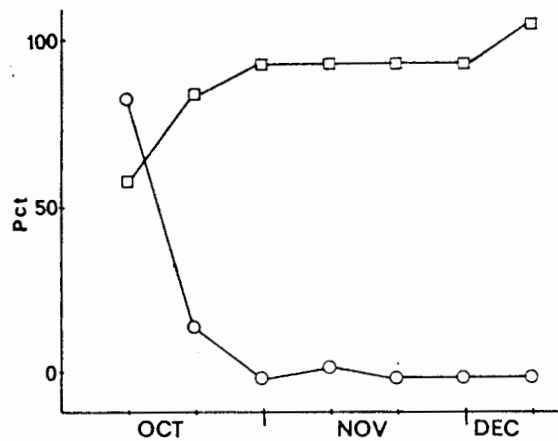


Figure 2--Percentage of total acorns dropped by 10-day periods from 1 October through 10 December, 1978 (open circles), and the cumulative percentage of available acorns removed by wildlife during this same period (open squares).

Root rot (*Armillaria* sp.) is evident on many older black oaks on East Mesa^{5/}. This condition may predispose these decadent oaks to severe damage during wind and ice storms. Indeed, Staley (1965) has implicated *Armillaria* as a secondary factor contributing to the decline of *Quercus ruber* and *Q. coccinea*. This problem is less pronounced in areas of lower deer density on East Mesa, as downed oaks typically stump sprout. However, where large numbers of deer occur, these sprouts are eaten back and eventually die.

There was no significant difference ($\chi^2 = 2.35, p > 0.05, 1 \text{ df}$) between the mean DBH of living black oaks ($\bar{x} = 63.7 \text{ cm}$) and the mean DBH for dead ones ($\bar{x} = 70.5 \text{ cm}$) throughout oak habitat. This suggests that many black oaks may be in imminent danger of being lost from the population.

The impact of deer on black oak was further assessed by comparing seven areas of varying deer densities with the corresponding DBH and BLH measurements of black oak. Significant positive correlations were found between deer density and both DBH and BLH (fig. 3). Moreover, the percentage of black oaks less than 150 cm in height in each area was negatively correlated with deer density, but not significantly (fig. 3). No black oaks less than 150 cm in height were found in areas where summer deer densities exceeded a total of 2.4 deer/ha (fig. 3), which includes all oak habitat on East Mesa.

^{5/} Personal communication from Joe Agozino, Resource Ecologist, California Department of Parks and Recreation, San Diego, California.

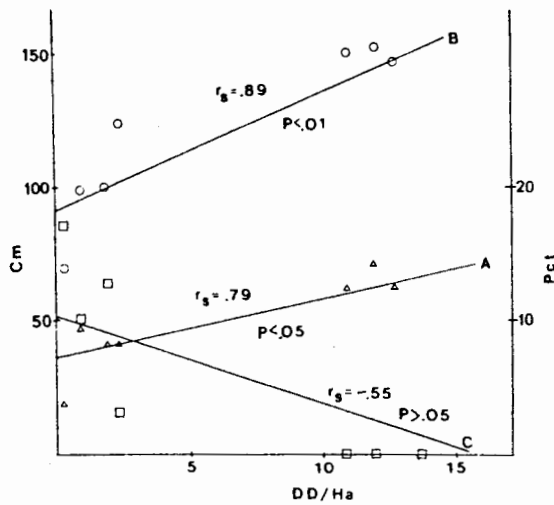


Figure 3--Regressions of DBH (line A, triangles), BLH (line B, circles) and percentage of trees less than 150 cm in height (line C, squares) for California black oak on total deer days of use per hectare (DD/Ha) during summer months. Regression equations for lines A, B, and C are $Y=2.12x+35.66$, $Y=4.34x+90.75$, and $Y=-0.66x+10.05$, respectively. r_s =Spearman rank correlation.

DISCUSSION

We hypothesize that the current relationships between southern mule deer and California black oak are linked to environmental changes which occurred approximately 25 years ago. Thus, we have attempted to reconstruct the range history of East Mesa through discussions with longtime residents and Park personnel, and by examining Park files.

Grazing pressure by cattle on East Mesa was relatively light during the first half of the 20th century. But, in the mid-1950's, the original objective of running Cuyamaca Rancho State Park as a cattle ranch was used to secure a lease permitting the grazing of 300 cattle on Park land. The majority of this livestock was pastured on East Mesa. The impact of cattle overgrazing on East Mesa's plant communities was catastrophic (fig. 4). A concerted effort by Park personnel finally resulted in the removal of cattle from East Mesa, but not before overgrazing had wrought dramatic changes. It is likely that this damage to the range contributed to the replacement of native perennial grasses by introduced annual forbs and grasses, as well as leading to tremendous increases in the densities of ground squirrels (*Spermophilus beecheyi*) and perhaps pocket gophers (*Thomomys bottae*).



Figure 4--Cattle overgrazing and range deterioration on East Mesa in December, 1955.

Simultaneously, other environmental permutations were further influencing East Mesa's plant communities. During the late 1940's and early 1950's, wildfires burned vast areas of chaparral adjacent to East Mesa. These fires created large tracts of newly available and productive deer habitat, and likely resulted in a population irruption of these animals. We know of no other environmental changes which might explain this increase in the deer population. However, burned chaparral declines rapidly in nutrient value, and provides suitable deer habitat for only about five years (Biswell 1961, Biswell et al. 1952, Dasmann 1956, and Taber and Dasmann 1958). As the chaparral once again became dense and the shrubs less palatable, it no longer would support this massive number of deer. Thus, we hypothesize an influx of large numbers of deer from the chaparral to East Mesa. Residents of this area recall seeing groups of several hundred deer on East Mesa during this period. Yet, this was considerably more deer than East Mesa was capable of supporting. DBH measurements suggest that the last black oak seedlings in oak habitat were established some time prior to this period of heavy use by deer and cattle.

The removal of cattle from East Mesa allowed the recovery of plant species which were not preferred by deer. Most spectacular was the rejuvenation of stands of native deer grass which the cattle had nearly eliminated. Unfortunately, the browselines on many shrubs and trees, and the lack of black oak seedlings, went largely unnoticed by Park personnel. Eventually, the deer population came to a new equilibrium at perhaps half its previous size. Today, groups of even 40 deer are observed only infrequently on East Mesa.

The decrease in the deer population from levels attained in the 1950's is probably the major reason for deer damage going unnoticed

for so many years. The general opinion was that a decreasing deer population must be well below carrying capacity, and therefore unlikely to cause further serious range problems. But, present deer densities are more than sufficient to prevent black oak regeneration for most areas of East Mesa. Furthermore, the current deer population is probably substantially larger than under pristine conditions. Oak groves on East Mesa are hundreds of years old, and it is difficult to explain the existence of these multiple-aged stands without postulating lower deer densities when they were established. Indeed, Amaral (1978), Peterkin and Tubbs (1965) and Stoeckler *et al.* (1957) demonstrated that grazing mammals are capable of almost completely preventing regeneration of other tree species.

The ramifications of this decline in the black oak population are enormous. Even if management practices designed to perpetuate black oaks were implemented immediately, the proliferation of multiple-aged stands could take decades. Moreover, the adverse impact of the loss of oak habitat on the myriad of wild-life species that rely on mast for food and/or oaks for nesting and cover (Graves 1977) may be immense.

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