HERBACEOUS PRODUCTIVITY IN OAK WOODLAND

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Abstract: Measurement of seasonal productivity over three years at the Hopland Field Station in Mendocino County, California, revealed significant differences in production and composition for the oak understory and adjacent open grassland. Productivity under the canopy was lower: about two-thirds of open grassland peak standing crop in spring, and about one-half of open grassland standing crop in winter. The understory and open differed significantly in species composition, but differences in forage quality were not important until late in the spring. Although species composition differed substantially between years, composition differences due to canopy effect remained consistent over the three years of the study.

The oak woodland and associated annual grassland have long been a center for range livestock production in California. Oaks dominate about 4 million ha, with an equal area in annual grassland, often adjacent at lower elevations (Passof and Bartolome 1985, Bartolome et al. 1980). This area of land provided the basic forage resource, which allowed settlement of the state by Europeans whose economy depended on livestock products. Only after 1850 did the rapid expansion of mining and crop agriculture provide alternatives to livestock (Burcham 1957). Range resources then became subject to continuing conflicts over management objectives.

Increased livestock productivity on California's annual grasslands and associated woodlands has been achieved through seeding of improved pasture species and through fertilization. Cutting woody overstory species has also increased forage production by removing the canopy effect and its presumed suppression of the understory. This practice has increased forage availability and stocking levels where oak canopy cover is high (Heady and Pitt 1979, Kay and Leonard 1980). Yet, Heady and Pitt (1979) found that productivity of woodland sites remained below that of grassland even after complete tree removal.

At low canopy cover spring standing crop may be enhanced under deciduous oaks (Holland 1980), although even individual live oaks greatly suppress understory productivity (Parker and Muller 1982). Jackson et al. (1985) found higher peak standing crop under blue oak canopy then in adjacent grassland at the Sierra Field Station in the Sacramento Valley. The higher peak followed a yearlong pattern of less productivity under the canopy. The composition and forage quality of the oak understory differed considerably from adjacent open grassland.

Clearing of dense oak stands has repeatedly been shown to increase herbaceous productivity in the short run, although not to the levels of naturally open grassland (Heady and Pitt 1979). With the exception of Pitt and Heady (1979), who measured February composition and standing crop, published studies have only reported spring results for manipulated sites. The lack of information documenting differences in understory and open productivity at other times of the year has led, in part, to conflicting recommendations for oak removal. Management recommendations for stands of low or intermediate density appear to be hampered by the lack of important information about the seasonal production curve needed to decide among alternatives (Passof et al. 1985). The information is important because oaks can affect the amount of scarce early season forage.

This paper reports results of a three-year study comparing composition and productivity of the understory in blue oak (*Quercus douglasii*) stands and adjacent open annual grassland in northern California. The objectives were to evaluate: (1) seasonal patterns of forage production, (2) yearly variations in productivity, and (3) yearly compositional differences. This kind of information has not been previously published for any California woodland site, and illustrates the information needed for development and evaluation of management programs.

STUDY AREA AND METHODS

The University of California's Hopland Field Station is located in Mendocino County, California. The station, about 2168 ha, supports vegetation typical of the inner coast ranges, a mixture of open annual grasslands, oak woodlands of varying

canopy coverage, and shrublands (Murphy and Heady 1983). Annual precipitation, concentrated in winter, averages about 100 cm.

The two study pastures, each approximately 30 ha, have historically been used by sheep since before the establishment of the station in 1951. About 90% of the pastures were in blue oak woodland or open grassland, the rest primarily consisted of dense oak stands, usually with liveoaks. From 1960 to 1979 the open grassland areas of the pastures were measured yearly for botanical composition and forage production at peak standing crop in the spring using small cages to exclude sheep, which continued to use the pastures seasonally (Vaughn and Murphy 1982). Twenty cages were placed in each pasture, located randomly in the open grassland, but at evenly spaced locations (macroplots). Cages were moved after each year's sample within the general location of the macroplot.

In October 1982, half of the macroplots were relocated to include woodland understory in the sample. Even numbered cages were moved from the previous (open grassland) plot to a new macroplot under the closest suitable stand of blue oak. Stands were chosen to consist primarily of blue oak, relatively large (over 10 cm dbh), with local canopy coverage of at least 75%.

Plots were clipped within cages four times at distinct growth stages during the year to determine live and dead standing biomass in a 25x25 cm quadrat. Sampling dates chosen were: early October (standing dead prior to first rains), late November (end of rapid fall growth), mid-February (beginning of rapid spring growth), and mid-May (peak standing crop, end of growing season). Species composition was measured in May through the use of the point frame, fifty points per cage. Sampling was repeated for three years beginning in October 1982.

RESULTS

Productivity follows the typical pattern for Mediterranean type grasslands (George et al. 1985), with rapid growth followed by death and seed set (Fig. 1). Decomposition rates for dead material also are typical of those reported elsewhere (Jackson et al. 1985, Heady et al. in press), with a short period of rapid decomposition in fall, slowing in winter, and a short new burst in early spring. Some range managers suggest that winter productivity is increased under the blue oak canopy, particularly in the San Joaquin Valley (Don Duncan, pers. comm.). However, the average for the three years at Hopland show an even greater difference between understory and open for fall and winter than later in the spring. Productivity was reduced by one-third in spring, but by one-half in fall and winter.

Seasonal productivity varied considerably in the understory and open from year to year (Table 1). This degree of variability is typical for peak standing crop in both woodland (Pitt and Heady 1978) and open grassland (Vaughn and Murphy 1982). The values for peak standing crop in the open grassland are somewhat above the 1960-1979 average of Vaughn and Murphy (1982), reflecting the relatively good growing conditions during the study. Amount of standing crop in February appeared to have little relationship to ultimate peak standing crop. The lowest winter standing crop (in February 1984) was in the year with highest peak (in May 1984) for both the open and understory. In 1984-5, the lowest production year, the understory dropped off relatively more than did the open grassland.

Species composition differed both among years and between the open grassland and the oak canopy. Overall cover declined significantly in 1985, the lowest production year (Fig. 2). Particularly striking was the decline in legume abundance after 1983 in the open grassland.

Several species were significantly affected by the canopy. Bromus rigidus is significantly more abundant in the understory, although the species is also present in the open at low cover. Annual Festuca species were much more common in the understory, although present in the open. Bromus mollis was a much more important element in the open grassland than the understory. Avena barbata and the overall number of non-legume forbs was not significantly affected by the canopy. Three species were common elements of one type but absent from the other. Erodium botrys and Taeniatherum asperum were not found under the canopy; Carduus pycnocephalus was not found in significant amounts in the open.

These species differences suggest that at peak standing crop forage quality will be better in the open grassland because the understory contains a higher proportion of low value dominants. Yet the especially undesirable Taeniatherum asperum does not occur under the canopy. However, for most of the season, differences in composition will have only a negligible effect on forage quality because the plants are in the vegetative stage and of similar

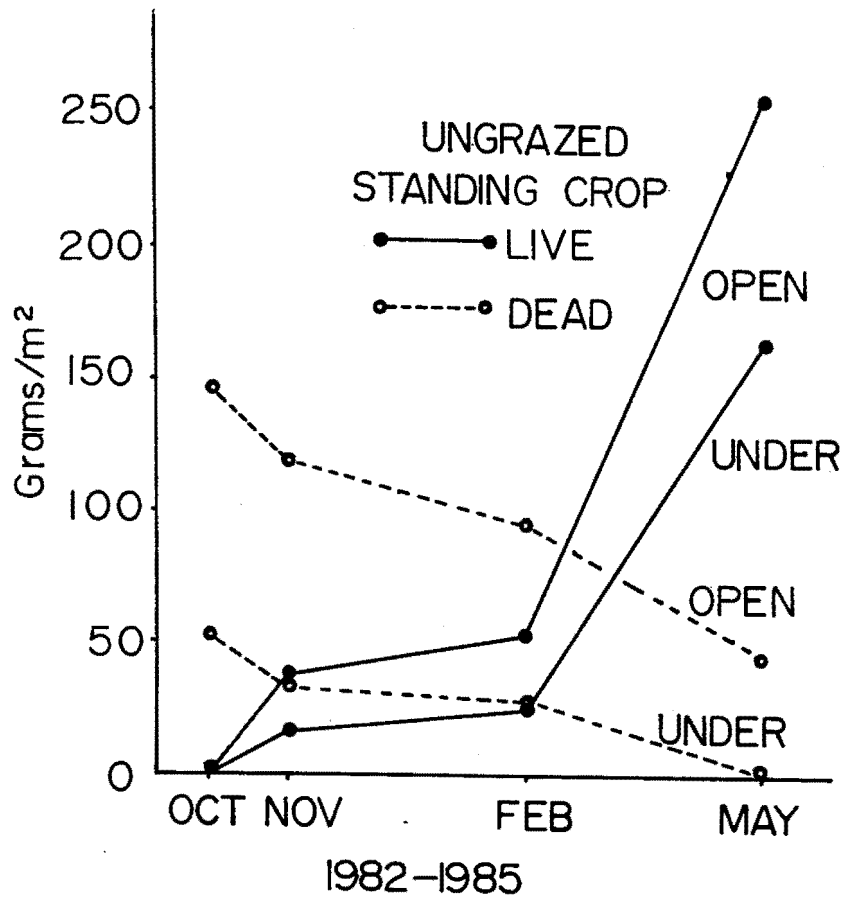

Fig. 1. Seasonal changes in standing crop for ungrazed open and understory herbaceous vegetation. Pairs of data points for live and dead biomass are significantly different ($P < 0.05$) for open and understory vegetation at each sampling date.

Table 1. Seasonal standing crop for oak understory and open annual grassland. Values are for live aboveground standing crop (grams per square meter), except for October, from ungrazed plots. Differences between open and understory are significant ($P < 0.05$) for each year.

		October	November	February	May
1982/	Open	81.1	49.9	58.7	272.2
1983	Understory	42.6	20.9	32.5	161.9
1983/	Open	158.2	30.1	32.3	284.3
1984	Understory	33.4	23.7	17.7	233.0
1984/	Open	198.4	33.6	59.2	204.4
1985	Understory	75.2	8.0	27.2	86.1

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