Tree canopy effects on herbaceous production of annual rangeland during drought

WILLIAM E. FROST AND NEIL K. MCDOUGALD

Abstract

Seasonal herbaceous production was measured beneath tree canopies of blue oak (*Quercus douglasii* Hook & Arn.), interior live oak (*Quercus wislizenii* DC), and digger pine (*Pinus sabiniana* Dougl.), and in adjacent open grassland during 2 drought years (1986–87 and 1987–88) at the San Joaquin Experimental Range, California. Early and mid-growing season herbaceous production was variable, with no increase in production beneath the canopies the first year and a 60 to 150 kg/ha increase the second year compared to the herbage produced in open grassland. Peak standing crop was about 1,000 kg/ha greater beneath blue oak canopies than in open grassland in both years. Peak standing crop beneath interior live oak canopies was about 700 and 1,000 kg/ha greater than in open grassland the first and second years of the study, respectively. Peak standing crop beneath digger pine canopies was about 500 kg/ha greater the first year and similar the second year to that of the open grassland.

Key Words: seasonal production, herbage production

California's annual rangelands (oak woodlands) are the state's most important source of range forage. While comprising only about 15% of the state's forest and range acreage this area supplies 65% of the state's AUM's of domestic livestock grazing (Clawson 1988). Removal of blue oak (*Quercus douglasii* H. & A.) and conversion to open grassland has been advocated as a method of increasing annual herbaceous production on oak woodlands in parts of northern California (Murphy and Crampton 1964, Murphy and Berry 1973, Jansen 1987, Kay 1987). These investigators found lower annual herbaceous production under blue oak canopy than in open grassland. Following tree removal herbaceous yield in areas which had been under the tree canopies increased to levels higher than those in open grassland. Similar overstory-understory relationships have been reported over a wide range of vegetation types (Hyder 1954, Pond 1964, Clary 1971, Thatcher and Hart 1974, Williams 1976, Woods et al. 1982, Thill et al. 1983).

In contrast, research in central California has shown annual herbaceous production to be 15% to over 100% greater under scattered living blue oaks than in open grassland (Duncan and Reppert 1960; Holland 1973, 1980; Duncan and Clawson 1980). In this region, death or removal of trees has resulted in a gradual decline in annual herbaceous production leading to herbage levels comparable to those of the less productive open grassland (Holland 1973, 1980). Greater herbaceous production beneath blue oaks has been attributed to more favorable physical and chemical soil properties and a more favorable, moderated soil temperature under the trees than in open grassland (Holland 1968, 1973).

Other overstory species are also prominent on the oak woodlands of central California. Interior live oak (*Quercus wislizenii* DC) and digger pine (*Pinus sabiniana* Dougl.) are common. While less attention has been paid to these species, they have a demonstrated effect of reducing annual herbaceous production over 30% as compared to open grassland (Ratliff et al. 1988).

Authors are research associate, California Agricultural Techology Institute, California State University, Fresno 93740 and livestock and range farm advisor, University California Cooperative Extension, Madera 93637.

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This study was initiated to examine the effects of all three major overstory species—blue oak, interior live oak, and digger pine—on seasonal as well as annual forage production. The study was begun in the fall of 1986, which coincided with the beginning of a drought cycle in the central Sierra Nevada foothills.

Study Area

The study area ws an open rolling site of Range Unit 41 of the San Joaquin Experimental Range (SJER) at an elevation of 335 m. The SJER is located in the lower Sierra Nevada foothills of central California about 25 miles northeast of Fresno.

Herbaceous cover consists of over 400 annual plants with *Bromus mollis* L., *B. diandrus* Roth., *Vulpia myuros* K.C., *Erodium botrys* Bertol. and *Trifolium* spp. predominating. The overstory consists of scattered blue oak, interior live oak, and digger pine. Tree canopy cover, as determined by line intercept (Canfield 1941), is 6% blue oak, 12% interior live oak, and 3% digger pine.

The soils are of granitic origin and less than 0.75 meters in depth. The soil is classified as the Ahwahnee series (coarse-loamy, mixed thermic Mollic Haploxeralf).

The average annual precipitation is 487 mm with a low of 254 mm and a high of 940 mm (unpublished data). Annual precipitation was only 283 and 305 mm the 2 years of the study. Monthly and annual precipitation amounts are presented in Table 1.

Table 1. Monthly and total precipitation (mm) for the San Joaquin Experimental Range.

Month	Year 1986–87	Year 1987–88	53 Year[1] Average
	(mm)		
July	0	0	1
Aug	0	0	1
Sept	14	0	7
Oct	7	37	24
Nov	2	23	57
Dec	18	48	81
Jan	53	53	86
Feb	101	12	89
Mar	77	42	81
Apr	3	79	45
May	8	9	12
June	0	2	3
Total	283	305	487

[1]Unpublished data.

Methods

A 1.6-ha area was exclosed to cattle grazing by using electric fencing until after sampling herbaceous production in May. Cattle were allowed to graze the area from approximately mid-May to late September or early October each year when moderate levels of residual dry matter were reached (Clawson et al. 1982). Stocking rate in the entire range until was 1 cow per 15 acres under yearlong grazing. Cattle were mature English or English crossbreeds.

Standing crop was measured at 8-week intervals during the green forage period and used as a measure of herbaceous production. Standing crop was determined by the comparative yield

method (Haydock and Shaw 1975), a double sampling technique, utilizing a 30 × 30-cm frame. Standing crop was measured beneath the canopies of blue oak, interior live oak, and digger pine as well as in open grassland. Sample size was eight 50-plot transects per overstory category at each sampling date. Sampling was conducted along randomly located pace transects. Sample plots were located along the transects when they occurred beneath the canopy of appropriate species. Sampling along each transect was conducted under 4 to 6 trees of each species.

Differences in herbaceous production among the different canopies were examined with analysis of variance. Least significant differences were calculated where significant tree canopy effects were detected (Little and Hills 1978). Significant differences were declared at $p \leq .05$.

Results

September Herbaceous Production

No early fall rains occurred during the 2 years of the study (Table 1). Thus, no herbage growth occurred prior to the mid-September sampling date (Table 2).

Table 2. Forage production (kg/ha) beneath blue oak, interior live oak and digger pine canopies and in open grassland at the San Joaquin Experimental Range.

Month-Year	Overstory			
	Blue oak	Interior live oak	Digger pine	Open grassland
	(kg/ha)			
Sept-1986	0a[1]	0a	0a	0a
Nov -1986	166a	155a	156a	141a
Jan -1987	251a	236a	237a	216a
Mar -1987	907a	860b	868b	808c
May -1987	2789a	2404b	2230b	1672c
Sept-1987	0a	0a	0a	0a
Nov -1987	421a	352b	315b	254c
Jan -1988	660a	646ab	637b	592c
Mar -1988	916a	899a	894a	816b
May -1988	2667a	2611a	1635b	1622b

[1]Means in the same row followed by the same letter are not significantly different ($p = .05$).

November Herbaceous Production

Low amounts of precipitation in 1986–87 resulted in little herbage growth beneath any of the overstory canopies or in the open grassland. Herbaceous production averaged 154 kg/ha in all areas (Table 2).

Above-average fall precipitation in 1987–88 produced greater herbage yield. Herbaceous production was significantly higher beneath blue oak canopies than in other areas. Herbaceous production in the open grassland was significantly lower than beneath tree canopies (Table 2).

January Herbaceous Production

No differences were found in 1986–87 in herbaceous production among the different canopies or open grassland. Average production in all areas was 235 kg/ha (Table 2).

Higher precipitation in 1987–88, though below normal, produced greater herbage growth than in 1986–87. Greatest herbaceous production was found beneath the canopies of blue oak and interior live oak. Herbaceous production in the open grassland was significantly lower than beneath any tree canopy (Table 2).

March Herbaceous Production

In both 1986–87 and 1987–88 significant differences were detected in herbaceous production among the different canopy categories. In 1986–87 the most herbaceous production occurred beneath blue oak and digger pine canopies, 907 and 868 kg/ha, respectively. Herbaceous production beneath interior live oak was intermediate at 860 kg/ha, with the production in the open grassland significantly lower than under any canopy (Table 2).

In 1987–88, herbage levels beneath the different canopies were similar, averaging 903 kg/ha. Herbaceous production was significantly lower in the open grassland, 816 kg/ha (Table 2).

May Herbaceous Production

In 1986–87 herbaceous production beneath blue oak canopy was significantly higher than under any other canopy or in the open grassland. Herbage levels were similar under interior live oak and digger pine canopies, averaging 2,317 kg/ha, and lowest in the open grassland at 1,622 kg/ha (Table 2).

A slightly different relationship occurred in 1987–88 with similar herbaceous production beneath the blue oak and interior live oak canopies, 2,667 and 2,611 kg/ha, respectively. These amounts were greater than those found either under digger pine or in the open grassland (Table 2).

Discussion

With adequate fall rains (1987–88) herbaceous production was greater early in the growing season beneath all tree species canopies than in the open grassland, with production being greatest beneath blue oaks. This follows the pattern found in this region for blue oak—open grassland comparison by McClaran and Bartolome (1987).

In mid- and late winter virtually the same relationships existed as in November. If fall rains were sufficient to allow for relatively normal herbaceous production, the differences brought about by the canopies continued into January and early March.

The bulk of herbaceous growth on oak woodlands occurs during the months of March, April, and May. At this time soil moisture is sufficient (in most years) and temperatures are warm. It was during this period that tree canopies exhibited the largest impact on herbaceous production as herbage levels beneath blue oak and interior live oak nearly tripled. Herbage levels beneath digger pine responded in a similar manner in 1986–87, increasing by 2.5 times, but only doubled during this period in 1987–88. In both years of this study herbage levels in the open grassland lagged behind those under oak canopies. Herbage levels in the open grassland only doubled during this rapid growth period.

The value of blue oak canopies in increasing early forage production in this region as found by McClaran and Bartolome (1987) and Duncan and Clawson (1980) only occurred in 1 of the 2 drought years. Total herbaceous production increased under blue oak canopies in both years as compared to open grasslands. These data are similar to earlier findings (Duncan and Reppert 1960; Holland 1973, 1980; Duncan and Clawson 1980; Ratliff et al. 1988) but contrary to results of McClaran and Bartolome (1987) which did not show an increase in forage production at peak standing crop.

Herbaceous production beneath interior live oak canopies followed a similar pattern to that under blue oak. Herbaceous production increased early in the growing season with adequate rainfall, but no increase was found in the fall when little rain was received. Total herbaceous production was greater in both years than in the open grassland. The increase in total herbaceous production of 44% in 1986–87 and 61% in 1987–88 are directly opposite the 36% reduction found beneath interior live oak canopy on a similar site by Ratliff et al. (1988). The decrease in production beneath interior live oak canopies may be attributed to the shading effect of the canopy of the evergreen interior live oak reducing herbage growth. It may be that canopy shading becomes extremely valuable in drought years, by reducing moisture loss from evapotranspiration.

Herbaceous production beneath digger pine was greater than in open grassland in both the March and peak standing crop samplings in 1986–87 and through the March sampling in 1987–88. The 33% increase in total herbaceous production in 1986–87 and similar herbaceous production in 1987–88 compared to open grassland differs from the reductions of 48% on swale sites and 21% on rocky brush sites reported by Ratliff et al. (1988). It is possible that the shading by digger pine canopies aids soil moisture conservation as mentioned previously for interior live oak. With fluctuating results over the 2 years it is difficult to develop a defendable hypothesis.

Conclusions

The effects of blue oak and interior live oak canopies on herbaceous production early in the growing season of both drought years was variable, but not detrimental. By the middle of the growing season herbaceous production beneath blue and live oak canopies was greater than in open grassland. This increase in herbaceous production continued until peak standing crop was reached during both drought years.

Digger pine canopies had a variable effect on herbaceous production. They may or may not be beneficial to herbage growth during drought years, but did not reduce herbaceous production.

These results reaffirm the value of blue oak for increasing annual herbaceous production and possibly greater early season herbage during drought years. Our results also demonstrate the value of interior live oak, usually considered detrimental to herbaceous production, for increasing herbaceous production during years of below normal precipitation.

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