Blue Oak Canopy Effect On Seasonal Forage Production and Quality[1]

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Abstract: Forage production and forage quality were measured seasonally beneath the canopy of blue oak (*Quercus douglasii*) and in open grassland at the San Joaquin Experimental Range. At the March and peak standing crop sampling dates forage production was significantly greater (p=.05) beneath blue oak compared to open grassland. At most sampling dates, the protein content was greater, and at some dates the acid detergent fiber and lignin concentration was lower, in forage beneath blue oak than in open grassland. Increased forage production and better forage quality beneath blue oak canopy demonstrate the value of scattered blue oaks in this region of California.

California's hardwood rangelands are the state's most important source of range forage, supplying about 65 pct of the state's AUM's for domestic livestock grazing (Clawson 1988). Removal of blue oak (*Quercus douglasii* Hook. & Arn.) and conversion to open grassland has been advocated as a method of increasing total 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 total annual herbaceous production under blue oak canopy than 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 and others 1982, Thill and others 1983).

In contrast, research in central California has shown total annual herbaceous production to be 15 pct to over 100 pct 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).

Forage quality has also been found to be significantly different for forage beneath blue oak canopy and in open grassland at the end of the growing season. Holland and Morton (1980) found that herbaceous plants beneath blue oaks had significantly higher levels of crude protein, P and K than those in open grassland. A similar result was reported by Kay and Leonard (1980) and Kay (1987) who found higher levels of N, P, and S present in forage beneath the canopy of blue oaks than in that of open grassland.

The objectives of this study are: (1) Quantify the forage production differences under the canopy of blue oak and in open areas outside the canopy periodically through the growing season; and (2) Compare the chemical composition of forage, both under and outside blue oak canopy throughout the year.

STUDY AREA

The San Joaquin Experimental Range (SJER) is located in Madera County, within the Sierra Nevada foothills of central California, 25 miles northeast of Madera and 30 miles north of Fresno. The SJER is typical of the blue oak phase of the foothill woodland vegetation type (Griffin 1977). The SJER lies primarily between 1,000 and 1,700 feet elevation; predominant aspect is southwest. Annual precipitation averages over 19 inches with recorded extremes of 9 and 37 inches (Coon 1989).

The study area consisted of open rolling sites, classified as blue oak-interior live oak/grass cover type (Allen and others 1989) with southwest aspects and slopes < 15 pct which have been grazed yearly since at least 1934 when the SJER was established. The overstory consists of scattered blue oak, interior live oak and digger pine. Canopy cover within the study area was 6 pct blue oak, 12 pct interior live oak and 3 pct digger pine. The major soil of the study area belongs to the Ahwahnee series (coarse-loamy, mixed, thermic mollic Haploxeralf) developed from intrusive igneous rocks of the Sierra Nevada Batholith.

METHODS

The sample area was exclosed to cattle grazing by using electric fencing until after sampling forage 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 and

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others 1982). Stocking rate in the entire range unit was one 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 forage production. Standing crop was determined by the comparative yield method (Haydock and Shaw 1975), a double sampling technique, utilizing a 1 by 1 foot frame. Standing crop was measured beneath the canopies of blue oak and 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 blue oak and in open grassland. Sampling along each transect was conducted under four to six trees.

Differences in forage production among the canopy categories and years were examined with analysis of variance. Least significant differences were calculated where significant tree canopy effects, area or year differences were detected (Little and Hills 1978). Significant differences were declared at $p \leq .05$.

Forage samples were collected every 8 weeks during the green forage period and and twice during the dry forage period from along the transects utilized in forage production determination beneath the canopy of blue oaks and in open areas. Ten grab forage samples were randomly collected beneath blue oaks or in open grassland and combined into one sample. Four samples were taken for blue oak and open areas at each sampling date. Samples were dried at 55°C, ground and neutral detergent fiber (NDF), on both a dry matter (NDFdmb) and ash (NDFash) basis, acid detergent fiber (ADF) and lignin (LS) concentrations determined using the procedures of Georing and Van Soest (1970) and nitrogen content determined using Kjedahl analysis. Nitrogen results were converted to crude protein values.

Differences in forage quality characteristics among the canopy categories and years were examined with analysis of variance. Least significant differences were calculated where significant tree canopy effects or year differences were detected (Little and Hills 1978). Significant differences were declared at $p \leq .05$.

RESULTS AND DISCUSSION

Precipitation

The years of this study (1986-90) coincided with a drought cycle in this region. Annual precipitation in these years has ranged from 58 pct to 68 pct of the long term average of 19.26 inches (table 1).

Forage Production

Over the 4 years (1986-90) there were significant differences in forage production among years for all sampling dates (table 2). This was expected as the large variation in yearly forage production, due to variations in weather, is well known (George and others 1985).

In the 1 year with adequate fall rains (1987-88) forage production was greater early in the growing season beneath blue oak canopies than in the open grassland (table 3). This follows the pattern found in this region by McClaran and Bartolome (1987). In mid- and late winter virtually the same relationship existed as in November, with fall rains sufficient to allow for relatively normal forage production the differences brought about by the blue oak canopy continued into January and March.

Table 1—*Monthly and annual precipitation (inches) for the San Joaquin Experimental Range.*

	1986-87	1987-88	1988-89	1989-90	40-Year Average
September	0.53	0.00	0.00	1.17	0.27
October	0.28	1.44	0.00	0.76	0.93
November	0.08	0.92	2.29	1.05	2.25
December	0.71	1.89	3.63	0.00	3.17
January	2.10	2.07	0.98	2.78	3.39
February	3.97	0.48	1.69	2.02	3.49
March	3.04	1.66	3.74	1.02	3.22
April	0.10	3.09	0.11	0.90	1.78
May	0.30	0.06	0.46	1.87	0.49
June	0.00	0.00	0.06	0.00	0.13
July	0.00	0.00	0.00	0.00	0.02
August	0.00	0.00	0.00	0.00	0.02
Total	11.11	11.61	12.96	11.57	19.16

Table 2—*Significant relationships in seasonal forage production for the 4 year period 1986-90.*

	Canopy	Year	CXY
September			
November		**	*
January		**	
March	**	*	
Peak	**		

* significant at p = .05

** significant at p = .01

Note:
CXY Canopy by year interaction

In the other years there was no significant difference in forage production between under the blue oak canopy and open grassland until the March sampling date (table 3). In all 4 years, and averaged across the years, forage production was significantly greater beneath blue oaks than in open grassland in March (table 3). The bulk of forage 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 blue oak canopies exhibited the largest impact on forage production as average forage levels beneath blue oak increased at a much greater rate than those in the open grassland.

Total forage production was significantly greater under blue oak canopies in all years, and averaged across the 4 years, as compared to that in open grasslands (table 3). These results are similar to earlier findings (Duncan and Reppert 1960, Holland 1973, 1980, Duncan and Clawson 1980, Ratliff and others 1988) but contrary to results of McClaran and Bartolome (1987) which did not show an increase in forage production at peak standing crop.

Table 3—*Forage production (lb./acre) at the San Joaquin Experimental Range.*

Date	Open	Blue Oak
Sept 1986	0a	0a
Nov 1986	126a	148a
Jan 1987	193a	224a
Mar 1987	721b	810a
Peak 1987	1493b	2490a
Sept 1987	0a	0a
Nov 1987	229b	376a
Jan 1988	529b	590a
Mar 1988	729a	818a
Peak 1988	1448b	2381a
Sept 1988	0a	0a
Nov 1988	0a	0a
Jan 1989	301a	343a
Mar 1989	974b	1510a
Peak 1989	1406b	2735a
Sept 1989	0a	0a
Nov 1989	0a	0a
Jan 1990	67a	84a
Mar 1990	423b	1420a
Peak 1990	864b	1963a
4 year average		
Sept	0a	0a
Nov	89a	131a
Jan	272a	310a
Mar	712b	1140a
Peak	1303b	2392a

(Values in a row followed by a similar letter are not significantly different [p = .05]).

Forage Quality

Clear differences in forage quality were measured between the open and blue oak sites (table 4). Under blue oaks the forage was consistently higher in crude protein concentration and lower in ADF and LS. On average the crude protein concentrations under the blue oaks were 54 pct higher than in the open and when combined with the differences in forage abundance between the two situations there was twice the amount of protein available

Table 4—*Forage quality characteristics for forage beneath blue oak canopy and in open grassland at the San Joaquin Experimental Range, California.*

Date	Overstory	NDFdmb	NDFash	ADF	LS	Crude Protein
Nov 87	Open	52.5a	6.7	33.8	8.9	15.17b
	Blue Oak	46.5b	4.7	29.3	7.6	19.61a
Jan 88	Open	52.7	7.8a	36.0a	9.0a	11.66b
	Blue Oak	46.7	2.8b	24.2b	5.1b	24.24a
Mar 88	Open	42.2	4.6	27.3	6.6a	11.58
	Blue Oak	50.3	2.0	27.4	3.7b	13.23
May 88	Open	67.0a	1.1	38.9a	5.4	6.03b
	Blue Oak	59.0b	1.2	33.7b	4.6	10.53a
July 88	Open	66.4	2.7	44.8a	7.1	4.23b
	Blue Oak	67.0	1.4	39.3b	5.5	8.16a
Sept 88	Open	68.4a	2.2a	46.0a	4.3	5.03
	Blue Oak	61.0b	1.1b	39.6b	4.7	6.50
Nov 88	Open	66.7a	1.8a	45.4	4.6	4.67b
	Blue Oak	62.3b	1.1b	41.3	4.8	6.23a
Jan 89	Open	43.9	10.9a	29.3a	12.9a	19.21b
	Blue Oak	40.3	3.4b	22.3b	6.4b	25.58a
Mar 89	Open	46.7	0.9	33.1	5.3	14.94b
	Blue Oak	50.6	0.6	30.5	4.3	21.43a
May 89	Open	66.3a	1.7	45.3	7.9	4.14b
	Blue Oak	71.6b	1.0	43.1	6.7	6.91a
July 89	Open	63.9	1.5	46.6	6.7	3.64b
	Blue Oak	68.4	1.3	44.8	6.5	4.69a
1987-1989	Combined					
Nov	Open	62.0	3.5	41.5	6.0	8.19
	Blue Oak	53.4	2.9	35.3	6.2	12.94
Jan	Open	46.8	9.9a	31.5a	11.6a	16.69b
	Blue Oak	43.5	3.1b	23.3b	5.8b	24.93a
Mar	Open	44.5	2.7	30.2	5.9a	13.25
	Blue Oak	50.4	1.3	29.0	4.0b	17.31
May	Open	66.7	1.4	42.1	6.7	5.06b
	Blue Oak	65.3	1.1	38.4	5.6	8.75a
July	Open	65.1	2.1	45.7a	5.6	3.94b
	Blue Oak	67.7	1.4	42.0b	6.0	6.44a

Note:
NDFdmb = Neutral detergent fiber, dry matter basis
NDFash = Neutral detergent fiber, ash basis
ADF =Acid detergent fiber
LS = Lignins

(lb/ac) under oaks than in the open grassland. While concentrations of NDF were significantly lower in some of the late fall and spring months under the oaks, there was a tendency for high NDF values in the forage beneath blue oaks in late spring and summer.

To estimate the integrated effect of forage abundance and quality on the grazing animal, crude protein intake of a nursing cow was calculated in both situations (beneath blue oak canopy and open grassland) and related to her daily requirements for protein. Values for forage abundance were converted to intake based on the formulation for beef cattle (National Research Council 1987) and intake requirements (National Research Council 1976). Dietary crude protein requirements were calculated for cows nursing calves - average milking ability - during the first 3-4 months postpartum (National Research Council 1976). The results for the two situations show a striking difference in nutritional quality. The open grassland has only one brief period (March) where daily dietary crude protein intake is in excess of the requirement, while beneath blue oak canopies an excess of crude protein is provided from the period from mid-December to May (figure 1).

These results are a comparison of two ends of the spectrum of hardwood rangeland environments: those with complete oak canopy cover and those with none. While most hardwood rangeland habitats represent a mosaic of these two, these data clearly demonstrate the value of maintaining an abundance of oaks for grazing animals.

CONCLUSIONS

The effects of blue oak canopies on forage production early in the growing season of drought years were variable, but not detrimental. By March forage production beneath blue oak canopies was consistently greater than in open grassland, an increase which was also present at the time of peak standing crop. In addition to the increased production, the forage beneath blue oaks was generally of better quality, particularly in terms of protein content. The increased forage production and higher protein content of understory forage reaffirm the value of scattered blue oaks in this region.

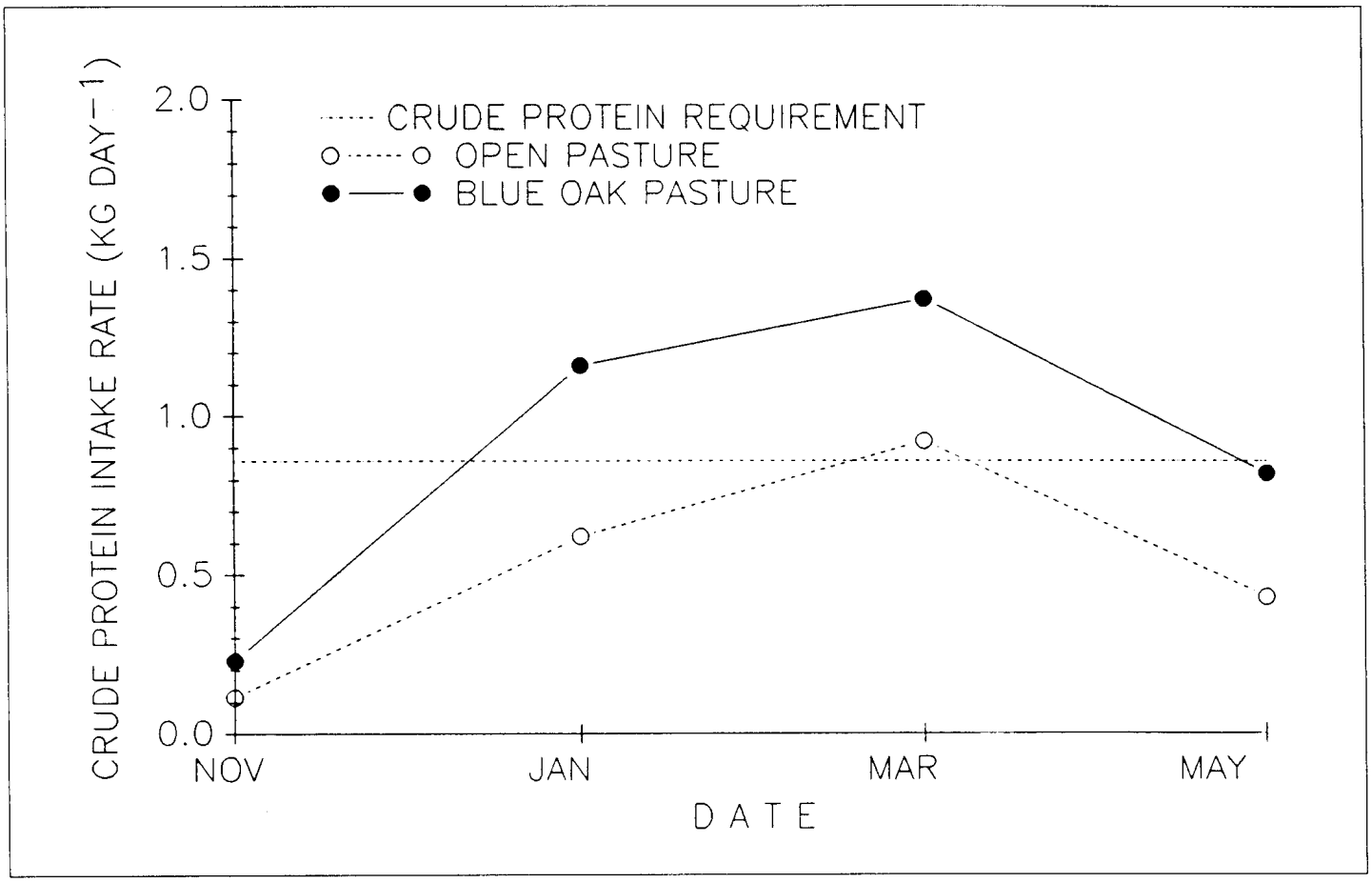

Figure 1—Calculated crude protein intake rate for lactating cows grazing in open grassland and beneath blue oak canopy, San Joaquin Experimental Range, California.

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