Quality and Yield of Forage as Affected By Chemical Removal of Blue Oak (Quercus douglasii)

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It is estimated that 6.5 percent of the land area in California is of the grass-woodland cover type. Blue oak *(Quercus douglasii)*, a major tree species of this type cover, modifies both yield and composition of the herbaceous understory. It has been demonstrated that oak trees lower forage production and affect the flow of water from springs and watersheds (Harvey, Johnson, and Bell, 1959; Biswell and Schultz, 1958). Johnson *et al.* (1959) conducted a 1-year study of yield and quality of range forage following chemical treatment of oak trees by the cut-surface method. Though significant results were obtained, rather wide fluctuations in forage yield and composition are known to occur from year to year on the annual type range in California. The present study is concerned with forage yield over a seven-year period and botanical composition for a 10-year span. Trees were chemically killed past the mid-point of the yield measurements and at the beginning of botanical evaluations.

Procedure

Data were gathered at two locations on the University of California's Hopland Field Station, located in southeastern Mendocino County approximately 40 miles inland from the coast. Blue oak-grassland is a major plant community in this general area. The average density of oak trees was 200 to 250 per acre with an average trunk diameter of 8 inches. The test site is at an elevation of 900 feet above sea level, has a southwest exposure, and an average rainfall of 37 inches. Table 1 shows annual rainfall for years 1952 through 1962. The soil is a medium texture, brown-colored, slightly acid, and classified as the Laughlin-Sutherlin series.

Oaks may be controlled by sawing, bulldozing, burning, girdling or by chemical treatment with 2,4-D applied in axe cuts or frills circling the trunk near the base (Leonard and Harvey, 1956; Leonard, 1956). A tree injector with a chisel-like cutting bit is equally as effective. Both axe cuts and injector methods were used in this study. Regardless of the type of injection, the best results are obtained when 2,4-D is applied during the winter or early spring while soil moisture is adequate. If the chemical is applied when the tree is bare of leaves, the tree will often fail to produce leaves in the spring. However, if the chemical is applied about the time new leaves are emerging, it may take several months before herbicidal symptoms are apparent. With correct application of chemical, a tree usually will lose most of its leaves before the end of summer and definitely will not leaf out the following spring. In the second and third years following treatment the tree will begin to drop branches, and the bark will separate from the trunk. Although the kill is complete, much debris accumulates; and the main trunk on larger trees is often slow in breaking down. Removal of debris can be hastened by burning three to five years following treatment.

Table 1. Annual precipitation—Hopland Field Station 1952-53 to 1961-62.

Year	Total precipitation	Departure from 10-year average
	— — (Inches) — —	
1952-53	41.13	+ 5.13
1953-54	37.52	+ 1.52
1954-55	24.84	−11.16
1955-56	50.94	+14.94
1956-57	29.38	− 6.62
1957-58	60.43	+24.43
1958-59	25.67	−10.33
1959-60	28.03	− 7.97
1960-61	30.65	− 5.35
1961-62	31.41	− 4.59

The trees in this study were treated between January and April using two cc of an amine formulation of 2,4-D (4 pounds acid equivalent per gallon) in each cut spaced at six-inch intervals around the circumference of the trunk.

To obtain forage yield data beehive-shaped chicken wire exclosure cages, two-feet wide at the base, were placed under the canopy of trees and randomly in open areas at the start of the growing season in September or October. The following June or July, when the forage was dry, an area of one square foot under each cage was harvested at ground level. All cages were moved at the start of the growing season so the same plot was not used in consecutive years.

The area of the botanical composition study, one mile away, had similar tree density, exposure and soil type. Three permanent plots, each 25-feet square, were established just before tree treatment, each in a different type of environment: (1) Open ground away from tree cover, (2) under oak to be treated, and (3) a check plot under trees not to be treated. The principal plants in the open

area at the beginning of the study were: Nitgrass *(Gastridium ventricosum)*, silver hairgrass *(Aira caryophyllea)*, soft chess *(Bromus mollis)*, little quakinggrass *(Briza minor)*, slender wild oats *(Avena barbata)*, broadleaf filaree *(Erodium botrys)*, wall bedstraw *(Galium parisiense)*, downy navarretia *(Navarretia pubescens)* and goldfields *(Baeria sp.)*. Under blue oak the common plants were: Ripgut *(Bromus rigidus)*, mouse barley *(Hordeum leporinum)*, soft chess, slender wild oats, hedge parsley *(Torilis nodosa)*, bur chervil *(Anthriscus scandicina)*, doves-foot geranium *(Geranium molle)*, common geranium *(Geranium dissectum)*, and shortpod mustard *(Brassica geniculata)*. Readings were made in late May of each year from 1953 (treatment year) through 1957 and again in 1962.

Sheep were the principal grazing animals in both study areas, but deer and small mammals were also abundant.

Results

Forage yield

Forage yield under blue oak averaged between 250 to 900 pounds per acre during the years 1956 through 1959 and between 1250 to 2300 pounds per acre on open ground for the same period. Oaks were killed early in 1960 but no marked increase of forage under the canopy was obtained during that year. In 1961 yield under the treated trees was 4051 pounds per acre in comparison to 1965 pounds on open ground. The following year 2343 pounds per acre were harvested from under treated trees while only 932 pounds were taken from open ground (Figure 1).

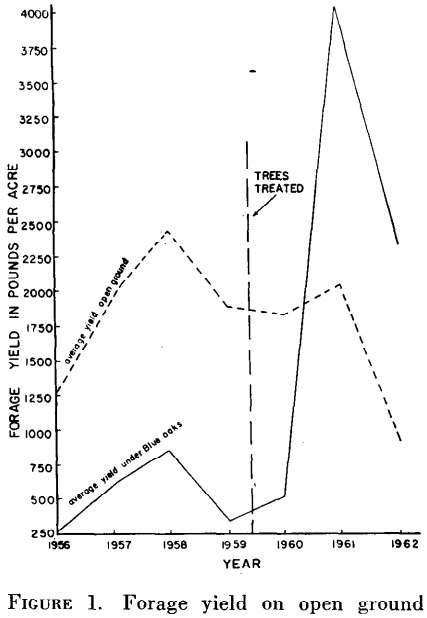

FIGURE 1. Forage yield on open ground and under blue oaks before and after chemical treatment.

Composition

None of the common plants of the open ground habitat were observed to invade the plot where oak had been treated. In 1962 the abnormally large percentage of annual legumes on open ground were also present in small amounts at the treated tree site. The desirable forage plant, soft chess, normally present in both open and shaded sites was notably favored by the tenth year after treatment. The generally inferior forage species, ripgut and mouse barley, were present only under oaks and did not invade the open ground following the death of trees. Both species fluctuated under both treated and untreated trees. Ripgut persisted in significant amount from year to year following tree treatment but by the tenth year mouse barley had substantially decreased to one percent as compared to 25 percent under untreated trees. Madrid brome *(Bromus madritensis)*, an undesirable forage grass, appeared at the treated site in 1954 and persisted there through 1956 but later disappeared altogether and was replaced by the equally undesirable annual fescue *(Festuca megalura)* and sterile brome *(Brome sterilis)*. The latter two species were recorded in significant amount in 1962. Inferior forage plants of hedge parsley, bur chervil, geranium and shortpod mustard, commonly of shaded sites, greatly fluctuated in amount from year to year and by 1962 had disappeared at the site where oak had been treated (Table 2).

Discussion

The phenomenal increase in forage yield under oaks killed the previous year could be attributable to several causes. One explanation may be that elimination of tree canopy allows more sunlight to penetrate to the soil surface to stimulate plant growth. Humphrey (1962) indicates that forage production is reduced or prevented partly because of less light intensity but apparently more because the light spectrum essential for photosynthesis is absorbed or reradiated by the canopy of tree leaves. Under leafless hardwoods he found light intensity reduced 55 percent but as leaves developed, less than five percent of the light reached the ground. Donald (1963) explains that competition for light is not immediately one of competition between species or even plants but competition between leaves.

Another explanation for increased forage growth may be the greater availability of nutrients to these herbaceous plants when trees are eliminated. Chemical treatment of oak species in Texas by Darrow and McCully (1959) indicated the resulting better growth of grasses and herbaceous cover was due to the release from tree competition for soil moisture and nutrients. In our study nutrients were probably a more critical factor as moisture is usually only critical for a limited part of the season with annual plants. The yearly rainfall as shown in Table 1 had no apparent effect on yield.

There is no clear trend as to whether removal of oak favors the desirable forage grasses, soft chess and slender wild oats, nor completely removes the less desirable ripgut and mouse barley. At least the undesirable annual

Table 2. Plant cover of species on treatment plots by years.

Species	Treatment	Year 1953	1954	1955	1956	1957	1962
Grasses		— — — — (Percent)[1] — — — —					
Aira caryophyllea	Open ground	15	25	20	20	15	5
Avena barbata	Untreated	5	10	5	5	1	1
	Treated	5	2	1	—	—	15
Briza minor	Open ground	5	5	10	5	1	5
Bromus madritensis	Treated	—	5	2	1	—	—
Bromus mollis	Open ground	15	20	20	25	10	5
	Untreated	3	15	2	2	4	3
	Treated	1	2	2	1	1	15
Bromus rigidus	Untreated	45	20	35	40	35	10
	Treated	50	75	35	50	10	15
Bromus sterilis	Treated	—	—	—	—	—	5
Festuca megalura	Treated	—	—	—	—	—	20
Gastridium ventricosum	Open ground	15	25	—	—	—	—
Hordeum leporinum	Untreated	1	20	15	20	20	25
	Treated	2	10	30	5	10	1
Legumes							
Trifolium spp. and *Medicago hispida*	Treated	—	—	—	—	—	3
	Open ground	—	—	—	—	—	40
Achillea borealis ssp. *californica*	Untreated	1	—	1	—	5	—
Amsinckia intermedia	Treated	—	—	—	—	—	5
Anthriscus scandicina	Untreated	2	—	—	1	2	10
	Treated	5	—	—	—	3	—
Baeria sp.	Open ground	10	—	—	—	—	5
Brassica geniculata	Treated	2	—	15	5	1	—
Forbs							
Erodium botrys	Open ground	2	15	5	4	15	15
Galium parisiense	Open ground	10	3	1	—	5	—
Geranium dissectum	Untreated	5	—	—	15	5	1
Geranium molle	Untreated	5	—	—	1	2	5
	Treated	2	—	—	—	15	—
Hypochoeris glabra	Open ground	—	—	5	15	10	5
Navarretia pubescens	Open ground	10	5	25	20	5	5
Sanicula spp.	Untreated	2	—	—	2	1	—
	Treated	1	—	—	—	—	—
Silene gallica	Open ground	1	—	—	—	5	—
Stachys bullata	Untreated	1	1	3	5	5	1
Torilis nodosa	Untreated	10	1	25	2	2	30
	Treated	15	—	15	5	2	—

[1]A minus sign (−) indicates less than one percent.

grasses, nitgrass, silver hairgrass, and little quakinggrass, of open ground were never recorded under oak before, or during the ten year span after removal of the canopy. The quality of forage under the treated trees as well as that of open ground could greatly be improved by seeding better grass species in mixture with annual legumes.

Conclusion

Treatment of blue oak by the cut-surface or basal frill method with 2,4-D results in some changes in species composition and considerable difference in yield. Forage yield was very sensitive to the tree treatment, with production exceeding that of open ground during the growing seasons following the chemical treatment.

Four annual grasses exhibited the greatest change in species composition under tree treatment with soft chess and wild oats increasing and ripgut and mouse barley decreasing. In the forbs, shade-loving species were eliminated, but others showed no consistent change due to tree treatment.

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