Reaction of a California Annual-plant Community to Fire

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THE occurrence of fires on annual-plant ranges of California poses a question to the range manager: How will the plant community react to burning and what will be the effects of fire on its grazing value?

Hart, Guilbert, and Goss (*4*) investigated variations in chemical composition of forage from adjoining burned and unburned areas in an attempt to explain the preference shown by cattle, sheep, and deer for the herbage of burned-over areas. They did not find either consistent or appreciable changes in the calcium, phosphorus, or protein content of individual forage species and consequently concluded that other factors were involved in the matter of preference shown by the grazing animals. They did note that more filaree grew on the burned than unburned areas. They also noted that plants on unburned areas attained nearly twice the height of those on burned sites.

Studies were made during the growing season of 1947–1948 on coastal foothill range lands near Berkeley, California, to determine the reaction of annual-plant communities to fire, particularly with respect to height growth, forage yield, and species composition. Four areas, each of which had been burned in July, 1947, were selected for study. They may be compared as follows:

AREA DESIGNATION	INTENSITY OF GRAZING USE DURING THE SEASON PRIOR TO BURNING	INTENSITY OF THE FIRE
Pasture I	Moderate to moderately light	Light
Pasture II	Ungrazed	Light
Pasture III	Moderate	Heavy
Pasture IV	Heavy	Light

The intensity of grazing use was determined from unburned portions of the pastures; intensity of burns was determined from general knowledge of atmospheric and fuel conditions at the time of the fire.

Vegetation on the pastures consisted of an annual-plant mixture of grasses and forbs. It corresponded closely to typical central coastal foothill ranges described by Bentley and Talbot (*1*). The major grasses were wild oat (*Avene fatua*), slender wild oat (*Avene barbata*), soft chess (*Bromus mollis*), ripgut (*Bromus rigidus*), foxtail fescue (*Festuca megalura*), Mediterranean barley (*Hordeum gussoneanum*), Italian rye grass (*Lolium multiflorum*), and mouse barley (*Hordeum megalura*). The main forbs were red stem filaree (*Erodium cicutarium*), broad-leaf filaree (*Erodium botrys*), and bur clover (*Medicago hispida*).

The soils have been classified by the Bureau of Chemistry and Soils (*2*) at Los Osos adobe clay and clay loam. At depths of one to two feet the soil was underlaid with disintegrated sandstone. The upper few inches of soil showed pH of 6.0. Steepness of topography made these areas unsuited to cultivation.

The climate is characterized by long dry summers and cool moist winters. Rains sufficient in amount to germinate annual-plant seed usually occur in October. The rainy season usually terminates in April, and soon thereafter soil moisture becomes a limiting factor for herbaceous plant growth. As a consequence, perennial herbs become dormant and annual plants die in May or early June. The season of 1947–1948 was a notably dry one throughout much of the foothill

region, yet a severe drought condition did not exist on the areas studied. The seasonal precipitation here for the period October 1, 1947 to May 1, 1948 was 20.39 inches. For a similar period during the past five years, precipitation averaged 22.60 inches and during the past ten years it averaged 27.96 inches.

Air temperatures dropped below 32°F. occasionally during December, January, and February, with the daily minimum generally reading between 30° and 40°F. during the months of November to April.

In Pasture I, duplicate exclosures, each 30 by 90 feet, were erected with their long axes paralleling the fire-line and with equal areas of burned and unburned vegetation included. By protecting the vegetation of these two exclosures from grazing, comparison could be made of height growth and forage yield on adjoining burned and unburned areas. Comparison was made of species composition on burned and unburned areas in these two exclosures and also in the other three pastures.

Effect of Fire on Species Composition

Estimates were made of the species composition at three stages of growth in exclosures I and II: (1) at the end of rapid fall growth; (2) at the end of slow winter growth; and (3) at the time of forage maturity. On the other three pastures, estimates of species composition were made only at the time of forage maturity. Composition was based upon the percent of total foliage density made up by each species.

The burning resulted in an increase of forbs during the first season; this was least on the heavily utilized pasture (Table 1). However, the unburned portion of this pasture also contained a relatively large percentage of forbs. The greatest increase in forbs as a result of fire occurred on the ungrazed pasture.

TABLE 1

Comparison of percentage of grasses and forbs present on adjoining burned and unburned portions of four pastures near Berkeley, California. Percentages are based upon foliage density at time of plant maturity

LOCATION	GRAZING TREATMENT PRIOR TO BURN	SEVERITY OF BURN	PERCENT COMPOSITION			
			Forbs		Grasses	
			Burn	Unburn	Burn	Unburn
Pasture I						
Exclosure I	Lightly grazed	Light	55.6	11.4	44.4	88.6
Exclosure II	Moderately grazed	Light	53.3	10.7	46.7	89.3
Pasture II	Ungrazed	Light	58.5	6.9	41.5	93.1
Pasture III	Moderately grazed	Heavy	45.2	13.1	54.8	86.9
Pasture IV	Closely grazed	Light	60.0	44.7	40.0	55.3

On the unburned area a significant reduction in forbs was noticed as the season progressed (Table 2). This change was brought about as a result of suppression of bur clover and filagrees by the grasses. On the burned area a similar reduction of forbs is indicated, yet in this case there was little or no actual suppression of bur clover and filarees. The change resulted from a more rapid increase in the foliage density of grass than that of forbs with neither class of plants seriously affecting the development of the other.

Changes in species composition of annual-plant communities similar to these resulting from burning were produced by Talbot, Biswell, and Hormay (*6*) by

merely removing the surface litter by hand from strips within an ungrazed exclosure.

Effect of Fire on Forage Yield

Forage yield was sampled during the first week in May when most of the vegetation was mature and just beginning to dry. On random square-foot plots all herbaceous growth was cut at a height of one-half inch above the ground. Each sample was separated according to species, then dried at 60° Centigrade for 24 hours, and weighed.

The difference in total forage yield between burned and unburned portions of Exclosure I, as shown in table 3, was not statistically significant; the difference in total forage yield between burned and unburned portions of Exclosure II was statistically significant, as are the differences between amount of grasses and forbs produced on burned and unburned areas.

The reason why there was 26% less forage on the burned portion than on the unburned portion of Enclosure II, and practically no difference in yield between burned and unburned portions of Enclosure I was not apparent. However, observations in the other three pastures indicated that commonly a decrease in forage yield accompanies burning. Clipped samples were also taken in Pasture II, which was ungrazed. Here the forage yield on the burned portion was 37% less than that on the unburned. Since Pastures III and IV were grazed, it was not possible to determine forage yield by clipping. However, after comparing forage densities and height, it was evident that burning decreased forage yield substantially on Pasture III, which had been moderately grazed prior to burning, and only very slightly decreased forage yield on Pasture IV, which had been heavily grazed prior to burning.

TABLE 2

Comparison of percentage of grasses and forbs present on adjoining burned and unburned portions of Exclosure I at three stages of plant development as the season progressed

DATE	FORBS		GRASSES	
	Burn	Unburn	Burn	Unburn
December 1 (End of fall growth period)	70.6	36.9	29.4	63.1
February 20 (Beginning of rapid growth in spring)	61.2	11.3	38.8	88.7
May 1 (Plants mature)	55.6	11.4	44.4	88.6

TABLE 3

Effect of fire on forage yield. Average weight of forage from square foot plots

	YIELD IN GRAMS			
	Exclosure I		Exclosure II	
	Unburned	Burned	Unburned	Burned
All grasses	44.2	33.8	45.6	32.8
All forbs	2.4	11.5	1.6	12.1
Plot total	46.6	45.3	47.2	34.9

TABLE 4

Effect of fire on the yield of some important forage species. Comparison of mean air dry weight of clippings from square-foot plots

SPECIES	LOCATION	YIELD IN GRAMS	
		Burn	Unburn
Wild Oat	Exclosure I	17.5	22.3*
Slender Wild Oat	Exclosure II	2.9	9.9
Soft chess	Exclosure I	0.8	3.1
	Exclosure II	4.6	13.9
Italian Rye Grass	Exclosure I	7.1	11.8
	Exclosure II	10.4	19.9
Bur Clover	Exclosure I	5.0	0.5
Red Stem Filaree	Exclosure I	4.8	1.2
	Exclosure II	1.0	0.5*
Broad Leaf Filaree	Exclosure II	9.1	0.8

* Differences between burned and unburned sites not statistically significant for this sample. All others are significant.

TABLE 5

Average heights of important forage species on adjoining burned and unburned portions of Exclosures I and II

FORAGE SPECIES	AVERAGE HEIGHT IN INCHES					
	Dec. 1, 1947		Feb. 20, 1948		May 1, 1948	
	Excl. 1	Excl. 2	Excl. 1	Excl. 2	Excl. 1	Excl. 2
Wild Oat						
Burn	2.9	3.1	5.2	3.5	21.7	20.2
Unburn	4.8	5.5	8.8	7.9	24.5	25.2
Italian Rye Grass						
Burn	2.4	2.8	3.5	3.2	13.7	13.0
Unburn	3.7	4.6	6.9	6.7	16.1	16.0
Foxtail Fescue						
Burn	1.5	2.0	3.1	2.4	14.7	12.0
Unburn	3.0	2.5	5.1	3.6	13.8	—
Soft Chess						
Burn	—	1.9	—	2.2	11.8	11.8
Unburn	3.6	3.0	5.3	4.8	13.8	15.4
Bur Clover						
Burn	1.1	1.2	1.7	1.4	7.7	4.4
Unburn	1.8	1.7	2.4	3.0	7.0	4.6
Red Stem Filaree						
Burn	0.9	1.2	1.5	1.5	4.8	2.7
Unburn	1.8	2.4	2.5	3.0	5.9	4.6

Effect of Fire Upon Plant Heights

The average height of forage plants was determined on 24 plots, each one foot square. These figures cover the growth made during three periods of the growing season. Data in table 5 indicate that burning causes slower height development of both grasses and forbs and less total height growth. All differences in the table are significant.

Effect of Burning on Certain Habitat Factors

Measurements were made of the effects of burning upon soil moisture, soil temperature, and organic matter in the top inch of soil. Summarized briefly, the results are: (1) burning did not significantly affect soil moisture during the growing season; (2) burning did significantly raise the temperature at the soil surface and also at a depth of $2\frac{1}{2}$ inches; and (3) a single burning of annual-plant communities did not significantly affect the amount of organic matter in the top inch of the soil. In the latter case, methods were used as reported by Hedrick (*5*).

Discussion

Results indicate that burning of annual-plant ranges may affect grazing management. Where yields are substantially reduced by burning, it may be expected that the carrying capacity will be reduced accordingly. However, where yields are not substantially reduced by burning, the increase of bur clover may actually bring about an increase in carrying capacity. This would result because of the fact that bur clover is a palatable legume which is higher in protein content than most grasses during the latter part of the growing season. It also stays green later than many other annual forage plants. Even after the herbage becomes dry, the burs furnish high value protein feed (*3*).

To compensate for slower height development, either the grazing season should be delayed on burned areas, or fewer animals placed on such areas until spring growth assures ample forage for the livestock. The replacement of grasses by red stem filaree on burned areas where bur clover does not occur tends to shorten the length of the grazing season, since filaree matures about a month ahead of the grasses. Upon maturing, filaree disintegrates, while grasses remain standing upon maturing and continue to be available as forage.

Summary and Conclusions

1. Studies were made during the growing season of 1947–1948 on adjoining burned and unburned annual-plant ranges near Berkeley, California.

2. Composition of the plant cover was significantly changed by burning. Red stem filaree, broad-leaf filaree, and bur clover increased in response to burning, whereas wild oat, soft chess, ripgut, meadow barley, and Italian ryegrass decreased.

3. The forage cover on four unburned areas consisted of approximately 90 percent grasses, while that on adjoining burned areas contained only 45 percent grasses. On a pasture which had been grazed heavily prior to burning, the change in percentage of grasses and forbs was not so great. Here, grasses composed 55 percent of the forage on unburned sites and 40 percent on burned.

4. On unburned sites, filarees and bur clover decreased significantly in abundance as the season progressed, while on burned sites they decreased only slightly.

5. Forage yield was less on burned portions of an exclosure than on those unburned, but in another exclosure the yield was similar for burned and unburned areas. Observations indicate that forage yield was significantly greater on unburned portions of a moderately grazed pasture but only very slightly greater on unburned portions of a heavily grazed pasture.

6. Forage yields of important grass species were decreased by burning, whereas yields of important forbs were increased.

7. Burning caused slower growth and a reduction in height of all forage species. To compensate for this slower forage

growth, either the grazing season should be delayed, or fewer animals placed on burned areas until spring.

8. An increase of red stem filaree in the forage cover of burned areas would reduce forage availability early in the season and during summer. On the other hand, an increase in bur clover would raise the grazing value by providing higher protein feed than grasses.

LITERATURE CITED

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