Effect of Winter Burning on Herbaceous Cover on a Converted Chaparral Watershed

C. P. PASE AND O. D. KNIPE

Highlight: Herbage production by weeping, Boer, and Lehmann lovegrasses was essentially unaffected by winter burning on a converted chaparral watershed in central Arizona. Burning opened up the stand and resulted in increased forb production, total herbage production, and frequency of some species.

Increasing forage and water yields, reduction of fire hazard, and improvement of wildlife habitat in Arizona chaparral require conversion from shrubs to a grass-shrub type. The future use of herbicides will likely be restricted because of possible adverse environmental impacts and high costs. At the present time it appears that burning is the only environmentally acceptable tool available for suppressing shrub growth on chaparral lands converted to grass-shrub types.

If grass is burned during the winter, spring regrowth reduces the danger of accelerated erosion during the summer rains. To

be beneficial, however, such treatment must not appreciably damage the grass stand. Summer burning of Lehmann lovegrass (*Eragrostis lehmanniana*)¹ results in considerable mortality (Humphrey and Everson 1951; Cable 1965) and may depress grasses native to the Southwest for as long as three years (Reynolds and Bohning 1956; Cable 1967; Dwyer and Pieper 1967). Pase (1971), working in the same areas as in the present study, found that density and vigor of Lehmann lovegrass were essentially unaffected by a February burn; increases were noted in Turkistan bluestem (*Bothriochloa ischaemum*) and its variety King Ranch bluestem.

The purpose of this study was to determine the effect of winter burning on species frequently used for seeding in the Arizona chaparral type.

Study Area

The study was conducted on Watershed C of the Three Bar Game Management Study Area on the Tonto National Forest in central

Authors are principal research forester and principal ecologist, U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Forest Hydrology Laboratory, Tempe, Arizona 85281.

Manuscript received March 3, 1977.

¹Common and scientific names of grasses follow Hitchcock, 1950; scientific names of forbs and shrubs follow Kearney and Peebles, 1960; common names of forbs and shrubs follow Kelsey and Dayton, 1942.

Arizona. The area has been protected from grazing by domestic livestock since 1947. This watershed was burned by wildfire in June 1959. At the time of the fire, shrub cover was 73%, consisting primarily of shrub live oak (*Quercus turbinella*) and birchleaf mountainmahogany (*Cercocarpus betuloides*). The fire reduced shrub cover to 6%. The watershed was seeded with a mixture of weeping, Boer, and Lehmann lovegrasses (*E. curvula*, *E. chloromelas*, and *E. lehmanniana*, respectively) in May 1960. The watershed was sprayed by helicopter with 2,4,5-T in 1960, 1961, 1962, and 1963; these treatments killed only 42% of the oak and 72% of the mountainmahogany. The surviving shrubs were hand-treated with pelleted fenuron in 1964; a portion was treated with pelleted fenuron and a portion with granulated karbutylate in 1968. These treatments reduced shrub cover to less than 3%. Forbs and especially seeded and native grasses steadily increased as a result of these treatments. Forage production averaged 1,200 lb/acre/year from the fourth through the tenth year following the fire.

The watershed was control-burned in the winter of 1971. Topkill of shrub live oak and birchleaf mountainmahogany was 71 and 68%, respectively.

Methods

The study used a split plot design with two replications of burned and nonburned plots (main plots) on both north- and south-facing slopes (subplots).

Plot length, which depended on length of slope, varied from 60 to 90 meters. The width of each plot was 20 meters. Burned and nonburned plots were separated by a 10-m burned buffer zone. Sample line bases were established 5 m in from the buffer-plot boundary to eliminate edge effects.

Herbage production (green weight) was estimated in October, prior to burning in March, and the following October by double-sampling (Wilm et al. 1944). Sample plot size was 1 meter square. Samples were taken at 3-m intervals from a random starting point (0.3 to 3 m from the base of the lines). Field herbage production estimates were corrected by regression analysis from oven-dry weights of a random one-sixth of the sample plots. Regression through the origin was oven-dry weight Y against green weight X. Plots randomly selected for preburn clipping were excluded from postburn sampling. Production of current year's growth of half shrubs was included in the estimates, but winter annuals and cool-season perennial grasses were excluded. Frequency of occurrence of species was determined as percent

Fig. 1. Pre- and postburn means and standard errors for herbage production on burned and nonburned plots; means not adjusted to account for low rainfall of 1971. Nodes represent means, bars represent standard errors (10).

occurrences per sample plot.

Results and Discussion

Herbage Production

Growing season precipitation in 1971 was below average (18.36 inches and 25.6 inches, respectively). Therefore blocks were combined and considered an index area in order to determine year effect on grass production independent of burning. Within-block sampling was used to evaluate year effect on the nonburned plots. A simple *t* test showed means of pre- and postfire years differed significantly. These results were used to adjust the differences between overall watershed means before and after the burning. For the burned plots, the two blocks were combined in the analysis of covariance. There was no significant difference in herbage production between north and south slopes. The effects of low rainfall in 1971 were not as marked on the burn plots. There was overlap in the pre- and postburning standard errors on burned plots whereas there was no overlap on nonburned plots (Fig. 1 shows the relationship of unadjusted means and standard errors for pre- and postfire

Table 1. Pounds per acre (oven-dry basis) and percent contribution to herbage production of the important species on burned plots before and after burning. (1971 burned plot values were adjusted upward to remove the effects of low rainfall in that year.)

Species	North slopes				South slopes			
	Preburn (1970)		Postburn (1971)		Preburn (1970)		Postburn (1971)	
	lb/acre	% prod.	lb/acre	% prod.	lb/acre	% prod.	lb/acre	% prod.
Grasses								
Boer lovegrass (<i>Eragrostis chloromelas</i>)	97	9	155	9	510	42	577	38
Lehmann lovegrass (<i>E. lehmanniana</i>)	6	1	2	tr ¹	100	8	84	6
Weeping lovegrass (<i>E. curvula</i>)	507	45	507	29	141	12	306	20
Roughstalk witchgrass (<i>Panicum hirticaule</i>) ²	62	6	158	9	87	7	106	7
Totals	672	61	822	47	838	69	1073	71
Forbs								
Scarlet spiderling (<i>Boerhaavia coccinea</i>)	95	8	215	12	2	tr ¹	8	1
Telegraph plant (<i>Heterotheca subaxillaris</i>) ²	81	7	188	11	1	tr ¹	14	1
Scarlet starglory (<i>Ipomoea coccinea</i>) ²	80	7	100	6	53	4	89	6
Missouri goldenrod (<i>Solidago missouriensis</i>)	8	1	11	1	119	10	144	9
Globemallow (<i>Sphaeralcea grossulariaefolia</i>)	9	1	30	2	10	1	18	1
Totals	273	24	544	32	185	15	273	18
Half shrubs								
Artemisia (<i>Artemisia ludoviciana</i>)	50	4	39	2	111	9	67	4
Other species ³	132	12	356	20	70	6	118	8
Totals	1127	101	1761	101	1204	99	1531	101

¹ tr = less than 0.5 lb/acre.

² Annual.

³ 38 species of minor individual importance.

herbage production). Upward adjustment of the 1971 herbage production values (lb/acre) for the burned plots to remove the effects of low rainfall in that year results in the following:

Preburn (1970) Postburn (1971)

North Slope	1,125	1,760
South Slope	1,203	1,531
Mean	1,164	1,646

Thus, there was a significant² (41.4%) increase in herbage production as a result of burning, due to increased production by forbs (Table 1).

Species Contribution to Production

The percent of total herbage production contributed by the most important species varied according to aspect (Table 1). Warm-season growers such as Missouri goldenrod³ and Boer and Lehmann lovegrass contributed a higher percentage on south slopes. Lehmann lovegrass was almost restricted to south slopes. Weeping lovegrass, scarlet spiderling, and telegraph plant contributed more on north slopes; the latter two species were almost restricted to north slopes.

Species differences in percent contribution to herbage production as a result of burning sometimes varied with aspect. Contribution to total herbage production by weeping lovegrass on north slopes decreased from 45.1% prefire to 28.8% postfire. Percent contribution to total herbage production by Boer and Lehmann lovegrasses was slightly less following burning. It is important to note that these decreases are only relative to behavior of other species; pounds of herbage was actually greater (Table 1). The reduction in percent contribution by grasses reflects a greater increase in forbs. These increases are no doubt due to elimination of deep ground litter and standing litter, and the resultant reduction in competition for light.

Frequency

The frequency of weeping lovegrass increased slightly on burned plots and decreased on nonburned plots (Table 2). Previous observations indicated that density of weeping lovegrass stands in converted Arizona chaparral, tend to decline 3 to 4 years after establishment when protected from grazing and fire (Pond 1968).

Lavin and Johnsen (in press) reported that density of weeping lovegrass and other bunchgrass stands, in converted pinyon-juniper areas, decreases when protected from grazing or fire. They attributed the decrease to a "smothering" effect of old growth on new growth. Although density was not determined in this study, we feel that the frequency data are indicative of density. Thus this study confirms Pond's earlier observations in the chaparral type, and those of Lavin and Johnsen in the pinyon-juniper type. Other research has shown that periodic burning stimulates production in weeping lovegrass (Hibbert et al. 1974). There was no appreciable change in frequency of the other major perennial grasses; Lehmann lovegrass showed a slight decrease on both burned and nonburned plots. Pase (1971) also observed a slight though insignificant decrease in density of Lehmann lovegrass following winter burning.

Frequency of roughstalk witchgrass (the only annual grass of importance) increased on the burned plots and decreased on nonburned plots. The increase on burned plots was no doubt due to opening of the stand, and the decrease on nonburned plots to severe competition during a year of relatively low rainfall.

There were no major differences in frequency of forbs

Table 2. Percent frequency of major plants prior to burning and following burning in 1970 and 1971.

Species	Burned		Nonburned	
	1970	1971	1970	1971
Grasses				
Boer lovegrass (<i>Eragrostis chloromelas</i>)	20	24	37	40
Lehmann lovegrass (<i>E. lehmanniana</i>) ¹	10	9	7	4
Weeping lovegrass (<i>E. curvula</i>)	19	22	19	11
Roughstalk witchgrass (<i>Panicum hirticaule</i>) ¹	48	63	60	49
Forbs				
Scarlet spiderling (<i>Boerhavia coccinea</i>)	4	12	11	19
Telegraph plant (<i>Heterotheca subaxillaris</i>) ¹	4	9	7	15
Scarlet starglory (<i>Ipomea coccinea</i>) ¹	57	75	38	36
Missouri goldenrod (<i>Salidago missouriensis</i>)	8	8	6	5
Globemallow (<i>Sphaeralcea grossulariaefolia</i>)	5	10	5	10
Half shrubs				
Artemisia (<i>Artemisia ludoviciana</i>)	14	14	5	5

¹ Annual.

between burned and nonburned plots, except for an apparently characteristic increase of scarlet starglory. We have noted that this species makes up a major portion of the forb stand following fire in Arizona chaparral.

Conclusions

Winter burning of a stand of weeping, Boer, and Lehmann lovegrass does not adversely affect herbage production by these species, and actually increases production by forbs. The obvious benefit to the forbs is probably due to a reduction of competition for light resulting from elimination of deep ground—and standing—litter.

Frequency of the major species was not reduced by burning; frequency of some species increased. Frequency of some species decreased on nonburned plots.

Chaparral shrubs are readily top-killed by hot, flashy grass fires. Winter burning can be used to maintain dominance by herbaceous species, in chaparral areas converted to lovegrass, without danger of damage to the grasses. Periodic burning would likely be effective and cost considerably less than maintenance with chemicals.

Literature Cited

- Cable, Dwight R. 1965. Damage to mesquite, Lehmann lovegrass, and black grama by a hot June fire. *J. Range Manage.* 18:326-329.
- Cable, Dwight R. 1967. Fire effects on semidesert grasses and shrubs. *J. Range Manage.* 20:170-176.
- Dwyer, Don D., and Rex D. Pieper. 1967. Fire effects on blue grama-pinyon-juniper rangeland in New Mexico. *J. Range Manage.* 20:359-362.
- Hibbert, Alden R., Edwin A. Davis, and David G. Scholl. 1974. Chaparral conversion potential in Arizona. Part I. Water yield response and effects on other resources. U.S. Dep. Agr. Forest Serv. Res. Pap. RM-126. Rocky Mountain Forest and Range Exp. Sta., Fort Collins, Colo.
- Hitchcock, A. A. 1950. Manual of the grasses of the United States. U.S. Dep. Agr. Misc. Pub. 200, second ed. 1,051 p.
- Humphrey, R. R., and A. C. Everson. 1951. Effect of fire on a mixed grass-shrub range in southern Arizona. *J. Range Manage.* 14:264-266.
- Kearney, Thomas H., and Robert H. Peebles. 1960. Arizona flora. Second ed. Univ. of Calif. Press, Berkeley and Los Angeles. 1,032 p.
- Kelsey, Harlan P., and William A. Dayton. 1942. Standardized plant names. J. Horace McFarland Co., Harrisburg, Pa. 675 p.
- Lavin, Fred, and T. N. Johnsen, Jr. [In press.] Species longevity for Arizona pinyon-juniper plantings. *J. Range Manage.*
- Pase, Charles P. 1971. Effect of a February burn on Lehmann lovegrass. *J. Range Manage.* 24:454-456.
- Pond, Floyd W. 1968. Changes in grass production on ungrazed converted chaparral. U.S. Dep. Agr. Forest Serv. Res. Note RM-98, 4 p. Rocky Mountain Forest and Range Exp. Sta., Fort Collins, Colo.
- Reynolds, H. G., and J. W. Bohning. 1956. Effects of burning on a desert grass-shrub range in southern Arizona. *Ecology* 37:769-776.
- Wilm, H. G., David F. Costello, and G. E. Klipple. 1944. Estimating forage yield by the double-sampling method. *Amer. Soc. Agron. J.* 6:194-203.

² .05 percent level.

³ Scientific names of plants mentioned in the discussion are shown in Tables 1 and 2.