

The Effects of Fire on a Dry, Thin-soil Prairie in Wisconsin

RALPH L. DIX AND JOHN E. BUTLER

Botany Department, University of Wisconsin, Madison, Wisconsin; and Biology Department, Wisconsin State College, Platteville, Wisconsin

THE effects of fire on vegetation have been debated from earliest times. This is especially true where man has attempted to study or control natural grasslands. In spite of the general acceptance by investigators (Gleason, 1913, 1923; Sauer, 1950; Humphrey, 1953) that native grasslands are subject to frequent and sometimes extensive burning, man's interpretation of the value of fire as a tool for pasture improvement has fluctuated greatly. The empirical knowledge of the practical land manager has usually led him to regard fire as a useful and sometimes necessary tool. Conversely, investigations carried on at stations in various sections of the country have sometimes indicated detrimental effects.

Aldous (1934) studied the effects of burning on the bluestem pastures of eastern Kansas and concluded that "...burning seems to be highly desirable if not essential on bluestem pastures about every other year..." Hopkins, Albertson

and Riegel (1948), in studies on the burning (late March) of the native mixed grass pastures of western Kansas, found that "...the detrimental effects of pasture burning, either accidentally or otherwise, cannot be over-emphasized." A reduction of 40 percent in total forage production was noted by Elwell, Daniel and Fenton (1941) following fall burning for two consecutive years on native pastures in north-central Oklahoma. They further noticed a decrease in the nitrogen and organic matter of the soil and an increase in soil and water loss. Annual spring burning has been found by Curtis and Partch (1948) to be essential in the re-establishment of native prairie on abandoned farmland in southern Wisconsin.

One of the most characteristic attributes of prairie vegetation is its versatility even under undisturbed conditions. Prairie vegetation constantly varies because its many component species respond, each in its own way, to the multitude of

environmental changes (biotic, climatic, etc.) occurring concurrently in the plant community. When the additional factor of fire is superimposed upon this already delicate sub-balance of natural forces, the responses of each species of the prairie community become even more complex. Thus, the conflicting results obtained by workers in various parts of the grassland formation are to be expected since the many studies have been carried out under a wide range of experimental conditions (climate, soils, time of burning, etc.) and their results are not directly comparable. It is suggested that the place of fire in grassland management will be resolved only after considerably more experimental evidence is available from local areas and, at that time, the mosaic of local studies will demonstrate the general nature of the phenomenon.

The purpose of the present study is to determine the effects of fire on mulch depth, flower stalk production, estimated cover and plant heights of the vegetation of a dry, thin-soil prairie along the prairie-forest border region of Wisconsin. It is hoped that this basic information may be of aid to the range manager in his quest for a better

understanding of the fundamental commodity of range production—the range plants.

Study Area

The area under study is a native, thin-soil prairie located along a low ridge two miles southwest of Arena in Iowa County, Wisconsin. Located in a non-glaciated region, the general topography consists of low ridges (200 feet or less) alternating with rather wide valleys. The ridges are composed of a dolomite which, upon weathering, gives rise to a fertile soil. An analysis of soil taken from the prairie gave the following results (in available p.p.m.): Ca, 5,000; Mg, 450; P, 5; K, 160; NO₃, 8; and NH₃, 3. The soil was found to have a pH of 8.0 and a water-retaining capacity of 61.8 percent. The soil depth varies from 0 to 18 inches, with a modal depth of about 3 inches. The prairie is located on a gentle slope (about 5°) with a western exposure. Climatic records from the nearest weather station at Dodgeville, 16 miles to the southwest, yield the following: average annual precipitation, 31 inches; January average temperature, 16° F; July average temperature, 71° F; and an average growing season of 146 days.

The weather records from the Dodgeville station show that the first four months of the 1952 and 1953 growing seasons (April through July) were similar with a total of about 16 inches of precipitation well distributed through these months. The records for August and September, however, show that these months were warmer and drier in 1953 than in 1952. In 1952 a total of 6.8 inches of rain was well distributed through the period. During the same period in 1953 only 4.8 inches were recorded of which nearly half fell during a rainstorm on August 2. The next measurable rain was recorded on September 4, when 0.33 inches fell.

The area consists of about four

acres of undisturbed native prairie with little bluestem (*Andropogon scoparius*), big bluestem (*A. gerardi*), Indian grass (*Sorghastrum nutans*) and side-oats grama (*Bouteloua curtipendula*) as dominants. A total of fifty-two species were recorded as present in the stand.

During the second week in April, 1952, an accidental fire occurred on a portion of the prairie. Since that time, no unnatural disturbances of any kind have occurred on the area.

Methods

A permanent line was established along the boundary between the burned and unburned areas. Side lines, ten paces apart, were then staked out at right angles to the center line and extending in both directions from it. Quadrats were placed at ten pace intervals along these side lines. Eighty 1-square-foot quadrats were used to sample the burned and unburned areas on September 15, 1952 and September 19, 1953.

The numbers of flowering stalks for each species were counted directly while the cover contributed

by each species was estimated with the aid of a previously prepared card ruled to show the exact size of various areas in square feet. This card was carried by the observer in the field so that direct comparisons of areas could be made. Plant heights were measured directly in inches for the five most important grasses. Thirty individuals of each species were sampled in the burned and unburned areas. Mulch depths were measured directly at thirty locations in each area. Data for all species found to have an estimated cover of 1.0 percent or greater in any area are presented in Table 1.

Results

Mulch.—The mulch depth in September, 1952 was 2.3 inches on the unburned part of the stand while no mulch cover existed on the burned area. This would indicate that the removal of organic debris by fire from the burned area was complete and therefore the samples taken in September, 1953 from this area must represent the amount of mulch produced by one growing season. The mulch depth on the un-

Table 1. Estimated cover, flower stalk production and plant height on burned and unburned prairie in 1952 and 1953

Species	Burned			Unburned		
	Est. cover	Flower stalks	Plant height	Est. cover	Flower stalks	Plant height
	%	no./sq. ft.	in.	%	no./sq. ft.	in.
1952						
Azure aster.....	1.16	0.3	—	0.80	0.2	—
Big bluestem.....	3.29	1.7	52.6	2.14	0.3	45.5
Goldenrod.....	1.16	0.3	—	0.35	0.3	—
Indian grass.....	0.36	0.3	57.0	2.78	1.4	50.6
Little bluestem.....	2.23	18.6	35.1	21.86	5.4	31.3
Prairie dropseed.....	2.73	1.28	35.7	0.09	0.1	31.1
Side-oats grama.....	1.09	0.7	32.0	0.87	0.7	27.2
1953						
Azure aster.....	0.69	0.1	—	1.15	0.2	—
Big bluestem.....	2.00	0.2	36.3	1.56	0.1	40.0
Goldenrod.....	0.56	0.2	—	0.75	0.1	—
Indian grass.....	3.42	0.5	40.2	1.58	0.5	40.7
Little bluestem.....	22.94	6.5	24.6	22.31	2.6	26.6
Prairie dropseed.....	1.67	0.1	26.8	1.77	0.1	26.5
Side-oats grama.....	1.58	0.5	26.9	0.78	0.4	29.4

burned area increased only slightly (from 2.3 inches to 2.5 inches) as a result of the 1952 growing season. Conversely, the vegetation on the burned area produced a mulch 0.68 inches deep, about $\frac{1}{4}$ th the total amount on the unburned prairie, during the first growing season. At this rate, four or five years would be required for the vegetation to completely replace the mulch removed by the fire.

Flower Stalk Production.—A comparison between the burned and unburned portions of the prairie in September, 1952, near the end of the first growing season, showed that three species produced more, three species produced about the same number, and one species produced fewer flowering stalks on the burned than on the unburned part of the prairie (Table 1). Prairie dropseed (*Sporobolus heterolepis*) showed the most conspicuous difference with the production of twenty-five times more flowering stalks on the burned than on the unburned area. Big bluestem and little bluestem, the principal dominants, also showed considerably greater production of flower stalks following the fire. The production of flower stalks by these two species was respectively six times and three times more on the burned than on the unburned area. Side-oats grama, goldenrod (*Solidago nemoralis*) and azure aster (*Aster azureus*) showed no apparent stimulation or retardation of flower stalk production due to the fire during the first growing season following the burn. Indian grass, with only $\frac{1}{4}$ th the number of flowering stalks produced on the burned as compared with the unburned area, was the only major species to suggest detrimental effects by fire to flower stalk production.

Observations at the end of the second growing season showed smaller differences in the production of flower stalks between the burned and unburned areas. The responses

of the dominant grasses of the prairie, with the exception of Indian grass and side-oats grama, tend to suggest that burning stimulates flower stalk development even into the second year since these species all retained levels of flower stalk production about twice that of the unburned parts of the prairie. During the second year, flower stalk production in Indian grass and side-oats grama was about the same in both parts of the stand.

If data from the unburned part of the prairie are compared for the two years of the study, it is clear that a general decline in flower stalk production occurred in 1953 which cannot be explained by fire. In general, this amounted to a decrease of 50 percent. The obvious variable factor between the two years is weather. An examination of the weather data presented above would tend to suggest that the hotter and drier conditions of the later summer months of 1953 were responsible for this difference.

Estimated Cover.—Near the end of the first growing season following the burning, two species had more and two species less estimated cover on the burned than on the unburned area. The remaining three species, big bluestem, azure aster and side-oats grama, showed little response to burning during the first year of the study. The most striking change occurred in prairie dropseed which had thirty times more estimated cover on the burned than on the unburned area. Goldenrod also showed substantially more estimated cover in the burned area. On the burned area, the cover of little bluestem and Indian grass was estimated to be one-tenth and one-seventh, respectively, of that found on the unburned area. Perhaps the most significant contrast was found in the total estimated cover—28.89 percent for the unburned and 12.02 percent for the burned area. The major cause for this difference was the reduction in cover of little blue-

stem, which represented about two-thirds of the total cover in the unburned part of the stand. In the burned area, it accounted for only about one-tenth of the total cover.

Examination of cover in 1953 showed a remarkable similarity between the two parts of the stand. Again, this is revealed most clearly in a comparison of the data for total estimated cover: 32.86 percent for the burned and 29.90 percent for the unburned parts of the stand. This was largely due to the recovery of little bluestem from 2.23 percent in 1952 to 22.94 percent in 1953 on the burned part of the prairie. Indian grass, which had been reduced considerably during the first growing season following the fire, seems to have recovered and, in fact, increased during the second growing season. Side-oats grama produced slightly more cover on the burned area for both years, while its flower stalk production remained almost constant.

Since the unburned area served as a control in the study, it is of interest to compare the unburned part of the stand for the two years of the study. Big bluestem and Indian grass showed slightly more cover in 1952 than in 1953. On the other hand, prairie dropseed had about thirty times more cover in 1953 than in 1952. This difference in prairie dropseed, along with minor contributions from other species, was enough to offset the losses sustained by big bluestem and Indian grass. Little bluestem, the most important single species in the stand, showed little change.

Plant Heights.—During the 1952 growing season all of the five species examined were taller on the burned than on the unburned area. This difference varied from 7.0 inches in big bluestem to 3.8 inches in little bluestem. Indian grass showed a difference amounting to 6.4 inches while side-oats grama and prairie dropseed were found to average about 4.0 inches more than

on the unburned prairie. As with flower stalk production and estimated cover, plant heights were more similar between the burned and unburned areas at the end of two growing seasons than at the end of one.

On the unburned part of the stand, all species except side-oats grama were shorter in 1953 than in 1952. Since this area served as a control for the study, it is clear that some factors other than fire (probably weather among them) were operating to produce this marked reduction in plant heights.

Discussion

Most of the prairie species produced substantially more flower stalks and were taller on the burned area of the prairie during the first growing season following the fire. These increases agree with the findings of other investigators. Curtis and Partch (1950) found that a sixfold increase in flower stalk production and a 60 percent increase in plant heights could be obtained by removing the mulch, either by fire or clipping, from plantings of big bluestem. Reductions in cover were noted in little bluestem during the first growing season following burning in western Kansas (Hopkins, Albertson and Riegel, 1948), and a similar decrease was noted in the present study. An explanation for this sharp decrease in cover is suggested in morphological studies by Evans and Grover (1940). They found that, under controlled conditions, grass stems which produce reproductive parts produce fewer leaves than those which remain vegetative. Thus, the stimulation to flower production caused by burning or mulch removal will necessarily reduce the number of leaves produced and consequently cover will show a decline. This phenomenon, however, does not appear to hold for all prairie grasses since side-oats grama was not stimulated to produce flowering stalks and prairie dropseed increased in both flower

stalk production and in cover following the fire on the Wisconsin prairie.

It seems clearly demonstrated that the response of prairie plants to fire varies according to species and to the particular climatic conditions present during and following the burning. From the data presented in Table 1 no general trends can be established. Regardless of the responses of a species to fire, however, its deviation from its position in the unburned community seems to be much less pronounced at the end of the second growing season following fire.

Summary

Studies were made of mulch accumulation, flower stalk production, cover, and plant height of important grasses for two growing seasons in the burned and unburned portions of a thin-soil prairie in southwestern Wisconsin.

A mulch cover 2.3 inches deep was completely removed by fire from the burned area. At the end of the first growing season, the burned prairie had produced 0.68 inches of mulch while 0.2 inches of mulch were added to the unburned area. At this rate of accumulation, the mulch cover would accumulate to its original depth in about five years.

Flower stalk production was greatly stimulated, during the first year following the fire, in prairie dropseed (twenty-fivefold), big bluestem (sixfold) and little bluestem (threefold). The only species to show a sharp decrease in flower stalk production was Indian grass (fourfold). During the second growing season following the fire, the burned and unburned parts of the stand showed more similarity in flower stalk production.

Prairie dropseed and goldenrod were the only species to increase in cover the first growing season following the fire; little bluestem and Indian grass showed considerable losses. By the end of the second

growing season, the total cover on the burned prairie slightly exceeded that on the unburned prairie, due largely to the recovery of little bluestem and Indian grass.

Plant heights for five important grasses on the prairie showed sharp increases the first year following the fire and a return to normalcy toward the end of the second growing season.

It is suggested that a better understanding of the effects of fire on native grasslands is to be found in careful observations and measurements of the responses by individual species within the grassland, rather than the response of the "grassland community".

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