Burning of Northern Mixed Prairie During Drought

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Abstract

Standing crop of current year's growth and response of key management species were evaluated following burning in mid-May (before emergence of warm-season grasses) and mid-June (after emergence of warm-season grasses). The study was conducted during 2 dry years in a mesic Mixed Prairie in South Dakota. Cool-season precipitation was 33% below average in both years of the study, while warm-season precipitation was only slightly below average both years. Standing crop of current year's growth was increased by burning on overflow range sites, but not on silty range sites. Big bluestem *(Andropogon gerardi)* standing crop was greatest with mid-May burning. Kentucky bluegrass *(Poa pratensis)* standing crop and leaf length were reduced with burning on both dates. Leaf length, basal area and number of inflorescences of native cool-season grasses were also reduced. Mid-May burning in drought years may be recommended for the reduction of Kentucky bluegrass. However, reductions in production of native cool-season vegetation can be expected on silty range sites. In contrast, mid-June burning in dry years is not recommended.

Burning has been widely recommended on the subhumid and humid grasslands of the Great Plains and the Midwestern prairie peninsula for manipulating botanical composition, increasing herbage production, and providing more nutritious forage for livestock. The True Prairie in the Flint Hills of eastern Kansas (McMurphy and Anderson 1965, Anderson et al. 1970) and the humid grasslands of the Midwest (Curtis and Partch 1948, Ehrenreich 1959, Kucera and Ehrenreich 1962, and Ehrenreich and Aikman 1963) can be effectively managed with fire. In the Northern Great Plains, fires have resulted in varying vegetation responses.

In the semiarid Mixed Prairie of the Northern Great Plains, fire has resulted in critical reductions in litter (Dix 1960) and decreased herbage yields (Gartner et al. 1978), although effects appear to be dependent on season of the burn and on precipitation. In the mesic (dry subhumid) Mixed Prairie (Kirsch and Kruse 1972) and the True Prairie (Kaiser et al. 1979), fire may benefit the warm-season tall grasses and result in a reduction of undesirable cool-season species. Before fire can be judiciously prescribed as a management tool in the mesic Mixed Prairie, data must be available for burning under a variety of environmental conditions. Series of dry years are common in the Northern Great Plains (Schumacher 1974) and this may limit the application of prescribed burning in these areas during extended drought periods.

Studies reviewed by Daubenmire (1968) as well as studies in the Kansas Flint Hills (Anderson et al. 1970, Owensby and Smith 1979) indicate that spring burning reduces Kentucky bluegrass *(Poa pratensis)*.[1] Smith and Owensby (1972) concluded that actively growing Kentucky bluegrass is more susceptible to injury than the warm-season native grasses that are dormant or just beginning to grow when spring burned. In this study, burning was timed during the latter part of the active growth stage of Kentucky bluegrass, both before and after the emergence of warm-season native grasses. Comparisons were made for 2 burning dates on 2 range sites during a period of below-average precipitation in the prairie pothole region of the mesic Mixed Prairie.

Methods and Materials

The study was conducted on the Samuel H. Ordway Memorial Prairie in north-central South Dakota. The study area is part of the prairie pothole region of the northern Mixed Prairie (Kuchler 1964). Average annual precipitation from 1940 to 1970 at Leola, S. Dak., about 10 km east of the study area, was 50.2 cm.

Soils of the study area are Williams loams (silty range site) and Bowbells loams (overflow range site). The Williams soils are fine-loamy, mixed Typic Argiborolls. The Bowbells soils are fine-loamy, mixed Pachic Argiborolls. Silty range sites in excellent range condition are dominated by western wheatgrass *(Agropyron smithii)*, needleandthread *(Stipa comata)*, and green needlegrass *(Stipa viridula)*. Overflow range sites in excellent condition are dominated by big bluestem *(Andropogon gerardi)*. Both range sites become progressively dominated by Kentucky bluegrass as range condition declines. At the time the study was initiated, Kentucky bluegrass was a major component on both the silty and overflow range sites, partly in response to repeated midsummer haying.

Treatment plots (25 × 50 m) were established in 1980 on native range neither grazed nor hayed for 3 years. A randomized block design with 3 replications was used in the experiment. Treatments consisted of 2 1980 burning dates and a control nested within 2 range sites (silty and overflow). The early burning date, applied before emergence of warm-season grasses, and the late burning date, applied after warm-season grasses had emerged to a height of 5 to 10 cm, were in mid-May and mid-June, respectively. In a normal year these growth stages would be expected to occur earlier in the season, but were later in 1980 because of late frosts and below normal precipitation. Plots were burned with a headfire after a base control line was established with a backfire. Weather conditions during the burns were monitored and appear in Table 1.

[1]Common and scientific names after Beetle (1970).

Table 1. Weather conditions for May and June 1980 burning treatments at Ordway Prairie.

Burn dates	Wind speed (km/h)	Air temperature (°C)	Relative humidity (%)
May 13–16	3–13	4–19	23–45
June 16	0–24	20–23	42–66

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Table 2. Least squares means of leaf length, number of inflorescences and basal area of dominant species at Ordway Prairie, as estimated on August 8-11, 1980.

Site	Species	Plant characteristic	1980 Burning Date		
			May 15[1]	June 16	Control
Silty	*Stipa viridula*	Leaf length (cm)	24.7 b[2]	23.3 b	41.1 a
		Inflorescences/m²	2.8 b	0 b	16.8 a
		Basal area (cm²)	10.3 b	6.9 b	20.8 a
	Agropyron smithii	Leaf length (cm)	11.7 b	9.3 c	13.5 a
	Poa pratensis	Leaf length (cm)	13.7 b	10.3 b	30.9 a
Overflow	*Andropogon gerardi*	Leaf length (cm)	21.3 b	16.8 b	42.4 a
		Inflorescences/m²	132.4 a	95.2 a	2.0 b
	Poa pratensis	Leaf length (cm)	17.7 b	13.5 b	38.7 a

[1]May burns were applied May 13, 14, and 16.
[2]Means in the same row followed by different letters are significantly different.

Ten, 0.25 m² circular quadrats on each treatment plot were randomly located and herbage was clipped to ground level between July 28 and August 1, 1980. Three 1.0 m² quadrats per treatment plot were clipped between July 27 and August 3 in 1981. Standing crop of current year's growth of hand separated species and vegetation classes was bagged and allowed to air dry before weighing. Species and vegetation classes were Kentucky bluegrass, big bluestem, needlegrasses (*Stipa* spp.), western wheatgrass, sedges (*Carex* spp.), other grasses, and forbs. Standing litter and mulch were also included in the harvest data in 1981. Fire effects on green needlegrass, western wheatgrass, Kentucky bluegrass (cool-season grasses) and big bluestem (a warm-season grass) were also evaluated by randomly selecting 2 plants in 5 randomly located quadrats (0.25 m²) within each treatment plot. Leaf length was measured as the average of the longest leaf of 2 plants of each species. Basal area (length × width) of 2 green needlegrass plants was measured and the number of seedheads per quadrat was counted for green needlegrass and big bluestem. Analysis of variance was performed on these measurements for species and vegetation class components by the General Linear Model Procedure in the Statistical Analysis System (Barr et al. 1979). Treatment means were separated using Tukey's *w*-procedure at the 0.05 level of probability (Steel and Torrie 1960).

Results and Discussion

Precipitation for the 1980 vegetation year (September 1979-August 1980) was 26% below average and 20% below average in 1981 (Fig. 1). A reduction in cool-season (September–May) precipitation may be more important than a reduction in annual precipitation to the production of cool-season species. In both years cool-season precipitation was 33% below average, whereas warm-season (June–August) precipitation was only 17 and 6% below average for 1980 and 1981, respectively.

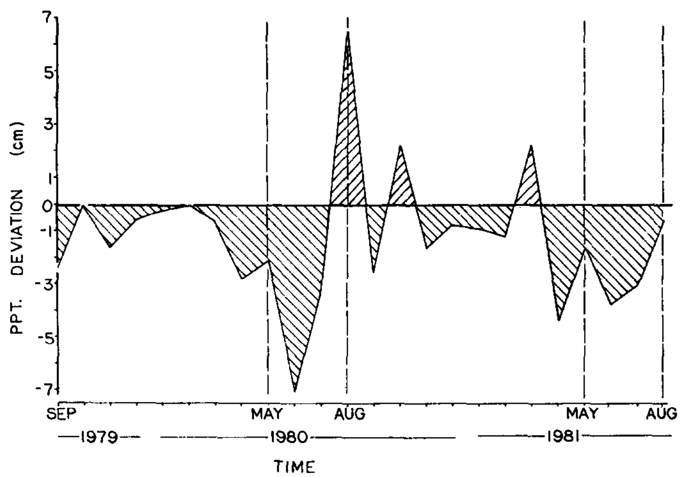

Fig. 1. *Deviation (cm) in precipitation from 30-year monthly average, September 1979 to August 1981, Leola, S. Dak. Vertical hatch lines separate months of cool-season (September through May) and warm-season (June through August) precipitation.*

Leaf length of cool-season species and the number of inflorescences and basal area of green needlegrass were reduced by burning

Table 3. Least squares means of leaf length, number of inflorescences and basal area of dominant species at Ordway Prairie, as estimated on August 10-11, 1981.

Site	Species	Plant characteristic	1980 Burning Date		
			May 15[1]	June 16	Control
Silty	*Stipa viridula*	Leaf length (cm)	38.9 b[2]	37.3 b	57.5 a
		Inflorescences/m²	32.9 a	34.0 a	19.7 b
		Basal area (cm²)	12.3 a	7.8 b	6.5 b
	Agropyron smithii	Leaf length (cm)	11.5 b	12.1 b	15.6 a
	Poa pratensis	Leaf length (cm)	23.1 b	24.3 b	33.0 a
Overflow	*Andropogon gerardi*	Leaf length (cm)	45.2 a	37.0 b	43.4 a
		Inflorescences/m²	69.8 a	53.8 a	15.1 b
	Poa pratensis	Leaf length (cm)	43.7 c	49.2 b	53.0 a

[1]May burns were applied May 13, 14, and 16.
[2]Means in the same row followed by different letters are significantly different.

(Tables 2 and 3). These effects were more pronounced on the June burn than on the May burn. Leaf length of big bluestem on overflow sites was reduced by burning although the number of inflorescences increased similarly to that reported in more humid grasslands (Kucera and Ehrenreich 1962). The burning treatment effects on most species were still evident the year following the burning treatments, especially on the June burned plots.

Standing crop of current year's growth of big bluestem on overflow sites was greater in 1980 and 1981 on plots burned in May but not on plots burned in June (Tables 4 and 5). In 1980, needlegrasses produced less growth on burned than on unburned plots on both sites. In 1981, however, needlegrasses produced as much growth on burned plots as on control plots. Kentucky bluegrass standing crop was decreased by burning on both sites, but the effect was greater and was still evident in the second year of the study on silty range sites burned in May.

Burning did not reduce standing crop of other species and vegetation classes. Only in the second year following burning was total current year's growth on overflow sites higher on burned plots than on control plots. However, burned plots on silty sites had lower standing crops than control plots in both years. The June burn plots on silty sites had less than 30% of the total standing crop of control plots in 1980. Mulch and litter levels were generally reduced by burning.

A portion of observed decreases in standing crops of cool-season species in the burned treatments may be attributed to consumption of spring growth, especially of Kentucky bluegrass, by the fires. Peak standing crops of green biomass on 2 communities in 1977 at Ordway Prairie were measured between June 16 and June 30, a year in which precipitation was 30% above average (Ode et al. 1980). Therefore, burning in either mid-May or mid-June of 1977 would have consumed substantial amounts of the current year's growth. Burning in mid-May or mid-June in years of below average cool-season precipitation would also be expected to result in a direct reduction of current year's growth.

In the True Prairie and prairie peninsula, herbage yields can generally be expected to increase or remain the same after spring burning (Curtis and Partch 1948, Kucera and Ehrenreich 1962, Anderson et al. 1970). However, in xeric portions of the northern Mixed Prairie, herbage yields have generally been reported to decline following spring burning (Clarke et al. 1943, Dix 1960, Coupland 1973), although herbage yield increases have been reported with burning under favorable soil water conditions (White and Currie 1983). In considering the usefulness of fire in the central grasslands of North America, Launchbaugh (1973) concluded that burning will result in increased yields when mulch accumulations are excessive and reduced yields when mulch is at lower levels. Under drought stress, even with excessive mulch accumulations, herbage yields were not increased by burning in our study. Considering that our treatments were applied at later calendar dates than are reported elsewhere in the literature it appears that in drought years mesic northern Mixed Prairie responds to spring burning more like xeric Mixed Prairie than True Prairie. However, the response is site dependent in that the reduction in herbage yield will be greater and of longer duration on the xeric sites than on mesic sites. Even so, these grasslands were capable of making a substantial recovery in the second year following a severe fire event. This is indicative of a fire tolerant system.

Kentucky bluegrass, the dominant introduced species, and green needlegrass, a desirable cool-season native species, were harmed with spring burning in a drought year. Green needlegrass, with accumulations of mulch and litter, may have been negatively impacted by fire in much the same manner as needleandthread (Wright 1971). Therefore, desirable decreases of Kentucky bluegrass may be offset by undesirable decreases in green needlegrass. We observed a number of green needlegrass plants on the silty sites that were killed by the fires. However, individual green needlegrass plants that survived the burn appeared to gain additional vigor the year after burning and were producing as much or more total growth as those on control plots. The authors observed that most desirable species, including green needlegrass, were in a depressed state of vigor prior to burning probably as a result of excessive mulch and litter accumulations. On silty sites the usual first year benefits of burning to remove excessive mulch and litter were probably offset by accentuating the existing drought.

Table 4. Least squares means of standing crops (air dry weight) of current year's growth (g/m²) (July 28–August 5, 1980) on plots burned in 1980 on two range sites.

		1980 Burning Date		
Species	Site	May 15[1]	June 16	Control
Poa pratensis	Silty	20.2 b[2]	10.8 b	94.4 a
	Overflow	7.2 b	7.8 b	77.2 a
Andropogon gerardi	Silty	0 a	0 a	0 a
	Overflow	128.8 a	71.4 ab	23.0 b
Stipa spp.	Silty	15.0 b	10.5 b	35.7 a
	Overflow	5.3 b	6.5 b	16.8 a
Agropyron smithii	Silty	8.0 a	6.0 ab	1.5 b
	Overflow	12.0 a	6.0 b	8.8 ab
Carex spp.	Silty	13.3 a	4.3 a	13.9 a
	Overflow	14.9 a	4.4 a	26.9 a
Other grasses	Silty	5.7 a	0.2 a	0.6 a
	Overflow	5.4 a	1.4 a	0.2 a
Forbs	Silty	44.1 a	10.5 b	6.0 b
	Overflow	55.5 a	25.9 b	20.8 b
Total grasses and grasslikes	Silty	62.1 b	31.8 b	146.1 a
	Overflow	174.3 a	98.6 b	152.9 ab
Total current year's growth	Silty	106.2 ab	42.4 b	152.0 a
	Overflow	230.9 a	124.5 b	173.7 ab

[1]May burns were applied on May 13, 14, and 16.
[2]Means in the same row followed by different letters are significantly different.

Table 5. Least squares means of standing crops (air dry weight) of current year's growth standing litter and mulch (g/m²) (July 27–August 3, 1980) on plots burned in 1980 on two range sites.

Species	Site	1980 Burning Date		
		May 15[1]	June 16	Control
Poa pratensis	Silty	62.5 c[2]	100.9 b	135.9 a
	Overflow	53.4 b	80.1 a	89.4 a
Andropogon gerardi	Silty	0	0	0
	Overflow	313.3 a	279.7 ab	232.8 b
Stipa spp.	Silty	43.4 a	51.7 a	63.8 a
	Overflow	32.6 a	23.5 a	25.2 a
Agropyron smithii	Silty	17.0 b	39.0 a	3.6 c
	Overflow	18.2 a	9.6 a	10.1 a
Carex spp.	Silty	38.4 a	26.5 b	13.7 c
	Overflow	31.0 a	12.4 b	5.0 b
Other grasses	Silty	24.2 a	8.5 b	4.5 b
	Overflow	9.4 ab	15.4 a	4.0 b
Forbs	Silty	58.1 a	7.6 b	18.7 b
	Overflow	30.9 a	33.1 a	20.4 a
Total grasses and grasslikes	Silty	185.6 a	226.6 a	221.6 a
	Overflow	457.7 a	420.7 ab	366.5 b
Total current year's growth	Silty	244.3 a	233.9 a	240.2 a
	Overflow	488.6 a	454.3 a	386.9 b
Standing litter	Silty	11.0 b	3.0 b	230.6 a
	Overflow	90.0 b	57.3 b	476.2 a
Mulch	Silty	22.7 b	21.6 b	182.7 a
	Overflow	124.4 ab	60.8 b	193.7 a

[1]May burns were applied on May 13, 14, and 16.
[2]Means in the same row followed by different letters are significantly different.

Conclusions

Burning in a dry year in a mesic northern Mixed Prairie provided some reduction of Kentucky bluegrass on both silty and overflow range sites and an increase in current year's growth on overflow sites. However, burning did not increase standing crop on silty sites and resulted in a period of reduced vigor of green needlegrass. If a primary objective of management is to control Kentucky bluegrass, mid-May burning (immediately prior to warm-season tall grass emergence) in dry years may be recommended. However, if increasing forage production is a major management objective on pastures where there is a mixture of both xeric and mesic sites, mid-May burning is not recommended in years of below average cool-season precipitation. Burning in mid-June (after emergence of warm-season grasses) in years of below average precipitation is not recommended.

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