Effects of Late Summer Prescribed Fire on Botanical Composition, Soil Cover, and Forage Production in Caucasian Bluestem-Infested Rangeland in the Kansas Smoky Hills: Year 2 of 4

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Abstract

Introduced old-world bluestem species (*Bothriochloa ischaemum* and *Bothriochloa bladhii*) pose a threat to the preservation of native prairies across the central and southern Great Plains. Recent research indicates that late summer prescribed fire may reduce the presence of old-world bluestems while maintaining or improving native plant populations. Eighteen one-acre plots were established in a section of private land that was heavily infested with Caucasian bluestem (*Bothriochloa bladhii*) and assigned to one of three treatments: no burn (i.e., control); single burn (i.e., burned only once in 2019); and biennial burn (i.e., burned in 2019 and 2021). Soil cover, botanical composition, and forage biomass were measured annually on each plot. The first fire treatment was applied on August 14, 2019; a second is planned for 2021. Within treatment, basal vegetation cover decreased ($P < 0.01$) from 2019 to 2020 on the biennial-burn treatment only; however, litter cover decreased ($P < 0.01$) and bare soil increased ($P < 0.01$) from 2019 to 2020 on burned plots compared to non-burned plots. Total grass cover and native grass cover were not affected ($P \geq 0.16$) by treatment; however, Caucasian bluestem decreased ($P = 0.04$) in burned plots compared with non-burned plots. No changes to total forb cover ($P = 0.13$) were observed in any treatments between 2019 and 2020; however, both grass and forb species richness increased ($P < 0.01$) in burned plots compared with non-burned plots. Within treatment, forage biomass was unchanged ($P \geq 0.11$) from 2019 to 2020. These data were interpreted to suggest that application of late-summer prescribed fire may be effective for control of Caucasian bluestem.

Introduction

The spread of introduced old-world bluestem species (*Bothriochloa ischaemum* and *Bothriochloa bladhii*) across the southern Great Plains represents a major concern to livestock producers and conservationists. Initially introduced as a source of forage and for soil conservation, old-world bluestems spread quickly in native rangelands, resulting in reduced forage quality, degraded wildlife habitat, and decreased botanical diversity.

While prescribed fire has been applied to Kansas rangelands to control many undesirable plant species, old-world bluestems are unaffected by the conventional spring burns.

Recent research suggested that prescribed burning late in the summer may result in significant control of yellow bluestem (*Bothriochloa ischaemum*). With similar morphology and phenology, Caucasian bluestem (*Bothriochloa bladhii*) may respond similarly to late summer fire. Therefore, the objective of our experiment was to document the effects of late-summer prescribed fire on soil cover, botanical composition, plant-species richness, and forage production in mixed-grass prairie with established Caucasian bluestem stands over a four-year period.

Experimental Procedures

This experiment was conducted on a private ranch in Ellsworth County, KS. The experimental site was native mixed-grass prairie which contained established stands of Caucasian bluestem. Eighteen plots of one square acre each were established, and then assigned randomly to one of three treatments (n = 6 plots/treatment): no burn, single year burn (i.e., in 2019 only), or biennial burn (i.e., in 2019 and again in 2021). Permanent 164-ft transects were established in each plot. Pre-fire soil cover, botanical composition, and forage biomass were measured in July 2019. The first fire treatment was applied on August 14, 2019; post-fire effects were assessed in July 2020.

Ground cover and botanical composition were evaluated along each transect using a modified step-point method. Forage biomass was estimated by clipping the vegetation inside three randomly placed 0.82-ft^2 clipping frames per plot. Litter was removed from the frame and the remaining plant matter was clipped to a height of 0.39 in. Clipped material was dried in a forced-air oven (131°F; 96 hours) and weighed to estimate forage biomass.

Results were analyzed using a mixed statistical model that contained treatment, year, and treatment × year as fixed effects and pasture within treatment as a random effect. When protected by a significant F-test ($P < 0.05$), least-squares means of treatment × year effects were separated using the method of least significant difference.

Results and Discussion

Within treatment, forage biomass was not influenced ($P \geq 0.11$) by prescribed fire (Table 1). One year following fire application, litter cover was less in burned plots compared with non-burned plots, whereas bare soil was greater ($P < 0.01$) in burned plots compared with non-burned plots. Basal vegetation cover did not change ($P > 0.35$) in non-burned controls and plots assigned to a single burn; however, basal vegetation cover decreased ($P < 0.01$) in plots assigned to the biennial burn treatment. These data are likely reflective of the late season in which plots were burned. Fire applied during summer clears litter accumulation and the short growing season between August and the first frost prevents dominant warm-season grasses from building up significant amounts of litter before the next growing season begins.

Evaluation of plant composition pre-fire indicated no differences ($P = 0.55$) between treatments in total grass cover. Total grass cover did not change between years or treat-

ments, ($P = 0.16$); however, burned plots were associated with lesser ($P < 0.01$) total warm-season grass cover (Table 2). This trend can likely be attributed to the reduction ($P = 0.04$) in Caucasian bluestem in fire-treated plots (Table 2). From 2019 to 2020, basal cover of Caucasian bluestem declined by approximately 38% in burned plots; whereas it was unchanged in non-burned plots. No changes ($P \geq 0.51$) in response to fire were detected in native-grass cover or warm-season (C4) tall-grass cover. Native grasses may be more tolerant of late-summer fire than Caucasian bluestem. While overall composition of introduced grasses did not change ($P = 0.31$) in response to fire, cool-season (C3) grass cover generally increased ($P < 0.01$) in fire-treated plots compared with non-burned plots (Table 2).

No treatment differences ($P \geq 0.10$) were detected in total forb cover or cover of native, introduced, perennial, nectar-producing, or leguminous forbs (Table 3). Small increases ($P = 0.03$) in annual forb cover were observed in burned plots, but not in non-burned plots. Likewise, grass- and forb-species richness in burned plots increased ($P < 0.01$) 20 to 40% in response to prescribed fire, whereas they were unchanged in non-burned plots (Table 4). Litter accumulation within stands of Caucasian bluestem may prevent light and water penetration to the soil. Removal of this litter with prescribed fire may have allowed greater numbers of native grass and forb species an opportunity for growth.

Implications

These data were interpreted to suggest that late-summer prescribed fire has the potential to allow low-cost, low-impact control of Caucasian bluestem in mixed-grass native rangeland. In addition, prescribed fire during late summer was also associated with improvements in plant-species richness and no change to basal cover of native grasses and forbs. We will continue to monitor these trends over the next two years.

Table 1. Effects of late-summer prescribed fire on mixed-grass prairie soil cover and forage biomass in the Kansas Smoky Hills

	Year 1			Year 2			Standard error of the mean	P-value
Item	No burn	Single burn	Biennial burn	No burn	Single burn	Biennial burn		
Bare soil, %	8.7[b]	10.3[b]	8.0[b]	5.7[b]	62.3[a]	69.3[a]	5.74	<0.01
Litter cover, %	80.0[a]	73.3[a]	71.3[a]	81.0[a]	24.7[b]	21.7[b]	5.85	<0.01
Basal vegetation cover, %	11.3[bc]	16.3[ab]	20.7[a]	13.3[b]	13.0[bc]	9.0[c]	2.00	<0.01
Forage biomass, lb dry matter/acre	2336[ab]	1817[bc]	2162[b]	2823[a]	1639[c]	1893[bc]	276.3	<0.01

[abc] Within rows, means with unlike superscripts differ ($P \leq 0.05$).

Table 2. Effects of late-summer burning on mixed-grass prairie graminoid composition in the Kansas Smoky Hills

	Year 1			Year 2			Standard error of the mean	P-value
Item, % of total	No burn	Single burn	Biennial burn	No burn	Single burn	Biennial burn		
Total grass	92.0	90.3	90.0	89.0	82.0	81.0	2.71	0.16
Native	42.3	39.0	48.7	39.0	36.7	42.0	6.85	0.85
Introduced	49.7	51.3	41.3	50.0	45.3	39.0	7.50	0.61
Total C4 grasses	63.0[a]	66.3[a]	65.0[a]	63.7[a]	46.0[b]	47.7[b]	5.87	<0.01
C4 tall grasses	17.7	17.3	19.3	16.0	12.7	20.3	4.80	0.51
C4 mid-grasses	13.7[ab]	10.0[b]	18.0[a]	17.7[ab]	9.0[b]	10.3	4.03	0.02
Caucasian bluestem	31.7[a]	38.3[a]	27.3[ab]	30.0[a]	23.7[bc]	17.0[c]	9.55	0.04
Total C3 grasses	29.0[ab]	24.0[b]	25.0[ab]	25.3[ab]	36.0[a]	33.3[ab]	5.49	<0.01

[abc] Within rows, means with unlike superscripts differ ($P \leq 0.05$).

Table 3. Effects of late-summer prescribed fire on mixed-grass prairie forb composition in the Kansas Smoky Hills

Item, % of total	Year 1			Year 2			Standard error of the mean	P-value
	No burn	Single burn	Biennial burn	No burn	Single burn	Biennial burn		
Total forbs	7.7	9.3	9.7	10.4	17.8	18.9	2.71	0.13
Native	7.6	9.1	9.7	10.3	16.3	17.2	2.56	0.21
Introduced	0.1	0.2	0.1	0.1	1.4	1.7	0.58	0.12
Perennial	7.4	9.0	9.5	10.3	15.7	16.7	2.53	0.30
Annual	0.3[b]	0.3[b]	0.2[b]	0.1[b]	2.1[a]	2.1[a]	0.62	0.03
Nectar-producing	3.5	4.6	4.7	5.0	9.1	10.3	1.58	0.10
Legumes	0.5	0.5	0.8	0.8	0.8	1.0	0.35	0.89

[a,b] Within rows, means with unlike superscripts differ ($P \leq 0.05$).

Table 4. Effects of late-summer prescribed fire on mixed-grass prairie grass and forb richness in the Kansas Smoky Hills

Item	Year 1			Year 2			Standard error of the mean	P-value
	No burn	Single burn	Biennial burn	No burn	Single burn	Biennial burn		
Grass species richness, number	7.8[b]	7.5[b]	7.7[b]	7.3[b]	9.3[a]	9.5[a]	0.65	<0.01
Forb species richness, number	13.3[a]	10.8[bc]	12.0[ab]	9.7[c]	15.2[a]	15.0[a]	1.89	<0.01

[a,b] Within rows, means with unlike superscripts differ ($P \leq 0.05$).