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M.P. Ramirez, A.J. Tajchman, Z.M. Duncan, J. Lemmon, and K.C. Olson

Abstract

The spread of introduced old-world bluestem species (*Bothriochloa ischaemum* and *Bothriochloa bladhii*) across the central and southern Great Plains represents a growing threat to the preservation of native rangelands. While current control methods rely on non-selective herbicides, 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 on native mixed-grass prairie that was heavily infested with Caucasian bluestem (*Bothriochloa bladhii*). Plots were assigned to one of two treatments: no burn (control) or burned (burned August 14, 2019). Soil cover, botanical composition, and forage biomass were measured annually within each plot. One and two years' post-treatment, bare soil was greater (treatment × time; $P < 0.01$) in burned plots compared with non-burned plots. In contrast, litter cover was greater ($P < 0.01$) in non-burned plots compared with burned plots in years one and two post-treatment. Basal vegetation cover did not differ ($P < 0.01$) between burned and non-burned plots in either post-treatment year. While there were no differences in basal cover of native ($P = 0.54$) or introduced grasses ($P = 0.10$) between treatments, total grass cover decreased (treatment main effect; $P < 0.01$) in burned plots while remaining unchanged in non-burned plots. In years one and two post-treatment, basal cover of Caucasian bluestem was reduced ($P < 0.01$) by approximately 48% and 52%, respectively, in burned plots compared with non-burned plots. This trend was associated with less (treatment main effect; $P < 0.01$) forage biomass post-treatment in burned plots compared with non-burned plots. Total basal cover of all forbs and perennial forbs was greater (treatment main effect; $P < 0.01$) in burned plots than in non-burned plots; moreover, grass-species richness was greater (treatment × time; $P < 0.01$) in burned plots compared with non-burned plots. Forb richness was greater ($P < 0.01$) in burned plots than in non-burned plots in year one post-treatment only. These data were interpreted to suggest that application of late-summer prescribed fire may be an effective means of control for Caucasian bluestem while increasing native plant diversity.

Introduction

Initially introduced to the southern Great Plains for livestock forage and soil conservation, old-world bluestems (*Bothriochloa ischaemum* and *Bothriochloa bladhii*) have spread beyond cultivation and now threaten prairie biodiversity and pastoral production systems in Kansas. Rangelands dominated by old-world bluestems produce inferior forage quality compared with native vegetation, while degrading wildlife habitat and decreasing botanical diversity. While prescribed fire has been traditionally applied in the spring to control undesirable plant species, old-world bluestems are unaffected by burning in the dormant season.

Recent research suggested that prescribed burning late in the summer may result in significant control of yellow bluestem. With similar morphology and phenology, Caucasian bluestem 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 two treatments: no burn (n = 6 plots) or burn (burned August 14, 2019; n = 12 plots). Permanent 164-ft transects were established in each plot. Pre-fire soil cover, botanical composition, and forage biomass were measured in July 2019. The fire treatment was applied August 14, 2019; post-fire effects were assessed in July 2020 and July 2021.

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 0.82^2-ft clipping frames per plot. Litter was removed from the frame and 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 and treatment × year effects were separated using the method of least significant difference.

Results and Discussion

Litter cover was less (treatment × time; $P < 0.01$) in burned plots compared with non-burned plots. Conversely, bare soil was greater (treatment × time; $P < 0.01$) in burned plots compared with non-burned plots (Table 1). These trends can likely be attributed to the late season in which fire was applied. Prescribed burns during late summer consume accumulated litter 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. One and two years' post-treatment, basal plant cover did not differ between treatments ($P < 0.01$).

Pre-fire total grass cover did not differ between treatments ($P = 0.47$; Table 2); subsequently, burned plots were associated with lesser total grass cover than non-burned plots (treatment main effect; $P < 0.01$). Despite the reduction in total grass cover within burned plots, there were no differences in native (treatment × time; $P \geq 0.10$) or introduced grass cover between treatments. Furthermore, warm-season (C4) tall grass and mid-grass cover were not influenced (treatment × time; $P \geq 0.06$) by treatment. Although the treatment × time effect for total cool-season grass cover was significant ($P < 0.01$), there were no treatment differences ($P \geq 0.06$) in basal cover of C3 grasses within year. These trends were associated with a reduction (treatment × time; $P < 0.01$) in basal cover of Caucasian bluestem in treated plots (Figure 1). Basal cover of Caucasian bluestem decreased by approximately 48% and 52%, respectively, in burned plots compared with non-burned plots. Based on these data, we concluded that Caucasian bluestem may be less tolerant of growing-season fires than native grasses.

Total forb cover was greater (treatment main effect; $P < 0.01$) in burned plots than in non-burned plots (14.2 and 8.5%, respectively; Table 3). There were no treatment differences ($P \geq 0.14$) in basal cover of native forbs. In contrast, burned plots were associated with greater (treatment main effect; $P = 0.01$) perennial forb cover than non-burned plots (13.3 and 8.3%, respectively). Basal cover of introduced forbs, annual forbs, and nectar-producing forbs was different ($P \leq 0.02$) between burned and non-burned plots during year one post-treatment only. Basal cover of leguminous forbs was not different ($P = 0.72$) between treatments at any time.

Grass-species richness was increased (treatment × time; $P < 0.01$) in burned plots while remaining unchanged in non-burned plots (Table 4). During this same period, forb-species richness increased (treatment × time; $P < 0.01$) in treated plots from the pre-treatment year to year one but no differences were detected two years post-treatment ($P = 0.67$; 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 intermittently allowed greater numbers of native grasses and forbs 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 with no change to basal cover of native grasses and forbs. We will continue to monitor these trends over the next two years. A second burn treatment was applied in August of 2021.

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

			Year post-treatment					
	Pre-treatment		Year 1		Year 2			
Item	No burn	Burn	No burn	Burn	No burn	Burn	SEM[1]	*P*-value
Bare soil, %	8.7[a]	5.7[a]	5.7[a]	65.8[b]	4.7[a]	63.0[b]	4.67	<0.01
Litter cover, %	80.0[a]	72.3[a]	81.0[a]	23.2[b]	87.7[c]	29.2[d]	4.58	<0.01
Basal vegetation cover, %	11.3[ab]	18.5[c]	13.3[b]	11.0[ab]	7.7[a]	7.8[a]	2.03	<0.01
Forage biomass, lb/acre*	2616	2229	3162	1978	3580	2859	208.9	0.30

[1]Standard error of the mean.
[a-c]Within rows, means with unlike superscripts differ ($P < 0.01$).
*Treatment main effect $P < 0.01$.

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

			Year post-treatment					
	Pre-treatment		Year 1		Year 2			
Item, % of total	No burn	Burn	No burn	Burn	No burn	Burn	SEM[1]	*P*-value
Total grass*	92.0	91.2	89.0	81.5	92.0	85.2	1.81	0.14
Native	42.3	43.8	39.0	39.3	36.3	42.8	5.08	0.54
Introduced	49.7	46.3	50.0	42.2	55.7	42.3	6.25	0.10
Total C4 grasses	63.0[bc]	65.7[c]	63.7[bc]	46.8[a]	62.3[bc]	55.8[b]	5.29	<0.01
C4 tall grasses	17.7	18.3	16.0	16.5	8.0	14.7	2.94	0.24
C4 mid-grasses*	13.7	14.0	17.7	9.7	54.0	39.7	2.41	0.06
Total C3 grasses	29.0[ab]	24.5[a]	25.3[ab]	34.7[b]	29.7[b]	29.3[b]	4.94	<0.01

[1]Standard error of the mean.
[a-c]Within rows, means with unlike superscripts differ ($P \leq 0.05$).
*Treatment main effect $P < 0.01$.

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

	Pre-treatment		Year post-treatment: Year 1		Year post-treatment: Year 2			
Item, % of total	No burn	Burn	No burn	Burn	No burn	Burn	SEM[1]	*P*-value
Total forbs*	7.7	9.5	10.4	18.3	7.4	14.7	1.79	0.10
Native	7.6	9.4	10.3	16.8	7.4	14.5	1.78	0.14
Introduced	0.1[a]	0.2[a]	0.1[a]	1.6[b]	0.0[a]	0.2[a]	0.44	0.02
Perennial*	7.4	9.3	10.3	16.2	7.3	14.3	1.75	0.16
Annual	0.3[a]	0.3[a]	0.1[a]	2.1[b]	0.1[a]	0.4[a]	0.47	<0.01
Nectar-producing	3.5[a]	4.6[a]	5.0[a]	9.7[b]	0.7[c]	0.8[c]	1.12	<0.01
Legumes	0.5	0.7	0.8	0.9	0.0	0.1	0.18	0.72

[1]Standard error of the mean.
[a-c]Within rows, means with unlike superscripts differ ($P \leq 0.05$).
*Treatment main effect $P \leq 0.01$.

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

	Pre-treatment		Year post-treatment: Year 1		Year post-treatment: Year 2			
Item	No burn	Burn	No burn	Burn	No burn	Burn	SEM[1]	*P*-value
Grass-species richness, number	7.8[a]	7.6[a]	7.3[a]	9.4[b]	7.3[a]	9.0[b]	0.57	<0.01
Forb-species richness, number	13.3[ab]	11.4[ac]	9.7[c]	15.1[b]	9.8[c]	10.4[c]	1.59	<0.01

[1]Standard error of the mean.
[a-c]Within rows, means with unlike superscripts differ ($P \leq 0.05$).

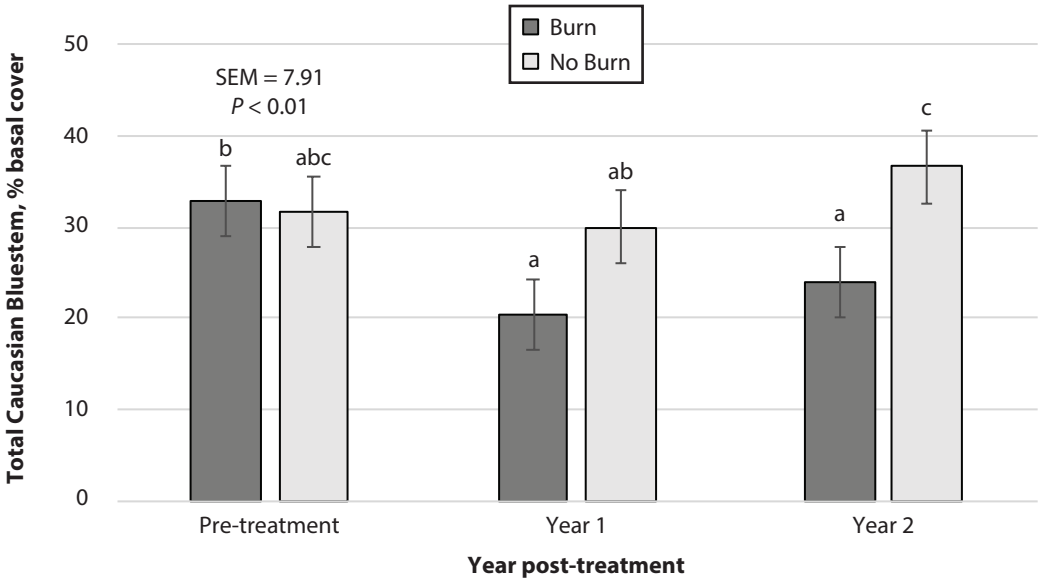

Figure 1. Effects of late-summer prescribed fire on Caucasian bluestem basal cover in the Kansas Smoky Hills