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Mixed-Grass Vegetation Response to an Extreme Wildfire Event

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Introduction

The wildfires of the 2021-2022 dormant season in Ellis, Osborne, Rooks, and Russell counties occurred under extreme weather conditions. However, most every dormant season contains conditions suitable for wildfires to occur: dried vegetation, low humidity, and potential for days of elevated temperatures and winds. A portion of the 122,000-acre area that burned in the December 2021 Four County Fire also burned in March 2017 during the dormant season. Dormant-season wildfire removes beneficial vegetative soil cover during the dormant season, and has ecological and financial impacts in the following growing seasons. Prior published dormant-season wildfire data showed that yield reductions the growing season after the fire ranged from 25% to 65%, depending on the time, location, and the main grass species consumed in the fire. Less soil cover and less production in the years after the fire may require lower stocking rates, which ultimately results in lower potential income. The Four County Fire burned approximately 12% of the range and pasture acres in these four counties. Therefore, fires of this magnitude have significant ecological and financial impacts on regional communities. To date, only a few historic wildfires in northwest Kansas have data available regarding rangeland response to those wildfires. This study was designed to provide producers with information for ecological and grazing animal planning for the years following dormant season wildfires in western Kansas.

Materials and Methods

This research took place on the 2,400-acre Kansas State University Saline Experimental Range (SER) in northeast Ellis County, KS. Approximately 1,800 acres of the site were burned in the Four County Fire that occurred December 15, 2021 (Figure 1). Wind speeds in excess of 80 mph and relative humidity less than 20% were recorded across western Kansas before and at the time the fire started. High winds blew ash and loose topsoil off of the soil surface directly following the headfire that occurred, giving the area the appearance of a bare, scoured surface. During the fire, a frontal boundary eventually passed over the area and caused the wind to subside and change direction. The fire that remained burning on the SER property after the initial headfire and frontal boundary passed had the characteristics of a much slower backfire that ended up extinguishing when it reached a graveled road that served as a fuel break. Ash and loose soil remained in place following the occurrence of the backfire. These conditions provided the opportunity to study the characteristics of two fire types (headfire and backfire) compared to unburned pasture area within close proximity. The pasture area consists of several ecological sites, but this study only included plots located on shallow limy and blue shale ecological sites, which compose close to half of the acreage of the entire

SER location. Nine exclosures (70 ft × 50 ft) were created to keep cattle out of the study plots, consisting of three replications of the three main study treatments (headfire, backfire, and unburned). Within each exclosure, vegetation was managed with each of three defoliation treatments by mowing, bagging, and removing the vegetation to simulate time of grazing following the fire. Vegetation was either removed in early June, mid-July, or remained undefoliated during the two growing seasons following the fire. The defoliation treatments within each exclosure were sampled for soil cover, new vegetative production, and vegetative composition in July and October of both 2022 and 2023.

Results and Discussion

Precipitation was greatly lacking on the SER in the growing season after the wildfire. In fact, the extreme drought affecting western Kansas had a greater impact on forage production during the 2022 growing season than did the dormant season wildfire. The long-term average yield (2120 lb/a) for the location was much greater (41%) than the 2022 average yield of the unburned treatment that had no effects from the fire, so drought had a large impact on yield reduction the first growing season. The dormant-season wildfire further reduced forage production in 2022 by 19% to 26% compared to areas that did not burn in the wildfire (Table 1). The combined effect of the drought and the dormant season wildfire resulted in forage production that was 53% to 57% lower than the long-term average forage production for the pasture area. Soil cover on burned plots was greatly reduced by the dormant-season wildfire compared to unburned plots, regardless of whether or not the area was burned by a headfire or a backfire (Table 2). Unburned pasture had 59% soil litter cover while burned pasture had 8% or less soil litter cover. Basal cover of plants on unburned pasture was more than twice as great than basal cover of plants on pasture burned by the headfire; therefore, the headfire appeared to reduce plant and/or stem density of the headfire region (Table 3). Surprisingly, big bluestem cover was greater on headfire areas compared to unburned areas (Table 4). However, little bluestem cover was nearly eight times greater on unburned areas compared to headfire areas (Table 4). Little bluestem suffered major cover reductions due to the dormant season headfire.

In 2023, the early growing season started with low precipitation but ended with near average total growing season precipitation levels. Forage production was greater in the headfire sites compared to the unburned and backfire sites (Table 1). This increase in production compared to unburned sites was unexpected. However, similar to 2022, big bluestem cover remained significantly greater on headfire sites compared to unburned sites, while little bluestem cover remained greater on unburned sites (Table 4). This was consistent across both years. The loss of little bluestem in the headfire stand and replacement by big bluestem appears to have increased production of the headfire sites 2 years post-wildfire. A divergence in the plant community was evident between the headfire and unburned locations in the first post-wildfire growing season based on bluestem cover. The change in composition of big and little bluestem, along with some small changes in forb species, created a statistically different plant community in the headfire burned area compared to the unburned area. Although many similar species were found within both fire treatments, the proportions of these plants created a divergence in the plant community. A principal component analysis showed the lack of overlap between the unburned and headfire plant communities in 2023, indicating that differences in composition proportions had occurred (Figure 2). The defoliation that occurred either

early or late in the first growing season following the fire to simulate time of grazing had no effect on forage production in the second growing season in either of the fire types or in the unburned sites. Soil litter cover remained lower on the burned sites, averaging less than 20% litter cover, while the unburned sites averaged just over 40% soil litter cover (Table 2). Although basal cover was lower at the headfire sites during the first year post-wildfire, all sites had similar basal cover during the second growing season post-wildfire (Table 3).

Implications

Published dormant season wildfire data show that yield reductions the growing season after a fire range from 25% to 65%, depending on the time, location, and dominant grass species consumed in the fire. The data of the current study show that yield is reduced approximately 25% during the first growing season after a fire, but pasture yields recover during the second growing season. This study also shows that drought effects on reducing pasture yield directly following a dormant season wildfire may have a greater impact than the dormant season wildfire itself. After the second growing season, burned portions had equal or greater forage production compared to unburned portions of pasture; meanwhile, previous studies showed that yield could still be lower in the second growing season following a wildfire. Whether the wildfire occurs during the early or late dormant season could also affect yields and vegetation, but those impacts could not be studied as part of the current research project. Also, defoliation that occurred either early or late in the first growing season following the fire had no effect on forage production in the second growing season. Therefore, areas burned in this dormant season wildfire could have been conservatively grazed in the first growing season with no reductions in yield the following year.

Table 1. Fall forage yield the first and second growing season after sites were burned by a backfire or a headfire in the Dec. 15, 2021, Four County Wildfire on the Kansas State University Saline Experimental Range

	2022	2023
	---------- lb/a ----------	
Backfire	1012 b	2351 b*
Headfire	923 b	3089 a*
Unburned	1244 a	2381 b*

Different letters within columns indicates a significant difference at the $P < 0.05$ probability level between fire types within a year. An * indicates a significant difference at the $P < 0.05$ probability level between years within a fire type.

Table 2. Fall soil litter cover the first and second growing season after sites were burned by a backfire or a headfire in the Dec. 15, 2021, Four County Wildfire on the Kansas State University Saline Experimental Range

	2022	2023
	%	
Backfire	8.0 b	19.6 b*
Headfire	2.2 b	14.4 b*
Unburned	59.1 a	40.2 a*

Different letters within columns indicates a significant difference at the P < 0.05 probability level between fire types within a year. An * indicates a significant difference at the P < 0.05 probability level between years within a fire type.

Table 3. Fall plant basal cover the first and second growing season after sites were burned by a backfire or a headfire in the Dec. 15, 2021, Four County Wildfire on the Kansas State University Saline Experimental Range

	2022	2023
	%	
Backfire	16.9 a	13.6*
Headfire	9.1 b	11.3
Unburned	19.3 a	14.2*

Different letters within columns indicates a significant difference at the P < 0.05 probability level between fire types within a year. An * indicates a significant difference at the P < 0.05 probability level between years within a fire type.

Table 4. Fall foliar cover of big bluestem and little bluestem the first and second growing season after sites were burned by a backfire or a headfire in the Dec. 15, 2021, Four County Wildfire on the Kansas State University Saline Experimental Range

	Big Bluestem			Little Bluestem		
	2022	2023	Avg.	2022	2023	Avg.
	%					
Backfire	27.3	34.0	30.7 b	16.2	13.7	15.0 b
Headfire	37.4	43.6	40.5 a	2.4	4.1	3.2 c
Unburned	17.8	23.5	20.7 c	22.8	31.5	27.2 a

Different letters within columns indicates a significant difference at the P < 0.05 probability level between fire types within a year.

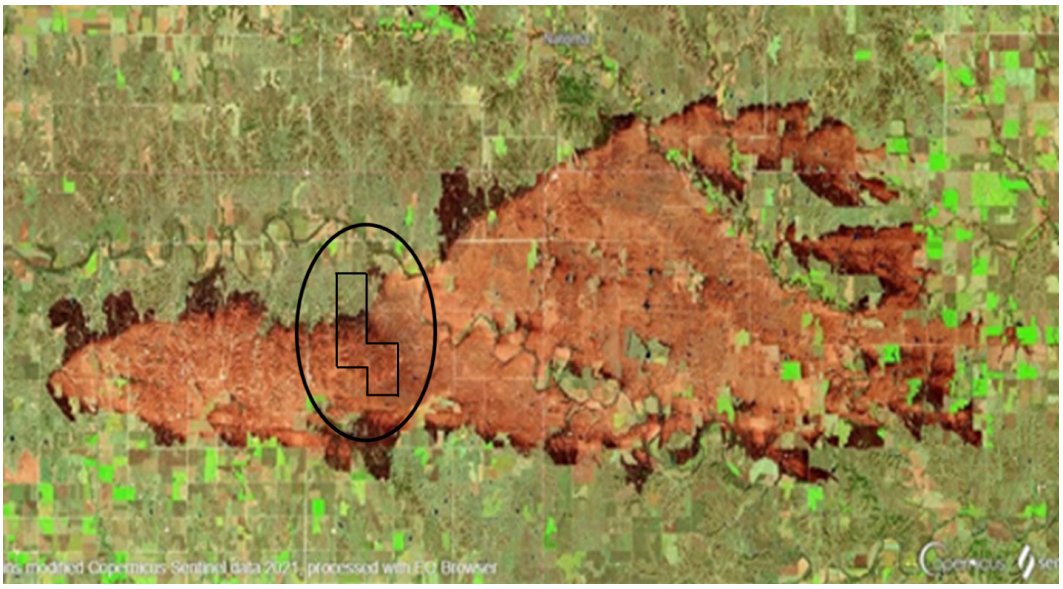

Figure 1. Satellite imagery of the 122,000-acre burn scar of the Dec. 15, 2021, Four County Fire in west central Kansas. The offset rectangular block within the oval indicates the location of the 2,400-acre Kansas State University Saline Experimental Range in relation to the wildfire.

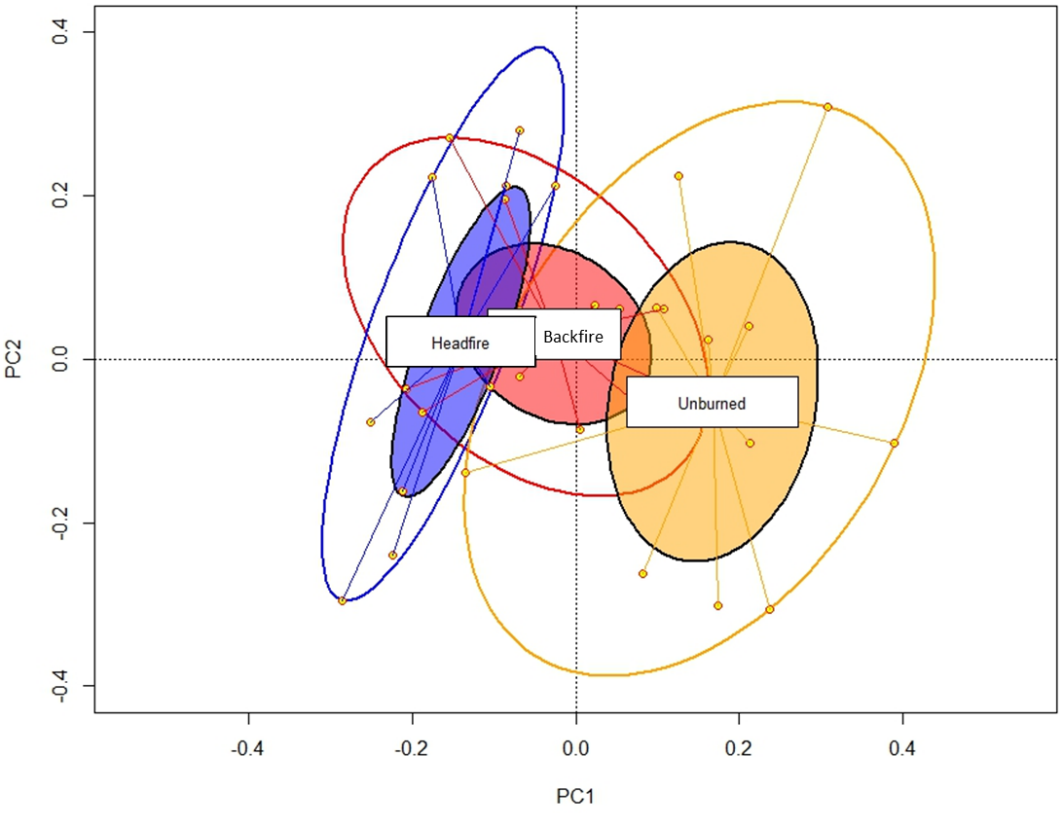

Figure 2. Principal component analysis of fall vegetative cover composition in 2023 after sites were burned by a backfire or a headfire in the Dec. 15, 2021, Four County Wildfire on the Kansas State University Saline Experimental Range. The lack of overlap in the circular rings of the headfire and unburned sites indicates that vegetation had undergone a significant shift in composition.