9-2015

Prescribed Fire Monitoring Report, Tallgrass Prairie National Preserve 2014 (IQCS fire number 285382, 285383, 266782, 285677)

Sherry A. Leis
United States National Park Service

Sarah E. Hinman
United States National Park Service

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

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Natural Resource Report NPS/HTLN/NRR—2015/1025

ON THE COVER
Photograph of prescribed burn at Tallgrass Prairie National Preserve taken on 16 October 2014.
Photograph courtesy of the Sherry Leis.

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Sherry A. Leis and Sarah E. Hinman

National Park Service
Missouri State University
901 S. National Ave.
Springfield, MO 65897

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National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

This report is available in digital format from the Heartland Inventory and Monitoring Network (http://science.nature.nps.gov/im/units/htln/fire.cfm), and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

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Contents

Page

Figures.....iv
Tables.....v
Appendices.....vi
Acknowledgments.....vii
List of Terms Acronyms.....vii
Introduction.....1
Burn Operations Summary.....1
Methods.....4
Results.....7
Burn Extent.....16
Summary.....17
Literature Cited.....19

Figures

Page

Figure 1. Progression of prescribed burn operation at Tallgrass Prairie National Preserve on October 16, 2014 2

Figure 2. Fire effects monitoring sites at Tallgrass Prairie National Preserve 4

Figure 3. Fuel loads for 2010-2014 in nine pastures (burn units) at Tallgrass Prairie National Preserve 8

Figure 4. Mean fuel loads from 2010-2014 varied by time since fire at Tallgrass Prairie National Preserve 8

Figure 5. Fall fuel loads were significantly greater than spring fuel loads for 2014 at Tallgrass Prairie National Preserve 9

Figure 6. Analysis of fire severity in (A.) vegetation and (B.) substrate with time since fire for four years of monitoring data (2010-2014) at Tallgrass Prairie National Preserve 14

Figure 7. Regression results of fuel load predicting fire severity as measured by standing vegetation at Tallgrass Prairie National Preserve 15

Figure 8. Areas of Tallgrass Prairie National Preserve burned by prescribed fire during 2014 16

Figure 10. SW Windmill, Tallgrass Prairie National Preserve, Kansas, 24 April 2014 Post-burn Site 53 AS-AF A-1

Figure 9. SW Windmill, Tallgrass Prairie National Preserve, Kansas, 25 March 2014 Pre-burn Site 53 AS-AF A-1

Figure 12. East Traps, Tallgrass Prairie National Preserve, Kansas, 23 April 2014 Post-burn Site VF237 AS-AF A-1

Figure 11. East Traps, Tallgrass Prairie National Preserve, Kansas, 25 March 2014 Pre-burn Site VF237 AS-AF A-1

Figure 14. East Trap, Tallgrass Prairie National Preserve, Kansas, 23 April 2014 Post-burn Site VF227 AS-AF A-2

Figure 13. East Trap, Tallgrass Prairie National Preserve, Kansas, 25 March 2014 Pre-burn Site VF227 AS-AF A-2

Figure 16. Big Pasture-North, Tallgrass Prairie National Preserve, Kansas, 23 April 2014 Post-burn Site 71 AS-AF A-2

Figure 15. Big Pasture-North, Tallgrass Prairie National Preserve, Kansas, 24 March 2014 Pre-burn Site 71 AS-AF A-2

Figure 17. NE Windmill, Tallgrass Prairie National Preserve, Kansas, 1 October 2014 Pre-burn Site 52 BS-BF B-1

Figure 18. NE Windmill, Tallgrass Prairie National Preserve, Kansas, 17 October 2014 Post-burn Site 52 BS-BF. B-1

Figure 20. NE Windmill, Tallgrass Prairie National Preserve, Kansas, 17 October 2014 Post-burn Site 62 BS-BF. B-1

Figure 19. NE Windmill, Tallgrass Prairie National Preserve, Kansas, 1 October 2014 Pre-burn Site 62 BS-BF. B-1

Figure 21. Big Pasture-South, Tallgrass Prairie National Preserve, Kansas, 2 October 2014 Pre-burn Site 29 AS-AF. B-2

Figure 22. Big Pasture-South, Tallgrass Prairie National Preserve, Kansas, 17 October 2014 Post-burn Site 29 AS-AF. B-2

Figure 23. Big Pasture-South, Tallgrass Prairie National Preserve, Kansas, 2 October 2014 Pre-burn Site 55 AS-AF. B-2

Figure 24. Big Pasture-South, Tallgrass Prairie National Preserve, Kansas, 17 October 2014 Post-burn Site 55 AS-AF. B-2

Tables

Page

Table 1. Details for prescribed burns at Tallgrass Prairie National Preserve for the year of 2014........ 1

Table 2. Prescription elements based on the prescribed burn plan for Tallgrass Prairie National Preserve (Beacham 2011). ROS (Rate of Spread). 3

Table 3. Mean fuel load, soil moisture, and 1-hour fuel moisture collected pre-burn for spring and fall burns at Tallgrass Prairie National Preserve in 2014.. 7

Table 4. Weather observations collected during prescribed fire at Tallgrass Prairie National Preserve on 28 March 2014 from the Remote Automated Weather Station (RAWS). 10

Table 5. Weather observations collected during prescribed fire at Tallgrass Prairie National Preserve on 29 March 2014 from the Remote Automated Weather Station (RAWS). 10

Table 6. Weather observations collected during prescribed fire at Tallgrass Prairie National Preserve on 15 April 2014 from the Remote Automated Weather Station (RAWS).. 11

Tables (continued)

Page

Table 7. Weather observations collected during the prescribed fire at Tallgrass Prairie National Preserve on 16 October 2014.. 11

Table 8. Smoke observations collected during the prescribed fire at Tallgrass Prairie National Preserve on Oct 16, 2014. 12

Table 9. Fire behavior at Tallgrass Prairie National Preserve on 16 October 2014.. 13

Table 10. Fire severity and reduction values by pasture collected at Tallgrass Prairie National Preserve on 23 and 24 April 2014 for the spring burns and 17 October 2014 for the fall burns. 13

Appendices

Page

Appendix A. Pre- and post-burn photographs at Tallgrass Prairie National Preserve taken in spring 2014. .... A-1

Appendix B. Pre- and post-burn photographs at Tallgrass Prairie National Preserve taken in fall 2014. .... B-1

Acknowledgments

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List of Terms Acronyms

Term	Definition
FL	Flame Length
FDFM	Fine Dry Fuel Moisture
FZD	Flame Zone Depth
HTLN	Heartland Inventory and Monitoring Network
RAWS	Remote Automated Weather Station
RH	Relative Humidity
ROS	Rate of Spread
TAPR	Tallgrass Prairie National Preserve, also preserve
TNC	The Nature Conservancy

Introduction

In 2014, the preserve's federal and NGO partners conducted prescribed fires during March, April, and October that encompassed 8129.8 acres of Tallgrass Prairie National Preserve (TAPR). This was a unique burn year in that prescribed burns occurred in the spring, the traditional burn season, and the fall. Fall burns were conducted to support needed archaeological surveys as part of the environmental compliance for a symphony event scheduled for June 2015 at the preserve. Burns at TAPR were coordinated with local US Fish and Wildlife Service (USFWS), The Nature Conservancy (TNC), and various units of the National Park Service.

Burns conducted in spring 2014 included: Red House Pasture, Crusher Hill Pasture, the southwest portion of Windmill Pasture, Big Pasture-North, Two Section, East Traps, and Bottomland Restorations (Fields 4, 8, and 18, and the east half of Field 20). In fall 2014, they included: the northeast portion of Windmill Pasture, Big Pasture-South, Southwind Nature Trail/Headquarters, and the northeast portion of Red House Pasture. These areas were successfully burned over the course of three days in the spring and two days in the fall (Table 1; See figure 8 for map of all burned areas.).

The fire ecologist was unable to participate in the spring burn events, but was onsite for one day of fall burning. This report presents the 2014 monitoring data in the context of available long-term data that has been collected at TAPR since 2010.

Table 1. Details for prescribed burns at Tallgrass Prairie National Preserve for 2014. All burns used fuel models GR5 and GR6 for tallgrass prairie (Beacham 2011, based on Scott and Burgen 2005)

Burn Unit	Date	IQCS #	Size of burn (planned/actual)	Time Since Last Fire Years (burn year)
Big Pasture-North	28 March 2014	285382	6457.8 / 6774.1 acres	3 (2011)
Red House, Crusher Hill, SW Windmill	29 March 2014	285383		Red House: 3 (2011) Crusher Hill: 3 (2011) SW Windmill: 2 (2012)
Two Section, East Traps, Restorations (4, 8, 18, and 20)	15 April 2014	266782		Two Section: 3 (2011) East traps : 3 (2011) Restorations: 3 (2011)
NE Windmill, Big Pasture-South, Southwind Nature Trail/Headquarters	16 October 2014	285677	2370 / 2357.8 acres	NE Windmill: 4 (2010) Big Pasture-South: 4 (2010) Southwind trail/Headquarters: 4 (2010)
Northeast Red House	21 October 2014	285677		< 1 (2014)

Burn Operations Summary

This burn operations summary describes the burn operations conducted on October 16, 2014 for the Symphony Burn (fall 2014). Deon Steinle with the U.S. Fish and Wildlife Service led the operation. Crews were briefed at the visitor center at 0910 and deployed to the test fire site at 1030. The test fire site was changed from point K to I and ignition occurred at 1110. Preserve managers requested that the unit be as completely burned as was feasible, so a ring fire technique was used with interior ignition by UTV torches. Operations for the day concluded using the tour road as the fire break rather than the planned fire break in Red House Pasture (Figure 1).

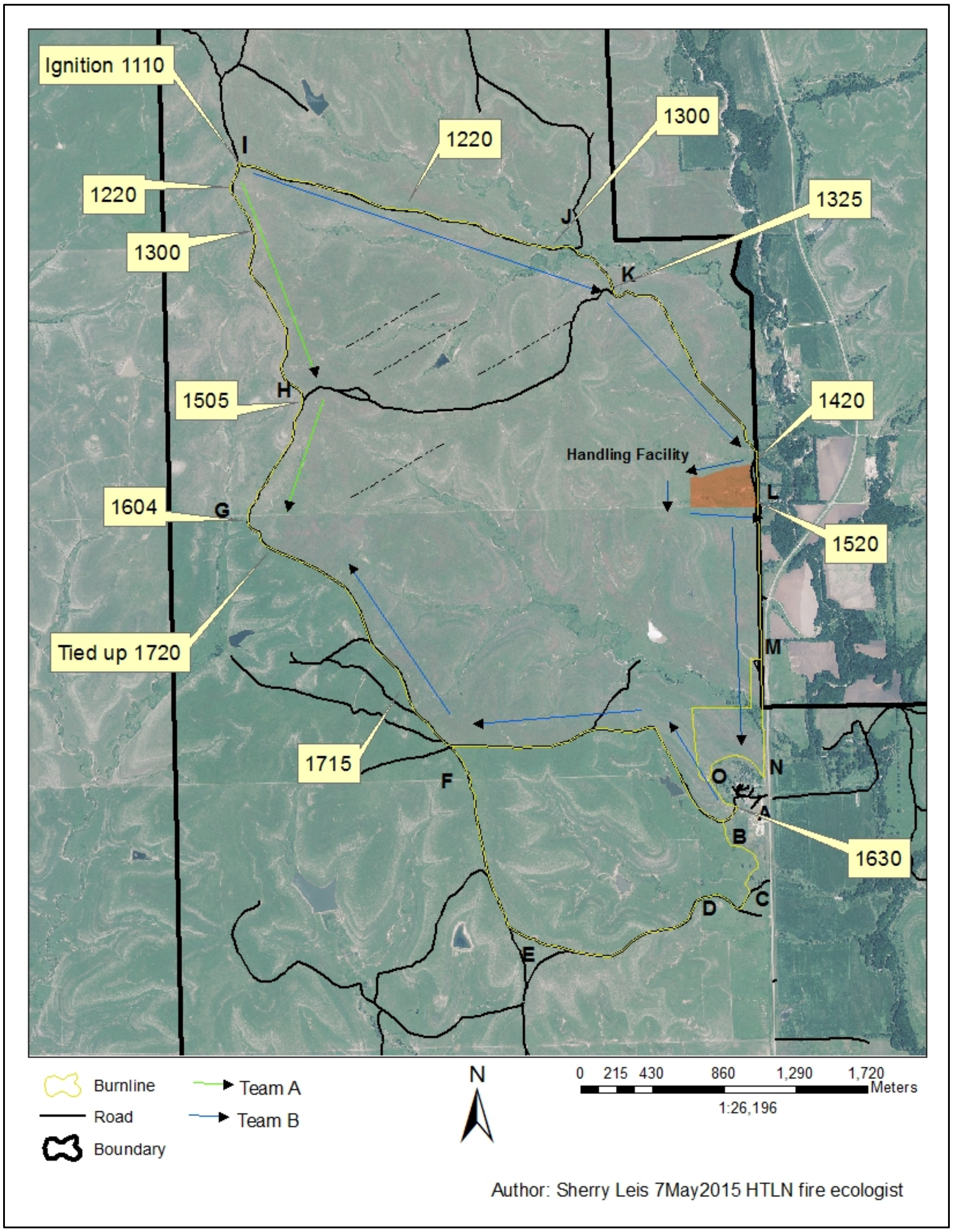

Figure 1. Progression of prescribed burn operation at Tallgrass Prairie National Preserve on October 16, 2014. Dotted lines across the northern part of the unit indicate interior ignition by ATV torches.

An after-action-review was held at the Visitor Center after the fire was tied up. Crews were commended for their flexibility to make adjustments for variations in wind, topography, fuels, and livestock as well as leadership during the fire. We discussed the potential benefit of an earlier ignition time in the future. The holding crew experienced heavy smoke most of the day and some smoke complaints were received by the Kansas Department of Transportation (KDOT) and Highway Patrol (KHP). The Preserve called the KHP as soon as crews recognized that smoke would be impacting highway 177. KDOT staff arrived on scene to escort motorists through the smoke. Work concluded for the day at 1900.

Additional burning in northeastern Red House Pasture was done on October 21 to complete the planned burn unit.

Burn Unit Goals

Goals for prescribed burns at TAPR (Beacham 2011):

1. Increase biological diversity by promoting varied plant structure to improve wildlife habitat by implementing a varied fire and grazing regime.

2. Secondary objectives include controlling woody and undesirable vegetation, removing dead or old growth vegetation build-up, promoting re-growth of warm season grass species, and increasing native plant diversity.

Goal for the fall burns from the Symphony Prescribed Burn plan (Steinle 2014).

1. Remove thatch to improve conditions for archaeological surveys, reduce fuel load, increase biological diversity, suppress woody and undesirable vegetation, and provide for firefighter and public safety.

Table 2. Prescription elements based on the prescribed burn plan for Tallgrass Prairie National Preserve (Beacham 2011). ROS (Rate of Spread).

	Fire Intensity		
Variables	**Low**	**Desired**	**High**
Relative Humidity (%)	60	30-45	25
Wind Direction	N/A	Directions that keep smoke off K-177, US-50 and out of Strong City.	N/A
Wind Speed (midflame)	5	7-10	15
Fuel Moisture 1-hr (%)	12	8	6
Live Fuel Moisture (%)	75	60	30
Maximum Mixing Height (ft)		2,000 feet AGL	

	Fuel Model (Number)	
	GR5 (105)	**GR6 (106)**
Rate of Spread (ch/h)	370 ch/h	581 ch/h
Headfire Flame Length (ft)	24 ft	33 ft
Backfire Flame Length (ft)	3 ft	4 ft
Backfire ROS (ch/h)	5 ch/hr	7 ch/hr

Methods

The Heartland Network's fire ecology program has monitored TAPR since 2010. This includes collecting a suite of data used to evaluate the effectiveness of fire on the landscape by way of documenting the fire environment (weather, fuel load, fuel moisture (1-hr and 10-hr), soil moisture), fire behavior (manner and rate of spread (ROS), flame length, smoke observations, etc.), and fire effects (fire severity, percent of fuels consumed, changes in plant and animal community composition and structure, etc.). Sampling methods for fire ecology monitoring are described in detail in the Fire Ecology Monitoring Protocol for the Heartland Inventory and Monitoring Network (Leis et al. 2011). Monitoring site locations are shown in Figure 2.

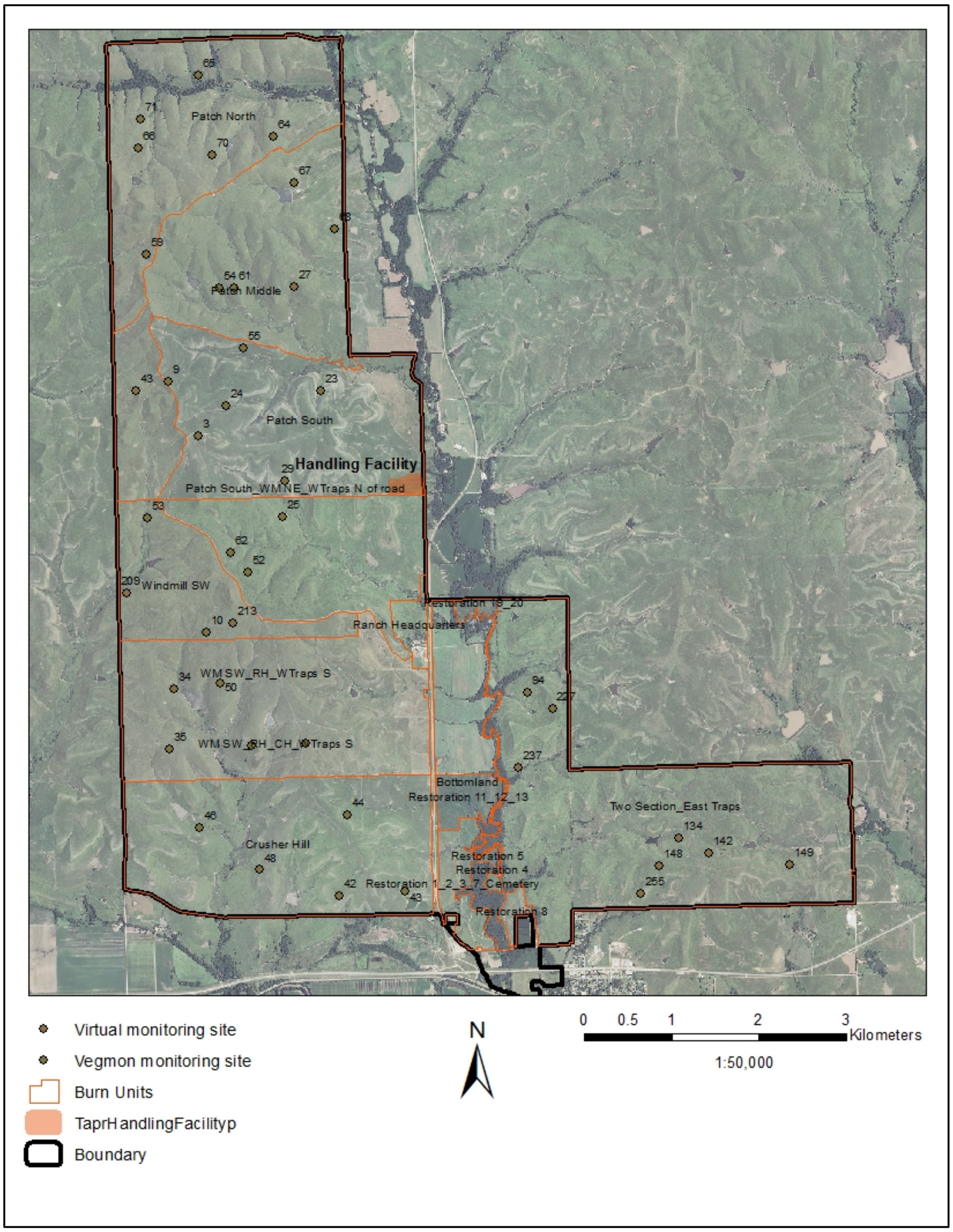

Figure 2. Fire effects monitoring sites at Tallgrass Prairie National Preserve.

Collection Dates

Fuel load sampling took place on March 24-25, 2014 in Big Pasture-North (6 sites), East Traps (3 sites), Two Section (5 sites) and SW Windmill Pasture (4 sites), three days before the start of spring burning. Also on March 24 and 25, 2014 soil moisture was measured at all sites in Big Pasture-North and SW Windmill Pasture. Fire severity was documented at all sample sites post-burn, on April 23-24, 2014.

For the fall burns in Big Pasture-South (6 sites) and NE Windmill Pasture (3 sites), fuel load sampling was conducted on October 1-3, 2014, fuel moisture and soil moisture were collected on October 15, the day before the burn, and fire severity was determined post-burn on October 17.

Analyses

Analyses are described in detail below. The statistical package R was used for basic calculation of site means and standard deviations (R Core Team 2015). Inferential analyses were performed using SPSS version 20.0 on site means as the unit of replication with alpha set to 0.05 (IBM SPSS Inc. 2011).

Fuel Load

We expected a 10-20% degradation of the fuel bed over the winter months; however, the anticipated degradation is within the measurement error of most pastures at TAPR (personal communication C. Owensby 2010). A one-way ANOVA with Tukey post hoc pairwise comparisons was used to assess whether fuel load varied with time since fire. We used an independent samples t-test to determine whether fuel loads differed between the spring and fall 2014 burns.

Fuel Moisture

In addition to 1-hour fuel moisture being collected on-site for the fall burns, 10-hr fuel moisture values were collected from the Remote Automated Weather Station (RAWS) for the spring and fall burn dates. Fuel moisture affects fire behavior and potentially fire severity. We were unable to collect fuel moisture in the spring, but did complete it for the fall burns.

Soil Moisture

Soil moisture was collected in conjunction with pre-burn fuel loads several days prior to the start of burning. Normally, soil moisture is collected within 24 hours of ignition, but we wanted to have a benchmark for the levels in the event if we could not be present for burn day. For the fall burn, soil moisture was collected according to the standard timing (day prior or day of a burn) in the protocol (Leis et al. 2011).

Weather

Weather data reported in Tables 4 and 5 for the spring burn days were collected from the RAWS and used to calculate 1-hr fuel moisture and probability of ignition for the burn days. For the fall burn, weather and fire behavior data were collected on-site by Sherry Leis, fire effects monitor (FEMO), and are reported in Table 6.

Fire Severity and Fuel Reduction

Post-burn monitoring (fire severity and photopoints) was completed on April 24 (spring) and October 17 (fall), 2014. Fire severity was measured for both vegetation and substrate using a categorical scale where 1 is severely burned and 5 is unburned (Leis et al. 2011). We used one-way ANOVA with Tukey post hoc pairwise comparisons to assess whether fire severity varied with time since fire and used an independent samples t-test to determine whether severity differed between the spring and fall 2014 burns. Fire severity data were corrected for normality using a $\log_{10}$ transformation; substrate severity was also $\log_{10}$ transformed. Lastly, we used regression analysis to determine the relationship of fuel load to fire severity over the long-term dataset.

Mean fire severity rankings for each site were used to infer fuel reduction. Proportions of categories for severity were assigned a fuel reduction percent and the sum for all the sites was converted to a percentage. Substrate fuels (litter, duff, soil surface) considered to be eliminated were in severity class 1, 2, and 50% of class 3; while vegetation fuels (standing plant matter) in severity class 1, 2, and 75% of class 3 were considered eliminated. The total for all sites was converted to a percentage for both substrate and vegetation to infer fuel reduction.

Geospatial Data

Spatial data for the burns were collected by heads-up digitizing polygons. For the spring burn, a April 25, 2014 image was used as a background to identify burned areas. For the fall burn, there was no aerial image that showed the burned area. Therefore, a combination of on the ground observations (personal communication, Kristen Hase March 2015), 2014 NAIP imagery, and trails/burn unit boundary spatial layers were used to create the fall burn polygons. No ground-based interior mapping of unburned areas was done for either burn. All spatial work was processed with ESRI ArcGIS version 10.2 software. Percent burned area for the preserve as a whole used the acres within the official boundary of the preserve, planned burn areas, and burned area boundaries for each season for calculation.

Results

We present our findings of pre-burn conditions for both the spring and fall burns in Table 3. Fuel moisture was not collected for the spring burns in 2014.

Table 3. Mean fuel load, soil moisture, and 1-hour fuel moisture collected pre-burn for spring and fall burns at Tallgrass Prairie National Preserve in 2014. Values in parentheses are standard deviation.

Monitored Pastures	N (sites/ pasture)	Time Since Burn (years)	Mean Fuel Load (tons/acre)	Mean Soil Moisture (%)	Mean 1-hr Fuel Moisture (%)
Spring Burns					
Big-North	6	3	1.3 (0.38)	24.2 (6.0)	not collected
SW Windmill	2	3	2.1 (0.97)	29.2 (6.0)	not collected
East Traps	3	3	1.9 (0.61)	25.6 (10.5)	not collected
Two Section	5	3	1.7 (0.32)	31.0 (6.9)	not collected
Park	**4**		**1.7 (0.61)**	**27.5 (7.6)**	
Fall Burns					
Big-South	6*	4	2.6 (0.30)	36.5 (3.2)	36.0 (8.62)
NE Windmill	3**	4	3.4 (0.66)	31.2 (4.4)	31.5 (6.45)
Park	**2**		**2.9 (0.58)**	**35.01 (4.28)**	**34.7 (8.20)**

*5 sites were sampled for soil moisture and fuel moisture

**2 sites were sampled for soil moisture and fuel moisture

Fuel Load

Mean fuel loads from 2010-2014 were variable within year and pasture likely as a result of variable disturbance histories, topography, and soils, and ranged from 0.7 tons/acre to 3.9 tons/acre with a mean of 2.0 tons/acre ±0.8 (standard deviation, Figure 3). Fuel loads often fell below the fuel model definitions for GR5 and GR6 at the preserve (Scott and Burgan 2005). Data represent mean spring fuel loads by pasture, except for the 2014 fall monitoring.

To better understand the relationship between fuels and fire effects at TAPR through time, we calculated a time since fire variable from the fire history geodatabase. Results indicated that time since fire influences fuel load (ANOVA: $F=16.71$, $df=120$, $p<0.001$) (Figure 4) although fuel loads at 2 and 3 years since the last burn were not significantly different.

Because a fall burn is unusual for TAPR, we did an additional fuel load analysis to understand whether those fires had different characteristics (Figure 5). We found that fuel load was significantly greater in the fall than the spring (T-test: $t=-4.64$, $df=25$, $p<0.001$) (fall fuel load: 2.86 ± 0.58 tons/acre, spring fuel load: 1.72 ± 0.14 tons/acre [mean ± 1 SD]). However, the fall burn units generally had longer time since fire intervals (4 years-fall, 2-3 years-spring) so we are unable to conclude if the differences in biomass are a result of burn season or time since burn or some combination of the two.

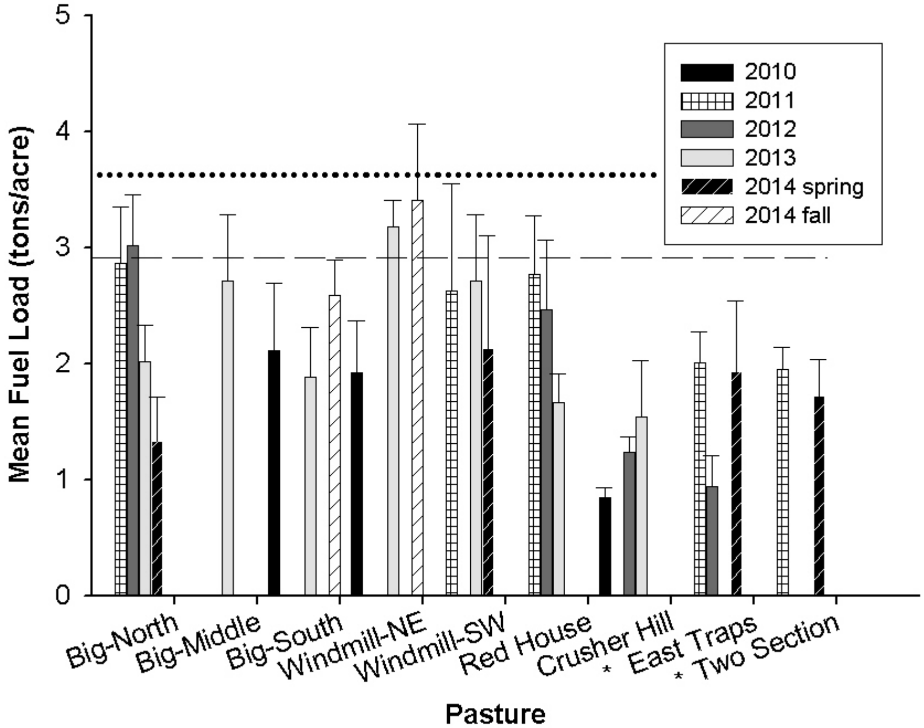

Figure 3. Fuel loads for 2010-2014 in nine pastures (burn units) at Tallgrass Prairie National Preserve. Error bars are ± 1 standard deviation. Dashed and dotted horizontal lines represent defined fuel loading for fuel models GR5 (2.9 tons/acre) and GR6 (3.5 tons/acre), respectively (Scott and Burgan 2005). Fires from 2010-2013 were spring burns. Starred pastures are located on the preserve's east side.

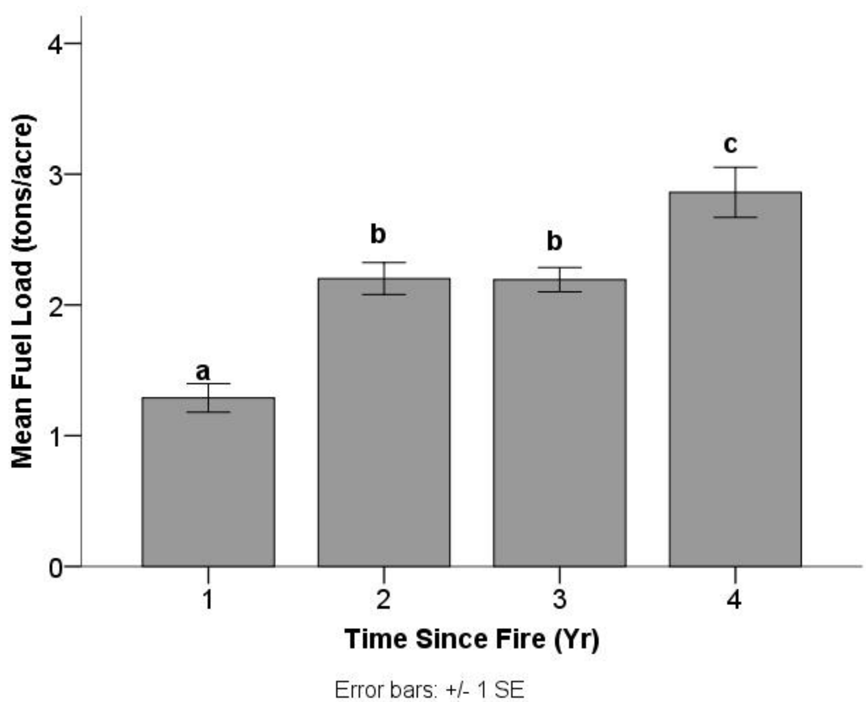

Figure 4. Mean fuel loads from 2010-2014 varied by time since fire at Tallgrass Prairie National Preserve. Letters above the bars indicate significantly different intervals.

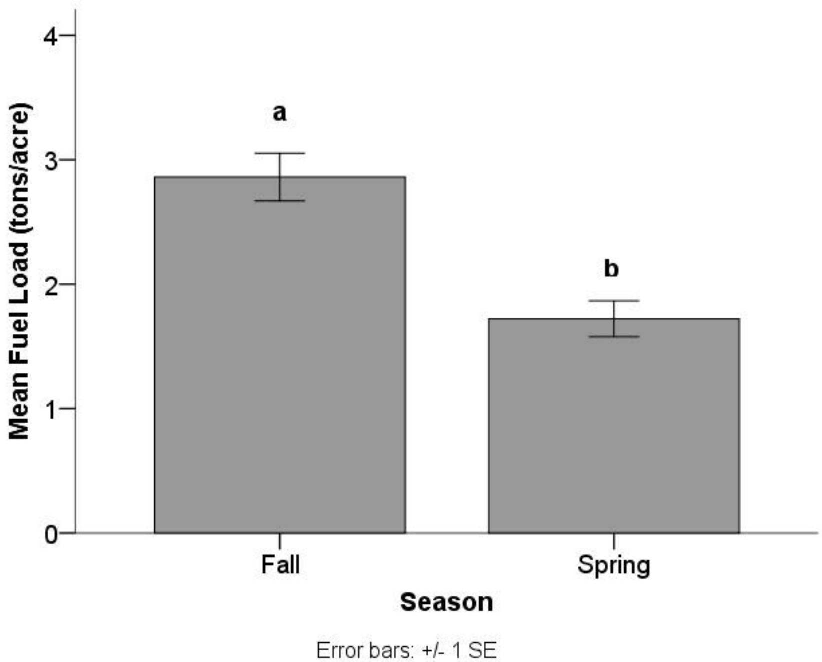

Figure 5. Fall fuel loads were significantly greater than spring fuel loads for 2014 at Tallgrass Prairie National Preserve. Fall burn units had greater time since fire intervals (4 years) than spring (2-3 years).

Soil Moisture

Soil moisture may influence moisture in the litter layer, live plant moisture, as well as post-burn plant recovery. Mean soil moisture was greater in the fall than the spring, however; 0.16 inches (0.4 cm) and 0.42 inches (1.1 cm) of rain fell between sampling and western preserve burns and eastern preserve burns, respectively. The additional rainfall could have increased soil moisture for the later burn. Soils are variable at TAPR, but silt clay loams are dominant. Moisture values we measured in the spring were in the range where moisture is available for root absorption and well above the wilting point (~15%) for these soils. This level of soil moisture would require any live fuels to be pre-heated and dried by fire prior to combustion, slowing ROS. Greater levels of soil moisture may also influence the duff or lower litter layer's moisture, also slowing fire spread.

Fuel Moisture

Fuel moisture was not collected in the spring, but in the fall it averaged 33.7% across the burn unit. Field notes on the fuel indicated that monitoring sites included 20-40% live fuels at the time of the burn. The most recent measurable precipitation event, >0.01 inches (>0.03 cm) prior to the burn was on March 26, 2014 where the RAWS recorded 0.09 inches (0.23 cm) of rain. TAPR received a total of 0.32 inches (0.81 cm) during the month of March and 0.26 inches (0.66 cm) from the 1st to 15th of April with 0.23 inches (0.58 cm) falling on the April 13, 2014 (RAWS 2014). The measured fuel moisture was below the moisture of extinction, 40%, for fuel models GR5 and GR6.

Weather and Fire Behavior

Weather parameters for the spring burns were obtained from the local RAWS station for March 28 (Table 4), 29 (Table 5) and April 15, 2014 (Table 6) and generally fell within the desired range of the prescription. Relative humidity and wind directions were within the desired parameters of the prescription on March 29 (Table 2). Wind speeds were slower with gusts occasionally in the high range. Fine dead fuel moisture was in the low category of the prescription. On April 1st, relative humidity ranged from desired to less than prescribed around 1300. Winds were in the desired direction, and average windspeeds were in the desired range while gusts were greater than prescribed later in the burn period.

Table 4. Weather observations collected during prescribed fire at Tallgrass Prairie National Preserve on 28 March 2014 from the Remote Automated Weather Station (RAWS). Windspeed values in parentheses are maximum gust speeds.

Time	Location	Temperature °F		Dew Point	RH (%)	Wind		% Fine dead fuel moisture	% 10-hr dead fuel moisture	Prob. of Ignition
		Dry	Wet			Speed (mph)	Direction	Unshaded	Unshaded	%
1000	RAWS (KTAL)	36	32	28	72	4 (9)	SE	14	14.9	10
1100		38	34	28	67	4 (7)	NW	NA	14.3	NA
1200		43	37	30	60	9 (13)	WNW	13	12.6	20
1300		43	37	30	61	9 (15)	NNW	NA	12.4	NA
1400		44	38	31	59	5 (14)	NNE	12	11.4	20
1500		47	39	31	53	6 (12)	NNE	NA	10.9	NA
1600		51	41	31	47	6 (11)	NNE	11	10.8	20
1700		52	42	31	44	3 (12)	N	NA	9.0	NA
1800		52	41	30	43	5 (8)	NNE	10	8.8	30
1900		49	40	31	49	3 (8)	ENE	NA	8.9	NA
2000		45	38	31	58	4 (6)	ENE	12	9.1	20

Table 5. Weather observations collected during prescribed fire at Tallgrass Prairie National Preserve on 29 March 2014 from the Remote Automated Weather Station (RAWS). Windspeed values in parentheses are maximum gust speeds.

Time	Location	Temperature °F		Dew Point	RH (%)	Wind		% Fine dead fuel moisture	% 10-hr dead fuel moisture	Prob. of Ignition
		Dry	Wet			Speed (mph)	Direction	Unshaded	Unshaded	%
1200	RAWS (KTAL)	55	44	34	44	3 (9)	W	7	10.0	40
1300		58	45	33	38	5 (14)	NNE	N/A	9.6	N/A
1400		61	46	32	33	4 (10)	SSW	6	8.1	50
1500		61	46	31	32	6 (11)	SE	N/A	7.6	N/A
1600		62	46	29	29	4 (8)	SSE	7	7.4	50
1700		64	47	30	28	5 (9)	S	N/A	6.2	N/A
1800		61	45	30	31	6 (13)	SE	9	7.5	30
1900		59	45	31	34	5 (10)	SE	N/A	7.2	N/A
2000		54	42	30	40	5 (11)	SE	N/A	7.5	N/A

Table 6. Weather observations collected during prescribed fire at Tallgrass Prairie National Preserve on 15 April 2014 from the Remote Automated Weather Station (RAWS). Windspeed values in parentheses are maximum gust speeds.

Time	Location	Temperature °F		Dew Point	RH (%)	Wind		% Fine dead fuel moisture	% 10-hr dead fuel moisture	Prob. of Ignition
		Dry	Wet			Speed (mph)	Direction	Unshaded	Unshaded	%
1000	RAWS (KTAL)	48	37	22	36	4 (8)	E	8	10.5	40
1100		51	38	22	32	6 (12)	SE	N/A	8.9	N/A
1200		54	39	21	27	8 (16)	S	6	8.0	50
1300		57	41	20	23	9 (17)	SSW	N/A	7.9	N/A
1400		60	42	21	22	11 (23)	SSW	5	7.5	60
1500		62	43	20	20	11 (21)	SSW	N/A	6.7	N/A
1600		61	42	18	19	14 (21)	S	5	6.3	60
1700		60	42	18	19	16 (24)	S	N/A	6.8	N/A
1800		60	41	16	18	15 (25)	S	7	6.6	50
1900		57	40	16	20	11 (25)	S	N/A	6.5	N/A
2000		52	38	18	26	8 (15)	SSE	N/A	6.6	N/A

Weather for the October burn also fell generally within the prescription (Table 2, 7). Relative humidity began to rise from desired to low toward the end of the burn period. Wind directions were out of prescription, so additional approval and safety measures were implemented. Windspeeds and calculated fine dead fuel moisture were in the desired range. Preferred live fuel moisture was 60% and our samples that included a mix of live and dead fuels averaged 33.7% as a whole.

Precipitation for the 12 months prior to the March burns was 115% of the 14-yr average. Precipitation for 2014 as a whole was 86% of the 14-yr average.

Table 7. Weather observations collected during the prescribed fire at Tallgrass Prairie National Preserve on 16 October 2014. Windspeed values in parentheses are maximum gust speeds.

Time	Location	Temperature (°F)		Dew Point	RH	Wind		% Fine dead fuel moisture	Prob. of Ignition
		Dry	Wet			Speed (mph)	Direction	Unshaded	%
0750	Top of hill; west traps-tour rd	49	46	43	80	2 (3)	S/SE	15	10
0800	Top of hill; west traps- tour rd	49	46	43	80	3 (5)	SE	15	10
1040	N of bison coral	71	58	46	49	6 (10)	S	11	30
1115	N of bison coral	75	59	48	38	11 (15)	W	7	50
1245	K	80	61	48	33	5 (8)	S	9	40
1355	Bison pen	81	63	52	37	3 (5)	SW	8	40
1500	North of bison pen	81	62	50	34	3 (6)	S/SW	9	40
1550	Between K & J	78	61	50	37	8 (12)	W/NW	9	40
1700	South of G	76	62	54	46	4 (8)	W/NW	9	40
1805	Trail to Red House	73	60	52	47	5 (7)	NW	9	40

Smoke Observations

Smoke dispersal varied during the fall burn (Table 8). Holding crews reported experiencing heavy smoke on the fireline. Winds also pushed smoke onto highway 177 resulting in the need for a traffic escort. Smoke dispersal was not observed by the fire ecologist, and no alternative sources of data were available for the spring burns.

Table 8. Smoke observations collected during the prescribed fire at Tallgrass Prairie National Preserve on Oct 16, 2014.

Time	Location	Elevation of smoke column (ft)	Smoke column direction	Smoke column description
1115	I - test	Ground – 50ft	NW	
1140	I			No column
1205	I			Column forming; dispersing well; fireline is little smoky
1300	K		N	Still not a solid column; smoke moving Northerly; N line is smoky with a few feet visibility in places
1320	Between I and H		N/NE	2 columns moving N/NE
1430	Between R and bison		NE	Column NE maybe falling down; smoke starting to drop back down
1520	Between J and I		NE	Cloud base to west Council Grove; NE; excellent fireline visibility; dispersal good at this point
1720	G/7		SE	Smoke not dispersing; hanging at ground or just below clouds

Fire Behavior

For the fall burn, rates of spread were considerable slower than the prescription (Table 2, 9). Recorded flame lengths were shorter than prescribed for all fire types (especially headfires); however, it was difficult to observe flame heights for interior ignitions. Average ROS recorded varied substantially with a mean of 5.8 ch/hr (standard deviation = ±6.4), which was similar to the prescribed rates (Table 2). Fireline intensity observed was well below modeled intensity in the plan (Beacham 2011). Fire behavior was not observed by the fire ecologist and no alternative sources of data were available for the spring burns.

Table 9. Fire behavior at Tallgrass Prairie National Preserve on 16 October 2014. All fuels were tallgrass prairie model 3. Intensity (kW/m) was calculated using the formula $3(10FH)^2$ then converted to BTU/ft/s. Flame length (FL), flame height (FH), rate of spread (ROS), flame zone depth (FZD).

Time	Location (Burn Unit)	Spread direction	ROS (Ch/hr)	FL (ft)	FH (ft)	FZD (ft)	Intensity (Btu/ft/s)
1115	I - test (test fire)	Back	0.9	1	1	1	8.1
1140	I	Flank	1.8	1	2	1	32.2
1215	East of I	Back	0.9	2	2	1	32.2
1310	Between I and H	Back	0.9	2.5	2	1	32.2
1315	Between I and H	Flank	2.7	4	3	2	72.5
1445	Between I and H	Head	3.6	2.5	2	5	32.2
1520	Rolling north through unit	Head	18.2	3-5	3-5	3	128.8
1640	N of Big Gate	Flank	0.9	2	1.5	1	18.1
1645	Windmill/big gate	Head	9.1	5	5	2	201.3
1700	Windmill/big gate	Flank	9.1	3.5	3	6	72.5
1720	G/F	Head	18.2	5	4	3	128.8
1740	F	Back	3.1	3	2.5	1.5	50.3
Mean Head	**(n=4)**		**12.3**	**4.1**	**3.75**	**3.3**	**122.8**
Mean Flank	**(n=4)**		**3.6**	**2.6**	**2.4**	**2.5**	**48.8**
Mean Back	**(n=4)**		**1.5**	**2.1**	**1.9**	**1.1**	**30.7**

Fire Severity

Fire severity based on assessment of the standing fuels was moderate for spring (mean = 2.2) and fall (1.9), while fire severity based on substrate fuels (i.e., litter, duff, and soil surface layers) was much closer to the light range (mean = 2.7) for the spring and moderate (2.5) for the fall (Table 10). Severity classes are as follows: 0 = NA, 1 = heavy, 2 = moderate, 3= light, 4 = scorched, 5 = unburned. Moderate standing severity is defined by vegetation with unburned grass stubble less than 2 inches tall, and plant bases burned to ground level and obscured in ash immediately after burning. Light substrate severity is defined as litter and duff that is only blackened to partially consumed.

Table 10. Fire severity and reduction values by pasture collected at Tallgrass Prairie National Preserve on 23 and 24 April 2014 for the spring burns and 17 October 2014 for the fall burns. Values in parentheses are standard deviations.

Monitored Pastures	N (sites/ pasture)	Time Since Last Burn (years)	Fire Severity (± 1 s.d.)		Fuel Reduction (± 1 s.d.)	
			Vegetation	Substrate	Vegetation	Substrate
Spring Burn						
Big North	6	3	2.4 (1.00)	2.9 (0.81)	84.1 (32.13)	60.8 (25.79)
SW Windmill	3	3	1.7 (0.12)	2.4 (0.35)	99.7 (0.45)	81.7 (17.52)
Two Sections	5	3	2.4 (0.12)	3.0 (0.14)	89.7 (3.05)	49.1 (6.79)
East Traps	3	3	1.9 (0.15)	2.3 (0.20)	99.5 (0.45)	84.1 (9.20)
Park	**4**	**4**	**2.2 (0.80)**	**2.7 (0.77)**	**91.2 (19.3)**	**65.2 (21.8)**
Fall Burn						
Big South	6	4	2.0 (0.24)	2.5 (0.19)	96.1 (2.19)	73.1 (9.34)
NE Windmill	3	4	1.8 (0.12)	2.5 (0.22)	97.6 (1.35)	74.3 (11.14)
Park	**2**	**2**	**1.9 (0.59)**	**2.5 (0.54)**	**96.6 (2.2)**	**73.5 (9.3)**

Severity classes: 1 = heavy, 2 = moderate, 3 = light, 4 = scorched, 5 = unburned

Fuel Reduction

Burns across all monitoring sites tended to be relatively complete with water sources (springs, streams, ponds) creating the greatest amount of unburned. However, we documented an unburned patch covering 32.4% of site 71 in Big Pasture-North. This is an indication of the patchy nature of the Spring 2014 burns.

Substrate fuels across the park were reduced by 65% and 74% and standing vegetation fuels were reduced by about 91% and 97% in the spring and fall, respectively (Table 10). Reduction of fall 1-hour fuels was critical to requirements for the anticipated archaeology survey. The values for substrate and vegetation cannot be combined since the proportion of the fuel load contributed by both elements is unknown. The proportion of fuel reduction calculations are indirect measurements and should be only applied as estimates

To put the 2014 burns in the context of the long-term monitoring data, we asked whether there was a relationship between time since burn and fire severity. We found that there was a difference for vegetation fuels (standing; one-way ANOVA: F=6.03, df=57, p=0.001), but pairwise comparisons were only significant for 1 and 2 years compared to 4 years since last burn (Figure 6A). Substrate severity (litter, duff, soil surface), however, did not differ with time since fire (one-way: ANOVA: transformed: F=1.00, df=57, p=0.4; Figure 6B).

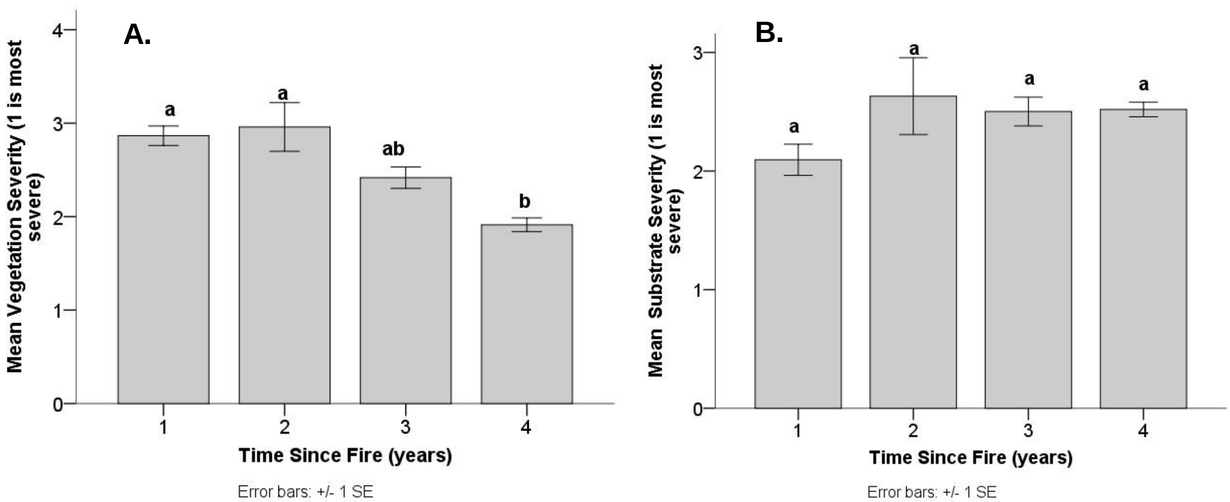

Figure 6. Analysis of fire severity in (A.) vegetation and (B.) substrate with time since fire for four years of monitoring data (2010-2014) at Tallgrass Prairie National Preserve. Letters above bars indicate significant differences.

Because fall burns are unusual for the preserve, we asked whether fire severity differed between different times of year in 2014 (i.e., spring burn vs. fall burn). Fire severity did not differ, neither vegetation nor substrate, between the two 2014 fire seasons (vegetation: t=1.35, df=24, p=0.19; substrate: t=1.02, df=24, p=0.32). However, the different time since fire statuses of the 2014 spring and fall units were not taken into account by this analysis.

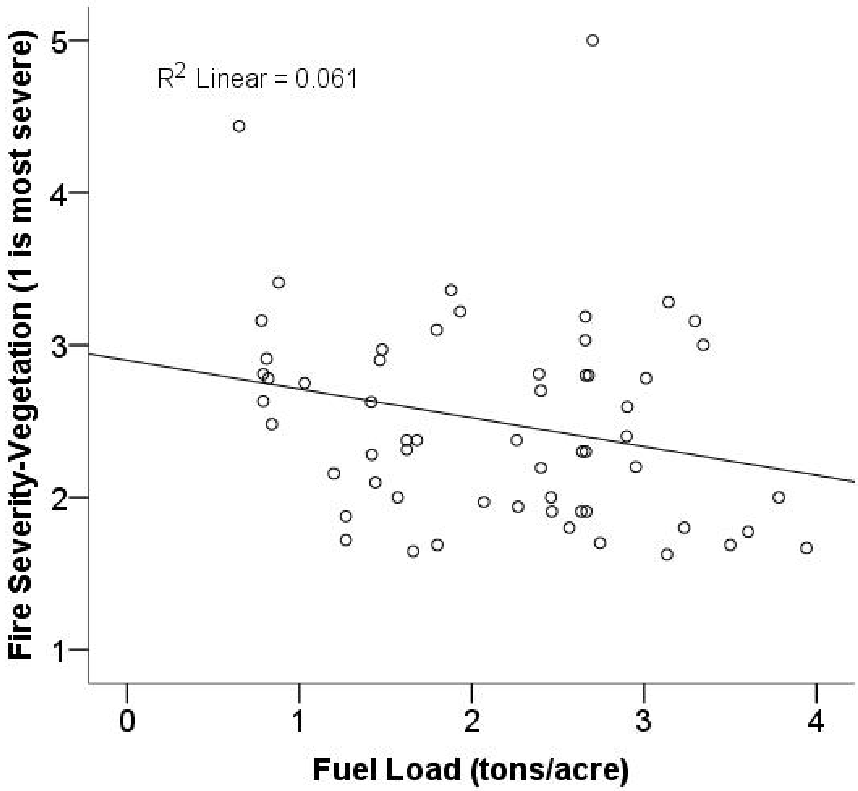

Figure 7. Regression results of fuel load predicting fire severity as measured by standing vegetation at Tallgrass Prairie National Preserve. The strength of the relationship was weak (R^2=0.06) over the four year dataset (2010-2014).

We also tested whether there was a relationship between fuel load and fire severity across the long-term dataset (Figure 7). Time since fire was critical to understanding the results. There was only a marginally significant relationship with vegetation severity across the whole dataset (r^2=0.06, df=57, p=0.06), and the strength of the regression was weak, explaining only 6% of the variability in the data. This weak relationship was due in part to a lack of differentiation in fuel load and vegetation severity as a function of time since burn for the 2- and 3-yr intervals (see Figures 4 and 6A). If only the shortest (1-yr) and longest (4-yr) intervals are included, the relationship is much stronger (r^2=0.80, df=16, p<0.01), and 80% of the variability in the data is explained. There was no significant relationship between substrate severity and fuel load (r^2=0.00, df=57, p=0.89) across the whole dataset.

Burn Extent

In 2014, 87.6% (9531.9 acres) of the preserve was burned over five burn days. Spring burning accomplished 104.9% of the acres planned for the season, while the fall burn accomplished roughly 95.3% of the planned unit (Table 1, Figure 8). Portions of Red House pasture burned twice during the year and portions of Big Pasture-Middle that burned were unplanned.

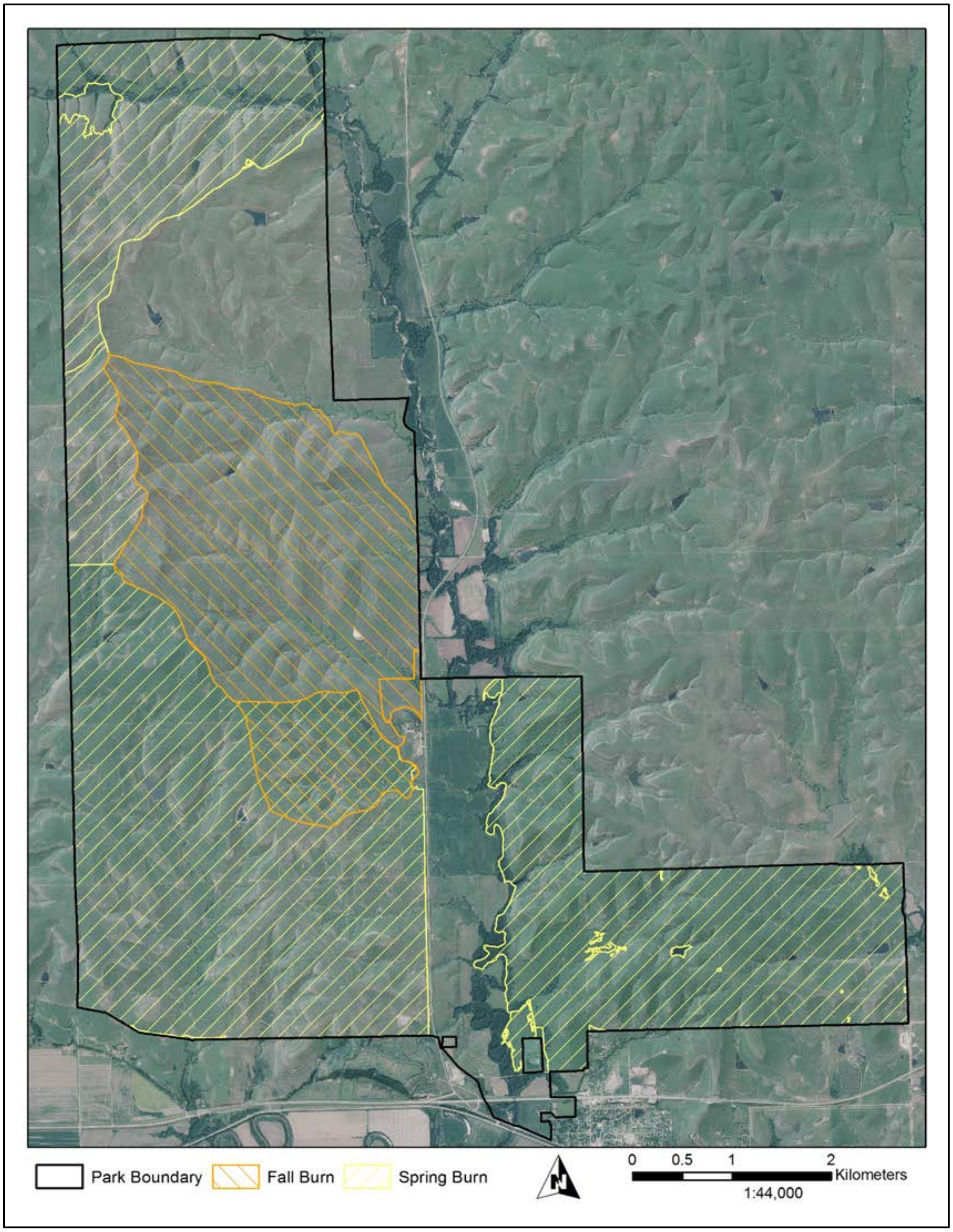

Figure 8. Areas of Tallgrass Prairie National Preserve burned by prescribed fire during 2014.

Summary

Prescribed fire in 2014 at TAPR was applied on several different days and included burns during the fall. Big Pasture-North burned first, followed by other western pastures, and finally pastures and restorations on the east side (Table 1). The fall burn was not anticipated at the beginning of the year, but was needed to improve the efficacy of upcoming archaeological surveys. This report focused on burn units where monitoring data was collected in 2014, although spatial data (burned area) is presented for the preserve as a whole. We also put the data into context of the long-term monitoring dataset that continues to build for TAPR (2010-2014).

Spring fire season in the Flint Hills can be unpredictable with regard to ever-changing weather conditions, and it is rare for fall burning to take place in that region. Shifting burn seasons meets the goal of implementing a varied fire regime (Goal 1, see Burn Unit Goals). Specific goals for the spring prescribed fires included a variety of natural resource related items including biological diversity, wildlife habitat, and woody plant control (Beacham 2011), while the fall burns were focused exclusively on fuel reduction. All burns in 2014 met safety objectives with regard to fire fighters and the public. Although not explicitly stated as a goal, completing the prescribed fires within the criteria set by the prescription was important to the operations. As practitioners of prescribed fire know, the ability to meet objectives is balanced with staying within the defined prescriptions. The prescription was flexible enough to allow operations to continue safely during variable weather conditions while meeting burn objectives. (Note: revised objectives have been drafted, but not incorporated in plans at this time.)

In line with natural landscape heterogeneity in prairies, we documented high levels of variability in fuel loads between 2010 and 2014 and in soil moisture between the spring and fall of 2014. Despite such variability in soil and fuel moisture, fuel loads, and natural landscape heterogeneity, fire behavior and severity was very similar across sites and burn periods during 2014. Fire behavior was moderate for the fall burn and often below expectations outlined in the burn plan, possibly a result of the proportion of green fuels in the matrix. Fuel reduction was also similar for the year, but more variable in the spring owing to one site that was mostly unburned. Fuel loads were variable within pastures and years despite receiving similar precipitation.

As time since burn increased, we detected increased fuel loads and increased fire severity (for standing fuels). In 2014, precipitation was about 86% of the 14-yr average (National Climatic Data Center 2014, RAWS Tallgrass Prairie (2014 data)) and plant communities may still be recovering from ongoing drought. The mosaic of burn histories across the preserve resulted in a mosaic of biomass density and burn severities across years. In comparison to fuel loads presented in this report, a 10-year average of live peak biomass in burned upland sites at Konza Prairie, Kansas was 1.6 tons/acre, somewhat less than the mean tons/acre at TAPR (Figure 3; Abrams et. al. 1986). However, the maximum in the Konza study, ~2.7 tons/acre, was similar to the fuel loads in the western pastures in 2010 (Figure 4).

Fuel loads were substantially reduced by the burns in the monitored pastures meeting expectations for the fall burn in particular. Although only marginally significant across the 4-yr dataset, we continue to see the relationship between fuel load and fire severity to trend positively. Interestingly, the extreme time since fire intervals (1- and 4-yr) had a strong relationship with fire severity (standing), but intermediate time intervals (2- and 3-yr) did not. Additional analyses which factor in stocking rates may help us to better understand these relationships, which in turn would be useful in the development of burn plans. To achieve a desired severity, for example, the fuel load could be manipulated through grazing or deferment and/or burning on a day with particular fuel moistures.

An evaluation of the primary objective of promoting varied vegetation structure (horizontal structure) showed that horizontal vegetation structure differs by time since burn as hypothesized (Leis et al. 2013). However, vegetation structure within the first 0.25 m recovers within one year, whereas vegetation structure in the 0.25-0.5 m range recovers two years post-burn. A difference in height was detected between the most recently burned patch and the other patches, but no difference was found between patches with greater than one year since burn (Leis et al. 2013). These results indicate that the preserve is meeting their structural heterogeneity goal. This pattern is also similar to our analysis of fuel load and time since burn in that years two and three since burn were similar.

The evaluation of objectives concerning the improvement of nesting bird habitat, control of woody and undesirable vegetation, and increasing native plant diversity will be addressed in HTLN project reports (Goal 1, see Burn Unit Goals). The most recent plant community report (James 2011) indicated a positive trend towards increased structural heterogeneity and consistent community level diversity (beta diversity). Conducting prescribed burns in this region, with its unique cultural legacy of landscape-style burning and grazing, also satisfies management objectives of controlling woody vegetation, removing old growth thatch, and promoting re-growth of native warm season plants (Goal 2, see Burn Unit Goals; James 2011).

Although the fall burn was motivated by the upcoming symphony, there are ecological benefits to burning at different times of year. A recent study corroborates findings from past work that indicates seasonal fire variation can result in subtle shifts in the plant community - particularly, sedges and cool season grasses, and spring forbs, which may benefit from burning in different seasons (Coppedge and Shaw 1998, Coppedge, et al. 1998, Towne and Craine 2014). For a thorough discussion of vegetation effects resulting from changing season of burn in tallgrass prairie, see a blog post by Leis 2014. Adjusting burn schedules to include burns throughout the year can benefit the grassland community and take advantage of personnel availability outside the spring period.

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Appendix A. Pre- and post-burn photographs at Tallgrass Prairie National Preserve taken in spring 2014.

Figure 9. SW Windmill, Tallgrass Prairie National Preserve, Kansas, 25 March 2014 Pre-burn Site 53 AS-AF.

Figure 10. SW Windmill, Tallgrass Prairie National Preserve, Kansas, 24 April 2014 Post-burn Site 53 AS-AF.

Figure 11. East Traps, Tallgrass Prairie National Preserve, Kansas, 25 March 2014 Pre-burn Site VF237 AS-AF.

Figure 12. East Traps, Tallgrass Prairie National Preserve, Kansas, 23 April 2014 Post-burn Site VF237 AS-AF.

Figure 13. East Trap, Tallgrass Prairie National Preserve, Kansas, 25 March 2014 Pre-burn Site VF227 AS-AF.

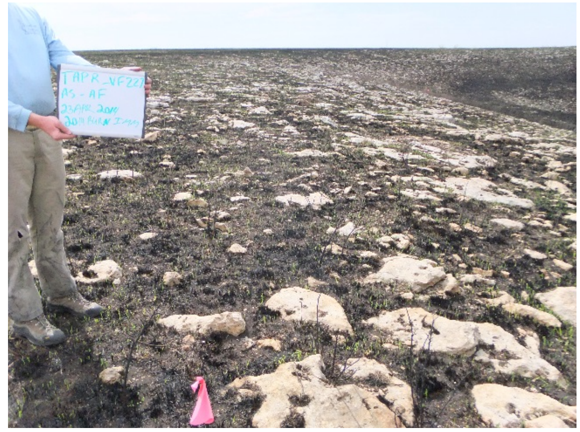

Figure 14. East Trap, Tallgrass Prairie National Preserve, Kansas, 23 April 2014 Post-burn Site VF227 AS-AF

Figure 15. Big Pasture-North, Tallgrass Prairie National Preserve, Kansas, 24 March 2014 Pre-burn Site 71 AS-AF.

Figure 16. Big Pasture-North, Tallgrass Prairie National Preserve, Kansas, 23 April 2014 Post-burn Site 71 AS-AF.

Appendix B. Pre- and post-burn photographs at Tallgrass Prairie National Preserve taken in fall 2014.

Figure 17. NE Windmill, Tallgrass Prairie National Preserve, Kansas, 1 October 2014 Pre-burn Site 52 BS-BF.

Figure 18. NE Windmill, Tallgrass Prairie National Preserve, Kansas, 17 October 2014 Post-burn Site 52 BS-BF.

Figure 19. NE Windmill, Tallgrass Prairie National Preserve, Kansas, 1 October 2014 Pre-burn Site 62 BS-BF.

Figure 20. NE Windmill, Tallgrass Prairie National Preserve, Kansas, 17 October 2014 Post-burn Site 62 BS-BF.

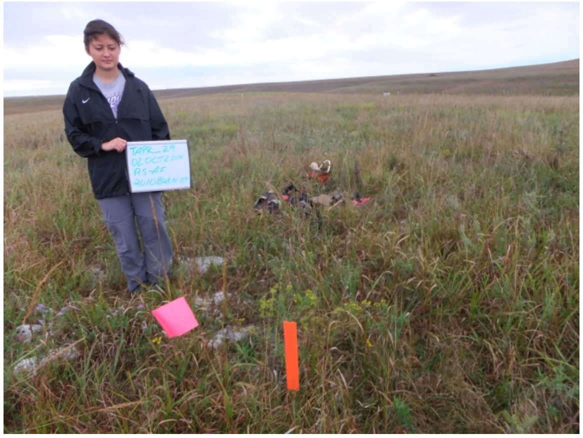

Figure 21. Big Pasture-South, Tallgrass Prairie National Preserve, Kansas, 2 October 2014 Pre-burn Site 29 AS-AF.

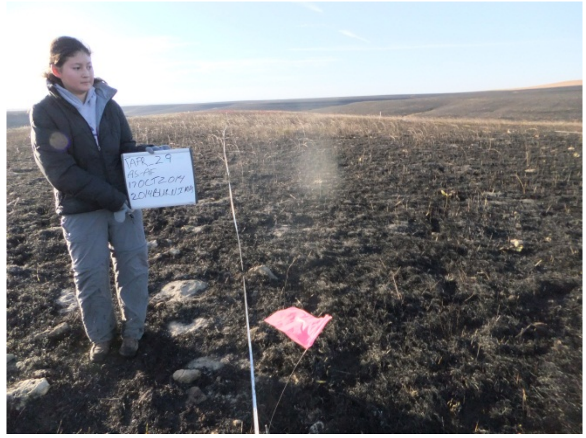

Figure 22. Big Pasture-South, Tallgrass Prairie National Preserve, Kansas, 17 October 2014 Post-burn Site 29 AS-AF.

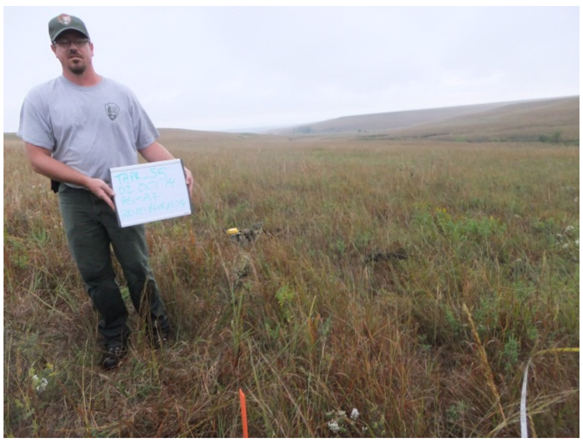

Figure 23. Big Pasture-South, Tallgrass Prairie National Preserve, Kansas, 2 October 2014 Pre-burn Site 55 AS-AF.

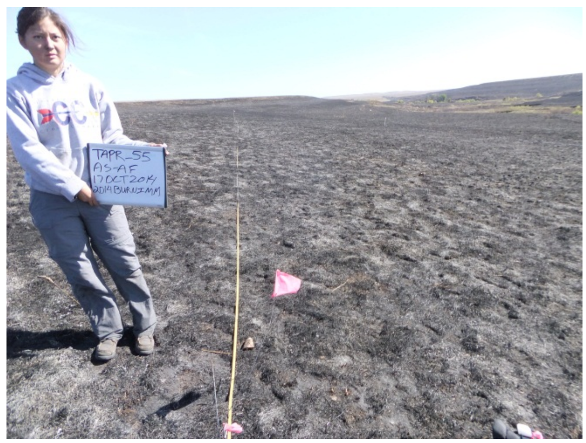

Figure 24. Big Pasture-South, Tallgrass Prairie National Preserve, Kansas, 17 October 2014 Post-burn Site 55 AS-AF.

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1201 Oakridge Drive, Suite 150
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