National Park Service
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Natural Resource Stewardship and Science

Prescribed Fire Monitoring Report

George Washington Carver National Monument, 2014 (NFPORS ID 3327768, -69, -63, -64)

Natural Resource Data Series NPS/HTLN/NRDS—2014/708



ON THE COVER
Prescribed fire operations at GWCA, March 2014
Photograph by: Sherry Leis, Fire Ecologist filed in the HTLN archives.

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Natural Resource Data Series NPS/HTLN/NRDS—2014/708

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Thanks to Adam Throckmorton for field support and GWCA staff for access to the park.

List of Acronyms

Term	Definition
AAR	After-action review
ATV	All-terrain vehicle
FEMO	Fire Effects Monitor
FL	Flame length
FZD	Flame zone depth
GWCA	George Washington Carver National Monument
HTLN	Heartland Inventory and Monitoring Network
MDC	Missouri Department of Conservation
NPS	National Park Service
RH	Relative humidity
ROS	Rate of spread
Stdev	Standard deviation
UTV	Universal terrain vehicle

Burn Operations Summary

All prairie burn units, (north block units: 1, 2, 7 and south block units: 3, 4, 5, 6) at George Washington Carver National Monument (GWCA) were burned on April 5, 2014 (Figure 1). Aaren Nellen led operations as burn boss trainee. The north block was last burned in 2011 and the south block in 2012. The fire management goal was to burn each block every second year to reduce invasive woody plants and enhance native grassland species.

Operations began with a briefing. Crews then proceeded to the test fire ignition site in the southwest corner of unit 2. A ring fire technique (fire is ignited on the downwind side of the unit and two crews progress in opposite directions towards the upwind or head of the fire) was most frequently used for ignition with modifications such as stripping and internal ignition as needed. The north units were burned as a single perimeter. Some internal ignition was needed as a result of mowed lines and trails within the area. Next, units 3 and 6 were burned together. The strip of woods north of the cemetery was then burned, protecting the cemetery. Unit 4 was more challenging to burn. Crews were unaware of the lift station within the unit, but discovered it in time to protect it. Last, unit 5 was completed beginning in the northwest corner. Wind shifts became common and made holding challenging. Burning was completed about 1558 hrs and mop-up commenced. All units planned for the day were completed. Burning appeared more complete than in recent previous burns.

An after action review (AAR) yielded many helpful suggestions for improvement. Crews suggested upgrades to maps to include more information as well as making time for everyone to tour the burn units prior to ignition in the future. The lift station has been a challenge for burning over the past few years and a suggestion was made for the park to set up a sprinkler on the area for 24 hours prior to the burn. The moisture may prevent it from burning and crews could work from the unit perimeter more safely than the technical interior ignition needed to protect the equipment otherwise. Some challenges with communication were also noted. Combining crews onto a single channel was suggested. Also, planning to limit burning in a single day to half the prairie (north or south) was recommended. In terms of line preparation, raking or using a blower to reduce thatch would be helpful. The use of foam instead of water might also improve holding when fuels are dense and dry and the lines contain thatch.

Burn Unit Measurements

Date: 04/05/2014

Unit: North prairie burn block (units: 1, 2, 7) last burned in 2011; South prairie burn block (units: 3, 4, 5, 6) last burned in 2012.

Size: Planned acres = 143.01, Actual acres burned = 142.2

Vegetation type: Tallgrass prairie (fuel model 3)

Personnel: The local fire department was also on hand to monitor the burn in addition to the personnel listed below.

- Burn Boss: Lee Dueker, Burn Boss Trainee Aaren Nellen
- FEMO: Sherry Leis

- Ignitions: Line Boss Matt Koller
  Kenn Perreault, Erik Andreassen, Angela Sokolowski
- Holding: Line Boss, Matt Brickner
  Greg Carlson, Adam Throckmorton, Dan Drees, Chris Reed

- Public safety: five park staff alerted motorists of smoke hazards on the road.

Objectives The summary section will address how well the burn met these objectives. A new set of objectives was drafted in 2013, but the plan has not yet been updated. The objectives shown here are from the 2010 plan (Mier and Morey 2010).

Resource objectives:

1. Encourage growth of native species by 5 – 10%.
2. Control and diminish exotic species by 5 – 10%.

Prescribed fire objectives:

1. Reduce dead and down fuels (1 & 10 hour fuels) by 20 – 50%.
2. Reduce dead and down fuels (100 & 1000 hour fuels) by 1 – 5%.

Tolerable deviation of objectives:

Treat (blacken) 75 to 95% of individual burn units. A mosaic of fire intensity and severity is acceptable and desirable.

Table 1. Selected environmental prescription elements for fuel model 3 for George Washington Carver National Monument. The full prescription can be found in the prescribed fire plan (Mier and Morey 2010).

Variables	Acceptable	Preferred
Temperature (°F)	20-100	70
Relative Humidity	18-75	30
Wind direction	All	SW
Wind Speed (midflame, mph)	0-8	4
Fuel moisture (%) 1-hour	3-12	7
Fuel moisture (%) 10-hour	6-15	8
Live fuel moisture (%)	50-300	75

Table 2. Selected fire behavior prescription elements for fuel model 3 for George Washington Carver National Monument. The full prescription can be found in the prescribed fire plan (Mier and Morey 2010).

Variable	Cool	Hot	Desired
Rate of spread (ch/hr)	28.1	291	82.8
Flame length (ft)	6.5	22.2	11.8
Probability of Ignition (%)	25	89	59

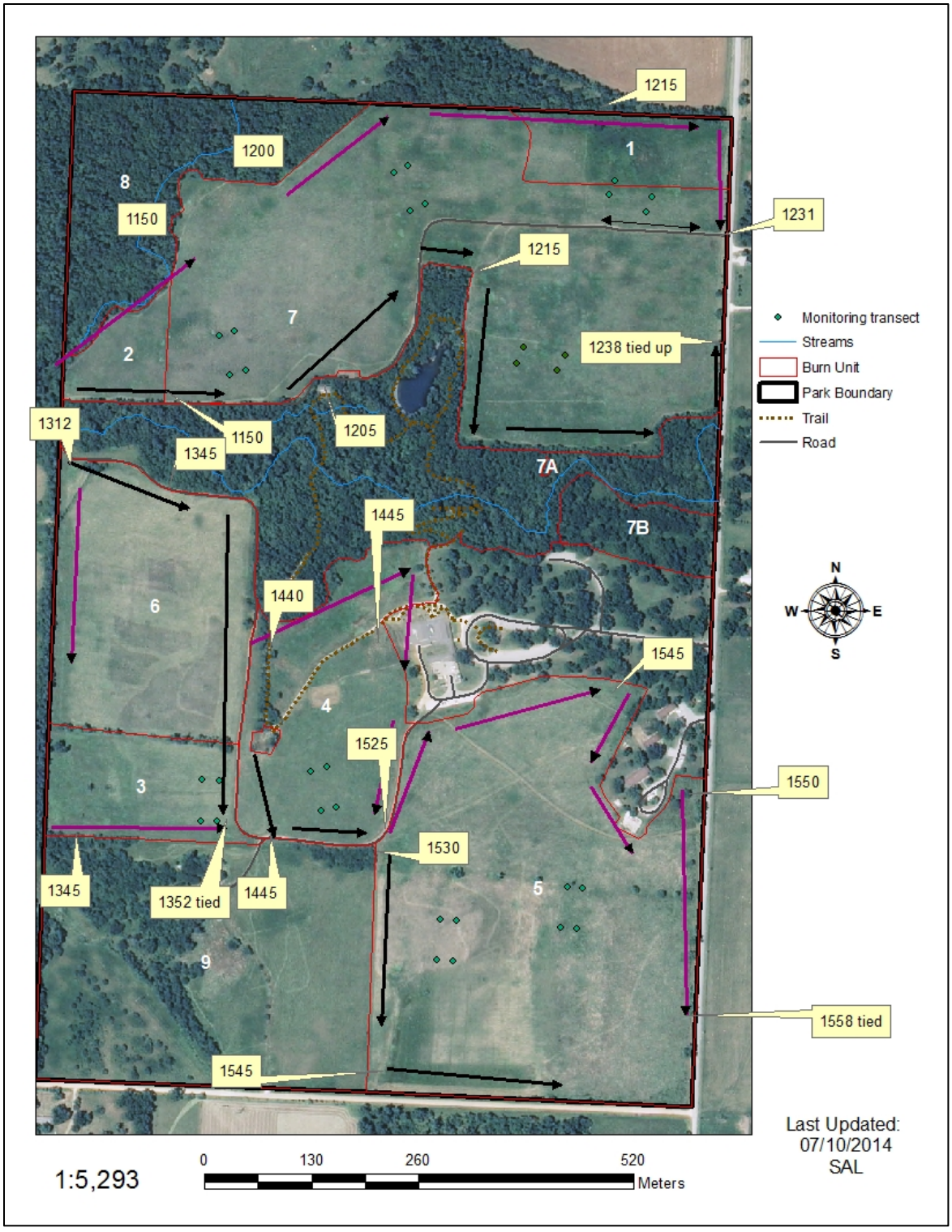


Figure 1. Map of operational progression through burn units at George Washington Carver National Monument on April 5, 2014. Burn units labeled in white were burned in the following order 2, 7, and 1 as a group, 6 and 3 as a group, 4, and lastly unit 5. Arrow colors indicate the direction of two crews progressing in a ring fire technique through each grouping of burn units. Time (24 hrs) of arrival are shown in the callout boxes.

Methods

This report will describe the fuel and environmental conditions present for the prescribed fire on April 5, 2014 as well as the operation and results. We will put these assessments in context of the stated goals of the prescribed fire plan as well as previously monitored burns. Sampling methods for fire ecology monitoring are described in detail in a published protocol available from the Heartland Inventory and Monitoring Unit (Leis et al. 2011). Monitoring sites were randomly distributed in burn units so that the north prairie and south prairie could be analyzed individually (Figure 1). Monitoring is conducted only within burn units planned to be burned in a given year.

Pre-burn fuel load and photopoint monitoring was conducted March 11, 2014. This included seven vegetation monitoring sites and one virtual site (VegMon sites 1-7 and vf 19). Fuel and soil moisture monitoring were completed the morning of the burn, but site 19 was not sampled due to time contraints. Soil moisture was measured with a meter to avoid destructive sampling techniques. Burn day weather (including temperature, humidity, wind, calculated fuel moisture and probability of ignition) as well as fire and smoke behavior measurements were collected by Sherry Leis. Fire intensity was converted to BTU/ft/s for ease of communication.

Fire management at GWCA has focused on burning either the north or south prairie burn units together as blocks since 2000. In 2006, the current burn frequency of burning half of the prairie (either north or south) every year, a two year return interval, was implemented. The goal of this rapid fire return interval was reduction of woody plant encroachment. Summaries and analyses in this report were done to understand if the fire history resulted in differences between the two blocks. This information is valuable for designing long term analyses.

Post-burn fire severity and photopoints were collected on April 8, 2014. Fire severity is measured using a categorical scale where 5 is unburned and 1 is severely burned (Leis et al. 2011). GPS collection of the burn unit perimeter was completed by HTLN staff. Minimum mapping units were set at 0.5-acre (SOP 3, Leis et al. 2011). Interior unburned patches were collected on foot using a Trimble Nomad GPS unit and archived in a geodatabase.

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

Statistical analyses were conducted using mean values for burn units. One way ANOVA was primarily used in addition to one instance of the Mann Whitney U test (Mann and Whitney 1947, Steel et al. 1997). SPSS statistical software (Version 20) was used for all analyses (IBM 2011).

Results

Fuel Load

Fuels were primarily dead as most plants had not yet initiated spring growth. Mean park fuel load (includes standing live, standing dead, as well as litter and duff) was 2.1 tons/acre (±0.6 standard deviation). Despite the difference in time since fire between the two burn blocks, mean fuel load did not significantly differ between the north (1.9±0.4) and south (2.4± 0.6) (one way ANOVA: df = 7, F = 2.66, P = 0.15). Fuel load has varied from 1.7 to 2.8 tons/acre since we began monitoring it in 2010, but there is a considerable amount of variation with standard deviations ranging from 0.4 - 0.8 tons/acre (Figure 2). The characteristics of the fuel are still similar to fuel model 3 on which the prescriptions have been based.

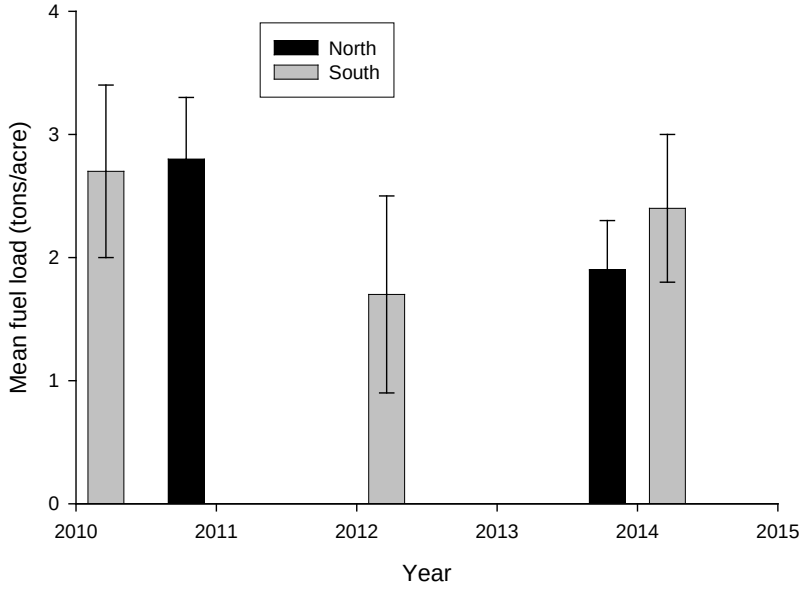


Figure 2. Comparison of mean fuel loading at George Washington Carver National Monument from 2010-2014. Error bars are standard deviation. Only locations that were planned to be burned were sampled in a given year.

Soil Moisture

Soil moisture is most likely to influence litter/duff moisture and moisture content of live fuel. Volumetric soil moisture of 50% is considered a saturated condition, while 25% is the field capacity for plant available water, and 10% indicates the permanent wilting point for plants. Soil moisture the day of the 2014 burn was moderate (30.5% ± 1.3) and greater than in 2012 when soil moisture measured 26.4% +/- 4.3. There was no significant difference between the north (31.8±1.6) and south (29.5±4.5) prairie soil moisture in 2014 (one way ANOVA: df = 6, F = 0.70, P = 0.44). Moisture readings in this range indicate that growing plants had adequate available water at the time of the burn. This level of soil moisture would require standing live fuels to be pre-heated and dried by fire

prior to combustion. Greater levels of soil moisture may also influence the duff or lower litter layer's moisture.

Fuel Moisture

Average one-hour fuel moisture of 58%±15.1 for standing fuels was much greater than the prescribed level of 7% (Table 1). Moisture of extinction of dead 1-hr fuels for fuel model 3 is considered to be 25% at which point fuels will need additional heat to ignite (National Wildland Coordinating Group 2006). The high level of moisture may have been a function of the timing of sampling rather than actual moisture at time of ignition. To complete sampling prior to ignition, we sampled while there was still some dew present on the fuels. Fine dry fuel moisture, as calculated on the fireline using standard tables the Fireline handbook (see Leis et al. 2011 SOP 9) was quite a bit lower, 10-14 %, which is in line with the prescription (Table 4). North prairie fuel moisture (46.0%±15.3) was less than in the south (67%±6.7), possibly due to sampling the north sites last giving them more time to dry (one-way ANOVA: df= 6, F= 6.273, P = 0.05).

Weather Observations

Table3. Weather observations collected during the prescribed fire at George Washington Carver National Monument on April 8, 2014. Windspeed values in () are maximum gust speeds.

		Temperature				Wind		Fine dead fuel moisture	Prob. Of Ignition
Time	Location	Dry	Wet	Dew Point	RH	Speed	Direction	(Unshaded) %	%
1009	South gravel pile	47	41	34	60	(9) 3	S/SE	14	10
1130	Ignition	56	46	35	46	(3) 1	E/SE	12	20
1230	N Line between plots 6 and 7	58	46	33	39	(6) 1	E	11	20
1320	NW corner by ignition	56	45	33	41	(5) 3	E/SE	11	20
1430	N Line of Unit 3	59	45	28	31	(6) 2	SE/E	10	30
1530	S end of Unit 3	57	45	31	37	(11) 4	E/SE	10	30

Weather parameters fell within the prescription (Table 1, 3). Although small amounts of precipitation (<0.1 cm) fell three times in the previous two weeks, the most recent sizable precipitation occurred 21 days prior to the burn (1.2 cm on 3/17; NOAA 2014). Precipitation was slightly above the 30-year average for the month of March (2014:4.5 cm (1.8 in), normal: 3.6 cm (1.4 in); NOAA 2014). Winds were primarily lighter than preferred, but acceptable. Probability of ignition calculations were primarily less than the cool fire intensity designation in the prescribed fire plan and all fell well below the desired range.

Smoke Observations

Smoke dispersal was adequate for avoiding hazards in the surrounding community (Table 4). Onsite, smoke was a challenge for holding crews along the west side of burn units 3 and 6 as well as along the west side of unit 5. At those points the smoke was heavy along the fireline decreasing visibility.

Table 4. Smoke observations collected during the prescribed fire at George Washington Carver National Monument on April 8, 2014.

Time	Location	Elevation of smoke column	Smoke column direction	Smoke column description
1140	W of house	Dispersed high	N	well dispersed north of unit
1205	W of house by plot 5	Shear off high	NW	
1345	SW corner of Unit 2	Layer dispersing	W	
1445	SW corner of Unit 3	200m	W	smoke both black and white
1435	SW side of Unit 4	200m	W	wind holding smoke down for first 50m

Fire Behavior

Mean rate of spread (ROS) and flame lengths (FL) even for head fires were below the upper limit of the cool range of 28.1 ch/hr and 6.5 ft., respectively (Table 2). Burns in 2011 and 2012 were also in this range. Fire behavior has been variable between fire types and years, but generally in the cool range of the prescription (Figure 3, 4).

Table 5. Fire behavior. 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)
1150	Unit 2, SW corner	Back	1.8	1.5	2.0	1	346.7
1205	Unit 7, South of site 5	Head	16.4	4	5	3	2166.7
1215	Unit 7, North of site 6	Back	1.8	2	1	1	86.7
1230	East line, unit 7	Head	8.2	6	5	4	2166.7
1345	West line 6	Back	0.9	1.5	1	1	86.7
1350	SW unit 3	Flank	22.7	2.5	2	1	346.7
1445	Unit 4, trail north of cemetery	Back	1.8	6	1	2	86.7
1525	Near site 3, unit 4	Head	8.2	7	6	3	3120.1
1535	Northwest side of unit 5	Back	2.3	1	1	2	86.7
1600	East side of unit 5	Head	10.9	6	5	40	2166.7
Mean Head			**10.9**	**5.8**	**5.3**	**12.5**	**2405.1**
Mean Back			**1.7**	**2.2**	**1.2**	**1.4**	**138.7**

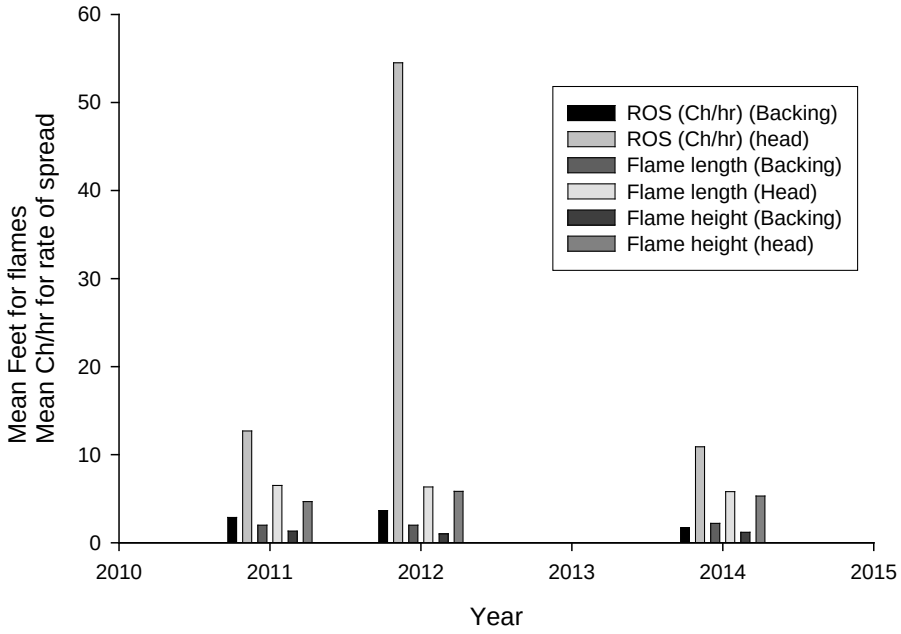


Figure 3. Comparison of rate of spread (ROS), flame length, and flame height of backing and head fires from 2011-2014 (no fires in 2013) during prescribed fires in George Washington Carver National Monument.).

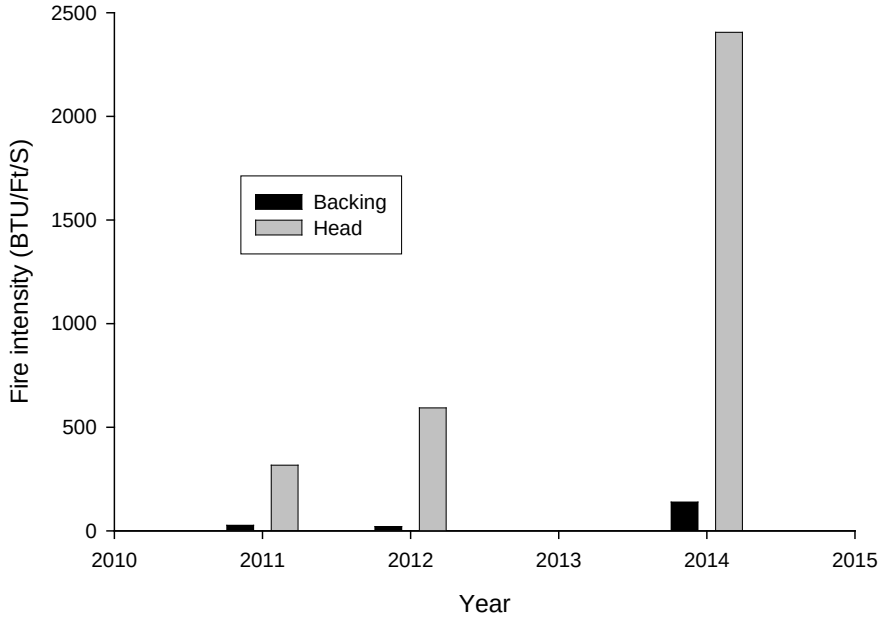


Figure 4. Comparison of backing and head fire intensity during prescribed burns in George Washington Carver National Monument from 2011-2014. There were no fires in 2013.

Fire Severity

Overall, fire severity based on assessment of the standing fuels, was moderate (mean = 2.4 ± 0.3) while fire severity based on substrate fuels (i.e., litter, duff, and soil surface layers) was much closer to the light range (mean = 2.9 ± 0.3). Severity classes are the following: 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 in. 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. Fire severity was very similar across the whole prairie. Severity was also not significantly different in north (2.56±0.22 for standing vegetation; 3.06±0.11 for substrate) and south (2.18±0.32 for standing vegetation; 2.80±0.43 for substrate) prairie blocks (as calculated by a Mann Whitney U test (P = 0.11 vegetation, P = 0.34 substrate). Soil moisture may have contributed to greater moisture of substrate fuels resulting in the lower severity on substrate fuels. Additionally, quickly moving fire will not consume as much fuel as a slow moving fire might.

Fuel reduction

Substrate fuels across the park were reduced by 48% and standing vegetation fuels were reduced by about 86%. Reduction of one-hour fuels exceeded the goal of 20-50% for standing fuels, while substrate fuel reduction was within the expected range. These values are very similar to the 2012 burn (88% standing vegetation, 44% substrate). Fuel reduction was inferred by calculating proportions of data in fire severity classes (see methods). 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.

Burn Extent

The burn units burned completely with only a few isolated locations remaining unburned (Figure 5). The goal of blackening 75-95% of the burn units was met with 142.2 acres (94.2%) of the area burned.

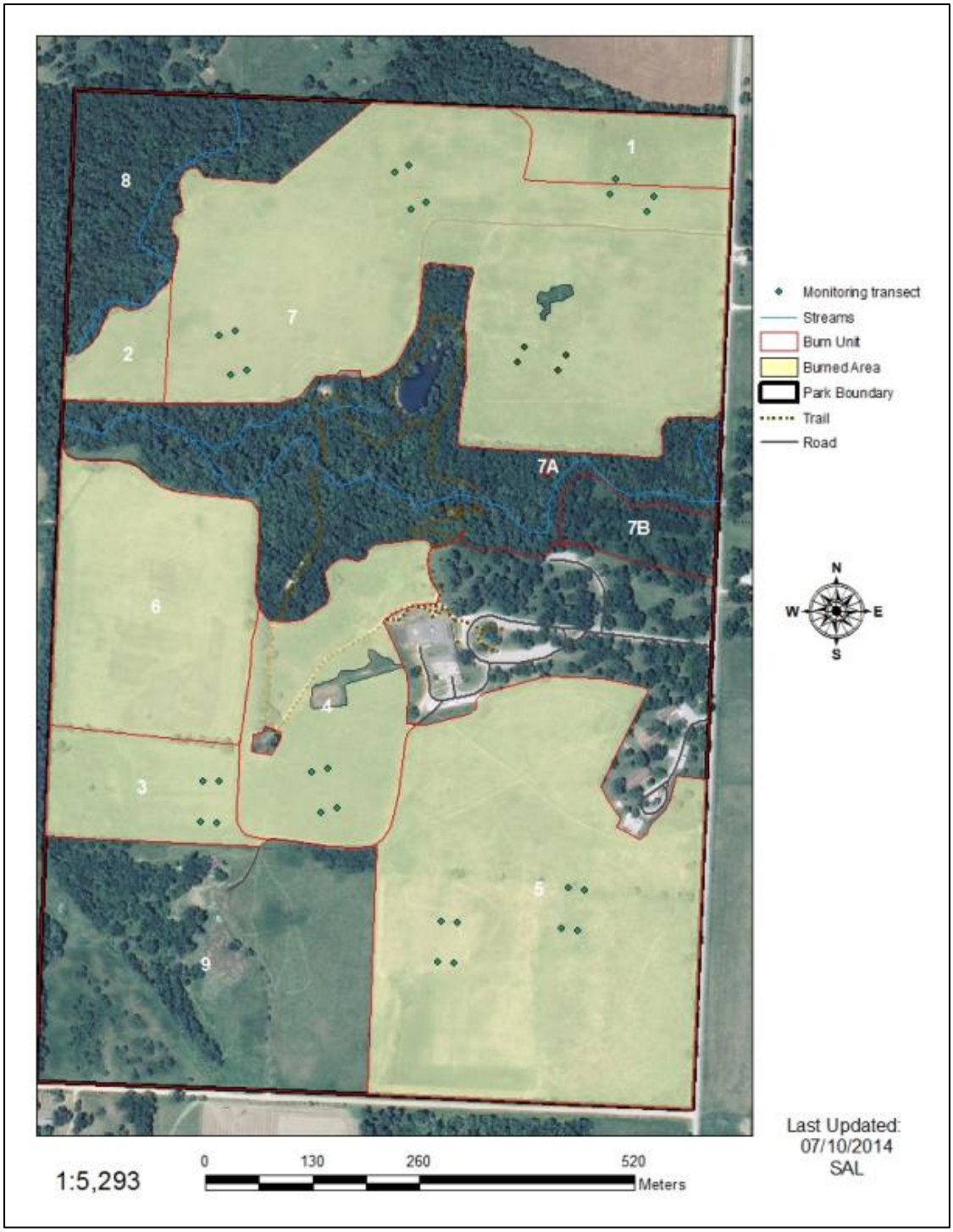


Figure 5. Area burned April 5, 2014 and monitoring sites at George Washington Carver National Monument. Data were collected with a Trimble Nomad GPS unit.

Summary

Fire effects monitoring is designed to evaluate whether a prescribed fire met the goals and objectives established in the Fire Management Plan, and more specifically the prescribed fire plan. This report also attempts to put the monitoring data in context of previous burns. Adaptive management can then be implemented using sound data and analysis (National Park Service 2008). Long-term "fire-centric" analysis will later look for trends and relationships of fire to vegetation goals.

The prescribed fire in both the north and south portions of the prairie at GWCA was successful in that firefighter and public safety were preserved. Weather along with ignition techniques allowed for good smoke dispersal and little impact on visitors or motorists.

Based on our post-burn mapping, the objective to blacken 75-95% of the burn units was met with 94.2% of the area burned. The prairie has been more completely burned with each successive burn since 2010 (84%, 92.4%, in 2010 and 2011, respectively; Cole 2010, Leis 2012). Decreasing amounts of shrubs may be a contributing factor to burn completeness as well as the reduction in mowing treatments at the park. Both of these management treatments are likely to contribute to continuity of combustible fuels, but the variability in our data mask any potential trends in fuel loads. Furthermore, fire intensity did vary throughout the burns depending on the timing of wind gusts and point in the ignitions process. This variability may be reflected in the plant community in that plants in areas with greater severity are more likely to be top-killed (Bragg and Hulbert 1976, Briggs et al. 2005), or some seeds require heating for germination and may be differentially affected (Collins and Gibson 1990, Rohn and Bragg 1989), for example.

Prescribed fire objectives focused on fuel reduction. Fuel loads did not differ between the north and south prairies, despite a longer time since fire in the north (north- 3years, south- 2 years). The direct reason for this is not known, but may be related to drought conditions. The goal of reducing 1- and 10-hour fuels by 20-50% was met for substrate fuels (48%) and surpassed for standing fuels (86%). These reduction percentages are estimates based on the severity data and should be applied with caution. No 100- or 1000-hr fuels were measured in the monitoring sites.

Precipitation influences soil and fuel moisture which in turn is reflected in fire behavior and severity. Moisture of extinction for one hour fuels is 25% (Simard 1968 in Miller 1994) and the calculated mean fuel moisture (Table 4) for the 2014 burn was well below that point. Collected fuel moisture samples (Table 3) were likely in error as they were taken early in the day with dew still on the vegetation. Calculated fuel moistures may be more accurate for the operational period especially since little live fuel was available.

Objectives also included increasing native species richness and reduction of exotic species. In 2012, there was a decline in plant species richness of the prairie (HTLN unpublished data). Although the cause of this decline is difficult to determine, the region experienced drought in the 2-3 previous years which may have contributed to the decline (Tilman and Haddi 1992).

It is hoped that greater fire intensity will provide greater control of invasive species (e.g. smooth sumac, tall fescue) than a less intense fire. The fire intensity values are an indication of the energy produced (heat over time) in a given location. Fire severity is a manifestation of the fire's ability to consume fuel components. Average fire severity was moderate, but the variation observed in fire intensity was also reflected in the severity measurements. The 2014 fire had very similar behavior characteristics to the 2012 fire overall, so we may expect similar results on the vegetation barring differences in precipitation. Later analysis of fire effects will aid in the understanding of long-term vegetation trends with respect to prescribed fire management.

Because monitoring is completed on units planned to be burned each year, the dataset is focused in a given year on half of the prairie. Since we burned the entire prairie this year, it was an opportunity to evaluate whether any differences in fuels or fire characteristics differed between the two burn blocks. Although I expected a difference in fuel load given that the north prairie had more time to accumulate fuel, the only difference we measured was that of fuel moisture. Fuel moisture in 1-hr fuels is dependent on two weather parameters, air temperature and relative humidity, that change rapidly as the morning progresses in the Missouri springtime. As monitoring progressed, fuels were rapidly drying and our sampling pattern from south to north is likely the source of difference in fuel moisture. Future analyses can look at the prairie as a whole. The similarity in the two burn blocks will allow each burn block to represent the prairie as a whole in future analyses.

Although not all the objectives stated in the prescribed fire plan (Mier and Morey 2010) can be evaluated with the data presented in this report, additional monitoring of plant communities by HTLN ecologists will address the status and trends of plant communities at GWCA (e.g., number of native and exotic species). The HTLN vegetation and invasive species monitoring programs will address native plant and exotic plant abundances during scheduled monitoring in 2016. Additionally, the fire ecology program will assess the success of reducing woody shrubs and trees in the prairie with a separate report.

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Appendix Selected Sample Site Photographs



Figure 6. Pre-burn site 1 AS-AF.

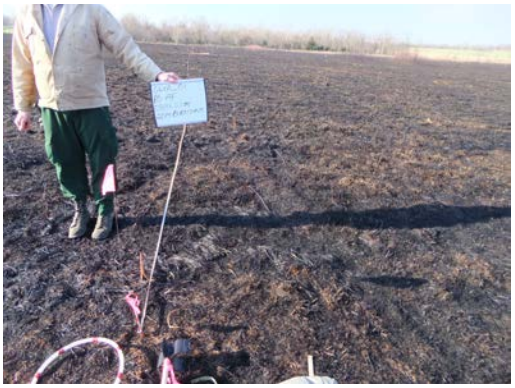


Figure 7. Post-burn site 1 AS-AF.



Figure 8. Pre-burn site 2 AS-AF.



Figure 9. Post-burn site 2 AS-AF.



Figure 10. Pre-burn site 3 AS-AF.



Figure 11. Post-burn site 3 AS-AF.



Figure 12. Pre-burn site VF 19 AS-AF.



Figure 13. Post-burn site VF19 AS-AF.

A.  B. 

Figure 14. Fire behavior was mixed with both A. low intensity, and B. higher intensity occurring across the prairie.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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