National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

George Washington Carver National Monument Woody Plant Monitoring Status Report

Natural Resource Data Series NPS/HTLN/NRDS—2015/776



ON THE COVER
Burned shrub base after the 2014 spring burn at George Washington Carver National Monument.
Photograph by: Sherry Leis.

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U.S. Department of the Interior
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Natural Resource Stewardship and Science
Fort Collins, Colorado

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

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Acknowledgments

Thanks to staff at George Washington Carver NM for access to the park. Also thanks to Craig Young for feedback on the project and L. Morrison for statistical support. Robin Graham and David Londe were excellent field staff.

Introduction

Concern over increases in woody plant encroachment at George Washington Carver National Monument (GWCA) led to targeted monitoring to supplement the data collected by the Heartland Inventory and Monitoring Network's (HTLN) plant community monitoring. This new monitoring aimed to understand the change in woody plant abundances with respect to the combination of fire and herbicide management actions. In 2009, a baseline plant community survey measured woody plant guild cover at 23.8% (±18.0 sd) (James and Rowell 2009). In response to this high level of woody plants, the prescribed fire interval was decreased to 2 years from ≥3 years, with half the prairie being treated in a given year. The network exotic plant management team also increased chemical treatment of invasive woody and exotic plant species at the monument. While long-term monitoring provides an understanding of the status and trends, it is not designed to understand treatment effects, such as from burning. Monitoring timed around the burn treatments and spatially distributed across the areas being treated was needed to evaluate whether target species were being reduced by the fire and herbicide treatments.

I implemented additional monitoring of trees and shrubs in the north prairie units to directly assess the effectiveness of these management treatments. Monitoring was implemented first in the north prairie units (2011) and the following year in the south prairie units (2012). This report describes changes to the target woody plants in the prairie at GWCA as compared to the initial belt transect surveys in both the north and south prairie units.

Methods

Belt transect locations were randomly chosen from points on the breeding bird monitoring grid (Peitz et al. 2008). Five transect locations were established in the north prairie (burn units 1, 2, 7) in 2011 and five transects were added in the south prairie (burn units 3, 4, 5, 6) in 2012 (Figure 1). Random points generated where any part of the transect was less than 5 m from a trail, road, or edge were not eligible and an alternative point was chosen. The azimuth of the transects (104º) was randomly chosen and applied to all transects. Because the belt transects are virtual rather than monumented on the ground, GPS error in placing the transects could result in slightly different areas being monitored from year to year. All live trees and shrubs were counted in a belt 100-m long and 6-m wide (total area per belt, 600 m^2), centered on the transect line. A ranging pole and flags were used to demarcate the belt transects into 10-m segments to facilitate data collection. In 2012 and 2014, pictures were taken at the start of each belt transect for visual comparison over time (Appendix A).

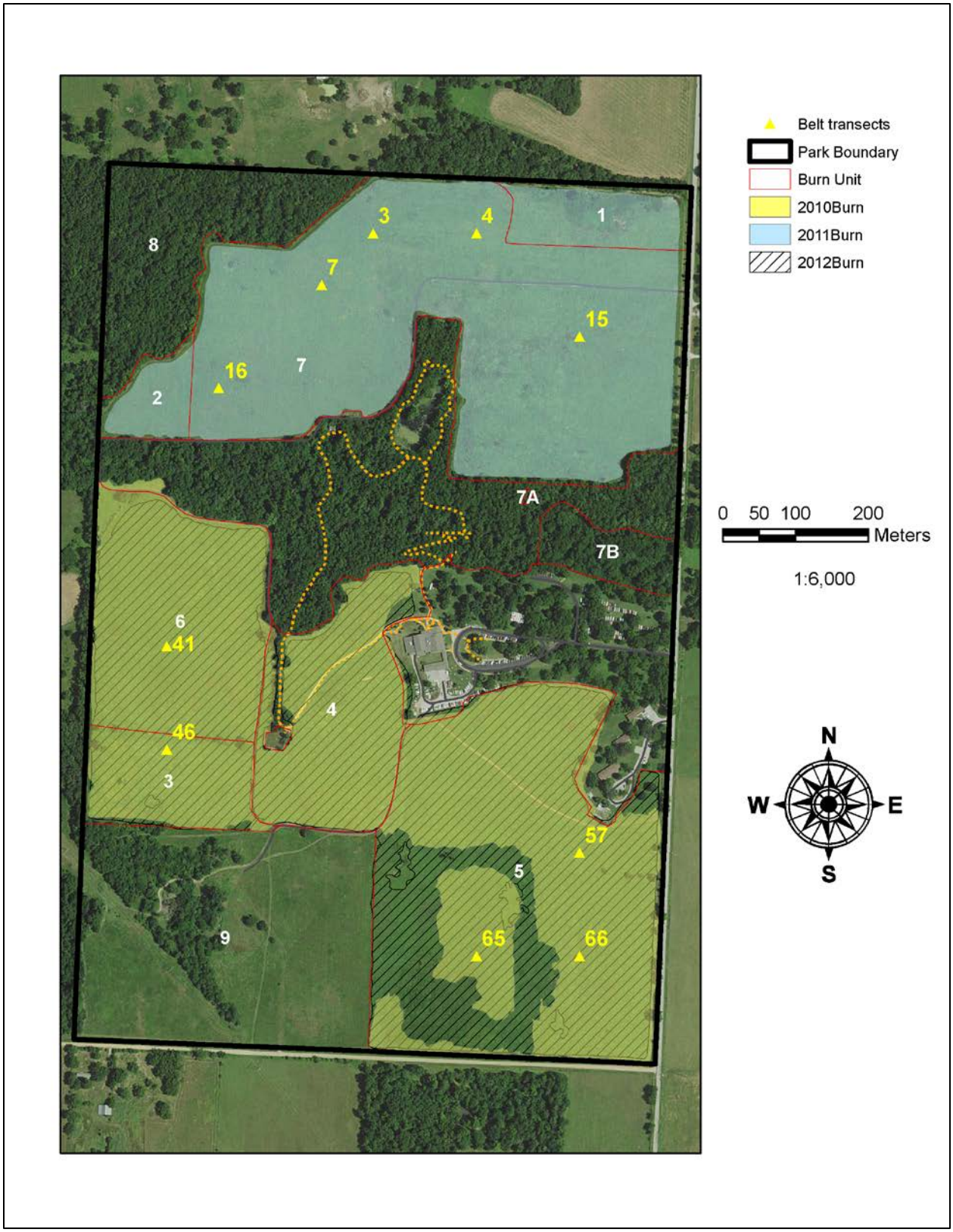


Figure 1. Belt transects and burn history 2010-2012 at George Washington Carver National Monument. No burns were conducted in 2013 and the whole park was burned in 2014.

Target species included all live trees and shrubs as designated in the VegMon database. Each woody stem was identified to species with the following exceptions: blackberries *(Rubus* spp.*),* elm *(Ulmus* spp.*),* hackberry (*Celtis* spp.*),* and hawthorn *(Crataegus* spp.*)* were lumped together by genus because identification at available life stages was unreliable. Stems were recorded by species and height class (0.1-1 m, 1-2 m, 2-3 m, 3-4 m, >4 m). Height classes were designed to provide a profile of the target plants in the prairie because treatments could reduce the stature without reducing stem densities.

Although not a tree or shrub, blackberries (*Rubus* spp.) were included because their fidelity to fire could lead to increases. Because of the volume of blackberry, stems were subsampled by counting *Rubus* spp. stems in a 2-m belt along the entire 100-m transect (200 m^2) and scaling up to 600m^2. The 2012 report describes a crosswalk method designed from an initial subsample method (Leis and Kopek 2012).

One motte of *Prunus Americana* (wild plum) and a bed of blackberry were also subsampled because of the difficulty in counting large dense stands accurately. The subsamples were scaled up to best represent populations along transects. Subsamping methods included counting stems in a smaller known area, 1 m^2 for example, and measuring the area to which to apply the subsample.

Two treatment types are being deployed in the prairie at GWCA (Figure 2). Herbicide treatments were conducted prior to the initial belt transect monitoring in both halves of the prairie. Belt transect monitoring occurred in mid-June of each year. Stems that appeared to be dying (e.g., brown and drying) as a result of herbicide treatments were not counted. Prescribed fires were conducted in the north prairie in August 2011 and April 2014. The south prairie was burned in April prior to the 2012 monitoring and again in April 2014 (Figure 2).

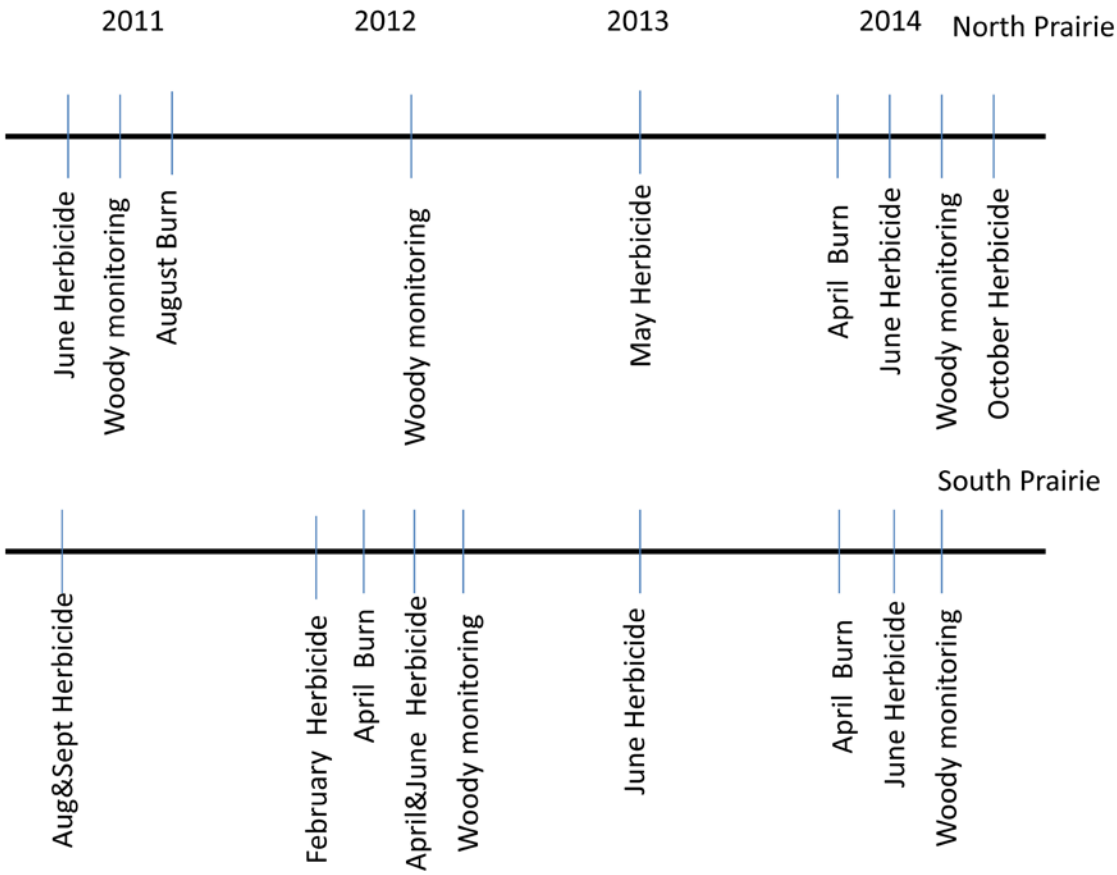


Figure 2. Timeline of treatments aimed at reducing woody plants at George Washington Carver National Monument with respect to targeted monitoring. Woody monitoring occurred mid-June where indicated.

To determine if stem abundances were reduced from initially monitored levels, data were log transformed, then assessed using a paired t-test (stem counts excluded blackberry). A one tailed test was used to evaluate the hypothesis that stems were reduced at an alpha of 0.05. We also assessed efficacy of the treatments through comparison of the absolute magnitude and percent change in stem densities by species.

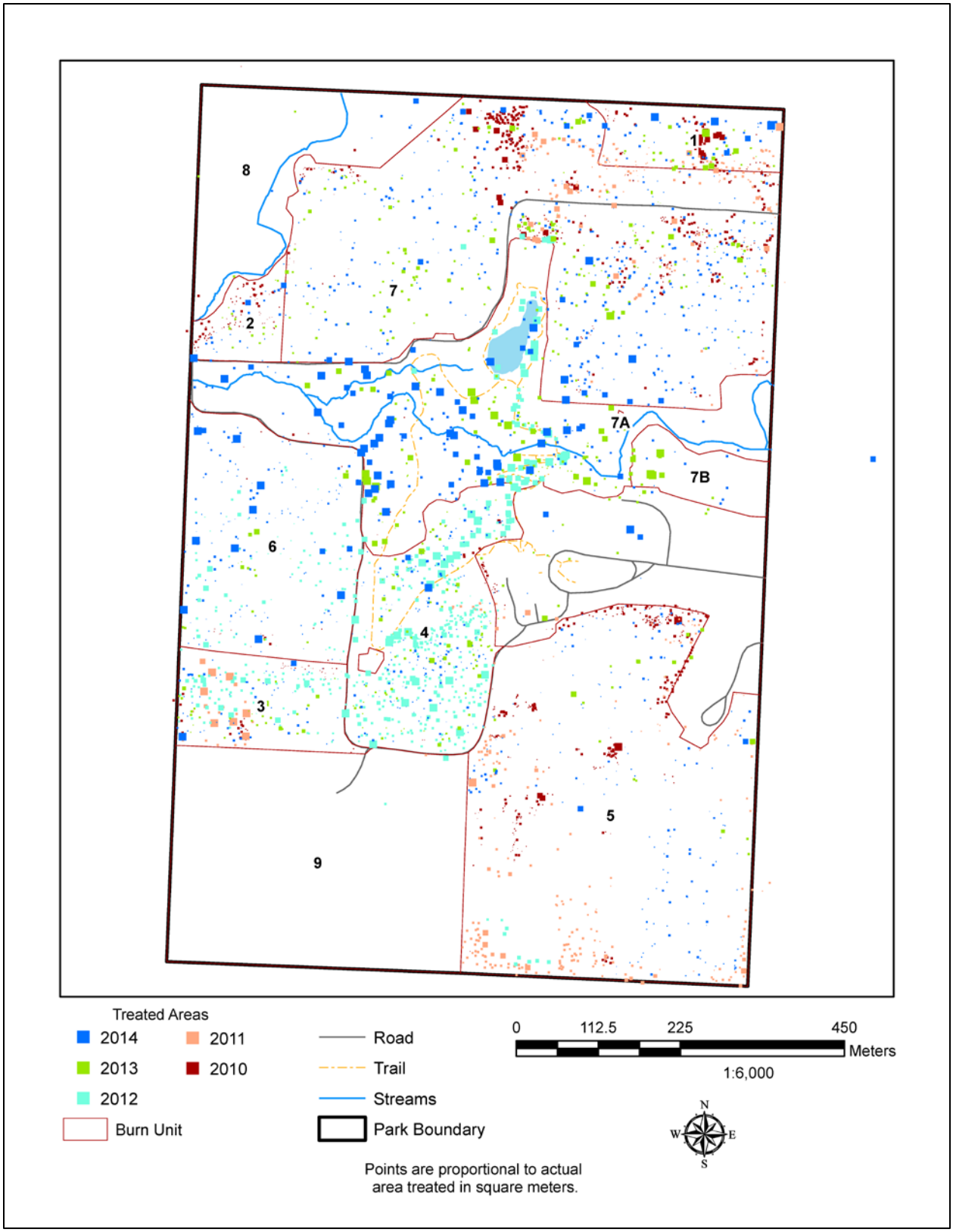


Figure 3. Exotic plant management treatment areas from 2010-2012 at George Washington Carver National Monument. Points are sized proportionally to number of square meters treated.

Results

Seventeen species were recorded in 2014, four more species than in 2012 (Table 1). The southern prairie had an increase in tree species that resulted from the siting of one transect closer to an old fence row than in previous years.

Table 1. Species recorded in belt transects in 2011-2014 at George Washington Carver National Monument. N-north prairie unit, S-south prairie unit.

Species	Common name	2011N	2012N	2012S	2014N	2014S
Campsis radicans	trumpet creeper			X		
Celtis spp	hackberry	X	X	X	X	X
Crataegus spp	hawthorn		X			X
Diosporos virginiana	persimmon	X	X	X	X	X
Fraxinus pennsylvanica	green ash	X	X	X	X	X
Gleditsia triacanthos	honey locust	X	X		X	X
Lonicera japonicus	Japanese honeysuckle			X		
Platanus occidentalis	sycamore	X	X		X	
Prunus americana	American plum	X	X	X	X	X
Prunus hortulana	hortulan plum					X
Rhus copalina	winged sumac	X	X	X	X	X
Rubus spp	blackberry	X	X	X	X	X
Sassafras albidum	sassafras		X			
Symporicarpos orbiculatus	coral berry	X	X	X	X	X
Ulmus spp	elm	X	X	X	X	X
Morus rubra	mulberry					X
Quercus macrocarpa	burr oak					X
Quercus muehlenbergiia	chinkapin oak					X
Quercus rubra	red oak					X
Prunus hortulaca	Mexican plum					X
Total		**10**	**13**	**10**	**10**	**15**

Following two prescribed fires and annual herbicide treatments (2011-2014), 7 woody plant species declined and 9 increased in number of stems for a net increase of 118.2% in the north prairie and 149% in the south (Table 2, 3). Five species found in 2014 were not recorded previously. The abundance of blackberry and wild plum stems drove the total stem increase (Figure 6). Excluding blackberry from the analysis, there was a 60.5% decline in northern woody stems and an 84.2% increase in the south. The southern increase was driven in large part by expansion of wild plum mottes (1015% increase in *Prunus Americana* over 2012 counts).

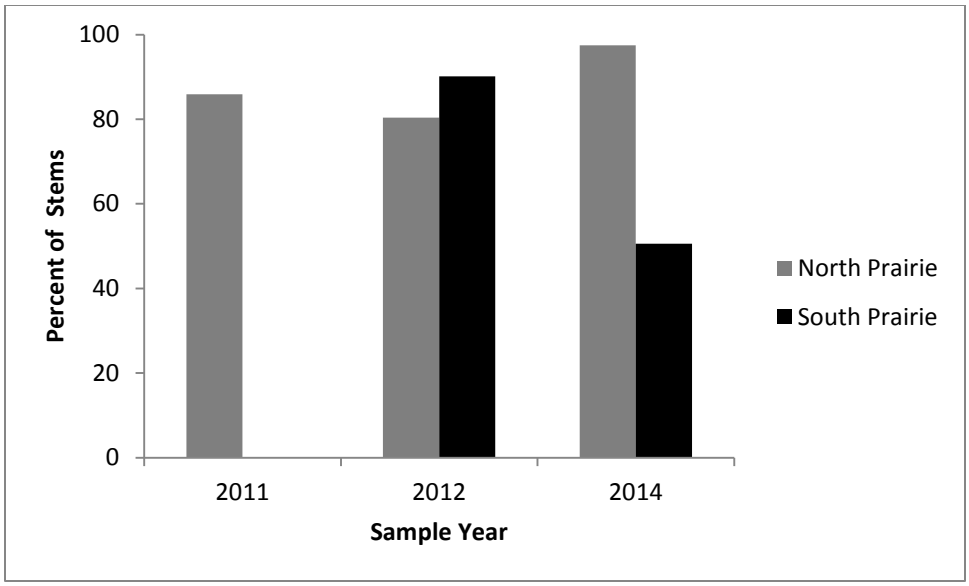


Figure 4. Percent of all stems counted during woody plant monitoring at George Washington Carver National Monument that were *Rubus* spp. (blackberry).

To evaluate changes in woody stems over time, 2014 levels were compared to initial stem counts (North units—2011 and South units—2012). The decline in stem densities in the northern prairie was marginally significantly lower ($t = 2.12$, $df = 4$, $P = 0.051$) compared to 2011 levels, but there was no significant reduction from 2012 levels in the southern prairie ($t = 0.55$, $df = 4$, $P = 0.3$; Figure 5). To further understand species specific changes in stem counts, we calculated percent change of stems by species (Figure 6, Table 2 and Table 3).

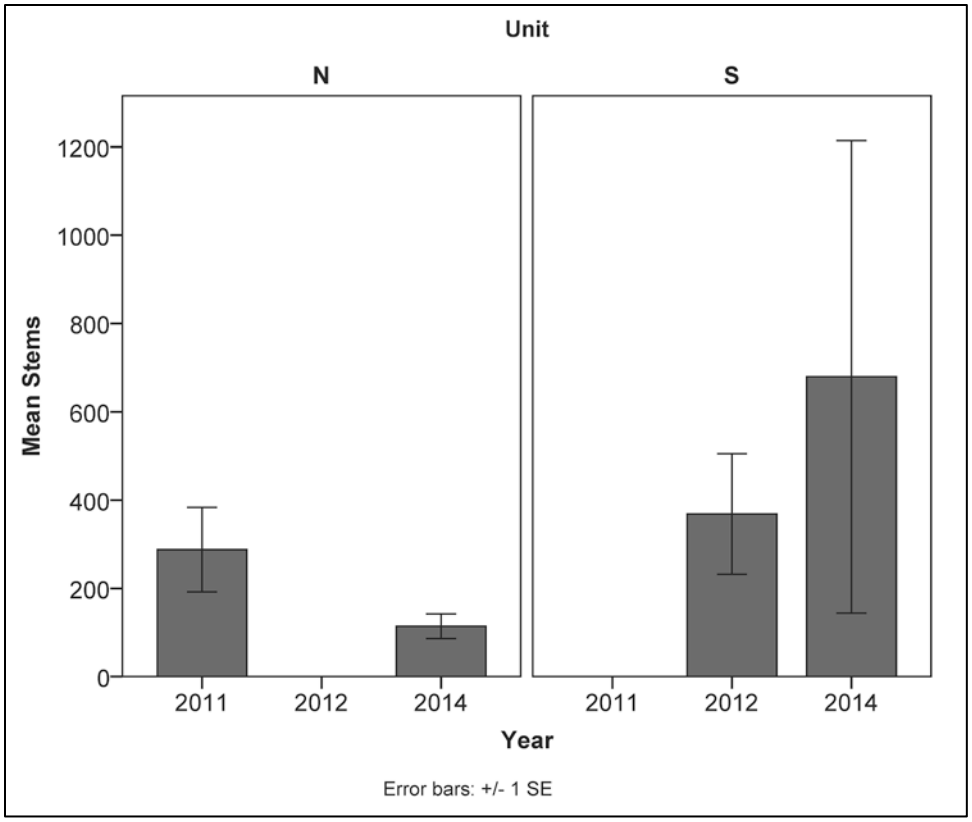


Figure 5. Mean number of stems per 600 m^2 transect in both prairie units. Error bars are ±1 SE.

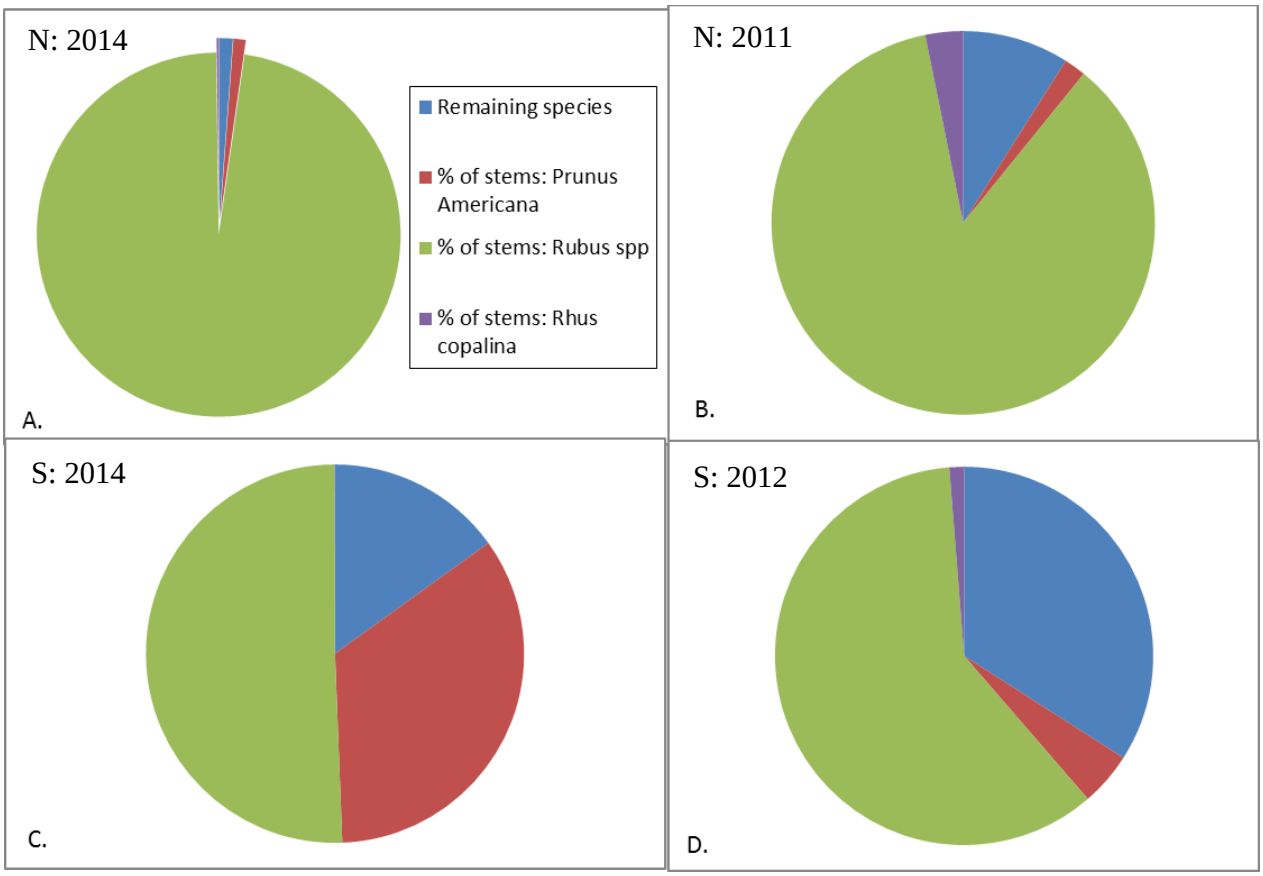


Figure 6. The proportion of all stems that were of three focal species (wild plum, blackberry, and winged sumac) and all the remaining species in the northern prairie in 2014 (A), and in 2011 (B). Stems in the southern prairie in 2014 (C) versus 2012 (D). (*Rhus copalina* was reduced <1% and is not visible in graphs A and C.)

At the start of the project, both invasive native and exotic species were targeted. In particular interest to this analysis, winged sumac was targeted. Although plum species were not initially part of the suite of focal species, they have increased across the prairie, but especially in the south (Figure 6C, D, Table 3). Although we tracked blackberry stems, they were not on the target treatment list. In the northern prairie blackberry is a greater proportion of the stems assessed. This is the result of an increase in blackberry stems and a decrease in stems of other woody plants. In the southern prairie, blackberry is presently a smaller portion of the stems counted as a result of the increase in plum stems.

The treatments were successful at reducing the stature of the taller target plants. Overall stem height in the northern prairie was reduced from 93.4% of stems to 99.7% in class 0.1-1 m. In the southern prairie, there was an increase in the number of tall stems with 2012 reporting 99.2 of stems in class 1 while only 77.8% of all southern stems were in that class in 2014 (Table 2).

Table 2. Change in species stem counts between northern belts 2011-2014 at George Washington Carver NM. Negative values indicate a decline in number of stems. Counts reflect number of stems along five 600-m^2 transects, or 3,000 m^2 total area.

	Total Stems			Change in # of stems by height class			
Species	**2011**	**2014**	**% change in total stems**	**Stems 0.1-1m**	**Stems 1-2m**	**Stems 2-3 m**	**Stems 3-4m**
Celtis spp	11	2	-82	-11	0	0	0
Crategeous spp	0	0	0	0	0	0	0
Diosporos virginiana	32	28	-13	-4	-3	0	0
Fraxinus pennsylvanica	325	79	-76	288	-7	-8	-1
Gleditsia triacanthos	5	20	300	-4	0	0	0
Platinus occidentalis	35	5	-86	19	1	-2	0
Prunus americana	189	245	30	31	-30	0	0
Rhus copalina	327	50	-85	185	0	0	0
Rubus spp	8834	21849	147	13014	0	0	0
Symporiocarpos orbiculatus	145	41	-72	-104	0	0	0
Ulmus spp	370	99	-73	-272	1	0	0
Total gain/loss of stems		**12144**	**118**	**13145**	**-38**	**-10**	**-1**
Total gain/loss of stems excluding *Rubus* spp.		**-871**	**-60.5**	**128**	**-38**	**-10**	**-1**

Table 3. Change in species stem counts between southern belts 2012-2014 at George Washington Carver NM. Negative values indicate a decline in number of stems. Counts reflect number of stems along five 600 m^2 transects, or 3,000 m^2 total area.

	Total Stems			Change in # of stems by height class			
Species	**2012**	**2014**	**% change in total stems**	**Stems 0.1-1m**	**Stems 1-2m**	**Stems 2-3 m**	**Stems 3-4m**
Celtis spp	28	26	-7	-9	7	0	0
Crategeous spp	0	12		12	0	0	0
Diosporos virginiana	63	29	-57	-37	1	0	0
Fraxinus pennsylvanica	48	29	-40	-12	-7	0	0
Gleditsia triacanthos	0	4		0	4	0	0
Morus spp	0	1		0	0	0	1
Prunus americana	212	2365	1016	-181	-28	0	0
Prunus hortulaca	0	23		21	2	0	0
Quercus muhlenbergia	0	3		1	1	1	0
Quercus rubra	0	1		0	1	0	0
Quercus macrocarpa	0	4		4	0	0	0
Rhus copalina	58	3	-95	-58	4	0	0
Rubus spp	2778	3474	25	696	0	0	0
Symporiocarpos orbiculatus	398	305	-23	-397	1	1	0
Ulmus spp	916	591	-35	-326	1	0	0
Total gain/loss of stems		**2248**	**149**	**-286**	**-13**	**2**	**1**
Total gain/loss of stems excluding *Rubus* spp.		**1552**	**84**	**-982**	**-13**	**2**	**1**

Discussion

GWCA began aggressively treating invasive plants with fire and herbicide in 2011 (Figure 2). The recent Natural Resource Condition Assessment characterized desired levels for woody shrubs in the grassland at GWCA as generally <10% (Annis et al. 2011). In 2008, however, woody vines and shrubs were measured at 22.4% of the prairie plant community. Stature of target woody plants decreased from initially monitored levels in the northern prairie, but there was an increase in taller stems in the southern prairie. Over the period of treatments and monitoring, stems of some target woody plant species also declined in the prairie (e.g., hackberry, ash, and winged sumac). Noteable increases were seen in stems for *Rubus* spp. (blackberry) in the north and *Prunus Americana* (wild plum), especially in the south. Some new *Quercus* species (oak) were recorded in 2014, likely as a result of GPS or compass error in siting one of the southern transects.

Initially, winged sumac was of the greatest concern and the focus of treatments. In the most recent evaluation, this species was greatly reduced in both number and stature. The next vegetation community monitoring event will help us to understand what role the woody plants currently play with respect to other plant functional groups and the prairie as a whole.

Two species of *Prunus* were recorded in 2014. It is possible that both species were previously present and not recognized. Future analyses should include the total *Prunus* spp. count. *Prunus americana* stems increased in 2014 over the initial counts, especially in the southern prairie units.

Although blackberry species were not targeted for treatment, we tracked their abundance. Species of blackberry exhibit a variable response to fire (Whitney 1986, Hruska and Ebinger 1995, Harrington and Kathol 2009). Germination has not been shown to be improved by fire, so increases are most likely driven by vegetative growth (Cain and Shelton 2003). Thus, is possible that the increase in blackberry is the result of the frequent fire return interval. In the event that the park chooses to reduce the fire interval, blackberry abundance may decline as well.

Fire conditions have been described in the fire event monitoring reports, but in general have been similar across burns (Leis and Kopek 2011, Leis 2014). Fire severity in both 2014 and 2013 was moderate for standing fuels and light for substrate fuels. Fuel loads and fire behavior were also similar across monitored years. Burns have been conducted primarily in the spring, but a late summer burn occurred in August 2011.

Progress has been made towards reducing abundance of some of the target woody plants in the GWCA prairie. Analysis of future vegetation monitoring data will help to inform managers as to their progress relative to desired conditions for the prairie (Annis et al. 2011). More specifically, mangers may look at the species that increased over the monitoring period and decide whether additional or continued actions are needed (Table 2, 3).

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Appendix A

2012 and 2014 images are juxtaposed from select woody plant monitoring transects at GWCA. Photographs were only taken in 2012 and 2014.



Figure 7. Transect 3 in the north prairie, 2012.



Figure 8. Site 3. North prairie 2014. *Rubus* spp. was subsampled because of density along this transect. It formed a solid mat for 20 meters.

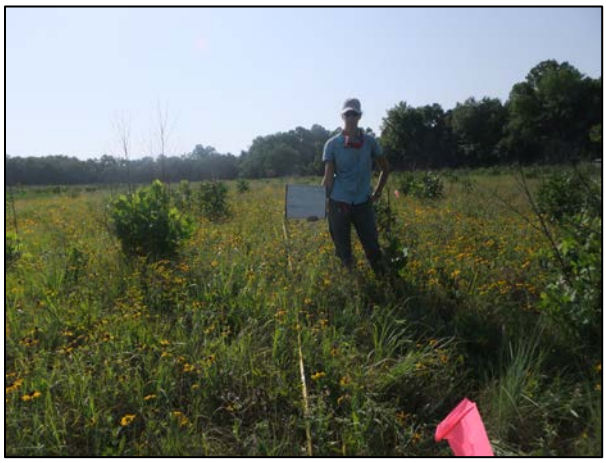


Figure 9. Site 16 in the north prairie, 2012. Ash and sycamore saplings were common along this transect.



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Figure 12. Site 41 in the south prairie, 2014. Sumac concentrations were greatly reduced.

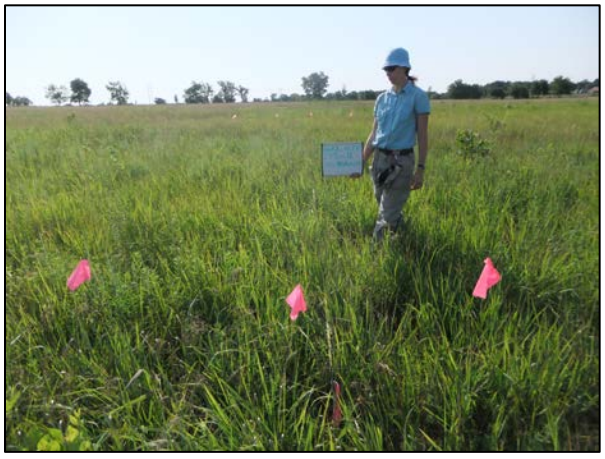


Figure 13. Site 65 in the south prairie, 2012.



Figure 14. Site 65 in the south prairie, 2014.

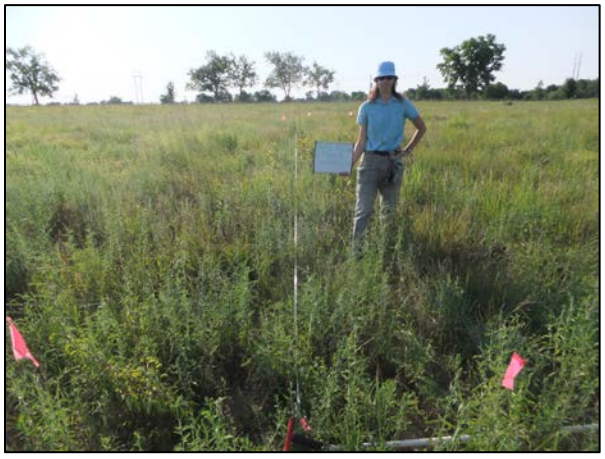


Figure 15. Site 66 in the south prairie, 2012.



Figure 16. Site 66 in the south prairie, 2014.

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