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Vegetation Community Monitoring at Hot Springs National Park, Arkansas

2007–2014

Natural Resource Data Series NPS/HTLN/NRDS—2017/1104

ON THE COVER
Landscape view of woodlands at Hot Springs National Park, Hot Springs, Arkansas
Photography by: Heartland Inventory and Monitoring Network, NPS

Vegetation Community Monitoring at Hot Springs National Park, Arkansas

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Abstract

The forest at Hot Springs National Park is an important resource for a variety of reasons. The mountain area is in the recharge zone for the hot springs and the forest provides other important ecosystem services. The Heartland Inventory and Monitoring Network installed seven monitoring sites in the northern forests in 2007. The sites were revisited in 2014. We conducted analyses of the overstory (basal area, density, and canopy cover) and understory communities. Our analyses indicate that the overstory continues to be characteristic of an oak-hickory-pine forest, although other early seral type trees are increasing. An increase of small diameter trees indicates that succession is occurring in the absence of fire in these sites. The regeneration data also indicate that early seral species are being recruited into more mature stages of forest growth. The understory was sparsely vegetated in both monitoring events. Very few exotic species were observed in any of the forest components assessed and understory composition of monitoring sites was fairly homogenous as evidenced by beta diversity values. Future monitoring events will allow for additional analysis of overstory composition as well as continued observations of the herbaceous community and fuels.

Acknowledgments

I would like to acknowledge the contributions of previous team members, K. James and K. Mlekush, who collected and processed much of these data. L. Morrison provided statistical support. Some basic language from the previous report by K. James was utilized in this manuscript (introduction and methods in particular are based on James et al. 2009 and James 2008).

Introduction

The woodlands at Hot Springs National Park (NP) provide an important ecosystem service as part of the recharge zone for the springs that are featured in the park (Petersen and Mott 2002). Goals for the woodlands include maintaining healthy ecological systems and preserving the entire hydrological system for the thermal springs (NPS 1998).

Forests of Hot Springs NP have been characterized by combinations of oak, hickory, pine, and other hardwood species. The ratio of these genera and community characterization is dependent upon slope, aspect, soil type, and disturbance history (Diamond et al. 2015; Dale and Ware 1999). Dale and Ware (1999) considered the oak-hickory-pine type as most pervasive in the park. Shortleaf pine is a matrix species distributed across topoedaphic gradients whereas other species are distributed based on soil, aspect, and slope. Shortleaf pine occurrence and abundance may be driven by disturbance (e.g., humans, fire, and wind storms), such that pines decrease in the absence of disturbances (Dale and Ware 1999). A recent vegetation mapping project (Diamond et al. 2015) described several woodland community types across the park as well as within the existing Heartland Inventory and Monitoring Network plant community sites (Table 1, Figure 1).

Prior to protection, the Hot Springs NP woodlands had been utilized for home sites, logging, and other forest purposes (NPS 1998). Presently, the park is interested in natural community management in the woodlands along the northern portion of the park. Fire management goals include: 1) reducing pole-sized tree (2.5-15 cm DBH) by 40% per ha after two burns and 2) increasing mean percent cover of native herbaceous species by 60% after two burns (Drees 2017). Management in the areas of network plant community monitoring sites at the park includes a limited amount of prescribed fire, however (Table 1). It was unclear if the monitoring plots burned along with the units that burned during the monitoring period.

The importance of non-native invasive species management and reintroduction of fire management to support species richness and diversity was highlighted in Witsell's (2003) floristic inventory report. Network monitoring data are well designed to understand long-term trends in both these areas.

Heartland Network installed seven plant community monitoring sites at Hot Springs NP in 2007 and the sites were monitored again in 2014. This report summarizes the overstory and understory woodland plant communities observed during those two monitoring events.

Table 1. Crosswalk of Heartland Inventory and Monitoring Network (HTLN) vegetation sites, plant community types (Diamond et al. 2015) and burn units. Burned status is based on knowledge from 2006 forward (personal communication Shelley Todd 15Feb2017).

HTLN Site	Vegetation Map Community Type	Burn Unit	Unit Burned?
1	*Ozark-Ouachita Dry-Mesic White Oak - Black Oak - Hickory Forest Ouachita-Ozark Small Stream Hardwood Forest Shortleaf Pine - Oak Dry-Mesic Woodland	None	No
2	*Ouachita-Ozark Small Stream Hardwood Forest Shortleaf Pine - Oak Dry-Mesic Woodland	Crabtree RX	2008, 2012
3	Ozark/Ouachita Shortleaf Pine - Oak Dry Woodland	SugarLoaf 1	No
4	Ozark/Ouachita Post Oak - Blackjack Oak / Little Bluestem Woodland Ozark-Ouachita Dry-Mesic White Oak - Black Oak - Hickory Forest	None	No
5	Ouachita-Ozark Small Stream Hardwood Forest	None	No
6	Ozark-Ouachita Dry-Mesic White Oak - Black Oak - Hickory Forest	None	No
7	Shortleaf Pine - Oak Dry-Mesic Woodland	Old Growth north (Sugarloaf 3)	2010

* indicates the primary community type

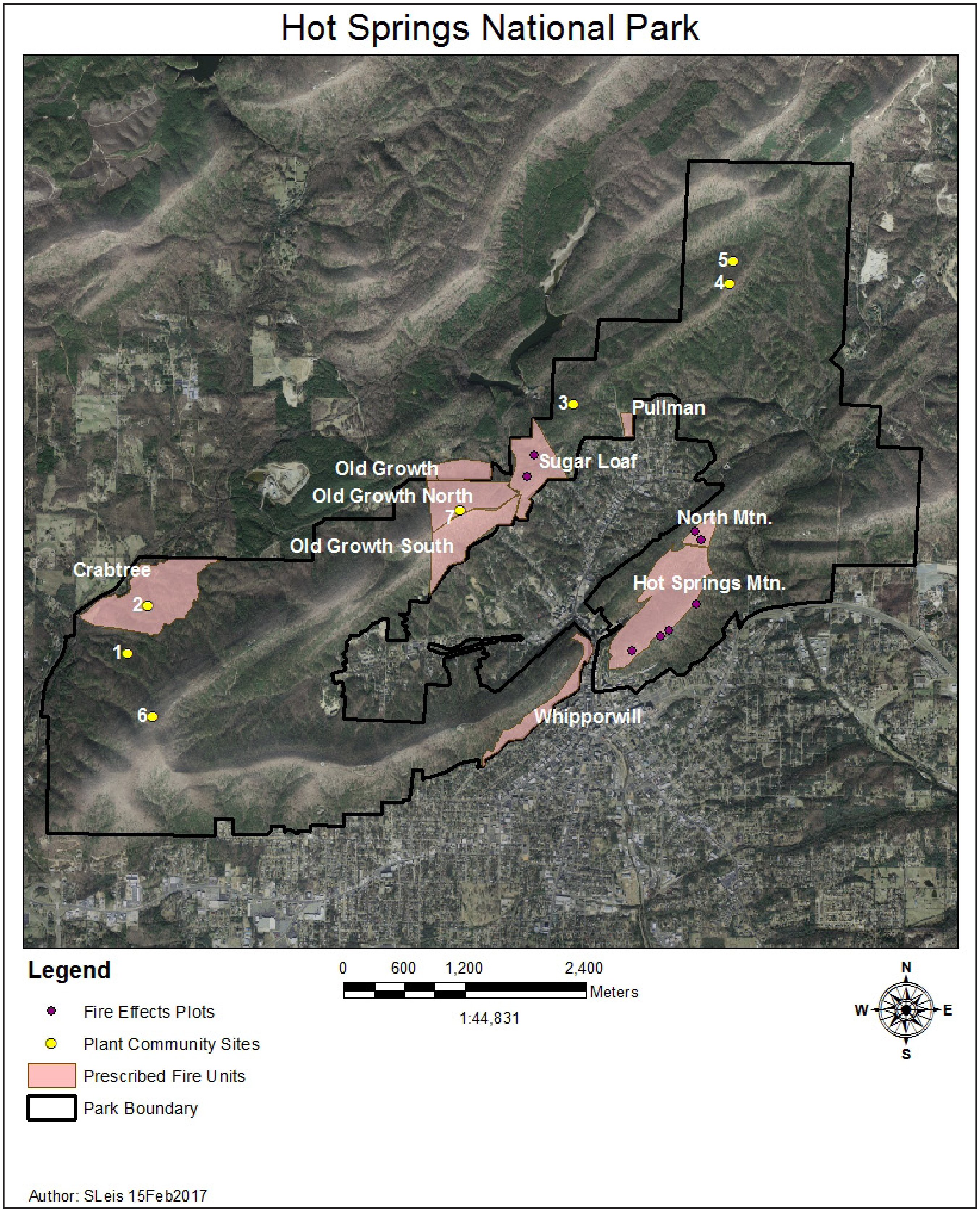

Figure 1. Heartland Network plant community monitoring sites with respect to burn units (prior to 2016 revision). Ozark Highlands fire effects monitoring plots are also shown for reference. The Sugarloaf 1 burn unit is not shown because it is a proposed burn unit.

Methods

The seven monitoring sites at Hot Springs NP were characterized as oak-hickory-pine forest although sites were stratified across slope positions (James 2008). Monitoring methods follow the woodland standard operating procedures outlined in the Heartland Network vegetation community monitoring protocol (James et al. 2009). Generally, monitoring sites were 50 m x 20 m (0.1 ha) in size with two focal transects bounding the site on the 50-m sides (Figure 2). For this protocol, overstory tree data are collected within the entire 0.1 ha area, while all other metrics are collected within 10 plots located along the site boundaries. (While each plot consists of a series of nested plots - 0.01 m^2, 0.1 m^2, 1 m^2, and 10 m^2 – observations were recorded at the 10 m^2 scale for this study.) Woodland monitoring consists of a suite of sampling methods for collecting data on overstory tree composition, canopy cover, regeneration, understory herbaceous species composition, and ground cover.

Data Summary

Forest overstory

Overstory tree composition in the forest was based on individual tree counts for each species and diameter at breast height (DBH) for each tree >5.0 cm dbh in the 0.1 ha site. Snags were calculated separately from live trees for overstory analysis unless specified in results. Basal area and stem density were calculated, within size classes (Table 2), as described in James et al. (2009). Some discrepancies in identification of oaks and hickories, in particular, were found between the two monitoring events. As a result, any species level analysis of overstory composition and structure were done by lumping oaks and hickories into their respective genera. Taken together, all tree metrics were used to describe the forest composition and structure for the park focus area.

Canopy cover data were collected using a densitometer. Densitometer readings were collected in the four cardinal directions in each of the ten 10-m^2 plots.

Table 2. Diameter at breast height (dbh) measurement range (cm) and size class used to group overstory trees.

DBH (cm)	Size Class
5.0 - 14.9	1
15.0 - 24.9	2
25.0 - 34.9	3
35.0 - 44.9	4
≥45	5

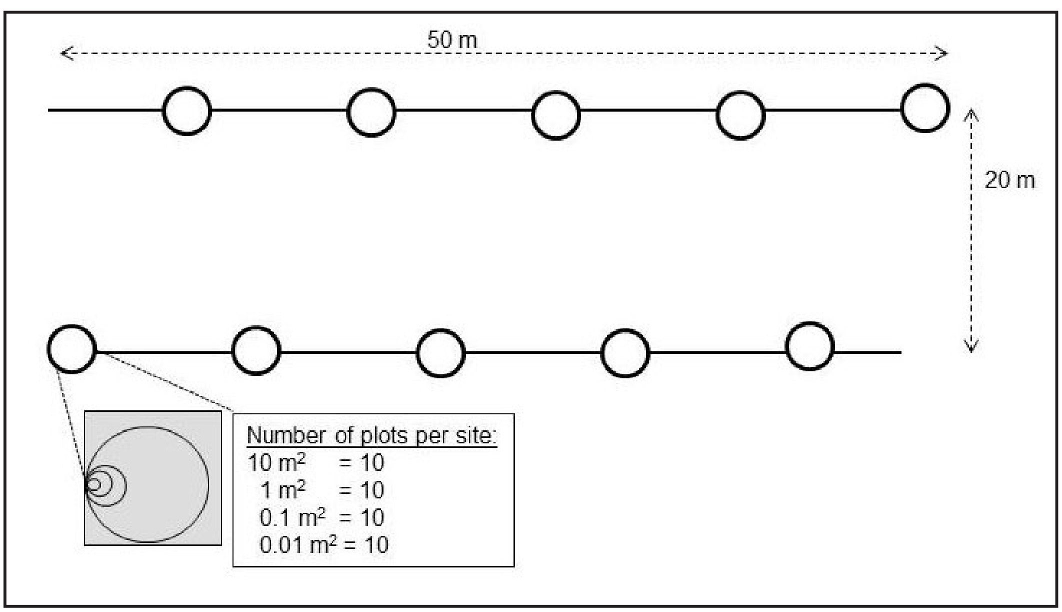

Figure 2. Plant community site monitoring design for Heartland Inventory and Monitoring Network parks.

These values from each plot were then averaged for each site. A grand mean was then calculated for all sites (n = 7).

Forest understory

Regeneration

The regeneration layer was tallied by species in the ten 10-m^2 plots and reported in three size classes: (1) seedlings: stems <0.5 m tall, (2) small saplings: stems ≥0.5 m tall but <2.5 cm DBH and (3) large saplings: stems ≥0. 5m but ≥2.5 m tall and <5.0 cm DBH. Using these data, I calculated the mean density (stems/ha) of each species across all sites (n = 7). Because of species level discrepancies between years, I lumped hickory species to *Carya* spp. and oak species by red or white oak group.

Understory species diversity

Mean site cover for all non-tree species was calculated using all plots within each site (n = 10). For each site within the community, species richness (S) along with the effective number of species derived from both Shannon diversity index (Shannon number, H_e) and Simpson's diversity index (Simpson's number, D_e) were calculated. Richness represents the number of species recorded. H_e represents a measure of diversity, while D_e refers to dominance within the community. Mean foliar cover estimates for each species in a site were imported to PC-ORD (version 6) to calculate these diversity indices (McCune and Medford 2011). A grand mean was then calculated for all sites (n = 7).

Initial plant diversity for each site was calculated using the Shannon diversity index:

$$\text{Shannon's Index: } H' = -\sum_{i=1}^{n} p_i \ln p_i$$

where p_i is the relative cover of species *i* (Shannon 1948).

Simpson's index of diversity for an infinite population (D) was calculated by site (McCune and Grace 2002). D is the likelihood that two randomly chosen individuals from a site will be different species and emphasizes common species (McCune and Grace 2002). It was calculated by site using the complement of Simpson's original index of dominance:

$$\text{Simpson's index: } D = 1 - \sum_{i}^{n} p_i^2$$

Shannon and Simpson's index values were converted into effective number of species for each community (H_e and D_e, respectively). This allowed for both diversity measures to be compared directly to species richness of the sites (S) within and among sample years based on counts of distinct species in the community (Jost 2006). Shannon index was converted into effective number of species (H_e) using the following formula:

$$H_e = exp^{H'}$$

where H was the Shannon index value. The effective number of species based on Simpson's index (D_e) was the inverse of the index value or:

$$D_e = 1/(1-D)$$

where D was the Simpson's index value.

For the purposes of interpretation, as S, H_e and D_e approach the same number, species begin to be equally abundant in the understory while large differences in the number of species between each measure reflect an increasing number of rare species and decreasing number of abundant species. See Jost (2006) and James et al. (2009) for a complete explanation and implementation of species diversity measures, respectively.

Understory community metrics

Community metrics are another way to think about how the plant community differs spatially. Alpha diversity is synonymous with species richness (mean number of species per monitoring site). This is equivalent to species richness in the diversity measures above. Gamma diversity is the park level diversity as measured by the number of species observed across our monitoring sites (park richness). Beta diversity is a measure of variation across monitoring sites such that small values, near 0, indicate a high degree of similarity across monitoring sites and greater values, >5, indicate a higher degree of variation between sites (McCune and Grace 2002).

Understory guild abundance

Understory species were also summarized by guilds, aka functional groups (per the USDA Plants database), to provide insight into the composition of the community. Guild assignments were grasses, forbs, sedges/rushes, ferns and woody species. A complete species list along with guild assignment is provided in Appendix A. Mean cover values were calculated for each guild-site-year combination. A grand mean was then calculated across all sites (n = 7).

Ground cover

Ground cover was assessed using cover classes (Table 2). A site mean was calculated by averaging the cover class midpoints for plots (n = 10) in each site. We observed areal cover of grass litter, leaf litter (woody plant leaves), rock (exposed rock), bare ground (soil), and the cover of woody debris (e.g. branches and sticks). Total unvegetated area reflects the basal area of stems in the plots (James et al. 2009).

Data Analysis

Paired t-tests and Wilcoxon signed ranks tests were used to determine whether significant differences existed within elements of the flora (i.e., canopy cover, regeneration, and diversity) between 2007 and 2014. SPSS statistical software (Version 20) was used for analyses (IBM 2011) and significance was evaluated at the alpha = 0.05 level.

Results

Overstory Structure

The Hot Springs NP forest has a relatively closed canopy (Table 3) and canopy cover was significantly less in 2014 than 2007 (Paired t-test: P = 0.04, t = 2.5, df = 6).This difference, however, may not be biologically meaningful.

With respect to overstory composition at the park, medium-sized trees made up the greatest mean basal area (Figure 3). Mean basal area was greater in 2014 compared to 2007 for class 1 (Wilcoxon signed ranks test: z = -2.37, P = 0.02), but similar for all other classes (P > 0.05). Mean basal area of snags remained low in both years (Figure 4).

Similar to basal area, density of tree stems was greater in 2014 than 2007 for class 1 (Wilcoxon signed ranks test; z = -2.37, P = 0.02), but in contrast to basal area was lower in 2014 than 2007 for classes 3, 4, and 5 (class 3: z = -2.20, P = 0.028; class 4: z = -2.05, P = 0.04; class 5: z = -2.06, P = 0.04; Figure 5).

Snags or standing dead trees are an important component of woodlands. At Hot Springs NP, snags made up 8.3% (2007) and 19.5% (2014) of the total tree basal area observed (Figure 6).

Table 3. Overstory percent canopy cover at Hot Springs NP, Arkansas 2007-2014. SE = standard error.

Year	N	Mean Canopy Cover (%)	SE
2007	7	93.8	1.0
2014	7	88.8	2.5

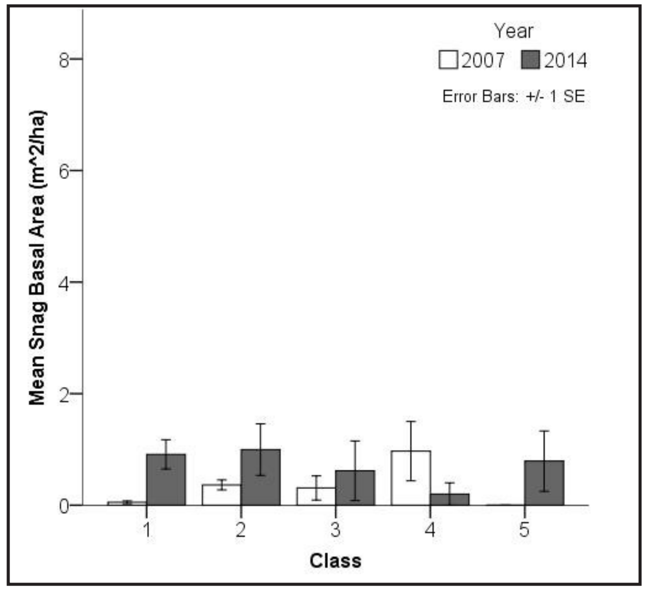

Figure 4. Mean basal area (m²/ha) of snags by size class at Hot Springs NP, Arkansas. Size class 5 includes the largest trees.

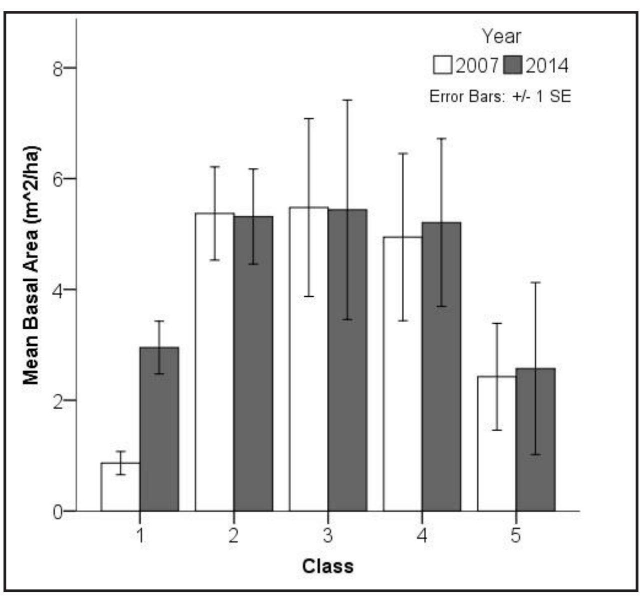

Figure 3. Basal area (m²/ha) of live overstory trees at Hot Springs NP by size class and year. The largest trees are category 5. Error bars are ±1 SE of the mean.

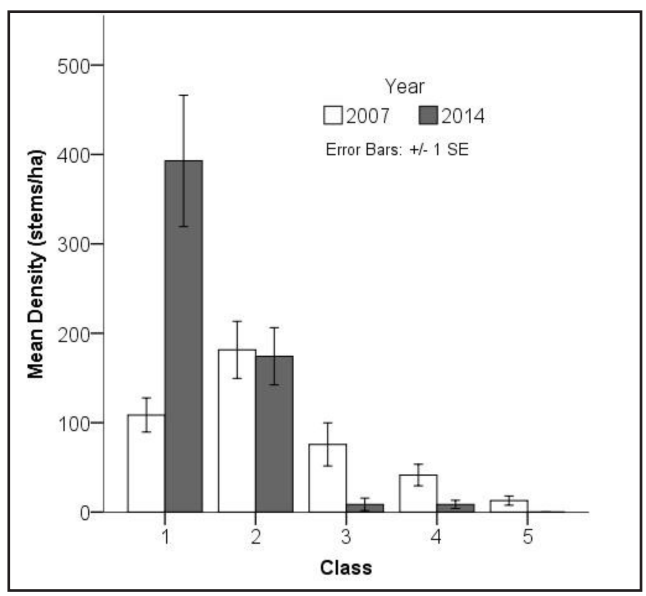

Figure 5. Mean density (stems/ha) of live trees by size class at Hot Springs NP, Arkansas. Size class 5 includes the largest trees.

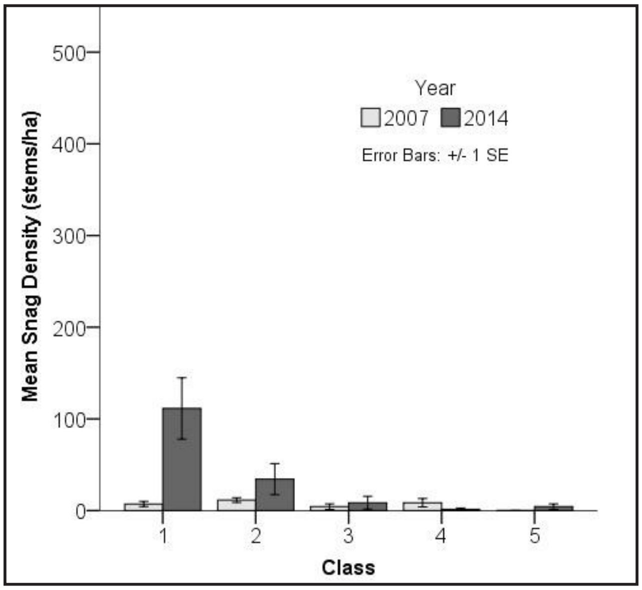

Figure 6. Mean density (stems/ha) of snags by size class at Hot Springs NP, Arkansas. Size class 5 includes the largest trees.

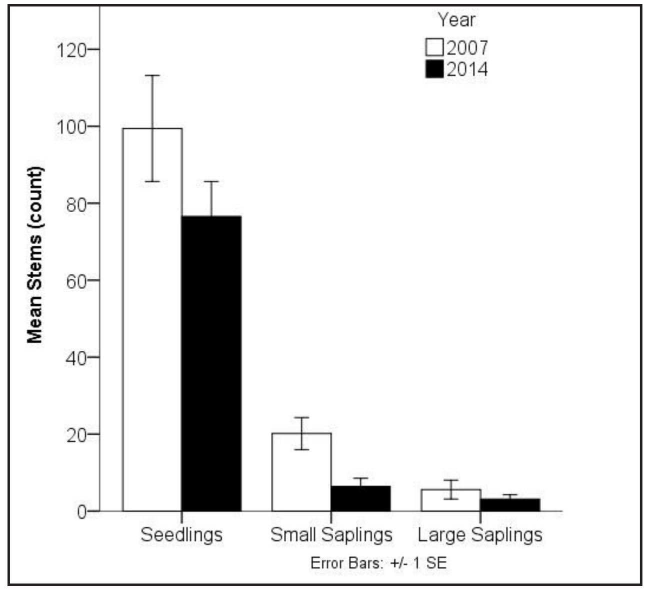

Figure 7. Mean number of stems for regeneration components of the forest monitoring sites at Hot Springs NP, Arkansas 2007, 2014. * indicates small saplings differed significantly between years.

Table 4. Ratio of number of stems for oak: hickory: other species: short leaf pine recorded during two years of monitoring at Hot Springs NP.

Year	Oak:	Hickory:	Other	Pine:
2007	3.0:	1.8:	6.7	1:
2014	3.4:	3.4:	10.6	1:

The forest in our monitoring sites is characterized as an Oak-Hickory-Pine type so we calculated a ratio of number of stems for oak, hickory, and other species lumped together, to pine for each year of monitoring (Table 4). In 2014, more early successional species such as *Ulmus rubra* (slippery elm), *Crataegus* spp. (hawthorn), *Juniperus virginiana* (eastern redcedar), and *Acer rubrum* (red maple) were observed than in 2007.

Regeneration

Regeneration includes seedlings, small saplings, and large saplings. Individuals in all regeneration phases – seedlings, small saplings, and large saplings - were represented, but recruitment into later phases was less (Figure 7, Table 5). There was a significant difference in regeneration phases for small saplings (paired t-test; *seedlings*: P = 0.31, t = -1.11 df = 6; *small saplings*: P = 0.004, t = 4.6, df = 6; *large saplings* P = 0.20, t = 1.43, df = 6). The shape of the distribution of regeneration stems is similar to a classic model of forest succession in the absence of significant disturbance (Kimmins 1987).

Herbaceous Understory

Herbaceous species richness was not significantly different between sampling years (t = 1.3, df = 6, p = 0.26). The difference between the diversity indices and species richness indicates that about 30% of the species are common and dominate the herbaceous community. The remaining species are relatively rare.

The understory plant community was similar within and between sites in the two monitoring years (Table 6). Alpha diversity is equivalent to species richness (Figure 8). Gamma richness is a park-wide calculation of richness based on the seven monitoring sites. Beta diversity measures close to 0 indicate a high degree of similarity between monitoring sites. A value of >5 would indicate a high degree of unique species at each site. Our data indicate that the plant community was similar across sites.

Hot Springs NP has three species of concern that occur in the old growth pine area of the park. Only one of these species—*Galium arkansanum* var. *pubiflorum* (Arkansas bedstraw) —was observed in the Heartland Network monitoring sites and only in 2007. The 2007 observations were minimal in that the plant was recorded at ≤1% cover in each of three plots.

Table 5. Tree regeneration by species (mean stems/ha) in Hot Springs NP. Negative changes indicate fewer stems in 2014 than 2007.

	Mean Seedlings		Mean Small Saplings		Mean Large Samplings		% Change		
Species	**2007**	**2014**	**2007**	**2014**	**2007**	**2014**	**Seedlings**	**Small Saplings**	**Large Saplings**
Acer rubrum	128.6	28.6	42.9	0.0	0.0	0.0	-77.8	-100.0	–
Acer saccharinum	0.0	14.3	0.0	0.0	0.0	0.0	–	–	–
Amelanchier arborea	142.9	0.0	71.4	0.0	14.3	28.6	-100.0	-100.0	100.0
Carya spp	2500.0	2385.7	657.1	157.1	300.0	57.1	-4.6	-76.1	-81.0
Cornus florida	271.4	414.3	114.3	71.4	0.0	14.3	52.6	-37.5	–
Crataegus spp	57.1	0.0	14.3	0.0	28.6	28.6	-100.0	-100.0	0.0
Diospyros virginiana	57.1	85.7	42.9	0.0	0.0	0.0	50.0	-100.0	–
Frangula caroliniana	71.4	200.0	14.3	28.6	71.4	14.3	180.0	100.0	-80.0
Ilex decidua	0.0	14.3	0.0	0.0	0.0	0.0	–	–	–
Juniperus virginiana	14.3	0.0	0.0	0.0	0.0	0.0	–	–	–
Nyssa sylvatica	328.6	0.0	242.9	14.3	14.3	0.0	-100.0	-94.1	-100.0
Ostrya virginiana	214.3	228.6	100.0	14.3	0.0	0.0	6.7	-85.7	–
Pinus echinata	1028.6	642.9	0.0	0.0	0.0	0.0	-37.5	–	–
Prunus spp	1342.9	714.3	228.6	142.9	71.4	57.1	-46.8	-37.5	-20.0
Red oak group	1357.1	1371.4	185.7	114.3	28.6	14.3	1.1	62.5	100.0
Robinia pseudoacacia	442.9	128.6	0.0	0.0	0.0	0.0	-71.0	–	–
Sassafras albidum	14.3	0.0	0.0	0.0	0.0	0.0	-100.0	–	–
Ulmus spp	42.9	171.4	171.4	57.1	14.3	14.3	75.0	-200.0	0.0
Ulmus pumila	0.0	0.0	0.0	0.0	0.0	14.3	–	–	–
Viburnum rufidulum	14.3	14.3	0.0	14.3	0.0	42.9	0.0	–	–
White oak group	1914.3	1242.9	128.6	28.6	14.3	28.6	-35.1	-77.8	100.0

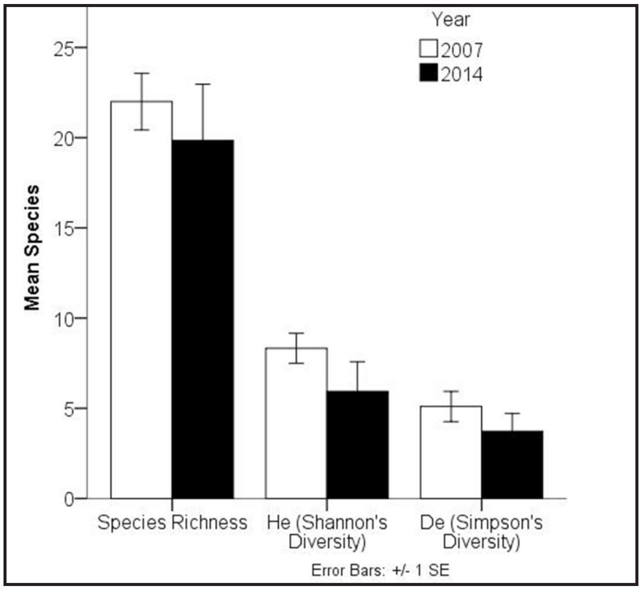

Figure 8. Measures of herbaceous species diversity calculated as effective number of species (S, H_e, D_e) for monitoring in 2007 and 2014 at Hot Springs NP.

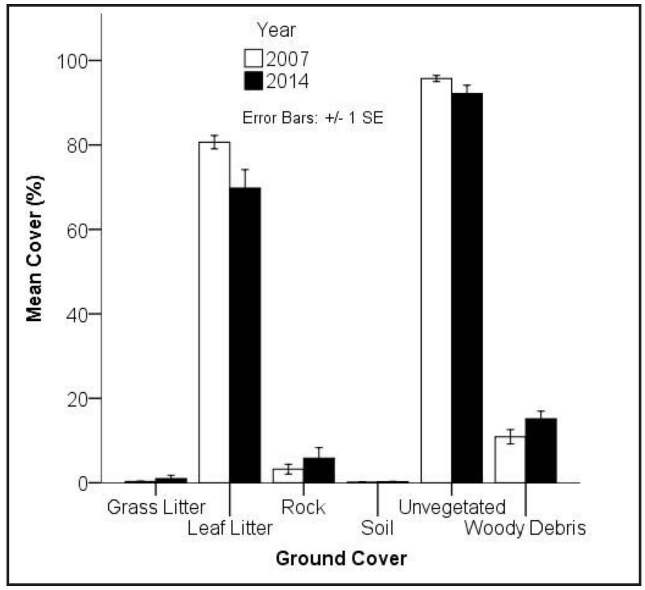

Figure 9. Measures of mean ground cover across 7 monitoring sites in 2007 and 2014 at Hot Springs NP, Arkansas.

Table 6. Measures of herbaceous plant community diversity by scale. Alpha diversity refers to the mean number of species per monitoring site; gamma diversity is the total number of herbaceous species across all monitoring sites; beta diversity is a measure of species heterogeneity.

Community Diversity Measure	2007	2014
Alpha (Mean site richness)	22.0	19.7
Gamma (Park richness)	58.0	56.0
Beta (Heterogeneity)	1.64	1.84

Measures of ground cover were very similar between the two years (Figure 9). Leaf litter differed the most with a decline of about 11% in 2014.

We found few exotic species in Hot Springs NP forests. One exotic tree was found in the overstory (*Ulmus pumila*) and three exotic species were found in the herbaceous understory. In 2007, mean cover for two exotic species observed (*Lactuca serriola* and *Lonicera* sp.) totaled 0.10 % and in 2014, the single species observed (*Nandiana domestica*) totaled 1.0% mean cover.

In assessing guild composition, forb, grass, and woody guilds expressed variability within and among years (Figure 10). The sparse understory appeared to be dominated by woody plants with lower numbers of forbs, grasses, and other guilds (Figure 10).

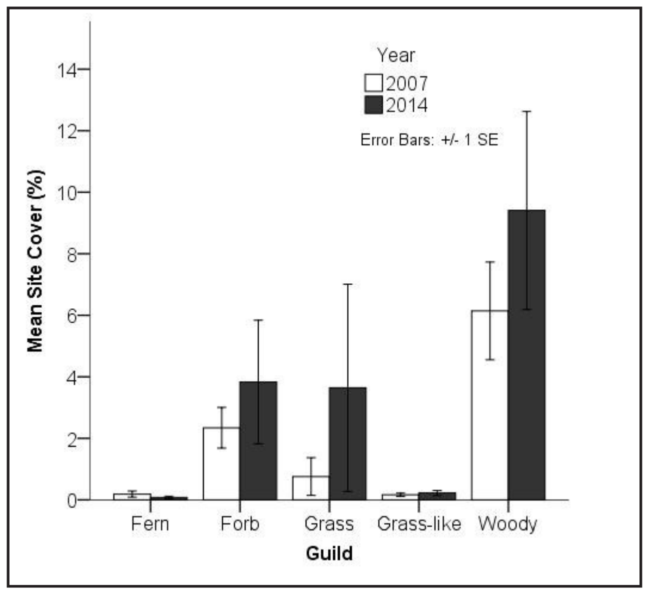

Figure 10. Mean percent cover of plant guilds for two monitoring events at Hot Springs NP, Arkansas.

While we are uncertain if the sites involved in this study were burned, the increase in herbaceous cover fell short of the 60% increase that was envisioned after two prescribed fires (Drees 2017). The difference in cover of all herbaceous guilds between 2007 and 2014 was minimal, increasing from 9.9 % (±2.0 SE) in 2007 to 17.2%, (±3.8 SE) in 2014.

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Appendix A

Table A1. Species recorded during monitoring events at Hot Springs NP in 2007 and 2014. Origin values: N (native), I (introduced). Although a variety of species for *Carya* and *Quercus* were recorded, I lumped them here as a result of inconsistencies.

Species	Common Name	Guild	Origin
Acalypha monococca	Ozarkian short-stalk copperleaf	forb	N
Acer rubrum	red maple	woody	N
Acer saccharinum	silver maple	woody	N
Amelanchier arborea	common serviceberry	woody	N
Amphicarpaea bracteata	American hogpeanut	forb	N
Andropogon virginicus	broomsedge bluestem	grass	N
Antennaria plantaginifolia	woman's tobacco	forb	N
Aralia spinosa	devil's walkingstick	forb	N
Aristolochia serpentaria	Virginia snakeroot	forb	N
Asclepias	milkweed	forb	N
Asplenium platyneuron	ebony spleenwort	fern	N
Aster spp.	aster	forb	N
Callicarpa americana	American beautyberry	forb	N
Camassia scilloides	Atlantic camas	forb	N
Carex spp.	sedge	grass-like	N
Carya spp.	hickory	woody	N
Cocculus carolinus	Carolina coralbead	woody	N
Conyza canadensis	Canadian horseweed	forb	N
Cornus florida	flowering dogwood	woody	N
Crataegus spp.	hawthorn	woody	N
Cunila origanoides	common dittany	forb	N
Danthonia spicata	poverty oatgrass	grass	N
Desmodium nudiflorum	nakedflower ticktrefoil	forb	N
Diarrhena americana	American beakgrain	grass	N
Dichanthelium	rosette grass	grass	N
Dichanthelium boscii	Bosc's panicgrass	grass	N
Dioscorea villosa	wild yam	forb	N
Diospyros virginiana	common persimmon	woody	N
Erechtites hieraciifolia	American burnweed	forb	N
Euphorbia corollata	flowering spurge	forb	N
Frangula caroliniana	Carolina buckthorn	woody	N
Galium arkansanum	Arkansas bedstraw	forb	N
Galium circaezans	licorice bedstraw	forb	N
Helianthus divaricatus	woodland sunflower	forb	N
Heuchera americana	American alumroot	forb	N
Hieracium gronovii	queendevil	forb	N
Ilex decidua	possumhaw	woody	N
Ilex opaca	American holly	woody	N
Iris cristata	dwarf crested iris	forb	N

Table A1, continued. Species recorded during monitoring events at Hot Springs NP in 2007 and 2014. Origin values: N (native), I (introduced). Although a variety of species for *Carya* and *Quercus* were recorded, I lumped them here as a result of inconsistencies.

Species	Common Name	Guild	Origin
Juniperus virginiana	eastern redcedar	woody	N
Lactuca serriola	prickly lettuce	forb	I
Lathyrus venosus	veiny pea	forb	N
Lespedeza procumbens	trailing lespedeza	forb	N
Lespedeza repens	creeping lespedeza	forb	N
Lespedeza violacea	violet lespedeza	forb	N
Liquidambar styraciflua	sweetgum	woody	N
Lonicera sp.	honeysuckle	woody	I
Menispermum canadense	common moonseed	woody	N
Monarda	beebalm	forb	N
Monarda fistulosa	wild bergamot	forb	N
Monarda russeliana	redpurple beebalm	forb	N
Nandina domestica	sacred bamboo	woody	I
Nyssa sylvatica	blackgum	woody	N
Ostrya virginiana	hophornbeam	woody	N
Oxalis spp.	woodsorrel	forb	N
Parthenocissus quinquefolia	Virginia creeper	woody	N
Phlox spp.	phlox	forb	N
Physalis virginiana	Virginia groundcherry	forb	N
Pinus echinata	shortleaf pine	woody	N
Piptochaetium avenaceum	blackseed speargrass	grass	N
Pleopeltis polypodioides	resurrection fern	forb	N
Prunus	plum	woody	N
Prunus serotina	black cherry	woody	N
Pteridium aquilinum	western brackenfern	fern	N
Quercus spp.	oak	woody	N
Red oak group		woody	N
Rhus aromatica	fragrant sumac	woody	N
Ribes missouriense	Missouri gooseberry	woody	N
Robinia pseudoacacia	black locust	woody	N
Rosa carolina	Carolina rose	woody	N
Rubus spp.	blackberry	woody	N
Ruellia pedunculata	stalked wild petunia	forb	N
Sanicula spp.	sanicle	forb	N
Sassafras albidum	sassafras	woody	N
Scutellaria ovata	heartleaf skullcap	forb	N
Sideroxylon lanuginosum ssp. *albicans*	gum bully	woody	N
Smilax bona-nox	saw greenbrier	Woody	N
Smilax tamnoides	bristly greenbrier	woody	N
Solidago spp.	goldenrod	forb	N
Symphoricarpos orbiculatus	coralberry	woody	N

Table A1, continued. Species recorded during monitoring events at Hot Springs NP in 2007 and 2014. Origin values: N (native), I (introduced). Although a variety of species for *Carya* and *Quercus* were recorded, I lumped them here as a result of inconsistencies.

Species	Common Name	Guild	Origin
Symphyotrichum patens var. patens	Clasping wild aster	forb	N
Toxicodendron radicans	eastern poison ivy	woody	N
Tradescantia hirsuticaulis	hairystem spiderwort	forb	N
Ulmus spp.	elm	woody	N
Ulmus alata	winged elm	woody	N
Ulmus pumila	Siberian elm	woody	I
Ulmus rubra	slippery elm	woody	N
Vaccinium spp.	blueberry	woody	N
Viburnum prunifolium	blackhaw	woody	N
Viburnum rufidulum	rusty blackhaw	woody	N
Viburnum rufidulum	rusty blackhaw	woody	N
Viola spp.	violet	forb	N
Vitis spp.	grape	woody	N
Vitis aestivalis	summer grape	woody	N
Vitis rotundifolia	muscadine	woody	N
White oak group		woody	N

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