



Plant Community Monitoring at Hot Springs National Park, Arkansas

2007–2024



A long-term vegetation monitoring site (site 2, A transect) at Hot Springs National Park in 2014.

NPS / HEARTLAND INVENTORY AND MONITORING NETWORK

Plant Community Monitoring at Hot Springs National Park, Arkansas: 2007–2024

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Abstract

Hot Springs National Park, Arkansas, is known for thermal hot springs but the forested landscape also contributes to the park's mission. The forests protect the hot springs recharge zone and provide recreational opportunities. The Heartland Inventory and Monitoring Network has conducted long-term plant community monitoring since 2007 in the park's forests. We collected data on seven monumented sites (50 m × 20 m) in 2007, 2014, and 2024. While midstory and overstory data were recorded across the whole 0.1 ha area, ground flora, ground cover, and canopy closure were observed in ten 10 m² plots. Plots were averaged to the site level and sites were averaged to represent the conditions at the park scale.

The environment at Hot Springs National Park includes regular periods of moisture and drought. The 2024 monitoring occurred during a period of above average precipitation. While maximum temperatures in 2024 were similar to the past, minimum temperatures were warmer during much of the year. The ground surface was more vegetated and had less leaf litter than in other years, possibly because of prescribed fires at two sites. The forested sites were similar in structure across years, but midstory tree (trees between 5 and 15 cm diameter at breast height [DBH]) density increased in 2024. We noted that abundance of the fire-sensitive species eastern redcedar (*Juniperus virginiana*) and basal area of the fire-tolerant shortleaf pine (*Pinus echinata*) had small increases during the last monitoring period. However, stem density of shortleaf pine decreased. We noted few problematic species (invasive species) in the ground flora, but sacred bamboo (*Nandina domestica*) expanded at one site. Gamma diversity (park-wide plant diversity) was greatest in 2024. Quality assessment procedures indicated a high level of agreement between observers for species (89%) and an acceptable level of agreement for percent cover (95% of observations within one class). Although fire effects monitoring reported that ecological objectives have been met in burned sites, our park-wide results differ with respect to pole-sized tree reduction, mean species richness increases, and vegetated cover increases. As a result, we suggest that wider use of prescribed fire may be helpful for the forest as a whole.

Acknowledgments

We are grateful to the park for access and field support during tree tagging in the fall of 2024. We were also supported by the Ozark Highlands Fire Effects team (led by J. Ladner) and by the Ouachita National Forest botanist, V. McDaniel. Without the collaboration of all of these people, the data could not have been collected in 2024. We are grateful for the generations of field crews that have participated in monitoring at Hot Springs National Park including E. Sload and S. Mead in 2024. Ms. Sload was an excellent field leader in a challenging situation. S. Mead also supported data summary.

Introduction

Hot Springs National Park was first designated in 1832 and became a national park in 1921. The Park's mission is to protect its unique geothermal spring water and associated lands for public health, wellness, and enjoyment (NPS 2012). While forests are not the focus of the park, they contribute to the protection of the recharge zone for the geothermal hot springs, as well as provide public access to the surrounding natural environment for recreational purposes. The old-growth forests, as well as other botanical members of the forest community, are among the important resources of the park. Problematic plants (invasive species) are listed as a park concern for the forest and trail system. In addition to the hot springs, the park interprets the Ouachita range ecosystems (NPS 2008).

Geologic resources underlying the forested long-term monitoring sites primarily include Arkansas novaculite, Stanley shale, and Stanley shale hot springs sandstone member. The folds and cracks in the rock resulting from the mountain formation created a unique context for the production of hot springs within the park (Johnson and Hanson 2011; Thornberry-Ehrlich 2013). Park forests were found to be typical of the Ouachita range and are dominated by a mixture of oak (*Quercus* spp.), hickory (*Carya* spp.), and shortleaf pine (*Pinus echinata*; Dale and Ware 1999). Several forest community types are represented by our seven plant community monitoring sites (Leis 2017); types range from shortleaf pine to oak dominated systems (Diamond et al. 2015).

The unique resources of the park led to a rich human history as well. Native Americans visited the hot springs long before Hernando de Soto's visit in 1541. A settlement began to form after the Dunbar-Hunter Expedition in 1804 that followed the Louisiana Purchase. During the different phases of habitation, the forests would have been used for a variety of needs including homesteads (NPS 2012). Those historical homesteading and settlement activities may have influenced the forests in many parts of the park, but more recently, limited management outside of prescribed fire has taken place in the monitoring sites. Prescribed fires were recorded in two of the sites since we began plant community monitoring (site 2 in 2008, 2012, and 2021 and site 7 in 2010 and 2022).

This report summarizes plant community trends for seven monitoring sites at Hot Springs National Park across three monitoring events (2007, 2014, and 2024). Fire effects sampling has documented progress on fire management goals in fire effects macroplots (Drees and Ladner 2023). These included maintaining increases in species richness and vegetation cover in the ground flora and decreasing pole-sized trees. While our monitoring design does not facilitate testing the role of fire on the vegetation in our sites, we can observe whether there were park-level trends in the related metrics identified by Drees and Ladner. For the purposes of reporting on the status and trend of the park's forests, we've pooled the seven sites together. We aim for the plant community trend information to be helpful for woodland management and, by extension, the protection of the hot spring recharge zone.

Methods

Study Site

The natural communities of Hot Springs National Park are in the Ouachita Mountains physiographic province. Steep ridges and valleys characterize this area of Arkansas (Thornberry-Ehrlich 2013). The Heartland Inventory and Monitoring Network (Heartland Network) plant community monitoring sites fall within several vegetation communities that are dominated by oak species (Table 1; Diamond et al. 2015). Geology, soil, and slope position help to define and restrict these forest types. The major characteristics of oak-hickory forests include a defined dominant overstory canopy composed of oak species, a defined sub-canopy of oaks or hickory species, and a sparse understory shrub and herbaceous layer.

Table 1. Crosswalk of Heartland Network vegetation sites, plant community types (Diamond et al. 2015), and burn units. Burned status is based on knowledge from 2006 forward (personal communications, Shelley Todd, 15 February 2017 and Jamie Ladner, 8 July 2024).

Monitoring Site	Vegetation Map Community Type	Burn Unit	Year (s) Unit Burned
1	- Ozark-Ouachita Dry-Mesic White Oak - Black Oak - Hickory Forest^A - Ouachita-Ozark Small Stream Hardwood Forest - Shortleaf Pine - Oak Dry-Mesic Woodland	None	Not burned
2	- Ouachita-Ozark Small Stream Hardwood Forest^A - Shortleaf Pine - Oak Dry-Mesic Woodland	Crabtree RX	2008, 2012, 2021
3	Ozark/Ouachita Shortleaf Pine - Oak Dry Woodland	SugarLoaf 1	Not burned
4	- Ozark/Ouachita Post Oak - Blackjack Oak / Little Bluestem Woodland - Ozark-Ouachita Dry-Mesic White Oak - Black Oak - Hickory Forest	None	Not burned
5	Ouachita-Ozark Small Stream Hardwood Forest	None	Not burned
6	Ozark-Ouachita Dry-Mesic White Oak - Black Oak - Hickory Forest	None	Not burned
7	Shortleaf Pine - Oak Dry-Mesic Woodland	Old Growth north (Sugarloaf 3)	2010, 2022

^A Primary community type.

Sampling Design

The Heartland Network established seven vegetation monitoring sites at Hot Springs National Park in 2007 (Figure 1). Although monitoring sites at the park were characterized as oak-hickory and pine forest types based on a vegetation map (Diamond et al. 2015; Table 1), we combined them here for analysis. Monitoring methods followed the woodland standard operating procedures outlined in the Heartland Network vegetation community monitoring protocol (Leis et al. 2022).

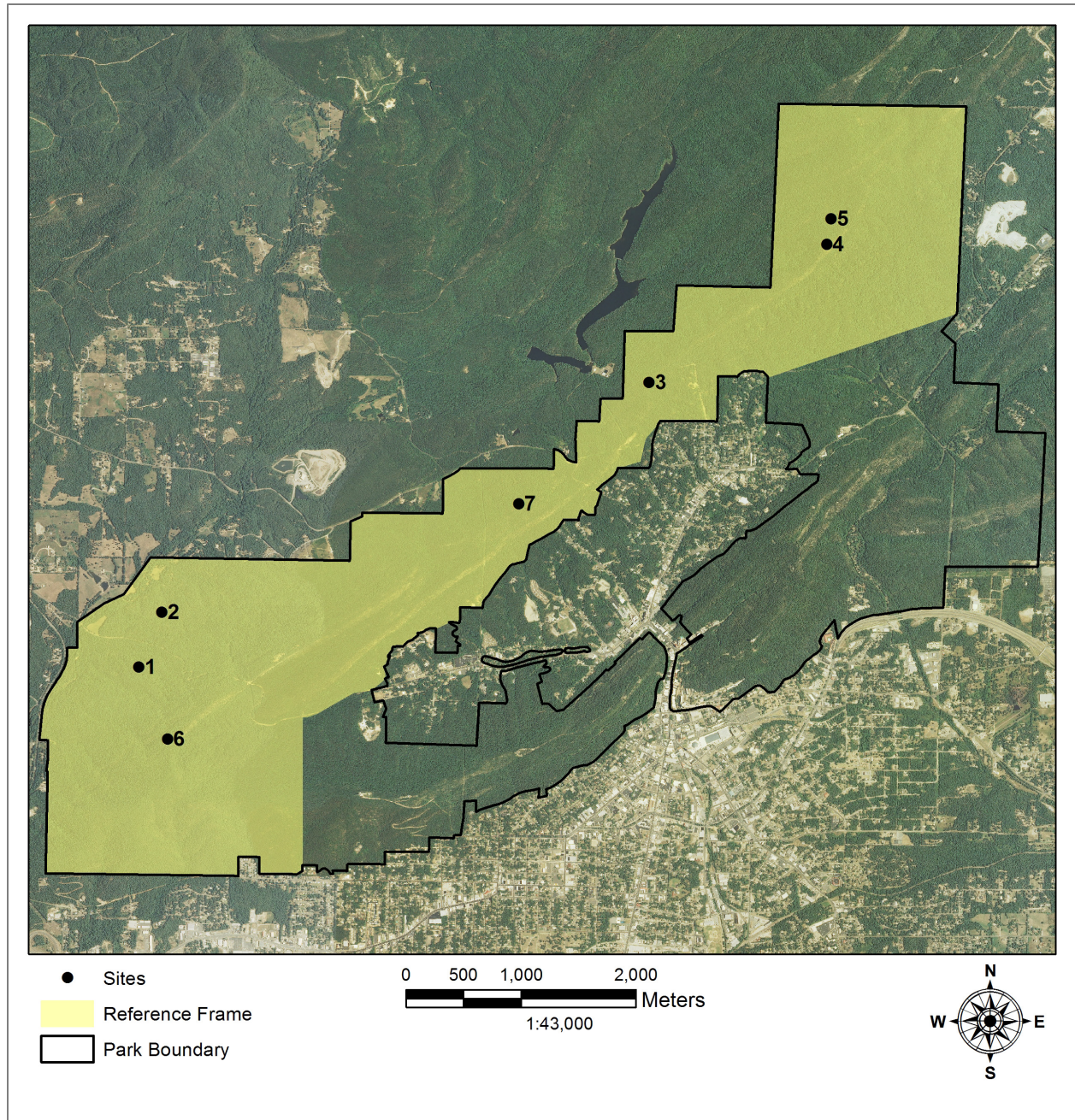


Figure 1. Plant community monitoring reference frame and long-term monitoring sites at Hot Springs National Park, Arkansas.

NPS

Monitoring sites were 50 m × 20 m (0.1 ha) in size with two focal transects bounding the site on the 50 m sides (Figure 2). For this protocol, midstory and overstory tree data were collected within the entire 0.1 ha area, while all other metrics were collected within 10 subplots located along the site boundaries. Each subplot consisted of a series of nested subplots (0.01 m², 0.1 m², 1 m², and 10 m²), but only observations at the 10 m² scale were used for this study. Midstory and overstory monitoring consisted of a suite of sampling methods for characterizing overstory tree composition, canopy

closure, and tree regeneration. Ground flora measurements included species level observations, ground cover, and tree regeneration.

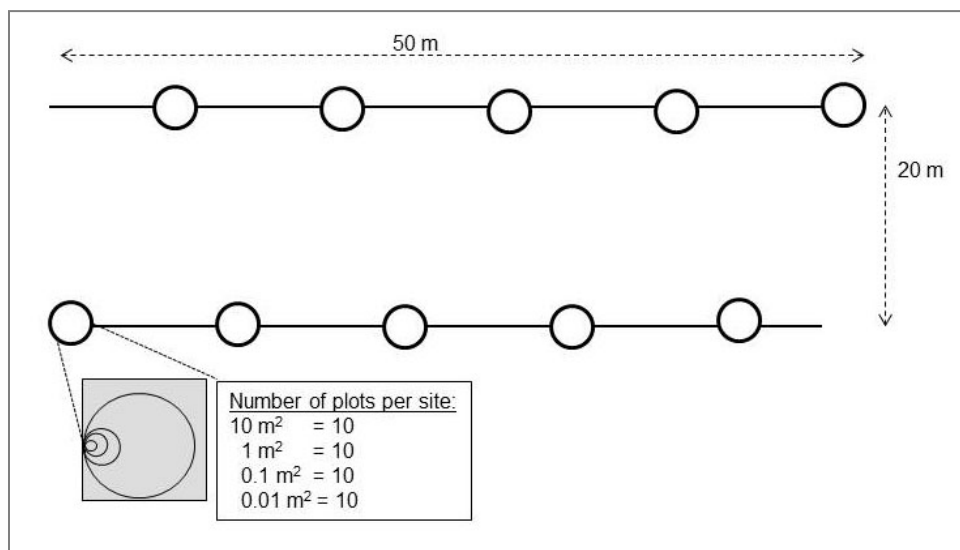


Figure 2. Plant community site monitoring design for Heartland Network parks.
NPS

In 2024, we encountered two issues that may affect data quality. First, we noted that site 4 was positioned with one transect close to a trail, and consequently, when the site was installed the transect identification labels were incorrectly placed. Although the problem was corrected in 2024, it is possible that long-term overstory data summaries were affected by the issue. Secondly, one of the observers misunderstood the ground flora cover class definition for class 1. They rated ground cover types that were not present as class 1. We expect that this error had minimal effect on the interpretation of results, however.

Data Summary

Sites were pooled together for analysis. For baseline descriptions by community type, see James (2008).

RStudio (R Core Team 2024) and Minitab Statistical Software (2020) were used to calculate summary statistics. All site means ($N = 7$) were calculated based on 10 subplots for each year (2007, 2014, and 2024).

Environment

We included a brief description of historical weather trends to provide context for plant communities. Data were obtained using the Climate Analyzer tool (climateanalyzer.org, Tercek 2025) for the Heartland Network parks. National Weather Service data from the station in Hot Springs, Arkansas (station ID USC00033466), was used to calculate the precipitation and temperature metrics (interpolated precipitation compared to long-term precipitation and a climogram). Additional climate outputs were referenced (CCRP 2024).

Ground Cover

Ground cover was assessed using cover classes (Table 2). A site mean was calculated by averaging the cover class midpoints for subplots in each site. We observed ground cover by type (unvegetated cover and cover of grass litter, leaf litter (deciduous plant leaves), exposed rock, bare ground, and woody debris (e.g., logs, branches, and sticks)). Total unvegetated area reflects space unoccupied by stem basal area in the subplots (Leis et al. 2022). We also measured litter depth in each subplot in 2024. One measurement in each subplot ($n = 10$) was averaged to create a site-level mean for litter depth.

Table 2. Modified Daubenmire cover value scale used to determine ground cover for the Heartland Network parks.

Cover Class Codes	Range of Cover (%)	Class Midpoints (%)
7	95.1–100	97.5
6	75.1–95.0	85.0
5	50.1–75.0	62.5
4	25.1–50	37.5
3	5.1–25.0	15.0
2	1.1–5.0	2.5
1	>0–1.0	0.5

Overstory and Midstory

Tree composition 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 sites. Snags were calculated separately from live trees. Basal area and stem density were calculated within size class categories (Table 3), as described in Leis et al. (2022). We distinguished class 1 (midstory trees) from classes 2–5 (overstory trees) for interpretation. Stem density and DBH were scaled to the hectare for analysis. Taken together, all tree metrics were used to describe the forest structure for Hot Springs National Park.

Table 3. Diameter at breast height (DBH) measurement range (cm) and size class used to group midstory and overstory trees.

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

We assessed change over time for midstory and overstory basal area and density by subtracting the baseline monitoring value from the current monitoring mean (e.g., 2024 basal area – 2007 basal

area). The occurrence of tree species in 2024 was calculated as the percent of all sites (N = 7) occupied by each species in that year (Appendix A).

Canopy Closure

Canopy closure data were collected using a densiometer. Densiometer readings were collected in the four cardinal directions in each of the 10 m² subplots and converted to canopy closure (multiplied by 1.04). Subplot-level mean canopy closure (n = 4 per subplot) was used to calculate site-level mean canopy closure. A grand mean was then calculated for all sites (N = 7).

Tree Regeneration

Tree regeneration stems were tallied by species in the 10 m² subplots and reported in three size classes: (1) seedlings = stems < 0.5 m tall; (2) small saplings = stems ≥ 0.5 m tall and < 2.5 cm DBH; and (3) large saplings = stems ≥ 0.5 m tall and DBH ≥ 2.5 cm and < 5.0 cm. Regeneration components are summed by species across the ten monitoring plots in a site, and the sums are converted to stems/ha. Park-level mean densities were calculated by averaging site level densities across the park.

Ground Flora

Plant Species Diversity Indices

Based on foliar cover measurements, diversity indices describe the number of species and their abundances. Mean site cover for all ground flora species was calculated using all subplots within each site. For each site within the community, species richness (S; for native and nonnative species separately), Shannon diversity index (H') and evenness (J') were calculated for native species. Native species richness, synonymous with alpha diversity, represents the number of native species observed. PC-ORD (version 7.02) was used to calculate these diversity indices (McCune and Mefford 2016). A grand mean was then calculated for all sites in the park (Minitab Statistical Software 2020).

Native plant diversity for each site was calculated using the Shannon diversity index (H'):

$$H' = -\sum_{i=1}^n p_i \ln p_i$$

where p_i is the relative cover of species i (Shannon and Weaver 1949).

Native species distribution evenness (J') was calculated by site according to Pielou (1969):

$$J' = \frac{H'}{\ln(S)}$$

where H' is the Shannon index and $\ln(S)$ is the maximum possible Shannon diversity for a given number of species if all species were present in equal abundance. Evenness is a measure of the distribution of species within a community as compared to equal distribution and maximum diversity

(Pielou 1969). A value of 1 indicates even communities, whereas 0 indicates a heterogeneous community.

Community Diversity Metrics

Native plant community richness metrics evaluate how species richness differs across monitoring sites and the park. We limited these calculations to native ground flora species (not including tree regeneration).

Alpha diversity is synonymous with species richness at the site scale (i.e., mean number of species per monitoring site). *Gamma* diversity is the community-level richness observed across all monitoring sites (i.e., total number of species in the community). *Beta* diversity is a measure of heterogeneity in species distributions across monitoring sites such that small values (near 0) indicate a high degree of similarity in species occurrence across monitoring sites and greater values (> 5) indicate a higher degree of variation in species between sites (more differentiated communities; McCune and Grace 2002).

$$\text{Beta Diversity} = \frac{\text{gamma}}{\text{alpha}} - 1$$

Guild Abundance

Native understory plant species were also summarized by guilds, also known as functional groups (designations per the USDA Plants database; Leis et al. 2022; USDA NRCS 2017). Guild assignments were grasses, forbs, grass-like (species including sedges and rushes), vines, and woody species for both native and nonnative 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. We also summarized nonnative species trends using mean cover values for each monitoring event.

Observer Error

We assessed errors in observing the ground flora with a double sampling method. At four of the seven monitoring sites, after the transects were read, one subplot from each of the two transects was randomly chosen for resampling. Sampling teams switched transects and sampled the ground flora in the randomly chosen subplot. Pseudoturnover was calculated by comparing the two species lists from each subplot and identifying species that were overlooked (a species was recorded by one observer but not the other), misidentified (the same specimen was apparently recorded as different species by the two observers), or recorded at different specificity levels (i.e., cautious errors; one observer identified a plant to species and the other identified it only to genus).

Pseudoturnover was calculated as in Nilsson and Nilsson (1985):

$$\frac{A + B}{S_A + S_B} \times 100$$

where A was the number of species recorded exclusively by observer 1, B was the number of species recorded exclusively by observer 2, S_A was the total number of species recorded by observer 1, and S_B was the total number of species recorded by observer 2. Pseudoturnover is expressed as a percentage.

Statistical Analysis

Descriptive (graphical) analyses of ground cover and nonnative plants included all seven sites over three monitoring events (21 total observations) to obtain more precise parameter estimates.

Vegetation summaries were calculated in Minitab version 20.1.3 (Minitab Statistical Software 2020) and RStudio (R Core Team 2024; Wickham et al. 2019). A non-parametric Friedman ranked sums test was used to determine whether there were any statistical differences in canopy cover among monitoring events. Statistical significance was assessed at the $\alpha = 0.05$ level.

Results/Discussion

Environment

Hot Springs National Park, Arkansas, has historically oscillated between periods of drought and moisture (Figure 3). Our first two years of monitoring, 2007 and 2014, were below average, while 2024 was wetter than average.

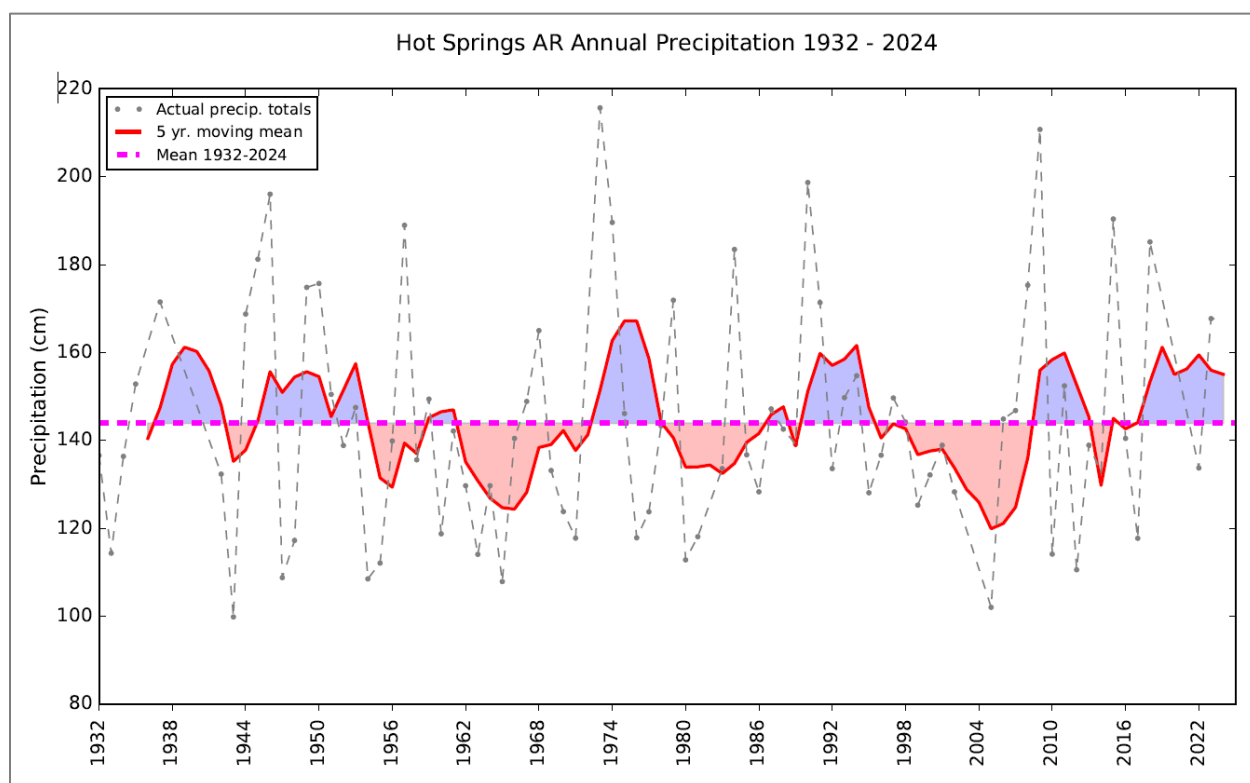


Figure 3. Annual precipitation for Hot Springs National Park, Arkansas, 1935–2024. The moving mean was based on a 5-year moving window. The running average includes the current year and four prior years.

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In 2024, the winter months were similar or above the 1981–2010 averages, while summer months were drier than normal (Figure 4). Unfortunately, July data (the month we completed surveys) was unavailable. Maximum temperatures for the year were very similar to historical averages, except for later in the year when it was warmer (October–December). However, it is of note that minimum temperatures were warmer than the 1981–2010 averages for the whole year, except for January. Warmer minimum temperatures are an important factor in understanding change over time. Extreme precipitation events have increased with 37% of rain falling in the heaviest events (CCRP 2024).

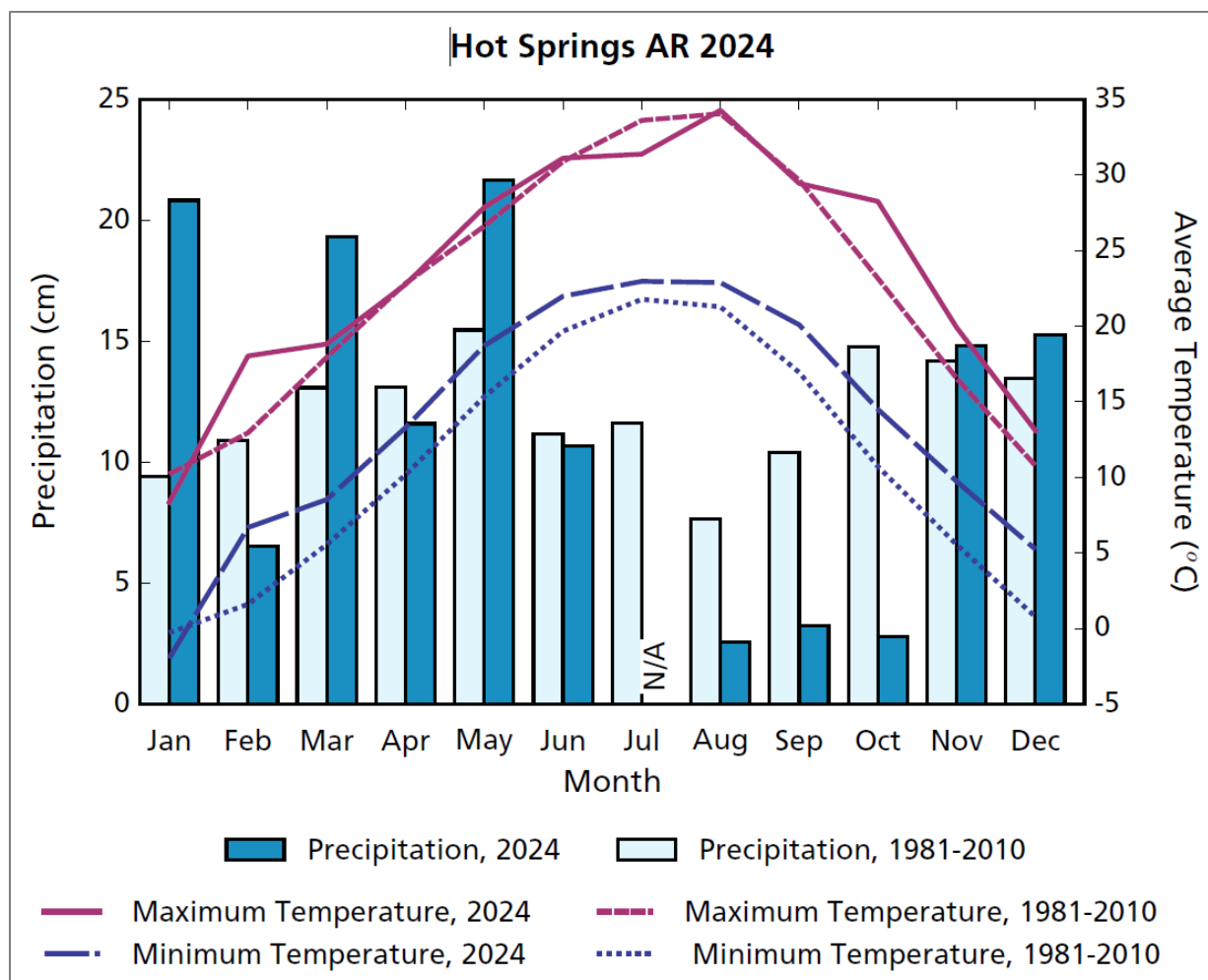


Figure 4. Precipitation and temperature for Hot Springs National Park, Arkansas in 2024 compared to 30-year normals (1981–2010).

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Midstory and Overstory Trees

The most commonly occurring trees at Hot Springs National Park were black hickory (*Carya texana*), black cherry (*Prunus serotina*), and winged elm (*Ulmus alata*; Appendix A). Interestingly, the characteristic oak species were slightly less pervasive; both red and white oak (*Quercus rubra* and *Q. alba*) were present in 57% of sites.

Canopy Closure

Canopy closure ranged from 83.8–95.7% across the three years. The canopy structure is characterized as a closed oak woodland for the sites as a group (Table 4; Hanberry et al. 2014). Canopy closure was not significantly different ($p < 0.05$) across the three years (Friedman chi-squared = 5.4, $df = 2$, $p = 0.07$). Although oak woodland types characteristically include variability in canopy characteristics, management goals include a more open structure (Drees and Ladner 2023).

Table 4. Mean midstory and overstory canopy closure at Hot Springs National Park, Arkansas, 2007–2024. CI = confidence interval.

Year	Mean Canopy Closure (%)	CI (95%)
2007	93.8	91.9–95.7
2014	88.8	83.8–93.7
2024	92.6	88.9–93.3

Basal Area

Mean basal area of live trees continues to increase but wide confidence intervals overlap, signaling variability across sites (Table 5). Although basal area for most size classes of live trees was similar across monitoring years, class 1 trees were more abundant in 2014 and 2024 than in 2007 (Figure 5; Leis 2017). Live class 5 trees were the most variable across the sites, and trees in that class were less common than typically expected.

Table 5. Mean midstory and overstory basal area (m²/ha) at Hot Springs National Park, Arkansas, 2007–2024 (N = 7). CI = confidence interval.

Year	Status (Live/Dead)	Mean Basal Area (m ² /ha)	CI (95%)
2007	Live	19.1	14.9–23.3
2014	Live	21.4	16.2–26.7
2024	Live	22.7	17.6–27.7
2007	Dead	1.7	0.4–3.0
2014	Dead	3.5	0.5–6.6
2024	Dead	2.4	1.3–3.4

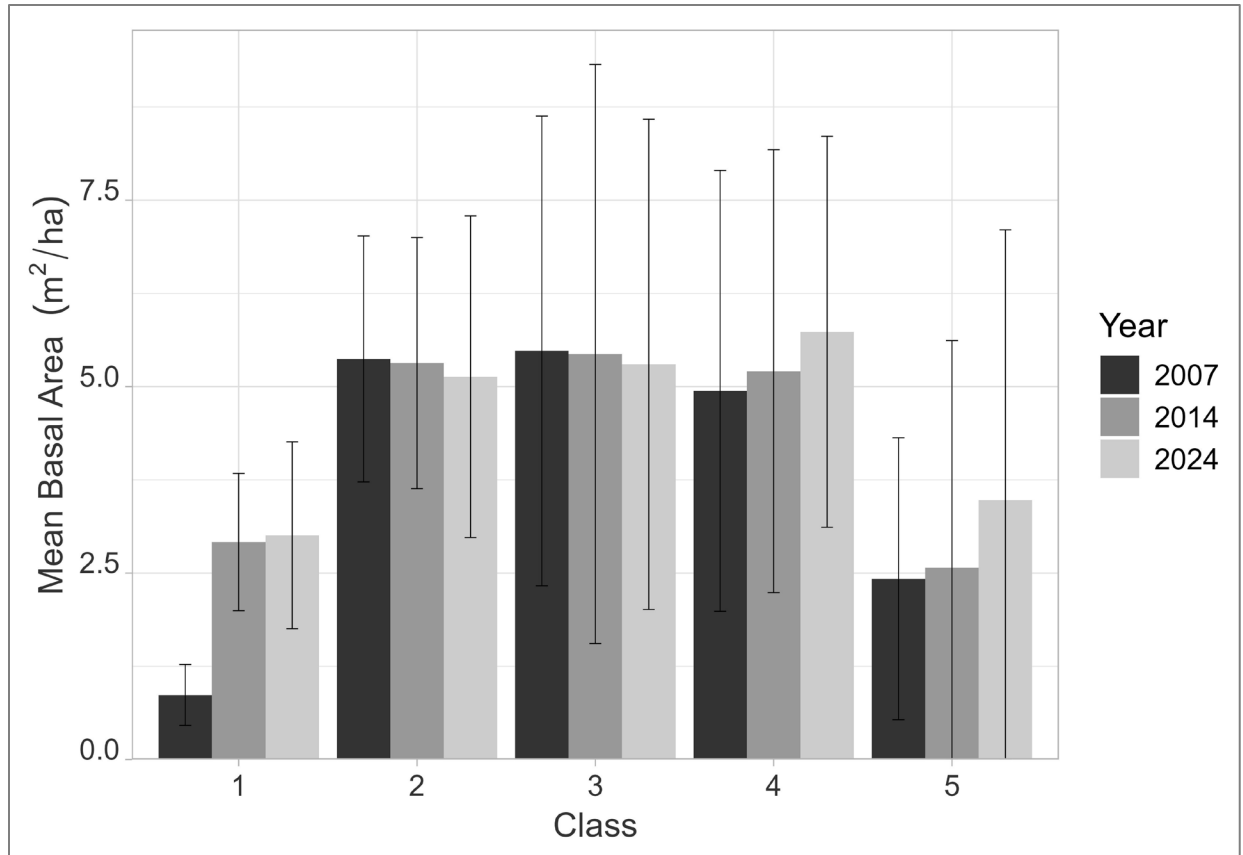


Figure 5. Basal area (m²/ha) of live overstory trees at Hot Springs National Park by size class and year. The largest trees are class 5. Error bars are 95% confidence intervals.

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Dead trees (snags) were a small component of standing trees comprising 8, 14, and 10% of the basal area of all trees in 2007, 2014, and 2024, respectively (Figure 6). Dead tree basal area was within the range observed in oak forests in the Missouri Ozarks (Shifley et al. 1997). We noted that with the increase of class 1 live trees there was an accompanying increase in mortality of class 1 trees over time. The mortality in young trees commonly occurs as forests become denser resulting in self-thinning (Woodall and Westfall 2009).

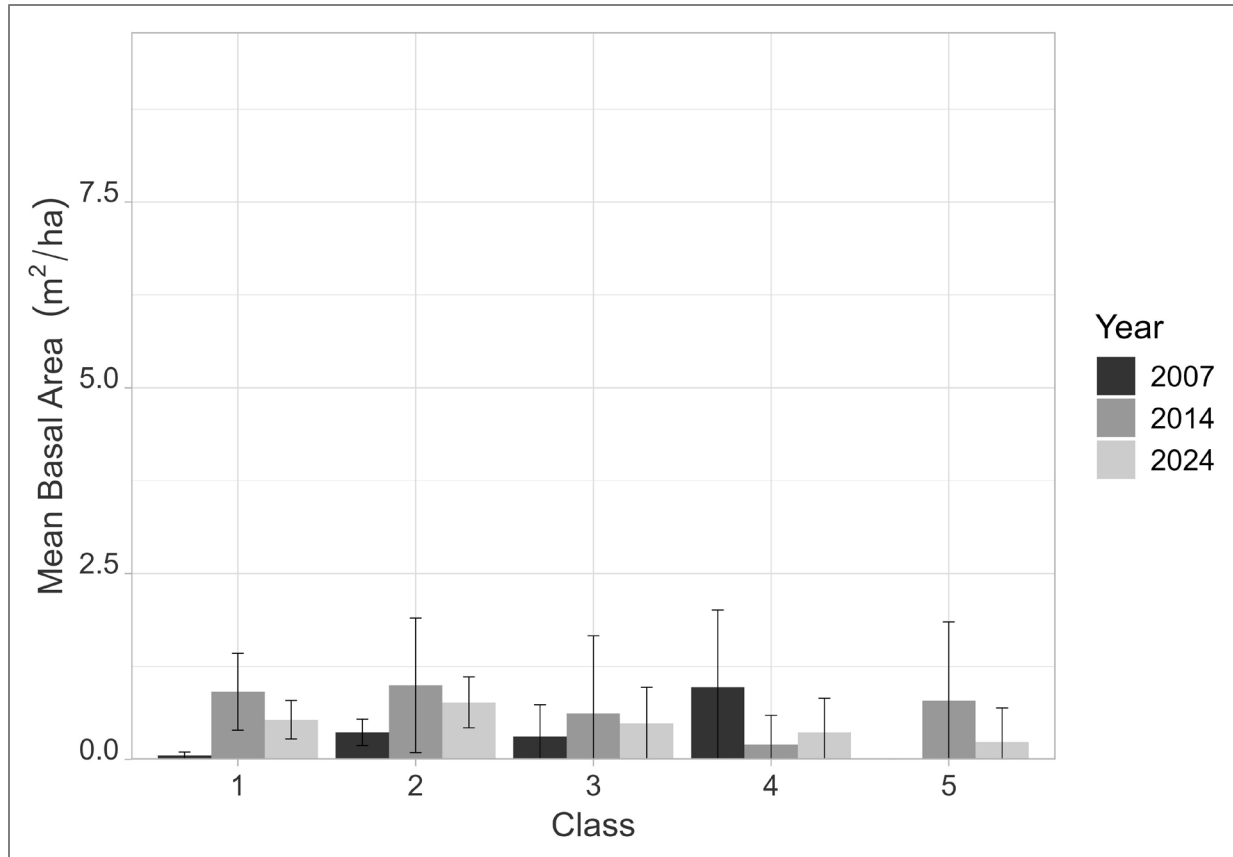


Figure 6. Basal area (m²/ha) of dead overstory trees at Hot Springs National Park by size class and year. The largest trees are class 5. Error bars are 95% confidence intervals.

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Change in live basal area by species indicated shifting composition (Figure 7). Black hickory and white oak notably increased in composition. These species are characteristic of dry, oak hickory forests of the region. However, increases from more mesic trees such as sweetgum (*Liquidambar styraciflua*), blackgum (*Nyssa sylvatica*), and black cherry (*Prunus serotina*) are more concerning. Coupled with losses from three species of oak, there may be indications of forest mesophication on the horizon (Nowacki and Abrams 2008). The increasing precipitation coupled with closed canopy conditions could be beginning to favor the more mesic cohort of species. Future monitoring is critical for tracking this trend. Management interventions, such as fire and tree cutting, to reopen the canopy to create more open woodland conditions could influence the transition in favor of the more xerically adapted species.

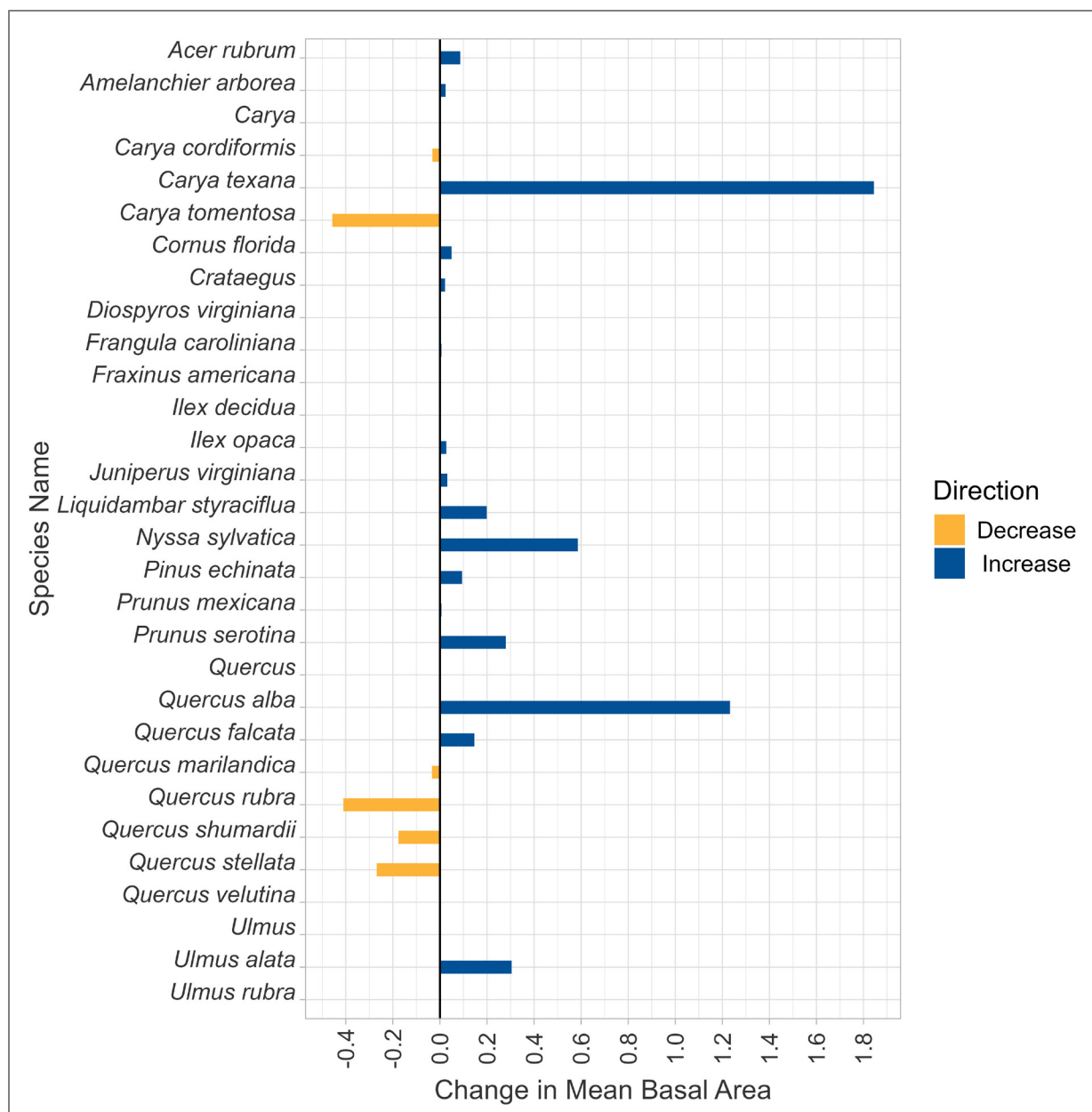


Figure 7. Change in tree species basal area (m²/ha) for monitoring sites at Hot Springs National Park, Arkansas (2024–2007). Appendix A includes a list of the species with common names.

NPS

Density

Live stem density increased over the monitoring record by 348.6 stems/ha; however, the confidence interval in 2024 (489.3 stems/ha) was wider than the mean stem density observed in 2007 (420 stems/ha; Table 6). Although all monitoring sites increased in stem density from 2007 to 2024, site 3 notably increased by 890 stems/ha (from 340 stems/ha to 1230 stems/ha). Stem increases were observed almost exclusively in class 1 trees (Figure 8). Fire management objectives targeted class 1

trees for a 20% reduction. Our data indicate that the forest as a whole did not respond to treatments, but fire effects monitoring indicated otherwise (Drees and Ladner 2023).

Table 6. Mean midstory and overstory stem density (stems/ha) at Hot Springs National Park, Arkansas, 2007–2024 (N = 7). CI = confidence interval.

Year	Status (Live/Dead)	Stem Density (stems/ha)	CI (95%)
2007	Live	420	312.4–527.6
2014	Live	690	539.4–840.6
2024	Live	768.6	523.9–1013.2
2007	Dead	31.4	14.3–48.5
2014	Dead	160	45.8–274.2
2024	Dead	111.4	67.8–155.1

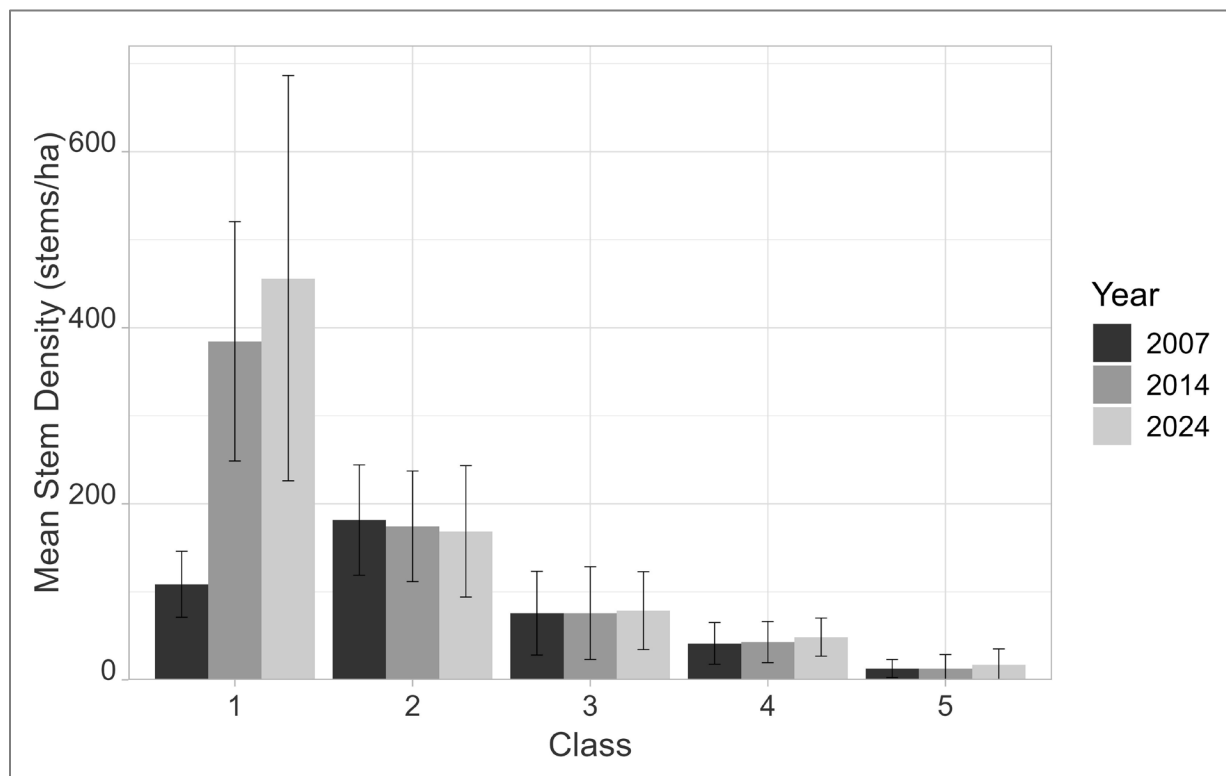


Figure 8. Live midstory and overstory stem density (stems/ha) at Hot Springs National Park by size class and year. The largest trees are class 5. Error bars are 95% confidence intervals.

NPS

The proportion of dead trees ranged from 7 to 19% across the three monitoring years, but the ratio of dead to live trees remained low (0.07, 0.21, and 0.14 for 2007, 2014, and 2024, respectively). Spetich and Guldin (1999) suggested that a healthy ratio of dead to live trees in Arkansas forests was 0.089

(0.080–0.098, 95% CI) and ratios > 0.1 should prompt further analysis. The forests at Hot Springs National Park had recommended levels of dead stems in 2007, but dead stems exceeded the recommended 95% confidence interval in the other years (Figure 9). We cannot determine the cause of the increase in dead stems. The pattern for individual sites is not consistent with the known fire history, and other disturbances—such as windthrow events—in the sites are unknown. The increase in snags may be related to natural stand exclusionary processes since more class 1 trees died than other classes, but more monitoring will be needed to better understand the pattern.

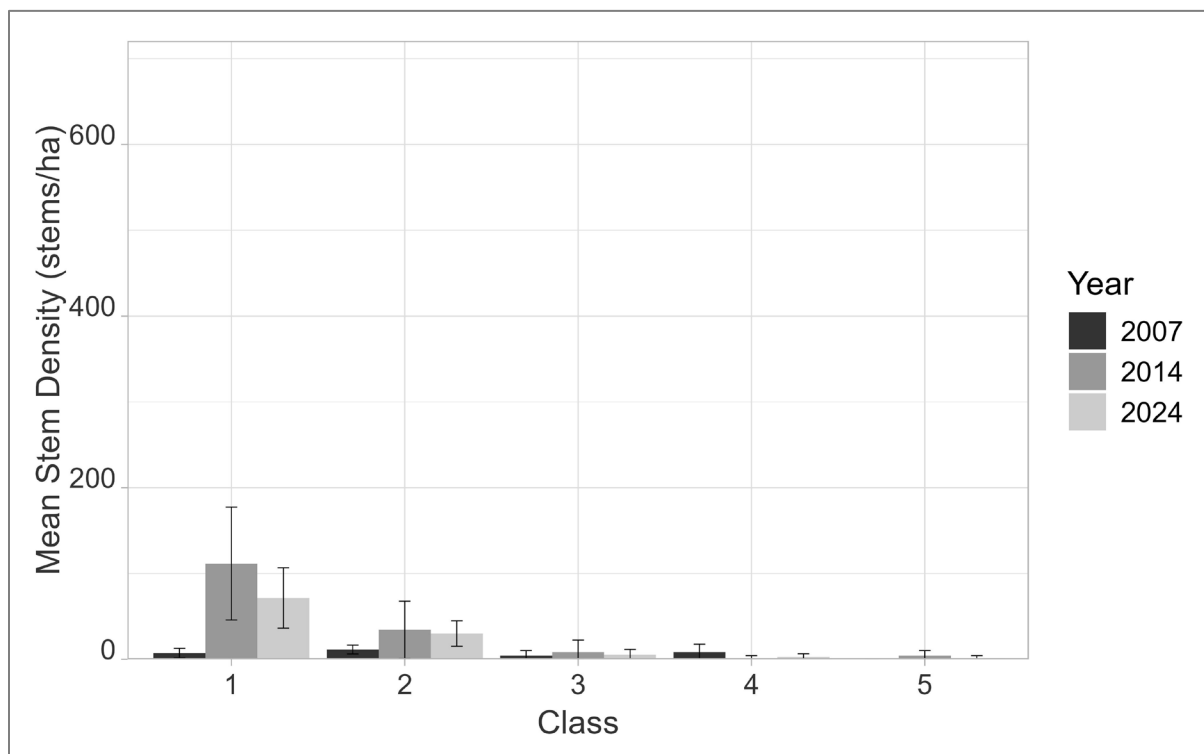


Figure 9. Dead midstory and overstory stem density (stems/ha) at Hot Springs National Park by size class and year. The largest trees are class 5. Error bars are 95% confidence intervals.

NPS

Tree stem density appears to have increased over time in the forest at Hot Springs National Park. Tree species occurrence is provided in Appendix A. Although the fire effects program documented declines in the density of pole-sized trees, we didn't observe this trend at the park level (Drees and Ladner 2023). Using canopy and basal area, the forest structure as a whole ranges between closed oak woodland and an oak forest type (Hanberry et al. 2014). However, the stem density exceeds those in the determination chart for any of the woodland types.

In terms of tree species composition as understood by stem density, trends were similar to those we described for basal area (Figure 10). We did note that while basal area of shortleaf pine trees increased slightly, stem density of this characteristic species declined.

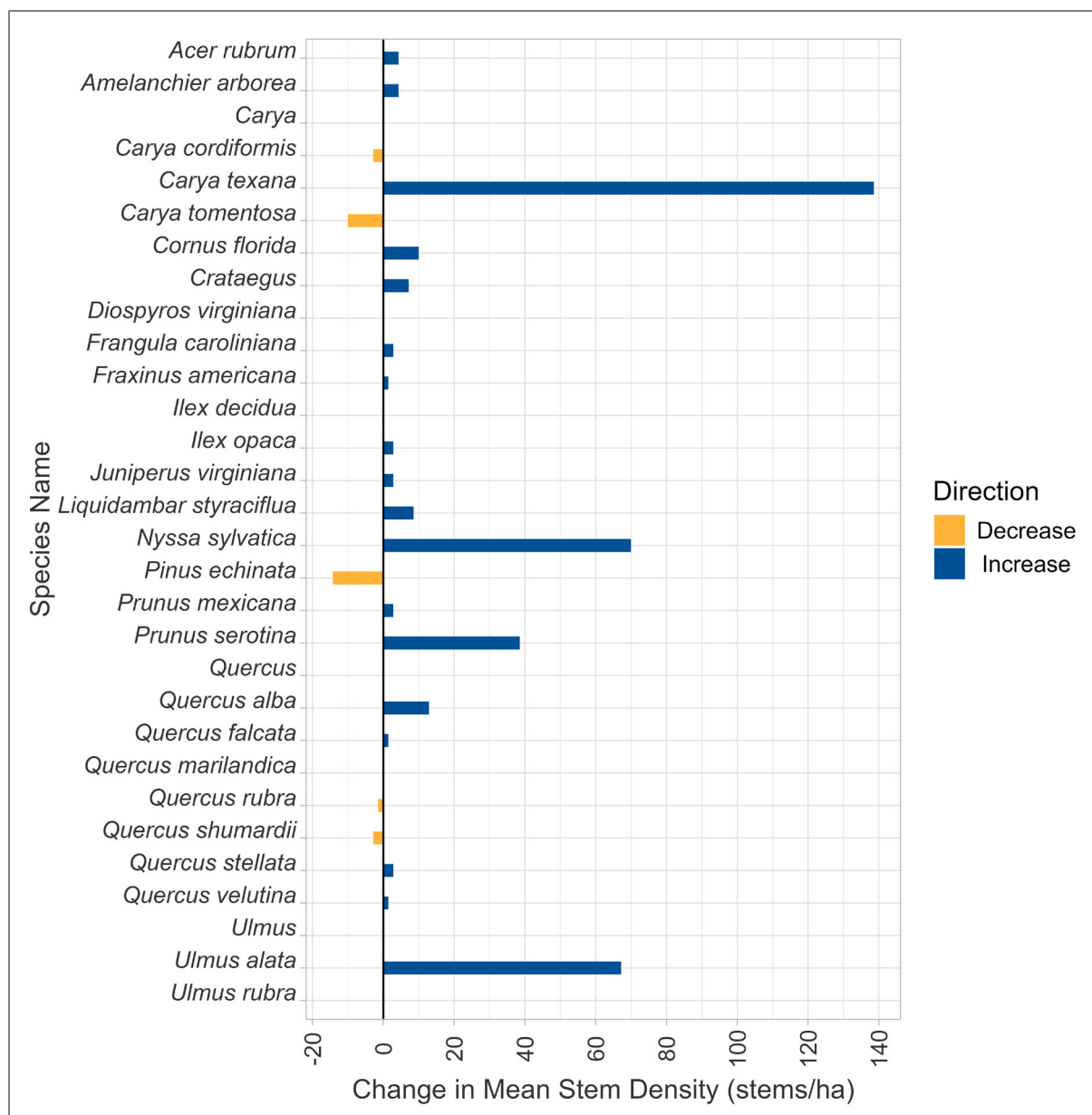


Figure 10. Change in tree species density at monitoring sites in Hot Springs National Park, Arkansas (2024–2007).

NPS

Ground Cover

Ground cover was mostly unvegetated types across all years in large part because of pervasive leaf litter, but 2024 included more vegetated cover than other years (Figure 11). Litter depth was measured at Hot Springs National Park for the first time in 2024. Mean litter depth was 2.8 cm (± 0.25 SE). Although litter was shallow, it covered most of the plot areas (Figure 11).

Sites 2 and 7 had notably more vegetated cover than other sites in 2024. Both sites experienced prescribed fire since the last monitoring event that may have reduced litter and stimulated plant

productivity. Drees and Ladner reported progress toward the goal of increasing vegetated cover by 20% (18.6% achieved, 2023), but we found a great deal of variability in 2024. Drees and Ladner reported increases in vegetation of 455% in the fire effects macroplots (2023).

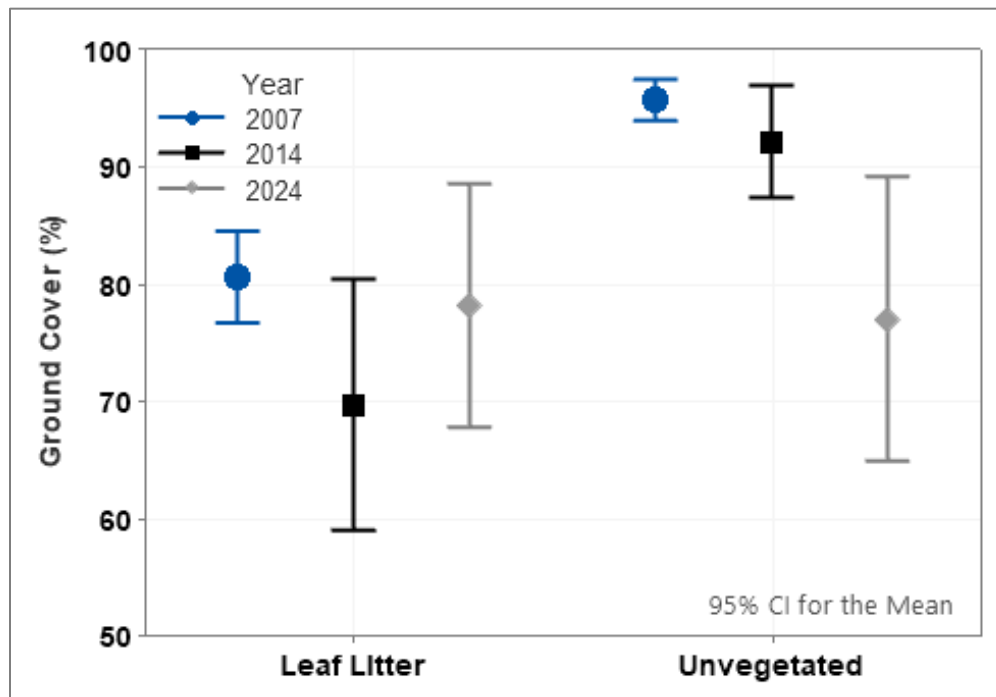


Figure 11. Mean ground cover (%) observations for deciduous leaf litter and all unvegetated components (including leaf litter) at Hot Springs National Park, 2007–2024. Bars are 95% confidence intervals.

NPS

Variability of some ground cover types increased through time (bare rock, bare soil, and grass litter). The reduction in leaf litter likely facilitated revealing other types of ground cover. Woody debris also declined at most sites (Figure 12).

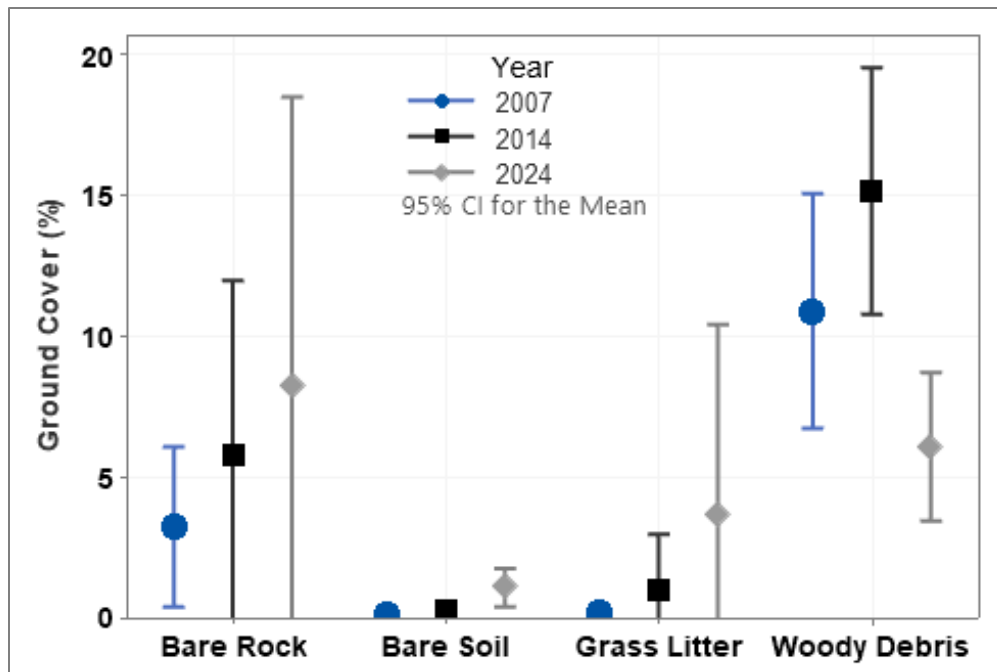


Figure 12. Mean ground cover (%) observations for bare rock, bare soil, grass litter, and woody debris at Hot Springs National Park, 2007–2024. Bars are 95% confidence intervals.

NPS

Guild

Tree Regeneration

We report tree regeneration in three size classes: seedlings, small saplings, and large saplings.

Although seedlings were consistently abundant, recruitment to later phases was limited (Figure 13).

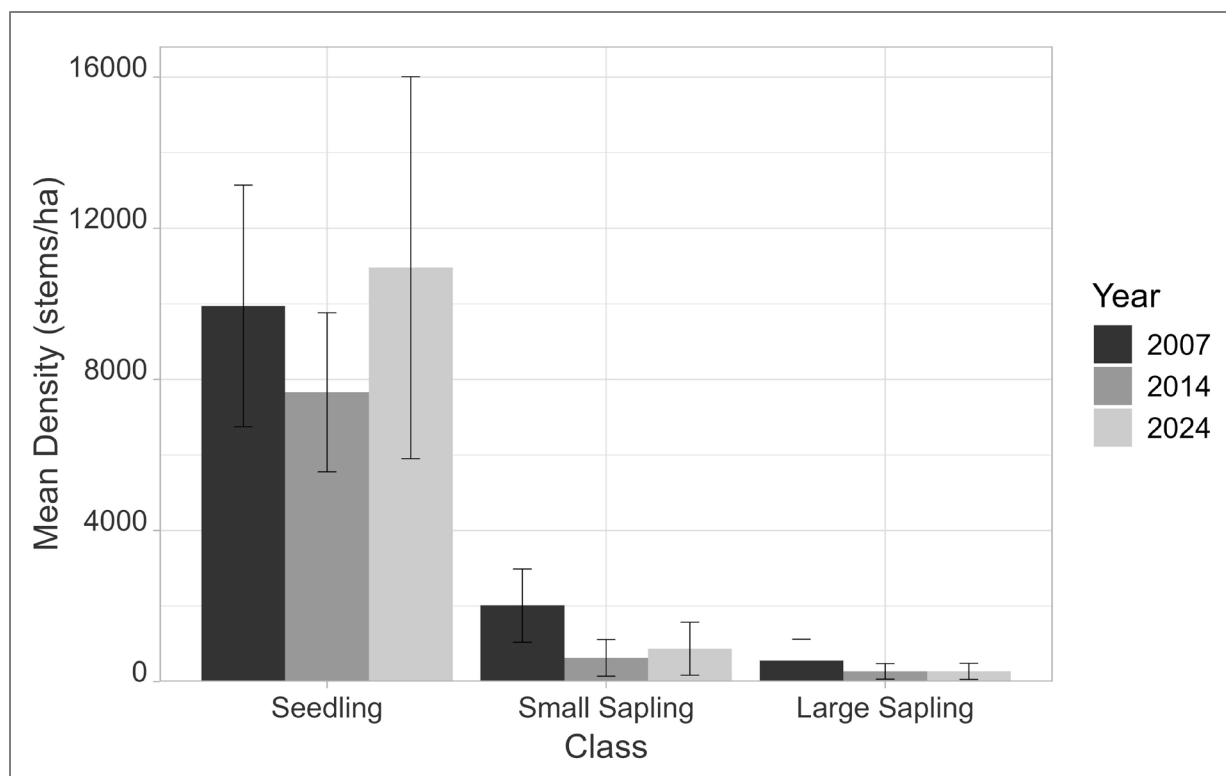


Figure 13. Mean stem density (stems/ha) for tree regeneration size classes at Hot Springs National Park, Arkansas, 2007–2024.

NPS

We compared the 2007 species level regeneration observations with the most recent observations (Figures 14–16) to understand whether regeneration species composition changed over time. Carolina buckthorn (*Frangula caroliniana*) was the most abundant species in the seedling and small sapling phases for 2024, but hickories were most abundant in the large sapling phase. Site 6 had most of Carolina buckthorn regeneration observations. We noted that Carolina buckthorn also increased in the overstory data. Hickory regeneration was the most abundant across phases in other years and second most abundant in 2024. However, hickory saplings have declined since the baseline observations in 2007. We noted that eastern hophornbeam (*Ostrya virginiana*), despite being absent in the midstory and overstory, has been increasing in all regeneration classes, though it was primarily represented in two monitoring sites through time (Figure 14). These two sites are flat areas in proximity to riparian corridors, making them preferred habitat for eastern hophornbeam (Metzger 1990). It is not clear what stimulated the increase, but we also noted that hophornbeam seedlings were transitioning to the later regeneration phases at site 1.

Of management concern, we found eastern redcedar (*Juniperus virginiana*) seedlings in four of the sites in 2024, whereas only one site had them previously. Site 2 had one seedling in 2007, but none later. There was a small increase in overstory basal area and stem density of eastern redcedar as well. This species is fire sensitive and can readily be controlled during regeneration phases with burning (Van Auken 2008; Wright and Bailey 1982).

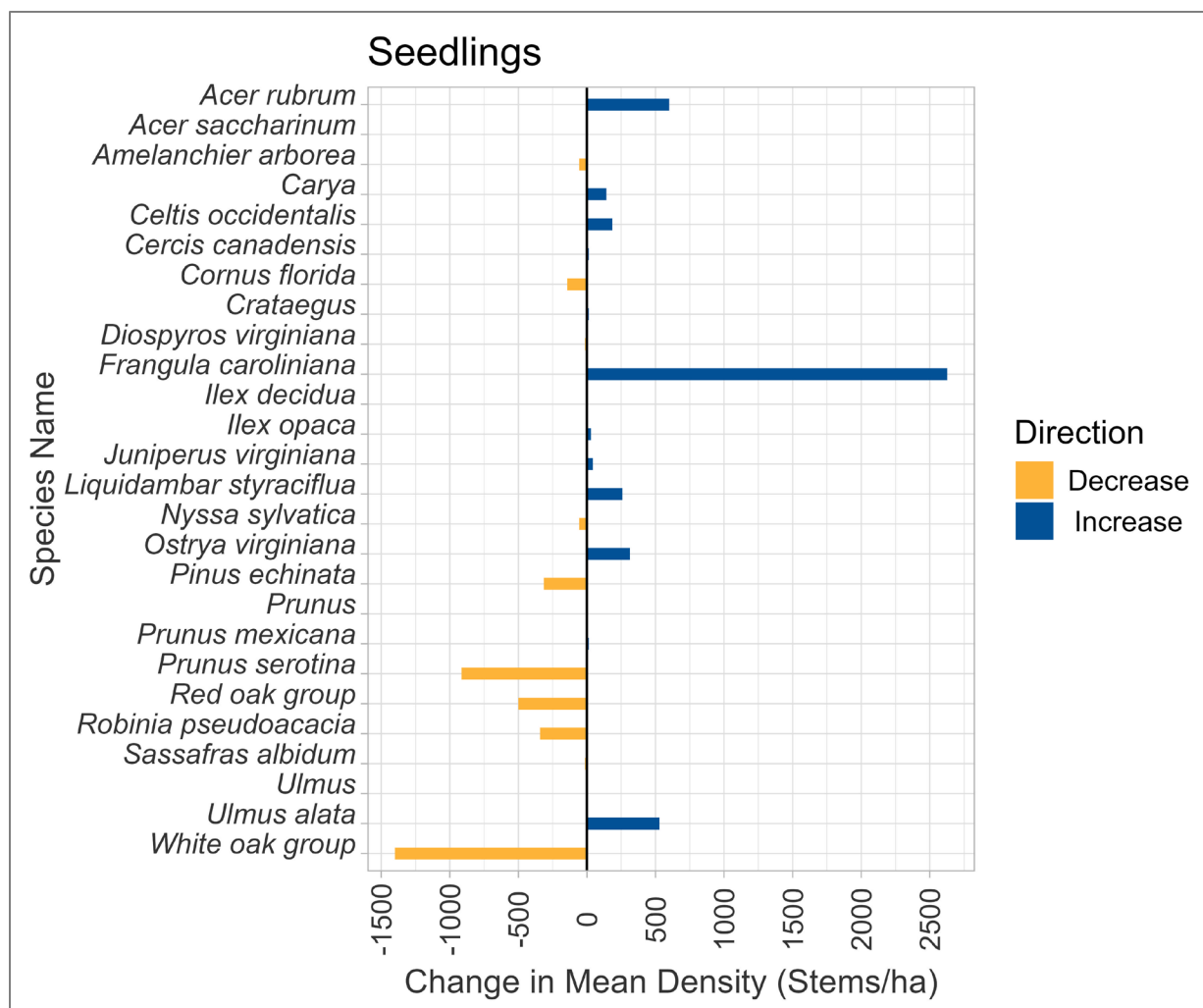


Figure 14. Change in tree regeneration density (mean stems/ha) in the seedlings class between baseline (2007) and the most recent observations (2024). Species with no bar were not present in 2007.

NPS

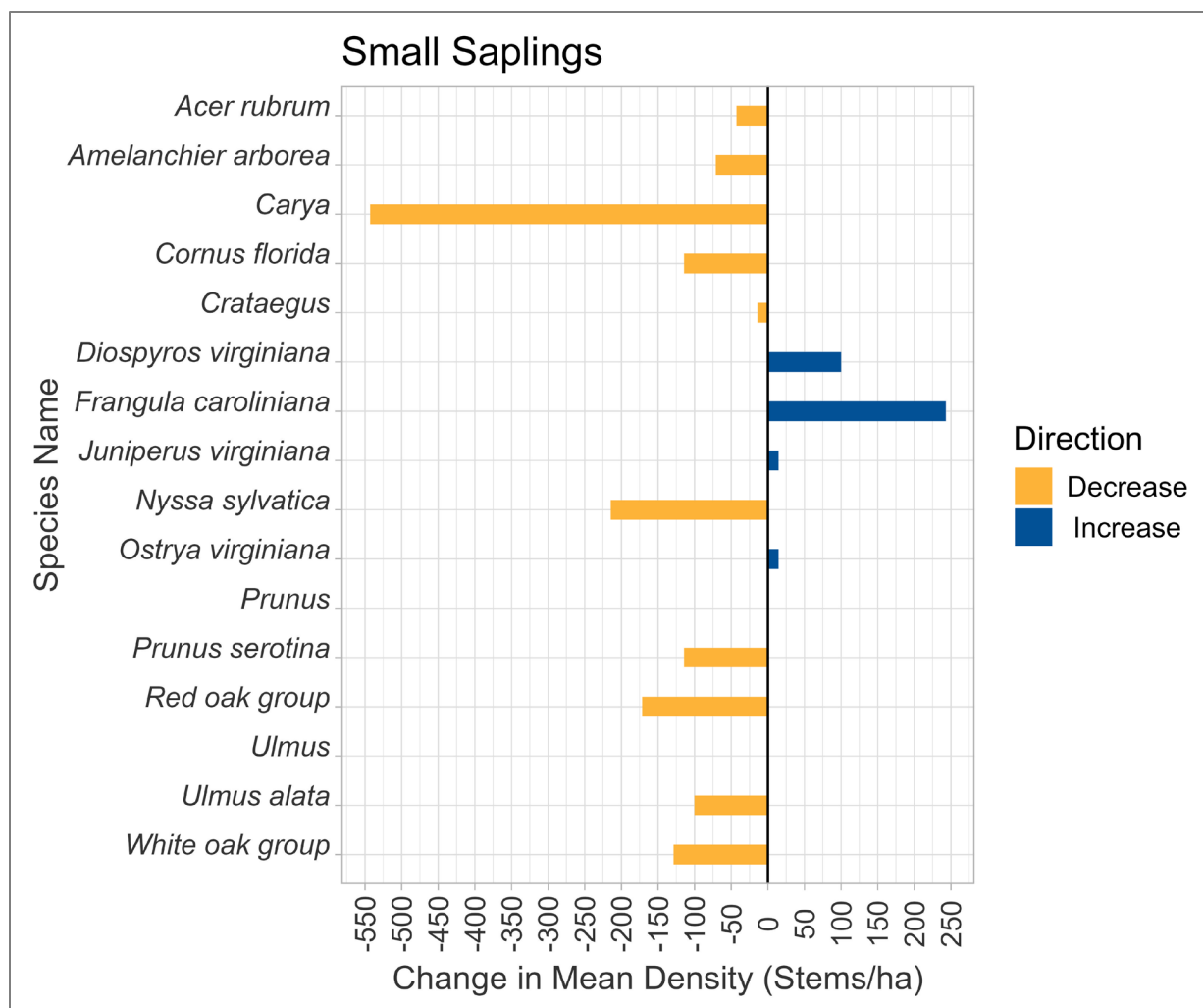


Figure 15. Change in tree regeneration density (mean stems/ha) in the small saplings class between baseline (2007) and the most recent observations (2024). Species with no bar were not present in 2007.
NPS

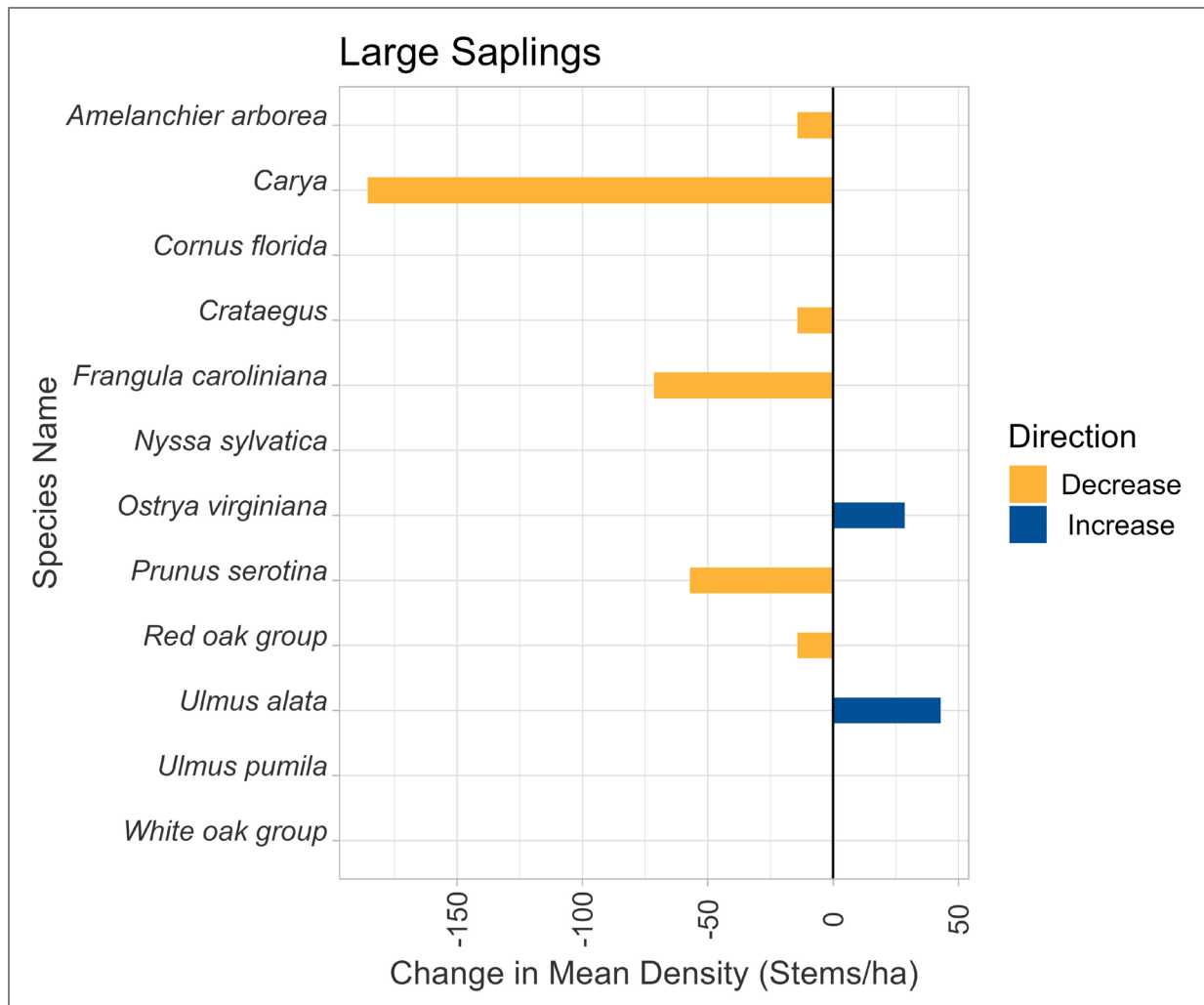


Figure 16. Change in tree regeneration density (mean stems/ha) in the large saplings class between baseline (2007) and the most recent observations (2024). Species with no bar were not present in 2007.
NPS

Native Ground Flora

Native vines and ferns were the least abundant plants through time (Figure 17). Grass-like plants had greater mean cover in 2024 than in other years but varied among sites. Site 4 had the greatest grass-like cover (*Carex* spp. cover was 4.1% in 2024 at site 4).

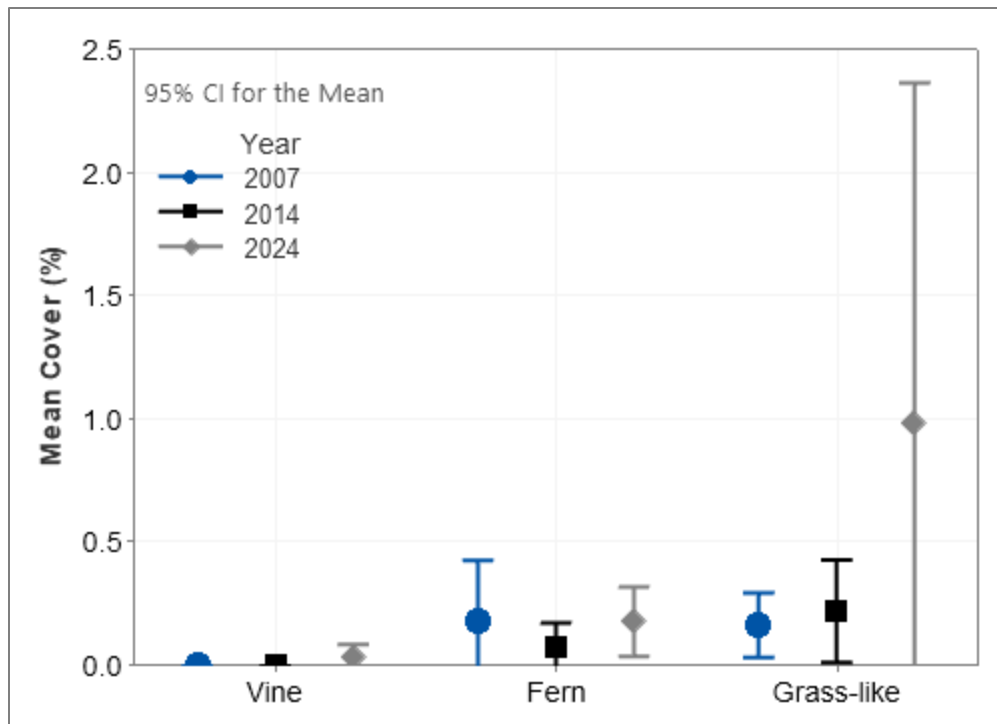


Figure 17. Mean cover for native ground flora guilds with mean cover < 1%. Vines, ferns, and grass-like plants are a small portion of the native flora at Hot Springs National Park, Arkansas, 2007–2024.

NPS

Plant species cover a small proportion of the ground within the monitoring sites at Hot Springs National Park. Grass cover at site 2 increased notably over time (4%, 24%, and 40% cover for 2007, 2014, and 2024, respectively; Figure 18). We noted that site 2 had been burned at least two times since monitoring began, whereas other sites were burned less often if at all. Although prescribed burning may have contributed to the increase in grasses, we do not know if other factors contributed to the trend. Woody plants were the most abundant in terms of percent cover in 2024, but grasses and woody plants were variable. Site 5 had the most woody plants (28% cover) while the other sites varied from 1–15% cover in 2024.

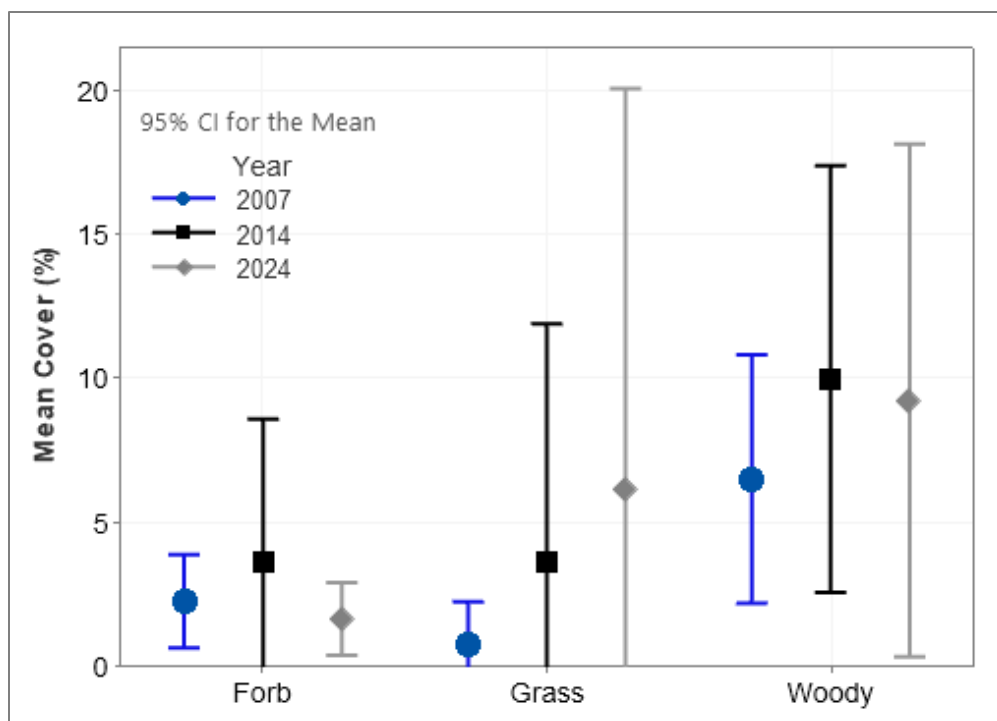


Figure 18. Mean cover for native ground flora guilds with mean cover > 1% (forbs, grasses, and woody plants) at Hot Springs National Park, Arkansas 2007–2024.

NPS

Nonnative Plants

Nonnative plants were rarely observed in the monitored years. Only four species were detected across 43% of the sites, but site 3 had more detections than other sites (Table 7). Furthermore, sacred bamboo (*Nandina domestica*) is the most problematic of the nonnative species detected, having more than doubled since 2014. In addition to increasing in abundance, frequency of this species increased from 50 to 80% of the plots in site 3 from 2014 to 2024, respectively.

Table 7. Nonnative species detected in monitoring sites at Hot Springs National Park, Arkansas, 2007–2024 (N = 7).

Species	Common Name	Year Detected	Site	Mean Plot Cover (%)
<i>Lactuca serriola</i>	prickly lettuce	2007	2	0.05
<i>Lonicera</i> sp.	honeysuckle	2007	6	0.05
<i>Nandina domestica</i>	sacred bamboo	2014	3	0.95
<i>Nandina domestica</i>	sacred bamboo	2024	3	2.35
<i>Kummerowia striata</i>	Japanese clover	2024	3	0.05

Diversity

Species Diversity

Mean species richness was similar through time (Table 8). We noted that site 2 in 2024 had the greatest species richness across monitoring sites and years, 36 species. Two prescribed fire events in the site over the history of monitoring may have stimulated the ground flora growth. However, the park as a whole did not meet the objective of increasing species richness from the initial monitoring period (Drees and Ladner 2023).

Table 8. Mean plant species richness for ground flora at Hot Springs National Park, Arkansas, 2007–2024 (N = 7).

Year	Mean Species Richness	CI (95%)
2007	22.0	17.8–26.2
2014	20.1	12.8–27.5
2024	22.4	15.2–29.6

Mean measures of diversity (Shannon’s Index H' and evenness J') were similar through time (Figure 19). We did note that confidence intervals were smaller in 2007 than in other years.

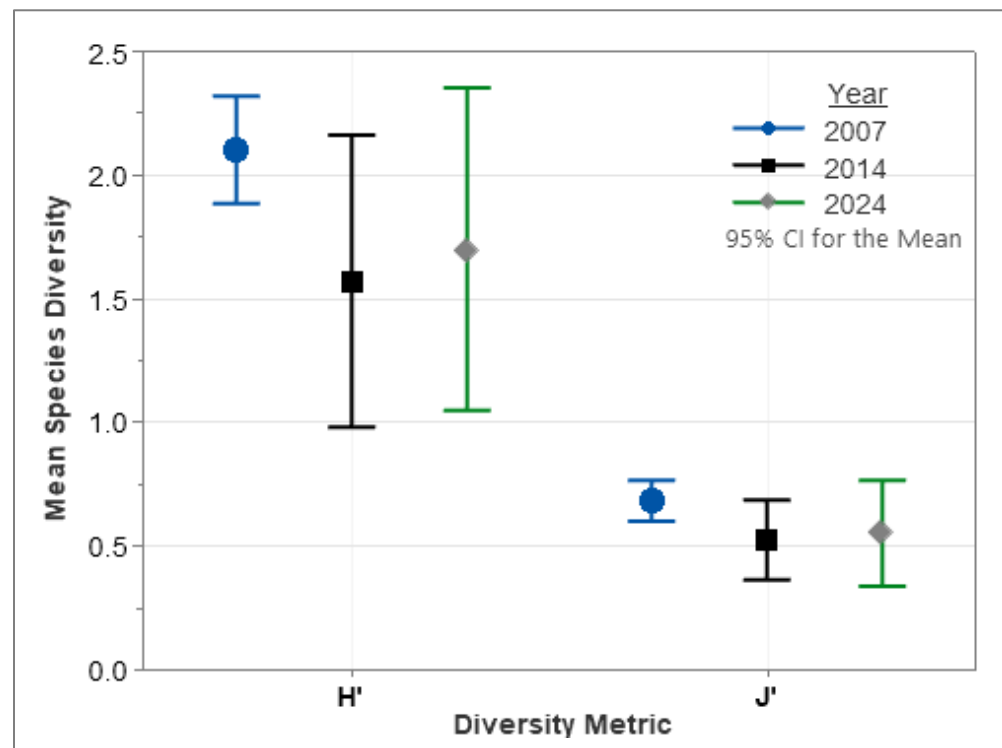


Figure 19. Mean plant species diversity of ground flora in plant community monitoring sites at Hot Springs National Park, Arkansas, 2007–2024 (N = 7).

NPS

Community Diversity

Although alpha diversity (mean site richness) was similar among years, gamma diversity (park-level species richness) was greatest in 2024 by more than 15 species (Table 9). Consequently, beta diversity (heterogeneity across sites) increased slightly; the increase in species at site 2 likely contributed to the gamma diversity increase. We also had an expert botanist on the crew in 2024 that could have contributed to improved species recognition. Another source for the increase in gamma diversity resulted from observers inexperienced with the protocol. Historically, Heartland Network observers have lumped species of the rosette grasses genus (*Dichanthelium*); however, one of the 2024 botanists recorded those observations to species level. The genus was represented by five individual species in 2024. Accounting for those five species, gamma diversity in 2024 was still greater than in other years (66 species). The discrepancy may have affected the mean species richness (alpha diversity) calculations as well, but the effect didn't result in a change in interpretation.

Table 9. Plant community diversity metrics for ground flora at Hot Springs National Park, Arkansas, 2007–2024. (N = 7).

Community Diversity Measure	2007	2014	2024
Alpha (Mean site Richness)	22	20.1	22.4
Gamma (Park richness)	58	56	71
Beta (Heterogeneity)	1.6	1.8	2.1

Observer Error

Observer error for the ground flora community was measured for the first time in 2024 (Table 10). Observer error has multiple components. In this study, we quantified overlooking error (i.e., when a species was present but not noticed by an observer), misidentification error (i.e., when a species was noticed but incorrectly identified), and cautious error (i.e., when one observer lumped an observation to genus level and the other observer identified it to species). The greatest source of error came from misidentification of species by one of the observers (7.6%). Overlooking and cautious error were low (3.6% and 0%, respectively). Total pseudoturnover is a function of all three types of error and averaged 11.2% for the sampling event, resulting in 88.8% agreement (Table 10), which exceeded our goal of 80% based on a survey of the literature (Morrison 2016; Morrison et al. 2020). We have mitigated for sample frame relocation using flagging, but trampling from the first plot read may affect the second reader's ability to recognize the plants. We do not have a quantitative assessment of the contribution of this source of error.

Table 10. Observer error rates for 2024 at Hot Springs National Park, Arkansas (N = 8).

Error Component	Mean Error Rate (%)
Overlooking Error	3.6
Misidentification Error	7.6
Cautious Error	0.00
Total Pseudoturnover	11.2

Our rate of pseudoturnover was less than previously recorded at other monitoring sites (Morrison et al. 2024). We included a botanical expert on the team in 2024, and team members from prior years were not present on the team. Interestingly, overlooking errors tend to be greater than misidentification errors, but that was not the case at Hot Springs National Park in 2024.

We also assessed the amount of agreement in the cover classes for species that both observers recorded. Overall, on average there was 73.0% agreement in cover classes; 21.6% of observations were within one cover class and 5.4% of observations differed by > 1 cover class. This level of agreement falls within the range of what we have measured across five network parks (range: 73–85% agreement; Leis and Morrison 2022, 2024; Morrison et al. 2020).

Ground cover class assignments agreed for 70.8% of the observations and were within 1 cover class for 27.1% of the observations. Only 2.1% of observations differed by > 1 cover class (a single observation varying by 2 classes). This level of agreement met our goals. We compared litter depth estimates for the same eight plots. Litter depth measurements proved more difficult to replicate than other measurements. None of the observations were in exact agreement, while 37.5% of observations were within 1 cm. Most of the observations were within 2 cm (62.5%). While trampling during the first plot read could contribute to the discrepancies, we have not evaluated sources of this error.

Conclusions

The Heartland Network completed three monitoring events in the forest at Hot Springs National Park, Arkansas, over 17 years. Over this time, mean precipitation was most often wetter than average, and 2024 maximum temperatures were similar to 30-year normals, while 2024 minimum temperatures were warmer. This condition may lead to increased water stress for plants. Canopy closure continued to be in the closed range resulting in a closed woodland structure. We observed small changes in the trees. Mean live basal area was similar through time, but mean density was greater in 2014 and 2024. Class 1 trees were much denser in 2024 than prior years, although mean basal area of this class was similar in 2014 and 2024. Species increases included a mix of mesophytic and xeric species including shortleaf pine; however, five xeric species declined in basal area.

Decreases in litter cover and unvegetated cover reflected recent fire management actions. Observers noted that site 2 (burned twice) was very grassy and open. Increased observations of eastern redcedar in the overstory and regeneration suggest a need for more widespread prescribed fire at the park. Grass and woody plant guild cover had wide confidence intervals. However, mean grass cover was less in 2007. Species diversity metrics were similar through time, but community diversity indicated an increase in the number of species at the park and a tendency for more heterogeneity among the sites. Our observer error rates were low, providing confidence in the team's ability to replicate observations. Data presented here from the first three monitoring events serve as a strong foundation for evaluating change over time as we accumulate additional data in future years. Together with monitoring information from the fire ecology program, our monitoring data are important for informing forest management decisions.

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Appendix A. Abundance and Occurrence Data

Species lists in conjunction with percent occurrence and abundance data for the 2024 monitoring event are provided below (Tables 11 and 12).

Table 11. Ground flora species observed at Hot Springs National Park, Arkansas. (N = 7 sites). Values for mean cover, standard error (SE), and occurrence are only for 2024 (most recent monitoring event). N/A = species observed in prior monitoring years but not in 2024. N = native, I = nonnative.

Species	Common Name	Guild	Origin	2024 Mean Cover (%)	SE	Occurrence (% Sites Observed) 2024
<i>Acalypha gracilens</i>	slender threeseed mercury	forb	N	0.01	0.01	14
<i>Acalypha monococca</i>	Ozarkian short-stalk copperleaf	forb	N	N/A	N/A	N/A
<i>Amphicarpaea bracteata</i>	American hogpeanut	forb	N	0.06	0.04	29
<i>Andropogon virginicus</i>	broomsedge bluestem	grass	N	N/A	N/A	N/A
<i>Antennaria plantaginifolia</i>	woman's tobacco	forb	N	0.01	0.01	14
<i>Aristolochia serpentaria</i>	Virginia snakeroot	forb	N	0.03	0.01	43
<i>Aralia spinosa</i>	devil's walkingstick	woody	N	N/A	N/A	N/A
<i>Asclepias</i> sp.	milkweed	forb	N	N/A	N/A	N/A
<i>Asplenium platyneuron</i>	ebony spleenwort	fern	N	0.11	0.05	57
<i>Aster</i> sp.	aster	forb	N	N/A	N/A	N/A
<i>Berchemia scandens</i>	Alabama supplejack	vine	N	0.01	0.01	14
<i>Bignonia capreolata</i>	crossvine	vine	N	0.02	0.02	14
<i>Callicarpa americana</i>	American beautyberry	forb	N	0.01	0.01	14
<i>Camassia scilloides</i>	Atlantic camas	forb	N	N/A	N/A	N/A
<i>Carex</i> sp.	sedge	grass-like	N	0.96	0.56	100
<i>Chasmanthium sessiliflorum</i>	longleaf woodoats	grass	N	0.05	0.04	29
<i>Clitoria mariana</i>	Atlantic pigeonwings	forb	N	0.6	0.53	57
<i>Cocculus carolinus</i>	Carolina coralbead	woody	N	N/A	N/A	N/A
<i>Conyza canadensis</i>	Canadian horseweed	forb	N	N/A	N/A	N/A
<i>Coreopsis grandiflora</i>	largeflower tickseed	forb	N	0.01	0.01	14
<i>Cunila origanoides</i>	common dittany	forb	N	0.02	0.01	43
<i>Danthonia spicata</i>	poverty oatgrass	grass	N	0.06	0.05	29
<i>Desmodium</i> sp.	ticktrefoil	forb	N	0.01	0.01	29
<i>Desmodium nudiflorum</i>	nakedflower ticktrefoil	forb	N	N/A	N/A	N/A
<i>Diarrhena americana</i>	American beakgrain	grass	N	N/A	N/A	N/A
<i>Dichanthelium</i> sp.	rosette grass	grass	N	0.07	0.05	29
<i>Dichanthelium acuminatum</i>	tapered rosette grass	grass	N	0.01	0.01	14

Table 11 (continued). Ground flora species observed at Hot Springs National Park, Arkansas. (N = 7 sites). Values for mean cover, standard error (SE), and occurrence are only for 2024 (most recent monitoring event). N/A = species observed in prior monitoring years but not in 2024. N = native, I = nonnative.

Species	Common Name	Guild	Origin	2024 Mean Cover (%)	SE	Occurrence (% Sites Observed) 2024
<i>Dichanthelium boscii</i>	Bosc's panicgrass	grass	N	0.3	0.21	71
<i>Dichanthelium commutatum</i>	Variable panicgrass	grass	N	0.11	0.05	57
<i>Dichanthelium dichotomum</i>	Cypress panicgrass	grass	N	0.04	0.04	29
<i>Dichanthelium laxiflorum</i>	openflower rosette grass	grass	N	0.01	0.01	14
<i>Dichanthelium linearifolium</i>	slimleaf panicgrass	grass	N	0.01	0.01	29
<i>Dioscorea villosa</i>	wild yam	forb	N	0.08	0.05	29
<i>Erechtites hieraciifolia</i>	American burnweed	forb	N	0.01	0.01	14
<i>Euphorbia corollata</i>	flowering spurge	forb	N	0.04	0.02	43
<i>Galactia regularis</i>	eastern milkpea	forb	N	0.01	0.01	14
<i>Galium arkansanum</i>	Arkansas bedstraw	forb	N	0.01	0.01	14
<i>Galium circaezans</i>	licorice bedstraw	forb	N	N/A	N/A	N/A
<i>Helianthus divaricatus</i>	woodland sunflower	forb	N	N/A	N/A	N/A
<i>Helianthus hirsutus</i>	hairy sunflower	forb	N	0.01	0.01	14
<i>Heuchera americana</i>	American alumroot	forb	N	N/A	N/A	N/A
<i>Hieracium gronovii</i>	queendevil	forb	N	0.03	0.03	14
<i>Ilex vomitoria</i>	yaupon	woody	N	0.28	0.28	14
<i>Ipomoea</i> sp.	morning-glory	forb	N	0.01	0.01	29
<i>Iris cristata</i>	dwarf crested iris	forb	N	0.01	0.01	14
<i>Kummerowia striata</i>	Japanese clover	forb	I	0.01	0.01	14
<i>Lactuca canadensis</i>	Canada lettuce	forb	N	0.01	0.01	29
<i>Lactuca serriola</i>	prickly lettuce	forb	I	N/A	N/A	N/A
<i>Lathyrus venosus</i>	veiny pea	forb	N	N/A	N/A	N/A
<i>Lespedeza procumbens</i>	trailing lespedeza	forb	N	0.01	0.01	14
<i>Lespedeza repens</i>	creeping lespedeza	forb	N	0.06	0.04	43
<i>Lespedeza violacea</i>	violet lespedeza	forb	N	0.01	0.01	14
<i>Lonicera</i> sp.	honeysuckle	woody	I	N/A	N/A	N/A
<i>Menispermum canadense</i>	common moonseed	woody	N	N/A	N/A	N/A
<i>Mitchella repens</i>	partridgeberry	forb	N	0.01	0.01	14
<i>Monarda</i> sp.	beebalm	forb	N	N/A	N/A	N/A
<i>Monarda fistulosa</i>	wild bergamot	forb	N	0.09	0.06	29
<i>Monarda russeliana</i>	redpurple beebalm	forb	N	0.07	0.06	29
<i>Nandina domestica</i>	sacred bamboo	woody	I	0.34	0.34	14

Table 11 (continued). Ground flora species observed at Hot Springs National Park, Arkansas. (N = 7 sites). Values for mean cover, standard error (SE), and occurrence are only for 2024 (most recent monitoring event). N/A = species observed in prior monitoring years but not in 2024. N = native, I = nonnative.

Species	Common Name	Guild	Origin	2024 Mean Cover (%)	SE	Occurrence (% Sites Observed) 2024
<i>Oxalis</i> sp.	woodsorrel	forb	N	0.02	0.01	29
<i>Parthenocissus quinquefolia</i>	Virginia creeper	woody	N	0.1	0.02	86
<i>Passiflora lutea</i>	yellow passionflower	forb	N	0.06	0.04	43
<i>Phlox</i> sp.	phlox	forb	N	N/A	N/A	N/A
<i>Phlox pilosa</i>	downy phlox	forb	N	0.01	0.01	14
<i>Physalis virginiana</i>	Virginia groundcherry	forb	N	0.01	0.01	14
<i>Piptochaetium avenaceum</i>	blackseed speargrass	grass	N	5.36	5.24	57
<i>Pleopeltis polypodioides</i>	resurrection fern	forb	N	0.08	0.06	29
<i>Pteridium aquilinum</i>	western brackenfern	fern	N	0.06	0.06	29
<i>Rhus aromatica</i>	fragrant sumac	woody	N	0.04	0.04	14
<i>Ribes missouriense</i>	Missouri gooseberry	woody	N	N/A	N/A	N/A
<i>Rosa carolina</i>	Carolina rose	woody	N	N/A	N/A	N/A
<i>Rubus</i> sp.	blackberry	woody	N	0.02	0.01	29
<i>Ruellia pedunculata</i>	stalked wild petunia	forb	N	0.03	0.01	43
<i>Sanicula</i> sp.	sanicle	forb	N	N/A	N/A	N/A
<i>Schizachyrium scoparium</i>	little bluestem	grass	N	0.15	0.1	29
<i>Scleria oligantha</i>	littlehead nutrush	grass-like	N	0.02	0.02	14
<i>Scutellaria ovata</i>	heartleaf skullcap	forb	N	N/A	N/A	N/A
<i>Sideroxylon lanuginosum</i> ssp. <i>albicans</i>	gum bully	woody	N	N/A	N/A	N/A
<i>Smilax bona-nox</i>	saw greenbrier	woody	N	0.07	0.03	57
<i>Smilax glauca</i>	cat greenbrier	forb	N	0.16	0.07	71
<i>Smilax herbacea</i>	smooth carrionflower	forb	N	0.01	0.01	14
<i>Smilax rotundifolia</i>	roundleaf greenbrier	woody	N	0.01	0.01	14
<i>Smilax tamnoides</i>	bristly greenbrier	woody	N	N/A	N/A	N/A
<i>Solidago</i> sp.	goldenrod	forb	N	0.01	0.01	14
<i>Solidago nemoralis</i>	gray goldenrod	forb	N	0.01	0.01	14
<i>Solidago petiolaris</i>	downy ragged goldenrod	forb	N	0.01	0.01	14
<i>Solidago ulmifolia</i>	elmleaf goldenrod	forb	N	0.01	0.01	29
<i>Symphyotrichum anomalum</i>	Limestone heart-leaved wild aster	forb	N	0.02	0.01	29
<i>Symphoricarpos orbiculatus</i>	coralberry	woody	N	N/A	N/A	N/A

Table 11 (continued). Ground flora species observed at Hot Springs National Park, Arkansas. (N = 7 sites). Values for mean cover, standard error (SE), and occurrence are only for 2024 (most recent monitoring event). N/A = species observed in prior monitoring years but not in 2024. N = native, I = nonnative.

Species	Common Name	Guild	Origin	2024 Mean Cover (%)	SE	Occurrence (% Sites Observed) 2024
<i>Symphyotrichum patens</i> var. <i>patens</i>	Clasping wild aster	forb	N	N/A	N/A	N/A
<i>Toxicodendron radicans</i>	eastern poison ivy	woody	N	0.11	0.03	100
<i>Trachelospermum difforme</i>	climbing dogbane	vine	N	0.01	0.01	14
<i>Tradescantia hirsuticaulis</i>	hairystem spiderwort	forb	N	N/A	N/A	N/A
<i>Vaccinium</i> sp.	blueberry	woody	N	N/A	N/A	N/A
<i>Vaccinium arboreum</i>	farkleberry	woody	N	0.12	0.09	29
<i>Vaccinium pallidum</i>	Blue Ridge blueberry	woody	N	6.96	3.32	57
<i>Vaccinium stamineum</i>	deerberry	woody	N	0.07	0.05	57
<i>Viburnum rufidulum</i>	rusty blackhaw	woody	N	0.09	0.06	29
<i>Viburnum prunifolium</i>	blackhaw	woody	N	N/A	N/A	N/A
<i>Vicia caroliniana</i>	Carolina vetch	forb	N	0.01	0.01	14
<i>Viola</i> sp.	violet	forb	N	0.01	0.01	29
<i>Vitis</i> sp.	grape	woody	N	N/A	N/A	N/A
<i>Vitis aestivalis</i>	summer grape	woody	N	N/A	N/A	N/A
<i>Vitis rotundifolia</i>	muscadine	woody	N	1.36	0.53	100
<i>Woodsia obtusa</i>	bluntlobe cliff fern	fern	N	0.01	0.01	14

Table 12. Midstory and overstory trees observed at Hot Springs National Park, Arkansas (N = 7 sites). Values for occurrence are only for 2024 (most recent monitoring event). N/A = species observed in prior monitoring years but not in 2024. All trees were native species.

Species	Common Name	Occurrence (% Sites Observed) 2024
<i>Acer rubrum</i>	red maple	28.6
<i>Amelanchier arborea</i>	common serviceberry	14.3
<i>Carya</i> sp.	hickory	N/A
<i>Carya cordiformis</i>	bitternut hickory	N/A
<i>Carya texana</i>	black hickory	85.7
<i>Carya tomentosa</i>	mockernut hickory	28.6
<i>Cornus florida</i>	flowering dogwood	42.9

Table 12 (continued). Midstory and overstory trees observed at Hot Springs National Park, Arkansas (N = 7 sites). Values for occurrence are only for 2024 (most recent monitoring event). N/A = species observed in prior monitoring years but not in 2024. All trees were native species.

Species	Common Name	Occurrence (% Sites Observed) 2024
<i>Crataegus</i> sp.	hawthorn	28.6
<i>Diospyros virginiana</i>	common persimmon	N/A
<i>Frangula caroliniana</i>	Carolina buckthorn	14.3
<i>Fraxinus americana</i>	white ash	14.3
<i>Ilex decidua</i>	possumhaw	N/A
<i>Ilex opaca</i>	American holly	14.3
<i>Juniperus virginiana</i>	eastern redcedar	28.6
<i>Liquidambar styraciflua</i>	sweetgum	28.6
<i>Nyssa sylvatica</i>	blackgum	57.1
<i>Pinus echinata</i>	shortleaf pine	71.4
<i>Prunus mexicana</i>	Mexican plum	14.3
<i>Prunus serotina</i>	black cherry	85.7
<i>Quercus</i> sp.	oak	N/A
<i>Quercus alba</i>	white oak	57.1
<i>Quercus falcata</i>	Southern red oak	14.3
<i>Quercus marilandica</i>	blackjack oak	14.3
<i>Quercus rubra</i>	northern red oak	57.1
<i>Quercus shumardii</i>	Shumard's oak	N/A
<i>Quercus stellata</i>	post oak	42.9
<i>Quercus velutina</i>	black oak	14.3
<i>Ulmus</i> sp.	elm	N/A
<i>Ulmus alata</i>	winged elm	85.7
<i>Ulmus rubra</i>	slippery elm	N/A

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