National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Forest Community Monitoring Baseline Report, Pea Ridge National Military Park

Natural Resource Technical Report NPS/HTLN/NRTR—2008/082

ON THE COVER
Split rail fence at Pea Ridge National Military Park
HTLN staff photograph

Forest Community Monitoring Baseline Report, Pea Ridge National Military Park

Natural Resource Technical Report NPS/HTLN/NRTR—2008/082

Kevin James
National Park Service, The Heartland I&M Network and Prairie Cluster Prototype Monitoring Program
Wilson's Creek National Battlefield, 6424 West Farm Road 182, Republic, MO 65738

February 2008

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The Natural Resource Publication series addresses natural resource topics that are of interest and applicability to a broad readership in the National Park Service and to others in the management of natural resources, including the scientific community, the public, and the NPS conservation and environmental constituencies. Manuscripts are peer-reviewed to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and is designed and published in a professional manner.

The Natural Resource Technical Report series is used to disseminate the peer-reviewed results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service's mission. The reports provide contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations. Current examples of such reports include the results of research that addresses natural resource management issues; natural resource inventory and monitoring activities; resource assessment reports; scientific literature reviews; and peer reviewed proceedings of technical workshops, conferences, or symposia.

Views and conclusions in this report are those of the authors and do not necessarily reflect policies of the National Park Service. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

Printed copies of reports in these series may be produced in a limited quantity and they are only available as long as the supply lasts. This report is also available from the Heartland I&M Network website (http://www.nature.nps.gov/im/units/HTLN) on the internet, or by sending a request to the address on the back cover.

Please cite this publication as:

James, K. 2008. Forest Community Monitoring Baseline Report, Pea Ridge National Military Park. Natural Resource Technical Report NPS/HTLN/NRTR—2008/082. National Park Service, Fort Collins, Colorado.

NPS D-53, February 2008

Table of Contents

Page

Figures iv

Tables iv

Executive Summary 1

Introduction 2

Methods 3

Results 9

Discussion 17

Literature Cited 18

Appendix 20

Figures

Page

Figure 1. Map of Pea Ridge National Military park displaying vegetation monitoring sites..... 4

Figure 2. Map of cultural, natural, and Elkhorn Tavern areas..... 5

Figure 3. HTLN vegetation community sample design..... 6

Figure 4. Comparison of understory species diversity for all sites and forest type..... 10

Figure 5. Comparison of understory foliar cover estimates for plant cover type 11

Figure 6. Total stem count for each overstory tree size class by forest type 15

Tables

Page

Table 1. Modified Daubenmire cover value scale used to determine herbaceous/shrub species cover for the HTLN Parks..... 7

Table 2. Diameter at breast height size class ranges for overstory trees 9

Table 3. Cover estimates for five ground cover classes..... 12

Table 4. Mean (± 1 standard deviation) overstory tree density and basal area by species size class among all sites..... 13

Table 5. Percent canopy cover for each site 14

Table 6. Mean (± 1 standard deviation) overstory tree density and basal area for the oak-hickory and the post oak-blackjack oak forest types 16

Table 7. Mean (± 1 standard deviation) tree regeneration density for the oak-hickory and post oak-blackjack oak forest types..... 17

Executive Summary

The overarching goal of resource management at Pea Ridge National Military Park (PERI) is to interpret the civil war battle that occurred on March 7-8, 1862. The objective for areas of the park not immediately connected to the battle is to provide a natural backdrop for this battle. Thus, the landscape should reflect the natural range of conditions present at the time of the battle, which will help interpret the cultural significance of both events and resources at the park as they pertain to the battle.

The oak-hickory communities of PERI are part of the Springfield Plateau, an ecological subsection of the Ozark Highlands. Rolling hills paired with narrow hollows and broad uplands characterize this area of northwest Arkansas. Seven HTLN vegetation monitoring sites were established and sampled in 2007 across the forested community of the park. Natural resources of the park were separated into two distinct working areas: a cultural resource area and a natural resource area, with all HTLN sites in the natural area. The resource areas were divided according to proximity to the battlefield and its associated viewshed.

The forested community in the natural area of PERI was post-stratified into two distinct forest types as described by the Ozark Highlands Fire Effects Monitoring Module. Five sites were grouped into the oak-hickory forest type and two sites into the post oak-blackjack oak forest type. The understory herbaceous layer and overstory canopy cover were similar among all sites regardless of site location or forest type. Understory vegetative cover was low and species diversity was similar across all sites. Dominant and sub-canopy overstory composition differed among forest types while structure was similar based on size class distribution and regeneration.

Well defined overstory canopy layers with a few larger oak and hickory trees coupled with some standing dead trees indicate that this forest has only recently been affected by changes to the natural disturbance regime, primarily fire suppression. With increased fire suppression, recruitment of oak species into the larger size classes has been limited by the increased density of shade tolerant species. As the canopy becomes more closed closer to the ground, successional pathways for oak and hickory species become restricted. The large presence of sassafras in the oak-hickory forest type is indicative of recent disturbance changes.

These baseline results can be used to complement data collected from fire module sites located in the natural area to better address fire management goals and monitoring objectives. Findings in this baseline report support the fire management goals and objectives for the park. Reduction in smaller size class trees will help to promote regeneration of oak species and favor the recruitment of oak and hickory species into larger size classes. This will ultimately promote the development of a late successional oak-hickory forest that was once characteristic of the region.

Introduction

The overarching goal of resource management at Pea Ridge National Military Park (PERI) is to interpret the civil war battle that occurred on March 7 and 8, 1862. The objective for areas of the park not immediately connected to the battle is to provide a natural backdrop for this battle. Thus, the landscape should reflect the natural range of conditions present at the time of the battle, which will help interpret the cultural significance of both events and resources at the park as they pertain to the battle.

The natural communities of PERI are part of the Springfield Plateau, an ecological subsection under the Ozark Highlands (Nelson, 2005). Rolling hills paired with narrow hollows and broad uplands characterize this area of northwest Arkansas. The primary forested community is oak-hickory, which can be divided into five types: 1) post oak-blackjack oak, 2) black oak, 3) white oak, 4) oak-hickory and 5) mixed hardwood forest types (Dale, 1983). 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, and a defined sub-canopy of oaks or hickory species with a sparse understory shrub and herbaceous layer. Further refinement such as the presence of flowering dogwood as a sub-canopy layer helps to define forest types. Within this forested community, Ozark chinquapin (*Castanea pumila* v. *ozarkensis*) is of particular interest due to the detrimental impact of chestnut blight on its populations throughout the region (Arkansas Natural Heritage Commission: http://www.naturalheritage.com).

Although it is difficult to know quantitatively what the natural forest conditions were at PERI in the spring of 1862, understanding the function and processes of the forest type naturally occurring in the region will provide both goals and direction for achieving park resource objectives. The main objective for the natural resources is to provide a backdrop to better interpret the battle and give the visitor a sense of the landscape in which the battle was fought. For the forested community, this does not require replicating the stage of succession of the oak-hickory forest in 1862, but rather creating a functioning oak-hickory forest with available successional pathways and an intact natural disturbance regime that could act as a proxy for 1862 forest conditions. The assumption is that in 1862 the area was still functioning as a natural system under a natural disturbance regime with little impact from settlement.

The fire management objectives and goals as outlined in the fire management plan (NPS, 2005) are pursuing this proxy for 1862 forested conditions. The seven Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program (HTLN) vegetation monitoring sites established and sampled in 2007 complement the existing efforts of 12 fire module sites in the forested areas. Alone the HTLN sites will provide baseline monitoring data for forest composition and stand structure; paired with the fire module sites they can be used to help assess effects of prescribed burns as they apply to fire management objectives and goals. Long-term sampling will monitor both the natural change as a result of succession as well as targeted management actions such as prescribed burns or mechanical thinning.

Methods

Field methods

The Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program (HTLN) implemented monitoring at PERI in 2007 to provide analysis of baseline conditions and to assess future change in forest communities (see DeBacker *et al.* 2004 for detailed information on the monitoring protocol). Seven forested sites (consisting of ten $10m^2$ plots at each site) were sampled in mid-July of 2007, to obtain cover estimates and species identification of the overstory canopy, understory shrub, and herbaceous layer (Fig. 1). Sites were established according to the protocols in DeBacker *et al.* 2004 using both aspect and soil type as strata.

The park Chief of Resource Management, along with HTLN staff, separated the 4,300 acre park into two distinct working areas: cultural resource area (2,007 acres) and natural resource area (2,025 acres). The resource areas were divided according to proximity to the battlefield and its associated viewshed. Areas within the park not directly tied to the interpretation of the battle were labeled as natural resources. An area of interest for both cultural and natural interpretation is the viewshed around Elkhorn Tavern. Due to its location in the park, surrounding forest community, and role in interpreting the battle, all monitoring efforts overlap in this resource area.

The cultural areas will receive the most active management to return the setting to battle-era conditions, while the natural resource area will be managed for natural forest community integrity. To maximize park and network efforts, monitoring of the cultural resource area is lead by PERI, while HTLN is the lead for natural resource area monitoring. In addition, fire effects monitoring has been ongoing at the park for the past six years and includes 14 sites. These fire module sites are primarily located in the natural resource area with the exception of two restored prairie sites and three sites in the vicinity of Elkhorn Tavern.

Network monitoring sites were located to compliment existing fire module sites previously established across the natural area (Fig. 2).

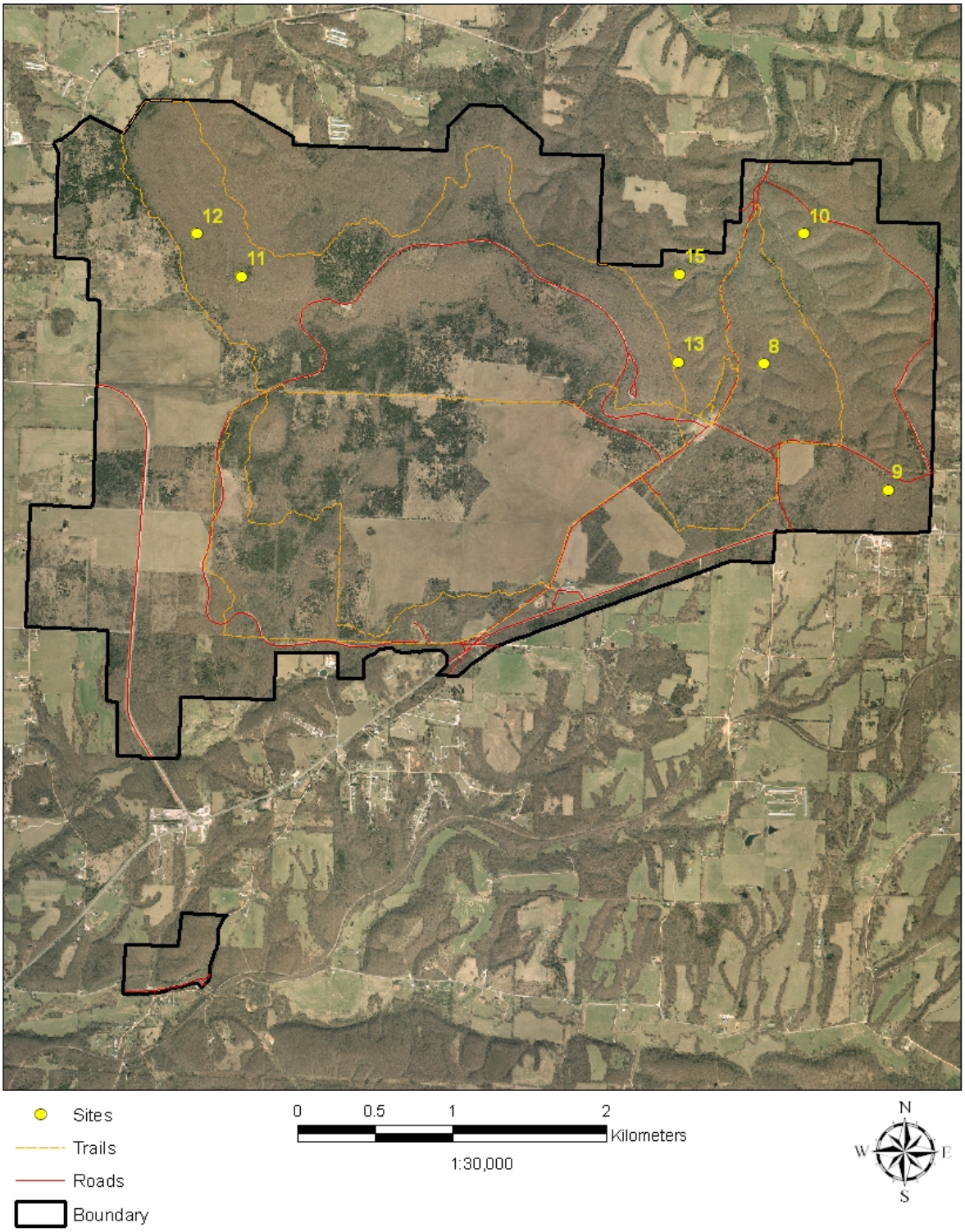

Figure 1. Map of Pea Ridge National Military park displaying vegetation monitoring sites.

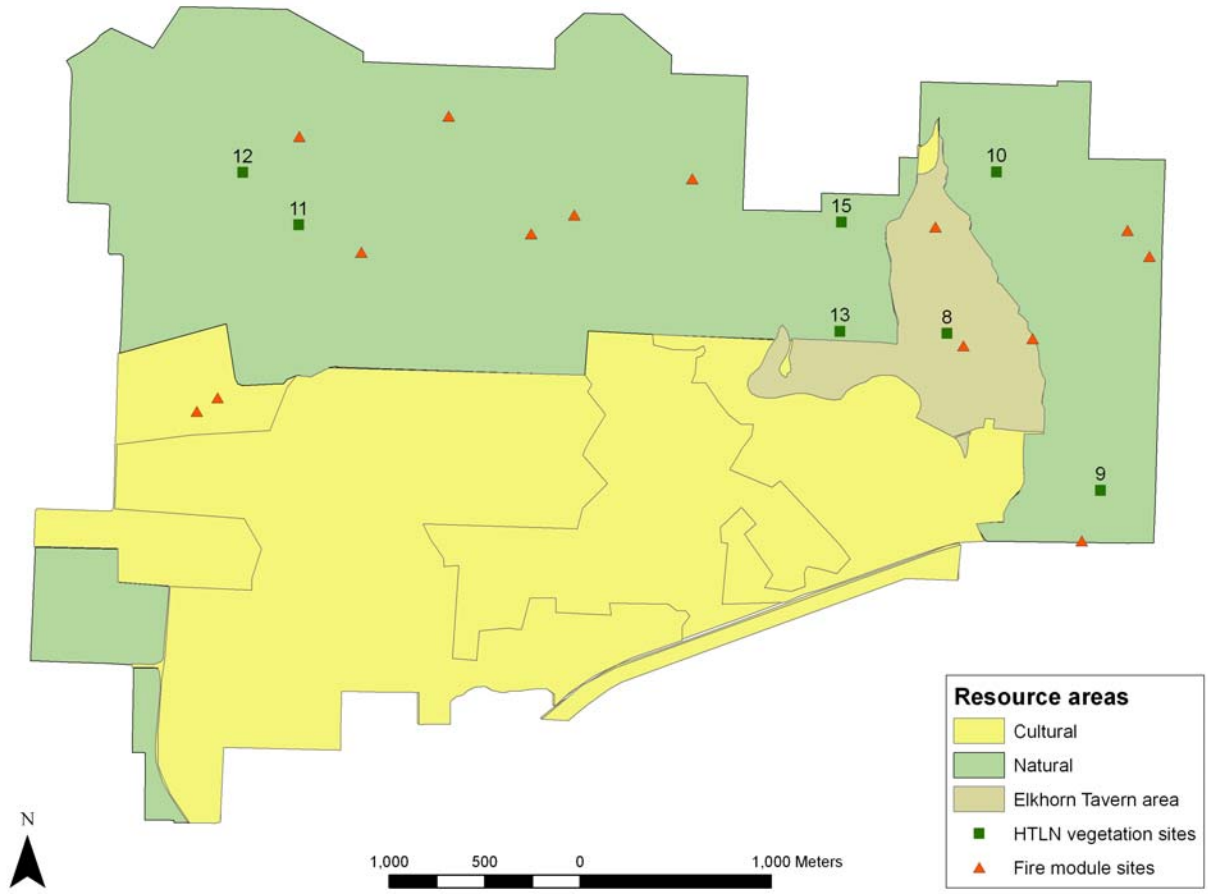

Figure 2. Cultural, natural, and Elkhorn Tavern areas with the location of HTLN vegetation monitoring sites and fire module sites at PERI.

The 2005 Fire Management Plan (FMP) for PERI defined four fire management units that are entirely within the natural area (NPS 2005). The Elkhorn Tavern area is contained within a fire management unit that is in both the natural and cultural areas. In the natural area, HTLN sites 11, 12, 13 and 15 were burned in 2006 in accordance with the FMP. Site 8 is scheduled to burn in 2008, while sites 9 and 10 are scheduled for the following year in 2009 (NPS 2005).

The HTLN sampling design, based on the design of the Konza Prairie Long-Term Ecological Research Program, consists of randomly located, permanent, paired transects 50 meters in length and 20 meters apart with five circular $10m^2$ plots systematically spaced along each transect (Fig. 3).

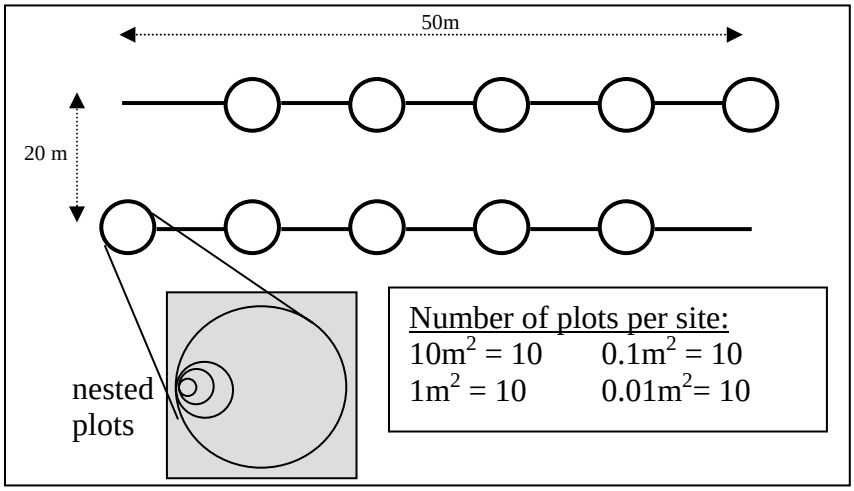

Figure 3. HTLN vegetation community sample design showing transects and plots including nested plots.

The primary sample unit is the site and circular plots along each transect are secondary sample units. Each $10m^2$ plot also includes nested subplots of $1m^2$, $0.1m^2$, and $0.01m^2$ for frequency estimates at multiple scales. For this report, both understory frequency and cover estimates are reported from the $10m^2$ plots. Working systematically from the smallest subplot ($0.01m^2$) to the largest ($10m^2$), all species are identified and foliar cover is estimated. Forest understory vegetation is sampled in this manner. For forested communities, overstory canopy cover and regeneration species composition and structure data are collected at secondary sample units (plot level). Overstory tree (stems $\geq$ 5.0 cm diameter at breast height, dbh) size (dbh) and condition data are collected for each species within the 0.1ha area in the 20x50m area formed between the two transects. This 0.1ha area is the primary sample site for overstory tree composition, density, and basal area measurements.

Analytical methods

For analyses, the site is used as the unit of replication and secondary sample units are pooled or averaged. Once estimates for all parameters have been obtained for each sample unit, averages with a measure of variability (standard deviation) among sample sites are obtained for individual forest types.

Individual species abundances

Individual species frequency and percent foliar cover are calculated for each site. Frequency is defined as the number of times a species is present in a given number of plots of a particular size (Raunkiaer 1934). With the primary sample unit (site) as the replicate, species frequency is reported as the proportion (or percentage) of plots in which the species occurs within each site.

Foliar cover serves as an estimate of abundance for herbaceous species. The cover class intervals are converted to median values to estimate percent cover for each herbaceous and shrub species (Table 1). Mean percent cover is then calculated as the species percent cover for a sampling unit,

averaged for all plots in which the species occurs (i.e., plots within a sampling unit with zero values for a species are excluded).

Table 1. Modified Daubenmire cover value scale used to determine herbaceous/shrub species cover for the HTLN Parks.

Cover Class Codes	Range of Cover (%)	Class Midpoints (%)
7	95-100	97.5
6	75-95	85.0
5	50-75	62.5
4	25-50	37.5
3	5-25	15.0
2	1-5	2.5
1	0-0.99	0.5

Understory species are grouped into two cover types according to Ozark Highlands Fire Effects Monitoring Module. All non-woody species are considered part of the herbaceous cover type while woody species (primarily shrub species) constitute the woody species cover type.

Plant species richness, diversity, and evenness

Plant diversity for each site is calculated using the **Shannon diversity index**:

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

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

Species distribution **evenness** is calculated by site using Pielou (J):

$$J' = H' / H_{max},$$

where H' is the Shannon diversity index and H_{max} is the maximum possible diversity for a given number of species if all species are present in equal numbers ((ln(species richness)). J' is a measure of distribution of species within a community as compared to equal distribution and maximum diversity (Pielou 1969).

Species **richness** (S) is determined as the total number of plant taxa recorded per site. Species richness is calculated with all species (native and exotic) included in the estimate.

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

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

Shannon and Simpson's diversity index values are converted into effective number of species for the understory vegetation (H_e and D_e, respectively). This allowed for both diversity measures to

be compared directly to species richness of the sites (S) and across the natural area (Joust 2006). Shannon diversity index was converted into effective number of species (H_e) using the following formula:

$$H_e = \exp^{(H)}$$

where H is the Shannon diversity index value. Effective number of species based on Simpson's diversity index (D_e) is the inverse of the index value or:

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

where D is the Simpson's diversity index value.

When interested in measuring diversity in a single community it is best to use all three diversity measures to most accurately reflect diversity (Joust 2006). At the most basic level of species diversity, species richness provides a total number of distinct species sampled per unit area. Richness is insensitive to species abundance. Therefore a single individual species occurring only once in a community is treated the same as a species with thousands of individuals in the community. This measure is an indicator of species diversity but does not provide any information about the composition of species within the community. Shannon diversity index weights species by their abundance. It is an intermediate between species richness and Simpson's diversity index in its sensitivity to rare species. Therefore this diversity measure provides information on both the count of unique species and their abundance or density in the community. Simpson's diversity index goes one step further by disproportionately favoring dominant species based on species abundance and is little affected by gain or loss of rare species.

Dominance takes into account the species abundance and evenness of species distribution in the community. The degree of species dominance in the community is reflected by the degree to which $S > H_e > D_e$ when evenness (E) remains constant in a single community. The difference in number of species between the diversity measures reflects both how each metric considers uncommon species and how species diversity is partitioned within the community. If all species occurred in equal abundance in the community, then $S = H_e = D_e$. Effective number of species for each diversity measure reflects the number of species found in a similar community when all species occur in equal density. For example, if S = 100 and D_e is equal to 20, than the community is dominated by 20 species and 80 species occur in low abundance. Such a community would be equivalent to a community with just 20 species all occurring in equal abundance.

Overstory and understory data summary

In the forest community, summary statistics for overstory and understory (stems ≥ 5.0 cm dbh) tree species are calculated. For each species, density and basal area are calculated. Density, or the number of stems per sample unit (scaled to hectare), is a measure of abundance for tree species. Overstory/understory density is calculated for five size classes (Table 2).

Table 2. Diameter at breast height (cm) size class ranges for overstory trees.

Size Class	dbh (cm)
1	5 - 14.9
2	15 - 24.9
3	25 - 34.9
4	35 - 44.9
5	45+

Basal area (m^2) is calculated using the standard formula: $dbh^2 \times 0.00007854$. Data are scaled to hectare, and summarized for the community and forest types using site data.

Seedling and sapling data summary

In the forested natural area, summary statistics for seedlings and sapling (stems < 5.0 cm dbh) tree species are calculated. Tree seedling/sapling density is reported in three size classes (cm dbh):

- seedlings (stems < 0.5 m in height)
- small saplings (stems ≥ 0.5 m in height but < 2.5 cm dbh)
- large saplings (stems ≥ 2.5 cm dbh but < 5.0 cm dbh)

When only a single small or large sapling was detected, regeneration data were summarized for all three size classes.

Results

Results are summarized for all HTLN monitoring sites as well as according to forest type. Findings are based on the initial monitoring effort during the summer of 2007. Post-stratification of monitoring sites in the natural area was done based on forest type as defined by the Ozark Highlands Fire Effects Monitoring Module. Two forest types were delineated based primarily on the dominance of two oak species. The post oak-blackjack oak savanna/woodland forest type (QUMA) is based on the dominance of *Quercus stellata* (post oak) and subdominant *Quercus marilandica* (blackjack oak). The other forest type, Ozark oak-hickory woodland/forest (OAH) has a dominant canopy of mixed oak (not including Q. *marilandica*) with a defined subcanopy of other hardwood species. Two HTLN monitoring sites were defined as QUMA (sites 11, 12), while the remaining were identified as belonging to the OAH forest type. These results will provide a monitoring baseline to be used in comparison with future monitoring efforts at these sites in the natural area of the park as well as provide additional fire effects monitoring data for the Ozark Highlands fire effects cluster.

Forested understory

A total of 84 non-tree understory species were sampled among the seven HTLN monitoring sites. The average number of species sampled per site (S) was 31.9 ± 9 species (mean ± 1 standard deviation). Figure 4 compares mean understory species diversity measures for all sites and for each forest type (OAH, QUMA). Effective number of species as measured by both Shannon's

index (H_e) and Simpson's index (D_e) were similar for each respective measure among all sites regardless of forest type. Mean evenness (J') ranged from 0.848 (± 0.124) in OAH to 0.946 (± 0.043) in QUMA, with all sites having a mean evenness value of 0.876 (± 0.113). The understory species sampled occurred in nearly equal abundance among all sites as well as within forest type.

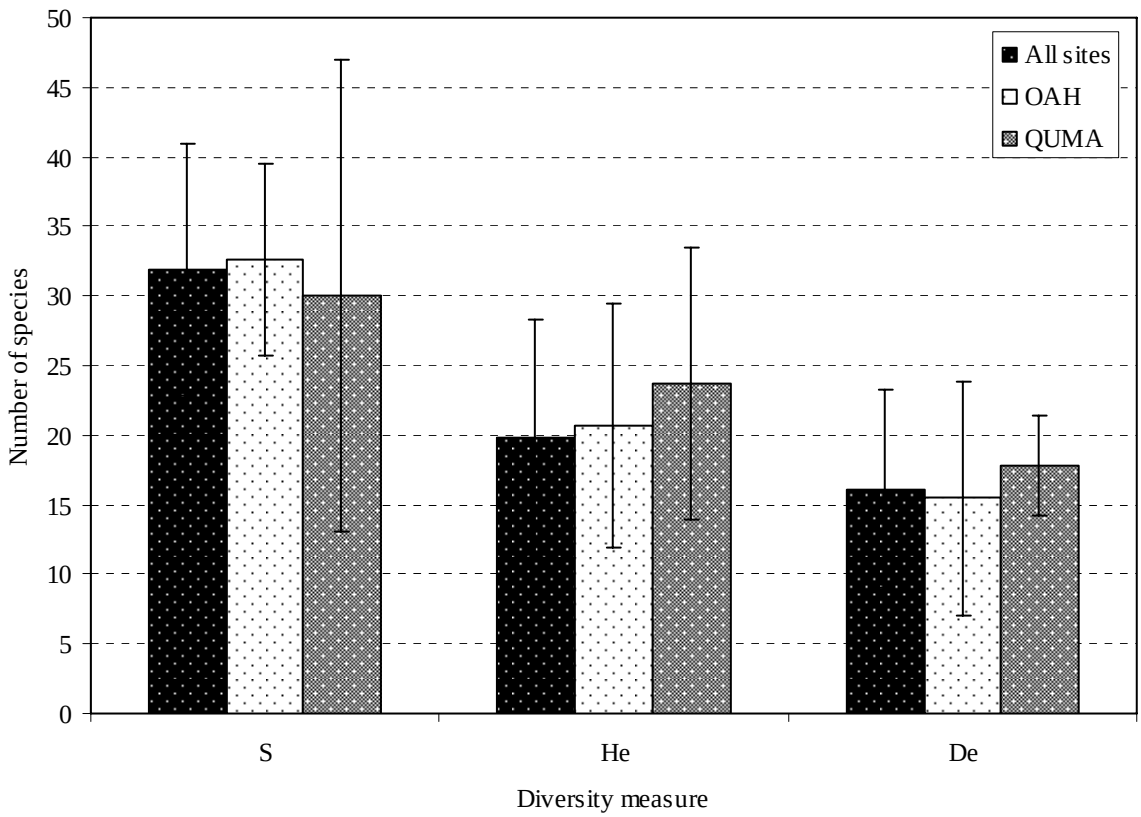

Figure 4. Mean (± 1 standard deviation) understory species diversity for all sites (n=7), oak-hickory forest type (OAH, n= 5) and the post oak-blackjack oak forest type (QUMA, n=2). Species diversity metrics: richness (S), Shannon number (H_e) and Simpson's number (D_e).

The QUMA forest type had the lowest number of species (49 for two sites) yet had the highest evenness value and effective number of species as derived from Simpson's index (D_e = 17.9 ± 3.6). Species were evenly distributed across the QUMA forest type. Further, 52% of the species in the QUMA forest type were considered dominant species as indicated by D_e.

Understory species were grouped into understory cover type groups to compare herbaceous and woody species foliar cover across the natural area (Fig. 5). Cover type delineation was based on Ozark Highlands Fire Effects Monitoring Module groups. Foliar cover for both groups was low for all sites as well as within forest types. Herbaceous foliar cover was slightly higher in OAH forest while woody species cover was slightly higher in QUMA forest type. However for all foliar cover estimates, mean values were less than two percent (Fig. 5).

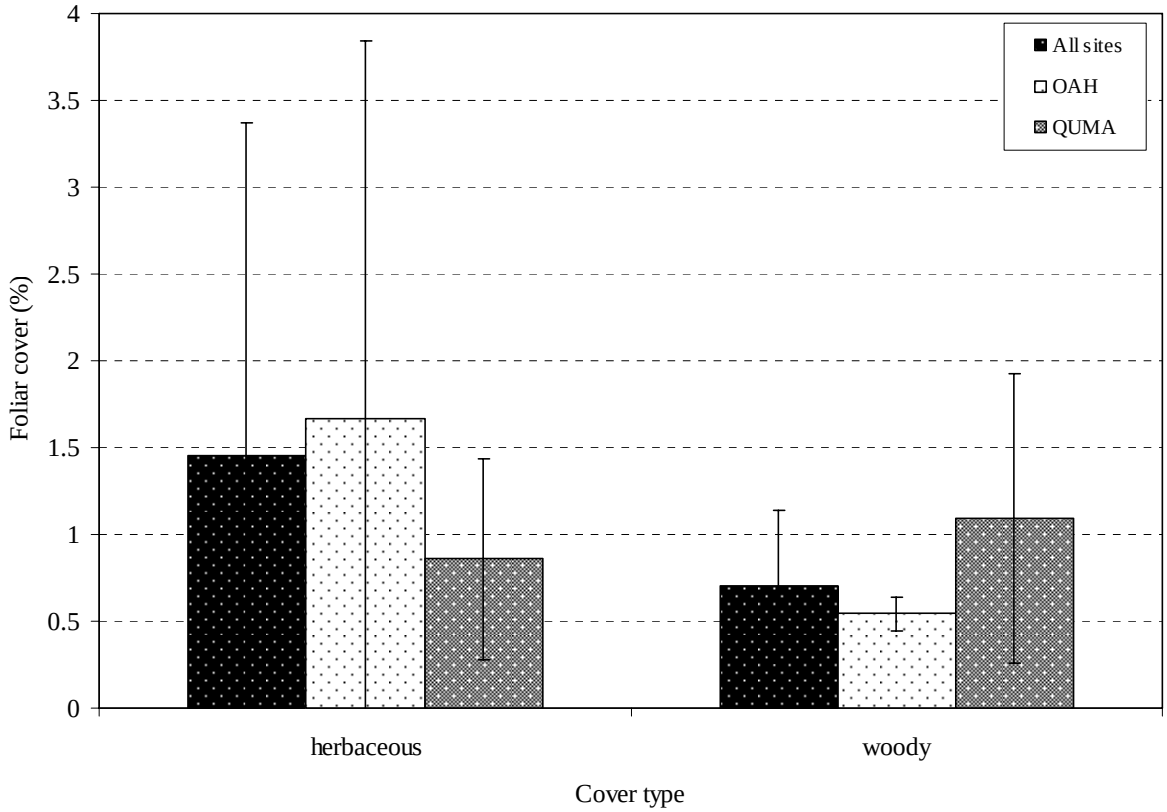

Figure 5. Mean (± 1 standard deviation) understory foliar cover estimates (%) for plant cover type across all sites (n=7), oak-hickory forest type (OAH, n= 5) and the post oak-blackjack oak forest type (QUMA, n=2).

Even though most species were evenly distributed within and among monitoring sites, the understory species did not occur in high abundance as measured by foliar cover estimates. See Appendix A for a complete list of individual understory species frequency and foliar cover estimates among all sites.

Ground cover estimates for all sites were dominated by leaf litter. Table 3 presents the cover estimates for five ground cover categories for each site as well as an average for all sites. The variability in ground cover was at the site level rather than the forest type group.

Table 3. Ground cover estimates (%) for five ground cover classes estimated for each site and averaged (± 1 standard deviation) for all sites in the natural area.

Site	Forest Type	Bare Soil	Rock	Grass Litter	Woody Debris	Leaf Litter
PERI_8	OAH		11.4	0.5	11.4	78.3
PERI_9	OAH	5.6	1.5	0.5	10.0	76.0
PERI_10	OAH		4.7	0.5	2.8	69.0
PERI_11	QUMA	0.5	2.3	0.5	6.6	80.5
PERI_12	QUMA	0.5	7.3	0.5	13.7	76.0
PERI_13	OAH	0.5	2.7	0.5	17.3	76.0
PERI_15	OAH	0.5	8.1	0.5	13.8	78.0
All sites		1.5 (2.3)	5.4 (3.7)	0.5	10.8 (4.9)	76.3 (3.6)

High leaf litter cover estimates and moderate woody debris estimates may have implications on both fuel loading and overstory tree regeneration. High percentage of cover for these two groups also has a limiting affect on total foliar cover of the herbaceous understory.

Exotic invasive species were detected in low abundance across the monitoring sites. Only two species were detected: *Lactuca serriola,* and *Taraxacum officinale*. All occurred at a frequency of 1.43% and foliar cover estimate of 0.5%. For a complete survey and results for exotic invasive species for the entire park refer to Young *et al*. (2007).

Forested overstory

Baseline overstory results for all seven HTLN sites in the natural area were summarized for the 2007 sample year. Overstory and regeneration data collected during 2007 were summarized for forest type as well as for all sites.

Overall the natural area was dominated by oak species, black hickory and flowering dogwood, for all size classes across the natural area. Most notable in the overstory across the natural area was the lack of post-oak and blackjack oak species in the largest size class (size class 5; Table 4). For all sites, ten tree species comprised the two largest size classes (dbh ≥ 35 cm). Of those ten species, *Quercus velutina* and Q. *rubra* had the greatest basal area when size class 4 and 5 were combined (2.044 ± 0.592 and 1.599 ± 0.992 m^2/ha, respectively). Across all sites, size class 5 had the lowest mean density (17.8 ± 14.0 stems/ha) and the highest mean basal area (2.248 ± 0.906 m^2/ha). In fact, mean basal area increased with size class as mean density tended to decrease (with the exception of size class 2). Over one-third of all trees sampled were in size class 2 with twelve distinct species. Oaks (post, red, blackjack) and black hickory comprised 65% of this size class.

Table 4. Mean (± 1 standard deviation) overstory tree density (trees/ha) and basal area (m^2/ha), by species size class among all sites (n=7).

SizeClass	Scientific names	Common name	Density	Basal Area
1	*Acer rubrum*	red maple	10	0.029
1	*Carya alba*	mockernut hickory	10	0.043
1	*Carya texana*	black hickory	13.3 (5.8)	0.097 (0.050)
1	*Castanea pumila* v. *ozarkensis*	Ozark chinquapin	10	0.044
1	*Cornus florida*	flowering dogwood	38.0 (33.5)	0.053 (0.029)
1	*Fraxinus americana*	white ash	10	0.050
1	*Juniperus virginiana*	eastern red cedar	60	0.114 (0.035)
1	*Nyssa sylvatica*	blackgum	40 (42.4)	0.087 (0.051)
1	*Quercus alba*	white oak	30	0.080 (0.029)
1	*Quercus rubra*	red oak	15.0 (7.1)	0.088 (0.036)
1	*Quercus stellata*	post oak	60	0.102 (0.042)
1	*Ulmus* spp.	elm spp.	30	0.038 (0.023)
2	*Carya glabra*	pignut hickory	13.3 (5.8)	0.333 (0.070)
2	*Carya texana*	black hickory	53.3 (75.1)	0.314 (0.095)
2	*Cornus florida*	flowering dogwood	30.0 (28.3)	0.216 (0.048)
2	*Diospyros virginiana*	common persimmon	40	0.302 (0.084)
2	*Juglans nigra*	black walnut	10	0.456 (0.011)
2	*Juniperus virginiana*	eastern red cedar	20.0 (14.1)	0.280 (0.087)
2	*Nyssa sylvatica*	blackgum	100	0.263 (0.052)
2	*Quercus alba*	white oak	12.5 (5.0)	0.322 (0.072)
2	*Quercus marilandica*	blackjack oak	150	0.329 (0.100)
2	*Quercus rubra*	red oak	42.5 (17.1)	0.364 (0.083)
2	*Quercus stellata*	post oak	63.3 (75.7)	0.318 (0.089)
2	*Ulmus* spp.	elm spp.	10	0.241
3	*Carya glabra*	pignut hickory	23.3 (15.3)	0.710 (0.156)
3	*Carya texana*	black hickory	30.0 (14.1)	0.624 (0.077)
3	*Cornus florida*	flowering dogwood	10	0.507
3	*Diospyros virginiana*	common persimmon	10	0.855
3	*Juniperus virginiana*	eastern red cedar	10.0 (0.0)	0.570 (0.084)
3	*Quercus alba*	white oak	22.5 (15.0)	0.731 (0.142)
3	*Quercus marilandica*	blackjack oak	15.0 (7.1)	0.706 (0.055)
3	*Quercus rubra*	red oak	37.5 (12.6)	0.739 (0.156)
3	*Quercus stellata*	post oak	75.0 (21.2)	0.674 (0.128)
4	*Carya alba*	mockernut hickory	10	1.340
4	*Carya glabra*	pignut hickory	10.0 (0.0)	1.323 (0.005)
4	*Diospyros virginiana*	common persimmon	10	1.534
4	*Juniperus virginiana*	eastern red cedar	10	0.968
4	*Quercus alba*	white oak	42.5 (22.2)	1.230 (0.183)
4	*Quercus rubra*	red oak	27.5 (22.2)	1.190 (0.175)
4	*Quercus stellata*	post oak	40	1.165 (0.070)
4	*Ulmus* spp.	elm spp.	10	1.340
5	*Carya texana*	black hickory	10	1.735
5	*Quercus alba*	white oak	25.0 (19.1)	2.092 (0.761)
5	*Quercus rubra*	red oak	10.0 (0.0)	3.076 (1.431)
5	*Quercus velutina*	black oak	20	2.044 (0.592

Canopy cover was similar among sites (Table 5). Canopy cover for all sites was above 86% in mid-July. There was no discernable difference in canopy cover among forest types when grouping sites. Total canopy cover within sites reflected the similarity in overstory density and basal area among sites, even though sites differed in species composition and size class membership.

Table 5. Percent canopy cover of the overstory for each forest site and averaged (± 1 standard deviation) for all sites during July 2007. Forest type OAH corresponds to oak-hickory forest and QUMA refers to the post oak-blackjack oak forest type.

Location	Forest Type	Canopy Cover
PERI_8	OAH	92.1
PERI_9	OAH	86.4
PERI_10	OAH	86.7
PERI_11	QUMA	86.4
PERI_12	QUMA	86.6
PERI_13	OAH	86.5
PERI_15	OAH	89.0
All sites		87.7 (3.81)

Although each site had a closed canopy the distribution of trees among size classes differed by forest type (Fig. 6). While both forest types had the greatest number of trees in size class 2, the post oak-blackjack oak sites (QUMA) did not have any trees in the largest size class and only five in size class 4. This was in contrast to the oak-hickory forest sites (OAH) that had over 25% of trees in the largest two size classes.

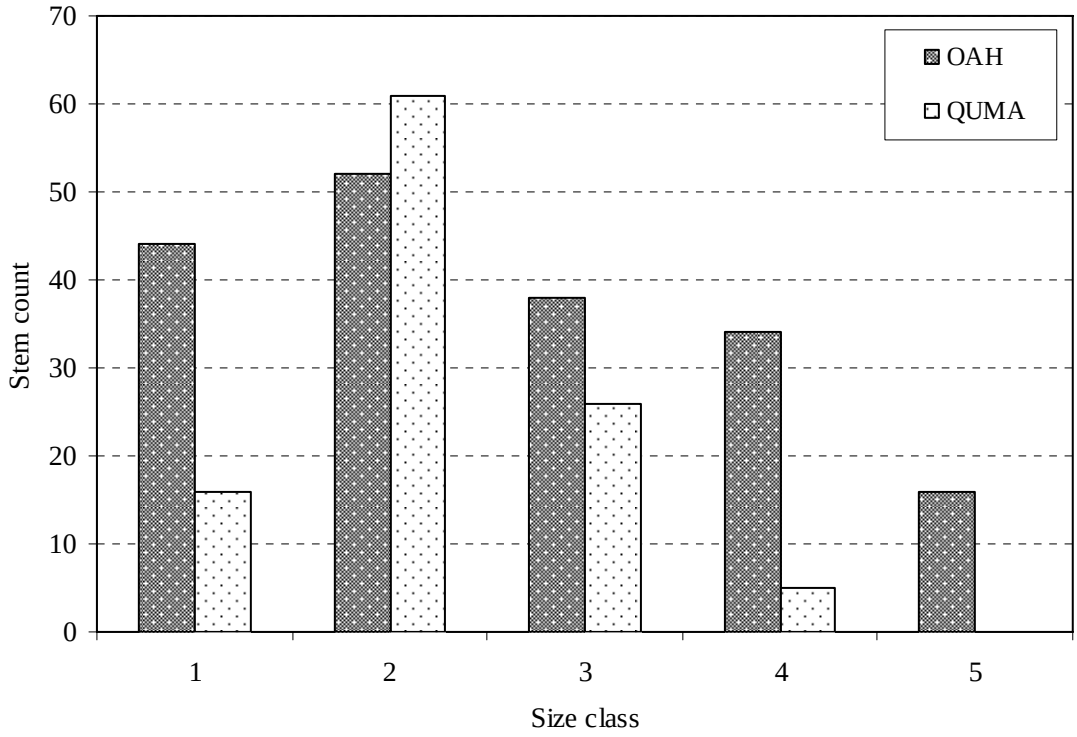

Figure 6. Total stem count for each size class by forest type (OAH corresponds to oak-hickory forest and QUMA refers to the post oak-blackjack oak forest type).

All *Quercus marilandica* and all but a single Q. *stellata* occurred in the QUMA forest type, thus delineating the two forest types in the natural area (Table 7). The post oak-blackjack oak forest type sub-canopy was primarily *Carya texana*. The oak-hickory forest type had a dominant canopy of Q. *rubra* and Q. *alba* with a sub-canopy of *Cornus florida*. Other trees present in both forest types occurred in lower abundance from the listed dominants as noted by their respective density and basal area (Table 6).

Table 6. Mean (± 1 standard deviation) overstory tree density (trees/ha) and basal area (m^2/ha) for the oak-hickory forest type (OAH, n= 5) and the post oak-blackjack oak forest type (QUMA, n=2).

		Density		Basal Area	
Scientific Name	Common Name	OAH	QUMA	OAH	QUMA
Acer rubrum	red maple	10		0.029	
Carya alba	mockernut hickory	10.0 (0.0)		0.691 (0.917)	
Carya glabra	pignut hickory	15.0 (12.2)	20	0.790 (0.364)	0.459 (0.192
Carya texana	black hickory	13.3 (5.2)	63.3 (68.1)	0.521 (0.548)	0.354 (0.163
Castanea pumila v. *ozarkensis*	Ozark chinquapin	10		0.044	
Cornus florida	flowering dogwood	32.5 (29.2)		0.108 (0.112)	
Diospyros virginiana	common persimmon	20.0 (17.3)		0.600 (0.513)	
Fraxinus americana	white ash	10		0.050	
Juglans nigra	black walnut	10	10	0.464	0.449
Juniperus virginiana	eastern red cedar	10.0 (0.0)	33.3 (25.2)	0.661 (0.292)	0.193 (0.133)
Nyssa sylvatica	blackgum	60.0 (45.8)		0.185 (0.103)	
Quercus alba	white oak	25.9 (18.0)		1.142 (0.737)	
Quercus marilandica	blackjack oak		60.0 (78.1)		0.392 (0.172)
Quercus rubra	red oak	29.4 (18.8)	20	0.833 (0.757)	0.349 (0.162)
Quercus stellata	post oak	10	71.7 (43.6)	0.445	0.488 (0.316)
Quercus velutina	black oak	20		2.044 (0.592)	
snag	snag	16.7 (5.2)	25.0 (10.0)	0.544 (0.319)	0.270 (0.167)
Ulmus spp.	elm spp.	20.0 (14.1)	10	0.089 (0.103)	1.340

The regeneration layer of the overstory was dominated by the seedling size class (906 total seedlings among all sites). In the larger regeneration size classes there were only 8 small saplings and 4 large saplings sampled among all sites. All size classes were grouped into a single regeneration value. *Quercus stellata* and *Cornus flordia* accounted for 50% of the small and large saplings detected. In the regeneration layer there were an additional four species not found in the overstory: hackberry, red mulberry, wild cherry, and sassafras. All were present in low amounts (as measured by mean density) except sassafras (3200.0 ± 3862.0 seedlings/ha), which was second only to the white oak group in density of all species of either forest type (Table 7). Regeneration in the OAH forest type consisted primarily of sassafras, flowering dogwood, and the white oak group. The QUMA forest type regeneration layer was dominated by the white oak group (5600.0 ± 3252.7 seedlings/ha).

Table 7. Mean (± 1 standard deviation) tree regeneration density (trees/ha) for the oak-hickory forest type (OAH, n= 5) and the post oak-blackjack oak forest type (QUMA, n=2).

Scientific Name	Common Name	OAH	QUMA
Acer rubrum	red maple	980.0 (944.5)	100
Carya spp.	hickory spp.	400.0 (435.9)	1000 (707.1)
Carya texana	black hickory		100
Celtis occidentalis	hackberry	200.0 (173.2)	2700
Cercis canadensis	eastern redbud	400	
Cornus florida	flowering dogwood	3000.0 (3604.9)	
Diospyros virginiana	common persimmon	700.0 (509.9)	100
Fraxinus americana	white ash	450.0 (353.6)	
Juniperus virginiana	eastern red cedar	433.3 (288.7)	650 (777.8)
Morus rubra	red mulberry	100.0 (0.0)	200
Nyssa sylvatica	blackgum	950.0 (70.7)	100
Prunus spp.	wild cherry	250.0 (173.2)	
Quercus marilandica	blackjack oak	300	
Quercus stellata	post oak		400
Red oak group	red oak group	1150.0 (1109.1)	1400
Sassafras albidum	sassafras	3200.0 (3862.0)	1200
Ulmus alata	winged elm	100	
Ulmus spp.	elm spp.	1420.0 (697.9)	600.0 (424.3)
White oak group	white oak group	2140.0 (2215.4)	5600.0 (3252.7)

A single Ozark chinquapin (*Castanea pumila* v. *ozarkensis*) was sampled at site 8 (Elkhorn Tavern area, OAH forest type). The individual was in size class 1 with a dbh of 7.5cm. No other specimens were sampled within the six other monitoring sites.

Discussion

The management goal for all areas of Pea Ridge National Military Park is to set the park within a range of conditions that is consistent with 1862 conditions. Within the park, the range of conditions varies by area and desired level of interpretation of the battle. The cultural, natural, and Elkhorn Tavern areas have different goals relative to 1862 conditions. HTLN monitoring is focused on the natural area and a portion of the Elkhorn Tavern area (site 8). Establishing baseline conditions to help inform natural resource managers of the current condition of the forested areas is the goal of HTLN monitoring. Monitoring data will aid managers in returning the natural area to the range of natural conditions possible during the time of the battle.

Heartland network vegetation monitoring sites were post-stratified by forest type as defined by the Ozark Highlands Fire Effects Monitoring Module. Both forest types have well defined sub-canopy layers of mixed hardwood species with appropriate composition. Overstory structure is disproportionately weighted toward smaller size classes of trees (≤ size class 3). The higher density of trees in these size classes increases canopy cover at lower levels in the canopy thus decreasing the amount of sunlight reaching the forest floor and limiting herbaceous foliar cover.

Moreover, it inhibits oak and hickory regeneration by favoring more shade tolerant species, preventing seedlings from reaching larger size classes.

Well defined overstory canopy layers with a few larger (≥ size class 3) oak and hickory trees coupled with some standing dead trees indicate a forest that only recently began to be affected by changes to the natural disturbance regime, primarily fire suppression. With increased fire suppression, recruitment of oak species into the larger size classes has been limited as density of shade tolerant species has increased and been promoted in the regeneration layer and smaller size classes. As the canopy becomes more closed closer to the ground, successional pathways for oak and hickory species become restricted. The large presence of sassafras in the OAH forest type is indicative of recent disturbance changes.

These baseline results can be used to complement data collected from the twelve fire module sites located in the natural area to better address fire management goals and monitoring objectives. Findings in this baseline report support the fire management goals and objectives for the park. Reduction in smaller size class trees (≤ size class 3) will help to promote regeneration of oak species and favor the recruitment of oak and hickory species into larger size classes. This will ultimately promote the development of a late successional oak-hickory forest that was once characteristic of the region.

Literature Cited

Dale, E.E. 1983. Plant Communities and Rare or Endangered Plant Species of Pea Ridge National Military Park, Benton County, Arkansas. Final report presented to the park.

Davis, L.S. and K.N. Johnson. 1987. Forest Management (3rd Edition). McGraw-Hill, Inc., New York, New York.

DeBacker, M.D., A.N. Sasseen, C. Becker, G.A. Rowell, L.P. Thomas, J.R. Boetsch, and G.D. Willson. 2004. Vegetation Community Monitoring Protocol for the Heartland I&M Network and Prairie Cluster Prototype Monitoring Program. National Park Service, Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program, Wilson's Creek National Battlefield, Republic, Missouri. 40 p. plus appendices.

Joust, L. 2006. Entropy and diversity. OIKOS 113:2.

McCune, B. and J.B. Grace. 2002. Analysis of Ecological Communities. MJM software Design.

National Park Service (NPS). 2005. Fire Management Plan for Pea Ridge National Military Park.

Nelson, P. W. 2005. The Terrestrial Natural Communities of Missouri. Missouri Natural Areas Committee.

Pielou, E.C. 1977. Population and Community Ecology. New York: Gordon and Breach.

Raunkiaer, C. 1934. The Life Forms of Plants and Statistical Plant Geography. Oxford: Oxford University Press.

Shannon, C.E. 1948. A Mathematical Theory of Communication. The Bell System Technical Journal 27: 379 – 423, 623 – 656.

Young C.C., J.T. Cribbs, J.L. Haack, and H.J. Etheridge. 2007. Invasive exotic plant monitoring at Pea Ridge National Military Park: Year 1 (2006). Natural Resource Technical Report NPS/MWR/HTLN/NRTR—2007/008. National Park Service, Omaha, Nebraska.

Appendix

Appendix A. Forest understory species frequency (%) and mean foliar cover (%) estimates for all sites (n=7).

Scientific Name	Common Name	Frequency	Mean Cover
Acalypha virginica	Virginia copperleaf	27.14	0.50
Ageratina altissima	Tall ageratina	17.14	1.33
Ambrosia artemisiifolia	Common ragweed	2.86	0.50
Amphicarpa bracteata	Hog-peanut	47.14	10.23
Amphiachyris dracunculoides	Broomweed	1.43	15.00
Anemone spp.		10.00	0.50
Antennaria plantaginifolia	Plantain pussytoes	7.14	0.50
Andropogon virginicus	Broom-sedge	10.00	1.21
Aristolochia serpentaria	Snakeroot	5.71	0.50
Aster patens	Clasping wild aster	2.86	0.50
Asplenium platyneuron	Ebony spleenwort	4.29	0.50
Aster spp.		5.71	0.50
Botrychium virginianum	Rattlesnake-fern	2.86	0.50
Brachyelytrum erectum	Grass	7.14	2.00
Campanulastrum americanum	Tall bellflower	1.43	0.50
Cardamine concatenata	Five-parted toothwort	1.43	0.50
Carex spp.		71.43	1.64
Ceanothus spp.	ceanothus	1.43	0.50
Chamaecrista nictitans	partridge pea	1.43	0.50
Cirsium altissimum	Tall thistle	2.86	0.50
Cimicifuga racemosa	black bugbane	7.14	1.00
Conyza canadensis	Horseweed	4.29	0.50
Cunila origanoides	common dittany	20.00	1.21
Danthonia spicata	Poverty oatgrass	27.14	1.16
Desmodium nudiflorum	Naked tick-trefoil	45.71	2.58
Desmodium obtusum	Tick-trefoil	17.14	1.33
Desmodium rotundifolium	Round-leaved tick-trefoil	2.86	1.75
Dichanthelium boscii	Panic grass	40.00	3.48
Dichanthelium spp.		48.57	1.87
Smilax spp.		1.43	0.50
Elymus virginicus	Virginia wild rye	17.14	0.71
Erechtites hieraciifolia	Fireweed	40.00	4.00
Erigeron spp.	Fleabane	2.86	0.50
Erigeron strigosus	Rough fleabane	8.57	0.50
Euphorbia corollata	Flowering spurge	2.86	0.50
Eupatorium serotinum	Late flowering thoroughwort	1.43	3.00
Galium arkansanum	Bedstraw, cleavers	1.43	0.50
Galium circaezans	Forest bedstraw, wild licorice	28.57	0.50
Gnaphalium obtusifolium	Fragrant cudweed	4.29	0.50
Hackelia virginiana	Stickseed, beggar's lice	7.14	1.00
Hieracium gronovii	Beaked hawkweed	4.29	1.33
Houstonia purpurea	Mountain houstonia	1.43	0.50
Hypericum hypericoides	St. Andrew's cross	10.00	0.50
Hypericum spp.		1.43	0.50

Lactuca canadensis	Tall lettuce	2.86	0.50
Lactuca serriola	Prickly lettuce	1.43	0.50
Lespedeza procumbens	Downy trailing lespedeza	21.43	1.00
Lespedeza repens	Creeping lespedeza	7.14	1.00
Lespedeza violacea	Violet lespedeza	5.71	0.50
Lespedeza virginica	Virginia lespedeza	8.57	0.50
Menispermum canadense	Moonseed	2.86	0.50
Monarda fistulosa	Wild bergamot	1.43	0.50
Muhlenbergia sobolifera	Muhly	21.43	2.63
Oxalis spp.	wood-sorrel	2.86	0.50
Paspalum laeve	field paspalum	1.43	0.50
Parthenocissus quinquefolia	Virginia-creeper, woodbine	71.43	0.50
Phytolacca americana	Pokeweed, pokeberry	2.86	1.75
Phryma leptostachya	Lopseed	1.43	0.50
Polystichum acrostichoides	Christmas fern	5.71	5.38
Rhus copallinum	Shining sumac	11.43	0.50
Rosa spp.	rose	2.86	0.50
Rubus spp.		31.43	0.61
Rudbeckia hirta	Black-eyed Susan	4.29	0.50
Ruellia strepens	Acanthus	1.43	0.50
Sanicula canadensis	Canada sanicle	2.86	0.50
Schrankia nuttallii	Sensitive brier	2.86	0.50
Scutellaria ovata	Forest-skullcap	4.29	1.33
Smilax bona-nox	saw greenbrier	4.29	0.50
Smilax tamnoides	Catbrier	1.43	0.50
Solanum carolinense	Horse-nettle	1.43	0.50
Solidago spp.		8.57	0.50
Stylosanthes biflora	sidebeak pencilflower	1.43	0.50
Symphoricarpos orbiculatus	Coralberry	24.29	2.79
Taraxacum officinale	Common dandelion	1.43	0.50
Thalictrum thalictroides	Meadow-rue	1.43	0.50
Toxicodendron radicans	Common poison-ivy	7.14	0.50
Tridens flavus	Purpletop	7.14	0.50
Vaccinium spp.	blueberry	17.14	1.54
Verbesina alternifolia	Wingstem	1.43	0.50
Verbena urticifolia	White vervain	1.43	0.50
Viola spp.		21.43	0.50
Viburnum rufidulum	Southern black haw	8.57	0.50
Vitis spp.		68.57	0.55
Woodsia obtusa	Blunt cliff fern	1.43	0.50

The NPS has organized its parks with significant natural resources into 32 networks linked by geography and shared natural resource characteristics. HTLN is composed of 15 National Park Service (NPS) units in eight Midwestern states. These parks contain a wide variety of natural and cultural resources including sites focused on commemorating civil war battlefields, Native American heritage, westward expansion, and our U.S. Presidents. The Network is charged with creating inventories of its species and natural features as well as monitoring trends and issues in order to make sound management decisions. Critical inventories help park managers understand the natural resources in their care while monitoring programs help them understand meaningful change in natural systems and to respond accordingly. The Heartland Network helps to link natural and cultural resources by protecting the habitat of our history.

The I&M program bridges the gap between science and management with a third of its efforts aimed at making information accessible. Each network of parks, such as Heartland, has its own multi-disciplinary team of scientists, support personnel, and seasonal field technicians whose system of online databases and reports make information and research results available to all. Greater efficiency is achieved through shared staff and funding as these core groups of professionals augment work done by individual park staff. Through this type of integration and partnership, network parks are able to accomplish more than a single park could on its own.

The mission of the Heartland Network is to collaboratively develop and conduct scientifically credible inventories and long-term monitoring of park "vital signs" and to distribute this information for use by park staff, partners, and the public, thus enhancing understanding which leads to sound decision making in the preservation of natural resources and cultural history held in trust by the National Park Service.

www.nature.nps.gov/im/units/htln/

Heartland Network

Natural Resource Monitoring

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

NPS D-53, February 2008

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nps.gov

EXPERIENCE YOUR AMERICA ™